Foundations of Technology

A Standards-Based High School Model Course Guide

2nd Edition

Engineering By Design

Advancing Technological Literacy

A Standards-Based Program Series

DRAFT Guide

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INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION

CENTER TO ADVANCE THE TEACHING OF TECHNOLOGY & SCIENCE

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Preface

Engineering By Design – A Standards-Based Approach

In 2004, the International Technology Education Association's (ITEA) Center to Advance the Teaching of Technology and Science (CATTS) began development of the Engineering By Design Program, of which the *Foundations of Technology* guide is one component. The Program is described in detail later in the chapter and has been written so that you, as the teacher, supervisor, principal, or teacher educator can implement or develop standards-based instruction. The reader will find that the entire Program is described so that a sense of the overall approach to developing technological literacy through the study of Technology, Innovation, Design, and Engineering (TIDE) in Grades K-12 can be seen.

More than anything else, the program has been developed through a process that is based on standards. Each course in the Program focuses on one organizing principle that was developed based on the content standards in *Standards for Technological Literacy: Content for the Study of Technology (STL)* (ITEA 2000/2002). As the reader and implementer, you will find that the approach is significantly different than the traditional "find the activities then develop the content" method. To be truly standards-based, the Program must be created around standards and benchmarks—not a series of activities. This guide is the first of many to be produced that will do just that, so that the assessments that are introduced can be used appropriately by educators to inform instruction and improve student achievement.

It is the goal of this guide to provide educators with a model for implementing a standards-based program and course. Each section will be related to standards and will use the forms that can be found in the ITEA Technological Literacy Standards Series and the supporting Addenda Guides.

This guide presents content and lessons in a cornerstone technology education model course for the high school. It is based on *Technology for All Americans: A Rationale and Structure for the Study of Technology (Rationale and Structure)* (ITEA, 1996) and *Standards for Technological Literacy: Content for the Study of Technology (Standards for Technological Literacy/STL)* (ITEA, 2000/2002). Further guidance is provided through *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL)* (ITEA, 2003). Because these ITEA publications contain the fundamentals of technological literacy curriculum, teachers, supervisors, and teacher educators are encouraged to review them prior to using this guide.

Technology for All Americans: A Rationale and Structure for the Study of Technology

Technology for All Americans: A Rationale and Structure for the Study of Technology provides a vision for the study of technology. It addresses the power and promise of technology and the need for every American student to be technologically literate when he/she graduates from high school. Understanding the nature of technological advances and processes and participating in society's decisions on technological issues is of utmost concern. This publication outlines the knowledge, processes, and contexts for the study of technology.

Standards for Technological Literacy: Content for the Study of Technology

What is *Standards for Technological Literacy*?

ITEA and TfAAP published *Standards for Technological Literacy: Content for the Study of Technology (STL)* in April of 2000. *STL* defines, through K-12 content standards, what students should

know and be able to do in order to be deemed technologically literate. However, it does not put forth a curriculum to achieve these outcomes. *STL* will help ensure that all students receive an effective education about technology by setting forth a consistent content for the study of technology.

Why is *STL* important?

- Technological literacy enables people to develop knowledge and abilities about human innovation in action.
- *STL* establishes requirements for technological literacy for all students from kindergarten through Grade 12.
- *STL* provides expectations of academic excellence for all students.
- Effective democracy depends on all citizens participating in the decision-making process; many decisions involve technological issues, so citizens need to be technologically literate.
- A technologically literate population can help our nation maintain and sustain economic progress.

Guiding Principles for *STL*

The standards and benchmarks were created with the following guiding principles:

- They offer a common set of expectations for what students should learn about technology.
- They are developmentally appropriate for students.
- They provide a basis for developing meaningful, relevant, and articulated curricula at the local, state, and provincial levels.
- They promote content connections with other fields of study in Grades K-12.
- They encourage active and experiential learning.

Who is a technologically literate person?

A person who understands—with increasing sophistication—what technology is, how it is created, how it shapes society, and in turn, how technology is shaped by society, is technologically literate. A technologically literate person can hear a story about technology on television or read it in the newspaper and evaluate its information intelligently, put that information in context, and form an opinion based on it. A technologically literate person is comfortable with and objective about the use of technology—neither scared of it nor infatuated with it. Technological literacy is important to all students in order for them to understand why technology and its use is such an important force in our economy. Anyone can benefit by being familiar with it. All people, from corporate executives to teachers to farmers to homemakers, will be able to perform their jobs better if they are technologically literate. Technological literacy benefits students who will choose technological careers—future engineers, aspiring architects, and students from many other fields. Students have a head start on their future with an education in technology.

What is included in *STL*?

There are 20 content standards that specify what every student should know and be able to do in order to be technologically literate. The benchmarks that follow each of the broadly stated standards at each grade level articulate the knowledge and abilities that will enable students to meet the respective standard. A summary of the content standards and benchmarks is presented in Appendix A of this document. Teachers are encouraged to obtain *STL* to review the benchmarks associated with each standard.

Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL)

While *A Rationale and Structure for the Study of Technology* provides a vision and *Standards for Technological Literacy: Content for the Study of Technology* provides the content, neither was designed to address other important elements that are critical to a comprehensive program of technological studies. As a result, ITEA's Technology for All Americans Project published *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL)*. *AETL* is currently available from ITEA and is designed to help schools implement new strategies and evaluate existing practices of assessing students for technological literacy, providing professional development for teachers and other professionals, and improving programs of teaching and learning.

Advancing Technological Literacy: ITEA Professional Series

The Advancing Technological Literacy: ITEA Professional Series is a set of publications developed by the International Technology Education Association (ITEA) based on *Standards for Technological Literacy* (ITEA, 2000/2002) and *Advancing Excellence in Technological Literacy* (ITEA, 2003). The publications in this series are designed to assist educators in developing contemporary, standards-based K-12 technology education programs. This exclusive series features:

- Direct alignment with technological literacy standards, benchmarks, and guidelines.
- Connections with other school subjects.
- Contemporary methods and student activities.
- Guidance for developing exemplary programs that foster technological literacy.

Titles and resources in the series include:

Technological Literacy Standards Series

- *Standards for Technological Literacy: Content for the Study of Technology*
- *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards*
- *Technology for All Americans: A Rationale and Structure for the Study of Technology*

Addenda to Technological Literacy Standards Series

- *Realizing Excellence: Structuring Technology Programs*
- *Developing Professionals: Preparing Technology Teachers*
- *Planning Learning: Developing Technology Curricula*
- *Measuring Progress: A Guide to Assessing Students for Technological Literacy*

Engineering By Design: Standards-Based Program Series

Elementary School Resources

- *Technology Starters: A Standards-Based Guide*
- *Models for Introducing Technology: A Standards-Based Guide*

Middle School Resources

- *Teaching Technology: Middle School, Strategies for Standards-Based Instruction*
- *Exploring Technology: A Standards-Based Middle School Model Course Guide*
- *Invention and Innovation: A Standards-Based Middle School Model Course Guide*
- *Technological Systems: A Standards-Based Middle School Model Course Guide*

High School Resources

- *Teaching Technology: High School, Strategies for Standards-Based Instruction*
- *Foundations of Technology: A Standards-Based High School Model Course Guide*

- *Engineering Design: A Standards-Based High School Model Course Guide*
- *Impacts of Technology: A Standards-Based High School Model Course Guide*
- *Technological Issues: A Standards-Based High School Model Course Guide*

Engineering By Design: Standards-Based Technological Study Lessons

Elementary School Resources

- Kids Inventing Technology Series (KITS)

Elementary/Middle School Resources (Grades 5-6)

- Invention, Innovation, and Inquiry (I^3) Lessons
  - Invention: The Invention Crusade
  - Innovation: Inches, Feet, and Hands
  - Communication: Communicating School Spirit
  - Manufacturing: The Fudgeville Crisis
  - Transportation: Across the United States
  - Construction: Beaming Support
  - Power and Energy: The Whispers of Willing Wind
  - Design: Toying with Technology
  - Inquiry: The Ultimate School Bag
  - Technological Systems: Creating Mechanical Toys

Secondary School Resources

- Humans Innovating Technology Series (HITS)
- Project ProBase – Engaging Technology Lessons
  - Agriculture and Related Technologies
  - Construction Technologies
  - Energy and Power Technologies
  - Entertainment and Recreation Technologies
  - Information and Communication Technologies
  - Manufacturing Technologies
  - Medical Technologies
  - Transportation Technologies

The Center to Advance the Teaching of Technology and Science: ITEA-CATTS

The International Technology Education Association's Center to Advance the Teaching of Technology and Science (ITEA-CATTS) was created to provide curriculum and professional development support for technology teachers and other professionals interested in technological literacy. ITEA-CATTS initiatives are directed toward four important goals:

- Development of standards-based curricula
- Professional development through learning communities
- Research on teaching and learning
- Curriculum implementation and diffusion

The Center addresses these goals to fulfill its mission to serve as a central source for quality professional development support for the teaching and learning of technology and science.

ITEA-CATTS Consortium was established as part of ITEA-CATTS to form professional leadership and alliances in order to effectively enhance teaching and learning about technology and science. Consortium members receive quality curriculum products and professional development based on the standards. This publication was conceptualized and developed through the ITEA-CATTS Consortium.

Pathways and Career Clusters

The Engineering Design Program has been designed with current research on the development of smaller learning communities around career-themed academies as the guiding principle. While technology education courses are not based on preparing students with vocational skills, they are preparing students for the global workplace by ensuring that they are technologically literate.

Scenario:

As schools work through a planning process to determine what types of Academies will be offered to students, they begin to look at the strengths of the community and the school. School leadership teams identify between three and six themes built on the career-cluster model. Research shows that these themes should identify one academy for every 250-300 students in a school. The concept of the academy uses a team of teachers to present the content around the theme. So, if the career-themed academy is Arts and Media, then all of the teachers identified in that academy plan their content around the Arts and Media theme. While some schools identify the theme that is directly related to a career cluster name, many do not. Some common Academy themes include: Arts and Media, Business and Finance, Entrepreneurship, Theatre, Science and Technology, Social Science, Human Services, Engineering, and International Studies.

In each of these examples, technology education and the delivery of technological literacy is critical to the success of students in their future. The courses Impacts of Technology and Technological Issues are written in such a way that the framework for content can be centered around *any of the listed academy themes*. A course in Technological Issues can easily be focused (given the way the product is written) on International Studies, etc. This makes them a valuable part of the articulated sequence of courses that students take in their academy focus. These courses emulate the transferability necessary in a world where changing technology impacts our everyday life and creates issues for society.

Using This Guide

This guide provides standards-based content, activities, and resources for teaching a cornerstone technology course at the high school level. The information contained in this guide will assist teachers in preparing to implement *STL*. In addition, it can be used by state, provincial, and local curriculum developers in creating standards-based curriculum.

The **Introduction** section addresses the Engineering By Design Program and how it was conceived to be standards-based. States, school districts, and schools will find that this chapter is a model for designing a program that teaches technological literacy that is truly standards-based. Each model uses the processes and forms that are prescribed in the ITEA Addenda Guides, *Planning Learning: Developing Technology Curricula*, and *Realizing Excellence: Structuring Technology Programs*.

The **Overview** features an introduction to *Foundations of Technology*, course information, and goals and objectives. The use of a pre- and post-assessment is discussed, as well as examples of assessment items. A Course Content Outline is provided, with the units of instruction for this course.

Units 1-8 provide the units of instruction in detail for use by the classroom teacher. Each unit presents standards-based content for students in the Foundations of Technology Course. The unit framework consists of an overview, standards/benchmarks, the BIG Idea for the unit, assessment tools, lessons, and learning activities that include teacher preparation, unit content, suggested learning activities, assessment, and resources.

The **Appendix** contains descriptions of resources, materials, and references that teachers may obtain as they develop curriculum and instructional materials. Teachers, curriculum developers, and other interested readers are encouraged to review the guide in its entirety. The content across the chapters and instructional units collectively contributes to quality instruction that addresses the standards.

Introduction
Engineering by Design: Model Program

Engineering By Design
A National Model for Standards-Based Programs

International Technology Education Association 2005

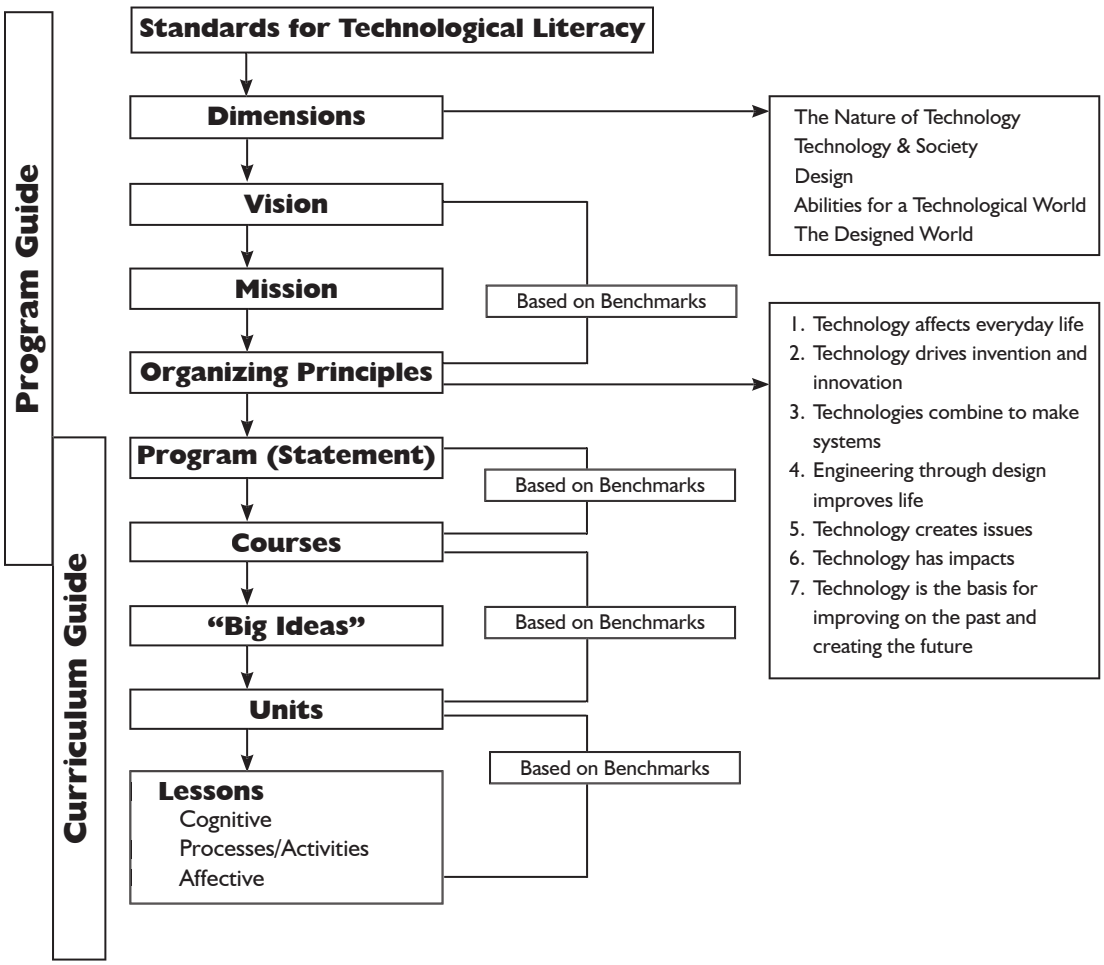
Introduction

Engineering By Design is a National Model Program that was developed in collaboration and consultation with the ITEA-CATTS Consortium, Technology Education Advisory Council, ITEA Institutional Members, and the Mathematics, Science, and Engineering Communities. The reader will see, as the structure of the program unfolds, that the intent is related to the development of technological literacy for students in Grades K-12 and delivered in the context of Technology, Innovation, Design, and Engineering (TIDE.)

States, districts, and schools may wish to use this chapter as the basis for the development of a new program in TIDE, or to use it just as it is written. Note that either way, the assessments that are used in the Program and in this course are designed specifically to measure achievement of the *STL* technological literacy standards and corresponding benchmarks.

Engineering-By-Design
A National Standards-Based Program Model*
ITEA's Center to Advance the Teaching of Technology and Science

* This model is based upon the model and process published in ITEA's addendum to the technological literacy standards in *STL, AETL*, and *Realizing Excellence: Structuring Technology Programs* (2005c).



The Vision - Engineering By Design

We live in a technological world. Living in the twenty-first century requires much more from every individual than a basic ability to read, write, and perform simple mathematics. Technology affects every aspect of our lives, from enabling citizens to perform routine tasks to requiring that they be able to make responsible, informed decisions that affect individuals, our society, and the environment. Citizens of today must have a basic understanding of how technology affects their world and how they exist both within and around technology.

Technological literacy is fundamentally important to all students. Technological processes have become so complex that the community and schools collaborate to provide a quality technology program that prepares students for a changing technological world that is progressively more dependent on an informed, technologically literate citizenry.

The Mission - Engineering By Design

The ITEA model technology program is committed to providing technological study in facilities that are safe and facilitate creativity, enabling all students to meet local, state, and national technological literacy standards. Technological study is required in sixth, seventh, and eighth grades. Students are prepared to engage in additional technological study in the high school years and beyond. Students will be prepared with knowledge and abilities to help them become informed, successful citizens who are able to make sense of the world in which they live. The technology program also enables students to take advantage of the technological resources in the local community.

The Organizing Principles

The program consists of seven organizing principles. These principles are very large concepts that identify major content organizers for the program. As stated earlier, Engineering By Design is to be taught in the context of Technology, Innovation, Design, and Engineering. In order of importance, the seven identified organizing principles are listed below:

1. Engineering through design improves life.
2. Technology has and continues to affect everyday life.
3. Technology drives invention and innovation and is a thinking and doing process.
4. Technologies are combined to make technological systems.
5. Technology creates issues that change the way people live and interact.
6. Technology impacts society and must be assessed to determine if it is good or bad.
7. Technology is the basis for improving on the past and creating the future.

Program Descriptions

The program statement on which the courses are developed is based on the identification of benchmarks for each organizing principle. (Note that the number of courses does not necessarily have to be the same as the number of organizing principles—there may be more than one organizing principle for each course.)

Engineering By Design: District/State Level Program Description

This program provides students with a foundation in the role of technology in everyday life, along with a broad range of technology skills that make them aware of technology around them. Students completing the program will become technologically literate by learning the concepts and role that engineering, design, invention, and innovation have in creating technology systems that help make life easier and better. Students learn that technology must be assessed to determine the positive and negative effects, and how these have shaped today's global society. The key

component of the program is that students become knowledgeable about technology, and use hands-on lessons to apply and transfer this knowledge to common problems. The program consists of seven courses in Grades 6-12 that build on experiences provided in elementary school.

K-2nd grades	Lessons integrated	
3rd-5th grades	Lessons integrated	
6th grade	Exploring Technology	9 weeks
7th grade	Invention and Innovation	12-18 weeks
8th grade	Technological Systems	18 weeks
9th grade	Foundations of Technology	1 credit 36 weeks
10-12th grades	Technological Issues	1 credit 36 weeks
	Impacts of Technology	1 credit 36 weeks
	Engineering Design	1 credit 36 weeks

Engineering By Design: Student-Oriented Program Description for Registration Booklets

Students in this program use hands-on lessons to learn the concepts and roles of engineering, design, invention, and innovation in creating technology systems that help make life easier and better. They learn to apply and transfer this knowledge to common, everyday problems. Students learn how to assess technology, its impacts and resulting issues, and present the positive and negative consequences and how these have shaped today's global society. The program incorporates the applications of mathematics and science concepts and provides a strong background for students investigating careers in all career-focused academies.

K-2nd Grades	Lessons integrated	
3rd-5th Grades	Lessons integrated	
6th Grade	Exploring Technology	9 weeks
7th Grade	Invention and Innovation	12-18 weeks
8th Grade	Technological Systems	18 weeks
9th Grade	Foundations of Technology	1 credit 36 weeks
10-12th Grades	Technological Issues	1 credit 36 weeks
	Impacts of Technology	1 credit 36 weeks
	Engineering Design	1 credit 36 weeks

Course Descriptions

The following is course information and interrelationships to ensure that students in all grades, K-12, have the opportunity to develop technological literacy.

Elementary Integration	**Lessons Integrated in Curricula in Grades K-2**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades K-2
Overview	Introducing young children to the natural world is a significant part of the elementary curriculum. Grades K-2 provide a unique opportunity to introduce and refine the knowledge and skills for understanding the designed world that is equally important during the early years. Children are as fascinated with the world of technology as the natural world, maybe even more intrigued. The earliest interest in "how things work" and what makes their environment function are clearly present in the earliest stages of a child's development. Making sense of the "natural" and "designed world" is the essence of the earliest attempts to learn by children. For every venture into the designed world, there are limitations, requirements, and elements that guide the process. Designing is a challenging and rigorous process. To design something means to apply all available resources, including knowledge and skills about all subjects, to effect a scheme, solution, concept, or theory that offers a reasonable and effective resolution to a problem. In order to comprehend the attributes of design, students in Grades K-2 learn that: • Everyone can design solutions to a problem. • Designing is a creative process that turns ideas into actions.
Course Length	Integrated throughout the year
Connections to: Foundations of Technology	These concepts connect to the Grades 3-5 emphasis on the design process and requirements for design, providing the basis for the middle and high school studies of Technology, Innovation, Design, and Engineering.

Elementary Integration	**Lessons Integrated in Curricula in Grades 3-5**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 3-5
Course Overview	In Grades 3-5, students should learn that: • The design process is a purposeful method of planning practical solutions to problems and includes: creating ideas, putting ideas on paper, using words and sketches, building models, testing the design or idea, and evaluating the solution based on requirements. • Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design such as, but not limited to, size, cost, type of material, weight, color, etc. Children have experiences in design at the earliest stages of development. Ingenuity is a natural human trait. It needs to be nurtured, developed, and refined. To design solutions to specific problems is the application of ingenuity. Add to this ingenuity several resources, parameters for the design solution, and some guidance, and children begin to display an interest in and ability to understand the design process. To this end, they have the foundation for understanding technological development and innovation.
Course Length	Integrated throughout the year
Connections to: Foundations of Technology	These concepts connect to the middle school Program of Study, where students learn about technology, invention and innovation, and how the core concepts of technology are combined to create technology systems. This background provides the basis for more focused high school studies in Technology, Innovation, Design, and Engineering.

Name of Course	**Exploring Technology**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	6th Grade students (no prerequisite)
Course Overview	In *Exploring Technology*, students develop an understanding of the progression and scope of technology through exploratory experiences. In group and individual activities, students experience ways in which technological knowledge and processes contribute to effective designs and solutions to technological problems. Students participate in design activities to understand how criteria, constraints, and processes affect designs. Brainstorming, visualizing, modeling, constructing, testing, and refining designs provide firsthand opportunities for students to understand the uses and impacts of innovations. Students develop skills in communicating design information and reporting results. This course is a cornerstone for a middle school technology education program.
Course Length	9 weeks
Connections to: Foundations of Technology	*Exploring Technology* builds on K-5 experiences and develops a student's understanding of the scope of technology and the iterative nature of technological design and problem-solving processes. Likewise, students will be able to communicate their ideas verbally and visually, and document the development of their plans through visual representation, journals, and portfolios. Teaming, peer monitoring, and individual actions contribute to student achievements at this level. Similarly, *Exploring Technology* provides the foundation for future studies in the sequence. Students learn how technology, innovation, design, and engineering interrelate and are interdependent. This background provides the basis for more focused high school studies.

Name of Course	**Invention and Innovation**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	7th Grade students (no prerequisite)
Course Overview	*Invention and Innovation* provides students with opportunities to apply the design process in the invention or innovation of a new product, process, or system. In this course, students will learn all about invention and innovation. They will have opportunities to study the history of inventions and innovations, including their impacts on society. They will learn about the core concepts of technology, and about the various approaches to solving problems, including engineering design and experimentation. Students will apply their creativity in the invention and innovation of new products, processes, or systems. Finally, students learn about how various inventions and innovations impact their lives. Students participate in engineering design activities to understand how criteria, constraints, and processes affect designs. Students are involved in activities and experiences where they learn about brainstorming, visualizing, modeling, constructing, testing, experimenting, and refining designs. Students also develop skills in researching for information, communicating design information, and reporting results.
Course Length	12-18 weeks recommended
Connections to: Foundations of Technology	*Invention and Innovation* builds on K-5 experiences as well as those in *Exploring Technology* and develops a student's understanding of the scope of technology and the iterative nature of technological design and problem-solving processes. Likewise, students participate in engineering design activities to understand how criteria, constraints, and processes affect designs. Students will be involved in activities and experiences where they learn about brainstorming, visualizing, modeling, constructing, testing, experimenting, and refining designs. Students will also develop skills in researching for information, communicating design information, and reporting results. *Invention and Innovation* provides the foundation for future studies in the sequence. Students learn how technology, innovation, design and engineering interrelate and are interdependent.

Name of Course	**Technological Systems**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	8th Grade students (no prerequisite)
Course Overview	This course is intended to teach students how technological systems work together to solve problems and capture opportunities. A system can be as small as two components working together (technical system/device level) or can contain millions of interacting devices (user system/network level). We often break down the macrosystems into less complicated microsystems in order to understand the entire system better. However, technology is becoming more integrated, and systems are becoming more and more dependent upon each other than ever before. Electronic systems are interacting with natural (i.e. bio) systems as humans use more and more monitoring devices for medical reasons. Electrical systems are interacting with mechanical and fluid power systems as manufacturing establishments become more and more automated. This course will give students a general background on the different types of systems but will concentrate more on the connections between these systems.
Course Length	12-18 weeks recommended
Connections to: Foundations of Technology	*Technological Systems* builds on K-5 experiences as well as those in *Exploring Technology* and *Invention and Innovation* to develop a student's understanding of the scope of technology and the iterative nature of technological design and problem-solving processes. Students participate in engineering design activities to understand how criteria, constraints, and processes affect designs. Students are involved in activities and experiences where they learn about brainstorming, visualizing, modeling, constructing, testing, experimenting, and refining designs. Students also develop skills in researching for information, communicating design information, and reporting results. As the suggested capstone middle school course, *Technological Systems* provides the foundation for future studies in a Technology Education sequence. Students learn how technology, innovation, design, and engineering interrelate and are interdependent.

Name of Course	**Impacts of Technology**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 10-12: *Foundations of Technology* recommended Advanced Technology Education
Course Overview	Students in *Impacts of Technology* learn that technology is a neutral topic that can have good or bad impacts on society. Technology assessment is a structured evaluation of the application of technology in an effort to avoid inappropriate or unwanted effects. Applying design and student imagination without considering the possible effects of new products or processes can lead to technological disasters, superfund sites, and unsafe products that could have been avoided in the initial design stages. Whether a new product, system, or process has an overall positive, neutral, or negative impact depends on the proper understanding of technology assessment. This aspect of *Impacts of Technology* gives students a head start on the road to technological literacy by focusing primarily on technology assessment and the impact on *technology design*.
Course Length	36 weeks recommended
Connections to: Foundations of Technology	The thrust of the *Impacts of Technology* course contributes to the development of each high school student's capacity to make responsible judgments about technology's development, control, and use. Critiquing appropriate technology and sustainable development are important. The structure of the course brings discussions of technological values that enable students to reflect and develop their own ethical standards. Students are actively involved in the organized and integrated application of technological resources, engineering concepts, and scientific procedures. Through high school technology education experiences, students address the complexities of technology and issues that stem from designing, developing, using, and assessing technological systems. In developing a functional understanding of technology, students comprehend how human conditions, current affairs, and personal preferences drive technological design and problem solving. Actively engaged in making and developing, using, and managing technological systems, students better understand the role of systems in meeting specific needs. Students are able to analyze and understand the behavior and operation of basic technological systems in different contexts. Students are able to extend their knowledge of systems to new and emerging applications by the time they graduate from high school.

Name of Course	**Technological Issues**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 10-12: *Foundations of Technology* recommended Advanced Technology Education
Course Overview	In *Technological Issues*, students learn that technology allows us to extend our ability to modify or change the natural world to meet our wants and needs. However, the resulting changes can be complicated and unpredictable. Solutions to a particular problem may cause other types of problems. Each potential technological solution creates certain issues, such as benefits, costs, risks, and limitations. Not all impacts of technology are predictable or show up right away. However, the key issues of a technology should be studied and debated prior to the technology being introduced or eliminated. Alternatives should be explored (scientific and mathematical dimensions should be integrated into the decision). Technological issues are not solely technical in nature. Attitudes towards technology can be influenced by social, cultural, economical, political, and ecological concerns. The decision to introduce or eliminate a technology will affect different people and vary depending on the timing. Issues can create some heated debates, which require that both sides of the debate acquire detailed information and ask the right questions. By studying technological issues, students learn that there may not be a solution that everyone agrees upon, nor will everyone benefit or receive the cost in the same way. The study of technological issues will not give students the correct answers but allows them to develop skills in asking critical questions, understanding alternative viewpoints and their origins, and gives them the confidence to be involved in deciding which technologies to develop, which to use, and how to use them.
Course Length	36 weeks recommended
Connections to: Foundations of Technology	*Technological Issues* contributes to the development of each high school student's capacity to make responsible judgments about technology's development, control, and use. Critiquing appropriate technology and sustainable development are important. The structure of the course brings discussions of technological values so that students can reflect and develop their own ethical standards. Students are actively involved in the organized and integrated application of technological resources, engineering concepts, and scientific procedures. Students address the complexities of technology and issues that stem from designing, developing, using, and assessing technological systems. In developing a functional understanding of technology, students comprehend how human conditions, current affairs, and personal preferences drive technological design and problem solving. Actively engaged in making and developing, using, and managing technological systems, students better understand the role of systems in meeting specific needs. Students are able to analyze and understand the behavior and operation of basic technological systems in different contexts. Students are able to extend their knowledge of systems to new and emerging applications by the time they graduate from high school.

Name of Course	**Engineering Design**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 10-12: *Foundations of Technology* recommended Advanced Technology Education
Course Overview	In *Engineering Design*, engineering scope, content, and professional practices are presented through practical applications. Students in engineering teams apply technology, science, and mathematics concepts and skills to solve engineering design problems and innovate designs. Students research, develop, test, and analyze engineering designs using criteria such as design effectiveness, public safety, human factors, and ethics. This course is the capstone experience for students who are interested in technology, innovation, design, and engineering.
Course Length	36 weeks recommended
Connections to: Foundations of Technology	*Engineering Design* contributes to the development of each high school student's capacity to make responsible judgments about technology's development, control, and use. Critiquing appropriate technology and sustainable development are important. The structure of the course brings discussions of technological values so that students can reflect and develop their own ethical standards. Students are actively involved in the organized and integrated application of technological resources, engineering concepts, and scientific procedures. Through high school technology education experiences, students address the complexities of technology and issues that stem from designing, developing, using, and assessing technological systems. In developing a functional understanding of technology, students comprehend how human conditions, current affairs, and personal preferences drive technological design and problem solving. Actively engaged in making and developing, using, and managing technological systems, students better understand the role of systems in meeting specific purposes. Students are able to analyze and understand the behavior and operation of basic technological systems in different contexts. Students are able to extend their knowledge of systems to new and emerging applications by the time they graduate from high school. As the capstone experience for the **Engineering By Design Program**, *Engineering Design* provides students with the knowledge and skills to delve deeper into engineering at the post-secondary level.

Overview:
Foundations of Technology

Engineering By Design
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Foundations of Technology Overview of the Course

Name of Course	**Foundations of Technology**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 9-12
Purpose of Course	Foundations of Technology prepares students to understand and apply technological concepts and processes that are the cornerstone for the high school technology program. Group and individual activities engage students in creating ideas, developing innovations, and engineering practical solutions. Technology content, resources, and laboratory/classroom activities apply student applications of science, mathematics, and other school subjects in authentic situations.
Course Overview	This course will focus on the three dimensions of technological literacy: knowledge, ways of thinking and acting, and capabilities, with the goal of students developing the characteristics of technologically literate citizens. It will employ teaching/learning strategies that enable students to build their own understanding of new ideas. It is designed to engage students in exploring and deepening their understanding of "big ideas" regarding technology and makes use of a variety of assessment instruments to reveal the extent of understanding. Students will develop an understanding of the influence of technology on history by exploring how people of all times and places have increased their capability by using their unique skills to innovate, improvise, and invent. They will gain an understanding of technology innovation and the fact that it often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields of study. Students will develop an understanding of engineering design, the formal process that transforms ideas into products or systems of the designed world. They will select and use manufacturing technologies and understand that modern manufacturing technologies produce quality goods at low prices, enhancing the quality of life for many people. Students will select and use construction technologies and recognize that cultural norms, environmental conditions, and the requirements of enterprises and institutions impact the design of structures. Opportunities will be provided that enable students to select and use energy and power technologies and to explore the processing and controlling of the energy resources that have been important in the development of contemporary technology. They will become familiar with information and communications technologies and their role in maintaining competitive economic growth. The course will conclude with the synthesizing of major ideas through an understanding of the core concepts of technology, with an emphasis on systems-thinking and related principles.
Course Length	36 weeks recommended
Connections to: *Engineering By Design Program Sequence*	The Foundations of Technology course is one component of the overall technology education program designed to prepare students for the technological world by preparing them to assume the roles of informed voters, productive workers, and wise consumers. The Foundations of Technology course will focus on the development of knowledge and skills regarding the following aspects of technology: 1) its evolution, 2) systems, 3) core concepts, 4) design, and 5) utilization. The Foundations of Technology is an introductory high school level learning experience that builds on student understanding gained in elementary and middle school courses. It capitalizes on the maturing adolescent's ability to understand technological concepts and analyze issues regarding the application of technology. The course will prepare students for more specialized technology courses at the high school level such as Engineering Design, Impacts of Technology, and Technological Issues.

Units of Instruction

The following units will be used to organize instruction:

1. The History of Technology
2. Relationships Among Technologies and Connections with Other Fields of Study
3. Engineering Design
4. Manufacturing
5. Construction
6. Power and Energy
7. Information and Communication
8. Systems Thinking: "Putting It All Together"

Course Goals and Objectives

At the completion of this course, students will know and understand:

1. The influence of technology on history. (ITEA/STL –7)
2. The relationships among technologies and connections with other fields of study. (STL-3)
3. The attributes of design. (ITEA/STL-8)
4. Engineering design. (ITEA/STL-9)
5. The core concepts of technology. (ITEA/STL-2)

At the completion of this course, students will be able to:

1. Applying the design process (ITEA/STL –11)
2. Select and use manufacturing technologies. (ITEA/STL –19)
3. Select and use agricultural and biotechnologies. (ITEA/STL-15)
4. Select and use medical technologies. (ITEA/STL-14)
5. Select and use energy and power technologies. (ITEA/STL –16)
6. Select and use information and communications technologies. (ITEA/STL –17)
7. Select and use construction technologies. (ITEA/STL –20)

Course Assessment Criteria

Performance Tasks and Projects:

Students will:

1. Apply the design process to solve problems in and beyond the laboratory-classroom.
2. Make two-dimensional and three-dimensional representations of a design solution.
3. Test and evaluate a design in relation to pre-established requirements.
4. Document problem solving procedures.
5. Evaluate a prototype in terms of design requirements and constraints.
6. Identify criteria and constraints and determine how these will affect the design process.
7. Refine a design by using prototypes and modeling.
8. Evaluate a design by using conceptual, physical, and mathematical models.
9. Develop and produce a product using a design process.
10. Evaluate a final solution and communicate observations, processes, and results.
11. Make a product or system.
12. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.
13. Reverse-engineer a product.
14. Address open-ended questions in verbal and written form.
15. Conduct effective and focused research.
16. Use computers and calculators to access, retrieve, organize, and evaluate data.
17. Organize and present data effectively.
18. Present research findings effectively using instructional technology.

19. Operate systems so that they function in the way they were designed.
20. Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision.
21. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.
22. Follow step-by-step directions to assemble and disassemble a product.
23. Use technical manuals and protocols effectively.
24. Conduct self-assessment of work performance.
25. Assess peers' work performance.
26. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
27. Work safely and accurately with a variety of tools, machines, and materials.
28. Actively participate in group discussions, ideation exercises, and debates.
29. Demonstrate curiosity, exhibit motivation for learning, and use class time effectively.
30. Exhibit and refine inherent personal qualities such as creativity and resourcefulness.

Written Assessments:

1. Pre-tests to determine prior knowledge
2. Quizzes to measure progress toward attainment of knowledge goals
3. Rubrics or checklists to measure progress toward skill and attitudinal goals
4. Unit tests
5. End of course test

Course Outline

I. The Influence of Technology on History
   A. Paleolithic Age
   B. Mesolithic Age
   C. Neolithic Age
   D. Iron Age
   E. Middle Ages
   F. Renaissance
   G. Industrial Age
   H. Information Age

II. The Relationships Among Technologies and Connections with other Fields of Study
   A. Relationships among technologies
   B. Technology's Relationships with Other Fields of Study

III. Engineering Design
   A. What is engineering?
   B. Principles of Design
   C. Engineering Resources (Core Technologies)
   D. The Engineering Design Process
   E. Project Management

IV. Manufacturing Technologies Evolution
   A. Processes
   B. Resources
   C. Systems
   D. Products
   E. Impacts

V. Construction
   A. Evolution
   B. Processes
   C. Resources
   D. Systems
   E. Products
   F. Impact

VI. Energy and Power Technologies
   G. Evolution
   H. Processes
   I. Resources
   J. Systems
   K. Products
   L. Impacts

VII. Information and Communication Technologies
   M. Evolution
   N. Processes
   O. Resources
   P. Systems
   Q. Products
   R. Impacts

VIII. Systems Thinking: Putting It All Together
   A. The Nature of Systems Thinking
   B. Core Concepts of Technology
   C. Tools for Systems Thinking

Foundations of Technology: Course Assessment Rubric

UNIT NO.	UNIT TITLE	Big Idea	Below Target	At Target	Above Target
1	The History of Technology	Knowledge of the history of technology helps people understand the world around them by seeing how people of all times and places have increased their capability by using their unique skills to innovate, improvise and invent.	The student has shallow grasp of the big idea; inadequately analyzes how different cultures develop their own technologies; concepts poorly developed in oral presentation; ignores or superficially analyzes concepts; draws unwarranted or fallacious conclusions; never reads related materials or contributes new knowledge to discussions; and never cites connections between past and present cause/effect relationships.	The student shows evidence of grasping the big idea; adequately analyzes how different cultures develop their own technologies; concepts well developed in oral presentation; offers analysis and evaluation of obvious alternative pints of view; draws warranted and non-fallacious conclusions; occasionally reads related materials or contributes new knowledge to discussions: and sometimes cites connections between past and present cause/effect relationships.	The student thoroughly grasps the big idea; accurately and proficiently analyzes how different cultures develop their own technologies; thoroughly developed concepts in oral presentation; thoroughly analyzes and evaluates major alternative points of view; draws warranted, judicious, non-fallacious conclusions; often reads related materials and contributes new knowledge to discussions; and often cites connections between past and present cause/effect relationships.
2	Relationships Among Technologies and Connections with Other Fields of Study	The interrelationships that exist among technologies and between technology and other fields of study enhance our ability to use, assess, design, and produce technology.	The student has shallow grasp of the big idea; inaccurately describes the relationship between technology and the study of science; poorly describes how mathematical concepts are key to the development of technology; provides few examples of how technological progress promotes the advancement of science and mathematics; minimally addresses how the development of computer databases has revolutionized research in the social sciences; ignores or superficially evaluates obvious alternative points of view.	The student shows evidence of grasping the big idea; accurately describes the relationship between technology and the study of science; states how mathematical concepts are key to the development of technology; provides several examples of how technological progress promotes the advancement of science and mathematics; summarizes how the development of computer databases has revolutionized research in the social sciences; offers analyses and evaluations of obvious alternative points of view.	The student thoroughly grasps the big idea; thoroughly describes the interrelationships that exist among technologies and between technology and other fields of study; contributes new knowledge on how mathematical concepts are key to the development of technology; cites numerous examples of how technological progress promotes the advancement of science and mathematics; analyzes how the development of computer databases has revolutionized research in the social sciences; thoughtfully analyses and evaluates major alternative points of view.

UNIT NO.	UNIT TITLE	Big Idea	Below Target	At Target	Above Target
3	Engineering Design	Engineering, the systematic application of mathematical, scientific, and technical principles, produces tangible end products that meet our needs and desires	The student has shallow grasp of the big idea; inadequately delineates the personal characteristics involved in engineering; describes few impacts of constraints on the engineering design process; demonstrates minimal skill in implementing the design process; demonstrates limited skill in problem solving; fails to safely and effectively use tools and materials; rarely uses the language of mathematics to express scientific and technological ideas precisely; and communicates processes or results poorly.	The student shows evidence of grasping the big idea; adequately delineates the personal characteristics involved in engineering; describes several impacts of constraints on the engineering design process; demonstrates satisfactory skill in implementing the design process; demonstrates satisfactory skill in problem solving; safely and effectively uses tools and materials; sometimes uses the language of mathematics to express scientific and technological ideas precisely; and communicates processes or results adequately.	The student thoroughly grasps the big idea; thoroughly delineates the personal characteristics involved in engineering; describes numerous impacts of constraints on the engineering design process; demonstrates significant skill in implementing the design process; demonstrates significant skill in problem solving; safely and effectively uses tools and materials; consistently uses the language of mathematics to express scientific and technological, ideas precisely; and effectively communicates processes or results.
4	Manufacturing	Modern manufacturing technologies produce quality goods at low prices, enhancing the quality of life for many people	The student has shallow grasp of the big idea; insufficiently identifies manufacturing processes; ineffectively describes mechanical processes; unsatisfactorily identifies manufacturing systems; inadequately researches chemical technologies; explains agricultural technology poorly; inadequately researches and reports on applications of biotechnology; and fails to identify the role transportation plays in the operation of manufacturing and agricultural enterprises.	The student shows evidence of grasping the big idea; identifies manufacturing processes; effectively describes mechanical processes; describes manufacturing systems; adequately researches chemical technologies; explains agricultural technology; adequately researches and reports on applications of biotechnology; and satisfactorily analyzes the role transportation plays in the operation of manufacturing and agricultural enterprises.	The student thoroughly grasps the big idea; systematically analyzes manufacturing processes; methodically describes mechanical processes; carefully analyzes manufacturing systems; thoroughly researches chemical technologies; meticulously analyzes agricultural technology; exhaustively researches and reports on applications of biotechnology; scrupulously analyzes the role transportation plays in the operation of manufacturing and agricultural enterprises.

UNIT NO.	UNIT TITLE	Big Idea	Below Target	At Target	Above Target
5	Construction	Construction is the systematic process of erecting structures to meet human needs and desires. It reflects cultural norms, environmental conditions, and the requirements of enterprises and institutions.	The student has shallow grasp of the big idea; inaccurately classifies heavy engineering structures; incorrectly identifies types of buildings including residential, commercial, and industrial; fails to identify the steps in the construction process; cannot explain the role transportation plays in the operation of manufacturing enterprises: has little or no empathy beyond intellectual awareness of others.	The student shows evidence of understanding most of the big idea; compares and contrasts heavy engineering structures; identifies types of buildings including residential, commercial, and industrial; describes the steps in the construction process; explains the role transportation plays in the operation of manufacturing enterprises; knows and feels that others see and feel differently.	The student demonstrates excellence in grasping the big idea; systematically analyzes heavy engineering structures; meticulously analyzes types of buildings, including residential, and industrial; analyzes the steps in the construction process; and fully analyzes the role transportation plays in the operation of manufacturing enterprises; able to see and feel what others see and feel.
6	Power and Energy	Advancements in the processing and controlling of energy resources have been an enabling factor in the development of technology.	The student has shallow grasp of the big idea; unsatisfactorily explains the production, conversion, transmission, and application of different forms of energy; fails to state that energy cannot be created nor destroyed (but it can be converted from one form to another); and inadequately analyzes power systems identifying the source of energy, the process, and loads; and never cites connections between past and present cause/effect relationships; and is unaware of boundaries on one's own understanding.	The student shows evidence of understanding most of the big idea; satisfactorily explains the production, conversion, transmission, and application of different forms of energy; states that energy cannot be created nor destroyed (but it can be converted from one form to another); adequately analyzes power systems identifying the source of energy, the process, and loads; and occasionally cites connections between past and present, cause/effect relationships; generally aware of what is and is not understood.	The student demonstrates excellence in grasping the big idea; thoroughly explains the production, conversion, transmission, and application of different forms of energy; effectively explains that energy cannot be created nor destroyed (but it can be converted from one form to another); systematically analyzes and diagrams power systems; often cites connections between past and present cause/effect relationships; and is generally aware of one's lack of understanding.

UNIT NO.	UNIT TITLE	Big Idea	Below Target	At Target	Above Target
7	Information and Communication	Information is an essential resource for competitive economic growth. Communication technology significantly impacts the way we live.	The student has shallow grasp of the big idea; rarely takes a stand on issues; inadequately explains how information and communication systems allow information to be transferred from human to human, human to machine, and machine to human; cannot identify the parts of a communication system; insufficiently describes the functioning and applications of information processing; justifies few results or procedures, seldom explains reasons: shows little or no understanding of the problem-solving process, and cannot assess how well it was applied to the current problem.	The student shows evidence of understanding most of the big idea; explains how information and communication systems allow information to be transferred from human to human, human to machine, and machine to human; identifies the parts of a communication system; describe the functioning and applications of information processing; justifies some results or procedures, explains reasons: can describe the problem-solving process, but may not critically assess how well it was applied to the current problem.	The student demonstrates excellence in grasping the big idea; illustrates how information and communication systems allow information to be transferred from human to human, human to machine, and machine to human; analyzes the parts of a communication system; analyzes the functioning and applications of information processing; justifies key results and procedures, explains assumptions and reasons; clearly and concisely articulates the problem-solving process and describes how well it was applied to the current problem.

UNIT NO.	UNIT TITLE	Big Idea	Below Target	At Target	Above Target
8	Systems Thinking: "Putting It All Together"	Systems-thinking principles provide a conceptual base for addressing the complex issues that confront us by providing ways of viewing the world as a whole and using that view to find the leverage points for fundamental change.	The student has shallow grasp of the big idea; cannot define or apply systems thinking to real-life problems; fails to identify or apply the core concepts of technology; misstates the relationship between technological processes and natural processes; is unable to identify technologies designed to reduce the negative consequences of other technologies; inadequately investigates processes that conserve water, soil, and energy; and fails to explore the use of technology to monitor environmental conditions.	The student shows evidence of understanding most of the big idea; states that systems-thinking applies logic and creativity with appropriate compromises in complex real-life problems; describes the core concepts of technology (including systems thinking, requirements, trade-offs, and optimization); explains the relationship between technological processes and natural processes; identifies technologies designed to reduce the negative consequences of other technologies; investigates processes that conserve water, soil, and energy; and explores the use of technology to monitor environmental conditions.	The student demonstrates excellence in grasping the big idea; explains that systems-thinking applies logic and creativity with appropriate compromises in complex real-life problems; applies the core concepts of technology (including systems thinking, requirements, trade-offs, and optimization) to solve practical problems; analyzes the relationship between technological processes and natural processes; investigates technologies designed to reduce the negative consequences of other technologies; researches and reports on processes that conserve water, soil, and energy; and assesses the effectiveness of the use of technology to monitor environmental conditions.

Unit 1
The History of Technology

Engineering By Design
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Unit 1: The History of Technology

Overview

Standards

- Students will develop an understanding of the influence of technology on history. (ITEA/STL –7)
- Students will develop an understanding of and be able to select and use information and communications technologies. (ITEA/STL –17)
- Students will develop an understanding of the nature of science. (AAAS – BSL)
- Students will develop an understanding of the designed world. (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM – MSE)
- Students will analyze change in various contexts. (NCTM - MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM – MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Most technological development has been evolutionary, the result of a series of refinements to a basic invention. • The evolution of civilization has been directly affected by, and has in turn affected the development of tools and materials. • Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. • Early in the history of technology, the development of many tools and machines was not based on scientific knowledge but on technological know-how. • The Iron Age was defined by the use of iron and steel as the primary materials for tools. • The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society. • The Renaissance, a time of rebirth of the arts and humanities, was also an important period in the history of technology. • The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time. • The Information Age places emphasis on the processing and exchange of information.	• Modern science is based on traditions of thought that came together in Europe about 500 years ago. • The Industrial Revolution happened first in Great Britain because that country made practical use of science, had access by sea to world resources and markets, and had an excess of farm workers willing to become factory workers. • The Industrial Revolution increased the productivity of each worker, but it also increased child labor and unhealthy working conditions, and it gradually destroyed the craft tradition. • The Industrial Revolution is still underway as electric, electronic, and computer technologies change patterns of work and bring with them economic and social consequences.	• Model and solve contextualized problems using various representations, such as graphs, tables, and equations. • Use the language of mathematics to express ideas precisely. • Draw reasonable conclusions about a situation being modeled. • Use graphs to analyze the nature of changes in quantities in linear relationships. • Approximate and interpret rates of change from graphical and numerical data • Identify essential quantitative relationships in a situation and determine the class or classes of functions that might model the relationships.

Big Idea:
Knowledge of the history of technology helps people understand the world around them by seeing how people of all times and places have increased their capability by using their unique skills to innovate, improvise, and invent.
(Adapted from STL & J. Hammond Chancellor emeritus, State College System, Massachusetts)

Unit 1 Objectives

At the completion of this unit, students will:

1. Explain why, early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how.
2. Explain that most technological development has been evolutionary, the result of a series of refinements to a basic invention.
3. Describe how the evolution of civilization has been directly affected by, and has in turn affected the development of tools and materials.
4. Identify the periods of human history associated with the evolution of technology.
5. Categorize inventions and innovations based on technological time periods.
6. Compare and contrast inventions or innovations based on how they evolved.
7. Describe anticipated positive and negative impacts as well as the unanticipated positive and negative impacts of technological innovations.
8. Compare and contrast life in periods of technological development.
9. Explain how the way people live and work has changed throughout history because of technology.
10. Identify and describe social, cultural, political, and economic significance of historical technological advancements.
11. Conduct effective and focused research.
12. Use computers and calculators to access, retrieve, organize, and evaluate data and information in order to communicate.
13. Organize and present data effectively.
14. Use mathematical modeling techniques for making predictions about the future applications of technology.
15. Present research findings effectively using instructional technology.
16. Conduct self-assessment of work performance.
17. Assess peers' work performance.
18. Explain mathematical functions (linear, quadratic, or exponential) and how they may represent an aspect of technological change.
19. Address open-ended questions in verbal and written form.
20. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
21. Work safely and accurately with a variety of tools, machines, and materials.
22. Actively participate in group discussions, ideation exercises, and debates.
23. Demonstrate curiosity, exhibit motivation for learning, and use class time effectively.
24. Exhibit and refine inherent personal qualities such as creativity and resourcefulness.

Unit 1 – The History of Technology Pre-Test

Directions: Circle the T or F in the column to the left of each true (T) or false (F) statement.

T F 1. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.

T F 2. The evolution of civilization has not been directly affected by the development of tools and materials.

T F 3. Throughout history, technology has been a minor force in reshaping the social, cultural, political, and economic landscape.

T F 4. Early in the history of technology, the development of many tools and machines was not based on scientific knowledge but on technological know-how.

T F 5. The Iron Age was defined by the use of iron and steel as the primary materials for tools.

T F 6. The Middle Ages saw the development of few technological devices that produced long-lasting effects on technology and society.

T F 7. The Renaissance, a time of rebirth of the arts and humanities, was also an important period in the history of technology.

T F 8. The Dark Ages saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time.

T F 9. The Information Age places little emphasis on the processing and exchange of information.

T F 10. The development and use of technology poses ethical issues.

Place the letter of the correct answer in the box at left of statement.

___	11.	Involves considering how every part relates to others. A. Science B. Technology C. Systems thinking D. Feedback
___	12.	Human innovation that involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. A. Computers B. Optimization C. Technology D. Management
___	13.	The parameters placed on the development of a product or system. A. Requirements B. Knowledge C. Standardization D. Trade-offs
___	14.	The use of _____ affects humans' comfort and safety. A. Trade-offs B. Technology C. Trend analysis D. Constraints
___	15.	Technological _____ is the ability to use, manage, understand, and assess technology. A. Mobility B. Optimization C. Literacy D. Forecasting

Unit 1 – The History of Technology Unit Test

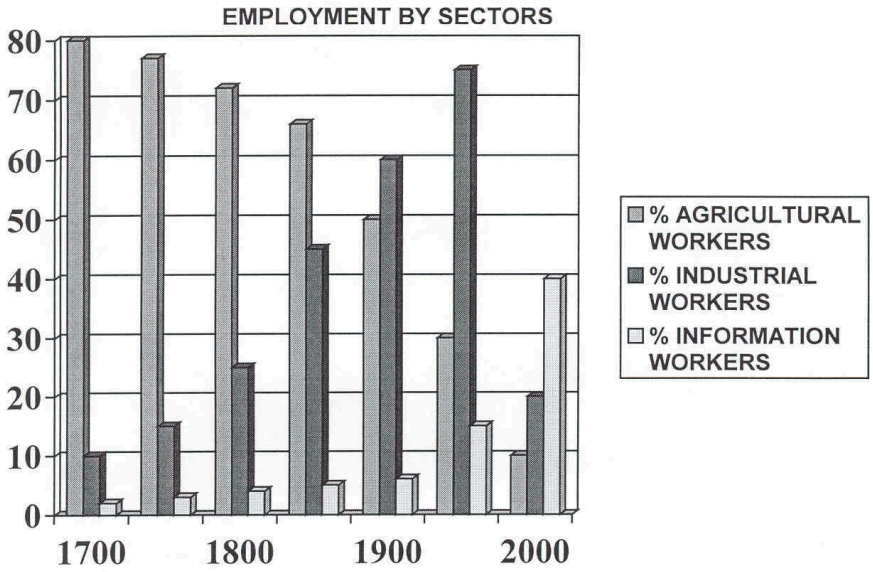
Use the terms in Column II to complete the sentences in Column I.

	Column I	Column II
1.	The evolution of civilization has been directly affected by the development of tools and _____.	Industrial Revolution
2.	Throughout history, _____ has been a major force in reshaping the social, cultural, political, and economic landscape.	Information Age
3.	The _____ was defined by the use of iron and steel as the primary materials for tools.	invention
4.	The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and _____.	Iron Age
5.	The _____, a time of rebirth of the arts and humanities, was also an important period in the history of technology.	materials
6.	The _____ saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time.	Renaissance
7.	The _____ places great emphasis on the processing and exchange of information.	society
8.	The _____ has been at the heart of many technological improvements.	specialization of function
		technology

Place the letter of the correct answer in the box at left of statement.

9.		Most technological development has been _____, the result of a series of refinements to a basic invention. A. evolutionary B. obsolete C. negative D. instantaneous
10.		Early in the history of technology, the development of many tools and machines was not based on scientific knowledge but on _____. A. technological know-how B. mathematics C. social science D. philosophy
11.		There are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, _____, and good arguments. A. the earth B. technology C. logic D. safety
12.		The early Egyptian, Greek, Chinese, Hindu, and Arabic cultures are responsible for many _____ and technological inventions. A. resources B. relationships among fields of study C. scientific and mathematical ideas D. transformations

13.		Modern science is based on traditions of thought that came together in Europe about _____ years ago. A. 50 B. 500 C. 5,000 D. 50,000



Briefly answer the following questions.

14. Based on the graph above, in approximately what year did industrial employment reach its peak?

15. Based on the graph above, what has been the general trend in employment in the information sector?

16. Based on the graph above, did the rate of change for agricultural employment increase or decrease between 1700 and 2000?

17. In general terms, explain how the way people live and work has changed throughout history because of technology.

Unit 1 – Lesson 1

Getting Familiar with the Big Idea

> Knowledge of the history of technology helps people understand the world around them by seeing how people of all times and places have increased their capability by using their unique skills to innovate, improvise and invent.
> *(Adapted from STL & J. Hammond Chancellor emeritus, State College System, Massachusetts)*

Lesson Duration: Three (3) hours.

Standards

- Students will develop an understanding of the influence of technology on history. (ITEA/STL –7)
- Students will develop an understanding of the nature of science. (AAAS – BSL)
- Students will develop an understanding of the designed world. (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM – MSE)
- Students will analyze change in various contexts. (NCTM – MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM – MSE)

Benchmarks

ITEA – Benchmarks for Technological Literacy	AAAS – Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Most technological development has been evolutionary, the result of a series of refinements to a basic invention. • The evolution of civilization has been directly affected by, and has in turn affected, the development of tools and materials. • Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. • Early in the history of technology, the development of many tools and machines was not based on scientific knowledge but on technological know-how. • The Iron Age was defined by the use of iron and steel as the primary materials for tools. • The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society. • The Renaissance, a time of rebirth of the arts and humanities, was also an important period in the history of technology. • The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time. • The Information Age places emphasis on the processing and exchange of information.	• Modern science is based on traditions of thought that came together in Europe about 500 years ago. • The Industrial Revolution happened first in Great Britain because that country made practical use of science, had access by sea to world resources and markets, and had an excess of farm workers willing to become factory workers. • The Industrial Revolution increased the productivity of each worker but it also increased child labor and unhealthy working conditions, and it gradually destroyed the craft tradition. • The Industrial Revolution is still underway as electric, electronic, and computer technologies change patterns of work and bring with them economic and social consequences.	• Model and solve contextualized problems using various representations, such as graphs, tables, and equations. • Use the language of mathematics to express ideas precisely. • Draw reasonable conclusions about a situation being modeled. • Use graphs to analyze the nature of changes in quantities in linear relationships. • Approximate and interpret rates of change from graphical and numerical data • Identify essential quantitative relationships in a situation and determine the class or classes of functions that might model the relationships.

Learning Objectives

Students will:

1. Explain that most technological development has been the result of a series of minor refinements to existing technologies rather than the introduction of completely new technologies.
2. Explain that most technological development has been evolutionary, the result of a series of refinements to a basic invention.
3. Describe how the evolution of civilization has been directly affected by, and has in turn affected, the development of tools and materials.
4. Explain why, early in the history of technology, the development of many tools and machines was based, not on scientific knowledge, but on technological know-how.
5. Use graphs to analyze the nature of changes in quantities in linear relationships.
6. Define terms associated with the influence of technology on history.
7. Identify the periods of human history associated with the evolution of technology.
8. Compare and contrast inventions or innovations based on how they evolved.
9. Demonstrate curiosity, exhibit motivation for learning, and use class time effectively.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials

Print-Based Sources

1. *The History of Science and Technology* by Alexander Hellemans, Houghton Mifflin (2004) ISBN: 0618221239
2. *Technology in World Civilization: A Thousand-Year History* by Arnold Pacey, The MIT Press; Reprint edition (1991) ISBN: 0262660725
3. *The Evolution of Technology* by George Basalla, Cambridge University Press (1989) ISBN: 0521296811

Audiovisual Materials

1. Connections by James Burke, Connections 2 (5pc) (Sub) DVD, Ambrose Video (2003) ASIN: B0000DIZSF
2. The Day the Universe Changed by James Burke, VHS, www.buyindies.com
3. Great Inventions-Modern Marvels 2000, A & E Home Video (2000) VHS, ASIN: B000050Y50

Internet Sites

1. Carnegie Mellon University Library's History of Technology and Science reference page.
2. Timelines of Invention and Technology – http://inventors.about.com/od/timelines/
3. How to Read and Understand Graphs – www.linktolearning.com/history_geo_plans.htm

Purpose of Lesson

To familiarize students with the periods of human history associated with the evolution of technology and to explore how people of all times and all places have increased their capability by innovating, improvising, and inventing.

Required Knowledge and/or Skills

Students should have some understanding of technology's role in determining the way people live, work, and produce things. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on history.

Lesson 1-1

Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to the periods of human history associated with the evolution of technology.
2. The teacher will present students with an actual technological artifact (clock, lightbulb, book) and ask how the artifact influenced the lives of the people who first used it.
3. Students will share their ideas on how the artifact may have impacted the way people lived, worked, or produced things.
4. The teacher will ask students to think about how the artifact may have influenced history.
5. Students will relate the use of the technological artifact to a "turning point" in history.

Exploration

1. Working in small groups, students will brainstorm a selected technological advancement (the plow, irrigation systems, cannons, printing press, steam engine, radar, computer).

> **Group Size**
>
> Keep groups as small as possible to promote positive interdependence, yet as large as necessary to provide sufficient diversity of opinions and backgrounds as well as resources to get the job done. The size of groups formed is directly dependent on the activity to be pursued and the length of time the group will stay together.

2. The student groups will develop and record information regarding the influence of the technological advancement on history. (Example: The invention of the printing press in the mid-15th century made books more widely available and increased literacy rates.)

Explanation

1. The student groups will present their ideas to the class and respond to questions.
2. The teacher will explain that:
   a. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.
   b. The evolution of civilization has been directly affected by, and has in turn affected the development of tools and materials.
   c. Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.
   d. Early in the history of technology, the development of many tools and machines was not based on scientific knowledge but on technological know-how.
3. The teacher will discuss why the study of history is facilitated by defining chronological periods.
4. The teacher will lead a discussion that will include defining technology and history, descriptions of the periods of human history associated with technology evolution, major technological advancements associated with the periods of history, and the impact of the advancements on history.

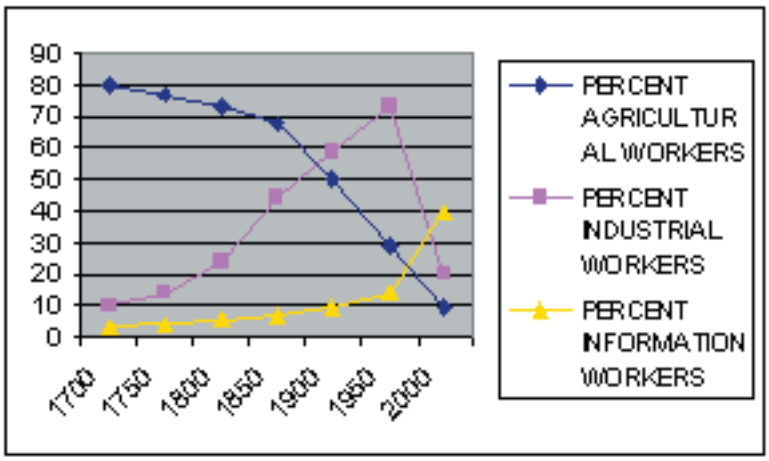
a. Technology – Human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities.
b. History – A chronological record of significant events often including an explanation of their causes.
c. Palaeolithic Age
   - Time period: 500,000 BC – 10,000 BC
   - Description: The archaeological period characterized by the earliest known stone tool manufacture.
   - Artifacts: stone axes, bone needles, hearth sites.
   - Impact of technology on history: improved diet and enhanced security enabled early humans to increase their numbers.
d. Mesolithic Age
   - Time period: 10,000 BC – 4000 BC
   - Description: The period between the Paleolithic and the Neolithic, associated with the rise to dominance of microliths (very small geometric-form tools commonly used in composite tools).
   - Artifacts: leatherwork, basketry, fishing tackle, stone adzes and wooden objects such as canoes and bows, domesticating animals first began, stone circles, henges.
   - Impact of technology on history: The gradual domestication of plants and animals led to the beginnings of settled communities.
e. Neolithic Age
   - Time period: 4000 BC – 2300 BC
   - Description: The period characterized by the development of agriculture and, hence, an increasing emphasis on year-round settlements.
   - Artifacts: pottery, polished stone tools, spinning and weaving tools, wooden and stone plows, sickles.
   - Impact of technology on history: Dependable year-round food supply enables division of labor and specialization that spurs invention and innovation.
f. Bronze Age
   - Time period: 2300 BC – 700 BC
   - Description: The stage of cultural history that includes the earliest civilizations and the development of metallurgy, mainly the combining of copper and tin to make bronze.
   - Artifacts: bronze jewelry, tools, and weapons.
   - Impact of technology on history: The use of bronze was a great technological step, eventually changing the course of everyday life as stone tools were gradually replaced by metal ones and enabled humans to alter their environment at a great rate.
g. Iron Age
   - Time period: 700 BC – 450 AD
   - Description: A period of human history characterized by the use of iron as the main metal.
   - Artifacts: iron dagger, iron chisels, small figurines, ornamental jewelry, swords, axes, spearheads.
   - Impact of technology on history: Military dominance for uses of iron weapons and the use of iron bladed plows enabled humans to cultivate heavier soils and increase food production.
h. Middle Ages
   - Time period: 450 –1400 AD
   - Description: The period of European history between fall of Rome and the Renaissance, often dated from A.D. 476 to 1453.

- Artifacts: wheeled plow, improved harness for horses, horseshoes, stirrups, water-wheels, crank, windmill, cast iron, cannons, mechanical clock, compass, ocean-going ships.
- Impact of technology on history: The rise and decline of serfdom and feudalism, the rise of the money economy and capitalism, the expansion and contraction of economic activity, and the beginnings of urbanization and industrialization.

i. Renaissance/Reformation/Enlightenment
- Time period: 1400-1750 AD
- Description: The transitional movement in Europe between the middle ages and modern times, marked by a humanistic revival of classical influence
- Artifacts: telescope, microscope, thermometer, clocks, barometer
- Impact of technology on history: Instrumentation enabled early scientists to observe and quantify natural phenomena.

k. Industrial Age
- Time period: 1750-1950 AD
- Description: The cultural stage characterized by the first use of complex machinery, factories, urbanization, and other economic and general social changes from strictly agricultural societies.
- Artifacts: steam engine, electricity, automobile, airplane, radio, television, telephone, and rocket.
- Impact of technology on history: The Industrial Revolution gave rise to urban centers requiring vast municipal services, created a specialized and interdependent economic life, and provided the economic base for the rise of the professions, population expansion, and improvement in living standards.

l. Information Age
- Time period: 1950 AD–Present
- Description: A period of activity starting in the 1950s and continuing today in which the gathering, manipulation, classification, storage, and retrieval of information is central to the workings of society.
- Artifacts: transistor, integrated circuit, computer, communication satellite, digital photography, artificial heart, nuclear power plant, space shuttle.
- Impact of technology on history: As information becomes more widely available, increasing numbers of individuals and organizations will be in a better position to make decisions that "experts" now make, decentralizing decision making and empowering more people.



5. The teacher will lead a discussion on how the nature of work has changed over time using the graph at right.
6. Students will clarify their understanding of concepts by asking questions.

Extension

1. For a given technological advancement that impacted history, students will develop a timeline that includes innovations that preceded their topic and those that followed. ("What was used before to meet the need?" and "What was used later to meet the need?")
2. Students will display and describe their timelines to the class, explaining the evolution of the idea and its impact on history.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, interpretation of a graph, a timeline and related presentation, brief constructed responses, and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Teaching Opportunity

When teaching this lesson and developing your group work, learn and/or implement the elements of cooperative learning: positive interdependence; face-to-face interaction; individual accountability; interpersonal and small group skills; and group processing.

Other Extension Activities

1. Students may be asked to identify an emerging technology and report on its potential influence on history.
2. Students may be assigned to visit a museum in person or online and report on how the influence of technology on history is presented.
3. Students may be asked to interview an older family member about the most significant technological advancements in their lives and report their findings to the class.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small group meetings, and research activities should be readied.

Tools/Materials/Equipment

- Computers
- Printers
- Poster Printer/Sign maker
- Computer Projector

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson 1-1 Assessment Instruments

Assessment Instrument - Selected Response Item

Directions: Circle the T or F in the column to the left of each true (T) or false (F) statement.

T F 1. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.

T F 2. The evolution of civilization has not been directly affected by the development of tools and materials.

T F 3. Throughout history, technology has been a minor force in reshaping the social, cultural, political, and economic landscape.

T F 4. Early in the history of technology, the development of many tools and machines was not based on scientific knowledge, but on technological know-how.

T F 5. The Iron Age was defined by the use of iron and steel as the primary materials for tools.

T F 6. The Middle Ages saw the development of few technological devices that produced long-lasting effects on technology and society.

T F 7. The Renaissance, a time of rebirth of the arts and humanities, was also an important period in the history of technology.

T F 8. The Dark Ages saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time.

T F 9. The Information Age places little emphasis on the processing and exchange of information.

T F 10. The development and use of technology poses ethical issues.

Assessment Instrument – Class Participation

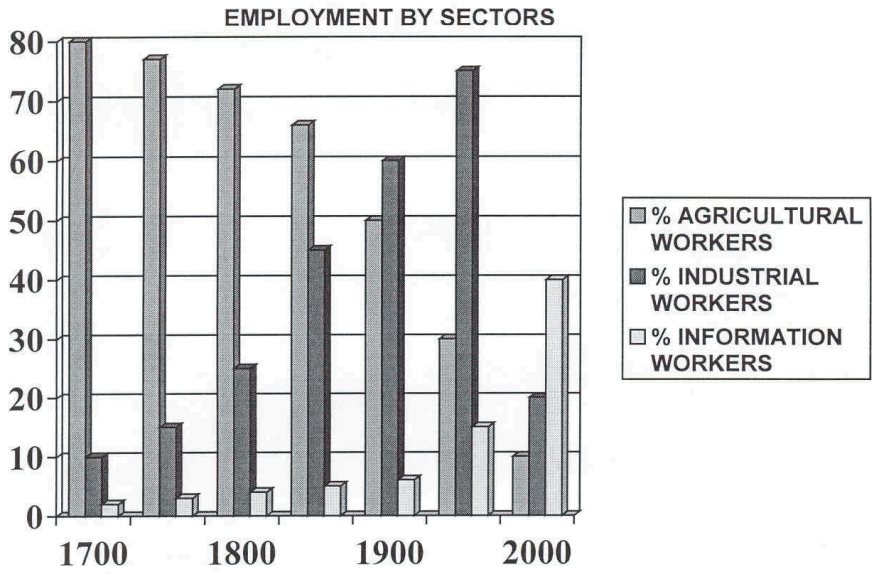
Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class, attempts to answer teacher generated questions.	Well prepared for class, attempts to answer teacher-generated questions and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation for Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily, is not engaged. Has difficulty remaining on task.	Makes good use of class time. to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

Assessment Instrument – Timeline

Category	Below Target	At Target	Above Target
Title	Title missing or difficult to locate.	Timeline has an effective title that accurately describes the material and is easy to locate.	Timeline has a creative title that accurately describes the material and is easy to locate.
Content-Facts	Facts often inaccurate for events reported on the timeline.	Facts accurate for almost all events reported on the timeline.	Facts accurate for all events reported on the timeline.
Graphics or Pictures	Several graphics are not effective.	All graphics are effective.	All graphics are effective and balanced with text use.
Dates	Dates inaccurate or missing for several events.	Accurate dates included for almost every event.	Accurate dates included for each event.
Style and Organization	Time period covered was inappropriate. Yearly divisions not uniform.	Timeline set up to cover the relevant time period. Contains yearly gradations, but not at set intervals.	Timeline set up to cover the relevant time period. Contains appropriate yearly gradations of set intervals.
Resources	Timeline covers five or fewer events.	Timeline contained at least 8-10 events related to the topic being studied.	Timeline contained at least 11-15 events related to the topic being studied.
Documentation	Sources not properly documented, too few, or inappropriate.	Less than four properly documented sources.	Four or more properly documented sources.
Objective or Thesis	No statement of thesis or objective for research.	Clearly stated but focus could have been sharper.	Clearly stated and appropriately focused.
Knowledge Gained	Lacks knowledge of the content and the processes used to create the timeline.	Accurately answers most questions related content and processes.	Accurately answered all questions, related content and processes.

Assessment Instrument – Use Graph to Analyze the Nature of Changes Related to the Impact of Technology

Category	Below Target	At Target	Above Target
Accurately Interpret Numerical Data	Inaccurately interprets the data or does not display understanding of what graph is showing.	Demonstrates an understanding of what the data is showing, with some supporting interpretive statements.	Displays a full understanding of what the data is showing through supporting statements of interpretation.
Synthesize Related Data	Fails to identify and summarize the data, does not understand the difference between facts, interpretation, and assumptions in summarizing graphs.	Identifies most of the relevant differences, similarities, and patterns in data; for the most part is able to distinguish fact from interpretation.	Identifies most of the relevant differences, similarities, and patterns in data; is able to distinguish fact from interpretation or assumptions when summarizing graphs.
Knowledge Gained	Demonstrates a lack of knowledge about the content and the processes used to create the poster.	Can accurately answer most questions related to content and the processes used to create the poster.	Can accurately answer all questions related to content and the processes used to create the poster.



Assessment Instrument – Brief Constructed Response Items

1. Explain why most technological development has been the result of a series of minor refinements to existing technologies rather than the introduction of completely new technologies.
2. Describe how the evolution of civilization has been directly affected by, and has in turn affected, the development of tools and materials.
3. Explain why, early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how.
4. Describe how the social, cultural, political, and economic landscape in any time period has been shaped by technology.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question..	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Items

1. Identify a technological development and describe how it influenced history.
2. Compare and contrast two inventions or innovations based on how they evolved.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause and effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate, and precise language. Cohesive organization. Very few grammatical errors.

Unit 1 – Lesson 2

Exploring Historical Periods of Technological Evolution

Lesson Duration: Three (3) hours.

Standards

- Students will develop an understanding of the influence of technology on history. (ITEA/STL –7)
- Students will develop an understanding of the nature of science. (AAAS – BSL)
- Students will develop an understanding of the designed world. (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM – MSE)
- Students will analyze change in various contexts. (NCTM – MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM – MSE)

Benchmarks

ITEA – Benchmarks for Technological Literacy	AAAS – Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Most technological development has been evolutionary, the result of a series of refinements to a basic invention. • The evolution of civilization has been directly affected by, and has in turn affected the development of tools and materials. • Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. • Early in the history of technology, the development of many tools and machines was not based on scientific knowledge but on technological know-how. • The Iron Age was defined by the use of iron and steel as the primary materials for tools. • The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society. • The Renaissance, a time of rebirth of the arts and humanities, was also an important period in the history of technology. • The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time. • The Information Age places emphasis on the processing and exchange of information.	• Modern science is based on traditions of thought that came together in Europe about 500 years ago. • The Industrial Revolution happened first in Great Britain because that country made practical use of science, had access by sea to world resources and markets, and had an excess of farm workers willing to become factory workers. • The Industrial Revolution increased the productivity of each worker but it also increased child labor and unhealthy working conditions, and it gradually destroyed the craft tradition. • The Industrial Revolution is still underway as electric, electronic, and computer technologies change patterns of work and bring with them economic and social consequences.	• Model and solve contextualized problems using various representations, such as graphs, tables, and equations. • Use the language of mathematics to express ideas precisely. • Draw reasonable conclusions about a situation being modeled. • Use graphs to analyze the nature of changes in quantities in linear relationships. • Approximate and interpret rates of change from graphical and numerical data. • Identify essential quantitative relationships in a situation and determine the class or classes of functions that might model the relationships.

Learning Objectives

Students will:

1. Describe anticipated positive and negative impacts as well as the unanticipated positive and negative impacts of technological innovations.
2. Compare and contrast life in periods of technological development.
3. Explain how the way people live and work has changed throughout history because of technology.
4. Use materials, tools, instruments, equipment, and procedures safely.
5. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
6. Develop a graphic representation that conveys accurate information in a logical, interesting sequence that an audience can follow.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials

Print-Based Sources

1. *A Message of Ancient Days: Level 6 - 21st Century Edition* by Beverly J. Armento, Houghton Mifflin School (1999) ISBN: 0395930650
2. *The Third Wave* by Alvin Toffler, Bantam; Reissue edition (1984) ISBN: 0553246984
3. *Guns, Germs, and Steel* by Jared Diamond, W. W. Norton & Company (1999) ISBN: 0393317552

Audiovisual Materials

1. *Connections*, James Burke Producer: BBC and Time Life (5 DVDs in series)
2. *The Day the Universe Changed* (1986) James Burke Producer: BBC and Time Life, a stunning overview of this evolution of thought since the days of the Greeks in a ten-part series co-produced by BBC-TV and RKO Pictures.

Internet Sites

1. Time Trek Interactive Presentations – www.timetrek.org/interact.htm
2. Human Historical Periods – http://en.wikipedia.org/wiki/List_of_time_periods#Human_historical_periods
3. Great Books Time Line – www.mercer.edu/gbk/gbk/gbktimln.html

Purpose of Lesson

To familiarize students with the way technology has influenced history by comparing and contrasting life in different periods of technological development.

Required Knowledge and/or Skills

Students should be familiar with the periods of human history associated with technology evolution. They should know that people of all times and all places have increased their capability by innovating, improvising, and inventing. They should have some understanding of technology's role in determining the way people live, work, and produce things. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher

will identify student misunderstandings and/or misconceptions about the historical periods of technological development.

Lesson 1-2

Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to the way technology has influenced history.
2. The teacher will present students with illustrations of nine technological advancements (one each from the nine periods in history of technological development) and ask students to speculate on how these advancements influenced the lives of the people who first used it.
3. Students will share their ideas on how the advancements cited may have influenced the way people lived, worked, or produced things.
4. Students will compare and contrast the amount of physical labor and knowledge required of people in each time period.

Exploration

1. Working in groups (one each from the nine periods in the history of technological development), students will use reference resources to categorize artifacts and processes according to their technological time period.

PALEOLITHIC AGE	MESOLITHIC AGE	NEOLITHIC AGE	BRONZE AGE	IRON AGE
• Use of fire • Unpolished stone tools • Sculpture • Musical instruments • Burial of dead • Cave dwellings • Cave painting • Stone axes • Bone needles • Hearth sites	• Microliths • Sail • Wheel and axle • Leatherwork • Basketry • Fishing tackle • Stone adzes • Canoes • Bows • Domesticated animals • Stone circles • Sickles	• Stone and mud brick dwellings • Pottery • Polished stone tools • Spinning and weaving tools • Wooden and stone plows	• Metal pots and pans • Pottery wheel • Chariot • Pulley • Metal jewelry • Metal tools • Metal weapons	• Block and tackle • Pump • Lathe • Iron dagger • Iron chisel • Iron axe • Iron spearhead
MIDDLE AGES	**RENAISSANCE**	**INDUSTRIAL AGE**	**INFORMATION AGE**	
• Waterwheel • Windmill • Cannon • Mechanical clock • Wheeled plow • Horseshoes • Stirrups • Crank • Compass • Ocean-going ships	• Telescope • Microscope • Thermometer • Barometer • Printing press • Rifle	• Steam engine • Electricity • Automobile • Airplane • Radio • Television • Telephone • Rocket	• Transistor • Integrated circuit • Computer • Communication satellite • Digital photography • Artificial heart • Nuclear power plants • Space shuttle	

2. The teacher will explain that:
   a. Modern science is based on traditions of thought that came together in Europe about 500 years ago.
   b. The Industrial Revolution happened first in Great Britain because that country made practical use of science, had access by sea to world resources and markets, and had an excess of farm workers willing to become factory workers.
   c. The Industrial Revolution increased the productivity of each worker but it also increased child labor and unhealthy working conditions, and it gradually destroyed the craft tradition.
   d. The Industrial Revolution is still underway as electric, electronic, and computer technologies change patterns of work and bring with them economic and social consequences
3. The student groups will develop a chart listing the advancements for their technological time period and identify a spokesperson to present the chart to the class.

Group size

Keep groups as small as possible to promote positive interdependence, yet as large as necessary to provide sufficient diversity of opinions and backgrounds as well as resources to get the job done. The size of groups formed is directly dependent on the activity to be pursued and the length of time the group will stay together.

Explanation

1. The student groups will share and justify their selections with the class in an informal presentation.
2. The teacher will assist the class is reconciling any discrepancies in the groups' work.
3. The teacher will demonstrate processes used to create a poster including:
   a. Composition and layout
   b. Creating, proof-reading, and attaching text
   c. Locating, copying, and attaching graphics
   d. Documenting sources
   e. Preparing the poster for display
   f. Preparing to answers questions about the content of the poster
   g. The teacher will assist students in guided practice of poster-making skills.
4. Students will clarify their understanding of concepts through questioning.

Extension

1. Students will use the exploration activity chart as the basis for creating a poster highlighting representative artifacts and processes from one of the technological time periods.
2. The teacher will review the criteria for assessment of a poster.
3. Students will make a brief presentation on their of their poster and answer questions from the class and/or the teacher.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for group work, a poster and related presentation, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the

activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities

1. Students may be asked to identify a piece of literature written in or depicting one of the periods of technological development and report on the references to technology made in the piece.
2. Students may be asked to identify a movie depicting one of the periods of technological development and report on the references to technology made in the piece.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, fabrication, small group meetings, and research activities should be readied.

Tools/Materials/Equipment

- Computers
- Printers
- Presentation software
- Poster Printer/Sign maker
- Computer projector

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument - Selected Response Item

Use the terms in Column II to complete the sentences in Column I.

	Column I	Column II
1.	Most technological development has been evolutionary, the result of a series of refinements to an earlier _____.	Industrial Revolution
2.	The evolution of civilization has been directly affected by the development of tools and _____.	Information Age
3.	Throughout history, _____ has been a major force in reshaping the social, cultural, political, and economic landscape.	invention
4.	Early in the history of technology, the development of many tools and machines was not based on _____ knowledge but on technological know-how.	Iron Age
5.	The _____was defined by the use of iron and steel as the primary materials for tools.	materials
6.	The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and _____.	Renaissance
7.	The _____, a time of rebirth of the arts and humanities, was also an important period in the history of technology.	scientific
8.	The _____saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time.	society
9.	The _____places great emphasis on the processing and exchange of information.	specialization of function
10.	The _____ has been at the heart of many technological improvements.	technology

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative. Does little work. Rarely offers useful ideas	Cooperative. Works at assignments. Usually offers useful ideas.	Always willing to help and do more. Does more than required. Routinely offers useful ideas.
Cooperation	Rarely listens to, shares with, or supports the efforts of others. Often is not a good team member.	Usually listens to, shares with, and supports the efforts of others. Does not cause problems in the group.	Always listens to, shares with, and supports the efforts of others. Tries to keep people working together.
Focus on the task	Does not focus on the task and what needs to be done. Lets others do the work.	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done. Self-directed.

Assessment Instrument – Poster Presentation

Category	Below Target	At Target	Above Target
Title	Title is too small and/or does not describe the content of the poster well.	Title can be read from six feet away and describes content well.	Title can be read from six feet away and is quite creative.
Graphics – Clarity	Graphics are not clear or are too small.	Easily viewed and identified from four feet away.	Easily viewed and identified from six feet away.
Mechanics	Numerous errors in capitalization or punctuation.	Minor errors in capitalization or punctuation.	Capitalization and punctuation are correct throughout the poster.
Content – Accuracy	Content is inaccurate and/or does not include additional artifacts and processes.	Content is accurate and includes several additional artifacts and processes.	Content is accurate and includes a significant number of additional artifacts and processes.
Attractiveness	Poster is distractingly messy or very poorly designed.	Poster is attractive in terms of design, layout, and neatness.	Poster is exceptionally attractive in terms of design, layout, and neatness.
Knowledge Gained	Lacks knowledge of the content and the processes used to create the poster.	Accurately answers most questions related to content and the processes used to create the poster.	Accurately answers all questions related to content and the processes used to create the poster.

Assessment Instrument – Brief Constructed Response Items

1. Explain why modern science is based on traditions of thought that came together in Europe about 500 years ago.
2. Why did the Industrial Revolution happen first in Great Britain?
3. Describe some of the negative results of the Industrial Revolution related to child labor and working conditions.
4. Describe some of the ongoing impacts of the Industrial Revolution related to patterns of work and economic and social consequences.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

1. Compare and contrast life in any two periods of technological evolution

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriateArgument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) providedIncludes obscure, but important evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause and effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate and precise language. Cohesive organization. Very few grammatical errors.

Unit 1 – Lesson 3

Analysis of the Historic Significance of Technological Advancements

Lesson Duration: Two (2) hours.

Standards

- Students will develop an understanding of the influence of technology on history. (ITEA/STL –7)
- Students will develop an understanding of the nature of science. (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM – MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM – MSE)

Benchmarks

ITEA – Benchmarks for Technological Literacy	AAAS – Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Most technological development has been evolutionary, the result of a series of refinements to a basic invention. • The evolution of civilization has been directly affected by, and has in turn affected, the development of tools and materials. • Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.	• Modern science is based on traditions of thought that came together in Europe about 500 years ago.	• Model and solve contextualized problems using various representations, such as graphs, tables, and equations. • Use the language of mathematics to express ideas precisely.

Learning Objectives

Students will:

1. Identify and describe social, cultural, political, and economic significance of historical technological advancements.
2. Create a graphic organizer for a selected technological development that identifies the social, cultural, political, and economic impacts.
3. Explain that the value of any given technology may be different for different groups of people and at different points in time.
4. Use materials, tools, instruments, equipment, and procedures safely.
5. Conduct self-assessment of work performance.
6. Assess peers work performance.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response items

3. Extended Response items
4. Performance Rubrics

Resource Materials

Print-Based Sources

1. Graphic Organizer Workbooks available at wwwteach-nologycom/web_tools/graphic_org
2. *Technology in World Civilization: A Thousand-Year History by Arnold Pacey*, The MIT Press; Reprint edition (1991) ISBN: 0262660725
3. *Science and Technology in World History: An Introduction* by James E McClellan, Harold Dorn, Johns Hopkins University Press (1999) ISBN: 080185869
4. *The History of Science and Technology : A Browser's Guide to the Great Discoveries, Inventions, and the People Who Made Them from the Dawn of Time to Today* by Bryan Bunch (Editor), Alexander Hellemans (Editor)

Audiovisual Materials

1. Time Trek Interactive Presentations – wwwtimetrekorg/interacthtm
2. The Paleolithic - Old Stone Age – wwwbergenorg/technology/stone2html
3. Our Ice Age Ancestors – wwweepdxedu/~igal/visocomm/paleolithtml
4. The Impact of Technology – Society, Quick Time Video –www.teachersdomain.org/9-12/sci/engin/design/techsociety/index.html

Internet Sites

1. Graphic Organizers – wwwncrelorg/sdrs/areas/issues/students/learning/lr1grorghtm
2. Electronic Graphic Organizers – wwwgraphicorg/electhtml
3. Impacts of Technology – wwwuniedu/darrow/frames/historyhtml
4. Technology Chronology – http://campusnorthparkedu/history/WebChron/Technology/Technologyhtml
5. The Influence Of Technology On The Human Mind – http://omicronfelkcvutcz/~bobr/hmind/

Purpose of Lesson

To enable students to analyze the historic significance of technological advancements and to gain an understanding of the influence of technology on history.

Required Knowledge and/or Skills

Students should have some understanding of the way technology influenced history in specific periods of human history. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about social, cultural, political, and economic impacts of technology

Lesson 1-3

Engagement

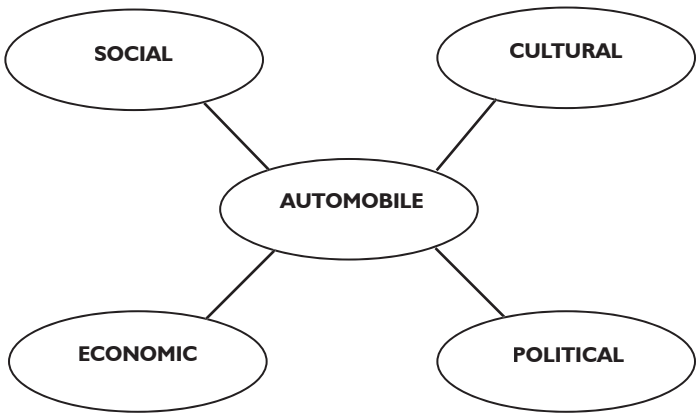
1. The teacher will assess prior knowledge and possible misconceptions related to the historic significance of technological advancements.
2. The teacher will present students with a historic technological advancement (wheel and axle or computer) and ask students to speculate on how these advancements influenced the lives of the people who first used it.
3. Students will be asked to identify aspects of civilized life that might be impacted by the advancement of technology (government, education, careers, recreation).
4. Students will compare and contrast the impact of two technological advancements.

Exploration

1. The teacher will identify aspects of civilized life that might be impacted by the advancement of technology (social, cultural, economic and political).
2. The student groups will develop a chart listing the impacts of several technological advancements on civilized life.

Explanation

1. The student groups will share their chart information, listing the impacts of several technological advancements on civilized life.
2. The teacher will explain that the value of any given technology may be different for different groups of people and at different points in time.
3. The teacher will introduce the concept of technological impacts and define four areas of human interaction (social, cultural, economic and political) that are influenced by technology.
4. The teacher will explain to students that graphic organizers are a pictorial or graphical way to organize information and thoughts for understanding.
5. The teacher will present the graphic organizer at the right, and ask the class to brainstorm ideas related to impacts in the four areas of human interaction for a sample topic such as the automobile.
6. The teacher will guide students through several additional analyses of technological impacts using the graphic organizer.
7. The teacher will guide the student groups in organizing their data from the exploration activity into the format of the graphic organizer.
8. Students will clarify their understanding of concepts through questioning.



Extension

1. Students will collect data, analyze, and organize data related to a selected technological development.
2. Students will create a graphic organizer for a selected technological development that identifies the social, cultural, political, and economic impacts.
3. Students will present the graphic organizer to the class.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using rubrics for a graphic organizer, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities

1. Students may be asked to identify an emerging technology and report on its potential social, cultural, economic, and political impacts.
2. Students may be assigned to design and create a bulletin board display on the periods of technological development including examples of artifacts from the period.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small group meetings, and research activities should be readied.

Tools/Materials/Equipment

- Computers
- Printers
- Presentation software
- Poster Printer/Sign maker
- Computer projector

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument – Graphic Organizer

Category	Below Target	At Target	Above Target
Arrangement of Concepts	Main concept not clearly identified; subconcepts don't consistently branch from main idea.	Main concept easily identified; most subconcepts branch from main idea.	Main concept easily identified; subconcepts branch appropriately from main idea.
Links and Linking Lines	Linking lines not always pointing in correct direction; linking words don't clarify relationships between concepts; hyperlinks don't function or fail to enhance the topic.	Most linking lines connect properly; most linking words accurately describe the relationship between concepts; most hyperlinks effectively used.	Linking lines connect related terms/point in correct direction; linking words accurately describe relationship between concepts; hyperlinks effectively used.
Graphics	Graphics used inappropriately and excessively; graphics poorly selected and don't enhance the topic; some graphics are blurry and ill-placed.	Graphics used appropriately most of the time; most graphics selected enhance the topic, are of good quality, and are situated in logical places on the page.	Graphics used appropriately; greatly enhance the topic and aid in comprehension; are clear, crisp and well situated on the page.
Content	Contains extraneous information; is not logically arranged; contains numerous spelling and grammatical errors.	Reflects most of the essential information; is generally logically arranged; concepts presented without too many excess words; fewer than three misspellings or grammatical errors.	Reflects essential information; is logically arranged; concepts succinctly presented; no misspellings or grammatical errors.
Text	Font too small to read easily; more than four different fonts used; text amount is excessive for intended audience.	Most text is easy to read; uses no more than four different fonts; amount of text generally fits intended audience.	Easy to read; appropriately sized; no more than three different fonts; amount of text is appropriate for intended audience; boldface used for emphasis.
Design	Cluttered design; low in visual appeal; requires a lot of scrolling to view entire diagram; choice of colors lacks visual appeal and impedes comprehension.	Design is fairly clean, with a few exceptions; diagram has visual appeal; four or fewer symbol shapes; fits page well; uses color effectively most of time.	Clean design; high visual appeal; four or fewer symbol shapes; fits page without a lot of scrolling; color used effectively for emphasis.
Knowledge Gained	Student demonstrates a lack of knowledge about the content and the processes used to create the poster.	Student can accurately answer most questions related to content and the processes used to create the poster.	Student can accurately answer all questions related to content and the processes used to create the poster.

Element	Criteria	Points Possible	Earned Assessment	
			Self	Teacher
Arrangement of Concepts	Main concept easily identified; subconcepts branch appropriately from main idea.			
Links and Linking Lines	Linking lines connect related terms/point in correct direction; linking words accurately describe relationship between concepts; hyperlinks effectively used.			
Graphics	Graphics used appropriately; greatly enhance the topic and aid in comprehension; are clear, crisp and well situated on the page.			
Content	Reflects essential information; is logically arranged; concepts succinctly presented; no misspellings or grammatical errors.			
Text	Easy to read; appropriately sized; no more than three different fonts; amount of text is appropriate for intended audience; boldface used for emphasis.			
Design	Clean design; high visual appeal; four or fewer symbol shapes; fits page without a lot of scrolling; color used effectively for emphasis.			
Knowledge Gained	Student can accurately answer all questions related to content and the processes used to create the poster.			

Assessment Instrument – Brief Constructed Response Items

1. Explain why the value of any given technology may be different for different groups of people and at different points in time.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Items

1. Identify and describe social, cultural, political, and economic significance of a selected historical technological advancement.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause and effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate, and precise language Cohesive organization Very few grammatical errors.

Unit 1 – Lesson 4

Research Activity: Influence of Technology on History

Lesson Duration: Five (5) hours.

Standards

- Students will develop an understanding of the influence of technology on history. (ITEA/STL –7)
- Students will develop an understanding of the nature of technology. (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM – MSE)
- Students will analyze change in various contexts. (NCTM – MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM – MSE)

Benchmarks

ITEA – Benchmarks for Technological Literacy	AAAS – Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Most technological development has been evolutionary, the result of a series of refinements to a basic invention. • The evolution of civilization has been directly affected by, and has in turn affected, the development of tools and materials. • Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.	• The value of any given technology may be different for different groups of people and at different points in time.	• Model and solve contextualized problems using various representations, such as graphs, tables, and equations. • Identify essential quantitative relationships in a situation and determine the class or classes of functions that might model the relationships. • Use graphs to analyze the nature of changes in quantities in linear relationships. • Approximate and interpret rates of change from graphical and numerical data.

Learning Objectives

Students will:

1. Conduct effective and focused research.
2. Use computers and calculators to access, retrieve, organize, and evaluate data and information in order to communicate.
3. Present research findings effectively using instructional technology.
4. Use the Internet to become familiar with literature related to technology.
5. Describe the professional and educational backgrounds of authors of literature related to technology.
6. Describe the purposes of research and its role in the development of an information base used to understand the influence of technology on history.
7. Use mathematical modeling techniques for making predictions about the future applications of technology.

8. Explain mathematical functions (linear, quadratic, or exponential) and how they may represent an aspect of technological change.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials

Print-Based Sources

1. *A History Of Invention: From Stone Axes To Silicon Chips* by Trevor Williams, Checkmark Books, (2000) ISBN: 0816040729
2. *A History Of Technology & Invention; Progress Through The Ages*. Daumas, Maurice, ed. Translated by Eileen B. Hennessy. New York, Crown Publishers, ASIN: B0007I6RXE
3. *Invention and Technology Magazine*, Forbes Inc. ASIN: B000066T17

Audiovisual Materials

1. The New Way Things Work by David Macaulay, Mac OS 9 and below, Windows 98 CD-ROM
2. Wright Brothers' Flying Machine: Nova (Pbs Series)
3. The Impact of Technology: Society, Quick Time Video – www.teachersdomain.org/9-12/sci/engin/design/techsociety/index.html

Internet Sites

1. Nature and History of Technology, NAE – www.nae.edu/NAE/techlithome.nsf/weblinks/NAEW-649HAZ?OpenDocument
2. The Society for the History of Technology – http://shot.jhu.edu/
3. Technology Throughout History – www.bergen.org/technology/techis.html
4. Timelines of Invention and Technology – http://inventors.about.com/od/timelines/
5. Internet Resources for History of Science and Technology – www2.lib.udel.edu/subj/hsci/internet.htm
6. Graph Analysis – http://mtsu32.mtsu.edu:11308/regression/level1/curvefit/definitions.htm

Purpose of Lesson

To familiarize students with the way technology influenced history in specific periods of human history.

Required Knowledge and/or Skills

Students should have some understanding of the historic significance of technological advancements. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the development of tools and its effect on the materials evolution of civilization.

Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to the way technology influenced history in specific periods of human history.
2. The teacher will present students with examples of popular literature that deals with the development of technology including data on the number of each title sold and the gross sales figures for these books. (*Invention by Design* by Henry Petroski, *Galileo's Daughter* by Dava Sobel, *Guns, Germs, and Steel* by Jared Diamond)
3. Students will be asked to give their opinions about why there is a market for this genre of literature.
4. The teacher will ask students to speculate on the educational backgrounds of writers of this type of literature.

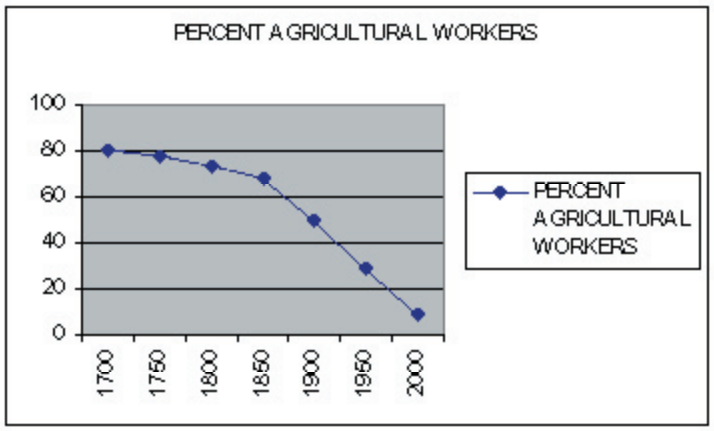
Exploration

1. The teacher will provide students with Internet citations for current literature dealing with the development of technology.
2. Students will find and briefly summarize a review for a current technology book.
3. Students will present their brief summaries to the class.

Explanation

1. The teacher will initiate discussion on the purposes of research and its role in the development of an information base used to understand the influence of technology on history.
2. The teacher will explain that:
   a. A literature review is an account of what has been published on a topic by accredited scholars and researchers.
   b. The purpose is to inform others about what knowledge and ideas already exist related to the topic.
   c. Besides enhancing knowledge about the topic, writing a literature review enables students to gain and demonstrate skills in two areas: a) information seeking: the ability to scan the literature efficiently, using manual or computerized methods, to identify a set of useful articles and books and b) critical appraisal: the ability to apply principles of analysis to identify unbiased and valid studies.
   d. Literature review must do these things:
      - Be organized around and related directly to the thesis or research question being developed
      - Synthesize results into a summary of what is and is not known
      - Identify areas of controversy in the literature
      - Formulate questions that need further research
3. The teacher will review research techniques:
   a. Selecting a topic
   b. Researching the topic
   c. Note-taking
   d. Data collection, graphing, and analysis
   e. Writing a rough draft
   f. Completing a written report
   g. Preparing for an oral presentation
   h. Presenting an oral report
4. The teacher will demonstrate the use of mathematical models for making predictions.
5. The teacher will review the classes of mathematical functions (linear, quadratic, or exponen-

tial) and how they may represent an aspect of technological change.
6. The teacher will demonstrate "curve fitting" techniques to determine the class of mathematical functions (linear, quadratic, or exponential) representing an aspect of technological change.
7. Students will clarify their understanding of research techniques by asking questions.



Extension

1. For a given technological advancement that impacted history, students will develop a research report on the historical impact of a selected technological advancement including a discussion of the anticipated positive and negative impacts as well as the unanticipated positive and negative impacts.
2. The teacher will discuss expectations for a written research paper and oral presentation.
3. Students will select a topic from a specified technological period.
4. The teacher will specify the type of information needed and will review resources.
5. Students will gather information, pictures, graphs, and diagrams.
6. Students will use graphs to analyze the nature of changes related to the impact of technology.
7. Students will determine the class of mathematical functions (linear, quadratic, or exponential) representing an aspect of technological change.
8. Students will make predictions of technological change based on a mathematical model.
9. Students will record information sources in a bibliography.
10. The teacher will review the criteria and grading procedure for the written report.
11. The teacher will review reporting techniques and the criteria and grading procedure for oral presentations.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using rubrics for research and reporting, oral presentation, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities

1. Students may be assigned to research and construct a model of their historical artifact.
2. Students may repeat their presentation in a history or social studies class and ask the audience to respond to an evaluation instrument developed by the student.
3. Students may repeat their presentation in a mathematics class and ask the audience to respond to an evaluation instrument developed by the student.

4. Students may be assigned to report back to their technology education class on their experiences in presenting to other classes.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, production and fabrication, product/prototype testing and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, small group meetings, and research activities should be readied.

Tools/Materials/Equipment

- Computers
- Printers
- Presentation software
- Poster Printer/Sign maker
- Computer projector

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument – Research Report

Category	Below Target	At Target	Above Target
Thesis/ Problem/ Question	Relied on teacher-generated questions or developed a question requiring little creative thought.	Constructed a question that lends itself to readily available answers.	Posed a thoughtful, creative question that leads to challenging or provocative research.
Information Seeking/ Selecting and Evaluating	Gathered information from a limited range of sources and displayed minimal effort in selecting quality resources.	Gathered information from a variety of relevant sources—print and electronic.	Gathered information from a variety of quality electronic and print resources. Sources are relevant, balanced and include critical readings relating to the thesis or problem.
Analysis	Conclusions simply involved restating information. Conclusions not supported by evidence.	Product shows good effort was made in analyzing the evidence collected.	Carefully analyzed the information collected and drew appropriate and inventive conclusions supported by evidence.
Synthesis	Work not logically or effectively structured.	Logically organized and makes connections among ideas.	Developed appropriate structure for communicating ideas. Incorporated a variety of quality sources.
Documentation	Greater care in documenting sources needed. Documentation poorly constructed or absent.	Documented sources with some care. Few errors noted.	Documented all sources. Documentation is error-free.
Product/ Process	Needs to work on communicating more effectively.	Effectively communicated the results of research to the audience.	Effectively communicated the results of research to the audience. Product displays creativity and originality.

Assessment Instrument – Oral Presentation

Category	Below Target	At Target	Above Target
Organization	Audience has difficulty following presentation because student jumps around.	Student presents information in logical sequence which audience can follow.	Student presents information in logical, interesting sequence that audience can follow.
Subject Knowledge	Student is uncomfortable with information and is able to answer only rudimentary questions.	Student is at ease with expected answers to all questions, but fails to elaborate.	Student demonstrates full knowledge (more than required) by answering all class questions with explanations and elaboration.
Graphics	Student occasionally uses graphics that rarely support text and presentation.	Student's graphics relate to text and presentation.	Student's graphics explain and reinforce screen text and presentation.
Mechanics	Presentation has three or more misspellings and/or grammatical errors.	Presentation has no more than two misspellings and/or grammatical errors.	Presentation has no misspellings or grammatical errors.
Eye Contact	Student occasionally uses eye contact, but still reads most of report.	Student maintains eye contact most of the time but frequently returns to notes.	Student maintains eye contact with audience, seldom returning to notes.
Elocution	Student's voice is low. Student incorrectly pronounces terms. Audience members have difficulty hearing presentation.	Student's voice is clear. Student pronounces most words correctly. Most audience members can hear presentation.	Student uses a clear voice and correct, precise pronunciation of terms so that all audience members can hear presentation.

Assessment Instrument – Brief Constructed Response Item

1. Describe the professional and educational backgrounds of authors of literature related to technology.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

1. Discuss the purposes of research and its role in the development of an information base used to understand the influence of technology on history.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important evidenc. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause and effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate and precise language. Cohesive organization. Very few grammatical errors.

Unit 2
Relationships Among Technologies and Connections With Other Fields of Study

Engineering By Design
A National Model for Standards-Based Programs

International Technology Education Association 2005

Unit 2: Relationships Among Technologies and Connections With Other Fields of Study

Overview

Standards

- Students will develop an understanding of the relationships among technologies and connections with other fields of study. (STL-3)
- Students will develop an understanding of the nature of science. (AAAS – BSL)
- Students will develop an understanding of the nature of mathematics. (AAAS – BSL)
- Students will develop an understanding of the nature of technology. (AAAS – BSL)
- Students will develop an understanding of mathematics processes (Communications). (NCTM – MSE)
- Students will develop an understanding of mathematics processes (Connections). (NCTM – MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS - Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• Technology transfer occurs when a new user applies an existing innovation developed for one purpose to a different function. • Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. • Technology ideas are sometimes protected through the process of patenting. • Technological progress promotes the advancement of science and mathematics.	• There are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, logic, and good arguments. • The early Egyptian, Greek, Chinese, Hindu, and Arabic cultures are responsible for many scientific and mathematical ideas and technological inventions. • Developments in science or technology often stimulate innovations in mathematics by presenting new kinds of problems to be solved. • Developments in mathematics often stimulate innovations in science and technology. • Technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs).	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics. • Use the language of mathematics to express ideas precisely.

Big Idea:
Understanding that interrelationships exist among technologies and between technology and other fields of study enhances our ability to use, assess, design, and prduce technology.

Unit Objectives

At the completion of this unit, students will be able to:

1. Describe the strong relationship between technology and the study of science.
2. Identify attributes of science experts.
3. Defend the statement that technology innovation often results when ideas, knowledge, or skills, are shared within a technology, among technologies, or across other fields.
4. Compare and contrast the interest of technology and science in natural scientific laws, systems, design, and modeling
5. Identify and describe the attributes of selected scientific instruments.
6. Express that mathematical concepts such as the use of measurement, symbols, estimation, accuracy, and the idea of scaling and proportion are key to the development of technology.
7. Explain that technology transfer occurs when a new user applies an existing innovation developed for one purpose to a different function.
8. Explain that ideas are sometimes protected through the process of patenting.
9. Explain that technological progress promotes the advancement of science and mathematics.
10. Explain that there are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, logic, and good arguments.
11. Explain that the early Egyptian, Greek, Chinese, Hindu, and Arabic cultures are responsible for many scientific and mathematical ideas and technological inventions.
12. Explain that developments in science or technology often stimulate innovations in mathematics by presenting new kinds of problems to be solved.
13. Explain that developments in mathematics often stimulate innovations in science and technology.
14. Explain that technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs).
15. Recognize and apply mathematics in contexts outside of mathematics.
16. Conduct effective and focused research.
17. Use computers and calculators to access, retrieve, organize, and evaluate data and information in order to communicate.
18. Organize and present data effectively.
19. Present research findings effectively using instructional technology.
20. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
21. Address open-ended questions in verbal and written form.
22. Demonstrate curiosity, exhibit motivation for learning, and use class time effectively.
23. Work safely and accurately with a variety of tools, machines, and materials.
24. Actively participate in group discussions, ideation exercises, and debates.
25. Exhibit and refine inherent personal qualities such as creativity and resourcefulness.

Unit 2 – Relationships Among Technologies and Connections With Other Fields of Study Pre-Test

Directions: Circle the T or F in the column to the left of each true (T) or false (F) statement.

T	F	1.	Science is a numbers tool.
T	F	2.	The purpose of mathematics is to meet our needs and desires by creating hardware, software, and systems.
T	F	3.	Technology provides science with tools and materials.
T	F	4.	Science is a process for studying the universe.
T	F	5.	Science provides technology with tools and materials.
T	F	6.	The purpose of technology is to answer questions and give us understanding.
T	F	7.	Technology is things and systems created by people.
T	F	8.	Mathematics provides science with tools.
T	F	9.	Mathematics provides technology with tools.
T	F	10.	The purpose of science is to enable us to measure, analyze, describe, predict, and to communicate.

Briefly answer the following questions.

11. Why do inventors patent their inventions?

12. Identify and describe a mathematical idea that originated in the Arabic culture.

Unit 2 – Relationships Among Technologies and Connections With Other Fields of Study

Use the terms in Column II to complete the sentences in Column I.

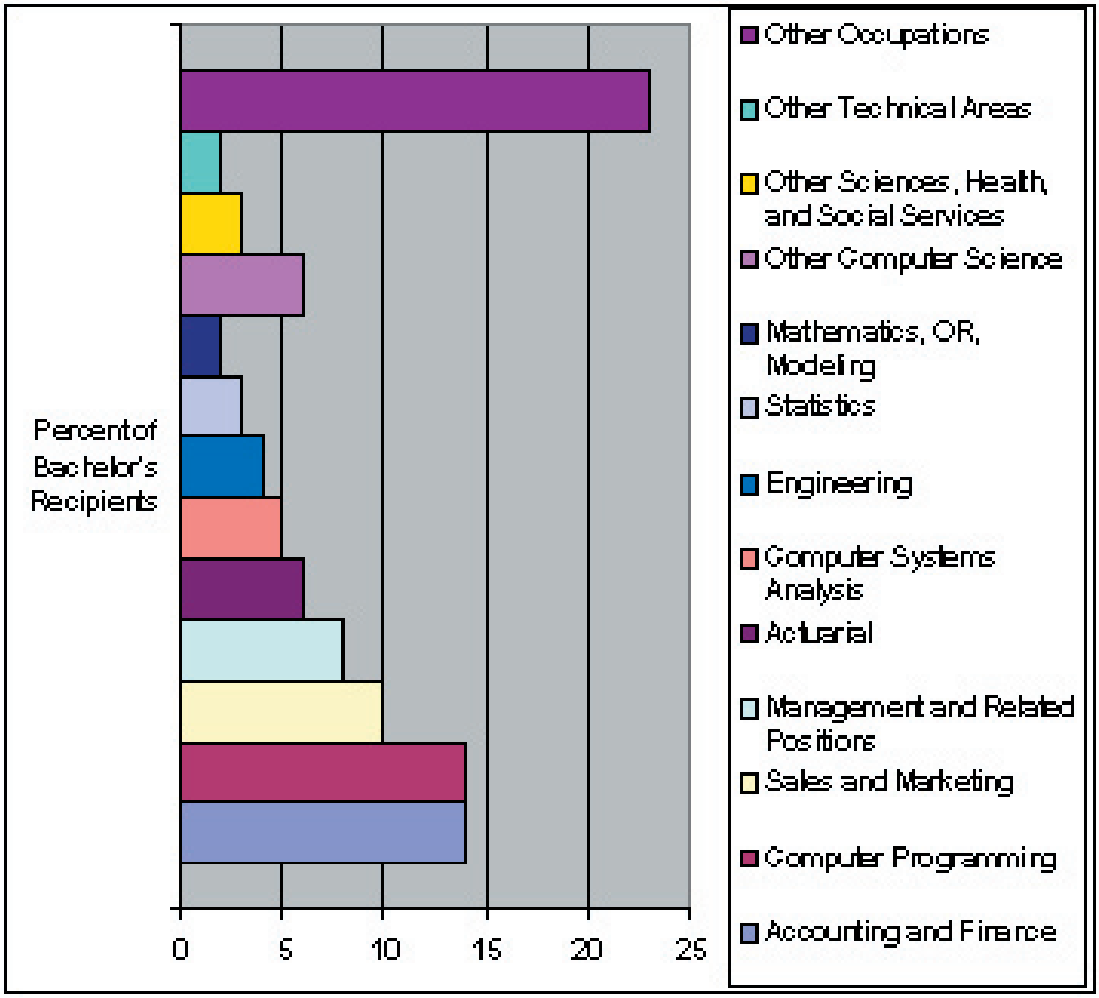
	Column I	Column II
1.	Mathematics is a _____.	materials
2.	The purpose of _____ is to meet our needs and desires by creating hardware, software, and systems.	information
3.	Technology provides science with tools and _____.	questions
4.	_____ is a process for studying the universe.	things and systems
5.	Science provides technology with _____.	tools
6.	The purpose of science is to answer _____ and give us understanding.	mathematics
7.	Technology is _____created by people.	technology
8.	_____ provides science with tools.	predict
9.	Mathematics provides technology with _____.	numbers tool
10.	The purpose of mathematics is to enable us to measure, analyze, describe, _____, and to communicate.	science

Place the letter of the correct answer in the box at left of statement.

11.		Technology _____occurs when a new user applies an existing innovation developed for one purpose to a different function. A. assessment B. evolution C. advancement D. transfer
12.		Technological _____ often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. A. trade-offs B. innovation C. traps D. constraints
13.		Technological ideas are sometimes protected through the process of _____ A. design B. optimization C. patenting D. copywriting
14.		Technological progress _____ the advancement of science and mathematics. A. inhibits B. prolongs C. restrains D. promotes
15.		Developments in science or technology often _____ in mathematics by presenting new kinds of problems to be solved. A. create confusion B. inhibit innovations C. stimulate innovations D. restrain innovation

Briefly answer the following questions.

16. Analyze the graph below (showing the percent of bachelor's degree recipients with a major in mathematical sciences working in a nonacademic position by occupation) and describe the connection between mathematics and computer technology.



17. Why do inventors patent their inventions?

18. Identify and describe an example of a development in science that stimulated an innovation in technology.

19. Defend the statement that technology innovation often results when ideas, knowledge, or skills, are shared within a technology, among technologies, or across other fields.

20. Explain how technology transfer occurs.

21. Explain why the development of scientific knowledge depends on mathematical concepts such as the use of measurement, symbols, estimation, accuracy, and the idea of scaling and proportion.

Unit 2 – Lesson 1

Getting Familiar with the Big Idea

Understanding that interrelationships exist among technologies and between technology and other fields of study enhances our ability to use, assess, design, and produce technology.

Lesson Duration: Five (5) hours.

Standards

- Students will develop an understanding of the relationships among technologies and connections with other fields of study. (STL-3)
- Students will develop an understanding of the nature of science. (AAAS-BSL)
- Students will develop an understanding of the nature of mathematics. (AAAS-BSL)
- Students will develop an understanding of the nature of technology. (AAAS-BSL)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• Technology transfer occurs when a new user applies an existing innovation developed for one purpose to a different function. • Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. • Technology ideas are sometimes protected through the process of patenting. • Technological progress promotes the advancement of science and mathematics.	• There are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, logic, and good arguments. • The early Egyptian, Greek, Chinese, Hindu, and Arabic cultures are responsible for many scientific and mathematical ideas and technological inventions. • Developments in science or technology often stimulate innovations in mathematics by presenting new kinds of problems to be solved. • Developments in mathematics often stimulate innovations in science and technology. • Technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs).	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics. • Use the language of mathematics to express ideas precisely.

Learning Objectives

Students will:

1. Defend the statement that technology innovation often results when ideas, knowledge, or skills, are shared within a technology, among technologies, or across other fields.
2. Explain that technology transfer occurs when a new user applies an existing innovation developed for one purpose to a different function.
3. Explain that ideas are sometimes protected through the process of patenting.
4. Explain that technological progress promotes the advancement of science and mathematics.
5. Explain that there are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, logic, and good arguments.
6. Explain that developments in science or technology often stimulate innovations in mathematics by presenting new kinds of problems to be solved.
7. Actively participate in group discussions, ideation exercises, and debates.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials

Print-Based Sources

1. *A History of Mathematics: A Reader* by Fauvel, John and Gray, Jeremy. Washington, DC: Math. Assoc. Amer., 1996. 640 p. $37.
2. *Mathematics, Science, & Technology Connections,* Teachers Helping Teachers Series, by Peel Board of Education Teachers, ISBN: 1-895579-37-6, 1996.
3. *The Encyclopedia of Science and Technology* by James S. Trefil, Harold Morowitz, Paul Ceruzzi, Taylor & Francis Group (July 1, 2001)

Audiovisual Materials

1. Scientific American Frontiers VIII: The Art of Science, PBS, Episode 4 of 5 (VHS
2. Science Odyssey, A: Origins, PBS - Episode 5 of 5 (VHS)
3. Closer to Truth: Science, Meaning and the Future: Science & Our World, PBS, - (VHS)

Internet Sites

1. Archibald, R.C. Outline of the History of Mathematics, 6th ed.
2. A Science Odyssey: People and Discoveries, NPR – www.pbs.org/wgbh/aso/
3. History of Science and Technology, Science Friday Kids' Connection – www.sciencefriday.com/kids/sfkc-history.html

Purpose of Lesson

To enable students to understand that interrelationships exist among technologies and between technology and other fields of study.

Required Knowledge and/or Skills

Students should have some understanding of how knowledge of the history of technology helps people understand the world around them by seeing how people of all times and places have increased their capability by using their unique skills to innovate, improvise, and invent. They should have some basic knowledge of technology's role in the determining the way scientists work. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Engagement

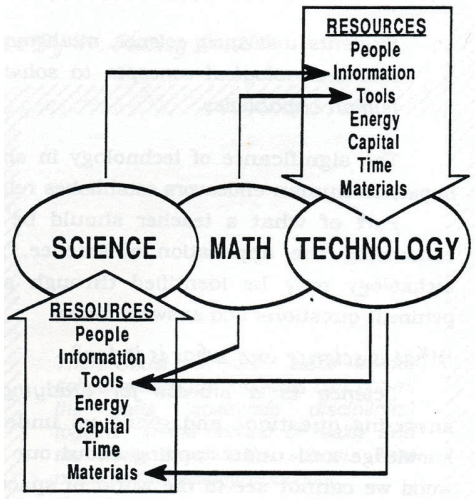
1. The teacher will assess prior knowledge and possible misconceptions related to the interrelationships that exist among technologies and between technology and other fields of study.
2. The teacher will pose the question, "Who advises the President of the United States on issues related to science and technology?"
3. Students will offer their thoughts on the question.
4. The teacher will ask students to think about the attributes and qualifications of advisors to the President on science and technology.

Exploration

1. The teacher will provide brief biographies of the members of The President's Council of Advisors on Science & Technology. Available on-line at - http://www.ostp.gov/PCAST/pcast.html
2. Students will read the biography of one of the Council members and list attributes and qualifications for the individual.
3. The teacher will ask students to take particular note of the member's area of academic training.

Explanation

1. The students will present their lists of attributes and qualifications to the class.
2. The teacher will focus on the breadth of academic training of the group and that it represents a broad spectrum that includes training in science, mathematics, technology, and the social sciences.
3. The teacher will present the following questions:
   a. What is science? (Science is the study of the natural world through observation, identification, description, experimental investigation, and theoretical explanations.)
   b. What is science for? (Science is for answering questions and giving us understanding.)
   c. What is mathematics? (Mathematics is the science of patterns and order and the study of measurement, properties, and the relationships of quantities; using numbers and symbols.)
   d. What is mathematics for? (Mathematics is a numbers tool. Through it we are able to measure, analyze, describe, make predictions, and communicate.)
   e. What is technology? (Technology is human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities.)
   f. What is technology for? (Technology helps us meet our needs and desires by creating hardware, software, and systems.)
   g. How do science, mathematics, and technology relate to one another? (See graphic at right.)
      - Mathematics, science, and technology as enterprises share many values and features: belief in order, ideals of honesty and openness, the importance of criticism by colleagues, and the essential role



played by imagination.
- Mathematics is a "tool" resource for both science and technology.
- Science provides a resource of "information" for technology.
- Technology provides "tools" and "materials" for science.

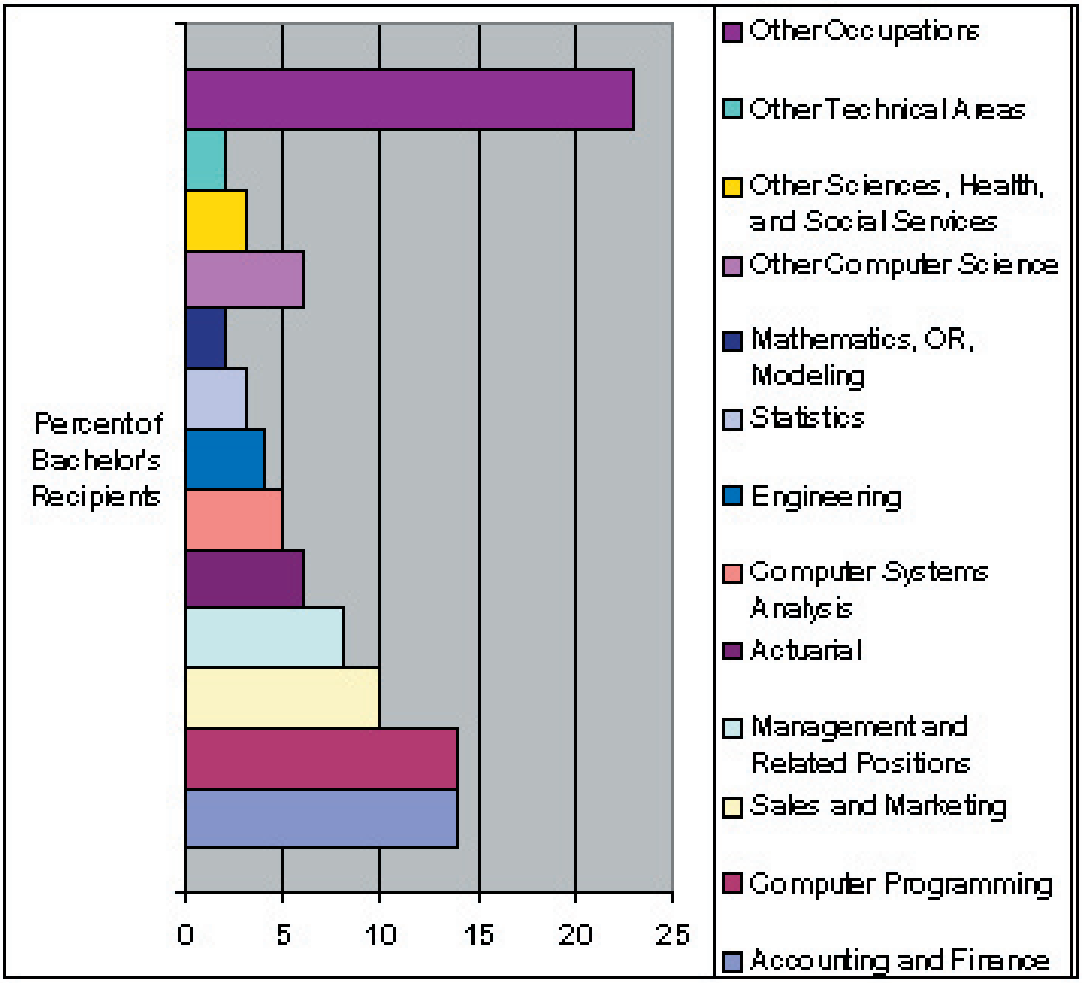
h. How does society impact technology?
- People, as individuals and collectively as society, determine the technologies that will be developed and employed.
- Decisions, based on values, are made that result in the promotion of some technologies and the obstruction of other technologies.
- People in proper control of technology will not promote detrimental technologies and will not obstruct beneficial technologies out of ignorance.

i. How does technology impact society?
- Technology impacts the routines of daily living, the ways we provide for livelihood, the ways we interact with other people, and the course of history.
- Technology impacts the way we earn a living.
- All human affairs are impacted by technology.

4. The teacher will explain that:
   a. Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.
   b. Technological ideas are sometimes protected through the process of patenting.
   c. Technological progress promotes the advancement of science and mathematics.
   d. There are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, logic, and good arguments.
   e. Developments in science or technology often stimulate innovations in mathematics by presenting new kinds of problems to be solved.
   f. Developments in mathematics often stimulate innovations in science and technology.
   g. Technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs).
5. Students will listen, take notes, and clarify thoughts through questioning.

Extension

1. The teacher will state that technical occupations are being pursued by people with diverse educational backgrounds. In particular, people with mathematics bachelor's degrees are finding employment in computer-related enterprises.
2. Students will analyze the graph "Percent of Bachelor's Degree recipients with a Major in Mathematical Sciences Working in a Nonacademic Position by Occupation," taking particular note of the connection between mathematics and computer technology. They will then write a one-paragraph summary of their analysis.



3. Students will write a newspaper opinion column based on one of the following questions:
   a) Some achievements have been both positive and negative (i.e. nuclear energy). Can you think of other developments that have yielded mixed outcomes? Is there any technology that you think we'd be better off without?
   b) Many people wish we could return to "the simple life." What do you imagine a simple life to be? What would you be willing to do without?
   c) How has science changed since you were born?
   d) How have those changes affected your life?
   e) Do you think we have become too dependent on technology to survive without it?

Evaluation

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, evaluation of a newspaper article, bulletin board design, analysis of a graph, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities

1. Students may be asked to prepare a list of questions and conduct a video interview with one of the following people on the topic, "How do technology, mathematics and science work together to meet our needs and desires?"
2. A mathematics teacher
3. A science teacher
4. A technology teacher
5. A scientist
6. A mathematician
7. A technologist (i.e. an engineer, dentist, computer programmer)
8. Students may be assigned to develop a multimedia presentation on examples of technological devices that are used by scientists and mathematicians.
9. Students may be assigned to research and construct models of historical scientific and mathematical devices.
10. Students may be assigned to research and design a bulletin board display on applications of science and mathematical concepts and processes in one of the following enterprises: a) medical technology, b) agricultural and biotechnologies, c) energy and power technologies, d) information and communication technologies, e) transportation technologies, f) manufacturing technologies, or g) construction technologies.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, production and fabrication, product/prototype testing and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, fabrication, small group meetings, and research activities should be readied.

Tools/Materials/Equipment

- Computers with Internet Access

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson 2-1 Assessment Instruments

Assessment Instrument - Selected Response Item

Directions: Circle the T or F in the column to the left of each true (T) or false (F) statement.

T F 1. Science is a numbers tool.

T F 2. The purpose of mathematics is to meet our needs and desires by creating hardware, software, and systems.

T F 3. Technology provides science with tools and materials.

T F 4. Science is a process for studying the universe.

T F 5. Science provides technology with tools and materials.

T F 6. The purpose of technology is to answer questions and give us understanding.

T F 7. Technology is things and systems created by people.

T F 8. Mathematics provides science with tools.

T F 9. Mathematics provides technology with tools.

T F 10. The purpose of science is to enable us to measure, analyze, describe, predict, and to communicate.

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class, attempts to answer teacher generated questions.	Well prepared for class, attempts to answer teacher-generated questions and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation for Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily, is not engaged. Has difficulty remaining on task.	Makes good use of class time. to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

Assessment Instrument – Newspaper Article

Element	Points Possible	Earned Assessment	
		Self	Teacher
The headline of the article catches the attention of the reader and relates well to the topic.			
The lead (or first sentence) captures the attention of the reader and sums up the focus of the article.			
The introductory paragraph tells the most important facts and answers the questions who, what, where, when, why, and how.			
Details and elaboration are evident in the body of the article and flow smoothly from the lead.			
Quotes are used to add interest and support to the story.			
The vocabulary is correct.			
The work is neat and presentable.			

Assessment Instrument – Graph Analysis

Category	Below Target	At Target	Above Target
Accurately Interpret Numerical Data	Inaccurately interprets the data or does not display understanding of what graph is showing.	Demonstrates an understanding of what the data is showing with some supporting interpretive .	Displays a full understanding of what the data is showing through supporting statements of interpretation.
Synthesize Related Data	Fails to identify and summarize the data. Foes not understand the difference between facts, interpretation, and assumptions.	Identifies most of the relevant differences, similarities, and patterns in data. Usually able to distinguish fact from interpretation.	Identifies all of the relevant differences, similarities, and patterns in data. Able to distinguish fact from interpretation or assumptions .
Knowledge Gained	Demonstrates a lack of knowledge about the content and the processes used to create the poster.	Accurately answer most questions related to content and the processes used to create the poster.	Accurately answers all questions related to content and the processes used to create the poster.

Assessment Instrument – Brief Constructed Response Items

1. Explain why ideas are sometimes protected through the process of patenting.
2. Explain how technological progress promotes the advancement of science and mathematics.
3. Describe that different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, logic, and good arguments.
4. Describe developments in science or technology that stimulate innovations in mathematics by presenting new kinds of problems to be solved.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Items

1. Defend the statement that technology innovation often results when ideas, knowledge, or skills, are shared within a technology, among technologies, or across other fields.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) providedIncludes obscure, but important evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause and effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportions to their importance
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate and precise language. Cohesive organization. Very few grammatical errors.

Unit 2 – Lesson 2

Technology Triggers a Scientific Revolution

Lesson Duration: Five (5) hours.

Standards

- Students will develop an understanding of the relationships among technologies and connections with other fields of study. (STL-3)
- Students will develop an understanding of the nature of science. (AAAS-BSL)
- Students will develop an understanding of the nature of mathematics. (AAAS-BSL)
- Students will develop an understanding of the nature of technology. (AAAS-BSL)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• Technology transfer occurs when a new user applies an existing innovation developed for one purpose to a different function. • Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. • Technology ideas are sometimes protected through the process of patenting. • Technological progress promotes the advancement of science and mathematics.	• There are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, logic, and good arguments. • Modern science is based on traditions of thought that came together in Europe about 500 years ago. • Developments in science or technology often stimulate innovations in mathematics by presenting new kinds of problems to be solved. • Developments in mathematics often stimulate innovations in science and technology. • Technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs).	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics • Use the language of mathematics to express ideas precisely.

Learning Objectives: Students will

1. Define terms related to technology and science.
2. Explain that technology transfer occurs when a new user applies an existing innovation developed for one purpose to a different function.
3. Explain that technological progress promotes the advancement of science and mathematics.
4. Recognize and apply mathematics in contexts outside of mathematics.
5. Explain the strong relationship between technology and the study of science including the common interest in natural scientific laws, systems, design, and modeling.
6. Identify and describe the attributes of selected scientific instruments.
7. Conduct effective and focused research.
8. Present research findings effectively using instructional technology.
9. Work safely and accurately with a variety of tools, machines, and materials.
10. Exhibit and refine inherent personal qualities such as creativity and resourcefulness.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Identify Resource Materials

Print-Based Sources

1. *The Scientists: A History of Science Told Through the Lives of Its Greatest Inventors* by John Gribbin, Random House, New York, 2002.
2. *Science and Technology in World History: An Introduction*, James E. McClellan, Harold Dorn, Johns Hopkins University Press, 1999.
3. *The History of Science and Technology: A Browser's Guide to the Great Discoveries, Inventions, and the People Who Made Them from the Dawn of Time to Today*, Bryan Bunch (Editor), Alexander Hellemans (Editor), Houghton Mifflin, 2004.

Audiovisual Materials

1. The Elegant Universe, NOVA, Grade level: Grade 7+, Closed captioned: Yes, 180 min on 1 VHS
2. Time Travel, Series: NOVA, Grade level: Grade 7+, Closed captioned: Yes
3. 60 min on 1 VH
4. Masters of Technology: Meet five men and women who are changing the way we live. 2PK (VHS) - AV Item, Item no: MTEC800
5. The Beginnings of the Telescope, animated essay, http://www.teachersdomain.org/9-12/sci/engin/design/galileotele/index.html

Internet Sites

1. The Scientific Revolution – web.clas.ufl.edu/users/rhatch/pages/03-Sci-Rev/SCI-REV-Teaching/03sr-definition-concept.htm
2. Optics for Kids – www.opticsforkids.com/
3. The Inventive Thinking Curriculum Project, An Outreach Program Of The United States Patent And Trademark Office – www.uspto.gov/web/offices/ac/ahrpa/opa/projxl/invthink/invthink.htm
4. How telescopes work – http://science.howstuffworks.com/question568.htm

Purpose of Lesson

To familiarize students with the ways technological progress promotes the advancement of science and mathematics, the different traditions in science about what is investigated and how, and the way technology affects society.

Required Knowledge and/or Skills

Students should have some understanding of how technological progress promotes the advancement of science and mathematics. They should be familiar with technology's role in determining the way scientists work. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Lesson 2-2

Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to the ways technological progress promotes the advancement of science and mathematics
2. The teacher will state that the "Scientific Revolution" refers to historical changes in thought and belief, to changes in social and institutional organization that unfolded in Europe between roughly 1550-1700; beginning with Nicholas Copernicus (1473-1543), who asserted a heliocentric (sun-centered) cosmos, it ended with Isaac Newton (1642-1727), who proposed universal laws and a Mechanical Universe.
3. The teacher will explain that:
   a. The learned view of things in 16th-century thought was that the world was composed of four qualities (Aristotle's Earth, Water, Air, Fire).
   b. In contrast, Newton's learned contemporaries believed that the world was made of atoms or corpuscles (small material bodies).
   c. Copernicus claimed that the earth is not fixed and stationary in the center of the cosmos (geocentric and geostatic) but instead argued that it rotates on its axis each day and revolves around the sun each year.
4. The teacher will present students with the following quote: "The scientific revolution 'coincides' with the development of the telescope and the microscope." (Gribbin, p. xix)
5. The teacher will ask students to think about and present their thoughts on how the development of the telescope and the microscope might have influenced the scientific revolution.

Exploration

1. The teacher will provide basic instruction on the operation of the telescope and microscope.
2. Working in small groups, students will list the attributes of the telescope and the microscope (What do they do?) and speculate on how they work.
3. The student groups will develop a list of questions regarding functioning and applications of the telescope and microscope.

Explanation

1. The student groups will present their list of attributes and questions to the class.
2. The teacher will review and clarify terms including: technology, science, mathematics, materials, information, and tools.
3. The teacher will explain the functioning of the telescope and microscope.
4. The teacher will review selected scientific advancements made possible by the use of the telescope and the microscope including the movement of the Earth and orbits of the planets and the circulation of the blood.

5. The teacher will explain that the use of the telescope and microscope were part of a revolutionary shift in the way people viewed the world.
6. The teacher will explain that in this time period acquired knowledge based on sensory evidence became the mode of understanding the world rather than believing implicitly the works handed down from past generations.
7. The teacher will explain that technological progress promotes the advancement of science and that the development of the telescope and microscope are examples of this phenomenon.
8. The teacher will lead a discussion on other technological advancements (continental drift and the genetic code) that have aided or stimulated scientific discovery in the last one hundred years.
9. The teacher will explain that technology transfer occurs when a new user applies an existing innovation developed for one purpose to a different function.
10. Students will clarify their understanding of concepts through questioning.

Extension

1. Students will research and develop a multimedia presentation on a selected 20th Century scientific advancement.
2. Students may chose from the following twentieth century scientific advancements.

   Technology and Earth Science
   - Earth's Core (1906)
   - Earth's Inner Core (1930s)
   - Continental Drift (1911)

   Astronomy
   - Gamma-Ray Bursts (1969 – 1997)
   - Planets Around Other Stars (1995 – 2004)
   - The Universe Is Accelerating (1998 – 2000)
   - The Big Bang Theory

   Chemistry
   - Radioactivity (1890s – 1900s)
   - Plastics (1869 and 1900s)
   - Isotopes (1985)

   Evolution
   - Australopithecus Afarensis or "Lucy" (1974)
   - Laetoli Footprints (1978)
   - Toumai skull (2002)

   Genetics
   - DNA Polymorphism (1985)
   - Humans Have 20,000 to 25,000 Genes (2003)
   - RNA Interferon (1998)

   Medicine
   - Insulin (1920s)
   - Oncogenes (1975)
   - The Human Retrovirus HIV (1980s)

   Physics
   - Superconductors (1911 – 1986)
   - Quarks (1962)
   - Nuclear Forces (1666 – 1957)
   - Isotopes in Manufacturing

Evaluation

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, multimedia presentation, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities

1. Students may build a simple microscope and determine its focal length and degree of magnification – www.opticsforkids.com/resources/16_Building_Microscope.pdf
2. Students may make a simple telescope and determine its focal length and degree of magnification – http://members.shaw.ca/vic1447x/mtelescope.htm or http://www.ehow.com/how_17057_make-simple-telescope.html
3. Have a science teacher or scientist come to your class to discuss the discovery of the planets.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, production and fabrication, product/prototype testing and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small group meetings, and research activities should be readied.

Tools/Materials/Equipment

- Telescopes
- Microscopes
- Computers
- Printers
- Presentation software
- Computer projector

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Assessment Instrument - Selected Response Items

Use the terms in Column II to complete the sentences in Column I.

	Column I	Column II
1.	Mathematics is a _____.	materials
2.	The purpose of _____ is to meet our needs and desires by creating hardware, software, and systems.	information
3.	Technology provides science with tools and _____.	questions
4.	_____ is a process for studying the universe.	things and systems
5.	Science provides technology with _____.	tools
6.	The purpose of science is to answer _____ and give us understanding.	Mathematics
7.	Technology is _____created by people.	technology
8.	_____ provides science with tools.	predict
9.	Mathematics provides technology with _____.	numbers tool
10.	The purpose of mathematics is to enable us to measure, analyze, describe, _____, and to communicate.	Science

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class, attempts to answer teacher-generated questions.	Well prepared for class, attempts to answer teacher-generated questions and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation for Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily, is not engaged. Has difficulty remaining on task.	Makes good use of class time. to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

Assessment Instrument – Multimedia Presentation

Category	Below Target	At Target	Above Target
Content - Accuracy	Content confusing or contains more than one factual error.	Most content accurate, but there is one piece of information that seems inaccurate.	All content throughout the presentation accurate. No factual errors.
Sequencing of Information	No clear plan for the organization of information.	Most information is organized in a clear, logical way. One slide or piece of information out of place.	Information organized in a clear, logical way. Easy to anticipate the next element.
Effectiveness	Lacking several key elements and has inaccuracies. Completely inconsistent with driving question.	Lacking a key element. Consistent with driving question.	Includes all material needed to give a good understanding of the topic.
Use of Graphics	Graphics unattractive and detract from the content of the presentation.	A few graphics unattractive but all support the topic of the presentation.	All graphics attractive (size and colors) and support the topic of the presentation.
Text/Font Choice and Formatting	Difficult to read the text material.	Format carefully planned to enhance readability.	Formats (color, bold, italic) carefully planned to enhance readability and content.
Spelling and Grammar	More than two grammatical and/or spelling errors.	One or two misspellings, but no grammatical errors.	No misspellings or grammatical errors.
Delivery	Spoke a little faster or slower than necessary, or too quietly or loudly. Used unacceptable grammar. Failed to maintain eye contact. Relied too much on notes.	Spoke at a good rate. Volume appropriate. Good grammar. Maintained some eye contact with audience.	Spoke at a good rate. Volume excellent for setting. Good grammar. Maintained eye contact with audience.

Assessment Instrument – Brief Constructed Response Items

1. Explain how technology transfer occurs.
2. Provide examples of how technological progress promotes the advancement of science.
3. Identify and describe the attributes of a selected scientific instrument.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

1. Explain the strong relationship between technology and the study of science including the common interest in natural scientific laws, systems, design, and modeling.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause-and-effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate, and precise language. Cohesive organization. Very few grammatical errors.

Unit 2 – Lesson 3

The Discovery of Neptune

Lesson Duration: Two (2) hours.

Standards

- Students will develop an understanding of the relationships among technologies and connections with other fields of study. (STL-3)
- Students will develop an understanding of the nature of mathematics. (AAAS-BSL)
- Students will develop an understanding of the nature of technology. (AAAS-BSL)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• Technology transfer occurs when a new user applies an existing innovation developed for one purpose to a different function. • Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. • Technological progress promotes the advancement of science and mathematics.	• Developments in science or technology often stimulate innovations in mathematics by presenting new kinds of problems to be solved. • Developments in mathematics often stimulate innovations in science and technology. • Technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs).	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics • Use the language of mathematics to express ideas precisely.

Learning Objectives

Students will:

1. Explain why the development of scientific knowledge depends on mathematical concepts such as the use of measurement, symbols, estimation, accuracy, and the idea of scaling and proportion.
2. Describe the role of technology in the confirmation of mathematical predictions.
3. Explain that developments in mathematics often stimulate innovations in science and technology.
4. Address open-ended questions in verbal and written form.
5. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
6. Actively participate in group discussions, ideation exercises, and debates.
7. Demonstrate curiosity, exhibit motivation for learning, and use class time effectively.
8. Exhibit and refine inherent personal qualities such as creativity and resourcefulness.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Identify Resource Materials

Print-Based Sources

1. *The Planet Neptune* by Patrick Moore (John Wiley, Chichester, 1988)
2. *Astronomy: A Beginner's Guide to the Universe, Fourth Edition* by Eric Chaisson, Steve McMillan, Prentice Hall; 4 edition, 2003
3. *Explorations: An Introduction to Astronomy* by Thomas T. Arny, McGraw-Hill Companies; 3rd Updtd edition, 2003

Audiovisual Materials

1. Foundations of Astronomy (with CD-ROM, virtual Astronomy Labs, AceAstronomy, and Infotrac) by Michael A. Seeds, Brooks Cole; 8th Edition, 2004
2. Astronomy: The Solar System and Beyond (with InfoTrac abd TheSky CD_ROM) by Michael A. Seeds, Brooks Cole; 3rd Edition, 2002
3. A Science Odyssey: 100 Years of Discovery (PBS Series) by Charles Flowers, PBS Home Video, 1998.
4. Stellar Velocity: The Doppler Effect, Flash Interactive – www.teachersdomain.org/9-12/sci/phys/mfw/radioint/index.html

Internet Sites

1. Leverrier, Urbain Jean Joseph – www.infoplease.com/ce6/people/A0829562.html
2. Gravitational Perturbations and the prediction of new planets – http://csep10.phys.utk.edu/astr161/lect/history/perturbations.html
3. Solar System Live – www.fourmilab.ch/cgi-bin/uncgi/Solar/action?sys=-Sf

Purpose of Lesson

To familiarize students with the relationship between technology, mathematics, and science by examining mathematical concepts, scientific laws, and the process of innovation.

Required Knowledge and/or Skills

Students should have some understanding of the ways technological progress promotes the advancement of science and mathematics, the different traditions in science about what is investigated and how, and the way technology affects society. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Lesson 2-3

Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to the relationship between technology, mathematics, and science.
2. The teacher will show students a picture of our solar system and then a picture of the planet Neptune.
3. The teacher will state that the planet Neptune was discovered through the application of mathematical processes and not the use of a telescope.
4. Students will be asked to speculate on how this was done.

Exploration

1. The teacher explains that a vignette is a presentation of material providing a description of people, circumstances, processes and/or events that represent an illustrative example within a particular area or topic of study.
2. Students will read " The Discovery of Neptune" vignette.
3. Students will complete the exercises at the end of the reading.

Explanation

1. The students will present their answers for the exercise and state their questions.
2. The teacher will define perturbation as a disturbance in the regular elliptic or motion of a heavenly body, produced by some force additional to that which causes its regular motion; as the perturbations of the planets are caused by their attraction on each other.
3. The teacher will explain that:
   a. The study of perturbations has led to important discoveries in astronomy.
   b. Within the solar system, the existence and position of Neptune was predicted because of the deviations of Uranus from its computed path.
   c. Neptune was discovered in 1846, after being predicted by two mathematicians who found that Uranus was not moving in a perfectly elliptical path.
   d. By calculating the gravitational tug necessary to pull Uranus in its orbit, they were able to tell astronomers where to point their telescopes to discover Neptune.
   e. Likewise, Pluto was discovered by its effect on Neptune.
   f. Beyond the confines of the solar system, perturbations in the orbits of stars caused by the gravitational forces of orbiting bodies have led to the discovery of a number of extra solar planetary systems.
4. Students will restate any questions that were not answered in the teacher's lecture and clarify any unresolved issues.

Extension

1. Students will read the vignette "Gravitational Perturbations and the Prediction of New Planets" and complete the exercise at the end.
2. The teacher will review the exercise questions with the class.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using rubrics for reading assignments (vignettes), brief constructed responses, and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of an-

notated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities

1. The gravitational constant is a fundamental **physical constant** that appears in Newton's **law of universal gravitation** and in Einstein's **theory of general relativity**. Find out what the value of the constant is and how it was first measured.
2. Investigate and report on the life of a nineteenth century astronomer.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, production and fabrication, product/prototype testing and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration should be readied.

Laboratory-Classroom Safety and Conduct

Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument – Rubric for Vignettes

Category	Below Target	At Target	Above Target
Conventions	Gives inappropriate examples.	Gives obvious or general examples to illustrate sufficient understanding of conventions.	Gives specific, well-chosen examples from the text to show in-depth understanding of conventions.
Comprehension	Demonstrates inaccurate and insufficient comprehension.	Demonstrates accurate and sufficient comprehension. Gets the main message but may not understand the subtleties.	Demonstrates thorough and insightful comprehension. Gets the full message, including subtleties.
Context	Demonstrates an inaccurate and insufficient understanding of the context.	Demonstrates an accurate and sufficient understanding of the context.	Demonstrates a thorough and insightful understanding of the context.
Exercise	Answers inaccurate or incomplete.	Accurately answers all questions.	Accurately answers all questions and adds insightful ideas.

Assessment Instrument – Brief Constructed Response Items

1. Explain how developments in mathematics stimulate innovations in science and technology.
2. Describe the role of technology in the confirmation of the existence of the planet Neptune.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

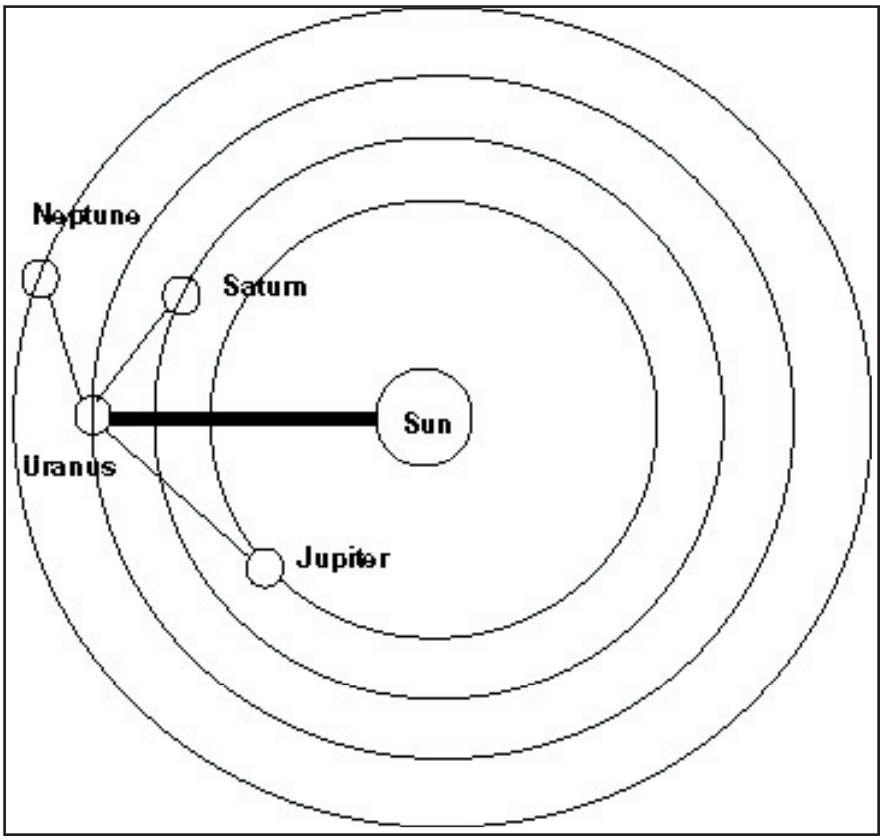
1. Explain why the development of scientific knowledge depends on mathematical concepts such as the use of measurement, symbols, estimation, accuracy, and the idea of scaling and proportion are key to the development of technology.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause-and-effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate and precise language. Cohesive organization. Very few grammatical errors.

Vignette 1
The Discovery of the New Planet Neptune

In 1846, the planet Neptune was discovered after its existence was predicted because of discrepancies between calculations and data for the planet Uranus. Astronomers found the new planet almost exactly at the position predicted by the calculations. The situation is illustrated schematically in the adjacent diagram. The dominant interaction between Uranus and the Sun is indicated with the heavy line, but some perturbations associated with other masses are indicated by thin lines. By using Newton's laws to calculate the perturbations on the orbit of Uranus by a hypothesized new planet, mathematicians were able to predict where the planet had to be in order to cause the observed deviations in the position of Uranus. Once astronomers took this calculation seriously, they found the new planet within hours of turning their telescopes on the region of the sky implicated by the calculations.

This precise prediction of the new planet and its location was striking confirmation of the power of Newton's theory of gravitation.



Later, similar calculations on supposed perturbations of the orbits of Uranus and Neptune suggested the presence of yet another planet beyond the orbit of Neptune. Eventually, in 1930, a new planet Pluto was discovered, but we now know that the calculations in this case were also in error because of an incorrect assumption about the mass of the new planet. It is now believed that the supposed deviations in the orbits of Neptune and Uranus were errors in measurement because the actual properties of Pluto would not have accounted for the supposed perturbations. Thus, the discovery of Pluto was a kind of accident.

Exercise

1. When was Neptune discovered?
2. What do you think the word perturbation means?
3. List three questions you have about this vignette.

Vignette 2
Gravitational Perturbations and the Prediction of New Planets

Computing the orbit of the Earth as an ellipse around the center of mass for the Earth-Sun system assumes that they are the only two masses in the universe. In reality, the Universal Law of Gravitation implies that the Earth interacts gravitationally not only with the Sun, but with every other mass in the Universe: the Moon, the other planets, asteroids and comets, the distant stars.

The Two-Body Approximation

However, from the form of the gravitational force we see that the interactions are largest when two situations are fulfilled: (1) the product of the masses of the two objects is large, which maximizes the numerator of the expression for the strength of the gravitational force, and (2) the objects are near each other, which minimizes the denominator of the force equation. The two-body approximation that the orbits of the planets are determined only by the gravitational interaction between the Sun and the planet is possible because

1. The Sun is so massive compared with every other object in the Solar System,
2. Objects outside the Solar System, such as stars, are so distant that the distance squared factor in the denominator renders their gravitational interactions with the planets negligible.

Law of Universal Gravitation

Every object in the universe attracts every other object with a force directed along the line of centers for the two objects that is proportional to the product of their masses and inversely proportional to the square of the separaion between the two objects.

$$F_g = G \frac{m_1 m_2}{r^2}$$

F_g is the gravitaional force
m_1 and m_2 are the masses of the two objects
r is the separation between the objects
G is the universal gravitational constant

For example, the Sun is about 300,000 times more massive than the Earth, and about 1000 times more massive than the largest planet. Thus, the product of the mass of a planet and the mass of the Sun is always much larger than the product of the masses of any two planets, and it is a good initial approximation to neglect all interactions except that of the planet and the Sun.

Gravitational Perturbations

However, the small deviations from this ideal picture have consequences if careful measurements are made. These small deviations from the simplified picture are called perturbations. They can be calculated systematically using Newton's laws of motion and gravitation from the positions of the known masses in the Solar System.

If we account carefully for all known gravitational perturbations on the motion of observed planets and the motion of the planet still deviates from the prediction, there are two options:

- Newton's Law of Gravitation requires modification,
- There is a previously undetected mass that is perturbing the orbits of the observed planets.

Exercise

1. What happens to the gravitational force if the distance between objects is increased?
2. The interactions between two bodies is greatest when what two situations are fulfilled?
3. Compare the products of the masses of the Sun and Mars with the product of the masses of Mars and the Earth.

Unit 3
Engineering Design

Engineering By Design
A National Model for Standards-Based Programs

International Technology Education Association 2005

Unit 3: Engineering Design

Overview

Standards

- Students will develop an understanding of the attributes of design (ITEA/STL-8)
- Students will develop an understanding of engineering design (ITEA/STL-9)
- Students will develop an understanding of and be able to apply the design process (ITEA/STL-11)
- Students will develop an understanding of the nature of technology (Forces of Nature) (AAAS-BSL)
- Students will develop an understanding of the physical setting. (Design and Systems) (AAAS-BSL)
- Students will develop an understanding of the common themes (Models) (AAAS-BSL)
- Students will develop an understanding of the habits of mind (Manipulation and Observation) (AAAS-BSL)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Problem Solving). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Representation). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. • Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. • Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. • Technological ideas are sometimes protected through the process of patenting. • A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. • Identify the design problem and decide whether or not to address it. • Identify criteria and constraints and determine how these will affect the design process. • Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. • Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. • Develop and produce a product or system using a design process. • Evaluate final solutions and communicate observations, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.	• In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. • The value of any given technology may be different for different groups of people and at different points in time. • Risk analysis is used to minimize the likelihood of unwanted side effects of a new technology. • To reduce the chance of system failure, performance testing is often conducted using small-scale models, computer simulations, analogous systems, or just the parts of the system thought to be least reliable. • Different kinds of materials respond differently to electric forces. • The basic idea of mathematical modeling is to find a mathematical relationship that behaves in the same ways as the objects or processes under investigation. • Computers have greatly improved the power and use of mathematical models by performing computations that are very long, very complicated, or repetitive. • The usefulness of a model can be tested by comparing its predictions to actual observations in the real world. • Use power tools to shape and join wood, plastic and soft metal.	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics. • Use the language of mathematics to express ideas precisely. • Build new mathematical knowledge through problem solving. • Apply and adapt a variety of appropriate strategies to solve problems. • Apply and adapt a variety of appropriate strategies to solve problems. • Monitor and reflect on the process of mathematical problem solving. • Use representations to model and interpret physical, social, and mathematical phenomena .

Big Idea:
Engineering, the systematic application of mathematical, scientific, and technical principles, produces tangible end products that meet our needs and desires.

Unit Objectives

At the completion of this unit, students will be able to:

1. Describe the types of engineering disciplines.
2. Describe the personal characteristics involved in engineering including creativity, resourcefulness, and the ability to visualize and think abstractly.
3. Explain the impact of constraints on the engineering design process.
4. Explain the role of project management in engineering enterprises.
5. Identify and describe the engineering resources (core technologies—mechanical, structural, electrical, electronic, thermal, fluid, optical, bio, and material) as they are applied in the designed world.
6. Analyze the functioning of the engineering resources (core technologies) in the designed world in terms of common components, basic system design, safety, simple controls, and system performance evaluation.
7. Describe the relationship of engineering resources (core technologies) to mathematics and science.
8. Research, refine, and apply at varying levels of sophistication the engineering resources (core technologies) in the solution of a design problem in engineering.
9. Compare and contrast the properties of materials.
10. Design and create tables, charts, and graphs to communicate and analyze data.
11. Apply the principles of design to the solution of problems.
12. Apply the engineering design process to the solution of a problem.
13. Use the language of mathematics to express mathematical ideas precisely.
14. Communicate mathematical thinking coherently and clearly to peers, teachers, and others.
15. Explain that ideas are sometimes protected through the process of patenting.
16. Troubleshoot mechanical and electrical systems.
17. Conduct effective and focused research.
18. Use computers and calculators to access, retrieve, organize, and evaluate data and information in order to communicate.
19. Organize and present data effectively
20. Present research findings effectively using instructional technology.
21. Describe what engineers do.
22. Describe the personal characteristics involved in engineering.
23. Describe the resources used in the engineering design process.
24. Explain that the design process is a systematic, iterative, approach to problem solving that yields design solutions.
25. Explain why designs need to be continually critiqued and refined.
26. Address open-ended questions in verbal and written form.
27. Conduct self-assessment of work performance.
28. Assess peers' work performance.
29. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
30. Work safely and accurately with a variety of tools, machines, and materials.
31. Actively participate in group discussions, ideation exercises, and debates.
32. Demonstrate curiosity, exhibit motivation for learning, and use class time effectively.
33. Exhibit and refine inherent personal qualities such as creativity and resourcefulness.

Unit 3 – Engineering Design Pre-Test

Use the terms in Column II to complete the statements in Column I.

	Column I	Column II
1.	The _____ includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.	brainstorming
2.	Expressing ideas to others using _____ is an important part of the design process.	communicate and test
3.	Design involves a _____, which can be performed in different sequences and repeated as needed.	constraints
4.	A group problem-solving design process in which each person presents ideas is called _____.	engineering design process
5.	Modeling and testing are used to _____ ideas into practical solutions.	personal characteristics
6.	Engineering design is influenced by the _____ _____, such as creativity and resourcefulness, of individuals and groups of people.	prototype
7.	A _____ is a working model used to test a design concept.	set of steps
8.	Models are used to _____ design ideas and processes.	sketches and models
		transform

Respond to the following:

9. Explain why designs need to be continually critiqued and refined.

10. What are patents and what do they do for inventors?

Use the terms in Column II to complete the statements in Column I.

	Column I	Column II
1.	The _____ includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.	brainstorming
2.	Expressing ideas to others using _____ is an important part of the design process.	communicate and test
3.	Design involves a _____, which can be performed in different sequences and repeated as needed.	constraints
4.	A group problem-solving design process in which each person presents ideas is called _____.	engineering design process
5.	Modeling and testing are used to _____ ideas into practical solutions.	personal characteristics
6.	Engineering design is influenced by the _____ _____, such as creativity and resourcefulness, of individuals and groups of people.	prototype
7.	A _____ is a working model used to test a design concept.	set of steps
8.	Models are used to _____ design ideas and processes.	sketches and models
		transform

Match the terms in Column II with the statements the in Column I.

		Column I		Column II
9.		A push or a pull	A	Efficiency
10.		The property of a system that enables it to do work	B	Energy
11.		The product of a force applied to an object and the distance the object moves	C	Force
12.		The rate of doing work	D	Friction
13.		The ratio of output work to input work	E	Gravity
14.		An attractive force acting at a distance between two or more masses	F	Mechanical Technology
15.		A force that opposes relative motion of two solids or a solid and a liquid	G	Power
16.		The technology of putting together mechanical parts to produce, control, and transmit motion	H	Work

Match the terms in Column II with the statements the in Column I.

		Column I		Column II
17.		A material containing many free electrons that move through the material easily	A	Circuits
18.		The opposition to the flow of electrical charge	B	Conductor
19.		The total amount of electrons flowing through a circuit per unit time	C	Current
20.		Materials whose electrical conductivity can be precisely altered by manufacturing processes	D	Electrical technology
21.		The force that moves electrons	E	Ohm's Law
22.		The rate of doing work or the rate of transferring energy	F	Power
23.		A complete path of an electric current including the source of electrical energy	G	Ratio
24.		The linear relationship between voltage and current through an electrical device	H	Resistance
25.		The relationship in quantity, amount, or size between two or more things	I	Semiconductor
26.		The technology of producing, storing, controlling, transmitting and getting work from electrical energy	J	Voltage

Match the terms in Column II with the statements the in Column I.

		Column I		Column II
27.		The technology of putting together mechanical parts to produce, control, and transmit motion	A	Biotechnology
28.		The technology of producing, storing, controlling, transmitting and getting work from electrical energy	B	Electrical Technology
29.		The technology of using small amounts of electricity for controlling; detecting; and information collecting, storing, retrieving, processing and communicating	C	Electronic Technology
30.		The technology of putting parts and materials together to create supports, containers, shelters, connectors, and functional shapes.	D	Fluid Technology
31.		The technology of using fluid, either gaseous (pneumatics) or liquid (hydraulic) to apply force of transport	E	Materials Technology
32.		The technology of producing light; using light for information collecting, storing, retrieving, processing and communicating; and using light to do work	F	Mechanical Technology
33.		The technology of producing, storing, controlling, transmitting and getting work from heat energy	G	Optical Technology
34.		The technology of using, adapting, and altering organisms and biological processes for a desired outcome	H	Structural Technology
35.		The technology of producing, altering, and combining materials	I	Thermal Technology

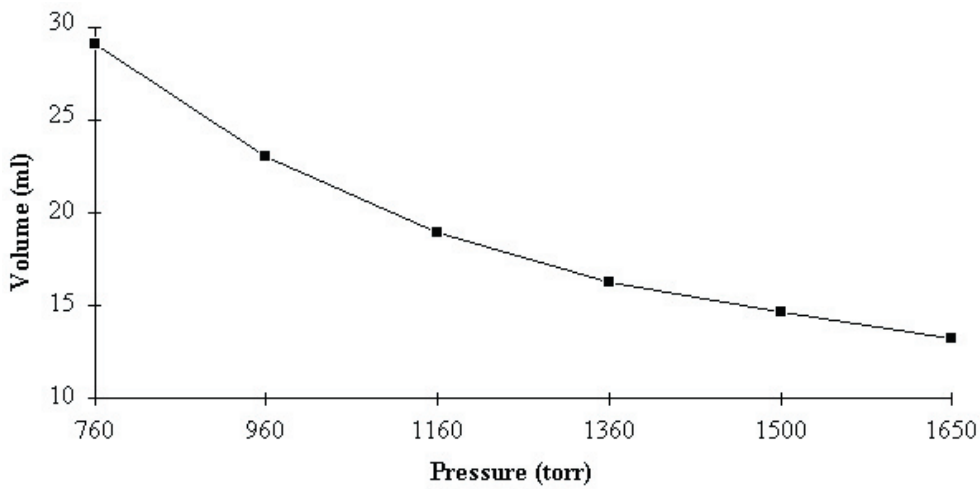
Place the letter of the correct answer in the box at left of statement.

36.		The _____ process is a systematic, iterative approach to problem solving that promotes innovation and yields designs. A. feedback B. design C. assessment D. investigation
37.		Established design principles are used to _____ existing designs, to collect data, and to guide the design process. A. clarify B. identify C. review D. evaluate
38.		A specific problem-solving approach that is used to prepare devices and systems for the marketplace. A. Engineering B. Science C. Research and development D. Advertising
39.		It is important to determine whether a design problem is _____. A. socially acceptable B. worthy of being solved C. environmentally neutral D. economically beneficial
40.		Identifying criteria and specifying _____ provides a basis for what a design should be and what the limits are. A. feedback B. controls C. inputs D. constraints
41.		Identifying criteria and specifying _____ provides a basis for what a design should be and what the limits are. E. feedback F. controls G. inputs H. constraints
42.		A working model used to refine a design concept. A. Prototype B. Portfolio C. Network D. By-product
43.		Checking the design solutions against criteria is central to the _____ process. A. Forecasting B. evaluation C. risk management D. troubleshooting
44.		Sometimes items can be produced in single quantity, while others can be made in batches or _____ production. A. dimensional B. laboratory C. volume D. experimental
45.		In the design process, the final results should be compared to the original goals, _____, and constraints. A. sketches B. models C. processes D. criteria

Briefly answer the following questions.

46. What is reverse engineering and why might it be employed?

47. Describe the relationship between volume and pressure shown in the graph below.



48. Describe in the relationship between current, voltage, and resistance in an electrical technology system.

49 Elaborate on the statement, "The design process is a systematic, iterative approach to problem solving that yields design solutions."

Unit 3 – Lesson 1

Getting Familiar with the Big Idea

Engineering, the systematic application of mathematical, scientific, and technical principles, produces tangible end products that meet our needs and desires.

Lesson Duration: Five (5) hours.

Standards

- Students will develop an understanding of the attributes of design (ITEA/STL-8)
- Students will develop an understanding of engineering design (ITEA/STL-9)
- Students will develop an understanding of the physical setting. (Design and Systems) (AAAS-BSL)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. • Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. • Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. • Technological ideas are sometimes protected through the process of patenting.	• In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. • The value of any given technology may be different for different groups of people and at different points in time.	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics. • Use the language of mathematics to express ideas precisely.

Learning Objectives

Students will:

1. Conduct and report on effective and focused research.
2. Describe the personal characteristics involved in engineering.
3. Describe the resources used in the engineering design process.
4. Explain that the design process is a systematic, iterative, approach to problem solving that yields design solutions.
5. Explain why designs need to be continually critiqued and refined.
6. Identify and describe the constraints on the engineering design process.
7. Identify and describe established design principles used to guide the design process.
8. Conduct self-assessment of work performance.
9. Assess peers' work performance.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials

Print-Based Sources

1. *The Existential Pleasures of Engineering* (Thomas Dunne Book) by Samuel C. Florman, St. Martin's Griffin; 2nd edition, 1996, ISBN: 0312141041
2. *Careers in Engineering, 2nd Edition*, by Geraldine Garner, McGraw-Hill, 2002, ISBN: 0071390413
3. *To Engineer is Human: The Role of Failure in Successful Design*, by Henry Petroski; Vintage; Reprint edition, 1992, ISBN: 0679734163

Audiovisual Materials

1. David Macaulay's World of Ancient Engineering: Roman City (2000), PBS Home Video.
2. David Macaulay's World of Ancient Engineering: Pyramid (2000) VHS, PBS Home Video.
3. David Macaulay's World of Ancient Engineering: Cathedral (2000) VHS, PBS Home Video.

Internet Sites

1. "Greatest Engineering Achievements of the 20th Century." (National Academy of Engineering – www.greatachievements.org/greatachievements/)
2. Engineering, Is it you? – www.micron.com/students/engineer/design.html
3. Ancient Engineering – www.fls.org.jm/users/worldeng/ancient/ancient.html

Purpose of Lesson

To familiarize students with the engineering design process by familiarizing them with the personal characteristics involved in engineering, the resources used in the engineering design process, steps in the design process, and the constraints on the engineering design process.

Required Knowledge and/or Skills

Students should have some understanding of the interrelationships that exist among technologies and between technology and other fields of study. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Lesson 3-1

Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to engineering design.
2. The teacher will present students with an illustration of a historic engineering project. (Roman aqueduct)
3. Students will be asked to identify the need or desire that led to these projects.
4. Students will be asked to speculate on what resources were used to create this engineering accomplishment.
5. The teacher will ask students to think about personal characteristics of the people who planned and built the project.

Exploration

1. The teacher will provide illustrations of engineering projects from different historical periods.
2. Working in small groups, students will identify the need or desire that led to these projects.

Teaching Opportunity

When teaching this lesson and developing your group work, learn and/or implement the elements of cooperative learning: positive interdependence; face-to-face interaction; individual accountability; interpersonal and small group skills; and group processing – http://edtech.kennesaw.edu/intech/cooperativelearning.htm

3. Students will list the resources used to create this engineering accomplishment with particular attention being paid to the knowledge (information) required and the personal characteristics of the people who planned and built the project.

Explanation

1. The student groups will present their information to the class.
2. The teacher will identify the seven resources used to create technology. (People, information, time, capital, machines and tools, materials, and energy)
3. The teacher will state that engineers are problem solvers.
4. The teacher will define engineering as the systematic application of mathematical, scientific, and technical principles, to yield tangible end products that meet our needs and desires.
5. The teacher will explain that engineering has evolved as civilization has progressed with each generation building on the accomplishments of their predecessors.
6. The teacher will describe the personal characteristics involved in engineering including:
   a. Creativity
   b. Resourcefulness
   c. Ability to visualize and think abstractly
7. The teacher will explain that design problems are seldom presented in a clearly defined form.
8. The teacher will explain constraints on the engineering design process, including:
   a. Safety
   b. Reliability
   c. Economic considerations
   d. Quality control
   e. Environmental concerns

   f. Manufacturability
   g. Maintenance
   h. Human factors engineering (ergonomics)
9. The teacher will describe established design principles used to evaluate designs including:
   a. Design is the result of a formal, sequential process.
   b. Design problems seldom arise in a clearly defined form.
   c. Design is driven by profit motive and market.
   d. Design requirements sometimes compete with each other.
   e. Design is the result of goal-oriented research.
   f. Designs must be continually checked, refined, and improved.
10. The teacher will explain that:
   a. In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.
   b. The basic idea of mathematical modeling is to find a mathematical relationship that behaves in the same ways as the objects or processes under investigation.
   c. Computers have greatly improved the power and use of mathematical models by performing computations that are very long, very complicated, or repetitive.
11. The teacher will describe how engineers:
   a. Use the language of mathematics to express mathematical ideas precisely.
   b. Analyze and evaluate the mathematical thinking and strategies of others.
   c. Create and use representations to organize, record, and communicate mathematical ideas.
   d. Select, apply, and translate among mathematical representations to solve problems.
   e. Use representations to model and interpret physical, social, and mathematical phenomena.
12. Students will listen, take notes, and clarify thoughts through questioning.

Extension

1. The teacher will introduce students to the "Greatest Engineering Achievements of the 20th Century." (National Academy of Engineering – www.greatachievements.org/greatachievements/)
2. Students will develop a brief (five-minute) oral presentation on one of the "Greatest Engineering Achievements of the 20th Century" that will address the following topics:
   a. The need or desire that led to these projects
   b. The resources used to create the project
   c. The personal characteristics of the people who planned and built the project
   d. The constraints that impacted the development of the project
   e. An analysis of the project based the four design principles

Note: The teacher may wish to develop some interdisciplinary connections with science, social studies, or mathematics teachers in your school. Provide them with the concepts that you are addressing in technology education and find commonality among the academic curricula.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, group work, evaluation of an oral presentation, brief constructed responses, and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities

1. Students may be asked to research and report on the professional and legal responsibilities associated with being an engineer.
2. Students may be assigned to plan and conduct an interview with an engineer focusing on the knowledge base and skills that are required for the engineer's specific area of interest.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, production and fabrication, product/prototype testing and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, small group meetings, and research activities should be readied.

Tools/Materials/Equipment

- Computers with Internet Access
- Printers
- Presentation software
- Poster Printer/Sign maker
- Computer projector

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Assessment Instrument - Selected Response Item

Match the terms in Column II with the statements the in Column I.

		Column I		Column II
1.		The systematic and creative application of scientific and mathematical principles to practical ends	A	Attribute
2.		The approach that engineering disciplines use to specify how to create or do something	B	Brainstorming
3.		A quality or characteristic inherent in or ascribed to someone or something	C	Constraints
4.		A method of shared problem solving in which all members of a group spontaneously contribute ideas	D	Creativity
5.		A limit to the design process	E	Design
6.		A full-scale working model used to test a design concept	F	Design Proposal
7.		A written plan of action for a solution to a proposed problem	G	Engineering Design
8.		A detailed, exact statement of particulars, especially a statement prescribing materials, dimensions, and quality of work for something to be built, installed, or manufactured	H	Iterative
9.		Characterized by or involving repetition, recurrence, or repetitiousness.	I	Prototype
10		Characterized by originality and expressiveness	J	Specifications

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class, attempts to answer teacher-generated questions.	Well prepared for class, attempts to answer teacher-generated questions and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation for Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily, is not engaged. Has difficulty remaining on task.	Makes good use of class time. to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative. Does little work. Rarely offers useful ideas.	Cooperative. Works at assignments. Usually offers useful ideas	Always willing to help and do more. Does more than required. Routinely offers useful ideas.
Cooperation	Rarely listens to, shares with, or supports the efforts of others. Often is not a good team member.	Usually listens to, shares with, and supports the efforts of others. Does not cause problems in the group.	Always listens to, shares with, and supports the efforts of others. Tries to keep people working together.
Focus on the task	Does not focus on the task and what needs to be done. Lets others do the work.	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done. Self-directed.

Assessment Instrument – Oral Presentation With Visuals

Element	Points Possible	Earned Assessment	
		Self	Teacher
The Content			
Concepts are accurately presented			
Supporting details are used to help explain the concepts			
Vocabulary is appropriate to both the content and the audience			
Visuals including pictures, diagrams, photographs, videos, and other props are used appropriately to support the presentation			
Description of each artifact clearly identifies its use			
There is a clear beginning, organized body, and clear closure			
The Presentation			
Vocal quality: rate, volume, articulation, enthusiasm			
Positive humor is used			
Body language: eye contact, posture, body movement appropriate			
The speaker gives the audience time to think			
The speaker responds well to questions			

Assessment Instrument – Brief Constructed Response Items

1. Describe the personal characteristics involved in engineering.
2. Identify and describe the resources used in the engineering design process.
3. Explain why designs need to be continually critiqued and refined.
4. What does the following statement mean? "Design problems seldom arise in a clearly defined form."

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

1. Identify and describe the constraints on the engineering design process.
2. Elaborate on the statement, "The design process is a systematic, iterative, approach to problem solving that yields design solutions."

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause-and-effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate, and precise language. Cohesive organization. Very few grammatical errors.

Unit 3 – Lesson 2

The Design Process: Transforming an Idea Into a Final Product or System

Lesson Duration: Ten (10) hours.

Standards

- Students will develop an understanding of the attributes of design (ITEA/STL-8)
- Students will develop an understanding of engineering design (ITEA/STL-9)
- Students will develop an understanding of and be able to apply the design process (ITEA/STL-11)
- Students will develop an understanding of the nature of technology (Forces of Nature) (AAAS-BSL)
- Students will develop an understanding of the physical setting. (Design and Systems) (AAAS-BSL)
- Students will develop an understanding of the common themes (Models) (AAAS-BSL)
- Students will develop an understanding of the habits of mind (Manipulation and Observation) (AAAS-BSL)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Problem Solving). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Representation). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. • Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. • Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. • A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. • Identify the design problem and decide whether or not to address it. • Identify criteria and constraints and determine how these will affect the design process. • Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. • Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. • Develop and produce a product or system using a design process. • Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.	• In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. • The usefulness of a model can be tested by comparing its predictions to actual observations in the real world. • Use power tools to shape and join wood, plastic, and soft metal.	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics. • Use the language of mathematics to express ideas precisely. • Build new mathematical knowledge through problem solving. • Apply and adapt a variety of appropriate strategies to solve problems. • Apply and adapt a variety of appropriate strategies to solve problems. • Monitor and reflect on the process of mathematical problem solving. • Use representations to model and interpret physical, social, and mathematical phenomena.

Learning Objectives

Students will:

1. Identify and describe the attributes of the design process that make it an efficient way to solve problems.
2. Explain why the design process is never considered to be final.
3. Describe the risk analysis process and how it minimizes the likelihood of unwanted side effects.
4. Apply the engineering design process to solve a problem.
5. Identify criteria and constraints and determine how these will affect the design process.
6. Make two-dimensional and three-dimensional representations of a design solution.
7. Fabricate a prototype or model of a design solution.
8. Evaluate a design by using conceptual, physical, and mathematical models.
9. Evaluate a prototype in terms of design requirements and constraints.
10. Organize and present data effectively.
11. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.
12. Work safely and accurately with a variety of tools, machines, and materials.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Identify Resource Materials

Print-Based Sources

1. *Engineering Design: A Materials and Processing Approach* by George Dieter, McGraw-Hill Science/Engineering/Math; 3rd Edition (1999) ISBN: 0073661368.
2. *Engineering Design: A Project-Based Introduction* by Clive L. Dym, Patrick Little, Wiley; 2nd Edition (2003), ISBN: 0471256870.
3. *Engineering Design: A Systematic Approach* by G. Pahl, W. Beitz, Ken Wallace, Lucienne Blessing, Frank Bauert, Springer-Verlag Telos; 2nd Edition (1996), ISBN: 3540199179

Audiovisual Materials

1. Design for Manufacturing, Society of Manufacturing Engineers, Vol 6 CD, 2003, Product ID: CD03PUB7, SME – www.sme.org/cgibin/storefront_display.pl?&CD&&84&
2. The Mothers of Invention # 490490, asme – www.asme.org/education/precollege/materials/index.htm
3. What Is The Design Process, Quick Time Video – www.teachersdomain.org/9-12/sci/engin/design/desprocess/index.html

Internet Sites

1. The Top Ten Reasons to Pursue a Technical Career, Micron For Students – www.micron.com/students/index.html
2. The Engineering Design Process for Children, Museum of Science, Boston – www.mos.org/doc/1247
3. Engineering Design Quotations – www.design.caltech.edu/erik/Misc/design_quotes.html

Purpose of Lesson
To enable students to understand and apply the design process.

Required Knowledge and/or Skills
Students should have some understanding of the engineering design process, the personal characteristics involved in engineering, the resources used in the engineering design process, and the constraints on the engineering design process. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Lesson 3-2

Engagement
1. The teacher will assess prior knowledge and possible misconceptions related to the engineering design process.
2. The teacher will present students with an intriguing contemporary technological innovation such as the "scramjet," an engine so blindingly fast that it could carry an airplane from San Francisco to Washington, DC, in about 20 minutes—or even quicker.)
3. Students will be asked to provide their thoughts about the impact of such a technological development.
4. The teacher will ask students to speculate about the steps that were followed to create such an amazing innovation.

Exploration
1. The teacher will provide students with twelve 5" x 8" index cards, each labeled with one of the 12 steps in the engineering design process.
2. Working in groups, students will arrange the cards in the order that engineers might have used to develop the intriguing contemporary technological innovation.
3. The teacher will ask students what, specifically, the engineers might have be thinking about and doing in each step as they developed the intriguing contemporary technological innovation.

Explanation
1. The student groups will present and defend their thoughts on the order of the tasks.
2. The teacher will state that:
   a. There are a variety of formal and informal problem solving strategies and provides examples.
   b. The engineering design process is a systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to a problem to satisfy human needs and wants.
   c. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.
3. The teacher will describe "risk analysis" and how it minimizes the likelihood of unwanted side effects.
4. The teacher will describe the steps in the engineer design process.
   a. Defining a problem
   b. Brainstorming
   c. Researching and generating ideas
   d. Identifying criteria and specifying constraints
   e. Exploring possibilities

   f. Selecting an approach
   g. Developing a design proposal
   h. Making a model or prototype
   i. Testing and evaluating the design using specifications
   j. Refining the design
   k. Creating or making it
   l. Communicating processes and results
2. The teacher will explain that:
   a. Design problems are seldom presented in a clearly defined form.
   b. The design needs to be continually checked and critiqued, and the design must be refined and improved.
   c. Risk analysis is used to minimize the likelihood of unwanted side effects of a new technology.
   d. To reduce the chance of system failure, performance testing is often conducted using small-scale models, computer simulations, analogous systems, or just the parts of the system thought to be least reliable.
3. The teacher will review the following concepts:
   a. The basic idea of mathematical modeling is to find a mathematical relationship that behaves in the same ways as the objects or processes under investigation.
   b. The usefulness of a model can be tested by comparing its predictions to actual observations in the real world.
4. Students will clarify their understanding of the steps in the engineer design process through discussion and questions directed to the teacher.

Extension

1. The teacher will state that elements of the engineering design process can be used in short-term problem-solving activities that enable students to a) learn and practice systematic problem solving, b) develop and apply their creativity and ingenuity, and c) make concrete applications of mathematics and science skills and concepts.
2. The teacher will present a problem and review the criteria and constraints related to the problem. (See Resources for Problem Solving Activities/Competitions at end of this lesson)
3. The teacher will demonstrate the procedures and apparatus to be used to test problem solutions.
4. The teacher will provide instruction on the science and mathematics concepts that may be of significance in the solution of the problem.
5. The teacher will provide instruction in the use of tools, equipment, materials, and processes required in designing, representing graphically, and constructing a problem solution.
6. Students will use the engineering design process to solve a problem.
7. The teacher will observe student activity, ask questions to assist students in focusing on problems, facilitate the use of resources, and provide additional instruction when necessary.
8. Students will conduct final testing of the problem solutions and document results.
9. Students will make written or oral presentations on their recommendations for further refinement of the problem solution.

Evaluation

Students knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, group work, engineering design, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher

may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities

1. Students will read "Understanding the Engineering Problem-Solving Process" at the ASME Web site and complete accompanying work sheets. http://www.asme.org/education/precollege/esp/act1sr2.htm
2. Students will develop skill in the use of the engineering design process by solving a series of increasingly complex problems.
3. Students may be assigned to diagram the product development cycle of an invention of their choice and report their findings to the class
4. Students may be assigned to research the development of a contemporary technological innovation focusing on the redesign and refinement phase of the process.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, design tools and equipment, fabrication tools and equipment, and testing tools should be readied.

Tools/Materials/Equipment

- Computers with Internet Access
- Design tools
- Fabrication tools and equipment
- Testing apparatus

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson 3-2 Assessment Instruments

Assessment Instrument – Selected Response Item

Directions: Circle the T or F in the column to the left of each true (T) or false (F) statement.

T F 1. Each step in the engineering design process involves obtaining information and specific skills.

T F 2. One of the drawbacks to brainstorming is that it doesn't allow for input from a number of people.

T F 3. The fewer ideas a person can draw from, the better the chance that an optimum solution can be found.

T F 4. Models are especially important for the designing of cars, spacecraft, and airplanes.

T F 5. An engineer is, in essence, a problem solver.

T F 6. A prototype is a non-working model that is created at the end of the design process.

T F 7. Collaboration tends to enhance creativity and expand the range of possibilities.

T F 8. It is not necessary to repeat the steps in the design process to optimize the design.

T F 9. Constraints are new products, systems, or processes that have never existed before.

T F 10. Feedback is used to regulate or control a technological system.

Assessment Instrument - Selected Response Item

Use the terms in Column II to complete the statements the in Column I.

	Column I		Column II
	The _____ includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.	A	brainstorming
	Expressing ideas to others using _____ is an important part of the design process.	B	communicate and test
	Design involves a _____, which can be performed in different sequences and repeated as needed.	C	constraints
	A group problem-solving design process in which each person presents ideas is called _____.	D	engineering design process
	Modeling and testing are used to _____ ideas into practical solutions.	E	personal characteristics
	Engineering design is influenced by the _____, such as creativity and resourcefulness, of individuals and groups of people.	F	prototype
	A _____ is a working model used to test a design concept.	G	set of steps
	Models are used to _____ design ideas and processes.	H	sketches and models
		I	transform

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class, attempts to answer teacher-generated questions.	Well prepared for class, attempts to answer teacher-generated questions and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation for Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily, is not engaged. Has difficulty remaining on task.	Makes good use of class time to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative. Does little work. Rarely offers useful ideas.	Cooperative. Works at assignments. Usually offers useful ideas	Always willing to help and do more. Does more than required. Routinely offers useful ideas.
Cooperation	Rarely listens to, shares with, or supports the efforts of others. Often is not a good team member.	Usually listens to, shares with, and supports the efforts of others. Does not cause problems in the group.	Always listens to, shares with, and supports the efforts of others. Tries to keep people working together.
Focus on the task	Does not focus on the task and what needs to be done. Lets others do the work.	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done. Self-directed.

Assessment Instrument – Engineering Design

Category	Below Target	At Target	Above Target
Defining the Problem	Rephrases the problem with limited clarity.	Rephrases the problem clearly.	Rephrases the problem clearly and precisely.
Brainstorming	Contributes few or implausible ideas.	Contributes a plausible idea.	Contributes multiple plausible ideas.
Researching and Generating Ideas	Contributes ideas but without documented research. Produces incomplete sketches. Does not present a concept.	Contributes one plausible idea based on documented research. Produces marginally accurate pictorial and orthographic sketches of design concepts.	Contributes multiple plausible ideas based on documented research. Produces accurate pictorial and orthographic sketches of design concepts.
Identifying Criteria and Specifying Constraints	Does not restate the criteria clearly and fails to identify constraints.	Restates the criteria clearly and identifies several constraints.	Restates the criteria clearly and precisely and identifies many constraints.
Exploring Possibilities	Inadequately analyzes the pluses and minuses of a variety of possible solutions.	Satisfactorily analyzes the pluses and minuses of a variety of possible solutions.	Thoroughly analyzes the pluses and minuses of a variety of possible solutions.
Selecting an Approach	Selection of solution is not based on consideration of criteria and constraints.	Selects a promising solution based on criteria and constraints.	Selects a promising solution based on a thorough analysis criteria and constraints.
Developing a Design Proposal	Design proposal is inadequate lacking pertinent information.	Design proposal is adequate containing all pertinent elements.	Design proposal is accurate and comprehensive.
Making a Model or Prototype	Prototype meets the task criteria to a limited extent.	Prototype meets the task criteria.	Prototype meets the task criteria in insightful ways.
Testing and Evaluating the Design Using Specifications	Testing and evaluation processes are inadequate.	Testing and evaluation processes are adequate for refining the problem solution.	Testing processes are innovative.
Refining the Design	Refinement based on testing and evaluation is not evident.	Refinements made based on testing and evaluation results.	Significant improvement in the design is made based on prototype testing and evaluation.
Creating or Making It	Finished solution (product) fails to meet specifications.	Finished solution (product) meets specifications.	Finished solution (product) exceeds specifications.
Communicating Processes and Results	Solution presented with limited accuracy. Limited supporting evidence on how the solution meets the task criteria.	Solution presented accurately. Some supporting evidence on how the solution meets the task criteria.	Solution presented concisely with clarity and accuracy. Extensive supporting evidence on how the solution meets the task criteria.

Assessment Instrument – Brief Constructed Response Items

1. Explain why the design process is never considered to be final.
2. Describe the risk analysis process and how it minimizes the likelihood of unwanted side effects.
3. Identify and describe two established design principles that are used to evaluate existing designs, to collect data, and to guide the design process.
4. What are patents and what do they do for inventors?

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

1. Identify and describe the attributes of the design process that make it an efficient way to solve problems.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause-and-effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate, and precise language. Cohesive organization. Very few grammatical errors.

Resources for Problem Solving Activities/Competitions

Problem Solving / Pre-Engineering, Product Gateway, Tech Directions
www.techdirections.com/projectsP.html

ASME Pre-College Education, High School Engineering
www.asme.org/education/precollege/bestpractice/bpengweek.htm

High School Student Engineering Competitions and Undergraduate Engineering Competitions
www.engineerinyou.com/competitions.html

Pre-Engineering Competitions
www.engineeringedu.com/competitions.html

High School Resource Center
Competitions and Research Opportunities
www.venturescholar.org/resource/competitions-hs.html

Future City Competition
www.futurecity-phoenix.org/VirtualEngineer/Eng101/EngExplain.htm

American Society for Engineering Education
Competitions and Special Programs
www.engineeringk12.org/students/resources/competitions_special_programs.htm

Junior Engineering Technical Society
Student Competitions
www.jets.org/resources/students.cfm

Society of Manufacturing Engineers
Robotic Technology and Engineering Challenge
www.sme.org/cgi-bin/eduhtml.pl?/educat/srcpg.html&&&SME&

The National Engineering Design Challenge (NEDC)
www.udeducation.org/teach/shortevents/competitions/nedc.asp

Unit 3 – Lesson 3

Engineering Resources (Core Technologies)

Standards

- Students will develop an understanding of the attributes of design. (ITEA/STL-8)
- Students will develop an understanding of engineering design. (ITEA/STL-9)
- Students will develop an understanding of and be able to apply the design process. (ITEA/STL-11)
- Students will develop an understanding of the nature of technology. (Forces of Nature) (AAAS-BSL)
- Students will develop an understanding of the physical setting. (Design and Systems) (AAAS-BSL)
- Students will develop an understanding of the common themes. (Models) (AAAS-BSL)
- Students will develop an understanding of the habits of mind. (Manipulation and Observation) (AAAS-BSL)
- Students will develop an understanding of mathematics processes. (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes. (Communications). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. • Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. • Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. • Technological ideas are sometimes protected through the process of patenting. • A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. • Identify the design problem and decide whether or not to address it. • Identify criteria and constraints and determine how these will affect the design process. • Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. • Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. • Develop and produce a product or system using a design process. • Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.	• In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. • The value of any given technology may be different for different groups of people and at different points in time. • Risk analysis is used to minimize the likelihood of unwanted side effects of a new technology. • To reduce the chance of system failure, performance testing is often conducted using small-scale models, computer simulations, analogous systems, or just the parts of the system thought to be least reliable. • Different kinds of materials respond differently to electric forces. • The basic idea of mathematical modeling is to find a mathematical relationship that behaves in the same ways as the objects or processes under investigation. • Computers have greatly improved the power and use of mathematical models by performing computations that are very long, very complicated, or repetitive. • The usefulness of a model can be tested by comparing its predictions to actual observations in the real world. • Use power tools to shape and join wood, plastic and soft metal.	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics. • Use the language of mathematics to express ideas precisely.

Learning Objectives

Students will:

1. Identify and describe engineering resources (core technologies) -- mechanical, structural, electrical, electronic, thermal, fluid, optical, bio, and material) as they are applied in the designed world.
2. Analyze the functioning of the engineering resources (core technologies) in the designed world in terms of common components, basic system design, safety, simple controls, and system performance evaluation.
3. Apply mathematics and science skills and concepts to the analysis of engineering resources (core technologies).
4. Apply the engineering design process to solve a problem.
5. Work safely and accurately with a variety of tools, machines, and materials.
6. Address open-ended questions in verbal and written form.
7. Actively participate in group discussions, ideation exercises, and debates.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Identify Resource Materials

Print-Based Sources

1. *Physics In Context: An Integrated Approach*, CCI Publishing (2001) ISBN 1-5737-275-5
2. *Design and Problem Solving in Technology* by Hutchinson and Karsnitz, Glencoe McGraw-Hill, (1997), ISBN 0-8273-5244-1
3. *Hands-On Physics Activities with Real-Life Applications: Easy-to-Use Labs and Demonstrations for Grades 8 - 12* (J-B Ed: Hands On) by James Cunningham, Norman Herr, Jossey-Bass (2002) ISBN: 087628845X

Audiovisual Materials

1. Understanding Physics, Video CD for Students by Karen Cummings, et al (CD-ROM)
2. Electrical Theory - DC Video Set on CD-ROM by Delmar, Delmar Learning, Delmar Thomson Learning, CD-Rom edition (2001) ISBN: 0766840905
3. The Core Technologies: Building Blocks of Technology Systems, VHS Technology Education Association of Maryland, (1995) – www.techedmd.org

Internet Sites

1. Introduction to Mechanisms – www-2.cs.cmu.edu/People/rapidproto/mechanisms/chpt2.html
2. Fluid Preliminaries – www.efunda.com/formulae/fluids/overview.cfm
3. Optics for Kids – www.opticalres.com/kidoptx.html

Purpose of Lesson

To familiarize students with the engineering resources (core technologies), the building blocks of the designed world by having students identify and describe the core technologies (mechanical, structural, electrical, electronic, thermal, fluid, optical, bio, and material) as they are applied in the designed world.

Required Knowledge and/or Skills

Students should have some understanding of the attributes of the design process. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Lesson 3-3

Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to engineering resources (core technologies).
2. The teacher will state that a technology system is a group of resources (subsystems) working together to solve problems and extend human capabilities.
3. The teacher will present students with an easily recognized technology system.
4. Students will be asked to identify the problem that the technology system solves.
5. Students will be asked to speculate on what resources (subsystems) are working together to solve a problem and extend human capability.

Exploration

1. Working in groups, students will analyze several technology systems focusing on their functioning and application.
2. Students will be asked to identify the problem that the technology system solves.
3. The teacher will ask students to list the resources (subsystems) they recognize in the technology systems.

Explanation

1. The student groups will present their analyses.
2. The teacher will state that there are several engineering resources (core technologies) that are the "building blocks" of all technology systems.
3. The teacher will ask students to imagine that we could store engineering resources (core technologies) on shelves and that we could go to those shelves and use technologies according to our needs in problem solving.
4. The teacher will define engineering resources (core technologies) and provide examples of applications.
   a. Mechanical Technology – The technology of putting together mechanical parts to produce, control, and transmit motion. (Example applications: gear systems in a car transmission, brakes on a bicycle, agitator in a washing machine, latch on a door)
   b. Structural Technology – The technology of putting mechanical parts and materials to create supports, containers, shelters, connectors, and functional shapes. (Example applications: legs on a chair, city water tower, swimming pool, roadways, bridges, storm sewer, airplane wing, satellite antenna disc)
   c. Electrical Technology – The technology of producing, storing, controlling, transmitting and getting work from electrical energy. (Example applications: power plant generator, flashlight, electric motor in a can opener, door bell, electric heater, hair dryer)
   d. Electronic Technology – The technology of using small amounts of electricity for controlling; detecting; and information collecting, storing, retrieving, processing and communicating. (Example applications: thermostat for controlling temperature, a metal detector, video tape recorder, computer, pocket calculator, telephone, radio, television)
   e. Fluid Technology – The technology of using fluid, either gaseous (pneumatics) or liquid (hydraulic) to apply force or to transport. (Example applications: air brakes on a truck,

tires on a car, airfoils on an airplane, warm air heating ducts, hydraulic jack, plumbing in a school)

f. Optical Technology – The technology of producing light; using light for information collecting, storing, retrieving, processing and communicating; and using light to do work. (Example applications: light bulb, light emitting diode, lenses to magnify or reduce, laser speed detector, laser compact disk, fiber optic telephone communication, laser cutting tools, laser surgical instruments)

g. Thermal Technology – The technology of producing, storing, controlling, transmitting and getting work from heat energy. (Example applications: furnace, hot water heater, toaster, insulation, heat exchanger, refrigerator, jet engine, hot air balloon)

h. Biotechnology – The technology of using, adapting, and altering organisms and biological processes for a desired outcome. (Example applications: stain "eating" enzymes in detergent, bacteria "leaching" of metals from ore, altering plant genes to produce better crops)

i. Materials Technology – The technology of producing, altering, and combining materials. (Example applications: producing paper form wood, producing aluminum from ore, drilling holes in wood, annealing to soften metal, laminating wood)

5. The teacher will describe the relationship between the core technologies and mathematics and science.
6. Students will clarify their understanding of the definitions of the core technologies and their applications.

Extension

1. The teacher will state that knowledge of engineering resources (core technologies) is an information resource that can help us in the engineering design process.
2. The teacher will present a problem and review the criteria and constraints related to the problem.
3. The teacher will demonstrate the procedures and apparatus to be used to test problem solutions.
4. The teacher will provide instruction on the science and mathematics concepts that may be of significance in the solution of the problem.
5. The teacher will provide instruction in the use of tools, equipment, materials and processes required in designing, representing graphically, and constructing a problem solution.
6. Students will analyze the engineering resources (core technologies) employed in the solution in terms of common components, basic system design, safety, simple controls, and system performance evaluation.
7. The teacher will observe student activity, ask questions to assist student in focusing on problems, facilitate the use of resources, and provide additional instruction when necessary.
8. Students will conduct final testing of the problem solutions and document results.
9. Students will make written or oral presentations on their recommendations for further refinement of the problem solution.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, group work, engineering problem solving, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the ru-

brics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities

1. Students may be assigned to solve engineering problems of increasing complexity and requiring the use of multiple core technologies.
2. Students may be assigned to research and report on the application of the core technologies in enterprises and institutions (education, agriculture, defense, home technology, transportation).

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, production and fabrication, and product/prototype testing and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, design tools and equipment, fabrication tools and equipment, and testing tools should be readied.

Tools/Materials/Equipment

- Computers with Internet Access
- Design tools
- Fabrication tools and equipment
- Testing apparatus

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Assessment Instrument – Selected Response Item

Match the terms in Column II with the statements the in Column I.

		Column I		Column II
1.		The technology of putting together mechanical parts to produce, control, and transmit motion	A	Biotechnology
2.		The technology of producing, storing, controlling, transmitting and getting work from electrical energy	B	Electrical Technology
3.		The technology of using small amounts of electricity for controlling; detecting; and information collecting, storing, retrieving, processing and communicating	C	Electronic Technology
4.		The technology of putting parts and materials together to create supports, containers, shelters, connectors, and functional shapes	D	Fluid Technology
5.		The technology of using fluid, either gaseous (pneumatics) or liquid (hydraulic) to apply force of transport	E	Materials Technology
6.		The technology of producing light; using light for information collecting, storing, retrieving, processing and communicating; and using light to do work	F	Mechanical Technology
7.		The technology of producing, storing, controlling, transmitting and getting work from heat energy	G	Optical Technology
8.		The technology of using, adapting, and altering organisms and biological processes for a desired outcome	H	Structural Technology
9.		The technology of producing, altering, and combining materials	I	Thermal Technology

Assessment Instrument – Selected Response Item

Directions: Circle the T or F in the column to the left of each true (T) or false (F) statement.

T F 1. A door latch is an example of mechanical technology.

T F 2. Laser surgical instruments are an example of fluid technology.

T F 3. A hot water heater is an example of biotechnology.

T F 4. Producing paper from wood is an example of materials technology.

T F 5. A swimming pool is an example of structural technology.

T F 6. Flashlights are examples of mechanical technology.

T F 7. A telescope is an example of optical technology.

T F 8. An artificial leg is an example of biotechnology.

T F 9. A bridge is an example of structural technology.

T F 10. Computers are examples of electronic technology.

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class, attempts to answer teacher-generated questions.	Well prepared for class, attempts to answer teacher-generated questions and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation for Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily, is not engaged. Has difficulty remaining on task.	Makes good use of class time to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative. Does little work. Rarely offers useful ideas.	Cooperative. Works at assignments. Usually offers useful ideas	Always willing to help and do more. Does more than required. Routinely offers useful ideas.
Cooperation	Rarely listens to, shares with, or supports the efforts of others. Often is not a good team member.	Usually listens to, shares with, and supports the efforts of others. Does not cause problems in the group.	Always listens to, shares with, and supports the efforts of others. Tries to keep people working together.
Focus on the task	Does not focus on the task and what needs to be done. Lets others do the work.	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done. Self-directed.

Assessment Instrument – Engineering Problem Solving

Category	Below Target	At Target	Above Target
Defining the Problem	Rephrases the problem with limited clarity.	Rephrases the problem clearly.	Rephrases the problem clearly and precisely.
Brainstorming	Contributes few or implausible ideas.	Contributes a plausible idea.	Contributes multiple plausible ideas.
Researching and Generating Ideas	Contributes ideas but without documented research. Produces incomplete sketches. Does not present a concept.	Contributes one plausible idea based on documented research. Produces marginally accurate pictorial and orthographic sketches of design concepts.	Contributes multiple plausible ideas based on documented research. Produces accurate pictorial and orthographic sketches of design concepts.
Identifying Criteria and Specifying Constraints	Does not restate the criteria clearly and fails to identify constraints.	Restates the criteria clearly and identifies several constraints.	Restates the criteria clearly and precisely and identifies many constraints.
Exploring Possibilities	Inadequately analyzes the pluses and minuses of a variety of possible solutions.	Satisfactorily analyzes the pluses and minuses of a variety of possible solutions.	Thoroughly analyzes the pluses and minuses of a variety of possible solutions.
Selecting an Approach	Selection of solution is not based on consideration of criteria and constraints.	Selects a promising solution based on criteria and constraints.	Selects a promising solution based on a thorough analysis criteria and constraints.
Developing a Design Proposal	Design proposal is inadequate, lacking pertinent information.	Design proposal is adequate, containing all pertinent elements.	Design proposal is accurate and comprehensive.
Making a Model or Prototype	Prototype meets the task criteria to a limited extent.	Prototype meets the task criteria.	Prototype meets the task criteria in insightful ways.
Testing and Evaluating the Design Using Specifications	Testing and evaluation processes are inadequate.	Testing and evaluation processes are adequate for refining the problem solution.	Testing processes are innovative.
Refining the Design	Refinement based on testing and evaluation is not evident.	Refinements made based on testing and evaluation results.	Significant improvement in the design is made based on prototype testing and evaluation.
Creating or Making It	Finished solution (product) fails to meet specifications.	Finished solution (product) meets specifications.	Finished solution (product) exceeds specifications.
Communicating Processes and Results	Solution presented with limited accuracy. Limited supporting evidence on how the solution meets the task criteria.	Solution presented accurately. Some supporting evidence on how the solution meets the task criteria.	Solution presented concisely with clarity and accuracy. Extensive supporting evidence on how the solution meets the task criteria.

Assessment Instrument – Brief Constructed Response Items

1. Define and describe several examples of mechanical technology, one of the engineering resources (core technologies) applied in the designed world.
2. Define and describe several examples of structural technology, one of the engineering resources (core technologies) applied in the designed world.
3. Define and describe several examples of electrical technology, one of the engineering resources (core technologies) applied in the designed world.
4. Define and describe several examples of electronic technology, one of the engineering resources (core technologies) applied in the designed world.
5. Define and describe several examples of fluid technology, one of the engineering resources (core technologies) applied in the designed world.
6. Define and describe several examples of thermal technology, one of the engineering resources (core technologies) applied in the designed world.
7. Define and describe several examples of optical technology, one of the engineering resources (core technologies) applied in the designed world.
8. Define and describe several examples of biotechnology, one of the engineering resources (core technologies) applied in the designed world.
9. Define and describe several examples of materials technology, one of the engineering resources (core technologies) applied in the designed world.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

1. How does knowledge of engineering resources (core technologies), help people analyze the function and application of technology systems?
2. Describe the relationship of engineering resources (core technologies), to mathematics and science.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause-and-effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate, and precise language. Cohesive organization. Very few grammatical errors.

Unit 3 – Lesson 4

An Introduction to Mechanical Technology

Standards

- Students will develop an understanding of the attributes of design (ITEA/STL-8)
- Students will develop an understanding of engineering design (ITEA/STL-9)
- Students will develop an understanding of and be able to apply the design process (ITEA/STL-11)
- Students will develop an understanding of the physical setting. (Motion) (AAAS-BSL)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. • Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. • Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. • Technological ideas are sometimes protected through the process of patenting. • A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. • Identify the design problem and decide whether or not to address it. • Identify criteria and constraints and determine how these will affect the design process. • Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. • Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. • Develop and produce a product or system using a design process. • Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.	• The change in motion of an object is proportional to the applied force and inversely proportional to the mass. • Whenever one thing exerts a force on another, an equal amount of force is exerted back on it. • All motion is relative to whatever frame of reference is chosen, for there is no motionless frame from which to judge all motion.	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics. • Use the language of mathematics to express ideas precisely.

Learning Objectives

Students will:

1. Explain how mechanical systems enhance human capabilities.
2. Describe factors that affect a mechanical system's efficiency.
3. Analyze the functioning of the mechanical systems in the designed world in terms of common components, basic system design, safety, simple controls, and system performance evaluation.
4. Apply the engineering design process to solve a problem.
5. Work safely and accurately with a variety of tools, machines, and materials.
6. Demonstrate curiosity, exhibit motivation for learning, and use class time effectively.
7. Exhibit and refine inherent personal qualities such as creativity and resourcefulness.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials

Print-Based Sources

1. *Mechanisms and Mechanical Devices Sourcebook* by Neil Sclater, McGraw-Hill Professional; 3rd Edition (2001), ISBN: 007136169
2. *Five Hundred and Seven Mechanical Movements* by Henry T. Brown, Astragal Press; Reprint Edition (1995), ISBN: 1879335638
3. *Ingenious Mechanisms for Designers and Inventors* (4-Volume Set) by Franklin D. Jones, Industrial Press (1977), ISBN: 0831110848

Audiovisual Materials

1. Simple Machines (2002), Format: Color, NTSC, Rated: NR, Studio: 100% Educational Vid, Video Release Date: August 15, 2002, VHS, ASIN: B00006JDWZ
2. Simple and Compound Machines (2002), Format: Color, NTSC, Rated: NR, Studio: 100% Educational Vid, Video Release Date: August 15, 2002, VHS, ASIN: B00006JDXY

Internet Sites

1. Simple Machines – http://camillasenior.homestead.com/files/machines_unit.pdf
2. Introduction to Mechanisms – www-2.cs.cmu.edu/People/rapidproto/mechanisms/chpt2.html
3. Mechanisms and Movement – www.flying-pig.co.uk/mechanisms/

Purpose of Lesson

To familiarize students with the functioning and applications of mechanical technology systems by having them analyze the functioning of mechanical systems in terms of their common components, basic system design, safety considerations, and simple controls.

Required Knowledge and/or Skills

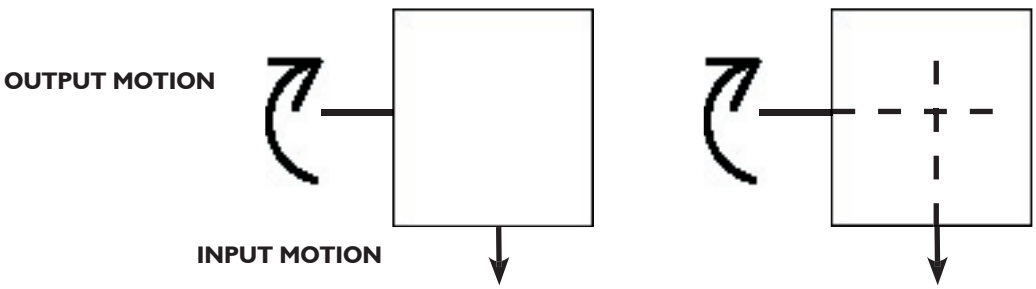
To meet this lesson's objectives, students should be familiar with the core technologies, the building blocks of the designed world. Students should be able to identify and describe the core technologies as they are applied in the designed world. They should be familiar with common components, basic system design, safety, simple controls, and system performance evaluation.

Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to the functioning and applications of mechanical technology systems.
2. The teacher will present students with a piece of wood with a nail partially driven in to it and ask a student to pull the nail out with his or her hands.
3. The students will then be give a claw hammer and ask to pull the nail out.
4. Students will be asked to speculate on how the hammer assists people in solving a problem or extending human capability.

Exploration

1. Given an input motion and a desired output motion, student groups will create two-dimensional machines using card stock and paper fasteners. (see illustration below and appendix)



2. Students will be asked to write one-sentence descriptions of the changes in motion created by the mechanism.
3. Students will be asked to identify common mechanical devices that exhibit the characteristics similar to the mechanisms they have created.

Explanation:

1. The students will present their descriptions of the changes in motion created by the mechanism and identify common mechanical devices that exhibit the characteristics similar to the mechanisms they created.
2. The teacher will elaborate on the attributes and applications of the mechanisms.
3. The teacher will define mechanical technology as the assembly mechanical components to produce, control, and transmit motion.
4. The teacher will describe mechanical technology in terms of:
   a. Common components (levers, inclined planes, wedges, wheels and axles, pulleys, screws, gears, cams, linkages, shafts, couplings, cables, bearings, brakes, clutches)
   b. Basic system design (sketching, symbols, notation)
   c. Simple controls (Complex systems may have layers of controls. Some controls operate particular parts of the system and some control other controls. Even the most fully automatic systems require human control at some point.)
   d. System performance evaluation (mechanical advantage, efficiency)
   e. Safety considerations
5. The teacher will explain science concepts and mathematic processes applied in mechanical systems.
   a. Force
   b. Motion

   c. Energy
   d. Work
   e. Power
   f. Efficiency
   g. Gravity
   h. Friction
6. The teacher will identify and describe applications of mechanical technology in the designed world.
7. Students will restate any questions that were not answered in the teacher's lecture and clarify any unresolved issues.

Extension

1. The teacher will present a problem that requires the design and fabrication of a mechanical system and review the criteria and constraints related to the problem. (See Resources for Problem Solving Activities/Competitions at end of this lesson)
2. The teacher will demonstrate the procedures and apparatus to be used to test problem solutions.
3. The teacher will provide instruction on the science and mathematics concepts that may be of significance in the solution of the problem.
4. The teacher will provide instruction in the use of tools, equipment, materials and processes required in designing, representing graphically, and constructing a problem solution.
5. The teacher will observe student activity, ask questions to assist students in focusing on problems, facilitate the use of resources, and provide additional instruction when necessary.
6. Students will conduct final testing of the problem solutions and document results.
7. Students will make written or oral presentations on their recommendations for further refinement of the problem solution.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, group work, engineering design, brief constructed responses, and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Identify or Develop Extension Activities

1. Students will create an instructional aid that describes the functioning of a mechanical system.
2. Students will create a display of a mechanical system from a household item they disassemble.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, production and fabrication, product/prototype testing and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, design tools and equipment, fabrication tools and equipment, and testing tools should be readied.

Tools/Materials/Equipment

- Card stock
- Paper fasteners
- Scissors
- Hole punch
- Design tools
- Fabrication tools and equipment
- Testing apparatus

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson 3-4 Assessment Instruments

Assessment Instrument – Selected Response Items

Match the terms in Column II with the statements in Column I.

		Column I		Column II
1.		A push or a pull	A	Efficiency
2.		The property of a system that enables it to do work	B	Energy
3.		The product of a force applied to an object and the distance the object moves	C	Force
4.		The rate of doing work	D	Friction
5.		The ration of output work to input work	E	Gravity
6.		An attractive force acting at a distance between two or more masses	F	Mechanical Technology
7.		A force that opposes relative motion of two solids or a solid and a liquid	G	Power
8.		The technology of putting together mechanical parts to produce, control, and transmit motion	H	Work

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class, attempts to answer teacher-generated questions.	Well prepared for class, attempts to answer teacher-generated questions, and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation for Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily, is not engaged. Has difficulty remaining on task.	Makes good use of class time to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative. Does little work. Rarely offers useful ideas.	Cooperative. Works at assignments. Usually offers useful ideas	Always willing to help and do more. Does more than required. Routinely offers useful ideas.
Cooperation	Rarely listens to, shares with, or supports the efforts of others. Often is not a good team member.	Usually listens to, shares with, and supports the efforts of others. Does not cause problems in the group.	Always listens to, shares with, and supports the efforts of others. Tries to keep people working together.
Focus on the task	Does not focus on the task and what needs to be done. Lets others do the work.	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done. Self-directed.

Assessment Instrument – Engineering Design

Category	Below Target	At Target	Above Target
Defining the Problem	Rephrases the problem with limited clarity.	Rephrases the problem clearly.	Rephrases the problem clearly and precisely.
Brainstorming	Contributes few or implausible ideas.	Contributes a plausible idea.	Contributes multiple plausible ideas.
Researching and Generating Ideas	Contributes ideas but without documented research. Produces incomplete sketches. Does not present a concept.	Contributes one plausible idea based on documented research. Produces marginally accurate pictorial and orthographic sketches of design concepts.	Contributes multiple plausible ideas based on documented research. Produces accurate pictorial and orthographic sketches of design concepts.
Identifying Criteria and Specifying Constraints	Does not restate the criteria clearly and fails to identify constraints.	Restates the criteria clearly and identifies several constraints.	Restates the criteria clearly and precisely and identifies many constraints.
Exploring Possibilities	Inadequately analyzes the pluses and minuses of a variety of possible solutions.	Satisfactorily analyzes the pluses and minuses of a variety of possible solutions.	Thoroughly analyzes the pluses and minuses of a variety of possible solutions.
Selecting an Approach	Selection of solution is not based on consideration of criteria and constraints.	Selects a promising solution based on criteria and constraints.	Selects a promising solution based on a thorough analysis of criteria and constraints.
Developing a Design Proposal	Design proposal is inadequate, lacking pertinent information.	Design proposal is adequate, containing all pertinent elements.	Design proposal is accurate and comprehensive.
Making a Model or Prototype	Prototype meets the task criteria to a limited extent.	Prototype meets the task criteria.	Prototype meets the task criteria in insightful ways.
Testing and Evaluating the Design Using Specifications	Testing and evaluation processes are inadequate.	Testing and evaluation processes are adequate for refining the problem solution.	Testing processes are innovative.
Refining the Design	Refinement based on testing and evaluation is not evident.	Refinements made based on testing and evaluation results.	Significant improvement in the design is made based on prototype testing and evaluation.
Creating or Making It	Finished solution (product) fails to meet specifications.	Finished solution (product) meets specifications.	Finished solution (product) exceeds specifications.
Communicating Processes and Results	Solution presented with limited accuracy. Limited supporting evidence on how the solution meets the task criteria.	Solution presented accurately. Some supporting evidence on how the solution meets the task criteria.	Solution presented concisely with clarity and accuracy. Extensive supporting evidence on how the solution meets the task criteria.

Assessment Instrument – Brief Constructed Response Items

1. Define and describe several examples of force applied in a mechanical technology system.
2. Define and describe an example of an efficiency calculation applied in a mechanical technology system.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

1. Explain how mechanical systems enhance human capabilities?
2. Describe several factors that affect a machine's efficiency.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important, evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause-and-effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate, and precise language. Cohesive organization. Very few grammatical errors.

Unit 3 – Lesson 5

An Introduction to Electrical Technology

Lesson Duration: Ten (10) hours

Standards

- Students will develop an understanding of the attributes of design (ITEA/STL-8)
- Students will develop an understanding of engineering design (ITEA/STL-9)
- Students will develop an understanding of and be able to apply the design process (ITEA/STL-11)
- Students will develop an understanding of the nature of technology (Forces of Nature) (AAAS-BSL)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. • Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. • Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. • Technological ideas are sometimes protected through the process of patenting. • A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. • Identify the design problem and decide whether or not to address it. • Identify criteria and constraints and determine how these will affect the design process. • Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. • Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. • Develop and produce a product or system using a design process. • Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.	• Electromagnetic forces acting within and between atoms are vastly stronger that the gravitational forces acting between the atoms. • There are two kinds of charges, positive and negative. Like charges repel one another, opposite charges attract. In materials, there are almost exactly equal proportions of positive and negative charges, making the materials as a whole electrically neutral.	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics. • Use the language of mathematics to express ideas precisely.

Learning Objectives

Students will:

1. Explain how electrical systems enhance human capabilities.
2. Describe factors that affect an electrical system's efficiency.
3. Analyze the functioning of the electrical systems in the designed world in terms of common components, basic system design, safety, simple controls, and system performance evaluation.
4. Apply the engineering design process to solve a problem.
5. Work safely and accurately with a variety of tools, machines, and materials.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials

Print-Based Sources

1. *Basic Electricity* by Nooger Van Valkenburgh, Prompt (DPI - 8/01); 1st Edition, 1995, ISBN: 0790610418
2. *Basic Electricity: A Self-Teaching Guide* (Wiley Self-Teaching Guides) by Charles Ryan, Wiley Press; 2nd Edition (1986), ISBN: 0471850853
3. *Schematic Diagrams* by Richard Johnson, Prompt (DPI - 8/01); 1st Edition (1994), ISBN: 0790610590

Audiovisual Materials

1. Tell Me Why: Electricity & Safety (1991), Color, NTSC, Vision Quest Video, VHS, ASIN: 6302086647
2. Electricity & Electric Safety, Color, Animated, NTSC, Vision Quest Video, 1998, VHS, ASIN: B00000INC6
3. Careers: Engineering Occupations (1997) Color, Closed-captioned, VHS Features: NTSC format ASIN: 1579980740

Internet Sites

1. Basic electricity, http://www.reprise.com/host/electricity/default.asp
2. Ohms Law, http://www.grc.nasa.gov/WWW/K-12/Sample_Projects/Ohms_Law/ohmslaw.html
3. AC / DC What's The Difference: HTML Interactive, http://www.teachersdomain.org/9-12/sci/phys/mfw/radioint/index.html

Purpose of Lesson

To familiarize students with the functioning and applications of electrical technology systems by having them analyze the functioning of electrical systems in terms of their common components, basic system design, safety considerations, and simple controls.

Required Knowledge and/or Skills

Students should have some understanding of the functioning and applications of physical systems (core technologies) including their common components, basic system design, safety considerations, and simple controls. They should have some basic graphic and research skills. In the

engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Lesson 3-5

Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to the functioning and applications of electrical technology systems.
2. The teacher will state that a technology system is a group of resources (subsystems) working together to solve problems and extend human capabilities.
3. The teacher will present students with an easily recognized electrical technology system. (flashlight)
4. Students will be asked to identify the problem that the technology system solves.
5. Students will be asked to speculate on how the device assists people in solving a problem or extending human capability.

Exploration

1. Working in groups, students will analyze several electrical or electronic systems focusing on their functioning and application.
2. Students will be asked to identify the problem that the technology system solves.
3. The teacher will ask students to list the resources (subsystems) they recognize in the technology systems.

Explanation

1. The student groups will present their analyses.
2. The teacher will define electrical technology as the technology of producing, storing, controlling, transmitting and getting work from electrical energy. (Example applications: power plant generator, flashlight, electric motor in a can opener, door bell, electric heater, hair dryer)
3. The teacher will define electronic technology as the technology of using small amounts of electricity for controlling; detecting; and information collecting, storing, retrieving, processing and communicating. (Example applications: thermostat for controlling temperature, a metal detector, video tape recorder, computer, pocket calculator, telephone, radio, television)
4. The teacher will facilitate a discussion of applications of electrical technology in the designed world such as generators, electric motors, alarm systems, and automobile electrical system.
5. The teacher will explain science concepts and mathematical concepts applied in electrical technology including:
   - Resistance
   - Conduction
   - Semi-conduction
   - Current (alternating and direct)
   - Voltage
   - Power
   - Circuits
   - Magnetism
   - Ohm's law
   - Ratio
6. The teacher will describe how electric circuits provide a means of transferring and using electrical energy to produce heat, light, sound, as well as chemical changes.

7. The teacher will facilitate a discussion of applications of electronic technology in the designed world such as computers, telephones, radio and television.
8. The teacher will review sketching techniques and demonstrate how to make a simple electrical schematic drawing.
9. The teacher will demonstrate how Ohm's Law can be used to analyze and modify an existing electrical circuit.
10. Students will restate any questions that were not answered in the teacher's lecture and clarify any unresolved issues.

Extension

1. The teacher will present a problem that requires the design and fabrication of an electrical system and review the criteria and constraints related to the problem. (See Resources for Problem Solving Activities/Competitions at end of this lesson)
2. The teacher will demonstrate the procedures and apparatus to be used to test problem solutions.
3. The teacher will provide instruction on the science and mathematics concepts that may be of significance in the solution of the problem.
4. The teacher will provide guidance in the use of tools, equipment, materials, and processes required in designing, sketching, and constructing a problem solution.
5. The teacher will observe student activity, ask questions to assist students in focusing on problems, facilitate the use of resources, and provide additional instruction when necessary.
6. Students will conduct final testing of the problem solutions and document results.
7. Students will make written or oral presentations on their recommendations for further refinement of the problem solution.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, group work, engineering design, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities

1. Students may be assigned to create a display of an electrical system from a household item they have disassembled.
2. Students may be assigned to research the functioning and applications of a contemporary electronic system.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, design tools and equipment, fabrication tools and equipment, and testing tools should be readied.

Tools/Materials/Equipment

- Computers with Internet Access
- Design tools
- Fabrication tools and equipment
- Testing apparatus

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson 3-5 Assessment Instruments

Assessment Instrument – Selected Response Items

Match the terms in Column II with the statements in Column I.

		Column I		Column II
1.		A material containing many free electrons that move through the material easily	A	Circuits
2.		The opposition to the flow of electrical charge	B	Conductor
3.		The total amount of electrons flowing through a circuit per unit time	C	Current
4.		Materials whose electrical conductivity can be precisely altered by manufacturing processes	D	Electrical Technology
5.		The force that moves electrons	E	Ohm's Law
6.		The rate of doing work or the rate of transferring energy	F	Power
7.		A complete path of an electric current including the source of electrical energy	G	Ratio
8.		The linear relationship between voltage and current through an electrical device	H	Resistance
9.		The relationship in quantity, amount, or size between two or more things	I	Semiconductor
10.		The technology of producing, storing, controlling, transmitting, and getting work from electrical energy	J	Voltage

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class, attempts to answer teacher-generated questions.	Well prepared for class, attempts to answer teacher-generated questions, and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation for Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily, is not engaged. Has difficulty remaining on task.	Makes good use of class time to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative. Does little work. Rarely offers useful ideas.	Cooperative. Works at assignments. Usually offers useful ideas	Always willing to help and do more. Does more than required. Routinely offers useful ideas.
Cooperation	Rarely listens to, shares with, or supports the efforts of others. Often is not a good team member.	Usually listens to, shares with, and supports the efforts of others. Does not cause problems in the group.	Always listens to, shares with, and supports the efforts of others. Tries to keep people working together.
Focus on the task	Does not focus on the task and what needs to be done. Lets others do the work.	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done. Self-directed.

Assessment Instrument – Engineering Design

Category	Below Target	At Target	Above Target
Defining the Problem	Rephrases the problem with limited clarity.	Rephrases the problem clearly.	Rephrases the problem clearly and precisely.
Brainstorming	Contributes few or implausible ideas.	Contributes a plausible idea.	Contributes multiple plausible ideas.
Researching and Generating Ideas	Contributes ideas but without documented research. Produces incomplete sketches. Does not present a concept.	Contributes one plausible idea based on documented research. Produces marginally accurate pictorial and orthographic sketches of design concepts.	Contributes multiple plausible ideas based on documented research. Produces accurate pictorial and orthographic sketches of design concepts.
Identifying Criteria and Specifying Constraints	Does not restate the criteria clearly and fails to identify constraints.	Restates the criteria clearly and identifies several constraints.	Restates the criteria clearly and precisely and identifies many constraints.
Exploring Possibilities	Inadequately analyzes the pluses and minuses of a variety of possible solutions.	Satisfactorily analyzes the pluses and minuses of a variety of possible solutions.	Thoroughly analyzes the pluses and minuses of a variety of possible solutions.
Selecting an Approach	Selection of solution is not based on consideration of criteria and constraints.	Selects a promising solution based on criteria and constraints.	Selects a promising solution based on a thorough analysis of criteria and constraints.
Developing a Design Proposal	Design proposal is inadequate, lacking pertinent information.	Design proposal is adequate, containing all pertinent elements.	Design proposal is accurate and comprehensive.
Making a Model or Prototype	Prototype meets the task criteria to a limited extent.	Prototype meets the task criteria.	Prototype meets the task criteria in insightful ways.
Testing and Evaluating the Design Using Specifications	Testing and evaluation processes are inadequate.	Testing and evaluation processes are adequate for refining the problem solution.	Testing processes are innovative.
Refining the Design	Refinement based on testing and evaluation is not evident.	Refinements made based on testing and evaluation results.	Significant improvement in the design is made based on prototype testing and evaluation.
Creating or Making It	Finished solution (product) fails to meet specifications.	Finished solution (product) meets specifications.	Finished solution (product) exceeds specifications.
Communicating Processes and Results	Solution presented with limited accuracy. Limited supporting evidence on how the solution meets the task criteria.	Solution presented accurately. Some supporting evidence on how the solution meets the task criteria.	Solution presented concisely with clarity and accuracy. Extensive supporting evidence on how the solution meets the task criteria.

Assessment Instrument – Brief Constructed Response Items

1. Describe the relationship between current, voltage, and resistance in an electrical technology system.
2. Define and describe several examples of resistance acting in a positive way in an electrical technology system.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

1. Explain how electrical systems enhance human capabilities.
2. Describe several factors that affect an electrical system's efficiency.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important, evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause-and-effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate, and precise language. Cohesive organization. Very few grammatical errors.

Resources for Problem Solving Activities/Competitions

Problem Solving / Pre-Engineering, Product Gateway, Tech Directions
www.techdirections.com/projectsP.html

ASME Pre-College Education, High School Engineering
www.asme.org/education/precollege/bestpractice/bpengweek.htm

High School Student Engineering Competitions and Undergraduate Engineering Competitions
www.engineerinyou.com/competitions.html

Pre-Engineering Competitions
www.engineeringedu.com/competitions.html

High School Resource Center
Competitions and Research Opportunities
www.venturescholar.org/resource/competitions-hs.html

Future City Competition
www.futurecity-phoenix.org/VirtualEngineer/Eng101/EngExplain.htm

American Society for Engineering Education
Competitions and Special Programs
www.engineeringk12.org/students/resources/competitions_special_programs.htm

Junior Engineering Technical Society
Student Competitions
www.jets.org/resources/students.cfm

Society of Manufacturing Engineers
Robotic Technology and Engineering Challenge
www.sme.org/cgi-bin/eduhtml.pl?/educat/srcpg.html&&&SME&

The National Engineering Design Challenge (NEDC)
www.udeducation.org/teach/shortevents/competitions/nedc.asp

Unit 3 – Lesson 6

Reverse Engineering

Lesson Duration: Six (6) hours

Standards

- Students will develop an understanding of the attributes of design (ITEA/STL-8)
- Students will develop an understanding of engineering design (ITEA/STL-9)
- Students will develop an understanding of the physical setting. (Design and Systems) (AAAS-BSL)
- Students will develop an understanding of the habits of mind (Manipulation and Observation) (AAAS-BSL)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. • Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. • Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. • Technological ideas are sometimes protected through the process of patenting.	• In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. • Risk analysis is used to minimize the likelihood of unwanted side effects of a new technology. • Different kinds of materials respond differently to electric forces.	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics. • Use the language of mathematics to express ideas precisely.

Learning Objectives

Students will:

1. Explain the reverse-engineering process.
2. Reverse-engineer a product.
3. Follow step-by-step directions to assemble and disassemble a product.
4. Identify criteria and constraints and explain how these will affect the design process.
5. Identify a system's electrical components and their interrelationships as part of the reverse-engineering process.
6. Identify a system's mechanical components and their interrelationships as part of the reverse-engineering process.
7. Make two-dimensional and three-dimensional representations of a product.
8. Test and evaluate a design in relation to pre-established requirements.
9. Calculate the mechanical advantage of simple machines in an electro-mechanical system.
10. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials

Print-Based Sources

1. *Basic Electricity* by Nooger Van Valkenburgh, Prompt (DPI - 8/01); 1st Edition, 1995, ISBN: 0790610418
2. *Basic Electricity: A Self-Teaching Guide* (Wiley Self-Teaching Guides) by Charles Ryan, Wiley Press; 2nd Edition (1986), ISBN: 0471850853
3. Schematic Diagrams by Richard Johnson, Prompt (DPI - 8/01); 1st Edition (1994), ISBN: 0790610590

Audiovisual Materials

1. Tell Me Why: Electricity & Safety (1991), Color, NTSC, Vision Quest Video, VHS, ASIN: 6302086647
2. Electricity & Electric Safety, Color, Animated, NTSC, Vision Quest Video, 1998, VHS, ASIN: B00000INC6
3. Careers: Engineering Occupations (1997) Color, Closed-captioned, VHS Features: NTSC format ASIN: 1579980740

Internet Sites

1. Basic electricity – www.reprise.com/host/electricity/default.asp
2. What Is Reverse Engineering? – www.npd-solutions.com/reoverview.html
3. Ohms Law – www.grc.nasa.gov/WWW/K-12/Sample_Projects/Ohms_Law/ohmslaw.html

Purpose of Lesson

To familiarize students with reverse engineering (RE), the process of taking something (a device, an electrical component, a software program, etc.) apart and analyzing its workings in detail, usually with the intention to construct a new device or program that does the same thing without actually copying anything from the original.

Required Knowledge and/or Skills

Students should have some understanding of the functioning and applications of mechanical and electrical technology systems, their common components, basic system design, safety considerations, and simple controls. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Lesson 3-6

Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to reverse engineering (RE).
2. The teacher will state that reverse engineering is the systematic process of obtaining critical design and engineering information from an existing product.
3. The teacher will present students with an easily recognized technology system that might have been subjected to the reverse engineering process. (power hand drill)
4. Students will be asked to identify the engineering resources (core technologies) that are present in the technology system.
5. Students will be asked to speculate on why an individual or organization might want to reverse engineer an existing product.

Exploration

1. Students will read article "How Soviets Copied America's Best Bomber During WWII." (See http://archives.cnn.com/2001/US/01/25/smithsonian.cold.war/)
2. Students will think about the technological and political implications of the event.

Explanation

1. The teacher will lead a discussion of the article, "How Soviets Copied America's Best Bomber During WWII."
2. The teacher will state that reverse engineering (RE) is the process of taking something (a device, an electrical component, a software program, etc.) apart and analyzing its workings in detail, usually with the intention to construct a new device or program that does the same thing without actually copying anything from the original.
3. The teacher will explain that resulting knowledge gained through the reverse engineering process can then be applied to the design of similar products and that capitalizing on successes and learning from the shortcomings of existing designs is the objective of reverse engineering.
4. The teacher will describe the steps in the reverse engineering process.
   a. Prediction
   a. What is the purpose of this product?
   b. How does it work?
   c. What market was it designed to appeal to?
   d. List some of the design objectives for the product.
   e. List some of the constraints that may have influenced the design.
   b. Observation
      - How do you think it works?
      - How does it meet design objectives (overall)?
      - Why is it designed the way it is?
   c. Disassemble
      - How does it work?
      - How is it made?

- How many parts?
- How many moving parts?
- Any surprises?

d. Analyze
- Carefully examine and analyze subsystems (i.e. structural, mechanical, and electrical) and develop annotated sketches that include measurements and notes on components, system design, safety, and controls.

e. Test
- Carefully reassemble the product.
- Operate the device and record observations about its performance in terms of functionality (operational and ergonomic) and projected durability.

f. Documentation
- Inferred design goals
- Inferred constraints
- Design (functionality, form (geometry), and materials)
- Schematic diagrams
- Lists (materials, components, critical components, flaws, successes, etc.)
- Identify any refinements that might enhance the product's usefulness.
- Upgrades and changes

5. The teacher will review sketching techniques and demonstrate how to make a simple electrical schematic drawing.
6. The teacher will review Ohm's Law used to analyze and modify an existing electrical circuit.
7. The teacher will review how to calculate mechanical advantage in a mechanical system.
8. Students will restate any questions that were not answered in the teacher's lecture and clarify any ambiguities.

Extension

1. The teacher will present an electromechanical product that will be reverse engineered and will provide students with the criteria for the processes including the analyzing of the functioning of the electrical or electronic components, making a pictorial and schematic drawing of the electrical circuit, and adding an electrical component to the circuit to improve its performance or usability.
2. Working in small groups, students will reverse engineer a product.
3. Students will make written or oral presentations on their recommendations for further refinement of the problem solution.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, group work, reverse engineering, brief constructed responses, and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities

1. Students will create a display of the product analyzed in the reverse engineering activity.
2. Students will identify products that might be improved by going through the reverse engineering process.

Laboratory-Classroom Preparation
The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, testing and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, design tools and equipment, fabrication tools and equipment, and testing tools should be readied.

Tools/Materials/Equipment
- Computers with Internet Access
- Design tools
- Fabrication tools and equipment
- Testing apparatus

Laboratory-Classroom Safety and Conduct
1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson 3-6 Assessment Instruments

Assessment Instrument – Selected Response Item

Directions: Circle the T or F in the column to the left of each true (T) or false (F) statement.

T	F	1.	The systematic process of obtaining critical design and engineering information from an existing product is called reverse engineering.
T	F	2.	Reverse engineering for the sole purpose of copying or duplicating programs constitutes a copyright violation and is legal.
T	F	3.	Hardware reverse engineering involves reversing a program's machine code.
T	F	4.	Software reverse engineering involves taking apart a device to see how it works.
T	F	5.	Reverse engineering involves producing 3D images of manufactured parts when a blueprint is not available in order to remanufacture the part.
T	F	6.	In general, hardware reverse engineering requires little expertise and is quite inexpensive.
T	F	7.	Forward engineering is the traditional process of moving from high-level abstractions and logical designs to the physical implementation of a system.
T	F	8.	Reverse engineering is uncommon in such diverse fields as software engineering, entertainment, automotive, consumer products, microchips, chemicals, electronics, and mechanical designs.
T	F	9.	Reverse engineering enables the duplication of an existing part by capturing the component's physical dimensions, features, and material properties.
T	F	10.	Reverse engineering is typically cost effective only if the items to be reverse engineered reflect a high investment or will be reproduced in large quantities.

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class, attempts to answer teacher-generated questions.	Well prepared for class, attempts to answer teacher-generated questions, and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation for Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily, is not engaged. Has difficulty remaining on task.	Makes good use of class time to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative. Does little work. Rarely offers useful ideas.	Cooperative. Works at assignments. Usually offers useful ideas	Always willing to help and do more. Does more than required. Routinely offers useful ideas.
Cooperation	Rarely listens to, shares with, or supports the efforts of others. Often is not a good team member.	Usually listens to, shares with, and supports the efforts of others. Does not cause problems in the group.	Always listens to, shares with, and supports the efforts of others. Tries to keep people working together.
Focus on the task	Does not focus on the task and what needs to be done. Lets others do the work.	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done. Self-directed.

Assessment Instrument – Reverse Engineering

Category	Below Target	At Target	Above Target
Contributions	Fails to identify user need. Does not describe the function and principles that solve these needs. Identifies few design objectives. Identifies few constraints.	Identifies user needs. Adequately describes the function and principles that solve these needs. Identifies some design objectives. Identifies some constraints.	Identifies user needs and completes market analysis. Completely describes the functions and principles that solve these needs. Identifies design objectivesIdentifies constraints.
Observation	Partially answers the following questions: • How does it operate? • How does it meet design objectives (overall)? • Why is it designed the way it is?	Adequately answers the following questions: • How does it operate? • How does it meet design objectives (overall)? • Why is it designed the way it is?	Completely answers the following questions: • How does it operate? • How does it meet design objectives (overall)? • Why is it designed the way it is?
Disassemble	Fails to adequately answer the following questions: • How is it made? • How many parts? • How many moving parts? • Any surprises?	Adequately answers the following questions: • How is it made? • How many parts? • How many moving parts? • Any surprises?	Completely answers the following questions: • How is it made? • How many parts? • How many moving parts? • Any surprises?
Analyze	Inadequately analyzes components using sketches and schematic drawings. Does not explain how the device meets the design objectives	Adequately analyzes components using sketches and schematic drawings. Explains how the device meets the design objectives	Completely analyzes geometry, mechanics, electronics, individual components, as a complete system using sketches and schematic drawings. Explains how the device meets the design objectives Identifies alternatives that the original designers may have considered.
Test	Partially evaluates performance including addressing functionality.	Evaluates performance including addressing functionality.	Thoroughly evaluates performance addressing functionality and durability.
Documentation	Incomplete formal report and inaccurate schematic diagrams.	Formal report addressing: • Inferred design goals • Constraints • Functionality • Components • Manufacturability • Accurate schematic diagrams	Complete formal report addressing: • Inferred design goals§ Constraints • Functionality • Form – geometry and materials • Components • Component interaction system • Physical principles • Manufacturability • Accurate schematic diagrams

Assessment Instrument – Brief Constructed Response Items

1. Describe the relationship between current, voltage, and resistance in an electrical technology system.
2. Define and describe several examples of resistance acting in a positive way an electrical technology system.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

1. What is reverse engineering and why might it be employed?
2. How is knowledge of electrical technology used in the reverse engineering process?

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important, evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause-and-effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate, and precise language. Cohesive organization. Very few grammatical errors.

Unit 3 – Lesson 7

An Introduction to Fluid Technology

Lesson Duration: Ten (10) hours

Standards

- Students will develop an understanding of the attributes of design (ITEA/STL-8)
- Students will develop an understanding of engineering design (ITEA/STL-9)
- Students will develop an understanding of and be able to apply the design process (ITEA/STL-11)
- Students will develop an understanding of the physical setting. (Design and Systems) (AAAS-BSL)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. • Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. • Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. • Technological ideas are sometimes protected through the process of patenting. • A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. • Identify the design problem and decide whether or not to address it. • Identify criteria and constraints and determine how these will affect the design process. • Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. • Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. • Develop and produce a product or system using a design process. • Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.	• In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. • Risk analysis is used to minimize the likelihood of unwanted side effects of a new technology. • To reduce the chance of system failure, performance testing is often conducted using small-scale models, computer simulations, analogous systems, or just the parts of the system thought to be least reliable.	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics. • Use the language of mathematics to express ideas precisely.

Learning Objectives

Students will:

1. Differentiate between hydraulic and pneumatic systems and provide examples of appropriate applications of each.
2. Differentiate between open (e.g., irrigation, forced hot air system) and closed (e.g., forced hot water system, hydroponics) fluid systems and their components such as valves, controlling devices, and metering devices.
3. Identify and explain sources of resistance (e.g., 45° elbow, 90° elbow, type of pipes, changes in diameter) for water moving through a pipe.
4. Explain the relationship between velocity and cross-sectional areas in the movement of a fluid.
5. Describe factors that affect a fluid system's efficiency.
6. Analyze the functioning of the fluid systems in the designed world in terms of common components, basic system design, safety, simple controls, and system performance evaluation.
7. Apply mathematics and science skills and concepts to the analysis of fluid systems.
8. Apply the engineering design process to solve a problem.
9. Work safely and accurately with a variety of tools, machines, and materials.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials

Print-Based Sources

1. *Fluid Power Technology* by Robert P. Kokernak (Merrill's International Series in Engineering Technology), Merrill Pub Co (1993) ISBN: 002305705X
2. *Fluid Power Technology* by F. Don Norvelle, Thomson Delmar Learning; 1st Edition (1994) ISBN: 0314012184
3. *Introduction to Fluid Power* by James Johnson, Thomson Delmar Learning; 1st Edition (2001) ISBN: 0766823652

Audiovisual Materials

1. Discovering Fluid Power: Hydraulics and Pneumatics at Work in Your World, Video – www.manufacturingiscool.com/cgi-bin/mfgcoolhtml.pl?/progs/000094.htm&
2. Discovering Fluid Power: Hydraulics and Pneumatics at Work in Your World, The Fluid Power Educational Foundation and Lego – www.fpef.org/video.html

Internet Sites

1. Boyle's Law, (excellent animated explanation) – www.grc.nasa.gov/WWW/K-12/airplane/boyle.html
2. Hydraulic Robot Arm Design Activity – www.ic.sunysb.edu/Stu/ppoggio/hydraulics/hydraulics.html
3. Students Get a Grip on Robotics – www.washingtonmesa.org/act_Main.cfm?act=55&mID=51

Purpose of Lesson

To familiarize students with the functioning and applications of fluid technology systems by having them analyze the functioning of fluid systems in terms of their common components, basic system design, safety considerations, and simple controls.

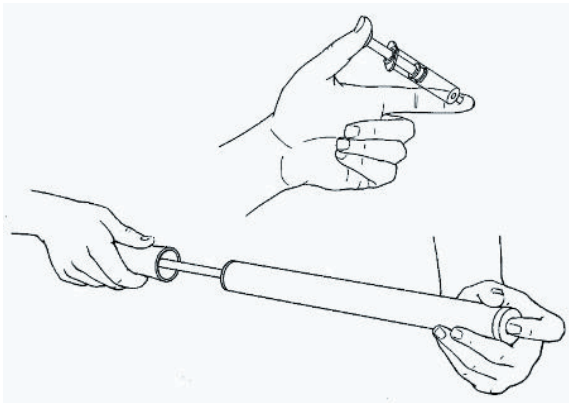
Required Knowledge and/or Skills

To meet this lesson's objectives, students should be familiar with the core technologies, the building blocks of the designed world. Students should learn the core technologies as they are applied in the designed world. They should be familiar with common components, basic system design, safety, simple controls, and system performance evaluation.

Lesson 3-7

Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to the functioning and applications of fluid technology systems.
2. The teacher will state that a technology system is a group of resources (subsystems) working together to solve problems and extend human capabilities.
3. The teacher will present students with a fluid technology system in the form of a bicycle tire pump.
4. The teacher will plug the bicycle pump's air hose with a stopper so air cannot escape the pump.



5. Letting the pump stand alone shows the students that the pump's handle will not fall all the way down. (Teacher note: This is because the air molecules are compressed, and the pressure inside the pump is holding the handle at certain spot.)
6. Students will be asked to speculate on how and why this happens.
7. Have a student volunteer push down on the handle and ask them to tell the class what he or she feels. (Teacher note: It should become harder to push down or the student may feel that something is pushing against the handle.) The harder the student pushes, the more the molecules become compressed. This creates an increase in the air pressure that already existed inside the pump.
8. Ask the student to let go of the handle and observe what happens. (Teacher note: The handle should rise up to original position.) The increased pressure created by forcing the molecules closer together will push the handle upward until the pressure is equalized.

9. Place the pump on top of the hot plate and let the pump heat up. (Teacher note: Pay close attention! Do not leave this unattended! Too much increased internal pressure may cause a dangerous situation.) The heat causes the molecules inside the pump to move farther apart, taking up more space. This increases the pressure, and the handle will begin to rise.
10. Remove the pump from the hot plate and allow it to cool inside the bucket of ice visible for all students to observe. As the inside molecules begin to cool they will become closer together. This will take up less space, and the handle will fall down.

Exploration:

1. Student groups will be given syringes and air pressure gauges.

Teaching Opportunity

When teaching this lesson and developing your group work, learn and/or implement the elements of cooperative learning: positive interdependence; face-to-face interaction; individual accountability; interpersonal and small group skills; and group processing.
http://edtech.kennesaw.edu/intech/cooperativelearning.htm

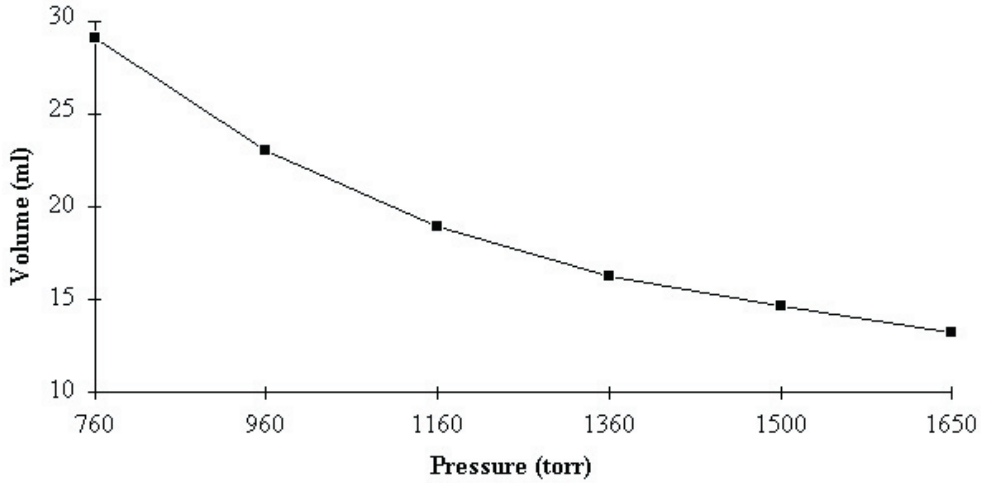
2. Students will be asked to connect a syringe to trap a small quantity of air in a syringe (a piston inside a cylinder) connected to the pressure gauge, and measure both the volume of air trapped inside the syringe and the pressure reading on the gauge.

Pressure (torr)	Volume (ml)

Sample data may look like this:

Pressure (torr)	Volume (ml)
760	20.0
960	23.0
1160	19.0
1360	16.2
1500	14.7
1650	13.3

3. Students will create a graph from the data collected with the "y" axis being Volume and the "x" axis being Pressure.



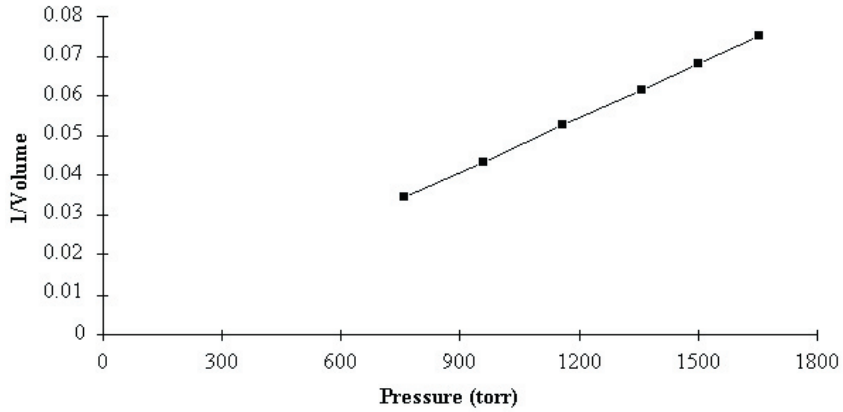
4. Students will be asked to speculate on the relationship between the pressure measurements and the volume measurements.

Explanation

1. To explore relationship between the pressure measurements and the volume measurements, we try to plot the data in such a way that both quantities increase together. This can be accomplished by plotting the pressure versus the inverse of the volume, rather than versus the volume.

   The data are given in the table above are plotted here:

Pressure (torr)	Volume (ml)	1/Volume (1/ml)
760	29.0	0.0345
960	23.0	0.0435
1160	19.0	0.0526
1360	16.2	0.0617
1500	14.7	0.0680
1650	13.3	0.0752



2. Notice that the data points form a straight line. Furthermore, the straight line seems to connect to the origin 0, 0.
3. This means that the pressure must simply be a constant multiplied by 1/V.
4. P=[k×1/V]
5. If we multiply both sides of this equation by V, then we notice that PV=k.
6. Boyle's Law states that pressure and volume of an ideal gas are inversely proportional.
7. The concept of Boyle's Law is that when the pressure of a gas is increased or decreased, the volume of the gas changes inversely proportional to it.
8. A gas that has an increase in pressure will have a decrease in its volume.
9. A gas that decreases in pressure will increase in volume. Therefore, it is inversely proportional.
10. The formula used for Boyle's Law is P1V1=P2V2 or PV=k.
11. The function of a syringe works in accordance to Boyle's Law.
12. When the syringe top is pulled to allow a solution enter it, the volume is increased while the pressure is decreasing
13. When the top of the syringe is pushed, the volume is decreased and the pressure inside the syringe is increased.
14. The teacher will define fluid technology as the technology of using fluid, either gaseous (pneumatics) or liquid (hydraulic) to apply force or to transport.
15. The teacher will differentiate between open (e.g., irrigation, forced hot air system) and closed (e.g., forced hot water system, hydroponics) fluid systems and their components such as valves, controlling devices, and metering devices.
16. The teacher will identify and explain sources of resistance (e.g., 45° elbow, 90° elbow, type of pipes, changes in diameter) for water moving through a pipe.
17. The teacher will explain the relationship between velocity and cross-sectional areas in the movement of a fluid.
18. The teacher will explain that all fluid systems have two things in common.
19. First, each system contains a fluid, either liquid or gas, that moves through a system.
    a. Second, a pressure difference in the system creates a net force, which causes fluids to move or perform some special function like pushing a piston or opening or closing a valve.
    b. Show the contrast between the behaviors of gas and liquid by filling a syringe with water, and then pushing on the piston.
20. The teacher will differentiate between hydraulic and pneumatic systems and provide examples of appropriate applications of each.
21. Students will restate any questions that were not answered in the teacher's lecture and clarify any unresolved issues.

Extension

1. The teacher will present a problem that requires the design and fabrication of a hydraulic robot.
2. The teacher will review the criteria and constraints related to the problem. Note: Examples of problem-solving activities include:
    a. Hydraulic Robot Challenge – www.ic.sunysb.edu/Stu/ppoggio/hydraulics/teachers.html
    b. Design Process Of Robotic Arm – http://wid.hdsb.ca/grassroots2003/grassroots/CLARKE-WINSLOW/roboticarmprocess.htm
    c. Mars Challenge – www.aetheronline.com/mario/Armagh/Planetarium/Armagh/SMC.htm
    d. Pump It Up – www.mcps.k12.md.us/curriculum/teched/Challenge2002/c_pump.html

3. The teacher will demonstrate the procedures and apparatus to be used to test problem solutions.
4. The teacher will provide instruction on the science and mathematics concepts that may be of significance in the solution of the problem.
5. The teacher will provide instruction in the use of tools, equipment, materials, and processes required in designing, representing graphically, and constructing a problem solution.
6. The teacher will observe student activity, ask questions to assist students in focusing on problems, facilitate the use of resources, and provide additional instruction when necessary.
7. Students will conduct final testing of the problem solutions and document results.
8. Students will make written or oral presentations on their recommendations for further refinement of the problem solution.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, group work, engineering design, brief constructed responses, and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Identify or Develop Extension Activities

1. Students will create an instructional aid that describes the functioning of a fluid system.
2. Students will create a display of a fluid system from a household item they disassemble.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, production and fabrication, product/prototype testing and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, design tools and equipment, fabrication tools and equipment, and testing tools should be readied.

Tools/Materials/Equipment

- Bicycle pump
- Hot plate
- Bucket of ice cubes
- Stopper for air hose
- Oven mittens
- Syringes
- Plastic tubing
- Air pressure gauge
- Rulers

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Assessment Instrument – Selected Response Items

Match the terms in Column II with the statements in Column I.

	Column I	Column II	
	A push or a pull	A	Force
	A sliding plug that fits closely inside the bore of a cylinder	B	Actuator
	A chamber in a pump from which the piston expels fluid	C	Closed System
	A liquid or a gas	D	Cylinder
	How much space an object occupies	E	Fluid
	A force applied over an area	F	Fluid Technology
	A sliding piece moved or moving against fluid pressure in a cylinder	G	Piston
	The technology of putting together mechanical parts to produce, control, and transmit motion	H	Pressure
	A mechanical device for moving or controlling something	I	Pump
	A system in which there is no place for either additional storage or release of fluid	J	Valves
		K	Volume

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class, attempts to answer teacher-generated questions.	Well prepared for class, attempts to answer teacher-generated questions, and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation for Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily, is not engaged. Has difficulty remaining on task.	Makes good use of class time to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative. Does little work. Rarely offers useful ideas.	Cooperative. Works at assignments. Usually offers useful ideas	Always willing to help and do more. Does more than required. Routinely offers useful ideas.
Cooperation	Rarely listens to, shares with, or supports the efforts of others. Often is not a good team member.	Usually listens to, shares with, and supports the efforts of others. Does not cause problems in the group.	Always listens to, shares with, and supports the efforts of others. Tries to keep people working together.
Focus on the task	Does not focus on the task and what needs to be done. Lets others do the work.	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done. Self-directed.

Assessment Instrument – Engineering Design

Category	Below Target	At Target	Above Target
Defining the Problem	Rephrases the problem with limited clarity.	Rephrases the problem clearly.	Rephrases the problem clearly and precisely.
Brainstorming	Contributes few or implausible ideas.	Contributes a plausible idea.	Contributes multiple plausible ideas.
Researching and Generating Ideas	Contributes ideas but without documented research. Produces incomplete sketches. Does not present a concept.	Contributes one plausible idea based on documented research. Produces marginally accurate pictorial and orthographic sketches of design concepts.	Contributes multiple plausible ideas based on documented research. Produces accurate pictorial and orthographic sketches of design concepts.
Identifying Criteria and Specifying Constraints	Does not restate the criteria clearly and fails to identify constraints.	Restates the criteria clearly and identifies several constraints.	Restates the criteria clearly and precisely and identifies many constraints.
Exploring Possibilities	Inadequately analyzes the pluses and minuses of a variety of possible solutions.	Satisfactorily analyzes the pluses and minuses of a variety of possible solutions.	Thoroughly analyzes the pluses and minuses of a variety of possible solutions.
Selecting an Approach	Selection of solution is not based on consideration of criteria and constraints.	Selects a promising solution based on criteria and constraints.	Selects a promising solution based on a thorough analysis of criteria and constraints.
Developing a Design Proposal	Design proposal is inadequate, lacking pertinent information.	Design proposal is adequate, containing all pertinent elements.	Design proposal is accurate and comprehensive.
Making a Model or Prototype	Prototype meets the task criteria to a limited extent.	Prototype meets the task criteria.	Prototype meets the task criteria in insightful ways.
Testing and Evaluating the Design Using Specifications	Testing and evaluation processes are inadequate.	Testing and evaluation processes are adequate for refining the problem solution.	Testing processes are innovative.
Refining the Design	Refinement based on testing and evaluation is not evident.	Refinements made based on testing and evaluation results.	Significant improvement in the design is made based on prototype testing and evaluation.
Creating or Making It	Finished solution (product) fails to meet specifications.	Finished solution (product) meets specifications.	Finished solution (product) exceeds specifications.
Communicating Processes and Results	Solution presented with limited accuracy. Limited supporting evidence on how the solution meets the task criteria.	Solution presented accurately. Some supporting evidence on how the solution meets the task criteria.	Solution presented concisely with clarity and accuracy. Extensive supporting evidence on how the solution meets the task criteria.

Assessment Instrument – Brief Constructed Response Items

1. Compare and contrast an open (e.g., irrigation, forced hot air system) and closed (e.g., forced hot water system, hydroponics) fluid systems and their components such as valves, controlling devices, and metering devices.
2. Identify and explain sources of resistance (e.g., 45° elbow, 90° elbow, type of pipes, changes in diameter) for water moving through a pipe.
3. Explain the relationship between velocity and cross-sectional areas in the movement of a fluid.
4. Describe several examples of the effect of gravity on a fluid technology system.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

1. Differentiate between hydraulic and pneumatic systems and provide examples of appropriate applications of each.
2. Compare and contrast an open (e.g., irrigation, forced hot air system) and closed (e.g., forced hot water system, hydroponics) fluid systems and their components such as valves, controlling devices, and metering devices.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important, evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause-and-effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate, and precise language. Cohesive organization. Very few grammatical errors.

Unit 3 – Lesson 8

An Introduction to Thermal Technology

Lesson Duration: Ten (10) hours

Standards

- Students will develop an understanding of the attributes of design (ITEA/STL-8)
- Students will develop an understanding of engineering design (ITEA/STL-9)
- Students will develop an understanding of the physical setting. (Design and Systems) (AAAS-BSL)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. • Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.	• Whenever the amount of energy in one place or form diminishes, the amount in other places or forms increases by the same amount. • Heat energy in a material consists of the disordered motions of its atoms or molecules. • Transformations of energy usually produce some energy in the form of heat, which spreads around by radiation or conduction into cooler places.	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics. • Use the language of mathematics to express ideas precisely.

Learning Objectives

Students will:

1. Define terms related to thermal technology.
2. Explain the difference between heat and thermal energy.
3. Explain the relationship between heat transferred to an object and the change in the object's temperature.
4. Describe the heat transfer processes of conduction, convection, and radiation.
5. Describe a situation in which you would use a material with a high thermal conductivity and a situation where you would use a material with low thermal conductivity.
6. Conduct and experiment.
7. Calculate the thermal resistance of a multiple layer exterior wall.
8. Work safely and accurately with a variety of tools, machines, and materials.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials

Print-Based Sources

1. *Heat Fundamentals: Funtastic Science Activities for Kids* by Robert W. Wood, Rick Brown (Illustrator), Chelsea House Publications (1997): ISBN:079104842X
2. *Turning Kids on to Science in the Home: Book 2*, *Energy: Easy to Follow Recipes for Doing 120 Science Activities on Heat, Magnetism, Electricity* by Tik L. Liem, Science Inquiry Enterprises (1992) ISBN: 1878106058
3. *Handbook of Applied Thermal Design* by Eric C. Guyer (Editor), David L. Brownell (Editor), Taylor & Francis Group; New Ed edition (1999) ISBN: 156032811

Audiovisual Materials

1. Heat Transfer, Bitesize In Video, BBC – www.bbc.co.uk/schools/gcsebitesize/physics/
2. Mr. Wizard's World™ Science Video: Heat Transfer, Item number IC29112 – www.etacuisenaire.com/catalog/product?deptId=OUTLET&prodId=29112&parentId=&bc=1
3. Science Inquiry Videos, VT5 - Volume 5 on ENERGY & HEAT (45 min.) – www.scienceinquiry.com/videos.htm

Internet Sites

1. Specific thermal resistance of various materials – www.repp.org/discussiongroups/resources/stoves/Escardo/valores%20R.htm
2. Insulation – www.ornl.gov/sci/roofs+walls/insulation/ins_02.html
3. Heat Transfer – www.school-for-champions.com/science/heattransfer.htm

Purpose of Lesson

To familiarize students with the functioning and applications of thermal technology systems by having them analyze the functioning of thermal systems in terms of their common components, basic system design, safety considerations, and simple controls.

Required Knowledge and/or Skills

To meet this lesson's objectives, students should be familiar with the core technologies, the building blocks of the designed world. Students should be familiar with the core technologies as they are applied in the designed world. They should be familiar with common components, basic system design, safety, simple controls, and system performance evaluation.

Lesson 3-8

Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to the functioning and applications of thermal technology systems.
2. The teacher will bounce a basketball several times and ask students if there is any change in temperature inside the ball after several bounces. (Mechanical energy is converted into thermal energy whenever you bounce a ball. Each time the ball hits the ground, some of the

energy of the ball's motion is converted into heating up the ball, causing it to slow down at each bounce)

3. Teacher will show infrared image of basketball before and after being bounced (http://cool-cosmos.ipac.caltech.edu/image_galleries/ball.html)
4. The teacher will show the class a picture of an iceberg and a boiling pot of water.
5. The teacher will ask the following question: "Which object contains the most heat, a boiling pot of water or a gigantic iceberg?"
6. Students will present and justify their answers.

Exploration

1. Student groups will investigate one of the properties of heat energy using the following apparatus. (can painted white, can painted black, graduated cylinder, water, two thermometers, incandescent light (200W lamp or floodlight), measuring tape or ruler, stopwatch)
2. Students will use the graduated cylinder to measure an equal amount of water into both containers so that they are about half full.
3. Students will measure the temperature of the water in each container and record these temperatures as the temperatures at time zero minutes in the table below.
4. Students will set the light so that it is the same distance from each container. Turn the lamp on and start the timer. After one minute, measure and record the temperature in each container. Continue to measure and record the temperature of each container every minute for ten minutes.
5. Students will construct a graph of time vs. temperature for your investigation. Plot the data from each container on the same graph using a different color for each container.

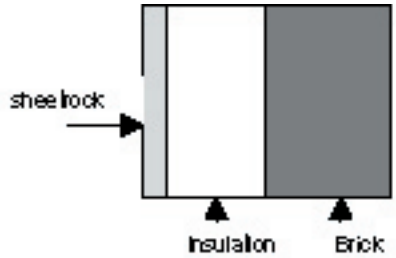
TIME (MINUTES	TEMPERATURE OF WHITE CAN (C)	TEMPERATURE OF BLACK CAN (C)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

6. Student groups will answer the following questions:
   a. Which container showed the greater increase in temperature?
   b. Which container absorbed more energy and how do you know this?
   c. What was the source of heat in this experiment?
   d. What were the controlled factors in this experiment?
   e. Why was it important to keep these factors the same for both containers?
   f. If you were going to use radiant energy from the Sun to heat your home, what colors would be best to use? Explain your answer.
   g. If the containers used in this experiment were filled with hot water, which one do you think would cool off more slowly? Explain your answer.
   h. Describe an experiment that you could do to test your hypothesis.

Explanation

1. The teacher will explain that engineers occasionally need the answer to a question in order to proceed with a design.
2. The teacher will review the exploratory activity and clarify answers to the questions posed in the exploratory activity and point out that research and experimentation is another problem-solving process used in engineering enterprises.
3. The teacher will review the definition of thermal technology (the technology of producing, storing, controlling, transmitting and getting work from heat energy) and remind them of some applications of thermal technology including the furnace, hot water heater, toaster, insulation, heat exchanger, refrigerator, jet engine, and hot air balloon.
4. The teacher will review the following concepts:
   a. The Universe is made up of matter and energy.
   b. Matter is made up of atoms and molecules (groupings of atoms) and energy causes the atoms and molecules to always be in motion—either bumping into each other or vibrating back and forth.
   c. The motion of atoms and molecules creates a form of energy called heat or thermal energy that is present in all matter.
   d. Thermodynamics is the science dealing with internal energy, heat, and work.
   e. Even in the coldest voids of space, matter has a very small but still measurable amount of heat energy.
   f. Energy can take on many forms and can change from one form to another.
   g. Many different types of energy can be converted into heat energy: Light, electrical, mechanical, chemical, nuclear, sound, and thermal energy itself can each cause a substance to heat up by increasing the speed of its molecules.
   h. Put energy into a system and it heats up, take energy away and it cools. (For example, when we are cold, we can jump up and down to get warmer.)
5. The teacher will describe a few examples of various types of energy being converted into thermal energy (heat) including:
   a. Mechanical energy is converted into thermal energy whenever you bounce a ball.
   b. Thermal energy can be transferred to other objects causing them to heat up. (When you heat up a pan of water, the heat from the stove causes the molecules in the pan to vibrate faster causing the pan to heat up. The heat from the pan causes water molecules to move faster and heat up. So, when you heat something up, you are just making its molecules move faster.)
   c. Electrical energy is converted into thermal energy when you use objects such as heating pads, electrical stove elements, toasters, hair dryers, or light bulbs.
   d. Chemical energy from the foods we eat is converted into heating our bodies.
   e. Light from the sun is converted to heat as the sun's rays warm the earth's surface.
   f. Energy from friction creates heat. For example when you rub your hands, sharpen a pencil, make a skid mark with your bike, or use the brakes on your car, friction generates heat.
6. The teacher will explain that heat can be transferred from one place to another by three methods: conduction in solids, convection of fluids (liquids or gases), and radiation through anything that will allow radiation to pass.
7. The teacher will state that:
   a. Thermal resistance is a measure of an object's ability to oppose heat transfer.
   b. Materials with high thermal resistance are used to insulate an object or a region of space.
8. The teacher will explain that walls are often constructed of layers of materials of varying thermal conductivity. (A house wall may consist of a layer of .5-inch sheetrock, a layer of 3-inch thick insulation, and an outer layer of brick 4 inches thick.)

9. The teacher will demonstrate how to calculate the thermal resistance of a 25' by 12' section of the wall pictured below.



Material	Thermal Conductivity Btu • ft2• °F
Sheetrock	5.2
Insulation	0.32
Brick	408

Solution: The area of the wall is A= 25 ft x 12 ft = 300 ft^2

Calculate the thermal resistance of each layer, where

$$R\ thermal = \frac{\text{thickness of material(in)}}{\text{thermal conductivity x area of wall}}$$

$$R1 = \frac{0.5\ in}{5.2 \times 300\ ft^2} = 0.00032\ \frac{h \cdot °F}{Btu}$$

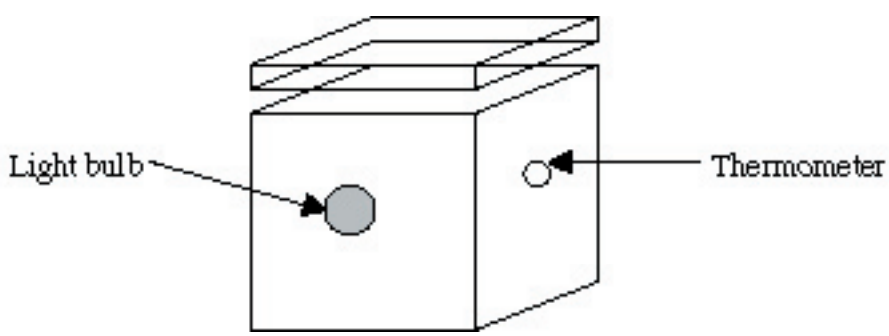
$$R2 = \frac{3\ in}{.32 \times 300\ ft^2} = 0.031\ \frac{h \cdot °F}{Btu}$$

$$R3 = \frac{4\ in}{4.8 \times 300\ ft^2} = 0.0028\ \frac{h \cdot °F}{Btu}$$

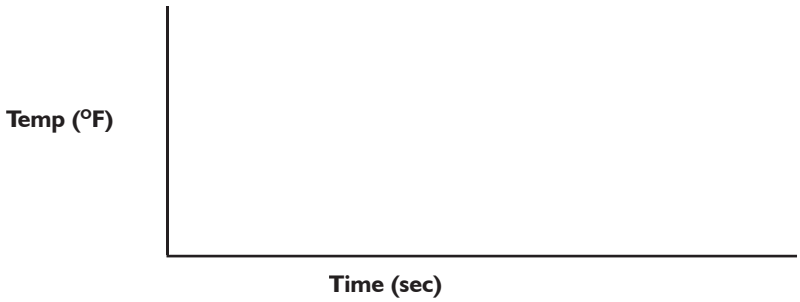
$$R\ total = R1 + R2 + R3 = (0.00032 + 0.031 + 0.0028) = 0.034\ \frac{h \cdot °F}{Btu}$$

Extension

1. The teacher will present a problem that requires the students to determine which home insulating material holds heat best. (The teacher will provide a box that will keep heat in. The box will be heated with a lightbulb and a thermometer will be used measure the drop in temperature.)



2. Materials to be tested may include pink insulation, Styrofoam, sawdust, newspaper, and cotton.
3. The teacher will assist students in identifying the variables in the experiment.
   a. Manipulated variable – the type of material being tested
   b. Responding variable – temperature
   c. Controlled variables – amount of heat in the box, outside heat sources, where heat escapes, room temperature, measurement error)
4. The box is preheated for 15 minutes using the lightbulb, before every test.
5. First, record the temperature drop for the box without any lining material. This provides an asset of data to compare various lining materials.
6. Students will line the box with the materials they select and measure the temperature every 30 seconds. Repeat this process twice and average the results.
7. After the data has been collected, the results are recorded on the chart, and displayed in a graph.



8. Students will recommend the best thermal insulating system for a home in their area.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, group work, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Identify or Develop Extension Activities:

1. Students will create an instructional aid that describes the functioning of a thermal technology system.
2. Students will create a display of a thermal system from a household item they disassemble.

> Note: The teacher may wish to develop some interdisciplinary connections with science, social studies, or mathematics teachers in your school. Provide them with the concepts that you are addressing in technology education and find commonality among the academic curricula.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, production and fabrication, product/prototype testing and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, design tools and equipment, fabrication tools and equipment, and testing tools should be readied.

Tools/Materials/Equipment

- Cans (painted white)
- Cans (painted black)
- 200 Watt light bulb
- Thermometers
- Insulating materials (pink insulation, foam insulation, sawdust, newspaper, and cotton.)
- Testing box

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson 3-8 Assessment Instruments

Assessment Instrument – Selected Response Items

Match the terms in Column II with the statements in Column I.

	Column I	Column II	
	The ability to do work	A	Conduction
	The total energy of random motion of vibration of all the particles that make up an object	B	Convection
	The energy transferred from one object to another because of temperature difference	C	Energy
	The movement of heat through a substance by the collision of molecules	D	Heat
	The transfer of heat by movement of a fluid	E	Heat flow rate
	The science dealing with internal energy, heat, and work	F	Insulation
	A measure of the ability of an object to oppose the flow of heat through an object	G	Microwave
	A layer of material with a high thermal resistance, used to reduce the heat transfer rate from a region	H	Prime mover
	The ration of the heat transferred to the time interval over which the transfer is measured	I	Radiation
	The entity responsible for motion in a system	J	Thermal energy
	The transfer of energy by electromagnetic waves	K	Thermal resistance
		L	Thermodynamics

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class, attempts to answer teacher-generated questions.	Well prepared for class, attempts to answer teacher-generated questions, and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation for Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily, is not engaged. Has difficulty remaining on task.	Makes good use of class time to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative. Does little work. Rarely offers useful ideas.	Cooperative. Works at assignments. Usually offers useful ideas	Always willing to help and do more. Does more than required. Routinely offers useful ideas.
Cooperation	Rarely listens to, shares with, or supports the efforts of others. Often is not a good team member.	Usually listens to, shares with, and supports the efforts of others. Does not cause problems in the group.	Always listens to, shares with, and supports the efforts of others. Tries to keep people working together.
Focus on the task	Does not focus on the task and what needs to be done. Lets others do the work.	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done. Self-directed.

Assessment Instrument – Brief Constructed Response Items

1. Explain the difference between heat and thermal energy.
2. Explain the relationship between heat transferred to an object and the change in the object's temperature.
3. Describe a situation in which you would use a material with a high thermal conductivity and a situation where you would use a material with low thermal conductivity.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

1. Describe the heat transfer processes of conduction, convection, and radiation.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important, evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause-and-effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate, and precise language. Cohesive organization. Very few grammatical errors.

Unit 3 – Lesson 9

An Introduction to Optical Technology

Standards

- Students will develop an understanding of engineering design (ITEA/STL-9)
- Students will develop an understanding of and ability to select and use information and communication technologies. (ITEA/STL-17)
- Students will develop an understanding of and be able to apply the design process (ITEA/STL-11)
- Students will develop an understanding of the designed world. (Forces of Nature) (AAAS-BSL)
- Students will develop an understanding of the common themes (Models) (AAAS-BSL)
- Students will develop an understanding of the habits of mind (Manipulation and Observation) (AAAS-BSL)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. • Information and communications technologies include inputs, processes, and outputs associated with sending and receiving information.	• Almost any information can be transformed into electrical signals. A weak electrical can be used to shape a stronger one, which can control other devices or radio waves. • Understanding how things work and designing solutions to problems can be facilitated by systems analysis.	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics. • Use the language of mathematics to express ideas precisely.

Learning Objectives

Students will:

1. Define terms related to optical technology.
2. Demonstrate three methods of controlling light.
3. Explain how controlled light is useful to humans.
4. Conduct research.
5. Describe the functioning and applications of lasers.
6. Describe the functioning of laser-coordinate-measuring machines and their application in the reverse engineering process.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials

Print-Based Sources

1. *Understanding Lasers: An Entry-Level Guide* (IEEE Press Understanding Science & Technology Series) by Jeff Hecht, Wiley-IEEE Press; 2nd Edition (1993) ISBN: 0780310055
2. *Introduction to Modern Optics* (Paperback) by Grant R. Fowles, Dover Publications; 2nd edition (1989) ISBN: 0486659577
3. *Handbook of Optical And Laser Scanning* (Optical Engineering) (Hardcover) by Gerald F. Marshall (Editor) Marcel Dekker (2004) ISBN: 0824755693

Audio/Visual Materials

1. Investigating Light Poster, Grades 6 – 12, Delta Education, Provides an illustrated view of such key concepts as light and its sources, the electromagnetic spectrum, light and color, human sight, and how colors are seen. 23” x 35”, laminated
2. The Magic Light Show: What Is Light, V7011W2, Science FUNdamentals, Explains the principles of light, light transmission, reflection and refraction in different materials. 15 min.
3. Science In Action, Color and Light, V5192W2, Explore the origins of color, basis of primary colors and perceptions of objects around us. 20 min

Internet Sites

1. The difference between normal light and laser light – http://users.netconnect.com.au/%7Ejackt/index.html
2. Physics in Context – www.learningincontext.com/
3. Laser demonstrations – www.physics.ubc.ca/~outreach/phys420/p420_95/mark/hdemo.html

Purpose of Lesson

To familiarize students with the functioning and applications of thermal technology systems by having them analyze the functioning of optical systems in terms of their common components, basic system design, safety considerations, and simple controls.

Required Knowledge and/or Skills

To meet this lesson’s objectives, students should be familiar with the core technologies, the building blocks of the designed world. Students should become familiar with the core technologies as

they are applied in the designed world. They should be familiar with common components, basic system design, safety, simple controls, and system performance evaluation.

Lesson 3-9

Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to the functioning and applications of optical technology systems.
2. The teacher will pose the question, "What is the difference between normal light and laser light?"
3. Students will present and justify their answers.
4. The teacher will ask students to identify the attributes of normal light and laser light and speculate on their usefulness in meeting human needs.
5. Students will present and justify their answers.

Exploration

1. The teacher will state that there are three basic ways to control light
2. Student groups will use a light source (flashlight), mirror, black construction paper, and a glass of water to control light in three ways: a. Block it with something (this makes a shadow), b. reflect it (change its path with a mirror), and c. bend it.) Note: There are actually other ways to bend or deflect light, including diffraction gratings and holographic lenses. These depend on the wave nature of light, and are a little more difficult to explain. Scientists have also found that gravity can bend light, but it takes a very large object with strong gravity such as a star to bend light very much, so it's not an effect you see every day!
3. The teacher will pose the question, "Why do we care about controlling light anyway?"
4. Student groups will list examples of how controlled light is useful to humans.

Explanation

1. Student groups will present their list of examples of how controlled light is useful to humans.
2. The teacher will clarify and augment the student lists. Possible items include:
   a. Your eyes
   b. Eyeglasses and contact lenses
   c. Lenses for TV, movie, and photographic camera
   d. Photocopiers and fax machines
   e. Binoculars and telescopes
   f. Microscopes and magnifiers
   g. Projectors (overhead, movie, slide, TV)
   h. CD players
   i. Supermarket product code laser scanners
   j. Weather and spy satellites
   k. Medical systems (to look inside the body)
   l. Solar energy systems
3. The teacher will ask the question, "What is 'white light?" (White light is regular light from the sun or from a light bulb. It really contains all the colors of the rainbow, but you have to split it up to see this.)
4. The teacher will ask the question, "Can light be split?" (Yes! You can split up white light into its colors with a prism.)
5. The teacher will ask the question, "So what is a laser?" (A laser is a special source of light of only one pure color. You can't break up laser light into other colors.)

6. The teacher will ask the question, "So what are some special attributes of lasers?"
   a. Focus (Lasers can be focused on a very small spot and can shine for long distances without spreading out very much, unlike a flashlight, which spreads out a lot.)
   b. Energy (The spot contains a lot of energy—so much that some lasers can cut through thick metal and smaller ones are used as scalpels.)
   c. Communication (Lasers can also send information through long threads of glass called optical fibers. A single laser can send thousands of phone conversations through a fiber at the same time.)
   d. Holograms (Lasers are also used to make 3D pictures called holograms. Some engineers are working on moving holograms, so someday we may have amazing 3D TV pictures.)
7. The teacher will ask the question, "How might engineers use lasers in the reverse engineering process?"
8. The teacher will explain that:
   a. In conventional computer aided design, the computer representation of objects are created by means of commands typically using an interactive design program with 3D graphics. This representation is used for further design, analysis and optionally for numerically controlled manufacturing.
   b. While conventional engineering transforms engineering concepts and models into real parts, in reverse engineering real parts are transformed into such computer models, which are suitable to exploit all advantages of modern CAD/CAM technologies and transfer real objects into virtual reality environments.
9. The teacher will explain that:
   a. Laser coordinate-measuring machines take precise measurements of the part by bouncing beams of laser light off its surface.
   b. As the laser scanner moves around the part, it sends over 15,000 beams per second.
   c. The reflected light from the beams is picked up by high-resolution cameras positioned on either side of the laser.
   d. These cameras create an image of the slice (cross section) of the object that the laser is scanning.
   e. A custom computer system collects the cross sections and combines them to create a perfect, seamless computer model of the part.
   f. The digital data captured can then be processed by CAD/CAM software to come up with a visual representation of the part as well as the CNC program needed to machine it.

Extension

1. Students will conduct research on currently available laser coordinate-measuring machines including:
   a. Technical data (x-axis measuring length, y-axis measuring length, z-axis measuring length, resolution, and repeatability)
   b. Measurement principles used
   c. Features (current improvements)
   d. Functioning
   e. Applications
   f. Cost
2. Students will write a newspaper article on the use of laser coordinate-measuring machines in reverse engineering.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, group work, engineering design, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Identify or Develop Extension Activities

1. Students will create an instructional aid that describes the functioning of an optical system.
2. Students will develop a time line for the history of optics.
3. Students will read and react to reverse engineering case studies – www.scansite.com/manufacturing.html

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson.

Tools/Materials/Equipment

- Flash lights
- Mirror
- Black construction paper
- Drinking glass

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson 3-9 Assessment Instruments

Assessment Instrument – Selected Response Items

Match the terms in Column II with the statements in Column I.

	Column I	Column II	
	The ability to do work	A	Conduction
	The total energy of random motion of vibration of all the particles that make up an object	B	Convection
	The energy transferred from one object to another because of temperature difference	C	Energy
	The movement of heat through a substance by the collision of molecules	D	Heat
	The transfer of heat by movement of a fluid	E	Heat flow rate
	The science dealing with internal energy, heat, and work	F	Insulation
	A measure of the ability of an object to oppose the flow of heat through an object	G	Microwave
	A layer of material with a high thermal resistance, used to reduce the heat transfer rate from a region	H	Prime mover
	The ration of the heat transferred to the time interval over which the transfer is measured	I	Radiation
	The entity responsible for motion in a system	J	Thermal energy
	The transfer of energy by electromagnetic waves	K	Thermal resistance
		L	Thermodynamics

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class, attempts to answer teacher-generated questions.	Well prepared for class, attempts to answer teacher-generated questions, and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation for Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily, is not engaged. Has difficulty remaining on task.	Makes good use of class time to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative. Does little work. Rarely offers useful ideas.	Cooperative. Works at assignments. Usually offers useful ideas	Always willing to help and do more. Does more than required. Routinely offers useful ideas.
Cooperation	Rarely listens to, shares with, or supports the efforts of others. Often is not a good team member.	Usually listens to, shares with, and supports the efforts of others. Does not cause problems in the group.	Always listens to, shares with, and supports the efforts of others. Tries to keep people working together.
Focus on the task	Does not focus on the task and what needs to be done. Lets others do the work.	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done. Self-directed.

Assessment Instrument – Newspaper Article

Element	Points Possible	Earned Assessment	
		Self	Teacher
The headline of the article catches the attention of the reader and relates well to the topic.			
The lead (or first sentence) captures the attention of the reader and sums up the focus of the article.			
The introductory paragraph tells the most important facts and answers the questions; who, what, where, when, why, and how.			
Details and elaboration are evident in the body of the article and flow smoothly from the lead.			
Quotes are used to add interest and support to the story.			
The vocabulary is correct.			
The work is neat and presentable.			

Assessment Instrument – Brief Constructed Response Items

1. Explain how controlled light is useful to humans.
2. Describe the functioning and applications of lasers.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

1. Describe the functioning of laser coordinate-measuring machines and their application in the reverse engineering process.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important, evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause-and-effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate, and precise language. Cohesive organization. Very few grammatical errors.

Unit 3 – Lesson 10

An Introduction to Materials Technology

Standards

- Students will develop an understanding of the nature of technology. (ITEA/STL-1)
- Students will develop an understanding of the core concepts of technology. (ITEA/STL-2)
- Students will develop an understanding of the effects of technology on the environment. (ITEA/STL-5)
- Students will develop an understanding of the influence of technology on history. (ITEA/STL-7)
- Students will develop an understanding of and be able to select and use manufacturing technologies. (ITEA/STL-19)
- Students will develop an understanding of the designed world. (Materials and Manufacturing) (AAAS-BSL)
- Students will develop an understanding of the physical setting. (Forces of Nature) (AAAS-BSL)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)

Benchmarks		
ITEA – Benchmarks for Technological Literacy	**AAAS – Benchmarks for Science**	**NCTM – Benchmarks for Mathematics**
• Materials have different qualities and can be classified as natural, synthetic, or mixed. (19) • Tools, materials and skills are used to make things and carry out tasks. (1) • Different materials are used in making things. (2) • Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time. (2) • Chemical technologies provide a means for humans to alter or modify materials to produce chemical products. (19) • Some materials can be reused and/or recycled. (5) • The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials.(7)	• Scientific research identifies new materials and new uses of known materials. • Different kinds of materials respond differently to electric forces, on conducting materials. • Increased knowledge of the molecular structure of materials helps in the design and synthesis of new materials for special purposes.	• Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics. • Use the language of mathematics to express ideas precisely.

Learning Objectives

Students will:

1. Analyze the development and impact of the common materials.
2. Defend the statement, "Improved materials have enhanced the performance of technology."
3. Explain that since the birth of materials science and engineering, materials researchers have consistently improved materials that have in turn enhanced the performance of the technologies that used them.
4. Explain that it is frequently found that "trade-offs" among the needed properties must be made to be consistent with the processing selected and the structural state desired or possible.
5. Test the elastic and plastic properties of metals.
6. Collect data and plot a graph of the elastic and plastic properties of metals.
7. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.

Student Assessment Tools and/or Methods

(See assessment instruments at end of lesson.)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials

Print-Based Sources

1. *Stuff: The Materials the World is Made Of* by Ivan Amato, BasicBooks, (1997) ISBN 0-465-08328-5
2. *Principles of Materials Science and Engineering* by William F. Smith (Mcgraw-Hill Series in Materials Science and Engineering) Mcgraw-Hill College; 3rd edition (1995) ISBN: 0070592411
3. *Materials and Design: The Art and Science of Material Selection in Product Design* by Michael Ashby, Kara Johnson, Butterworth-Heinemann; 1st edition (December, 2002) ISBN: 0750655542

Audio/Visual Materials

1. Videos For Composites – http://matse1.mse.uiuc.edu/~tw/comp/comp.html
2. Challenge of Materials – This is an online exhibit from the Science Museum based in the UK (formerly the National Museum of Science & Industry). It provides excellent introductory information aimed at the general public. This is one of several digital exhibits on the exhibits page—the pages have recently been reorganized so it is no longer possible to provide a direct link to specific exhibits – www.sciencemuseum.org.uk/online/exhibitions.asp#
3. Materials Interactive – This site uses advanced simulation techniques, using JAVA and VRML, to model the behavior of materials. It is put together by the National Physical Laboratory in the United Kingdom. Subjects include surfaces, laminate damage, electron backscatter patterns, educational, and experimental. http://materials.npl.co.uk/
4. Elements of Steel, Flash Interactive, http://www.teachersdomain.org/9-12/sci/engin/design/elements/index.html

Internet Sites

1. A+ Materials Science and Engineering: Glossary of Terms – www13.brinkster.com/justinmc/glossary/index.html

2. Career Resource Center: MSE, Materials Science & Engineering – www.crc4mse.org/
3. ASM Handbooks On-Line, The Materials Information Society – http://products.asminternational.org/hbk/index.jsp
4. Materials Lab, Flash Interactive – www.teachersdomain.org/9-12/sci/phys/mfw/bbmatrls/index.html

Purpose of Lesson

To familiarize students with the connection between materials science and engineering materials and how researchers have consistently improved materials that have in turn enhanced the performance of the technologies that used them.

Required Knowledge and/or Skills

To meet this lesson's objectives, students should be familiar with the core technologies, the building blocks of the designed world. Students should understand the core technologies as they are applied in the designed world. They should be familiar with common components, basic system design, safety, simple controls, and system performance evaluation.

Lesson 3-10

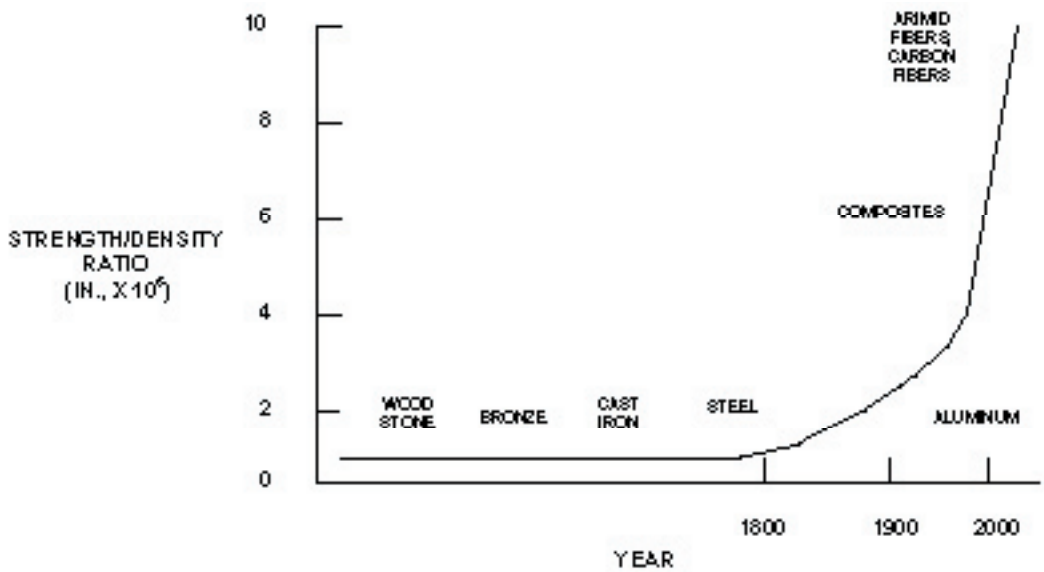
Engagement

1. The teacher will assess prior knowledge and possible misconceptions related to the functioning and applications of materials technology.
2. The teacher will present students with the following quote.

   "Since the birth of materials science and engineering, materials researchers have consistently improved materials that have in turn enhanced the performance of the technologies that used them."

   Ivan Amato, Stuff: The Materials The World Is Made Of

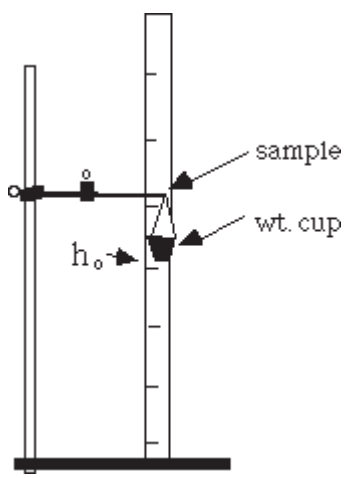
3. The teacher will ask students to think of examples of improved materials that have enhanced the performance of technology. (They may cite things such as aluminum baseball bats, vinyl siding, and fiberglass auto body parts.)
4. Students will identify and justify their examples.
5. The teacher will present the following graph and ask students to give their interpretation of what the graph shows.



6. The teacher will ask students to speculate on what the graph means. (The strength/density ratio indicates how much of a material it takes to support a given load. The higher the ratio the less material you need.)

Exploration

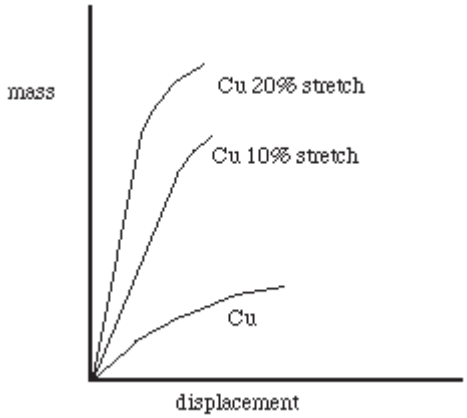
1. Student groups will test the elastic and plastic properties of metals.
2. Students will use the set up pictured below to discover that wires of the same gauge, but made of different metals typically support different loads (masses) before going through the point at which they change from being elastic to being plastic.



Sample Table

mass	height	disap.

3. Student groups will use the following procedure to generate a data table for each wire; including the values for mass, height, and displacement.
   a) Clamp the solid copper wire in the clamp and attach the small cup to the end of the metal wire. See diagram of setup.
   b) Adjust the wire so it extends horizontally about 8 to 10 cm beyond the edge of the clamp.
   c) Measure the height of the end of the wire above the surface of the work area. This height will be your reference height.
   d) Carefully place three small washers (approximately 3g) into the cup and again measure the height of the end of the metal wire above the surface of the work area. Record this mass and the new height. (Using your hand, gently support the cup and show the students how to check to see that the wire returns to approximately its original height.)
   e) Continue increasing the mass in the cup by 3 washers at a time, recording both the mass in the cup and the height of the end of the wire above the surface of the work area, until the wire no longer returns to approximately original height. Record this value of mass.
   f) Now take 3 or 4 more sets of data on this wire after straightening it.
   g) Replace the original copper wire with annealed copper wire of the same gauge.
   h) Replace the annealed copper wire with the piece of copper wire that has been annealed and then stretched (cold-worked) by 10%.
   i) Repeat procedures 1-8 above for the other wires, time permitting. Be sure the distance from the clamp to the point where the weights are attached is the same for the annealed wire as it was for the original wire.
4. Student groups will plot a graph of mass (on vertical axis) versus displacement for each of the different types of wires. (Note that the slope of the curve represents the relative stiffness of the wire represented by the curve. See sample graph below.)



5. For each of the types of metal wires, find the maximum mass for which the curve remained basically a straight line (the slope was constant.) This defines the yield strengths of the metal.
6. Student groups will generate three questions about the experiment.

Explanation

1. The teacher will clarify the exploratory activity by addressing the following questions:
   a. What is happening to the bonded metal atoms during elastic deformation? (The bonds between the atoms are stretching.)
   b. What is happening to the bonded metal atoms during plastic deformation? (Metal atoms

are sliding past each other.)

c. Give the maximum mass placed on each wire before permanent deformation occurred. (Student answers.)

d. Why would an engineer be interested in the yield strength of a metal for a particular application? (In most applications, it is not desirable to exceed the yield strength of the product. If the yield strength is exceeded the object will be permanently deformed and likely will no longer be useful.)

2. The teacher will state that:
   a. The physical properties of the material are generally a basic reason for selecting the material for the needed product performance.
   b. The performance of a product frequently requires various behaviors and thus types of properties.
   c. It is frequently found that a compromise among the needed properties must be made to be consistent with the processing selected and the structural state desired or possible.
   d. Most of the useful properties are related to the structural state of the material.
3. The teacher will ask, "What are Materials?" (The clothes we wear are made from a variety of materials. Our home is made of materials—mostly manufactured. The glass in the windows, the vinyl siding, the ceramic dinnerware, the metal silverware, and everywhere we look we see products made from materials.)
4. The teacher will state that most products are made from many different kinds of materials to satisfy the needs of the product. One way to look at materials is to consider the various generic descriptions such as:
   a. Metals – Materials that are normally combinations of "metallic elements." These elements, when combined, usually have electrons that are non-localized and as a consequence have generic types of properties. Metals usually are good conductors of heat and electricity. Also, they are quite strong, but malleable and tend to have a lustrous look when polished.
   b. Ceramics – Ceramics are generally compounds between metallic and nonmetallic elements and include such compounds as oxides, nitrides, and carbides. Typically they are insulating and resistant to high temperatures and harsh environments.
   c. Plastics – Plastics (or polymers) are generally organic compounds based upon carbon and hydrogen. They are very large molecular structures. Usually they are low density and are not stable at high temperatures.
   d. Semiconductors – Semiconductors have electrical properties intermediate between metallic conductors and ceramic insulators. Also, the electrical properties are strongly dependent upon small amounts of impurities.
   e. Composites – Composites consist of more than one material type. Fiberglass, a combination of glass and a polymer, is an example. Concrete and plywood are other familiar composites. Many new combinations include ceramic fibers in metal or polymer matrix.
5. The teacher will explain that the typical properties of interest may be classified into:
   a. Mechanical: tensile strength, fracture toughness, fatigue strength, creep strength, hardness, etc.
   b. Electrical: tonductivity or resistivity, ionic conductivity, semiconductor conductivity (mobility of holes and electrons), etc.
   c. Magnetic: magnetic susceptibility, Curie Temperature, Neel Temperature, saturation magnetization, etc.
   d. Optical and Dielectric: polarization, capacitance, refractive index, absorption, etc.
   e. Thermal: coefficient of thermal expansion, heat capacity, thermal conductivity, etc.
   f. Environmental Related: corrosion behavior, wear behavior, etc.

6. The teacher will state that paying attention to the materials in your life generates an endless stream of fascinating questions (and even more fascinating answers) such as:
   a. Why is a skyscraper's frame made of steel, not copper or polyethylene?
   b. What is so special about the silicon crystal that it became the foundation of a society-changing electronics revolution?
   c. What kind of materials does it take to build a plane that can take off like a jet, accelerate at 20,000 miles per hour, zoom into outer space, and then land two hours later in an airport on the other side of the planet?
   d. How did humans learn to transform the raw stuff of the wilderness into the wondrous contemporary array of materials?
7. Students will clarify their understanding of concepts through questioning.

Extension

1. Students groups will create timelines on the development and impact of the following materials:
   a. Metals – http://matse1.mse.uiuc.edu/~tw/metals/time.html
   b. Ceramics – http://matse1.mse.uiuc.edu/~tw/ceramics/time.htm
   c. Semiconductors – http://matse1.mse.uiuc.edu/~tw/concrete/time.html
   d. Concrete – http://matse1.mse.uiuc.edu/~tw/concrete/time.html
   e. Polymers – http://matse1.mse.uiuc.edu/~tw/polymers/time.html
   (Note: The citations of Web sites are for the teacher's information.)
2. Students groups will make an oral presentation on their timelines.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for group work, timelines, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Identify or Develop Extension Activities

1. Students may investigate and report on "metals" including a description of the crystal structure of metals, the typical mechanical properties of metals, how metals are made into useful products, describing what an alloy is, the conditions and chemistry of corrosion, and how metals are removed from their ore.
2. Students may investigate and report on "concrete" including defining concrete, its properties, chemical changes in concrete, and determining the overall strength of concrete.

Laboratory-Classroom Preparation

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson.

Tools/Materials/Equipment

- 15 to 20 cm long pieces of 16 or 18 gauge wire of copper, aluminum, steel, etc.
- Wires saved from Experiment 3
- Ring stand

- Adjustable single-burette clamp
- Meter stick
- Small paper cup (1-oz)
- Variable masses (lead shot or small ring-washers)

Laboratory-Classroom Safety and Conduct

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson 3-10 Assessment Instruments

Assessment Instrument – Selected Response Items

Match the terms in Column II with the statements in Column I.

	Column I	Column II	
	Good conductors of heat and electricity	A	Atomic Bonding
	Consist of more than one material type	B	Ceramics
	Have electrical properties intermediate between metallic conductors and ceramic insulators	C	Composites
	Very large molecular organic compounds based upon carbon and hydrogen	D	Electrical Properties
	Typically they are insulating and resistant to high temperatures and harsh environments	E	Environmental-Related Properties
	Tensile strength, fracture toughness, fatigue strength, creep strength, hardness, etc.	F	Magnetic Properties
	Conductivity or resistivity, ionic conductivity, semiconductor conductivity (mobility of holes and electrons), etc.	G	Mechanical Properties
	Magnetic susceptibility, Curie Temperature, Neel Temperature, saturation magnetization, etc.	H	Metals
	Polarization, capacitance, permittivity, refractive index, absorption, etc.	I	Optical and Dielectric Properties
	Coefficient of thermal expansion, heat capacity, thermal conductivity, etc.	J	Polymers
	Corrosion behavior, wear behavior, etc.	K	Semiconductors
		L	Thermal Properties

Assessment Instrument – Timeline

Category	Below Target	At Target	Above Target
Title	Title missing or difficult to locate.	Timeline has an effective title that accurately describes the material and is easy to locate.	Timeline has a creative title that accurately describes the material and is easy to locate.
ContentFacts	Facts often inaccurate for events reported on the timeline.	Facts accurate for almost all events reported on the timeline.	Facts accurate for all events reported on the timeline.
Graphics orPictures	Several graphics are not effective.	All graphics are effective.	All graphics are effective and balanced with text use.
Dates	Dates inaccurate or missing for several events.	Accurate dates included for almost every event.	Accurate dates included for each event.
Style and Organization	Time period covered was inappropriate. Yearly divisions not uniform.	Timeline set up to cover the relevant time period. Contains yearly gradations, but not at set intervals.	Timeline set up to cover the relevant time period. Contains appropriate yearly gradations of set intervals
Resources	Timeline covers 5 or fewer events.	Timeline contained at least 8-10 events related to the topic being studied.	Timeline contained at least 11-15 events related to the topic being studied.
Documentation	Sources not properly documented, too few, or inappropriate.	Less than four properly documented sources.	Four or more properly documented sources.
Objective orThesis	No statement of thesis or objective for research.	Clearly stated but focus could have been sharper.	Clearly stated and appropriately focused.
Knowledge Gained	Lacks knowledge of the content and the processes used to create the timeline.	Accurately answers most questions related content and processes.	Accurately answer all questions related to content and processes.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative. Does little work. Rarely offers useful ideas.	Cooperative. Works at assignments. Usually offers useful ideas	Always willing to help and do more. Does more than required. Routinely offers useful ideas.
Cooperation	Rarely listens to, shares with, or supports the efforts of others. Often is not a good team member.	Usually listens to, shares with, and supports the efforts of others. Does not cause problems in the group.	Always listens to, shares with, and supports the efforts of others. Tries to keep people working together.
Focus on the task	Does not focus on the task and what needs to be done. Lets others do the work.	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done. Self-directed.

Assessment Instrument – Brief Constructed Response Items

1. Defend the statement, "Improved materials have enhanced the performance of technology."
2. Explain that it is frequently found that "trade-offs" among the needed properties must be made to be consistent with the processing selected and the structural state desired or possible.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.	Response demonstrates an understanding of the text.	Response demonstrates an understanding of the complexities of the text.
Focus	Lacks transitional information to show the relationship of the support to the question.	Addresses the demands of the question.	Exceeds the demands of the question.
Use of Related Information	Uses minimal information from the text to clarify or extend meaning.	Uses some expressed or implied information from the text to clarify or extend meaning.	Effectively uses expressed or implied information from the text to clarify or extend meaning.

Assessment Instrument – Extended Constructed Response Item

1. Explain that since the birth of materials science and engineering, materials researchers have consistently improved materials that have in turn enhanced the performance of the technologies that used them.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate. Argument unsatisfactory.	Context appropriate. Argument satisfactory.	Context appropriate. Argument satisfactory. Clearly stated thesis included.
Evidence	Evidence is largely missing or generalized.	Ample and appropriate evidence provided.	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided. Includes obscure, but important, evidence. Thorough chronology.
Analysis	Minimal analysis or fallacious reasoning.	Organizes argument and uses data to support conclusions. Recognizes causation, change, and continuity.	Well-reasoned cause-and-effect arguments. Fully explained conclusions. Refers to views of others.
Historical Accuracy	Many errors.	May have a few errors. Mistakes may slightly hinder argument, but do not detract from the overall accuracy.	Virtually error free; minor mistakes do not compromise argument.
Thoroughness	Covers question superficially. May not complete all tasks.	Covers entire question, but may be slightly imbalanced.	Covers all areas of question in approximate proportions to their importance.
Presentation	Inconsistent organization. Grammatical errors cloud argument to a major degree.	Uses clear language. Well organized. Contains few grammatical errors.	Uses clear, appropriate, and precise language. Cohesive organization. Very few grammatical errors.

Chapter 4

Manufacturing Technologies

Chapter 4 - Manufacturing Technologies

Overview

Standards:

- Students will develop an understanding of and be able to select and use medical technologies. (ITEA/STL-14)
- Students will develop an understanding of and be able to select and use agricultural and biotechnologies. (ITEA/STL-15)
- Students will develop an understanding of and be able to select and use manufacturing technologies. (ITEA/STL-16)
- Students will develop an understanding of and be able to select and use transportation technologies. (ITEA/STL-18)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. (ITEA/STL-10)
- Students will develop an understanding of the designed world. (Materials and Manufacturing) (AAAS-BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Connections). (NCTM-MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM-MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
▪ Materials have different qualities and can be classified as natural, synthetic, or mixed. ▪ Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time. ▪ Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production. ▪ Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it. ▪ Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems in which health is protected and maintained. ▪ Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. ▪ Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture. ▪ Intermodalism is the use of different	▪ Manufacturing processes have been changed by improved tools and techniques based on more thorough scientific understanding, increases in the forces that can be applied and the temperatures that can be reached, and the availability of electronic controls that make operations occur more rapidly and consistently	• Model and solve contextualized problems using various representations, such as graphs, tables, and equations. • Draw reasonable conclusions about a situation being modeled. • Recognize and use connections among mathematical ideas. • Recognize and apply mathematics in contexts outside of mathematics • Use the language of mathematics to express ideas precisely.

modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another. ▪ Research and development is a problem solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.		

Big Idea: Modern manufacturing technologies produce quality goods at low prices, enhancing the quality of life for many people.

Unit Objectives: At the completion of this unit, students will be able to

1. Analyze manufacturing processes including designing, developing, producing, and servicing.
2. Describe mechanical processes that change the form of materials including separating, forming, combining, and conditioning.
3. Classify manufacturing systems as being customized production, batch production, or continuous production.
4. Describe how the interchangeability of parts increases the effectiveness of a manufacturing process.
5. Research chemical technologies used to modify or alter chemical substances in the manufacturing process including synthetic fibers, pharmaceuticals, plastics, and fuels.
6. Explain that agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemicals, and other useful products.
7. Research and report on applications of biotechnology such as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering.
8. Analyze the role information and communication systems play in the operation of manufacturing and agricultural enterprises.
9. Analyze the role transportation plays in the operation of manufacturing and agricultural enterprises.
10. Explain that intermodalism is the use of different modes of transportation in an interconnected system that moves people and goods.

Foundations of Technology
Chapter 4 – Manufacturing Technologies

Unit Pre-Test

Directions: Circle the T or F in the column to the left of each true (T) or false (F) statement.

T	F	1.	Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.
T	F	2.	Casting and molding are manufacturing processes.
T	F	3.	Genetic materials can be used in manufacturing processes.
T	F	4.	The two broad categories of manufacturing are resources processing and product manufacturing.
T	F	5.	Steel production is a mechanical process.
T	F	6.	The glassmaking process involves several genetic materials.
T	F	7.	Petroleum and natural gas are fossil fuel resources.
T	F	8.	Natural gas is a combustible gas that is found in nonporous rock formations.
T	F	9.	Manufacturing is the process of converting industrial materials into products.
T	F	10.	Research and development involves promoting and selling a product.

Briefly answer the following questions.

11. Explain how communication and information systems impact manufacturing processes.

12. Describe how the development of improved industrial materials enable manufacturers to produce quality goods at low prices, enhancing the quality of life for many people.

Foundations of Technology
Chapter 4 – Manufacturing Technologies

Unit Test

Directions: Circle the T or F in the column to the left of each true (T) or false (F) statement.

T F 1. Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.

T F 2. Casting and molding are manufacturing processes.

T F 3. Genetic materials can be used in manufacturing processes.

T F 4. The two broad categories of manufacturing are resources processing and product manufacturing.

T F 5. Steel production is a mechanical process.

T F 6. The glassmaking process involves several genetic materials.

T F 7. Petroleum and natural gas are fossil fuel resources.

T F 8. Natural gas is a combustible gas that is found in nonporous rock formations.

T F 9. Manufacturing is the process of converting industrial materials into products.

T F 10. Research and development involves promoting and selling a product.

T F 11. Most industrial materials are made using a mechanical, thermal, chemical and electrochemical processes.

T F 12. Thermal processes may use pressure to crush a material to reduce its size or change its texture.

T F 13. Chemical or electrochemical processes break down or build up materials by changing their chemical composition.

T F 14. Aluminum is an alloy, a mixture of iron and carbon, made using a thermal process.

T F 15. Sorting the materials by size using screens is a mechanical process.

T F 16. Smelting is a chemical process used to extract metals from their ores.

T F 17. Industrial materials produced using mechanical processes include lumber, plywood, and crushed stone.

T F 18. Mechanical forces cannot change the form of natural resources.

T F 19. Chemical or electrochemical processes are used to make synthetic fibers, pharmaceuticals, and plastics.

T F 20. Some materials are made from combinations of mechanical, thermal, chemical and electrochemical processes

Match the terms in Column II with the statements in Column I.

		Column I	Column II	
	21.	The umbrella acronym for a variety of automated manufacturing	A	Cellular

		technologies		Manufacturing
	23.	A way of integrating many aspects of product design, development, and manufacture so that critical phases of product design proceed concurrently within the boundaries of the manufacturing system infrastructure	B	CIM
	24.	A manufacturing philosophy that attempts to eliminate waste throughout the system, including inventory at both ends of production and all machinery and manpower not adding directly to the value of the product	C	Concurrent Engineering
	25.	Workers are encouraged to stop production if they find a defect and work together to solve any problems. Was developed in Japan by Toyota	D	Just-In-Time
	25.	Uses data from a three-dimensional CAD file to construct a model	E	Lean Manufacturing
	27.	A method of equipment layout in which the machines are grouped into cells rather than being placed on an assembly line or divided into different functions	F	Rapid Prototyping
	28.	A regulatory process through which performance is first measured and them compared with pre-established standards	G	Statistical Process Control
			H	Total Quality Management

Place the letter of the correct answer in the box at left of statement.

29.		Materials have different qualities and can be classified as _____, synthetic, or mixed. A. normal B. biological C. natural D. formed
30.		Goods that are designed to operate for a short period of time. A. Durable B. Non-Durable C. Synthetic D. Non-Renewable
31.		May be classified into types, such as customized production, batch production, and continuous production A. Power and energy systems B. Transportation systems C. Communication systems D. Manufacturing systems
32.		Involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it A. Prototyping B. Marketing C. Assessing D. Modeling
33.		The successful operation of a designed system usually involves _____ A. innovation

		B. decoding C. feedback D. support systems
34.		Computers have greatly improved the power and use of _____ by performing computations that are very long, very complicated, or repetitive. A. machine tools B. mathematical models C. transportation systems D. data collection
35.		Engineers create and use _____ to organize, record, and communicate mathematical ideas. A. the scientific method B. representations C. feedback D. specifications

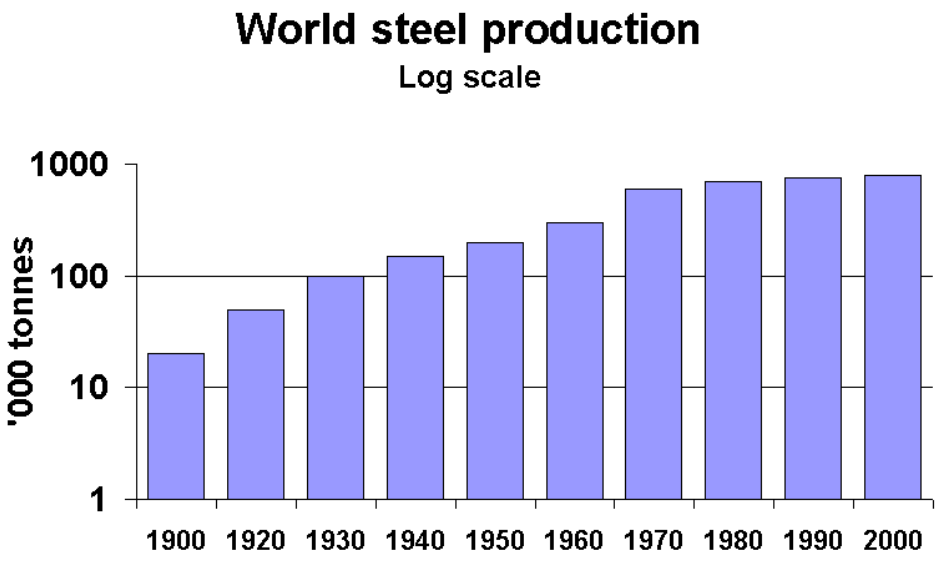
Briefly answer the following questions.

36. Explain how communication and information systems impact manufacturing processes.

37. Explain that medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems in which health is protected and maintained.

38. Describe how mechanical, electrical, and informational subsystems are combined to produce computer-integrated-manufacturing systems.

39. Explain the history of steel production using the following graph and explain why it is useful to use a log scale on one axis or a graph.



Extended Constructed Response Item

40. Describe the benefits reported from companies using computer-integrated-manufacturing.

Chapter 4 – Manufacturing Technology

Lesson 1 - Getting Familiar with the Big Idea

Modern manufacturing technologies produce quality goods at low prices, enhancing the quality of life for many people.

Lesson Duration: Five (5) hours.

Standards:

- Students will develop an understanding of and be able to select and use medical technologies. (ITEA/STL-14)
- Students will develop an understanding of and be able to select and use agricultural and biotechnologies. (ITEA/STL-15)
- Students will develop an understanding of and be able to select and use manufacturing technologies. (ITEA/STL-16)
- Students will develop an understanding of and be able to select and use transportation technologies. (ITEA/STL-18)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. (ITEA/STL-10)
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- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)
- Students will develop an understanding of mathematics processes (Connections). (NCTM - MSE)
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▪ Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. ▪ Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture. ▪ Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another. ▪ Research and development is a problem solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.		

Learning Objectives: Students will:

1. Analyze manufacturing processes including designing, developing, producing, and servicing.
2. Describe mechanical processes that change the form of materials.
3. Identify the major areas of manufacturing and leading enterprises from each segment.
4. Compare and contrast manufacturing and construction in terms of outputs.
5. Describe natural material resources.
6. Identify and provide examples of types of primary processing.
7. Describe the major manufacturing processes.
8. Describe how manufacturing systems capture, develop, produce, and market creative ideas.
9. Research, design and fabricate a display depicting a primary manufacturing process.
10. Make an oral presentation to the class and other audiences.

Student Assessment Tools and/or Methods:

(See assessment instruments at end of lesson)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials:

- Print-Based Sources

1. Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 2nd Edition by Mikell P. Groover, Wiley; (2001) ISBN: 0471400513
2. All I Need to Know About Manufacturing I Learned in Joe's Garage by William B. Miller, Vicki L. Schenk, Bayrock Pr (1993) ISBN: 0963043935
3. Career Ideas For Teens In Manufacturing (Career Ideas for Teens) by Diane Lindsey Reeves, Gail Karlitz, Facts on File (2005) ISBN: 0816052948

- Audiovisual Materials

1. The Industrial revolution in America, http://ctap295.ctaponline.org/~marchandb/
2. Power of Manufacturing Instructional Posters, http://ctap295.ctaponline.org/~marchandb/
3. Women In Engineering Poster Series, http://www.asme.org/bmw/womenposter.html

- Internet Sites

1. How Everyday Things Are Made, Alliance for Innovative Manufacturing, Stanford, http://manufacturing.stanford.edu/
2. Manufacturing's Might, http://www.industryweek.com/ReadArticle.aspx?ArticleID=890&SectionID=40
3. National Association of Manufacturers, http://www.nam.org/s_nam/index.asp

Purpose of Lesson: To familiarize students with the functioning and organization of manufacturing enterprises.

Required Knowledge and/or Skills: Students should have some understanding that manufacturing is a production system that uses technological resources to transform ideas into products that meet human needs and desires. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on history.

Lesson

Engagement:

1. The teacher will assess prior knowledge and possible misconceptions related to the functioning and organization of manufacturing enterprises.
2. The teacher will show the class a video of a product being assembled in fast motion. (i.e. Boeing 777 Assembly, http://manufacturing.stanford.edu/)
3. After viewing the video, students will answer the following questions:
   a. What was the "real time" duration of the process shown?
   b. What are some things that manufacturers have to do before a product is assembled?
   c. What resources were used to assemble the product?
   d. Who controlled the processes we saw?
4. The teacher will ask students to speculate on the impacts of manufacturing on individuals, society, economics, politics, and the environment.

Exploration:

1. The teacher will state that manufacturing remains the world's economic power source. (Industry Week, April 2005, http://www.industryweek.com/ReadArticle.aspx?ArticleID=890&SectionID=40)
2. The teacher will explain that the annual global ranking of the largest manufacturing firms proves that publicly held companies continue to be the power generators of the world's wealth.
3. Students working in small groups will match the names of leading manufacturers with their products.

	PRODUCT		MAUFACTURER
	Petroleum	A	Caterpillar Inc.
	Autos and auto parts	B	Exxon Mobil
	Electronics/electrical equipment	C	GE
	Food	D	GM
	Chemicals	E	IBM
	Computer systems/office equipment	F	Merck & Co. Inc
	Metals	G	Nestlé SA

	Pharmaceuticals	H	Procter & Gamble Co
	Industrial equipment	I	ThyssenKrupp AG
	Publishing/printing	J	Verizon Communications Inc.

Explanation:

1. The teacher will review the manufacturers/products matching and provide additional details.
   a. Petroleum (The petroleum industry's revenue giant is Exxon Mobil)
   b. Autos and auto parts (GM produced the most revenues in 2000 among the 70 manufacturers in the motor vehicle and auto parts industry)
   c. Electronics/electrical equipment (Among the 115 companies in the electronics/electrical equipment industry on the list, GE had the highest revenues, $129.4 billion)
   d. Food (Switzerland's Nestlé SA produced the highest revenues,)
   e. Chemicals (Although 2000 was a rough year for Cincinnati-based Procter & Gamble Co., it nevertheless posted the highest revenues ($40.0 billion) of the 101 companies in the IW 1000 chemicals sector.)
   f. Computer systems/office equipment (IBM faced many challenges in 2000, but it posted the most revenues, $88.4 billion, of the 31 companies on the list that make computer systems and office equipment.)
   g. Metals (ThyssenKrupp AG earned $35.1 billion, the highest revenues among the 79 companies in the metals industry)
   h. Pharmaceuticals (Merck & Co. Inc. took in $40.4 billion, the highest revenue figure among the 33 pharmaceutical manufacturers on the IW 1000, while Amgen Inc. had the highest profit margin, 31.4%).
   i. Industrial equipment (Among the 65 industrial-equipment producers on the IW 1000, Caterpillar Inc. generated the most revenues—$20.2 billion.)
   j. Publishing/printing (Verizon Communications Inc. had the highest revenues—$63.4 billion—of IW 1000 companies that are engaged in publishing. Verizon, one of the largest publishers of telephone directories, also posted the best profit margin—17%—in the industry.)
2. The teacher will explain that production activities either result in a product or a structure.
   a. Production activities that result in products are called manufacturing.
   b. Production activities that result in structures are called construction.
3. The teacher will explain that:
   a. Manufacturing processes have been changed by improved tools and techniques based on more thorough scientific understanding, increases in the forces that can be applied and the temperatures that can be reached, and the availability of electronic controls that make operations occur more rapidly and consistently.
   b. Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time.
   c. Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.
   d. Marketing involves establishing a product’s identity, conducting research on its potential, advertising it, distributing it, and selling it.
   e. Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering.
   f. Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems in which health is protected and maintained.

g. Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.
h. Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another.

4. The teacher will explain that there are two broad categories of manufacturing.
   a. Resources processing (primary manufacturing)
   b. Product manufacturing (secondary manufacturing)
5. The teacher will discuss the types of natural material resources including:
   a. Genetic material
   b. Fossil fuel materials
   c. Minerals
6. The teacher will identify and provide examples of types of primary processing including:
   a. Mechanical processes (Producing lumber and plywood)
   b. Thermal processes (Producing steel, glass, refining petroleum)
   c. Chemical and electrochemical processes (Producing aluminum)
7. The teacher will describe and show examples of the major manufacturing processes including:
   a. Casting and molding
   b. Forming
   c. Separating
   d. Conditioning
   e. Assembling
   f. Finishing
8. The teacher will explain that manufacturing is part of a larger system that captures, develops, produces, and markets creative ideas and includes:
   a. Research and development
   b. Production
   c. Marketing
   d. Industrial relations
   e. Financial management

Extension:

1. Students working in groups will research, design, and fabricate a display depicting a primary manufacturing process (mechanical, thermal, chemical or electromechanical).
2. The student groups will make an oral presentation to the class and other audiences on their research.

Evaluation:

Students' knowledge, skills, and attitudes will be assessed using rubrics for class participation, group work, display and presentation, brief constructed responses, and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities:

1. Student groups may be asked to research and report on natural material resources.

2. Students may be assigned to research and report on the system that captures, develops, produces, and markets creative ideas including research and development, production, marketing, industrial relations, and financial management.

Laboratory-Classroom Preparation:
The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small group meetings, and research activities should be readied.

Laboratory-Classroom Safety and Conduct:
1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument - Selected Response Item
Directions: Circle the T or F in the column to the left of each true (T) or false (F) statement.

T F 1. Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.
T F 2. Casting and molding is a manufacturing process.
T F 3. Genetic materials can be used in manufacturing processes.
T F 4. The two broad categories of manufacturing are resources processing and product manufacturing.
T F 5. Steel production is a mechanical process.
T F 6. The glassmaking process involves several genetic materials.
T F 7. Petroleum and natural gas are fossil fuel resources.
T F 8. Natural gas is a combustible gas that is found in nonporous rock formations.
T F 9. Manufacturing is the process of converting industrial materials into products.
T F 10. Research and development involves promoting and selling a product.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative Does little work Rarely offers useful ideas	Cooperative Works at assignments Usually offers useful ideas	Always willing to help and do more Does more than required Routinely offers useful ideas
Cooperation	Rarely listens to, shares with,	Usually listens to, shares with,	Always listens to, shares with,

	or supports the efforts of others Often is not a good team member	and supports the efforts of others Does not cause problems in the group	and supports the efforts of others Tries to keep people working together
Focus on the task	Does not focus on the task and what needs to be done Lets others do the work	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done Self-directed

Assessment Instrument – Display and Presentation

Category	Below Target	At Target	Above Target
Overall display	The display is not organized OR the items are not securely attached to the display. Display is not professional.	The display is somewhat organized. The items are securely attached to the display. Display is partly clean and professional.	The display is attractive and well organized. The items are neatly and securely attached to the display. Display is clean and professional.
Number of Items /colors	The display has less than 3 items OR the items are all the same OR are in poor condition.	The display has at least 4 different, but related items. At least 3 of these are in good condition.	The display has 10 or more different, but related, items in good condition.
Labels	One of more items are not labeled. There are more than 2 errors in capitalization or punctuation. There are more than 2 grammatical mistakes on the poster.	Each item has a label, but some lack some required information. There are 2 errors in capitalization or punctuation. There are 2 grammatical mistakes on the poster.	Each item has a small neat label describing the item. Capitalization and punctuation are correct throughout the poster. There are no grammatical mistakes on the poster.
Participation	Student often lost focus or became frustrated and distracted others.	Student did work, but lost focus or became frustrated. Did not distract others.	Student showed great enthusiasm and focused on the task. Was helpful to others, if asked.
Knowledge Gained	Had trouble answering questions about the topic without using the labels in the display.	Was able to accurately answer at least 3 questions about the topic accurately, without reading the labels.	Was able to accurately answer at least 5 questions about the topic without reading the labels.

Assessment Instrument – Brief Constructed Response Items

1. Compare and contrast manufacturing and construction in terms of outputs.
2. Describe two mechanical processes that change the form of materials.
3. Explain that research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.
4. Explain that medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems in which health is protected and maintained.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text

	the text and/or the question		
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Constructed Response Items

1. Describe how manufacturing systems capture, develop, produce, and market creative ideas.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or generalized	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence Thorough chronology
Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder argument, but do not detract from the overall accuracy	Virtually error free; minor mistakes do not compromise argument
Thoroughness	Covers question superficially May not complete all tasks	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportions to their importance
Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree	Uses clear language Well organized Contains few grammatical errors	Uses clear, appropriate and precise language Cohesive organization Very few grammatical errors

Chapter 4 – Manufacturing Technology

Lesson 2 - What's New In Manufacturing?

Lesson Duration: Five (5) hours.

Standards:
- Students will develop an understanding of and be able to select and use medical technologies. (ITEA/STL-14)
- Students will develop an understanding of the designed world. (Materials and Manufacturing) (AAAS – BSL)
- Students will develop an understanding of mathematics processes (Communications). (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS – Benchmarks for Science	NCTM – Benchmarks for Mathematics
▪ Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.	• Manufacturing processes have been changed by improved tools and techniques based on more thorough scientific understanding, increases in the forces that can be applied and the temperatures that can be reached, and the availability of electronic controls that make operations occur more rapidly and consistently	• Use the language of mathematics to express ideas precisely.

Learning Objectives:
Students will:
1. Explain how communication and information systems impact manufacturing processes.
2. Prepare an annotated diagram of an integrated communication system serving a human enterprise.
3. Describe how mechanical, electrical, and informational subsystems are combined to produce integrated automated process technologies.
4. Identify and describe the common attributes of integrated automated process technologies.
5. Identify and describe the role computers play in integrated automated process technologies.
6. Explain the functions of centralized databases in integrated automated process technologies.
7. Describe the benefits reported from companies using integrated automated process technologies.
8. Create a concept map that analyzes integrated automated process technologies.

Student Assessment Tools and/or Methods:
(See assessment instruments at end of lesson.)
1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials:
- Print-Based Sources

1. Computer Integrated Manufacturing: From Concepts to Realisation by Roger Hannam, Prentice Hall; 1st edition (1997) ISBN: 0201175460
2. CIM Justification and Optimization by Grier C. I. Lin, Sev V. Nagalingam, CRC Press (2000) ISBN: 0748408584
3. CIM Technology: Fundamentals and Applications by Russell Biekert, David Berling, Richard J. Evans, Donald G. Kelley, Dale E. Palmgren, Michael W. Pelphrey, Joe Richardson, David L. Thorson, W. Van, Jr. Twelves, Goodheart Wilcox Company (1998) ISBN: 156637426X

- Internet Sites

1. Manufacturing Systems, http://www.bergen.org/technology/manuf.html
2. What is the relationship between Lean Manufacturing and CIM? http://akss.dau.mil/askaprof-akss/normal/qdetail2.asp?cgiSubjectAreaID=6&cgiQuestionID=10036
3. Computer Integration for Streamlining Your Manufacturing Processes, http://www.ecicomplete.com/lean_manufacturing.html

Purpose of Lesson: To familiarize students with the functioning of integrated automated process technologies and their impact on quality control and productivity.

Required Knowledge and/or Skills: Students should have some understanding that manufacturing is a production system that uses technological resources to transform ideas into products that meet human needs and desires. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on history.

Lesson

Engagement:

1. The teacher will assess prior knowledge and possible misconceptions related to the functioning of integrated automated process technologies.
2. The teacher will ask students to imagine a school where the classrooms are located in four separate buildings, with clocks that are all individually set, there is no intercom or public address system, memos are inefficiently distributed, and there are only two phone lines for the whole complex.
3. The teacher will ask students to speculate how efficiently the school would operate.
4. The teacher will ask students to imagine a football team where the head coach could not talk to the offensive or defensive coordinators, the quarterback could not receive signals from the sideline, and the scoreboard was not visible from the team's bench area.
5. The teacher will ask students to speculate on how this football might perform.

Exploration:

1. The teacher will state that good communication is critical to the success of any organization.
2. Students working in small groups will design an integrated communication system for either of the scenarios presented above.
3. The teacher will provide a brief review of techniques for producing an annotated diagram.
4. The teacher will encourage students to be as creative as possible in identifying and describing the elements of their system.
5. Students will prepare an annotated diagram of their system and be prepared to present their ideas to classmates and other audiences.

Explanation:

1. The teacher will review elements of the students' systems from the exploratory activity with particular emphasis on those elements that are found in contemporary manufacturing systems.
2. The teacher will state that managers of manufacturing enterprises have adopted a striking array of integrated automated process technologies.
3. Computer-Integrated-Manufacturing (CIM) - The teacher will explain that:
   a. The umbrella acronym (pronounced "sim") for a variety of automated manufacturing technologies.
   b. CIM integrates functions that traditionally have been separate, seeking "to streamline with quality control and just in-time manufacturing, and to give every machine and employee the ability to talk with each other and 'watch' a product as it moves through the entire corporate pipeline."
   c. CIM systems rely on the integration of mechanical, electrical, and informational subsystems.
   d. It does not refer to one specific technology, but to the integrated use of computers in all sections of the enterprise.
   e. The benefits reported from CIM users include lower energy bills; less scrap and rework problems, better quality control; higher competitive standing; faster product introduction; and increased flexibility in design, product mix, production volumes, and process routings.
4. Just-In-Time (JIT) - The teacher will explain that Just-In-Time:
   a. Is a manufacturing philosophy that attempts to eliminate waste throughout the system, including inventory at both ends of production and all machinery and manpower not adding directly to the value of the product.
   b. Focuses on achieving integrated, highly consistent, short cycle operations requiring minimal work in process inventory.
   c. Requires the steady purchase of parts in small lot sizes as opposed to conventional purchasing practices in which raw materials are ordered from suppliers in anticipation of future production.
5. Concurrent Engineering (CE) - The teacher will explain that Concurrent Engineering:
   a. Is a way of integrating many aspects of product design, development, and manufacture so that critical phases of product design proceed concurrently within the boundaries of the manufacturing system infrastructure.
   b. The key element in CE is increased communication between the different stages of the design process.
   c. The goal is to reduce the product cost by designing a product that can be manufactured from the beginning without any problems.
6. Lean Manufacturing - The teacher will explain that Lean Manufacturing:
   a. Lean means "manufacturing without waste."
   b. Improve material handling, inventory, quality, scheduling, personnel and customer satisfaction.
   c. Workers are encouraged to stop production if they find a defect and work together to solve any problems.
   d. Was developed in Japan by Toyota.
7. Rapid Prototyping (RP) - The teacher will explain that Rapid Prototyping:
   a. Makes use of prototypes early in the development stage to identify errors in design and make necessary modifications.
   b. Allows designers to produce a prototype within minutes of completing a computer-aided-design (CAD) drawing of a part.

c. Avoids the lengthy process of traditional design used conventional tooling and casting processes.
d. Uses data from a three-dimensional CAD file to construct a model.
e. Systems have increased in recent years and include, stereolithography, laser modeling systems, solid ground curing, and laminated object manufacturing.

8. Cellular Manufacturing - The teacher will explain that Cellular Manufacturing:
   a. Is a method of equipment layout in which the machines are grouped into cells rather than being placed on an assembly line or divided into different functions.
   b. Uses Group Technology (GT) to maximize production efficiency, grouping together similar and recurring tasks, procedures, problems, and bottlenecks.
   c. Has attracted a great deal of interest from manufacturing firms because of its proven capacity to simplify material flow on the production floor.
   d. Uses a formal coding system in which each part receives a numeric or alphanumeric code describing specific characteristics or attributes.
9. Total Quality Management (TQM) - The teacher will explain that:
   a. The management of productivity and quality has emerged as a major business strategy in numerous organizations.
   b. Three forces driving this trend are global competition, the need to improve the productivity of labor, and the increased awareness of quality by consumers.
   c. TQM is a regulatory process through which performance is first measured and then compared with pre-established standards.
   d. In TQM corrective action is taken, if necessary.
   e. The foundation of TQM is the internal, national, and international standards that organizations work toward.

Extension:

1. Students working in groups will conduct research and identify common attributes of integrated automated process technologies.
2. Student groups will develop concept maps that illustrate the common attributes of integrated automated process technologies.
3. The student groups will present their concept maps to the class and other audiences.

Evaluation: Students' knowledge, skills, and attitudes will be assessed using rubrics for class participation, group work, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities:

1. Student groups may be asked to research and report on the implications of integrated automated process technologies on workers and their job environments.
2. Students may be assigned to research and report on advances in robotics and their application in manufacturing enterprises.

Laboratory-Classroom Preparation: The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small group meetings, and research activities should be readied.

Laboratory-Classroom Safety and Conduct:

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument - Selected Response Items
Match the terms in Column II with the statements the in Column I.

	Column I	**Column II**	
	The umbrella acronym for a variety of automated manufacturing technologies	A	Cellular Manufacturing
	A way of integrating many aspects of product design, development, and manufacture so that critical phases of product design proceed concurrently within the boundaries of the manufacturing system infrastructure	B	CIM
	A manufacturing philosophy that attempts to eliminate waste throughout the system, including inventory at both ends of production and all machinery and manpower not adding directly to the value of the product	C	Concurrent Engineering
	Workers are encouraged to stop production if they find a defect and work together to solve any problems. Was developed in Japan by Toyota	D	Just-In-Time
	Uses data from a three-dimensional CAD file to construct a model	E	Lean Manufacturing
	A method of equipment layout in which the machines are grouped into cells rather than being placed on an assembly line or divided into different functions	F	Rapid Prototyping
	A regulatory process through which performance is first measured and them compared with pre-established standards	G	Statistical Process Control
		H	Total Quality Management

Assessment Instrument - Selected Response Item
Directions: Circle the T or F in the column to the left of each true (T) or false (F) statement.

T F 1. Computer-integrated-manufacturing systems rely on the integration of mechanical, electrical, and informational subsystems.
T F 2. Efficient decision-making is facilitated by workers being able to enter data from any location
T F 3. Computer-integrated-manufacturing systems separate functions that traditionally have been integrated
T F 4. By separating each aspect of the manufacturing process via computer links, costly time delays and lack of communication between sales representatives and production engineers can be minimized.
T F 5. Centralized databases used in CIM systems contain files on tools, equipment detailing maintenance and depreciation time lines.
T F 6. In CIM systems, prototypes can be prepared and tested quickly.
T F 7. CIM allows customers to acquire current data from both design and manufacturing departments promoting centralized control of the production process.
T F 8. In the future, CIM systems may enable computers to control machine tools.
T F 9. A goal of CIM systems is the reduction in the duplication of data concerning product specifications, tolerances, order quantities, inventory, and raw materials.
T F 10. In CIM systems, computers no longer are required to execute routine clerical tasks.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative Does little work Rarely offers useful ideas	Cooperative Works at assignments Usually offers useful ideas	Always willing to help and do more Does more than required Routinely offers useful ideas
Cooperation	Rarely listens to, shares with, or supports the efforts of others Often is not a good team member	Usually listens to, shares with, and supports the efforts of others Does not cause problems in the group	Always listens to, shares with, and supports the efforts of others Tries to keep people working together
Focus on the task	Does not focus on the task and what needs to be done Lets others do the work	Focuses on the task and what needs to be done most of the time	Almost always focused on the task and what needs to be done Self-directed

Assessment Instruments – Graphic Organizer, Concept Map

Category	Below Target	At Target	Above Target
Arrangement of Concepts	Main concept not clearly identified; subconcepts don't consistently branch from main idea	Main concept easily identified; most subconcepts branch from main idea	Main concept easily identified; subconcepts branch appropriately from main idea
Links and Linking Lines	Linking lines not always pointing in correct direction; linking words don't clarify relationships between concepts; hyperlinks don't function or fail to enhance the topic	Most linking lines connect properly; most linking words accurately describe the relationship between concepts; most hyperlinks effectively used	Linking lines connect related terms/point in correct direction; linking words accurately describe relationship between concepts; hyperlinks effectively used

Graphics	Graphics used inappropriately and excessively; graphics poorly selected and don't enhance the topic; some graphics are blurry and ill-placed	Graphics used appropriately most of the time; most graphics selected enhance the topic, are of good quality, and are situated in logical places on the page	Graphics used appropriately; greatly enhance the topic and aid in comprehension; are clear, crisp and well situated on the page
Content	Contains extraneous information; is not logically arranged; contains numerous spelling and grammatical errors	Reflects most of the essential information; is generally logically arranged; concepts presented without too many excess words; fewer than three misspellings or grammatical errors	Reflects essential information; is logically arranged; concepts succinctly presented; no misspellings or grammatical errors
Text	Font too small to read easily; more than four different fonts used; text amount is excessive for intended audience	Most text is easy to read; uses no more than four different fonts; amount of text generally fits intended audience	Easy to read/ appropriately sized; no more than three different fonts; amount of text is appropriate for intended audience; boldface used for emphasis
Design	Cluttered design; low in visual appeal; requires a lot of scrolling to view entire diagram; choice of colors lacks visual appeal and impedes comprehension	Design is fairly clean, with a few exceptions; diagram has visual appeal; four or fewer symbol shapes; fits page well; uses color effectively most of time	Clean design; high visual appeal; four or fewer symbol shapes; fits page without a lot of scrolling; color used effectively for emphasis
Knowledge Gained	Student demonstrates a lack of knowledge about the content and the processes used to create the poster	Student can accurately answer most questions related to content and the processes used to create the poster	Student can accurately answer all questions related to content and the processes used to create the poster

Assessment Instrument – Brief Constructed Response Items

1. Explain how communication and information systems impact manufacturing processes.
2. Describe how mechanical, electrical, and informational subsystems are combined to produce computer-integrated-manufacturing systems.
3. Explain the functions of centralized databases in computer-integrated-manufacturing systems.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Constructed Response Items

1. Describe the benefits reported from companies using computer-integrated-manufacturing.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or	Ample and appropriate evidence	Abundant, relevant specifics

	generalized	provided	(names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence Thorough chronology
Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder argument, but do not detract from the overall accuracy	Virtually error free; minor mistakes do not compromise argument
Thoroughness	Covers question superficially May not complete all tasks	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportions to their importance
Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree	Uses clear language Well organized Contains few grammatical errors	Uses clear, appropriate and precise language Cohesive organization Very few grammatical errors

Chapter 4 – Manufacturing Technology

Lesson 3 - Stuff: What We Use to Make Things

Lesson Duration: Five (5) hours.

Standards:

- Students will develop an understanding of and be able to select and use manufacturing technologies. (ITEA/STL-16)
- Students will develop an understanding of the designed world. (Materials and Manufacturing) (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)
- Students will use analyze change in various contexts. (NCTM - MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
▪ Materials have different qualities and can be classified as natural, synthetic, or mixed.	▪ Manufacturing processes have been changed by improved tools and techniques based on more thorough scientific understanding, increases in the forces that can be applied and the temperatures that can be reached, and the availability of electronic controls that make operations occur more rapidly and consistently	• Use graphs to analyze the nature of changes in quantities in linear relationships. • Approximate and interpret rates of change from graphical and numerical data. • Model and solve contextualized problems using various representations, such as graphs, tables, and equations. • Use the language of mathematics to express ideas precisely.

Learning Objectives: Students will:

1. Classify industrial materials based on how they were made.
2. Identify and describe industrial materials made using mechanical processes.
3. Identify and describe industrial materials made using thermal processes.
4. Identify and describe industrial materials made using chemical processes.
5. Identify and describe industrial materials made using electromechanical processes.
6. Research the primary processing of an industrial material.
7. Explain why it is useful to use a log scale on one axis or a graph.
8. Explain how the development of new industrial materials processes impact the quality and prices of manufactured goods.
9. Design and fabricate a three-dimensional model or display panel that illustrates the processing of the material.

Student Assessment Tools and/or Methods:

(See assessment instruments at end of lesson)

1. Selected Response Items
2. Brief Constructed Response Items

3. Extended Response Items
4. Performance Rubrics

Resource Materials:

- Print-Based Sources

1. Ceramics and Glass: a Basic Technology by Charles Bray, Society of Glass Technology, https://secure.societyofglasstechnology.org.uk/cgi-bin/mi.cgi?pplace=15&sessionid=4956105&page=Books
2. Glass Science, 2nd Edition by Robert H. Doremus, Wiley-Interscience; 2nd edition (1994) ISBN: 0471891746
3. Smart Materials and Technologies in Architecture by Michelle Addington, Daniel L. Schodek Architectural Press (2004) ISBN: 0750662255

- Audiovisual Materials

1. Making Steel (1998), Format: Color, NTSC Studio: Blackboard Entertainment, VHS: ASIN: B000006Q1J
2. Field Trip Videos: Making Steel (1995) Color, NTSC, Alpha-Omega Publications ASIN: 156371373X
3. Materials Timeline, http://www.makingthemodernworld.org.uk/stories/the_second_industrial_revolution/05.ST.01/

- Internet Sites

1. Cement and Concrete Basics, http://matse1.mse.uiuc.edu/~tw/concrete/prin.html
2. How Aluminum is Produced, http://www.rocksandminerals.com/aluminum/process.htm
3. Kevlar, Making the Modern World, http://www.makingthemodernworld.org.uk/learning_modules/chemistry/03.TU.02/?section=10

Purpose of Lesson: To familiarize students with major mechanical, thermal, chemical, and electrochemical processes for producing industrial materials.

Required Knowledge and/or Skills: Students should have some understanding that manufacturing is a production system that uses technological resources transform ideas into products that meet human needs and desires. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on history.

Lesson

Engagement:

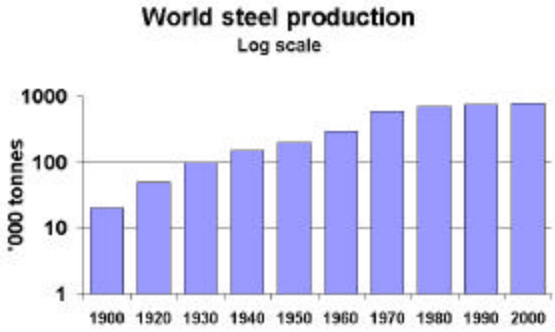
1. The teacher will assess prior knowledge and possible misconceptions related to the major mechanical, thermal, chemical and electrochemical processes for producing industrial materials.
2. The teacher will show students samples of industrial materials and ask them to identify them and speculate on how they were made.
3. The teacher will ask to think about and speculate on the raw materials used in the production of the industrial materials.
4. The teacher will ask students to think about and speculate on the processes used to make the industrial materials shown.

Exploration:

1. The teacher will state that most industrial materials are made using a mechanical, thermal, chemical, and electrochemical processes.
2. The teacher will briefly describe mechanical, thermal, chemical, and electrochemical processes.
3. The teacher will provide each group with samples of industrial materials or pictures of the materials.
4. Students working in small groups will attempt to classify industrial materials based on how they were made.

Explanation:

1. The teacher will review and clarify the students' classification of industrial materials based on how they were made.
2. The teacher will state that industrial materials are the "stuff" we use to make "things."
3. The teacher will restate that most industrial materials are made using a mechanical, thermal, chemical, and electrochemical processes.
4. The teacher will explain that some materials are made from combinations of these processes.
5. The teacher will explain that mechanical processes:
   a. Use mechanical forces to change the form of natural resources.
   b. May use compression (pressure) to crush the material to reduce its size or change its texture.
   c. May use shearing forces to cut and fracture the material.
   d. May use screens to sort the materials by size.
   e. Are used in the manufacture of lumber, plywood, and crushed stone.
6. The teacher will explain that thermal processes:
   a. Use heat to melt and reform a natural resource.
   b. Smelting is a thermal process used to extract metals from their ores.
   c. Are used to make glass and cement.
   d. Steel is an alloy, a mixture of iron and carbon.
7. The teacher will explain the history of steel production using the following graph and note that sometimes, when a plot has drastic changes in one of its variables, it is useful to use a log scale on that axis.



8. The teacher will explain that chemical or electrochemical processes:
   a. Are used to make synthetic fibers, pharmaceuticals, and plastics.
   b. Break down or build up materials by changing their chemical composition.
   c. Are used in making aluminum.
9. The teacher will check for student understanding by asking questions and clarifying conceptual understanding.

10. The teacher will provide instruction related to the design and fabrication of a three-dimensional model or display panel.

Extension:
1. Students working in groups will research the primary processing of an industrial material.
2. The student groups will design and fabricate a three-dimensional model or display panel that illustrates the processing of the material.
3. The student groups will make an oral presentation explaining their three-dimensional model or display panel.

Evaluation:
Students' knowledge, skills, and attitudes will be assessed using rubrics for class participation, group work, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities:
1. Student groups may be asked to research and report on natural material resources.
2. Students may be assigned to research and report on

Note: The teacher may wish to develop some interdisciplinary connections with science, social studies, or mathematics teachers in your school. Provide them with the concepts that you are addressing in technology education and find commonality among the academic curricula.

Laboratory-Classroom Preparation: The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small group meetings, and research activities should be readied.

Laboratory-Classroom Safety and Conduct:
1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument - Selected Response Item
Directions: Circle the T or F in the column to the left of each true (T) or false (F) statement.

T F 1. Most industrial materials are made using a mechanical, thermal, chemical, and electrochemical processes.
T F 2. Thermal processes may use pressure to crush the material to reduce its size or change its texture.

T F 3. Chemical or electrochemical processes break down or build up materials by changing their chemical composition.

T F 4. Aluminum is an alloy, a mixture of iron and carbon, made using a thermal process.

T F 5. Sorting the materials by size using screens is a mechanical process.

T F 6. Smelting is a chemical process used to extract metals from their ores.

T F 7. Industrial materials produced using mechanical products include lumber, plywood, and crushed stone.

T F 8. Mechanical forces cannot change the form of natural resources.

T F 9. Chemical or electrochemical processes are used to make synthetic fibers, pharmaceuticals, and plastics.

T F 10. Some materials are made from combinations of mechanical, thermal, chemical, and electrochemical processes

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative Does little work Rarely offers useful ideas	Cooperative Works at assignments Usually offers useful ideas	Always willing to help and do more Does more than required Routinely offers useful ideas
Cooperation	Rarely listens to, shares with, or supports the efforts of others Often is not a good team member	Usually listens to, shares with, and supports the efforts of others Does not cause problems in the group	Always listens to, shares with, and supports the efforts of others Tries to keep people working together
Focus on the task	Does not focus on the task and what needs to be done Lets others do the work	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done Self-directed

Assessment Instrument – Display and Presentation

Category	Below Target	At Target	Above Target
Overall display	The display is not organized OR the items are not securely attached to the display. Display is not professional.	The display is somewhat organized. The items are securely attached to the display. Display is partly clean and professional.	The display is attractive and well organized. The items are neatly and securely attached to the display. Display is clean and professional.
Number of Items /colors	The display has less than 3 items OR the items are all the same OR are in poor condition.	The display has at least 4 different, but related items. At least 3 of these are in good condition.	The display has 10 or more different, but related, items in good condition.
Labels	One of more items are not labeled. There are more than 2 errors in capitalization or	Each item has a label, but some lack some required information. There are 2 errors in capitalization	Each item has a small neat label describing the item. Capitalization and punctuation are correct

	punctuation. There are more than 2 grammatical mistakes on the poster.	or punctuation. There are 2 grammatical mistakes on the poster.	throughout the poster. There are no grammatical mistakes on the poster.
Participation	Student often lost focus or became frustrated and distracted others.	Student did work, but lost focus or became frustrated. Did not distract others.	Student showed great enthusiasm and focused on the task. Was helpful to others, if asked.
Knowledge Gained	Had trouble answering questions about the topic without using the labels in the display.	Was able to accurately answer at least 3 questions about the topic accurately, without reading the labels.	Was able to accurately answer at least 5 questions about the topic without reading the labels.

Assessment Instrument – Brief Constructed Response Items

1. Identify and describe industrial materials made using mechanical processes.
2. Identify and describe industrial materials made using thermal processes.
3. Identify and describe industrial materials made using chemical processes.
4. Identify and describe industrial materials made using electromechanical processes.
5. Explain why it useful to use a log scale on one axis or a graph.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Constructed Response Items

1. Describe how the development of improved industrial materials enable manufacturers to produce quality goods at low prices, enhancing the quality of life for many people.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or generalized	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence Thorough chronology
Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder argument, but do not detract from the overall accuracy	Virtually error free; minor mistakes do not compromise argument

Thoroughness	Covers question superficially May not complete all tasks	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportion to their importance
Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree	Uses clear language Well organized Contains few grammatical errors	Uses clear, appropriate and precise language Cohesive organization Very few grammatical errors

Chapter 5

Construction Technologies

Chapter 5 - Construction Technologies

Overview

Standards:

- Students will develop an understanding of and be able to select and use construction technologies. (ITEA/STL-20)
- Students will develop an understanding of and be able to select and use transportation technologies. (ITEA/STL-18)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/STL 12)
- Students will develop an understanding of engineering design (ITEA/STL-9)
- Students will develop an understanding of and be able to apply the design process (ITEA/STL – 11)
- Students will develop an understanding of the designed world. (Materials and Manufacturing) (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
▪ The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. ▪ Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. • Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize. • Infrastructure is the underlying base or basic framework of a system. • Structures are constructed using a variety of processes and procedures. • The design of structures includes a number of requirements. • Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use. • Structures can include prefabricated materials. • Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.	• Manufacturing processes have been changed by improved tools and techniques based on more thorough scientific understanding, increases in the forces that can be applied and the temperatures that can be reached, and the availability of electronic controls that make operations occur more rapidly and consistently	• Model and solve contextualized problems using various representations, such as graphs, tables, and equations.

Big Idea: Construction is the systematic process of erecting structures to meet human needs and desires. It reflects cultural norms, environmental conditions, and the requirements of enterprises and institutions.

Unit Objectives: At the completion of this unit, students will be able to:

1. Identify and describe heavy engineering structures.
2. Identify and describe types of buildings.
3. Explain how cultural norms, environmental conditions, and the requirements of enterprises and institutions might affect the design of structures.
4. Describe the role transportation plays in the operation of construction enterprises.
5. Describe the role information and communication technologies play in the operation of construction enterprises.
6. Describe the major processes and procedures used to create buildings.
7. Analyze construction business activity using a table.
8. Conduct research.
9. Develop a multimedia presentation.
10. Calculate the efficiency of a structure.
11. Create a structural model, test a design, and optimize a design.
12. List and describe the functions of management.
13. Describe the responsibilities of managers to workers, owners, and to the public.
14. Develop a flowchart for a construction project.
15. Describe the tasks that a construction manager must be able to perform.
16. Describe the training required to become a construction manager.
17. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.

Foundations of Technology
Chapter 5 – Construction Technologies

Unit Pre-Test

Place the letter of the correct answer in the box at left of statement.

1.		Structures are constructed using a variety of _____ and procedures. A. outputs B. demands C. processes D. cultural priorities
2.		Laws, codes, and professional standards are examples of _____ that regulate the design and construction process. A. inputs B. outputs C. criteria D. requirements
3.		Structures require _____, alteration, or renovation periodically to improve them or to alter their intended use. A. regulation B. maintenance C. automated systems D. regeneration

Briefly answer the following questions.

4. List and briefly describe the major processes used to create buildings.

5. List and describe the functions of management.

Foundations of Technology
Chapter 5 – Construction Technologies

Unit Test

Place the letter of the correct answer in the box at left of statement.

1.		The underlying base or basic framework of a system. A. Criteria B. Infrastructure C. Design D. Climate
2.		Structures are constructed using a variety of _____ and procedures. E. outputs F. demands G. processes H. cultural priorities
3.		Laws, codes, and professional standards are examples of _____ that regulate the design and construction process. E. inputs F. outputs G. criteria H. requirements
4.		Structures require _____, alteration, or renovation periodically to improve them or to alter their intended use. E. regulation F. maintenance G. automated systems H. regeneration
5.		Some sections of building projects can be prefabricated to _____. A. reduce cost B. reduce inventory C. increase cost D. save materials

Briefly answer the following questions.

6. Describe the role transportation plays in the operation of construction enterprises.
7. Describe the role information and communication technologies plays in the operation of manufacturing enterprises.
8. List and briefly describe the major processes used to create buildings.
9. List and describe the functions of management.
10. Explain how truss bridges counteract the forces acting on structures.
11. Describe the relationship between the % Change Prior Month and the % Change Prior Year for the economic indicators shown in the table below.

Economic Indicators	% Change Prior Month	% Change Prior Year
Building Permits	-2.7%	+6.0%
Housing Starts	+0.5%	+15.8%
New Home Sales	+9.4%	+5.2%
Existing Home Sales	-0.4%	+6.1%
Construction Spending	0.7%	+10.6%

12. Describe the responsibilities of managers to workers, owners, and to the public.
13. Describe three tasks that a construction manager must be able to perform.
14. Describe the training required to become a construction manager.

Extended Constructed Response Items

15. How do construction enterprises meet human needs and desires and what is the impact of cultural norms, environmental conditions, and the requirements of enterprises and institutions on the design of structures?

Chapter 5 – Construction Technology

Lesson 1 - Getting Familiar with the Big Idea

Construction is the systematic process of erecting structures to meet human needs and desires. It reflects cultural norms, environmental conditions, and the requirements of enterprises and institutions.

Lesson Duration: Five (5) hours.

Standards:

- Students will develop an understanding of and be able to select and use construction technologies. (ITEA/STL-20)
- Students will develop an understanding of and be able to select and use transportation technologies. (ITEA/STL-18)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/STL 12)
- Students will develop an understanding of the designed world. (Materials and Manufacturing) (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Infrastructure is the underlying base or basic framework of a system. • Structures are constructed using a variety of processes and procedures. • The design of structures includes a number of requirements. • Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use. • Structures can include prefabricated materials. • Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.	• Manufacturing processes have been changed by improved tools and techniques based on more thorough scientific understanding, increases in the forces that can be applied and the temperatures that can be reached, and the availability of electronic controls that make operations occur more rapidly and consistently	• Model and solve contextualized problems using various representations, such as graphs, tables, and equations.

Learning Objectives: Students will:

1. Identify and describe heavy engineering structures.
2. Identify and describe types of buildings.
3. Explain how cultural norms, environmental conditions, and the requirements of enterprises and institutions might affect the design of structures.
4. Describe the role transportation plays in the operation of construction enterprises.
5. Describe the role information and communication technologies play in the operation of construction enterprises.

6. Describe the major processes and procedures used to create buildings.
7. Analyze construction business activity using a table.
8. Conduct research.
9. Develop a multimedia presentation.
10. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.

Student Assessment Tools and/or Methods:
(See assessment instruments at end of lesson)
1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials:
- Print-Based Sources

1. Structures and Buildings, 5th Edition by Daniel L. Schodek, Prentice Hall; (2003) ISBN: 0130488798
2. Structures: Or Why Things Don't Fall Down by J. E. Gordon, Da Capo Press; Reprint edition (2003) ISBN: 0306812835
3. The Art of Construction: Projects and Principles for Beginning Engineers and Architects by Mario Salvadori, Saralinda Hooker, Christopher Ragus, Chicago Review Press; 3rd edition (1990) ISBN: 1556520808

- Audiovisual Materials

1. Great Projects: The Building of America: The Big Dig (VHS), PBS
   Item no: GPBA904
2. Great Projects: The Building of America 4PK (VHS), PBS
   Item no: GPBA900
3. All About Heavy Construction Equipment (2001) • Color, NTSC, Rated: NR , Goodtimes Home Video (2001), VHS Features: NTSC format, ASIN: B00003BDYT
4. Building the Channel Tunnel, Quick Time Video, http://www.teachersdomain.org/9-12/sci/phys/mfw/bbchunnel/index.html

- Internet Sites

1. Exploration Activity. http://www.pbs.org/wgbh/buildingbig/educator/act_columns_ho.html
2. Building Big, http://www.pbs.org/wgbh/buildingbig/
3. Engineering Simulation, usa.siemens.com/buildingbig

Purpose of Lesson: To familiarize students with construction technology and how cultural norms, environmental conditions, and the requirements of enterprises and institutions might affect the design of structures.

Required Knowledge and/or Skills: Students should have some understanding of technology's role in determining the way people live, work, and produce things. They should have some basic graphic and

research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on history.

Lesson

Engagement:

1. The teacher will assess prior knowledge and possible misconceptions related to construction technology and how cultural norms, environmental conditions, and the requirements of enterprises and institutions might affect the design of structures.
2. The teacher will present students with the following list and ask them what they have in common. (If possible, show pictures of these structures)
3. Students will share their ideas.

	References for Teachers
Three Gorges Dam - Sandouping, Yichang, China	http://en.wikipedia.org/wiki/Three_Gorges_Dam
Burj Dubai - Dubai, United Arab Emirates	http://www.emporis.com/en/wm/bu/?id=182168
International Space Station (ISS)	http://www.shuttlepresskit.com/ISS_OVR/
Hangzhou Bay Bridge - Cixi and Zhapu, China	http://www.chinapage.org/bridge/hangzhou/hangzhoubaybridge.html
Beijing Airport - Beijing, China	http://www.thebeijingguide.com/airport/
The World – Dubai, United Arab Emirates	http://www.theworld.dubai-city.de/
Freedom Tower – New York City	http://www.cnn.com/2003/US/Northeast/12/19/wtc.plan/
Millau Viaduct - Millau, France	http://www.viaducdemillau.com/
Queen Mary II	http://www.cunard.com/QM2/home.asp

2. The teacher will ask students to think about the major reasons people build structures (shelter, support, and contain).
3. Students will relate their thoughts on why humans build structures.

Exploration:

1. The teacher will hold up a toilet paper tube and announce that he/she is going to stand on it.
2. The teacher will ask, “Do you think this tube will hold me up?”
3. Working in pairs, students will use the material provided (sand or salt, cardboard box lid to catch any spilled sand or salt, masking tape, and funnel) to modify the toilet paper tube so that it will support a person.
4. The teacher will supervise this activity carefully to ensure safety. Limit testing to one person at a time. Have someone sit in the chair to hold it steady while the tester leans on the back of the chair.
5. The student groups will predict which will support a greater weight: a single column with a circumference of 24 cm or three columns with circumferences of 8 cm each?

Explanation:

1. The student groups will present their ideas to the class and respond to questions.
2. The teacher will explain that the answer depends on how they arrange the columns. Three smaller columns arranged a small distance apart in a triangular shape might support more weight than a single large central column.
3. The teacher will explain that construction is the systematic process of erecting structures to meet human needs and desires.

4. Students will use the "think-pair-share" approach to explain how cultural norms, environmental conditions, and the requirements of enterprises and institutions might affect the design of structures.
5. Students will clarify their understanding of concepts by asking questions.
6. The teacher will discuss and cite examples of:
   a. Types of structures including a) buildings (residential, commercial) b) and industrial and heavy engineering structures (airports, canals, highways, hydroelectric and flood control dams, pipelines, power transmission and communication towers, and rail lines)
   b. The design of structures includes a number of requirements.
   c. Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use.
   d. Structures can include prefabricated materials.
   e. The role information and transportation technologies play in the operation of construction enterprises.
   f. The role information and communication technologies play in the operation of construction enterprises.
7. The teacher will discuss the major processes and procedures used to create buildings.
   a. Preparing the site
   b. Setting foundations
   c. Building the framework
   d. Enclosing the structure
   e. Installing utilities
   f. Finishing the exterior
   g. Completing the site
8. The teacher will explain that construction activity is a major indicator of the economic well being of a state or nation.
9. The teacher will facilitate the interpretation of the following table addressing construction activity.

Economic Indicators	% Change Prior Month	% Change Prior Year
Building Permits	-2.7%	+6.0%
Housing Starts	+0.5%	+15.8%
New Home Sales	+9.4%	+5.2%
Existing Home Sales	-0.4%	+6.1%
Construction Spending	0.7%	+10.6%

10. The teacher will ask students to speculate on how we might answer the following questions.
    a. How does a dam withstand the crushing pressure of a lake full of water?
    b. How does a suspension bridge resist the forces of wind and traffic?
    c. Why can we walk in the shadows of mammoth skyscrapers, drive through tunnels deep underground, and sit beneath soaring stadium domes, confident that these giant structures will not collapse?

11. The teacher will explain that through the research process, answers to the preceding questions can be found and that the results of the research can be conveyed to others via a multimedia presentation.

Extension:

1. Students working in groups will research and develop a multimedia presentation on construction, the systematic process of erecting structures to meet human needs and desires.
2. Students working in groups will explain how construction projects reflect cultural norms, environmental conditions, and the requirements of enterprises and institutions.
3. Sub-topics for the research will include bridges, domes, skyscrapers, dams, and tunnels.
4. The teacher will discuss the areas of investigation to be completed in the research. (Evolution of design, construction processes used, resources required, requirements and constraints, examples of historic and contemporary structures and impacts)
5. Student groups will deliver their multimedia presentations to the class and other audiences.

Evaluation:

Students' knowledge, skills, and attitudes will be assessed using rubrics for class participation, group work, interpretation of a graph, multimedia presentation, brief constructed responses, and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment**.**

Other Extension Activities:

1. Student groups may be asked to identify and report to the class on the requirements and constraints for a sports arena and exhibition center that could be used for sporting events, concerts, trade shows, and conventions.
2. Students may be assigned to identify and report on how cultural norms, environmental conditions, and the requirements of enterprises and institutions might impact the design of a monument honoring war veterans.

Laboratory-Classroom Preparation:

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small group meetings, and research activities should be readied.

Tools/Materials/Equipment:

- Thirty empty toilet-paper tubes
- Sand or salt
- Dishpan, tray, or cardboard box lid to catch any spilled sand or salt
- Masking tape
- Sturdy chair
- Funnel

Laboratory-Classroom Safety and Conduct:

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared Minimal effort to participate	Prepared for class, attempts to answer teacher generated questions	Well prepared for class, attempts to answer teacher generated questions and adds additional information to class when relevant
Curiosity	Rarely demonstrates curiosity	Usually demonstrates curiosity	Consistently demonstrates curiosity
Motivation For Learning	Rarely demonstrates motivation for learning	Usually demonstrates motivation for learning	Consistently demonstrates motivation for learning
Use of Time	Gives up easily, is not engaged Has difficulty remaining on task	Makes good use of class time to work on assignments and projects	Makes excellent use of class time to work on assignments and projects

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative Does little work Rarely offers useful ideas	Cooperative Works at assignments Usually offers useful ideas	Always willing to help and do more Does more than required Routinely offers useful ideas
Cooperation	Rarely listens to, shares with, or supports the efforts of others Often is not a good team member	Usually listens to, shares with, and supports the efforts of others Does not cause problems in the group	Always listens to, shares with, and supports the efforts of others Tries to keep people working together
Focus on the task	Does not focus on the task and what needs to be done Lets others do the work	Focuses on the task and what needs to be done most of the time	Almost always focused on the task and what needs to be done Self-directed

Assessment Instrument – Multimedia Presentation

Category	Below Target	At Target	Above Target
Content - Accuracy	Content confusing or contains more than one factual error	Most content accurate but there is one piece of information that seems inaccurate.	All content throughout the presentation accurate No factual errors
Sequencing of Information	No clear plan for the organization of information	Most information is organized in a clear, logical way One slide or piece of information out of place	Information organized in a clear, logical way. Easy to anticipate the next element

Effectiveness	Lacking several key elements and has inaccuracies Completely inconsistent with driving question	Lacking a key element Consistent with driving question	Includes all material needed to give a good understanding of the topic
Use of Graphics	Graphics unattractive and detract from the content of the presentation.	A few graphics unattractive but all support the topic of the presentation	All graphics attractive (size and colors) and support the topic of the presentation
Text - Font Choice and Formatting	Difficult to read the text material	Format carefully planned to enhance readability	Formats (color, bold, italic) carefully planned to enhance readability and content
Spelling and Grammar	More than 2 grammatical and/or spelling errors	1-2 misspellings, but no grammatical errors.	No misspellings or grammatical errors
Delivery	Spoke a little faster or slower than necessary, or too quietly or loudly. Used unacceptable grammar. Failed to maintain eye contact Relied too much on their notes	Spoke at a good rate Volume appropriate Good grammar Maintained some eye contact with audience	Spoke at a good rate Volume excellent for setting Good grammar Maintained eye contact with audience

Assessment Instrument – Brief Constructed Response Items:

1. Describe the role transportation plays in the operation of construction enterprises.
2. Describe the role information and communication technologies play in the operation of construction enterprises.
3. List and briefly describe the major processes used to create buildings.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Constructed Response Items

1. How do construction enterprises meet human needs and desires and what is the impact of cultural norms, environmental conditions, and the requirements of enterprises and institutions on the design of structures?

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or generalized	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence Thorough chronology

Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder argument, but do not detract from the overall accuracy	Virtually error free; minor mistakes do not compromise argument
Thoroughness	Covers question superficially May not complete all tasks	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportions to their importance
Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree	Uses clear language Well organized Contains few grammatical errors	Uses clear, appropriate, and precise language Cohesive organization Very few grammatical errors

Chapter 5 – Construction Technology

Lesson 2 - Bridge Building

Lesson Duration: Five (5) hours.

Standards:

- Students will develop an understanding of and be able to select and use construction technologies. (ITEA/STL-20)
- Students will develop an understanding of and be able to select and use transportation technologies. (ITEA/STL-18)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/STL 12)
- Students will develop an understanding of engineering design (ITEA/STL-9)
- Students will develop an understanding of and be able to apply the design process (ITEA/STL – 11)
- Students will develop an understanding of the designed world. (Materials and Manufacturing) (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Infrastructure is the underlying base or basic framework of a system. • Structures are constructed using a variety of processes and procedures. • The design of structures includes a number of requirements. • Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use. • Structures can include prefabricated materials. • Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture. ▪ The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. ▪ Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. • Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize	• Manufacturing processes have been changed by improved tools and techniques based on more thorough scientific understanding, increases in the forces that can be applied and the temperatures that can be reached, and the availability of electronic controls that make operations occur more rapidly and consistently.	• Model and solve contextualized problems using various representations, such as graphs, tables, and equations.

and think abstractly.		

Learning Objectives: Students will:

1. Identify and describe the forces that act on very large bridges.
2. Explain how truss bridges counteract the forces acting on structures.
3. Describe the three major types of bridges.
4. Calculate the efficiency of a structure.
5. Create a structural model, test a design, and optimize a design.
6. Maintain a journal for an engineering design project.
7. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.

Student Assessment Tools and/or Methods:

(See assessment instruments at end of lesson)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials:

- Print-Based Sources

1. The Great Bridge-Building Contest by Bo Zaunders, Roxie Munro (Illustrator), Harry N. Abrams (2004) ISBN: 0810949296
2. Building Paper Bridges by E. Anthony Seiler, PublishAmerica (2005) ISBN: 1413754597
3. Bridges (Building Amazing Structures) by Chris Oxlade, Heinemann Library (December 1, 2000) ISBN: 1575722755

- Audiovisual Materials

1. Super Bridge from PBS NOVA Online, http://www.pbs.org/wgbh/nova/bridge/
2. "Bridges" Video (22mins) School Library by Kaw Valley Films and Video, Box 3541, Shawnee, KS, 66203, 800-332-5060
3. Arch Bridge, Quick Time Video, http://www.teachersdomain.org/9-12/sci/phys/mfw/bbarch/index.html
4. Train Truss, Quick Time Video, http://www.teachersdomain.org/9-12/sci/phys/mfw/bbtrussanim/index.html

- Internet Sites

1. Building Big, http://www.pbs.org/wgbh/buildingbig/
2. International Bridge Building Competition, http://www.iit.edu/~hsbridge/database/search.cgi/:/public/index
3. Technology Education - Bridge Building, http://www.geocities.com/tech_ed_2000/units/wadd/bridgebuilding.htm

Purpose of Lesson:

To familiarize students with bridge design and construction including an understanding of the forces acting on bridges.

Required Knowledge and/or Skills:
Students should have some understanding that construction is the systematic process of erecting structures to meet human needs and desires. It reflects cultural norms, environmental conditions, and the requirements of enterprises and institutions. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on history.

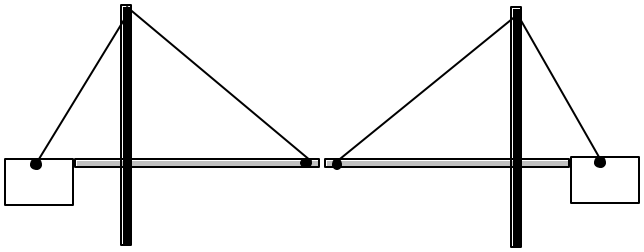
Lesson

Engagement:

1. The teacher will assess prior knowledge and possible misconceptions related to bridge design and construction.
2. The teacher will state that everyone has seen a bridge, and it's almost as likely that you've traveled over one today. If you've ever laid a plank or log down over a stream to keep from getting wet, you've even constructed a bridge. Bridges are a natural part of everyday life. A bridge provides passage over some sort of obstacle: a river, a valley, a road, railroad tracks, etc.
3. The teacher will ask students to think about the longest and highest bridge they have ever crossed.
4. The teacher will state that:
   a) The highest bridge in the world can be found in the Ladakh valley between the Dras and Suru rivers in the Himalayan mountains. The valley lies at an altitude of about 5,602 m (18,379 ft) above sea level on the India side of Kashmir. Called the Baily Bridge, it is only 30 metres (98 ft) long, and was built by the Indian Army in August 1982.
   b) The bridge that stands highest over water, is the Royal Gorge Bridge over the Arkansas River in Colorado. Built in 1929 for $350,000, it spans 321 m and is 1,053 ft above the water.
   c) The largest bridge in the world is the 13.27 km (8.25 miles) long Trans Bay Bridge which links San Francisco to Oakland. It was built in 1936 at a cost of $77 million.
   d) The longest bridge in the world is the Pontchartrain bridge in New Orleans, with a total length of 38.6 km (24 miles). It was completed in 1956.
   e) The most expensive bridge is the Seto-Ohashi-Kojima bridge in Japan. At 13.22 km (8.21 miles) long, it was built in 1988 at a cost of $8.3 billion.
   f) The world's largest natural bridge is the Rainbow Bridge, tucked away among the rugged, isolated canyons at the base of Navajo Mountain, Utah, USA. It is a natural wonder. From its base to the top of the arch, it reaches 88.4 m (290 ft)—nearly the height of the Statue of Liberty—and spans 83.8 m (275 ft) across the river. The top of the arch is 12.8 m (42 ft) thick and 10 m (33 ft) wide.
5. The teacher will ask students to identify the forces that might act on very large bridges.

Exploration:

1. The teacher will tie a piece of string to a shoe or other weight and ask, “Who can lift this shoe in the air only by pulling down on the string? (Guide students to the solution of passing the string over the back of a chair or other support and using it as a pulley to lift the shoe.)
2. The teacher will state that this basic suspension bridge design can be applied using other materials to build larger, stronger bridges.
3. With the materials provided, student groups will design and construct a suspension bridge. (At right)



4. The teacher will assist students in discovering:
   a) How forces act in a suspension bridge, by having them experiment with attaching the cables from the bridge deck only to the tops of the towers, instead of extending them back down to the surface at the ends of the bridge.
   b) Asking how strong is the bridge this way? Why? (This model is less strong than the model in which the cables extend back down to the ground on the other sides of the towers. A load on this bridge deck pulls the tips of the towers inward. There is no balancing tension pulling the towers back out toward the ground.)
   c) Adding the cables to their straw bridge and anchoring the cables on both sides significantly increases the load that the bridge can support.
   d) A suspension bridge's cables and towers transmit the dead load of the bridge deck and the live load of traffic to the massive anchor blocks at each end of the bridge.
   e) The tension in the cables leading up from the bridge deck is balanced by the tension in the cables leading to the anchor blocks, as well as the compression in the towers.
   f) The anchor blocks must be massive enough to resist the tension in the cables caused by the weight of the bridge deck.
5. Student groups will develop three questions about the performance of their bridge.

Explanation:

1. The student groups will present their questions about the performance of their bridge.
2. The teacher will explain that:
   a) There are three major types of bridges (beam bridges, arch bridges, and suspension bridges).
   b) The biggest difference between the three is the distances they can cross in a single span. A span is the distance between two bridge supports, whether they are columns, towers, or the wall of a canyon. A modern beam bridge, for instance, is likely to span a distance of up to 200 feet (60 meters), while a modern arch can safely span up to 800 or 1,000 feet (240 to 300 m). A suspension bridge, the pinnacle of bridge technology, is capable of spanning up to 7,000 feet (2,100 m).
3. The teacher will ask, “What allows an arch bridge to span greater distances than a beam bridge, or a suspension bridge to span a distance seven times that of an arch bridge?”
4. The teacher will state that the answer lies in how each bridge type deals with two important forces called compression and tension.
   a) Compression is a force that acts to compress or shorten the thing it is acting on.
   b) Tension is a force that acts to expand or lengthen the thing it is acting on.
5. The teacher will explain that:
   a) A simple, everyday example of compression and tension is a spring.
   b) When we press down, or push the two ends of the spring together, we compress it.
   c) The force of compression shortens the spring.
   d) When we pull up, or pull apart the two ends, we create tension in the spring.
   e) The force of tension lengthens the spring.
   f) Compression and tension are present in all bridges, and it's the job of the bridge design to handle these forces without buckling or snapping.
   g) Buckling is what happens when the force of compression overcomes an object's ability to handle compression, and snapping is what happens when the force of tension overcomes an object's ability to handle tension.
   h) The best way to deal with these forces is to either dissipate them or transfer them.
   i) To dissipate force is to spread it out over a greater area, so that no one spot has to bear the brunt of the concentrated force.

j) To transfer force is to move it from an area of weakness to an area of strength—an area designed to handle the force.
k) An arch bridge is a good example of dissipation, while a suspension bridge is a good example of transference.
l) Bridge efficiency is determined by dividing the load the bridge can withstand by the weight of the bridge structure.

6. The teacher will discuss the nature of truss bridges including that:
   a) A single beam spanning any distance experiences compression and tension.
   b) The very top of the beam experiences the most compression, and the very bottom of the beam experiences the most tension.
   c) The middle of the beam experiences very little compression or tension.
   d) If the beam were designed so that there was more material on the top and bottom, and less in the middle, it would be better able to handle the forces of compression and tension. (For this reason, I-beams are more rigid than simple rectangular beams.)
   e) A truss system takes this concept one step further. Think of one side of a truss bridge as a single beam. The center of the beam is made up of the diagonal members of the truss, while the top and bottom of the truss represent the top and bottom of the beam.
   f) Looking at a truss in this way, we can see that the top and bottom of the beam contain more material than its center (corrugated cardboard is very stiff for this reason).
   g) In addition to the above-mentioned effect of a truss system, there is another reason why a truss is more rigid than a single beam: A truss has the ability to dissipate a load through the truss work.
   h) The design of a truss, which is usually a variant of a triangle, creates both a very rigid structure and one that transfers the load from a single point to a considerably wider area.

Extension:

1. Students working in groups will create a structural model, test a design, and optimize the design of a truss bridge. (http://bridgecontest.usma.edu/)
2. Students groups will maintain a journal documenting the design process.

Evaluation:

Students' knowledge, skills, and attitudes will be assessed using rubrics for class participation, group work, interpretation of a graph, multimedia presentation, brief constructed responses, and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities:

1. Student groups may be asked to develop a display documenting the design process for their bridge.
2. Students may be assigned to identify and report a current construction (bridge, dam, dome, skyscraper, or tunnel) project.

Laboratory-Classroom Preparation: The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, production and fabrication, product/prototype testing and analysis. The

teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, design tools and equipment, fabrication tools and equipment, and testing tools should be readied.

Tools/Materials/Equipment:
(Per group of two)

- 7 drinking straws
- Masking tape
- 100 cm (about 4 ft.) Dental floss or thread
- Scissors
- 4 large paper clips
- Paper cup
- Pennies, metal washers, or other small weights
- Ruler

Laboratory-Classroom Safety and Conduct:

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative Does little work Rarely offers useful ideas	Cooperative Works at assignments Usually offers useful ideas	Always willing to help and do more Does more than required Routinely offers useful ideas
Cooperation	Rarely listens to, shares with, or supports the efforts of others Often is not a good team member	Usually listens to, shares with, and supports the efforts of others Does not cause problems in the group	Always listens to, shares with, and supports the efforts of others Tries to keep people working together
Focus on the task	Does not focus on the task and what needs to be done Lets others do the work	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done Self-directed

Assessment Instrument – Brief Constructed Response Items

1. Explain how truss bridges counteract the forces acting on structures.
2. Describe the three major types of bridges.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text

	the text and/or the question		
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Constructed Response Items

1. Identify and describe the forces that act on very large bridges

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or generalized	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence Thorough chronology
Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder argument, but do not detract from the overall accuracy	Virtually error free; minor mistakes do not compromise argument
Thoroughness	Covers question superficially May not complete all tasks	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportions to their importance
Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree	Uses clear language Well organized Contains few grammatical errors	Uses clear, appropriate, and precise language Cohesive organization Very few grammatical errors

Chapter 5 – Construction Technology

Lesson 3 - Construction Management

Lesson Duration: Five (5) hours.

Standards:

- Students will develop an understanding of and be able to select and use construction technologies. (ITEA/STL-20)
- Students will develop an understanding of and be able to select and use transportation technologies. (ITEA/STL-18)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/STL 12)
- Students will develop an understanding of the designed world. (Materials and Manufacturing) (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Infrastructure is the underlying base or basic framework of a system. • Structures are constructed using a variety of processes and procedures. • The design of structures includes a number of requirements. • Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use. • Structures can include prefabricated materials. • Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.	• Manufacturing processes have been changed by improved tools and techniques based on more thorough scientific understanding, increases in the forces that can be applied and the temperatures that can be reached, and the availability of electronic controls that make operations occur more rapidly and consistently	• Model and solve contextualized problems using various representations, such as graphs, tables, and equations.

Objectives: Students will:

1. Define management.
2. List and describe the functions of management.
3. Describe the responsibilities of managers to workers, owners, and to the public.
4. Develop a flowchart for a construction project.
5. Describe the tasks that a construction manager must be able to perform.
6. Create a Gantt chart.
7. Describe the training required to become a construction manager.
8. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.

Student Assessment Tools and/or Methods:
(See assessment instruments at end of lesson)
1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials:
- Print-Based Sources

1. Construction Management, 2nd Edition by Daniel W. Halpin, Ronald W. Woodhead, Wiley, (1997) ISBN 0471083933
2. Construction Management Fundamentals by Clifford J. Schexnayder and Richard Mayo, McGraw-Hill Science/Engineering/Math; 1st Edition, (2003) ISBN 0072922001
3. Construction Project Management (2nd Edition) by Frederick E. Gould and Nancy E. Joyce, Prentice Hall (2002) ISBN 0130480541

- Audiovisual Materials

1. Super Bridge from PBS NOVA Online, http://www.pbs.org/wgbh/nova/bridge/
2. Hoover Dam, www.hooverdam.usbr.gov
3. "Bridges" video (22 minutes) School Library by Kaw Valley Films and Video, Box 3541, Shawnee, KS 66203, 800-332-5060

- Internet Sites

1. The Big Dig, http://www.masspike.com/bigdig/multimedia/photo_feb04.html
2. Construction Management Glossary, http://www.c-risk.com/Reference_Library/CM_Glossary_01.htm
3. University of Maryland Eastern Shore, Department of Technology, Construction Management, www.umes.edu/tech

Purpose of Lesson:
To familiarize students with the functions, applications, and requirements of construction management.

Required Knowledge and/or Skills:
Students should have some understanding that construction is the systematic process of erecting structures to meet human needs and desires. It reflects cultural norms, environmental conditions, and the requirements of enterprises and institutions. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on history.

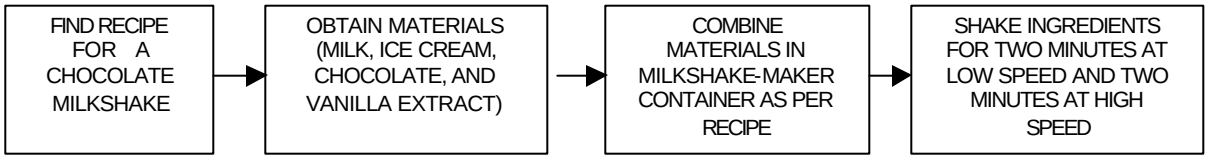
Lesson

Engagement:
1. The teacher will assess prior knowledge and possible misconceptions related to the concept that construction is the systematic process of erecting structures to meet human needs and desires
2. The teacher will show the class pictures of the "The Big Dig," Boston's Central Artery/Tunnel Project, constructed under the management of the Massachusetts Turnpike Authority.

3. Students will read the "Big Dig Information Sheet" (The Big Dig, http://www.masspike.com/bigdig/multimedia/photo_feb04.html)
4. The teacher will state that management is the act of planning, directing, and evaluating any activity.
5. The teacher will ask students to think about the major management challenge faced by the Massachusetts Turnpike Authority. (The Central Artery project's unique challenge was to construct this project in the middle of Boston without crippling the city.)
6. Students will speculate on the challenges and the teacher will clarify their answers.

Exploration:

1. The teacher will state that a flowchart is a means of visually presenting the operations performed within a system and the sequence in which they are performed.
2. The teacher will explain the following flow chart presenting the operations performed in the process of making a milkshake.



3. Students working in small groups will be assigned to develop a flowchart for the construction of a children's playground to be built somewhere on their school's property.

Explanation:

1. The students will explain their flowcharts to the class in a brief presentation.
2. The teacher will state that a playground is an example of purposeful technology that meets a human need or desire.
3. The teacher will explain that to achieve the desired results, technology enterprises must be managed efficiently.
4. The teacher will explain that management involves four factors.
   a) Authority – The power to influence behavior
   b) Responsibility – Moral and legal accountability
   c) Risks – Chances of loss
   d) Rewards – Things given for good service or attainment of goals
5. The teacher will explain that in order to efficiently manage large projects, construction managers must perform the following functions.
   a) Planning - The ongoing process of developing the business' mission and objectives and determining how they will be accomplished. Planning includes both the broadest view of the organization, e.g., its mission, and the narrowest, e.g., a tactic for accomplishing a specific goal
   b) Organizing - Establishing the internal organizational structure of the organization. The focus is on division, coordination, and control of tasks and the flow of information within the organization. It is in this function that managers distribute authority to jobholders.
   c) Staffing - Filling and keeping filled with qualified people all positions in the business. Recruiting, hiring, training, evaluating, and compensating are the specific activities included in the function. In the family business, staffing includes all paid and unpaid positions held by family members including the owner/operators.
   d) Directing - Influencing people's behavior through motivation, communication, group dynamics, leadership, and discipline. The purpose of directing is to channel the behavior of

all personnel to accomplish the organization's mission and objectives while simultaneously helping them accomplish their own career objectives.

e) Controlling - A four-step process of establishing performance standards based on the firm's objectives, measuring and reporting actual performance, comparing the two, and taking corrective or preventive action as necessary.

6. The teacher will explain tasks that a construction manager must be able to perform including:
   a) Analyze and interpret all types of construction drawings and documents.
   b) Develop conceptual programs and detail in order to calculate quantities of material, labor, and equipment needed for a project.
   c) Analyze financial data relative to cost budget data of construction work in the field and office.
   d) Apply data analysis to identify construction problems, specify goals, and execute projects including understanding risk management and safety loss prevention.
   e) Utilize the critical path and Gantt bar chart methods to organize, track, and update as necessary construction projects.
   f) Identify, understand, and apply the elements in construction employee relations and contract law.
   g) Utilize industry standard software for estimating, planning, scheduling, and cost control.
   h) Understand the processes of construction disputes, claims, and project documentation.
   i) Obtain working knowledge of safety, health, and environmental issues.
7. The teacher will explain that a Gantt Chart: (See example at the end of this lesson.)
   a) Is a horizontal bar chart developed as a production control tool in 1917 by Henry L. Gantt, an American engineer and social scientist.
   b) Is frequently used in project management.
   c) Provides a graphical illustration of a schedule that helps to plan, coordinate, and track specific tasks in a project.
   d) May be a simple version created on graph paper or more complex automated version created using project management applications such as Microsoft Project or Excel.
   e) Is constructed with a horizontal axis representing the total time span of the project, broken down into increments (for example, days, weeks, or months) and a vertical axis representing the tasks that make up the project (for example, if the project is outfitting your computer with new software, the major tasks involved might be: conduct research, choose software, install software).
   f) Has horizontal bars of varying lengths that represent the sequences, timing, and time span for each task. (Using the same example, you would put "conduct research" at the top of the vertical axis and draw a bar on the graph that represents the amount of time you expect to spend on the research, and then enter the other tasks below the first one and representative bars at the points in time when you expect to undertake them. The bar spans may overlap, as, for example, you may conduct research and choose software during the same time span. As the project progresses, secondary bars, arrowheads, or darkened bars may be added to indicate completed tasks, or the portions of tasks that have been completed.)
   g) Uses vertical lines to represent the report date.
   h) Explain Gantt Chart’s relationship to time versus completion curves. (See example at end of lesson.)
8. The teacher will discuss the training required to become a construction manager.
   a) Traditionally, persons advanced to construction management positions after having substantial experience as construction craft workers—for example, as carpenters, masons, plumbers, or electricians—or after having worked as construction supervisors or as owners

of independent specialty contracting firms overseeing workers in one or more construction trades.

b) However, more and more employers—particularly, large construction firms—seek to hire individuals who combine industry work experience with a bachelor's degree in construction or building science or construction management.

Extension:

1. The teacher will present students with specifications for a construction project.
2. Students working in groups will create a Gantt chart for a construction project.
3. Student groups will make an oral presentation to class members and other audiences on their Gantt chart.

Evaluation: Students' knowledge, skills, and attitudes will be assessed using rubrics for class participation, group work, graphic organizer (Gantt chart), brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities:

1. Student groups may be asked to develop a display documenting the design process for their bridge.
2. Students may be assigned to identify and report a current construction project (dam, dome, skyscraper, or tunnel)

Note: The teacher may wish to develop some interdisciplinary connections with science, social studies, or mathematics teachers in your school. Provide them with the concepts that you are addressing in technology education and find commonality among the academic curricula.

Laboratory-Classroom Preparation: The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small group meetings, and research activities should be readied.

Laboratory-Classroom Safety and Conduct:

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target

Contributions	Seldom cooperative Does little work Rarely offers useful ideas	Cooperative Works at assignments Usually offers useful ideas	Always willing to help and do more Does more than required Routinely offers useful ideas
Cooperation	Rarely listens to, shares with, or supports the efforts of others Often is not a good team member	Usually listens to, shares with, and supports the efforts of others Does not cause problems in the group	Always listens to, shares with, and supports the efforts of others Tries to keep people working together
Focus on the task	Does not focus on the task and what needs to be done Lets others do the work	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done Self-directed

Assessment Instruments – Graphic Organizer (Gantt Chart)

Category	Below Target	At Target	Above Target
Arrangement of Concepts	Main concept not clearly identified; subconcepts don't consistently branch from main idea	Main concept easily identified; most subconcepts branch from main idea	Main concept easily identified; subconcepts branch appropriately from main idea
Links and Linking Lines	Linking lines not always pointing in correct direction; linking words don't clarify relationships between concepts; hyperlinks don't function or they fail to enhance the topic	Most linking lines connect properly; most linking words accurately describe the relationship between concepts; most hyperlinks effectively used	Linking lines connect related terms/point in correct direction; linking words accurately describe relationship between concepts; hyperlinks effectively used
Graphics	Graphics used inappropriately and excessively; graphics poorly selected and don't enhance the topic; some graphics are blurry and ill-placed	Graphics used appropriately most of the time; most graphics selected enhance the topic, are of good quality, and are situated in logical places on the page	Graphics used appropriately; greatly enhance the topic and aid in comprehension; are clear, crisp, and well situated on the page
Content	Contains extraneous information; is not logically arranged; contains numerous spelling and grammatical errors	Reflects most of the essential information; is generally logically arranged; concepts presented without too many excess words; fewer than three misspellings or grammatical errors	Reflects essential information; is logically arranged; concepts succinctly presented; no misspellings or grammatical errors
Text	Font too small to read easily; more than four different fonts used; text amount is excessive for intended audience	Most text is easy to read; uses no more than four different fonts; amount of text generally fits intended audience	Easy to read/appropriately sized; no more than three different fonts; amount of text is appropriate for intended audience; boldface used for emphasis
Design	Cluttered design; low in visual appeal; requires a lot of scrolling to view entire diagram; choice of colors lacks visual appeal and impedes comprehension	Design is fairly clean, with a few exceptions; diagram has visual appeal; four or fewer symbol shapes; fits page well; uses color effectively most of time	Clean design; high visual appeal; four or fewer symbol shapes; fits page without a lot of scrolling; color used effectively for emphasis
Knowledge Gained	Student demonstrates a lack of knowledge about the content and the processes used to create the poster	Student can accurately answer most questions related to content and the processes used to create the poster	Student can accurately answer all questions related to content and the processes used to create the poster

Assessment Instrument – Brief Constructed Response Items

1. Describe the responsibilities of managers to workers, owners, and to the public.
2. Describe three tasks that a construction manager must be able to perform.
3. Describe the training required to become a construction manager.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Constructed Response Items

1. List and describe the functions of management.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or generalized	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence Thorough chronology
Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder argument, but do not detract from the overall accuracy	Virtually error free; minor mistakes do not compromise argument
Thoroughness	Covers question superficially May not complete all tasks	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportions to their importance
Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree	Uses clear language Well organized Contains few grammatical errors	Uses clear, appropriate, and precise language Cohesive organization Very few grammatical errors

Gantt Chart

A Gantt chart is a horizontal bar chart developed as a production control tool in 1917 by Henry L. Gantt, an American engineer and social scientist. Frequently used in project management, a Gantt chart provides a graphical illustration of a schedule that helps to plan, coordinate, and track specific tasks in a project. Gantt charts may be simple versions created on graph paper or more complex automated versions created using project management applications such as Microsoft Project or Excel

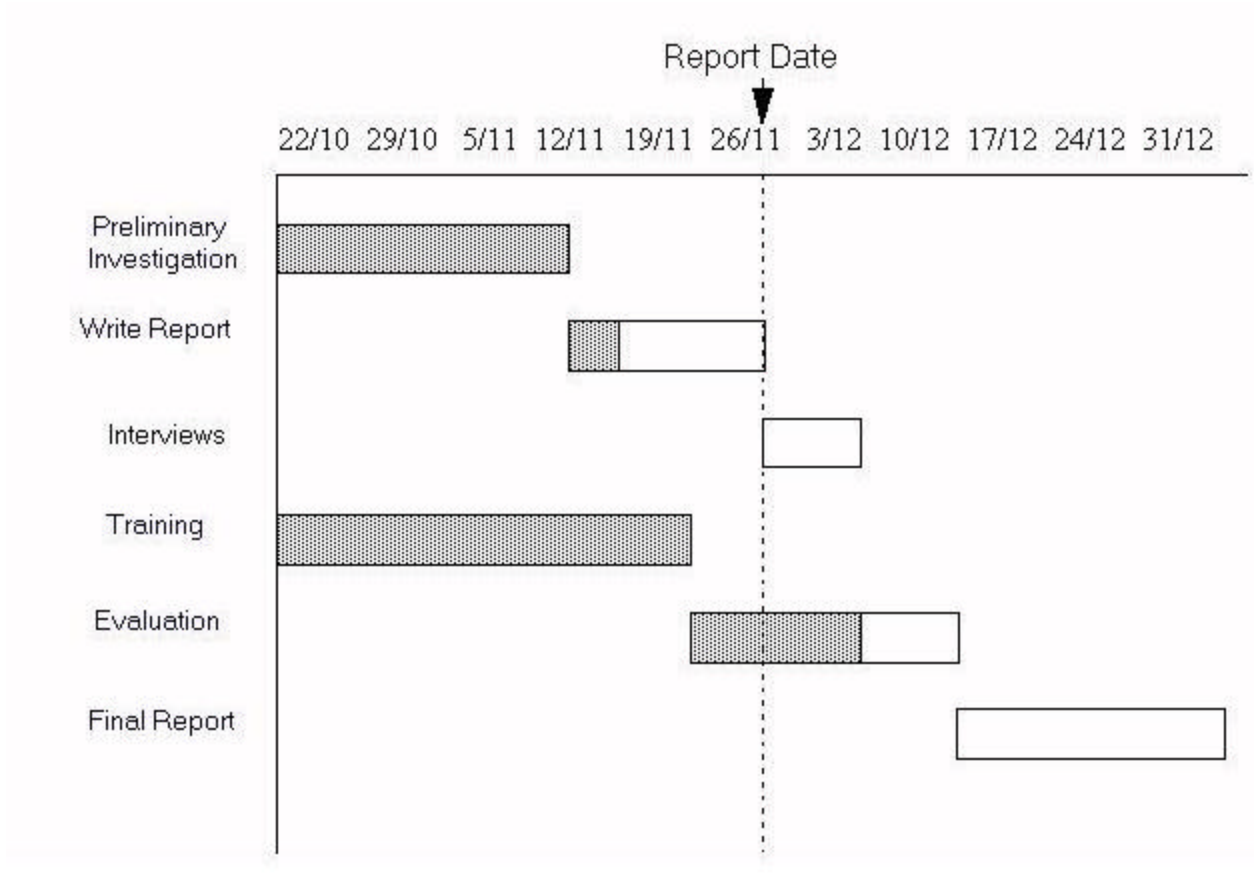
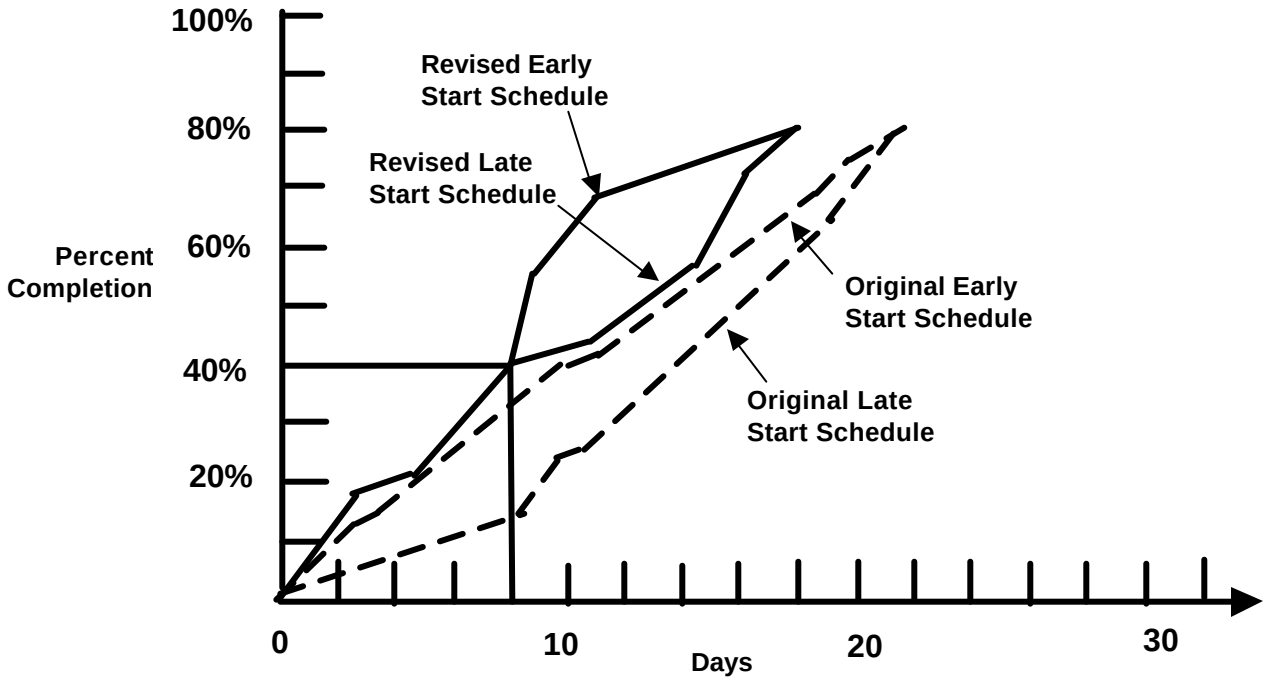


Figure 1: Gantt Chart

A Gantt chart is constructed with a horizontal axis representing the total time span of the project, broken down into increments (for example, days, weeks, or months) and a vertical axis representing the tasks that make up the project (for example, if the project is outfitting your computer with new software, the major tasks involved might be: conduct research, choose software, install software). Horizontal bars of varying lengths represent the sequences, timing, and time span for each task. Using the same example, you would put "conduct research" at the top of the vertical axis and draw a bar on the graph that represents the amount of time you expect to spend on the research, and then enter the other tasks below the first one and representative bars at the points in time when you expect to undertake them. The bar spans may overlap, as, for example, you may conduct research and choose software during the same time span. As the project progresses, secondary bars, arrowheads, or darkened bars may be added to indicate completed tasks, or the portions of tasks that have been completed. A vertical line is used to represent the report date.

Time Versus Completion Curves

Time versus completion curves are useful in construction project monitoring. The history of the project can be easily viewed and future possibilities for earliest and latest start times can seen. The graph below illustrates a project that is forty percent complete after eight days. The project is well ahead of the original schedule with some activities completed in less than expected time. The earliest and latest possible start time schedules are also shown.



Chapter 6

Energy and Power Technologies

Chapter 6 - Energy and Power Technologies

Overview

Standards:

- Students will develop an understanding of and be able to select and use energy and power technologies. (ITEA/STL-16)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/STL-12)
- Students will develop an understanding of the physical setting. (Design and Systems) (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Energy cannot be created or destroyed; however, it can be converted from one form to another. • Energy can be grouped into major forms; thermal, radiant, electrical, mechanical, chemical, nuclear, and others. • It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. • Energy resources can be renewable or nonrenewable. • Power systems must have a source of energy, a process, and loads. • Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information.	• It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. • Power systems must have a source of energy, a process, and loads.	▪ Model and solve contextualized problems using various representations, such as graphs, tables, and equations. ▪ Draw reasonable conclusions about a situation being modeled.

Big Idea: Advancements in the processing and controlling of energy resources have been an enabling factor in the development of technology.

Unit Objectives:

1. Define and differentiate energy, power, instrumentation, and control.
2. Differentiate between kinetic and potential energy.
3. Identify and describe the major sources of energy.
4. Describe energy conversion processes using a systems model.
5. Describe how alternative forms of energy may be used in the future.
6. Explain how electric motors operate.
7. Explain how engines convert energy into mechanical force and motion.
8. Describe how power is transmitted.
9. Explain the production, conversion, transmission, and application of different forms of energy including mechanical, radiant, chemical, thermal, electrical, and nuclear.
10. Explain that energy cannot be created nor destroyed; however, it can be converted from one form to another.
11. Analyze power systems identifying the source of energy, the process, and loads.

Foundations of Technology
Chapter 6 – Power and Energy Technologies

Unit Pre-Test

Place the letter of the correct answer in the box at left of statement.

1.		Energy cannot be created or destroyed; it can be _____from one form to another. A. synthesized B. optimized C. converted D. communicated
2.		Its major forms include thermal, radiant, electrical, mechanical, chemical, and nuclear A. energy B. power C. force D. resistance
3.		It is impossible to build a/an _____that does not exhaust thermal energy to the surroundings. A. model B. problem solution C. engine D. process

Briefly answer the following questions.

4. Identify and describe the common sources of energy.

5. Compare and contrast renewable and non-renewable energy sources.

Foundations of Technology
Chapter 6 – Power and Energy Technologies

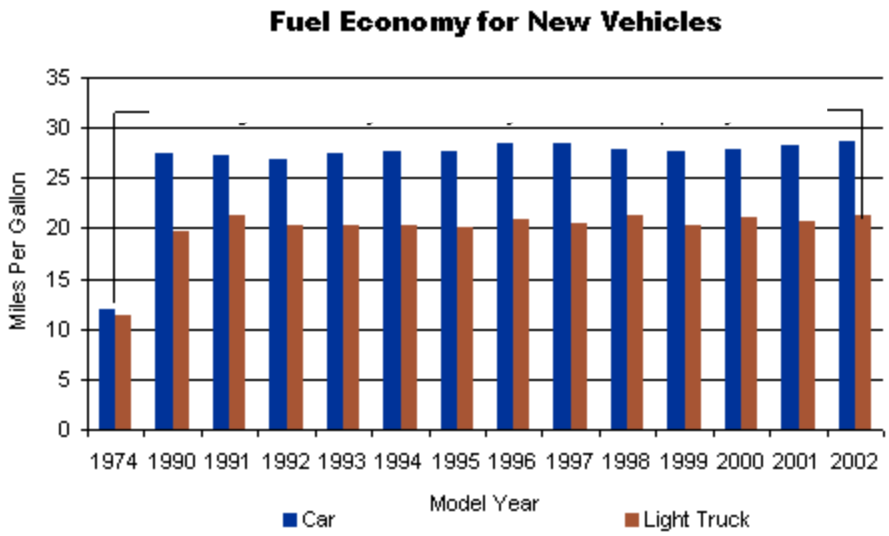
Unit Test

Place the letter of the correct answer in the box at left of statement.

1.		Energy cannot be created or destroyed; it can be _____from one form to another. A. synthesized B. optimized C. converted D. communicated
2.		Its major forms include thermal, radiant, electrical, mechanical, chemical, and nuclear A. energy B. power C. force D. resistance
3.		It is impossible to build a/an _____that does not exhaust thermal energy to the surroundings. A. model B. problem solution C. engine D. process
4.		Alternate and sustainable energy sources are being developed and tested in order to replace or supplement _____ sources. A. renewable B. environmental C. biological D. non-renewable
5.		Power systems must have a source of energy, _____, and loads. A. a generator B. a process C. power D. resources
6.		The disordered motions of its atoms or molecules in a material A. Heat energy B. Solar energy C. Electrical energy D. Geothermal energy
7.		Transformations of _____ usually produce some energy in the form of heat, which spreads around by radiation or conduction into cooler places. A. light B. temperature C. energy D. power

Briefly answer the following questions.

8. Using the graph below, characterize the change in fuel economy over the last 30 years.



9. Identify and describe the common sources of energy.
10. Compare and contrast renewable and non-renewable energy sources.
11. Explain how improvements in battery design have promoted the advancement of other technologies.
12. Describe the environmental, political, and cultural factors that might contribute to a desire for cars with higher fuel efficiency or cars that use alternative energy sources.
13. Describe factors that might detract from creating cars with higher fuel efficiency or cars that use alternative energy sources.

Extended Constructed Response Items

14. Explain how the processing and controlling of energy resources have been an enabling factor in the development of technology.
15. Describe how changing attitudes toward fossil fuel use and alternative energy sources may affect car technology.

Unit 6 – Power and Energy Technologies

Lesson 1 - Getting Familiar with the Big Idea

Advancements in the processing and controlling of energy resources have been an enabling factor in the development of technology.

Lesson Duration: Five (5) hours.

Standards:

- Students will develop an understanding of and be able to select and use energy and power technologies. (ITEA/STL-16)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/STL-12)
- Students will develop an understanding of the physical setting. (Design and Systems) (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Energy cannot be created or destroyed; however, it can be converted from one form to another. • Energy can be grouped into major forms; thermal, radiant, electrical, mechanical, chemical, nuclear, and others. • It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. • Energy resources can be renewable or nonrenewable. • Power systems must have a source of energy, a process, and loads. • Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information.	• It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. • Power systems must have a source of energy, a process, and loads.	▪ Model and solve contextualized problems using various representations, such as graphs, tables, and equations. ▪ Draw reasonable conclusions about a situation being modeled.

Learning Objectives: Students will:

1. Define "energy."
2. Describe kinetic and potential energy.
3. Identify and describe the common sources of energy.
4. Compare and contrast renewable and non-renewable energy sources.
5. Describe how batteries convert chemical energy into electrical energy.
6. Explain how improvements in battery design have promoted the advancement of other technologies.
7. Explain how the processing and controlling of energy resources have been an enabling factor in the development of technology.
8. Design a Web page.

Student Assessment Tools and/or Methods:
(See assessment instruments at end of lesson)
1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials:
- Print-Based Sources

1. Introduction to Energy : Resources, Technology, and Society by Edward S. Cassedy, Peter Z. Grossman, Cambridge University Press; 2nd edition (1998) ISBN: 0521637678
2. ENERGY: The Master Resource by Robert Bradley, Kendall Hunt Pub Co (2004) ISBN: 0757511694
3. Global Science: Energy, Resources, Environment by John W. Christensen, Kendall Hunt Pub Co; 4th Student Edition (1996) ISBN: 0840374836

- Audiovisual Materials

1. Earth Day Posters, http://www.nesea.org/energy/posters.html
2. Fueling the Future, http://www.nef1.org/ftf/materials.html
3. How a Wind Turbine Works, http://www.eere.energy.gov/consumerinfo/

- Internet Sites

1. How Batteries Work, How Stuff Works, http://electronics.howstuffworks.com/battery2.htm
2. Timeline of Battery History, http://inventors.about.com/library/inventors/blbattery.htm
3. Battery Power, http://inventors.about.com/library/inventors/blbattery1.htm

Purpose of Lesson:
To familiarize students with how advancements in the processing and controlling of energy resources have been an enabling factor in the development of technology.

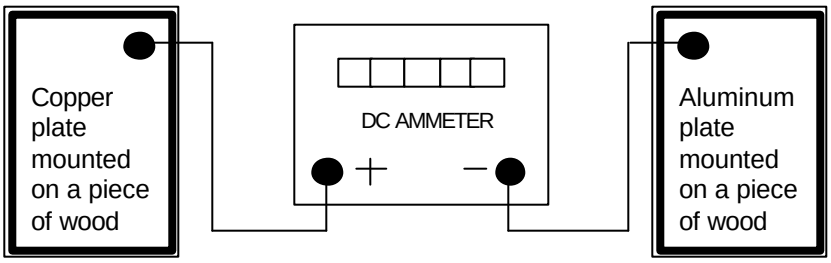
Required Knowledge and/or Skills:
Students should have some understanding of technology's role in determining the way people live, work, and produce things. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about energy and power technologies.

Lesson

Engagement:
1. The teacher will assess prior knowledge and possible misconceptions related to how advancements in the processing and controlling of energy resources have been an enabling factor in the development of technology.
2. The teacher will present students with pictures or an actual collection of batteries.
3. Students will create a ranked list of battery-powered devices that are critical to their lives.
4. Students will be asked to describe how their lives would be changed if batteries had not been invented.

Exploration:

1. The teacher will present students with the laboratory set-up for an experiment that will demonstrate that we can create an electric current using nothing more than our own bodies.



2. Working in pairs, students will record their prediction on what will happen when they place their hands on the metal plates.
3. Students will
   a. Place one hand on each metal plate. (Note: They should see an electric current generated on the meter. If they don't see a reading then simply reverse the connections. If they still don't see a reading then they may need to clean the metal plates
   b. Students will record meter readings.
   c. Wet hands and place one hand on each metal plate.
   d. Students will record meter readings.
4. Students will write a brief statement explaining what has occurred.
5. Students will write two questions concerning the experiment.

Explanation:

1. The student groups will present their explanations and questions to the class.
2. The teacher will explain that:
   a. A battery is a device that converts chemical energy into electrical energy.
   b. Energy is the ability to do work.
   c. Kinetic energy is energy in motion.
   d. Potential energy is energy at rest waiting to do work.
   e. Each battery has two electrodes, an anode (the positive end) and a cathode (the negative end).
   f. An electrical circuit runs between these two electrodes, going through a chemical called an electrolyte (which can be either liquid or solid).
   g. This unit, consisting of two electrodes, is called a cell (often called a voltaic cell or pile).
   h. Batteries are used to power many devices and make the spark that starts a gasoline engine.
3. The teacher will explain that:
   a. When they placed their hands on the metal plates, a thin film of sweat on their hands acts just like the acid in a battery, producing a chemical reaction with the copper plate and a chemical reaction with the aluminum plate.
   b. Their hands actually took negatively charged electrons away from the copper plate (leaving positive charges behind) and gives electrons to the aluminum plate (causing it to become negatively charged). This difference in charges produces an electrical current that flows through the meter.
   c. When you wet your hands you greatly decrease the resistance and thus increase the current giving you a higher reading on the meter.

4. The teacher will state that:
   a. Batteries are an essential part of everyday life.
   b. Batteries are the power source for millions of consumer, business, medical, military, and industrial appliances worldwide.
   c. Batteries are an energy source that has spurred the development of other technologies.
   d. Other energy sources have been crucial in the development of technology.
5. The teacher will ask students to name some other energy resources that can be converted into electricity.
6. The teacher will review the major energy resources.
7. Fossil Fuels: The teacher will explain that:
   a. Coal, oil and gas are called "fossil fuels" because they have been formed from the fossilized remains of prehistoric plants and animals.
   b. Fossil fuels provide around 66% of the world's electrical power, and 95% of the world's total energy demands (including heating, transport, electricity generation and other uses)
   c. Coal provides around 28% of our energy, and oil provides 40%.
   d. Burning coal produces sulphur dioxide, an acidic gas that contributes to the formation of acid rain.
   e. Crude oil (called "petroleum") is easier to get out of the ground than coal, as it can flow along pipes. This also makes it cheaper to transport
   f. Natural gas provides around 20% of the world's consumption of energy, and as well as being burnt in power stations, is used by many people to heat their homes.
   g. It is easy to transport along pipes, and gas power stations produce comparatively little pollution.
   h. Fossil fuels are not a renewable energy resource.
8. Nuclear Power: The teacher will explain that:
   a. Nuclear power is generated using uranium, which is a metal mined in various parts of the world.
   b. Nuclear power produces around 11% of the world's energy needs, and produces huge amounts of energy from small amounts of fuel, without the pollution that you'd get from burning fossil fuels.
   c. Nuclear power stations work in pretty much the same way as fossil fuel-burning stations, except that a "chain reaction" inside a nuclear reactor makes the heat instead.
   d. The reactor uses uranium rods as fuel, and the heat is generated by nuclear fission. Neutrons smash into the nucleus of the uranium atoms, which split roughly in half and release energy in the form of heat.
   e. Carbon dioxide gas is pumped through the reactor to take the heat away, and the hot gas then heats water to make steam.
   f. The steam drives turbines that drive generators.
      Modern nuclear power stations use the same type of turbines and generators as conventional power stations
   g. Nuclear energy from uranium is not renewable.
9. Hydro-Electric Power: The teacher will explain that:
   a. We have used running water as an energy source for thousands of years, mainly to grind corn.
   b. The first use of water to generate electricity was in 1882 on the Fox River, in the USA, which produced enough power to light two paper mills and a house.
   c. Currently there are many hydroelectric power stations, providing around 20% of the world's electricity.
   d. A dam is built to trap water, usually in a valley where there is an existing lake.

e. Water is allowed to flow through tunnels in the dam, to turn turbines and thus drive generators.
f. Hydroelectric power is renewable.

10. The teacher will ask students to identify other energy sources (solar, wind, tidal, and geothermal).
11. The teacher will check for student understanding by asking questions and clarifying conceptual understanding.

Extension:

1. The teacher will explain that:
   a. In August 1999, the National Academy of Engineering (NAE) invited 60 professional engineering societies to solicit nominations from their members for the greatest engineering achievements of the 20th century.
   b. The chief criteria for nominations was the significance that each engineering achievement had in terms of its impact on the quality of life during the 20th century.
   c. The number one engineering achievement of the 20th Century, according to the NAE study, was a power and energy advancement: electrification.
   d. This extraordinary advancement in the processing and controlling of energy resources has been an enabling factor in the development of technology and has had a profound impact on our quality of life.
2. The teacher will describe the "Six Steps for Web Design." http://www.siec.k12.in.us/~west/online/steps.htm
3. Students will:
   a. Design a web page on "Electrification and Quality of Life."
   b. Generate a list of enterprises and institutions that have been impacted by electrification. (i.e. Family & Household, Personal Services, Government, Hospitality, Education, Military, Public Safety, Law Enforcement, Commerce, Finance, Recreation, Agriculture, Health and Medicine, Communications, Transportation, Construction, Manufacturing)

Evaluation:

Students' knowledge, skills, and attitudes will be assessed using rubrics for group work, Web page, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities:

1. Student groups may be asked to
2. Students may be assigned to

Laboratory-Classroom Preparation:

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small group meetings, and research activities should be readied.

Laboratory-Classroom Safety and Conduct:

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared Minimal effort to participate	Prepared for class, attempts to answer teacher generated questions	Well prepared for class, attempts to answer teacher generated questions and adds additional information to class when relevant
Curiosity	Rarely demonstrates curiosity	Usually demonstrates curiosity	Consistently demonstrates curiosity
Motivation For Learning	Rarely demonstrates motivation for learning	Usually demonstrates motivation for learning	Consistently demonstrates motivation for learning
Use of Time	Gives up easily, is not engaged Has difficulty remaining on task	Makes good use of class time to work on assignments and projects	Makes excellent use of class time to work on assignments and projects

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative Does little work Rarely offers useful ideas	Cooperative Works at assignments Usually offers useful ideas	Always willing to help and do more Does more than required Routinely offers useful ideas
Cooperation	Rarely listens to, shares with, or supports the efforts of others Often is not a good team member	Usually listens to, shares with, and supports the efforts of others Does not cause problems in the group	Always listens to, shares with, and supports the efforts of others Tries to keep people working together
Focus on the task	Does not focus on the task and what needs to be done Lets others do the work	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done Self-directed

Assessment Instrument – Web Page

Category	Below Target	At Target	Above Target
Layout / Design	The pages appear "busy" or "boring." Text may be difficult to read. The backgrounds are somewhat distracting.	The pages are eye-catching and attractive. Text is easy to read. The backgrounds are subtle and appropriate.	The pages are well organized with tables. Text spacing and alignment make reading easy. The backgrounds enhance the page.
Graphics	Photos are blurry or fuzzy; icons and clip art do not "fit" with the topic. Too many	Photos, icons, and clip art are appropriate, of high quality, and download fairly quickly.	Photos, icons, and clip art are used creatively and may follow a theme.

	pictures make the download time slow.		
Information	Information could be better written and too much information is given in each section.	Information is well written and interesting to read and is presented in short sections.	Information is creatively written and cleverly presented.
Navigation / Links	The user may become confused when navigating between pages. Some links may not work.	Links are consistent and easy to find so that the user can easily navigate back and forth through pages.	Links are created with images and icons to enhance the text links.

Assessment Instrument – Brief Constructed Response Items

1. Describe kinetic and potential energy.
2. Identify and describe the common sources of energy.
3. Compare and contrast renewable and non-renewable energy sources.
4. Describe how batteries convert chemical energy into electrical energy.
5. Explain how improvements in battery design have promoted the advancement of other technologies.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Constructed Response Items

1. Explain how the processing and controlling of energy resources have been an enabling factor in the development of technology.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or generalized	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence Thorough chronology
Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder argument, but do not detract from the overall accuracy	Virtually error free; minor mistakes do not compromise argument
Thoroughness	Covers question superficially	Covers entire question, but may	Covers all areas of question in

	May not complete all tasks	be slightly imbalanced	approximate proportions to their importance
Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree	Uses clear language Well organized Contains few grammatical errors	Uses clear, appropriate, and precise language Cohesive organization Very few grammatical errors

Chapter 6 – Power and Energy Technologies

Lesson 2 - Energy and Cars: What Does the Future Hold?

Lesson Duration: Five (5) hours.

Standards:

- Students will develop an understanding of and be able to select and use energy and power technologies. (ITEA/STL-16)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/STL-12)
- Students will develop an understanding of the physical setting. (Design and Systems) (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Energy cannot be created or destroyed; however, it can be converted from one form to another. • Energy can be grouped into major forms; thermal, radiant, electrical, mechanical, chemical, nuclear, and others. • It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. • Energy resources can be renewable or nonrenewable. • Power systems must have a source of energy, a process, and loads. • Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information.	• It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. • Power systems must have a source of energy, a process, and loads.	▪ Model and solve contextualized problems using various representations, such as graphs, tables, and equations. ▪ Draw reasonable conclusions about a situation being modeled.

Learning Objectives:

Students will:

1. Explain why attitudes toward fossil fuel use and alternative energy sources may change over the next 50 years.
2. Describe how changing attitudes toward fossil fuel use and alternative energy sources may affect car technology.
3. Compare and contrast the types of alternative energy sources that are currently under research, particularly for use in cars.
4. Explain the functioning of present-day internal-combustion car engines.
5. Describe how fuel is processed in the engine in order to make the car operate.
6. Describe the environmental, political, and cultural factors that might contribute to a desire for cars with higher fuel efficiency or cars that use alternative energy sources.
7. Describe factors that might detract from creating cars with higher fuel efficiency or cars that use alternative energy sources.

Student Assessment Tools and/or Methods:
(See assessment instruments at end of lesson.)
1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials:
- Print-Based Sources

1. Forward Drive: The Race to Build "Clean" Cars for the Future by Jim Motavalli, Club Books for Children (2000) ISBN: 1578050359
2. Electric and Hybrid Vehicle Technology (Sp-915) Society of Automotive Engineers (1992) ISBN: 1560912324
3. Electric and Hybrid Cars: A History by Curtis D. Anderson & Judy Anderson, McFarland & Company (2004) ISBN: 0786418729

- Audiovisual Materials

1. Extreme Oil, PBS Videos, 180 Minutes on 3 VHS, Item # WT255 (2004)
2. Horatio's Drive, Ken Burns, 120 min on 1 DVD, PBS Videos, Item # WG2482, UPC # 794054881721, 2003
3. Ford Escape Hybrid Pictures and Videos, http://www.autobytel.com/content/research/photogallery/index.cfm/action/ViewPhotos/photo_type_int/18/series_id_int/37457
4. The Impact of Technology – Cars, Quick Time Video, http://www.teachersdomain.org/9-12/sci/engin/design/techcars/index.html
5. Virtual Car: Velocity and Acceleration, Graphing, Flash Interactive, http://www.teachersdomain.org/9-12/sci/phys/mfw/bbtrussanim/index.html

- Internet Sites

1. Energy and Cars: What Does the Future Hold? http://school.discovery.com/lessonplans/programs/energyandcars/
2. Instructional Strategies Online, Think-Pair-Share, http://olc.spsd.sk.ca/DE/PD/instr/strats/think/
3. DOE's Hybrid Electric Vehicle Program, http://www.nrel.gov/vehiclesandfuels/hev/

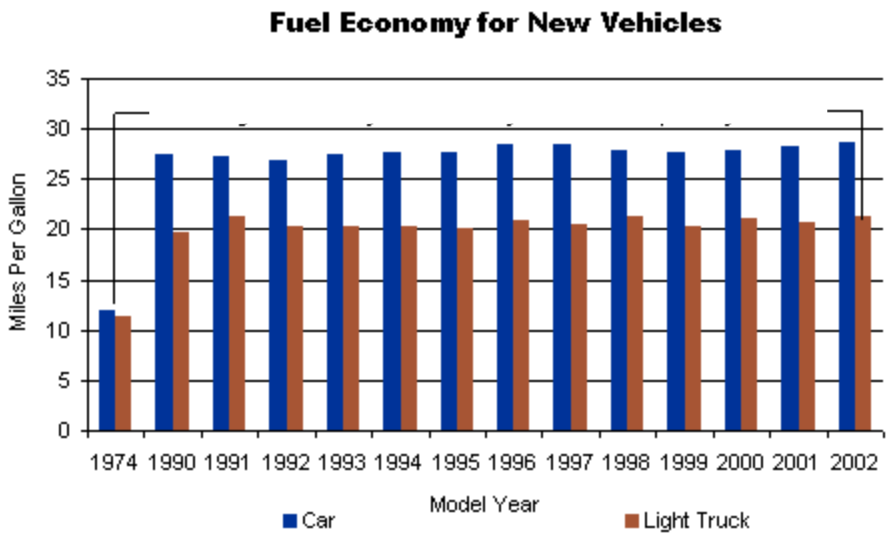
Purpose of Lesson:
To familiarize students with how changing attitudes toward fossil fuel use and alternative energy sources may affect car technology.

Required Knowledge and/or Skills:
Students should have some understanding of how advancements in the processing and controlling of energy resources have been an enabling factor in the development of technology. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about energy and power technologies.

Lesson

Engagement:

1. The teacher will assess prior knowledge and possible misconceptions related to how changing attitudes toward fossil fuel use and alternative energy sources may affect car technology.
2. The teacher will show the following graph and ask students to characterize the change in fuel economy over the last 30 years.



3. The teacher will pose the following questions.
   a. Which types of cars are the most fuel efficient and why?
   b. What factors might contribute to a desire for increased fuel efficiency in cars?
   c. How fuel efficient are cars today compared to 50 years ago?
4. Students will actively participate in group discussions.

Exploration:

1. The teacher will divide the class into small groups of approximately four students each.
2. The teacher will read the following scenario to the class with the students listening and taking notes.

> Pretend that you live in the year 3000. Your group is a team of archaeologists who have been studying the very interesting time period of A.D. 2000-2050. You've just excavated a site that reveals a great deal about transportation during this time period. At this site, you've found dozens of old cars and car pieces. You've also found an old sign that says "Joe's Junkyard, Established 2015." Therefore, you assume the oldest cars in this junkyard are from about the year 2000. You know that in 2050, a catastrophic earthquake leveled this part of town and all businesses ceased to operate. You can assume that cars in this junkyard are models from about 2000 to 2050. Your assignment is to present a report to the country's leading archaeologists explaining the following things:
>
> - The ways in which attitudes toward fossil fuel use and the use of alternative energy sources changed between 2000 and 2050, and the reason for these changes.
> - Changes to automobile technology and power sources between 2000 (the year when the oldest cars junked in 2015 would probably have been built) and 2050, and the

ways in which these changes reflected changing attitudes toward fossil fuel use and alternative energy sources.

3. Students will take themselves out of the futuristic scenario and into the present time and record their predictions about the following things:
   a. How and why (or whether) attitudes toward fossil fuel use will change over the next 50 years.
   b. The reasons why we might see changes in the way cars are powered.
   c. The changes that will occur in car technology in order to accommodate changing attitudes toward fuel efficiency and energy sources.

Explanation:

1. The student groups will present their predictions to the class.
2. The teacher will ask students to use the "Think-Pair-Share" strategy to address the following tasks.
   a. Speculate on the design features that could increase a car's fuel efficiency.
   b. Discuss how aspects of the engine, body, and other components of the car could be modified to minimize the amount of fuel the car requires.
   c. Explain why you think there are many more sport utility vehicles on the road today than there were 10 years ago.
   d. Compare the design features of a sport utility vehicle with those of a car in terms of their fuel efficiency.
   e. Describe the reasons why car manufacturers dramatically increased their cars' fuel efficiency over the past 50 years.
   f. Explain the environmental effects that a large number of cars might have on a city like Los Angeles, which is very spread out and surrounded by mountains.
   g. Describe the reasons why people might be reluctant to abandon their sport utility vehicles and trucks in favor of more fuel-efficient cars or to give up their traditional cars for electric vehicles or other alternative energy cars.
   h. Discuss what events could cause car manufacturers to drastically change the fuel efficiency or energy sources of their cars.
3. The teacher will explain that:
   a. Energy cannot be created or destroyed; however, it can be converted from one form to another.
   b. Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.
   c. It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings.
   d. Energy resources can be renewable or nonrenewable.
   e. Power systems must have a source of energy, a process, and loads.

Extension:

1. Student groups will use the Internet, the library, and any other relevant resources they can find to answer the following questions:
   a. How do present-day internal-combustion car engines work?
   b. How is fuel processed in the engine in order to make the car operate?
   c. What can be done to increase a car's fuel efficiency?
   d. What types of alternative energy sources are being developed for future cars?
   e. How do these energy sources power the car?

f. What are the advantages and disadvantages of each type of energy source?
g. Which energy sources seem most likely to be commonly used in cars of the future?
h. What environmental, political, and cultural factors might contribute to a desire for cars with higher fuel efficiency or cars that use alternative energy sources?
i. What factors might detract from creating cars with higher fuel efficiency or cars that use alternative energy sources?

2. When the student groups have finished their research, they will make oral presentations to a panel of archaeologists (i.e., the rest of the class) describing the things that their team has found in Joe's Junkyard and the conclusions it has reached concerning changes in automobile energy sources and attitudes toward energy use from 2000 to 2050. Their presentations should address the questions they investigated and should include visual aids when appropriate. For example, they can include diagrams of car engines that use different energy sources (traditional versus hybrid, for example) or charts showing the projected supply of fossil fuels or smog reduction goals for a particular city.
3. Each student individually will write a two- to three-page paper describing the conclusions his or her group has drawn from Joe's Junkyard and summarizing the group's predictions for the ways in which energy sources and attitudes toward energy sources will change over the next 50 years (2000-2050).
   Note: It's entirely possible that students will conclude that the public is not likely to change its attitudes toward fossil fuel use, that car companies will not follow through with plans to create cars powered by alternative energy sources, and that

Evaluation:
Students' knowledge, skills, and attitudes will be assessed using rubrics for group work, interpretation of a graph, research, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities:
1. Student groups may be asked to look through car magazines and/or brochures and identify design features that are more and less fuel efficient. Ask them to figure out which cars are being marketed as fuel efficient and which are not.
2. Students may be assigned to interview their parents, grandparents, and teachers to find out how they think attitudes toward fossil fuel use and alternative energy sources have changed in their lifetime. Have they noticed significant changes? If so, have they noticed these changing attitudes reflected in car design? Have these changes affected their behavior as consumers? For example, do they take fuel efficiency into consideration when purchasing a vehicle? Why or why not?

Note: The teacher may wish to develop some interdisciplinary connections with science, social studies, or mathematics teachers in your school. Provide them with the concepts that you are addressing in technology education and find commonality among the academic curricula.

Laboratory-Classroom Preparation: The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the

requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small group meetings, and research activities should be readied.

Tools/Materials/Equipment:

- Pens or pencils and paper
- Poster board or construction paper (for group presentations)
- Markers or crayons
- Computers with Internet access (optional for research)

Laboratory-Classroom Safety and Conduct:

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative Does little work Rarely offers useful ideas	Cooperative Works at assignments Usually offers useful ideas	Always willing to help and do more Does more than required Routinely offers useful ideas
Cooperation	Rarely listens to, shares with, or supports the efforts of others Often is not a good team member	Usually listens to, shares with, and supports the efforts of others Does not cause problems in the group	Always listens to, shares with, and supports the efforts of others Tries to keep people working together
Focus on the task	Does not focus on the task and what needs to be done Lets others do the work	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done Self-directed

Assessment Instrument– Research Report

Category	Below Target	At Target	Above Target
Thesis/Problem/ Question	Relies on teacher-generated questions or developed a question requiring little creative thought	Constructed a question that lends itself to readily available answers	Posed a thoughtful, creative question that leads to challenging or provocative research
Information Seeking/Selecting and Evaluating	Gathered information from a limited range of sources and displayed minimal effort in selecting quality resources	Gathered information from a variety of relevant sources—print and electronic	Gathered information from a variety of quality electronic and print resources Sources are relevant, balanced and include critical readings relating to the thesis or problem
Analysis	Conclusions simply involved restating information Conclusions were not	Product shows good effort was made in analyzing the evidence collected	Carefully analyzed the information collected and drew appropriate and inventive conclusions supported by

	supported by evidence		evidence
Synthesis	Work is not logically or effectively structured	Logically organized and makes connections among ideas	Developed appropriate structure for communicating ideas Incorporates a variety of quality sources
Documentation	Greater care in documenting sources needed Documentation poorly constructed or absent	Documented sources with some care Few errors noted	Documented all sources Documentation is error-free
Product/Process	Needs to work on communicating more effectively	Effectively communicated the results of research to the audience	Effectively communicated the results of research to the audience Product displays creativity and originality

Assessment Instrument – Brief Constructed Response Items

1. Describe the environmental, political, and cultural factors that might contribute to a desire for cars with higher fuel efficiency or cars that use alternative energy sources.
2. Describe factors that might detract from creating cars with higher fuel efficiency or cars that use alternative energy sources

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Constructed Response Items

1. Describe how changing attitudes toward fossil fuel use and alternative energy sources may affect car technology.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or generalized	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence Thorough chronology
Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder	Virtually error free; minor mistakes do not compromise

		argument, but do not detract from the overall accuracy	argument
Thoroughness	Covers question superficially May not complete all tasks	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportions to their importance
Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree	Uses clear language Well organized Contains few grammatical errors	Uses clear, appropriate, and precise language Cohesive organization Very few grammatical errors

Chapter 6 – Power and Energy Technologies

Lesson 3 - The Great Energy Debate

Lesson Duration: Five (5) hours.

Standards:

- Students will develop an understanding of and be able to select and use energy and power technologies. (ITEA/STL-16)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/STL-12)
- Students will develop an understanding of the physical setting. (Design and Systems) (AAAS – BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Energy cannot be created or destroyed; however, it can be converted from one form to another. • Energy can be grouped into major forms; thermal, radiant, electrical, mechanical, chemical, nuclear, and others. • It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. • Energy resources can be renewable or nonrenewable. • Power systems must have a source of energy, a process, and loads. • Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information.	• It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. • Power systems must have a source of energy, a process, and loads.	▪ Model and solve contextualized problems using various representations, such as graphs, tables, and equations. ▪ Draw reasonable conclusions about a situation being modeled.

Learning Objectives: Students will:

1. Identify sources of energy used in the United States.
2. Distinguish between fossil fuels and renewable energy.
3. Describe how energy production and consumption can impact public lands.
4. Identify the attributes of various alternatives to fossil fuels.
5. Participate in a debate over whether to use public lands as sources of energy.

Student Assessment Tools and/or Methods:
(See assessment instruments at end of lesson)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials:

- Print-Based Sources

1. The Final Energy Crisis by Andrew McKillop (Editor),Pluto Press (2005) ISBN: 0745320929
2. The Coming Oil Crisis by C. J. Campbell, Multi-Science Publishing Co. Ltd. (2004) ISBN: 0906522110
3. The Bottomless Well: The Twilight of Fuel, the Virtue of Waste, and Why We Will Never Run Out of Energy by Peter W. Huber, Mark P. Mills; Basic Books (2005) ISBN: 0465031161

- Audiovisual Materials

1. Global Warming: Beyond Fossil Fuels, test of interview, http://www.teachersdomain.org/9-12/sci/engin/design/beyondfossil/index.html
2. Global Warming: Graphs Tell the Story, http://www.teachersdomain.org/9-12/sci/engin/design/beyondfossil/index.html
3. Three Mile Island: What Happened, Shockwave Interactive, http://www.teachersdomain.org/9-12/sci/engin/design/threemile2/index.html

- Internet Sites

1. The Great Debate, National Geographic, http://www.nationalgeographic.com/xpeditions/lessons/16/g912/energydebate.html
2. 1979 Energy Crisis, http://en.wikipedia.org/wiki/1979_energy_crisis
3. Enron Manipulated Energy Crisis, http://news.bbc.co.uk/1/hi/business/1972574.stm

Purpose of Lesson:
To familiarize students with how energy production and consumption can impact society, productivity, and the environment.

Required Knowledge and/or Skills:
Students should have some understanding of changing attitudes toward fossil fuel use and alternative energy sources. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about energy and power technologies.

Lesson

Engagement:

1. The teacher will assess prior knowledge and possible misconceptions related to how energy production and consumption can impact society, productivity, and the environment.
2. The teacher will ask the students to list the ways they depend upon energy in their everyday lives.
3. Students will develop a list of activities that are dependent upon fossil fuels (e.g., oil, coal, and natural gas). List answers on the board.
4. The teacher will ask them to think about and then discuss as a group the following questions:
   a. Where do these energy resources come from?
   b. How are our public lands connected to these resources?
   c. What is meant by the term "alternative energy"?
   d. What are some examples of alternative energy sources?

Exploration:

1. The teacher will lead a discussion about the advantages and disadvantages of renewable and nonrenewable sources of energy.

2. The teacher will:
   a. Ask students if they know of any renewable sources of energy in their area (e.g., windmills, hydroelectric dams, and solar panels). Write the six most common renewable energy sources on the board or overhead (e.g., hydroelectric, geothermal, wind, biomass, tidal, and solar).
   b. Divide the class into six groups and assign each group to research one source of energy.
   c. Have groups provide the following information about their alternative energy source to the class: a definition, three examples of how the source is used, and three advantages and three disadvantages of using the source. (Much of this information can be found on the Web sites listed under Related Links below.)
3. Once they have completed this research, have the groups make a summary presentation of their findings to the rest of the class.

Explanation:

1. The student groups will present a summary presentation of their findings to the rest of the class.
2. The teacher will check for student understanding by asking questions and clarifying conceptual understanding.

Extension:

1. The teacher will explain that:
   a. Students will now be participating in a mock hearing of the U.S. Senate Committee for Energy and Natural Resources.
   b. The hearing is being held to determine whether or not to explore for renewable energy sources on a specific parcel of public land. (The teacher may provide the students with a fictitious or real-life public land example.)
   c. Each group will assume the role of one of the stakeholders in the debate, trying to persuade the committee that its opinion is the right one.
2. The teacher will review the list of possible stakeholders below, add additional appropriate stakeholders for your example, and discuss how each might contribute to the debate.
   - Economists
   - Energy experts
   - Members of Youth for Environmental Action
   - Native Americans
   - President of the American Petroleum Institute
   - President of the Sierra Club
   - Senator
   - Tourism officials
   - U.S. Secretary of the Interior
   - Unemployed people
   - Wildlife experts

3. Assign or have student groups select the stakeholder they wish to represent.
4. Give students a few days to conduct research related to their role. They can start online research with the Web sites in the Related Links section. Caution students that, in a highly controversial issue like this, certain information might be presented with a bias. For example, one particular group may present possible environmental damage as minimal, while another will present it as significant. Students must use their best judgment about what is factual and may even want to try to find additional sources to validate information.

5. Conduct the committee hearing. Each group will have 10 minutes to state its case. Then the committee (which can be played by students, faculty, or even parents) will be permitted to ask additional questions. After each group testifies, ask the committee to determine which group was most persuasive and why.

Evaluation:
Students' knowledge, skills, and attitudes will be assessed using rubrics for class participation, group work, debates, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities:
1. Student groups may be asked to write a paragraph explaining their opinion about conserving energy resources. What measures do they believe individuals can (or should) take to conserve resources such as coal? What, if any, measures should the government take to regulate individual or industrial rates of consumption?

Laboratory-Classroom Preparation:
The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small group meetings, and research activities should be readied.

Tools/Materials/Equipment:
- Computers
- Printers
- Presentation software
- Computer projector

Laboratory-Classroom Safety and Conduct:
1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared Minimal effort to participate	Prepared for class, attempts to answer teacher generated questions	Well prepared for class, attempts to answer teacher generated questions and adds additional information to class when relevant

Curiosity	Rarely demonstrates curiosity	Usually demonstrates curiosity	Consistently demonstrates curiosity
Motivation For Learning	Rarely demonstrates motivation for learning	Usually demonstrates motivation for learning	Consistently demonstrates motivation for learning
Use of Time	Gives up easily, is not engaged Has difficulty remaining on task	Makes good use of class time to work on assignments and projects	Makes excellent use of class time to work on assignments and projects

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative Does little work Rarely offers useful ideas	Cooperative Works at assignments Usually offers useful ideas	Always willing to help and do more Does more than required Routinely offers useful ideas
Cooperation	Rarely listens to, shares with, or supports the efforts of others Often is not a good team member	Usually listens to, shares with, and supports the efforts of others Does not cause problems in the group	Always listens to, shares with, and supports the efforts of others Tries to keep people working together
Focus on the task	Does not focus on the task and what needs to be done Lets others do the work	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done Self-directed

Assessment Instrument – Debate

Category	Below Target	At Target	Above Target
Addresses Issues	Rarely addresses topic	Usually addresses topic	Always addresses topic
Support with Facts	Uses few facts that support topic	Uses some facts that support topic	Uses many facts that support topic
Persuasiveness	Arguments are rarely clear and convincing	Arguments are sometimes clear and convincing	Arguments clear and convincing
Teamwork	One member does the talking 100% of the time	One member does the talking 75% of the time	Used team member effectively Equal timing
Organization	Introduces topic and brings some closure to the debate	Grabs attention Brings closure to the debate	Electrifies audience in opening statement Closure convinces audience
Addresses Issues	Rarely addresses topic	Usually addresses topic	Always addresses topic
Support with Facts	Uses few facts that support topic	Uses some facts that support topic	Uses many facts that support topic

Assessment Instrument – Brief Constructed Response Items

1. Identify sources of energy used in the United States.
2. Distinguish between fossil fuels and renewable energy.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities

	superficial understanding of the text and/or the question		of the text
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Constructed Response Items

1. Describe how energy production and consumption can impact public lands.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or generalized	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence Thorough chronology
Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder argument, but do not detract from the overall accuracy	Virtually error free; minor mistakes do not compromise argument
Thoroughness	Covers question superficially May not complete all tasks	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportions to their importance
Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree	Uses clear language Well organized Contains few grammatical errors	Uses clear, appropriate and precise language Cohesive organization Very few grammatical errors

Chapter 7

Information and Communication Technologies

Chapter 7 - Information and Communication Technologies

Overview

Standards:

- Students will develop an understanding of and be able to select and use information and communications technologies. (ITEA/STL 17)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. (ITEA/STL 10)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/STL 12)
- Students will develop an understanding of the attributes of design (ITEA/STL-8)
- Students will develop an understanding of and be able to apply the design process. (ITEA/STL – 11)
- Students will develop an understanding of the design world. (AAAS-BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Information and communication systems that allow information to be transferred from humans to humans, humans to machines, machine to human, and machine to machine. • Information and communications technologies include inputs, processes, and outputs associated with sending and receiving information. • There are many ways to communicate information, such as graphic and electronic means. • Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. • Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. • Research and development is a problem solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. ▪ Identify the design problem and decide whether or not to address it. ▪ Identify criteria and constraints and determine how these will affect the design process. ▪ Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. • Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design.	▪ Written records and photographic and electronic devices enable human beings to share, compile, use, and misuse great amounts of information and misinformation. ▪ Computer modeling explores the logical consequences of a set of instructions and a set of data. ▪ As technologies that provide privacy in communication improve, so do those for invading privacy.	▪ Model and solve contextualized problems using various representations, such as graphs, tables, and equations. ▪ Use the language of mathematics to express ideas precisely. ▪ Draw reasonable conclusions about a situation being modeled.

Big Idea: Information is an essential resource for competitive economic growth and communication technology significantly impacts the way we live.

Unit Objectives: At the completion of this unit, students will be able to:

1. Analyze information and communication technologies using a systems model that includes inputs, processes, and outputs.
2. Identify and analyze information and communication systems that allow information to be transferred from humans to humans, humans to machines, machine to human, and machine to machine.
3. Compare and contrast information and communication systems designed to inform, persuade, entertain, control, manage, and educate.
4. Identify and describe the components of a communication system including the source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.
5. Explain that technological knowledge and processes are communicated using symbols, measurements, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.
6. Identify and describe that major types of communication systems.
7. Explain the functioning and applications of the major types of printing processes.
8. Define photographic communications and identify examples of photographic products.
9. Define and describe the major types of technical graphic communication.
10. Define telecommunications and describe the major types of telecommunications systems (radio broadcast, television broadcast, mobile communication systems, satellite communication systems).
11. Design information and communications products.
12. Explain that messages are influenced by factors such as timing, sequencing, and processing.
13. Explain that the usefulness of information depends on such factors as relevancy, timeliness, truth, completeness, and cultural value.

Foundations of Technology
Chapter 7 – Information and Communications Technologies

Pre-Test

Place the letter of the correct answer in the box at left of statement.

1.		Information and _____technologies include inputs, processes, and outputs associated with sending and receiving information. A. biotechnologies B. mechanical C. communication D. medical
2.		Can be transferred from human to human, from human to machine, from machine to human, and from machine to machine A. Information B. Photochemical processes C. Interconnected components D. Measurements
3.		Information and communication systems can be used to inform, _____ , entertain, control, manage, and educate. A. maintain B. experiment C. persuade D. build

Assessment Instrument – Brief Constructed Response Items

a. Explain why messages are influenced by factors such as timing, sequencing, and processing.

b. Explain how relevancy, timeliness, truth, completeness, and cultural values influence the effectiveness and usefulness of information.

Foundations of Technology
Chapter 7 – Information and Communications Technologies

Unit Test

Place the letter of the correct answer in the box at left of statement.

1.		Information and _____technologies include inputs, processes, and outputs associated with sending and receiving information. E. biotechnologies F. mechanical G. communication H. medical
2.		Can be transferred from human to human, from human to machine, from machine to human, and from machine to machine E. Information F. Photochemical processes G. Interconnected components H. Measurements
3.		Information and communication systems can be used to inform, _____ , entertain, control, manage, and educate. E. maintain F. experiment G. persuade H. build
4.		Made up of a source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination A. Biotechnology systems B. Transportation systems C. Communication systems D. Medical systems
5.		There are many ways to communicate information, such as _____ and electronic means. A. nonlinear B. open-loop C. alternative D. graphic
6.		Symbols, measurement, and _____ are used to communicate technological information. A. forces B. conventions C. supplements D. controls

Briefly answer the following questions.

7. Compare and contrast information and communication systems designed to inform and entertain.
8. Analyze components of e-mail communication including the source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.
9. Describe information and communication systems used in navigation technologies today.
10. Explain why messages are influenced by factors such as timing, sequencing, and processing.
11. Explain how relevancy, timeliness, truth, completeness, and cultural values influence the effectiveness and usefulness of information.

Extended Response Items

12. Defend the statement, "Information is an essential resource for competitive economic growth."

Chapter 7 – Information and Communications Technologies

Lesson 1 - Getting Familiar with the Big Idea

Information and communications technologies that process information in digital form have revolutionized society's information handling capacity and have proven to be a critical resource for competitive economic growth.

Lesson Duration: Six (6) hours

Standards:

- Students will develop an understanding of and be able to select and use information and communications technologies. (ITEA/STL-17)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. (ITEA/STL-10)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/STL-12)
- Students will develop an understanding of the design world. (AAAS-BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Information and communication systems that allow information to be transferred from humans to humans, humans to machines, machine to human, and machine to machine. • Information and communications technologies include inputs, processes, and outputs associated with sending and receiving information. • There are many ways to communicate information, such as graphic and electronic means. • Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. • Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. • Research and development is a problem solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.	▪ Written records and photographic and electronic devices enable human beings to share, compile, use, and misuse great amounts of information and misinformation. ▪ Computer modeling explores the logical consequences of a set of instructions and a set of data. ▪ As technologies that provide privacy in communication improve, so do those for invading privacy.	▪ Model and solve contextualized problems using various representations, such as graphs, tables, and equations. ▪ Use the language of mathematics to express ideas precisely. ▪ Draw reasonable conclusions about a situation being modeled.

Learning Objectives:
Students will:
1. Analyze information and communication technologies using a systems model that includes inputs, processes, and outputs.
2. Identify and analyze information and communication systems that allow information to be transferred from humans to humans, humans to machines, machine to human, and machine to machine.
3. Compare and contrast information and communication systems designed to inform, persuade, entertain, control, manage, and educate.
4. Identify and describe the components of a communication system including the source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.
5. Explain that technological knowledge and processes are communicated using symbols, measurements, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.
6. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
7. Explain that information is an essential resource for competitive economic growth.
8. Actively participate in group discussions, ideation exercises, and debates.
9. Demonstrate curiosity, exhibit motivation for learning, and use class time effectively.

Student Assessment Tools and/or Methods:
(See assessment instruments at end of lesson.)
1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials:
- Print-Based Sources

1. The Essential Guide to Telecommunications (3rd Edition) by Annabel Z. Dodd, Prentice Hall PTR; 3 Edition (2001) ISBN: 0130649074
2. Ethics and Technology: Ethical Issues in an Age of Information and Communication Technology by Herman T. Tavani, Wiley; 1st edition (2003) ISBN: 0471249661
3. Principles of Information Systems, Sixth Edition by Ralph Stair, Course Technology; 6th Edition (2003) ISBN: 0619064897

- Internet Sites

1. American Telecommuting Association, http://www.knowledgetree.com/ata.html
2. E-commerce, How Stuff Works, http://www.howstuffworks.com/ecommerce.htm
3. History of Internet and WWW, http://www.internetvalley.com/intval.html

Purpose of Lesson: To familiarize students with the proposition that communications and information technologies are an essential resource for competitive economic growth and that they profoundly impact our personal lives.

Required Knowledge and/or Skills: Students should have some understanding of the functioning and applications of electronic and electrical technology systems, their common components, basic system

design, safety considerations, and simple controls. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Lesson

Engagement:

1. The teacher will assess prior knowledge and possible misconceptions related to the proposition that communications and information technologies are an essential resource for competitive economic growth.
2. The teacher will state that technology has changed the nature of communication in our society.
3. Teacher will ask students to think about some of the ways contemporary communication technology has impacted their lives.
4. The teacher will state that today the worldwide market for cell phones is outstripping even the most enthusiastic predictions (500 million in 2004).
5. Students will be asked to speculate on the number of phone users today (1.5 billion—about one quarter of the world's population, according to the International Telecommunication Union, 2004).

Exploration:

1. The teacher will present students with illustrations or actual artifacts representing communication technologies that connect humans to humans (telephone), humans to machines (TV remote control), machines to humans (alarm clock), and machines to machines (thermostat).
2. Students, working in pairs, will classify communications technology using the chart below.

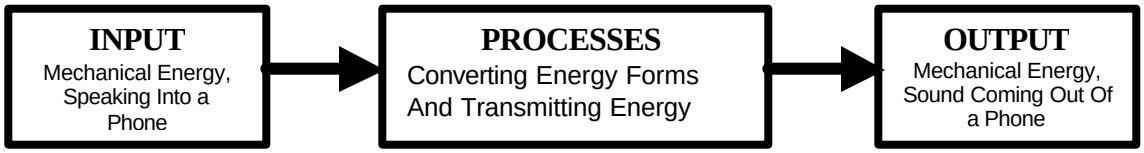
HUMAN TO HUMAN COMMUNICATION TECHNOLOGY	HUMAN TO MACHINE COMMUNICATION TECHNOLOGY	MACHINE TO HUMAN COMMUNICATION TECHNOLOGY	MACHINE TO MACHINE COMMUNICATION TECHNOLOGY
TELEPHONE	TV REMOTE CONTROL	ALARM CLOCK	THERMOSTAT

Explanation:

1. Students will share their lists of communication technology classified by whether they connect humans to humans, humans to machines, machines to humans or machines to machines.
2. The teacher will state that information and communication systems are designed to inform, persuade, entertain, control, manage, and educate.
3. The teacher will ask students to think of examples of information and communication technologies that are used for each purpose. (Note that some information and communication technologies have multiple purposes)

INFORM	PERSUADE	ENTERTAIN	CONTROL	MANAGE	EDUCATE

4. The teacher will state that information and communications technologies include inputs, processes, and outputs associated with sending and receiving information.



5. The teacher will state that communication systems can be analyzed by describing their components including the source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.
6. The teacher will state that technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.
7. The teacher will explain that there are many ways to communicate information, such as graphic (printing and photochemical processes) and electronic means (computers, DVD players, digital audio tapes, and telephones).
8. The teacher will explain and provide examples illustrating information and communication technologies that process information in digital form and have revolutionized society's information handling capacity and have proven to be a critical resource for competitive economic growth.
   a. Internet and e-mail
   b. Communication satellites for navigation
   c. CAD-CAM systems for manufacturing
   d. Telecommuting
   e. E-commerce
9. Students will restate any questions that were not answered in the teacher's lecture and clarify any unresolved issues.

Extension:

1. Students will write a friendly letter to a person in another country describing the information and communications technologies they use and how they affect their lives.
2. Students will research an aspect of competitive economic growth (i.e. personal services, hospitality, finance, recreation, agriculture, health and medicine, transportation, construction, manufacturing) and create a graphic organizer that describes how information and communications technologies are employed to enhance the enterprise.

Evaluation:

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, group work, graphic organizer, friendly letter, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities:

1. Students will research and report on the concept of virtual reality and speculate on how this technology might one day figure prominently in our daily routine.
2. Students will identify and describe two forms of computer-mediated communication.

Laboratory-Classroom Preparation:

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson.

Tools/Materials/Equipment:

- Computers with Internet Access
- Library resources
- Graphic tools, materials, and equipment

Laboratory-Classroom Safety and Conduct:

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument - Selected Response Items

Match the terms in Column II with the statements in Column I.

	Column I	Column II	
	Unorganized facts	A	Data
	Organized data	B	Communication
	Information applied to a task	C	Decoder
	The sending and receiving of information	D	Encoder
	A device that changes a message into a form that can be transmitted	F	Information
	A device that sends a signal (encoded message)	G	Knowledge
	A device that acquires a signal (encoded message)	H	Receiver
	A device that changes a coded message into an understandable form	I	Storage
		J	Transmitter

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared Minimal effort to participate	Prepared for class, attempts to answer teacher generated questions	Well prepared for class, attempts to answer teacher generated questions and adds additional information to class when relevant
Curiosity	Rarely demonstrates curiosity	Usually demonstrates curiosity	Consistently demonstrates curiosity
Motivation For Learning	Rarely demonstrates motivation for learning	Usually demonstrates motivation for learning	Consistently demonstrates motivation for learning
Use of Time	Gives up easily, is not engaged	Makes good use of class time to	Makes excellent use of class time

	Has difficulty remaining on task	work on assignments and projects	to work on assignments and projects

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative Does little work Rarely offers useful ideas	Cooperative Works at assignments Usually offers useful ideas	Always willing to help and do more Does more than required Routinely offers useful ideas
Cooperation	Rarely listens to, shares with, or supports the efforts of others Often is not a good team member	Usually listens to, shares with, and supports the efforts of others Does not cause problems in the group	Always listens to, shares with, and supports the efforts of others Tries to keep people working together
Focus on the task	Does not focus on the task and what needs to be done Lets others do the work	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done Self-directed

Assessment Instrument– Friendly Letter

Category	Below Target	At Target	Above Target
Layout/ Design	Letter appears busy or boring. Text may be difficult to read. May have some grammar and/or punctuation that indicates it is a friendly letter.	The letter is eye-catching and attractive. Text is easy to read. Grammar, style, and punctuation are indicative of a friendly letter.	The letter is creatively designed with easily read text. Grammar, style, and purpose all excellent for a friendly letter.
Information, style, audience, tone	Some information is provided, but is limited or inaccurate.	Information is well written and interesting to read.	Information is accurate and complete, is creatively written, and is cleverly presented.
Accurate Parts of the Friendly Letter	Most friendly letter elements (the heading, the salutation, the body, the closing, and the signature) out of place or missing.	Some friendly letter elements (the heading, the salutation, the body, the closing, and the signature) may be missing.	Letter is complete with all required elements (the heading, the salutation, the body, the closing, and the signature).
Grammar, Punctuation, and choice of words for the friendly letter	Information mislabeled or missing. Inaccurate punctuation or grammar.	Style, purpose, audience, grammar, and punctuation all fair and indicative of a friendly letter.	Excellent job on presentation, style, grammar, and punctuation.

Assessment Instruments – Graphic Organizer

Category	Below Target	At Target	Above Target
Arrangement of Concepts	Main concept not clearly identified; subconcepts don't consistently branch from main idea	Main concept easily identified; most subconcepts branch from main idea	Main concept easily identified; subconcepts branch appropriately from main idea
Links and Linking Lines	Linking lines not always pointing in correct direction; linking words don't clarify relationships between concepts; hyperlinks don't function or fail to enhance the topic	Most linking lines connect properly; most linking words accurately describe the relationship between concepts; most hyperlinks effectively used	Linking lines connect related terms/point in correct direction; linking words accurately describe relationship between concepts; hyperlinks effectively used
Graphics	Graphics used inappropriately and excessively; graphics poorly	Graphics used appropriately most of the time; most graphics	Graphics used appropriately; greatly enhance the topic and

	selected and don't enhance the topic; some graphics are blurry and ill-placed	selected enhance the topic, are of good quality, and are situated in logical places on the page	aid in comprehension; are clear, crisp and well situated on the page
Content	Contains extraneous information; is not logically arranged; contains numerous spelling and grammatical errors	Reflects most of the essential information; is generally logically arranged; concepts presented without too many excess words; fewer than three misspellings or grammatical errors	Reflects essential information; is logically arranged; concepts succinctly presented; no misspellings or grammatical errors
Text	Font too small to read easily; more than four different fonts used; text amount is excessive for intended audience	Most text is easy to read; uses no more than four different fonts; amount of text generally fits intended audience	Easy to read/appropriately sized; no more than three different fonts; amount of text is appropriate for intended audience; boldface used for emphasis
Design	Cluttered design; low in visual appeal; requires a lot of scrolling to view entire diagram; choice of colors lacks visual appeal and impedes comprehension	Design is fairly clean, with a few exceptions; diagram has visual appeal; four or fewer symbol shapes; fits page well; uses color effectively most of time	Clean design; high visual appeal; four or fewer symbol shapes; fits page without a lot of scrolling; color used effectively for emphasis
Knowledge Gained	Student demonstrates a lack of knowledge about the content and the processes used to create the poster	Student can accurately answer most questions related to content and the processes used to create the poster	Student can accurately answer all questions related to content and the processes used to create the poster

Assessment Instrument – Brief Constructed Response Items

1. Compare and contrast information and communication systems designed to inform and entertain.
2. Analyze components of e-mail communication including the source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Response Items

1. Defend the statement, "Information is an essential resource for competitive economic growth."

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or generalized	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence

			Thorough chronology
Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder argument, but do not detract from the overall accuracy	Virtually error free; minor mistakes do not compromise argument
Thoroughness	Covers question superficially May not complete all tasks	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportions to their importance
Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree	Uses clear language Well organized Contains few grammatical errors	Uses clear, appropriate, and precise language Cohesive organization Very few grammatical errors

Chapter 7 – Information and Communications Technologies

Lesson 2 - Communication Systems

Lesson Duration: Six (6) hours

Standards:

- Students will develop an understanding of and be able to select and use information and communications technologies. (ITEA/STL-17)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. (ITEA/STL-10)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/STL-12)
- Students will develop an understanding of the attributes of design. (ITEA/STL-8)
- Students will develop an understanding of and be able to apply the design process. (ITEA/STL – 11)
- Students will develop an understanding of the design world. (AAAS-BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Information and communication systems that allow information to be transferred from humans to humans, humans to machines, machine to human, and machine to machine. • Information and communications technologies include inputs, processes, and outputs associated with sending and receiving information. • There are many ways to communicate information, such as graphic and electronic means. • Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. • Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. • Research and development is a problem solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. • Research and development is a problem solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. ▪ Identify the design problem and decide whether or not to address it.	▪ Written records and photographic and electronic devices enable human beings to share, compile, use, and misuse great amounts of information and misinformation. ▪ Computer modeling explores the logical consequences of a set of instructions and a set of data. ▪ As technologies that provide privacy in communication improve, so do those for invading privacy.	▪ Model and solve contextualized problems using various representations, such as graphs, tables, and equations. ▪ Use the language of mathematics to express ideas precisely. ▪ Draw reasonable conclusions about a situation being modeled.

▪ Identify criteria and constraints and determine how these will affect the design process. ▪ Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. • Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design.		

Learning Objectives: Students will:

1. Identify and describe that major types of communication systems.
2. Explain the functioning and applications of the major types of printing processes.
3. Define photographic communications and identify examples of photographic products.
4. Define and describe the major types of technical graphic communication.
5. Define telecommunications and describe the major types of telecommunications systems. (radio broadcast, television broadcast, mobile communication systems, satellite communication systems)
6. Design information and communications products.
7. Explain that messages are influenced by factors such as timing, sequencing, and processing.
8. Explain that the usefulness of information depends on such factors as relevancy, timeliness, truth, completeness, and cultural value.

Student Assessment Tools and/or Methods:

(See assessment instruments at end of lesson)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials:

- Print-Based Sources

1. Communications Systems and Networks by Ray Horak, Harry Newton, Mark A. Miller; Wiley; 3rd Edition (2002) ISBN: 0764548999
2. Basics of the Video Production Diary by Des Lyver, Focal Press (August, 2001) ISBN: 0240516583
3. Guide to Graphic Print Production by Kaj Johansson, Peter Lundberg, Robert Ryberg; Wiley (2002) ISBN: 0471273473

- Audiovisual Materials

1. Radio Transmission, Shockwave Interactive, http://www.teachersdomain.org/9-12/sci/phys/mfw/radioint/index.html

- Internet Sites

1. Creating a Brochure, http://desktoppub.about.com/od/lessonplans/l/aa_brochure2a.htm
2. Information And Telecommunication Technologies, http://www.idrc.ca/en/ev-9303-201-1-DO_TOPIC.html
3. Types of Communication, http://writing.colostate.edu/references/documents/ce-com/list3.cfm

Purpose of Lesson: To familiarize students with the major types of communication systems.

Required Knowledge and/or Skills: Students should have some understanding of the proposition that information and communications technologies that process information in digital form have revolutionized society's information handling capacity and have proven to be a critical resource for competitive economic growth. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Lesson

Engagement:

1. The teacher will assess prior knowledge and possible misconceptions related to the major types of communication systems.
2. The teacher will present to the class the following list.

Telephone	DVD	Newspaper	Remote Control	Comic Strip
Book	Magazine	Headphones	A Painting	Billboard
Videotape	Photograph	Computer	Camera	Traffic Light

3. The teacher will ask students to identify those that can be categorized as information and communication technology.
4. Students will make their selections and justify their choices.

Exploration:

1. The teacher will state that the usefulness of information depends on such factors as relevancy, timeliness, truth, completeness, and cultural value.
2. The teacher will show the class with examples of information/communication.
   a. Printed graphic communication (newspaper, magazine, poster, brochure)
   b. Photographic communication (photographs, slides, filmstrips, motion pictures)
   c. Telecommunication (radio broadcast, television broadcast, mobile communication systems, satellite communication systems)
   d. Technical graphic communication (engineering drawings)
3. Students will be asked to think about additional factors that affect the quality of media.
4. Students, working in groups, will analyze examples of advertising media and assess the items based on criteria presented by the teacher and additional criteria suggested by students.

Explanation:

1. Student groups will share their analyses with class.
2. The teacher will state that graphic communication systems involve visual messages, newspapers, magazines, and other print media.
3. The teacher will describe the functioning and applications of the major types of printing processes including:
   a. Relief
   b. Lithography
   c. Gravure
   d. Screen
   e. Electrostatic
   f. Ink jet

4. The teacher will state that photographic communication is the process of using photographs to communicate a message and includes photographs, slides, and motion pictures.
5. The teacher will state that telecommunications, communicating over a distance, relies on the principles of electricity and electromagnetism.
6. The teacher will state that there are two, major types of telecommunication systems.
    a. Hard-wired systems (telephone, cable, and fiber-optic)
    b. Broadcast systems (radio and TV broadcasting, mobile phone systems)
7. The teacher will explain that technical graphic communication (engineering drawing or technical illustration) is used to communicate specific information about a product or its parts including:
    a. Size and shape.
    b. How parts are to be assembled.
    c. How to install, adjust, operate, or maintain a device.
8. The teacher will explain that:
    a. Communication systems are made up of a source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.
    b. Information and communications technologies include inputs, processes, and outputs associated with sending and receiving information.
    c. Describe the training required to become a construction manager.
    d. There are many ways to communicate information, such as graphic and electronic means.
    e. Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.
    f. Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.
    g. Written records and photographic and electronic devices enable human beings to share, compile, use, and misuse great amounts of information and misinformation.
    h. As technologies provide privacy in communication improve, so do those for invading privacy.
9. Students will restate any questions that were not answered in the teacher's lecture and clarify any unresolved issues.

Extension:

1. The teacher will state that:
    a. Brochures are often created to explain something in a brief, enticing format.
    b. These types of brochures tell how to do something or explain how something works using simple descriptions, diagrams, or lists of steps.
    c. They are intended for readers who don't need to know absolutely everything on a subject but do need the basics.
2. Students will create a brochure about one of the four types of communication systems (print graphic, photographic, telecommunications, or technical graphic communication).

Evaluation:

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, group work, brochure, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as

benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Laboratory-Classroom Preparation:
The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, design tools and equipment, fabrication tools and equipment, and testing tools should be readied.

Tools/Materials/Equipment:
- Computers with Internet Access
- Library resources
- Graphic tools, materials, and equipment

Laboratory-Classroom Safety and Conduct:
1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared Minimal effort to participate	Prepared for class, attempts to answer teacher generated questions	Well prepared for class, attempts to answer teacher generated questions and adds additional information to class when relevant
Curiosity	Rarely demonstrates curiosity	Usually demonstrates curiosity	Consistently demonstrates curiosity
Motivation For Learning	Rarely demonstrates motivation for learning	Usually demonstrates motivation for learning	Consistently demonstrates motivation for learning
Use of Time	Gives up easily, is not engaged Has difficulty remaining on task	Makes good use of class time to work on assignments and projects	Makes excellent use of class time to work on assignments and projects

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative Does little work Rarely offers useful ideas	Cooperative Works at assignments Usually offers useful ideas	Always willing to help and do more Does more than required Routinely offers useful ideas
Cooperation	Rarely listens to, shares with, or supports the efforts of others Often is not a good team member	Usually listens to, shares with, and supports the efforts of others Does not cause problems in the group	Always listens to, shares with, and supports the efforts of others Tries to keep people working together

Focus on the task	Does not focus on the task and what needs to be done Lets others do the work	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done Self-directed

Assessment Instruments – Brochure Rubric

Category	Below Target	At Target	Above Target
Attractiveness and Organization (Organization)	The brochure has well-organized information.	The brochure has attractive formatting and well-organized information.	The brochure has exceptionally attractive formatting and well-organized information.
Content - Accuracy (Ideas)	The brochure has most of the required information (see checklist).	The brochure has all of the required information (see checklist).	The brochure has all of the required information (see checklist) and some additional information
Writing - Mechanics (Conventions)	Some of the writing is done in complete sentences. Some of the capitalization and punctuation are correct throughout the brochure.	Most of the writing is done in complete sentences. Most of the capitalization and punctuation are correct throughout the brochure.	All of the writing is done in complete sentences. Capitalization and punctuation are correct throughout the brochure.
Graphics/Pictures	The graphics go well with the text, but there are too few.	The graphics go well with the text, but there are so many that they distract from the text.	The graphics go well with the text and there is a good mix of text and graphics.
Sources	There are a few citations accurately listed on the brochure.	There are some citations from a variety of sources accurately listed on the brochure.	There are many citations from a variety of sources accurately listed on the brochure.
Attractiveness and Organization (Organization)	The brochure has well-organized information.	The brochure has attractive formatting and well-organized information.	The brochure has exceptionally attractive formatting and well-organized information.
Content - Accuracy (Ideas)	The brochure has most of the required information (see checklist).	The brochure has all of the required information (see checklist).	The brochure has all of the required information (see checklist) and some additional information

Assessment Instrument – Brief Constructed Response Items

1. Explain why messages are influenced by factors such as timing, sequencing, and processing.
2. Explain how relevancy, timeliness, truth, completeness, and cultural values influence the effectiveness and usefulness of information.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Response Items

1. Identify and describe that major types of communication systems.

Category	Below Target	At Target	Above Target

Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or generalized	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence Thorough chronology
Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder argument, but do not detract from the overall accuracy	Virtually error free; minor mistakes do not compromise argument
Thoroughness	Covers question superficially May not complete all tasks	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportions to their importance
Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree	Uses clear language Well organized Contains few grammatical errors	Uses clear, appropriate, and precise language Cohesive organization Very few grammatical errors

Chapter 7 – Information and Communications Technologies

Lesson 3 - The Global Positioning System (GPS)

Lesson Duration: Two (2) hours

Standards:

- Students will develop an understanding of and be able to select and use information and communications technologies. (ITEA/STL-17)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. (ITEA/STL 10)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/STL-12)
- Students will develop an understanding of the design world. (AAAS-BSL)
- Students will use mathematical models to represent and understand quantitative relationships. (NCTM - MSE)
- Students will develop an understanding of mathematics processes (Communications). (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Information and communication systems that allow information to be transferred from humans to humans, humans to machines, machine to human, and machine to machine. • Information and communications technologies include inputs, processes, and outputs associated with sending and receiving information. • There are many ways to communicate information, such as graphic and electronic means. • Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. • Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. • Research and development is a problem solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.	▪ Written records and photographic and electronic devices enable human beings to share, compile, use, and misuse great amounts of information and misinformation. ▪ Computer modeling explores the logical consequences of a set of instructions and a set of data. ▪ As technologies that provide privacy in communication improve, so do those for invading privacy	▪ Model and solve contextualized problems using various representations, such as graphs, tables, and equations. ▪ Use the language of mathematics to express ideas precisely. ▪ Draw reasonable conclusions about a situation being modeled.

Learning Objectives: Students will:

1. Describe the functioning and applications of the global positioning system.
2. Describe the navigation technology used in ancient times and during the Age of Exploration.
3. Describe navigation technologies used today.
4. Create graphics that will pinpoint a location using a map and a drawing compass.

5. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
6. Address open-ended questions in verbal and written form.
7. Demonstrate curiosity, exhibit motivation for learning, and use class time effectively.
8. Work safely and accurately with a variety of tools, machines, and materials.

Student Assessment Tools and/or Methods:
(See assessment instruments at end of lesson)
1. Brief Constructed Response Items
2. Extended Response Items
3. Performance Rubrics

Resource Materials:
- Print-Based Sources

1. Communications Systems and Networks by Ray Horak, Harry Newton, Mark A. Miller; Wiley; 3rd Edition (2002) ISBN: 0764548999
2. Basics of the Video Production Diary by Des Lyver, Focal Press (August, 2001) ISBN: 0240516583
3. Guide to Graphic Print Production by Kaj Johansson, Peter Lundberg, Robert Ryberg; Wiley (2002) ISBN: 0471273473

- Audiovisual Materials

1. History of Navigation, animation, http://www.bbc.co.uk/history/discovery/exploration/navigation_animation.shtml

- Internet Sites

2. Creating a Brochure, http://desktoppub.about.com/od/lessonplans/l/aa_brochure2a.htm
3. Information And Telecommunication Technologies, http://www.idrc.ca/en/ev-9303-201-1-DO_TOPIC.html
4. Types of Communication, http://writing.colostate.edu/references/documents/ce-com/list3.cfm

Purpose of Lesson:
To familiarize students with the functioning and applications of the global positioning system.

Required Knowledge and/or Skills:
Students should have some understanding of the proposition that information and communications technologies that process information in digital form have revolutionized society's information handling capacity and have proven to be a critical resource for competitive economic growth. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Lesson

Engagement:
1. The teacher will assess prior knowledge and possible misconceptions related to the functioning and applications of the global positioning system.

2. The teacher will explain that:
    a. From the time of the Thales (circa 640-546 B.C.) who first postulated that the earth was a sphere until 1760 when John Harrison developed his first workable chronometers, the technologies of navigation left much to chance.
    b. Ancient navigation relied mostly upon staying close enough to shore and familiar landmarks to get from one port to another.
    c. Dead (from deduced) reckoning was a widely used navigation technique. In dead reckoning, ships would start off on course and continue on it until they arrived at their destination.
    d. The speed of a ship was calculated by throwing knotted lines overboard and counting how many knots passed through a sailor's hands in a minute.
    e. This technique worked well for voyages across the Mediterranean but voyages across oceans were often disastrous.
3. The teacher will state that, from the 14th through 16th centuries, technological innovations enabled sailors to explore all the corners of the earth and ask students the following questions.
    a. Who were some of the famous navigators of this time period? (Five Spanish explorers were Ferdinand Magellan, Vasco da Gama, De Soto, Ponce de Leon, and Christopher Columbus. Sir Frances Drake was English.)
    b. What navigation systems (technologies) replaced dead reckoning and promoted this Age of Exploration. (Celestial navigation, astrolabe, quadrant, sextant, astronomical charts, magnetic compass)

Exploration:

1. Students will research and make a brief report on navigation technology used in the Age of Exploration addressing the following questions.
    a. When was it used?
    b. How did it work?
    c. Who invented it?
    d. What was its impact?
2. Students will make a brief oral presentation on their research.
3. The teacher will ask students to list of navigation technologies used today.

Explanation:

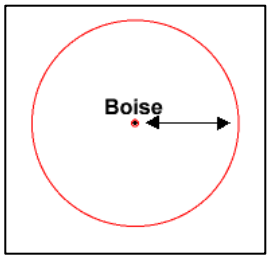
1. Students will present items from their list of navigation technologies used today.
2. The teacher state that:
    a. The Global Positioning System (GPS) is a worldwide telecommunications system formed from a constellation of 24 satellites and their ground stations.
    b. GPS uses these "man-made stars" as reference points to calculate positions accurate to a matter of meters.
    c. In fact, with advanced forms of GPS you can make measurements to better than a centimeter.
    d. GPS receivers have been miniaturized to just a few integrated circuits and so are becoming very economical. That makes the technology accessible to virtually everyone.
    e. These days GPS is finding its way into cars, boats, planes, construction equipment, movie making gear, farm machinery, and even laptop computers.
    f. Soon GPS will become almost as basic as the telephone.
3. The teacher will describe the functioning of GPS by explaining that:
    a. GPS uses satellites in space as reference points for locations here on earth.
    b. GPS was developed by the Defense Department primarily for military purposes.

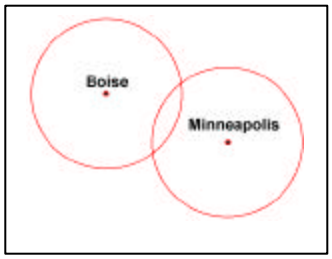
c. By very, very accurately measuring our distance from three satellites we can "triangulate" our position anywhere on earth.
d. Suppose we measure our distance from a satellite and find it to be 11,000 miles.
e. Knowing that we're 11,000 miles from a particular satellite narrows down all the possible locations we could be in the whole universe to the surface of a sphere that is centered on this satellite and has a radius of 11,000 miles.
f. We measure our distance to a second satellite and find out that it's 12,000 miles away.
g. That tells us that we're not only on the first sphere but we're also on a sphere that's 12,000 miles from the second satellite. Or in other words, we're somewhere on the circle where these two spheres intersect. We then make a measurement from a third satellite and find that we're 13,000 miles from that one, that narrows our position down even further, to the two points where the 13,000 mile sphere cuts through the circle that's the intersection of the first two spheres.
h. By ranging from three satellites we can narrow our position to just two points in space.
i. Usually one of the two points is a ridiculous answer (either too far from Earth or moving at an impossible velocity) and can be rejected without a measurement.

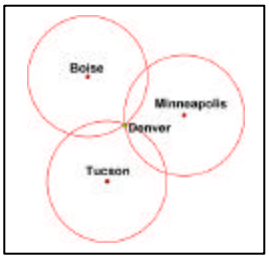
4. Students will restate any questions that were not answered in the teacher's lecture and clarify any unresolved issues.

Extension:

1. The teacher presents the following scenario.
   a. Imagine that you somewhere in the United States and you are totally lost—for whatever reason, you have absolutely no clue where you are.
   b. You find a friendly local and ask, "Where am I?" He says, "You are 625 miles from Boise, Idaho."
   c. You ask somebody else where you are, and she says, "You are 690 miles from Minneapolis, Minnesota." Now you're getting somewhere. If you combine this information with the Boise information, you have two circles that intersect. You now know that you must be at one of these two intersection points, if you are 625 miles from Boise and 690 miles from Minneapolis.
   d. If a third person tells you that you are 615 miles from Tucson, Arizona, you can eliminate one of the possibilities, because the third circle will only intersect with one of these points. You now know exactly where you are—Denver, Colorado.
2. Students, working in small groups, will create graphics that will pinpoint their location using a map and a drawing compass. Note to teacher: The students will need to use scaling techniques to complete this activity. The graphics should like this.







Evaluation:

Students' knowledge, skills, and attitudes will be assessed using selected response items and rubrics for class participation, group work, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the

activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities:

1. "It's eleven o'clock ... do you know where your kids are? Would you like to? One way to track them would be to have a GPS receiver installed in the car!" Students will write a brief essay on the plusses and minuses of this application of GPS.
2. Students will research and report on differential GPS.

Laboratory-Classroom Preparation: The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, design tools and equipment, fabrication tools and equipment, and testing tools should be readied.

Tools/Materials/Equipment:

- Drawing Compass
- String (approximately 12 inches long)
- Pencil
- Colored Pencils
- Ruler

Laboratory-Classroom Safety and Conduct:

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared Minimal effort to participate	Prepared for class, attempts to answer teacher generated questions	Well prepared for class, attempts to answer teacher generated questions and adds additional information to class when relevant
Curiosity	Rarely demonstrates curiosity	Usually demonstrates curiosity	Consistently demonstrates curiosity
Motivation For Learning	Rarely demonstrates motivation for learning	Usually demonstrates motivation for learning	Consistently demonstrates motivation for learning
Use of Time	Gives up easily, is not engaged Has difficulty remaining on task	Makes good use of class time to work on assignments and projects	Makes excellent use of class time to work on assignments and projects

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative Does little work Rarely offers useful ideas	Cooperative Works at assignments Usually offers useful ideas	Always willing to help and do more Does more than required Routinely offers useful ideas
Cooperation	Rarely listens to, shares with, or supports the efforts of others Often is not a good team member	Usually listens to, shares with, and supports the efforts of others Does not cause problems in the group	Always listens to, shares with, and supports the efforts of others Tries to keep people working together
Focus on the task	Does not focus on the task and what needs to be done Lets others do the work	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done Self-directed

Assessment Instrument – Brief Constructed Response Items

1. Describe the navigation technology used in ancient times.
2. Describe the navigation technology used during the Age of Exploration.
3. Describe navigation technologies used today.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Response Items

1. Describe the functioning and applications of the global positioning system.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or generalized	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence Thorough chronology
Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder argument, but do not detract from the overall accuracy	Virtually error free; minor mistakes do not compromise argument
Thoroughness	Covers question superficially May not complete all tasks	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportions to their importance

Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree	Uses clear language Well organized Contains few grammatical errors	Uses clear, appropriate and precise language Cohesive organization Very few grammatical errors

Chapter 8

Systems Thinking: Putting it all Together

Chapter 8 - Systems Thinking: Putting it all Together

Overview

Standards:

- Students will develop an understanding of the core concepts of technology. (ITEA/STL-2)
- Students will develop an understanding of common themes (Systems). (AAAS-BSL)
- Students will develop an understanding of data analysis and probability. (NCTM - MSE)
- Students will develop and evaluate inferences and predictions that are based on data. (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. • New technologies create new processes. • Management is the process of planning, organizing, and controlling work. • Humans devise technologies to reduce the negative consequences of other technologies. • Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.	▪ A system usually has some properties that are different from those of its parts, but appear because of the interaction of those parts. ▪ Understanding how things work and designing solutions to problems of almost any kind can be facilitated by systems analysis. ▪ The successful operation of a designed system usually involves feedback. ▪ Even in some very simple systems, it may not always be possible to predict accurately the result of changing some part or connection.	▪ Develop an understanding of large numbers and recognize and appropriately use exponential, scientific, and calculator notation; ▪ Understand the differences among various kinds of studies and which types of inferences can legitimately be drawn from each ▪ Understand how basic statistical techniques are used to monitor process characteristics in the workplace.

Big Idea: Systems thinking principles provide a necessary conceptual base for addressing the complex issues that confront us. It provides ways of viewing the world as a whole and using that view to find the leverage points for fundamental change. It enables a new level of understanding of why things are as they are, and offers insight for breakthrough solutions.

Unit Objectives: At the completion of this unit, students will be able to:

1. Explain that systems thinking applies logic and creativity with appropriate compromises in complex real-life problems.
2. Explain that requirements are the parameters placed on the development of a product or system.
3. Explain that a trade-off is a decision process recognizing the need for careful compromises among competing factors.
4. Explain that optimization is the process used to make a design or system as effective as possible within the given criteria (desired specifications) and constraints (limits on the design process).
5. Explain that "quality control" is a planned process designed to ensure that a product, service, or system meets established criteria and is sometimes based on international standards.
6. Explain that complex systems have many layers of controls and feedback loops to provide information about a system.

7. Describe how simulation and mathematical modeling are useful in enhancing or optimizing designs.
8. Explain that, when systems thinking is applied to the design and development process, potentially costly conflicts and incompatibilities and can be avoided.
9. Explain that applying systems thinking to the design and development requires managers to address societal, environmental, and economic impacts throughout the process.
10. Apply systems thinking principles to the engineering design process.
11. Explain how knowledge of the history of technology helps people understand the world.
12. Describe the interrelationships that exist among technologies and between technology and other fields of study.
13. Describe how engineering, the systematic application of mathematical, scientific, and technical principles, produces tangible end products that meet our needs and desires.
14. Explain some of the techniques used in modern manufacturing technologies that produce quality goods at low prices, enhancing the quality of life for many people.
15. Explain how cultural norms, environmental conditions, and the requirements of enterprises and institutions impact the process of designing and erecting structures.
16. Describe how advancements in the processing and controlling of energy resources have been an enabling factor in the development of technology.
17. Explain why information and communications technologies have proven to be a critical resource for competitive economic growth.
18. Explain that systems thinking principles provide a conceptual base for addressing the complex issues that confront.

Foundations of Technology
Chapter 8 – Systems Thinking

Pre-Test

Match the terms in Column II with the statements in Column I.

	Column I	Column II	
	1. A mindset for understanding how things work	A	Automation
	2. Involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development	B	Complex systems
	3. Useful in enhancing or optimizing designs	C	Management
	4. The process used to make a design or system as effective as possible	D	Optimization
	5. A planned process designed to ensure that a product, service, or system meets established criteria	F	Quality control
	6. Have many layers of controls and feedback loops to provide information about a system	G	Requirements
	7. Human innovation in action	H	Simulation and mathematical modeling
	8. A decision process recognizing the need for careful compromises among competing factors	I	Systems thinking
	9. The process of planning, organizing, and controlling work	J	Technology is
		K	Trade-off

Briefly answer the following questions.

10. Explain how optimization is used to make a design or system as effective as possible.

11. Explain that systems thinking principles provide a conceptual base for addressing the complex issues that confront us.

Foundations of Technology
Chapter 8 – Systems Thinking

Unit Test

Match the terms in Column II with the statements in Column I.

	Column I	Column II	
	1. A mindset for understanding how things work	A	Automation
	2. Involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development	B	Complex systems
	3. Useful in enhancing or optimizing designs	C	Management
	4. The process used to make a design or system as effective as possible	D	Optimization
	5. A planned process designed to ensure that a product, service, or system meets established criteria	F	Quality control
	6. Have many layers of controls and feedback loops to provide information about a system	G	Requirements
	7. Human innovation in action	H	Simulation and mathematical modeling
	8. A decision process recognizing the need for careful compromises among competing factors	I	Systems thinking
	9. The process of planning, organizing, and controlling work	J	Technology is
		K	Trade-off

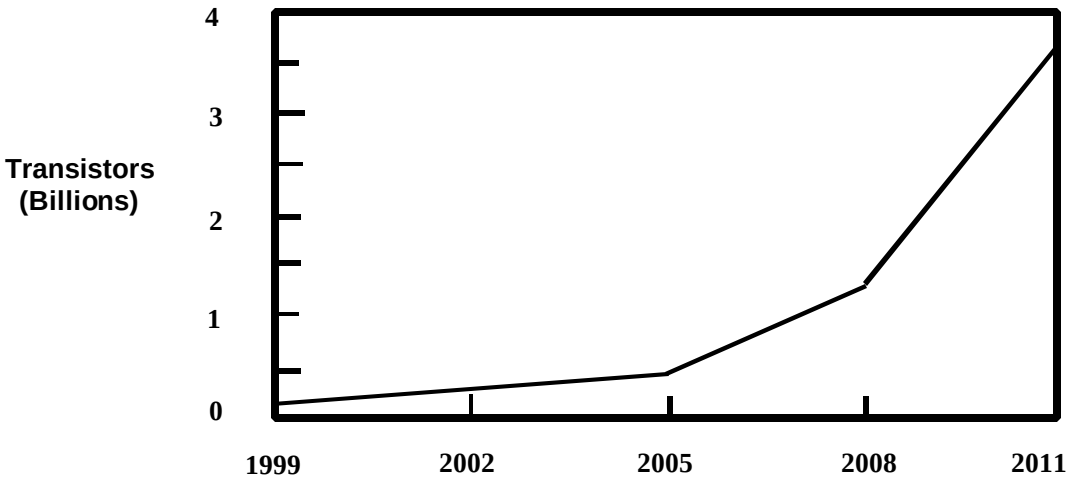
Place the letter of the correct answer in the box at left of statement.

10.		Systems, which are the building blocks of technology, are _____ larger technological, social, and environmental systems. A. embedded within B. excluded from C. derived from D. managed by
11.		New technologies _____ processes. A. create new B. replicate old C. bypass all D. ignore new
12.		The process of planning, organizing, and controlling work is _____. A. Management B. Optimization C. Technology

		D. Innovation
13.		The process used to minimize the likelihood of unwanted side effects of a new technology. A. Optimization B. Risk analysis C. Specification D. Technology transfer
14.		Complex systems have layers of _____. A. constraints B. controls C. criteria D. collaboration
15.		To reduce the chance of system failure, _____ is often conducted using small-scale models, computer simulations, analogous systems, or just the parts of the system thought to be least reliable. A. a time-and-motion study B. an impact study C. a design process D. performance testing

Briefly answer the following questions.

16. Explain how optimization is used to make a design or system as effective as possible.
17. Explain that applying systems thinking to the design and development requires managers to address societal, environmental, and economic impacts throughout the process.
18. Analyze the graph below, showing how the number of components in an integrated chip has changed and is expected to change and describe the impact of the data on the size of electronic products.



19. Explain that, when systems thinking is applied to the design and development process, potentially costly conflicts and incompatibilities and can be avoided.
20. Explain how knowledge of the history of technology helps people understand the world.

21. Describe that interrelationships exist among technologies and between technology and other fields of study.
22. Describe how engineering, the systematic application of mathematical, scientific, and technical principles, produces tangible end products that meet our needs and desires.
23. Explain how systems thinking principles provide a conceptual base for addressing the complex issues that confront us.

Chapter 8 – Systems Thinking: Putting It All Together

Lesson 1 - Getting Familiar with the Big Idea

Systems thinking principles provide a conceptual base for addressing the complex issues that confront us by providing ways of viewing the world as a whole and using that view to find the leverage points for fundamental change.

Lesson Duration: Six (6) hours

Standards:

- Students will develop an understanding of the core concepts of technology. (ITEA/STL-2)
- Students will develop an understanding of common themes. (Systems) (AAAS-BSL)
- Students will develop an understanding of data analysis and probability. (NCTM - MSE)
- Students will develop and evaluate inferences and predictions that are based on data. (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. • New technologies create new processes. • Management is the process of planning, organizing, and controlling work. • Humans devise technologies to reduce the negative consequences of other technologies. • Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.	▪ A system usually has some properties that are different from those of its parts, but appear because of the interaction of those parts. ▪ Understanding how things work and designing solutions to problems of almost any kind can be facilitated by systems analysis. ▪ The successful operation of a designed system usually involves feedback. ▪ Even in some very simple systems, it may not always be possible to predict accurately the result of changing some part or connection.	▪ Develop an understanding of large numbers and recognize and appropriately use exponential, scientific, and calculator notation; ▪ Understand the differences among various kinds of studies and which types of inferences can legitimately be drawn from each ▪ Understand how basic statistical techniques are used to monitor process characteristics in the workplace.

Learning Objectives: Students will:

1. Explain that systems thinking applies logic and creativity with appropriate compromises in complex real-life problems.
2. Describe that requirements are the parameters placed on the development of a product or system.
3. Describe that a trade-off is a decision-making process recognizing the need for careful compromises among competing factors.
4. Explain that optimization is the process used to make a design or system as effective as possible within the given criteria (desired specifications) and constraints (limits on the design process).
5. Explain that "quality control" is a planned process designed to ensure that a product, service, or system meets established criteria and is sometimes based on international standards.

6. Explain that complex systems have many layers of controls and feedback loops to provide information about a system.
7. Describe how simulation and mathematical modeling are useful in enhancing or optimizing designs.

Student Assessment Tools and/or Methods:
(See assessment instruments at end of lesson.)
1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials:
- Print-Based Sources

1. Systems Thinking: Managing Chaos and Complexity : A Platform for Designing Business Architecture by Jamshid Gharajedaghi, Butterworth-Heinemann (1999) 0750671637
2. The "Thinking" in Systems Thinking: Seven Essential Skills by Barry Richmond, Pegasus Communications (2000) 188382348X
3. An Introduction to General Systems Thinking by Gerald M. Weinberg, Dorset House Publishing Company, Incorporated; 1st edition (2001) 0932633498

- Audiovisual Materials

1. Systems Thinking in Design, PowerPoint presentation, slides 41 to 57 http://www.centerwest.org/projects/energy/payne.html

- Internet Sites

1. Systems thinking, http://www.thinking.net/Systems_Thinking/systems_thinking.html
2. Benefits of Systems Thinking for Leaders and Supervisors in Organizations, http://www.mapnp.org/library/systems/systems.htm#anchor123477
3. Systems thinking, http://www.systems-thinking.de/

Purpose of Lesson:
To familiarize students with how systems thinking principles provide a conceptual base for addressing the complex issues that confront us by providing ways of viewing the world as a whole and using that view to find the leverage points for fundamental change.

Required Knowledge and/or Skills:
Students should have some understanding that systems thinking involves considering how every part related to others and that technology systems have inputs, processes, and outputs. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Lesson

Engagement:

1. The teacher will assess prior knowledge and possible misconceptions related to how systems thinking principles provide a conceptual base for addressing the complex issues.
2. The teacher will show the class a diagram or picture illustrating the huge electrical grids that connect areas of the world.
3. The teacher will state that:
   a. Technology is human innovation in action.
   b. Technology involves the use of processes to develop systems that solve problems and extend human capabilities.
   c. Systems are embedded within larger technological, social, and environmental systems.
4. The teacher will ask students to name other major technology systems that solve problems and extend human capabilities. (i.e. air, land, and sea transportation systems, telecommunication systems, water supply systems)
5. The teacher will state that, in our study of technology, we need to shift from focusing on how the development of technology affects us locally to a broader, global outlook.
6. Students will be asked to think about the electrical generation and distribution system that serves our nation.
7. Students will be asked to share their ideas about the benefits and consequences of the electrical generation and distribution system.

Exploration:

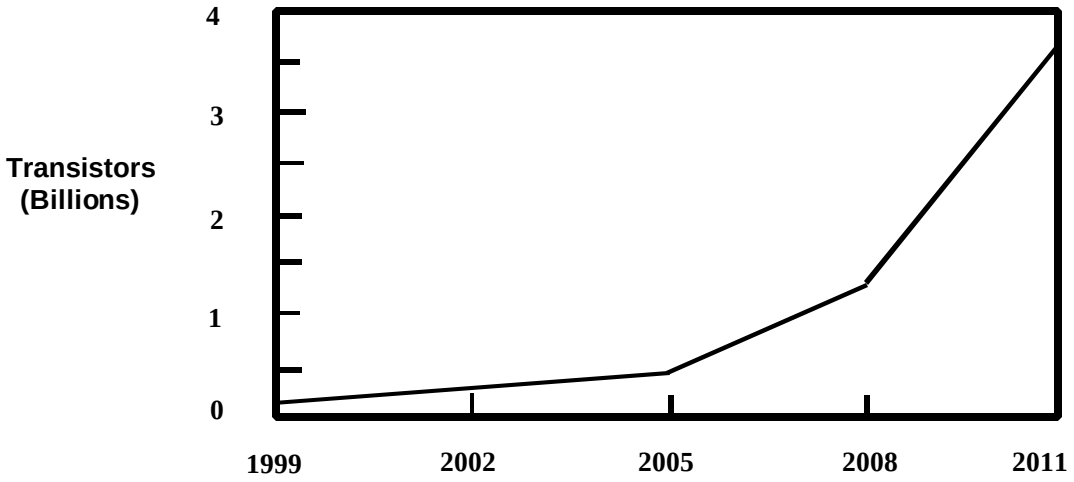
1. The teacher will state that:
   a. Humans devise technologies to reduce the negative consequences of other technologies.
   b. "Systems thinking" is a mindset for understanding how things work.
   c. It helps us determine if a particular technology system is worth the cost and effort involved in its development.
   d. The stability (how reliable it is) of a technological system is influenced by all of the components of the system.
2. The teacher will describe some technology systems that are currently being proposed such as high-speed rail service, implanted identification computer chips, an additional airport for a city, a nuclear power plant, a "star wars" missile defense system, hydrogen-powered vehicles)
3. Students, working in pairs, will analyze a proposed technology system that has been purposed for your area.
4. Students will list benefits and consequences of the proposed system.

Explanation:

1. Students will share their analyses of proposed technology systems.
2. The teacher will state that "Systems Thinking":
   a. Is a perspective for going beyond events, to looking at underlying systemic relationships that are for responsible for patterns of behavior.
   b. Embodies a world-view, which implies that the foundation for understanding lies in interpreting interrelationships within systems.
   c. Interrelationships are responsible for the manner in which systems operate.
3. The teacher will explain that:
   a. Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.
   b. Simulation and mathematical modeling are useful in enhancing or optimizing designs.
   c. Optimization is the process used to make a design or system as effective as possible within the given criteria (desired specifications) and constraints (limits on the design process).

d. Selecting resources involves trade-offs (exchanges of one thing in return for another) between competing values such as cost, desirability, and waste.

4. The teacher will ask students to think about instances where new technologies create new processes. (Example: Processes used to put more components in an integrated chip.)
5. The teacher will ask students to analyze the graph showing how the number of components in an integrated chip has changed and is expected to change.



6. The teacher will explain that:
   a. "Quality control" is a planned process designed to ensure that a product, service, or system meets established criteria and is sometimes based on international standards (i.e., ISO 9000).
   b. Complex systems have many layers of controls and feedback loops to provide information about a system.
   c. Controls do not always succeed or work perfectly.
   d. Management is the process of planning, organizing, and controlling work.
7. The teacher will summarize by stating that "systems thinking."
   a. Provides a necessary conceptual base and a powerful tool set for working the most complex issues that confront us as individuals, in teams, or in organizations.
   b. Provides ways of viewing the world as a whole and using that view to find the leverage points for fundamental change.
   c. Makes use of mapping methods for visual representation of system structure, especially feedback loops.
   d. Enables a new level of understanding of why things are as they are, and offers insight for breakthrough solutions.
   e. Involves the use of simulation tools for building quantitative system models that enable the exploration of alternative courses of action.
8. Students will restate any questions that were not answered in the teacher's lecture and clarify any unresolved issues.

Extension:

1. Students will solve an engineering design problem and optimize the design using simulation and mathematical modeling

a. Airfoil Analysis software, http://www.hanleyinnovations.com/airfoils.html
b. Race care aerodynamics, http://www.hanleyinnovations.com/racecarpack.html
c. Bridge design, http://bridgecontest.usma.edu/tutorial3.htm

2. Students will apply a variety of "systems thinking" concepts and tools as they design and fabricate a problem solution.

Evaluation:
Students' knowledge, skills, and attitudes will be assessed using selected response items and a rubric for engineering design and systems thinking, brief constructed responses and extended constructed responses summarizing the lesson. The rubric will be presented in advance of the activities to familiarize students with the expectations and performance criteria. It will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities:
1. Students will research and report on the case studies provided by industries and businesses that have had success using systems-thinking principles.
2. Students will identify and describe commercially available computer simulation programs.

Laboratory-Classroom Preparation:
The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, design tools and equipment, fabrication tools and equipment, and testing tools should be readied.

Tools/Materials/Equipment:
- Computers with simulation programs
- Library resources
- Graphic tools, materials, and equipment
- Design tools
- Fabrication tools and equipment
- Testing apparatus

Laboratory-Classroom Safety and Conduct:
1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Lesson Assessment Instruments

Assessment Instrument – Selected Response Items
Match the terms in Column II with the statements in Column I.

	Column I	Column II

	A mindset for understanding how things work	A	Automation
	Involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development	B	Complex systems
	Useful in enhancing or optimizing designs	C	Management
	The processed used to make a design or system as effective as possible	D	Optimization
	A planned process designed to ensure that a product, service, or system meets established criteria	F	Quality control
	Have many layers of controls and feedback loops to provide information about a system	G	Requirements
	Human innovation in action	H	Simulation and mathematical modeling
	A decision process recognizing the need for careful compromises among competing factors	I	Systems thinking
	The process of planning, organizing, and controlling work	J	Technology is
		K	Trade-off

Assessment Instrument– Engineering Design and Systems Thinking

Category	Below Target	At Target	Above Target
Defining the Problem	Rephrases the problem with limited clarity	Rephrases the problem clearly	Rephrases the problem clearly and precisely
Requirements	Does not take into account requirements placed on the development of a product or system	Takes into account several requirements placed on the development of a product or system	Takes into account numerous requirements placed on the development of a product or system
Trade-offs	Does not consider trade-offs in the design process	Makes trade-offs recognizing the need for careful compromises among competing factors.	Makes effective trade-offs that enhance the usefulness of the usefulness and acceptability of the product
Simulation Tools	Simulation tools not used to exploration of alternative courses of action	Simulation tools used to exploration of alternative courses of action	Simulation tools used effectively to exploration of alternative courses of action and enhance design performance
Optimization	Does not use the process of optimization	Applies the process of optimization to make the design or system as effective as possible within the given criteria and constraints	Effectively uses the process of optimization to make the design or system as effective as possible within the given criteria (desired specifications) and constraints (limits on the design process)
Refining the design	Refinement based on testing and evaluation is not evident	Refinements made based on testing and evaluation results	Significant improvement in the design is made based on prototype testing and evaluation
Creating or making it	Finished solution (product) fails to meet specifications	Finished solution (product) meets specifications	Finished solution (product) exceeds specifications
Communicating processes and results	Solution presented with limited accuracy Limited supporting evidence on how the solution meets the	Solution presented accurately Some supporting evidence on how the solution meets the task criteria	Solution presented concisely with clarity and accuracy Extensive supporting evidence on how the solution meets the

	on how the solution meets the task criteria	criteria	task criteria

Assessment Instrument – Brief Constructed Response Items

1. Describe how simulation and mathematical modeling are useful in enhancing or optimizing designs.
2. Explain how optimization is used to make a design or system as effective as possible.
3. Explain that requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.
4. Explain how humans devise technologies to reduce the negative consequences of other technologies.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Response Items

1. Identify and describe the principles associated with systems thinking and how they are applied to real-life problems.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or generalized	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence Thorough chronology
Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder argument, but do not detract from the overall accuracy	Virtually error free; minor mistakes do not compromise argument
Thoroughness	Covers question superficially May not complete all tasks	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportions to their importance
Presentation	Inconsistent organization Grammatical errors cloud argument to a major degree	Uses clear language Well organized Contains few grammatical errors	Uses clear, appropriate, and precise language Cohesive organization Very few grammatical errors

Unit 8 – Systems Thinking: Putting It All Together

Lesson 2 - Systems Thinking and the Design Process

Lesson Duration: Six (6) hours

Standards:

- Students will develop an understanding of the core concepts of technology. (ITEA/STL-2)
- Students will develop an understanding of common themes. (Systems) (AAAS-BSL)
- Students will develop an understanding of data analysis and probability. (NCTM - MSE)
- Students will develop and evaluate inferences and predictions that are based on data. (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. • New technologies create new processes. • Management is the process of planning, organizing, and controlling work. • Humans devise technologies to reduce the negative consequences of other technologies. • Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.	• A system usually has some properties that are different from those of its parts, but appear because of the interaction of those parts. • Understanding how things work and designing solutions to problems of almost any kind can be facilitated by systems analysis. • The successful operation of a designed system usually involves feedback. • Even in some very simple systems, it may not always be possible to predict accurately the result of changing some part or connection.	• Develop an understanding of large numbers and recognize and appropriately use exponential, scientific, and calculator notation; • Understand the differences among various kinds of studies and which types of inferences can legitimately be drawn from each • Understand how basic statistical techniques are used to monitor process characteristics in the workplace.

Learning Objectives:

Students will:

1. Explain that, when systems thinking is applied to the design and development process, potential costly conflicts and incompatibilities and can be avoided.
2. Explain that applying systems thinking to the design and development requires managers to address societal, environmental, and economic impacts throughout the process.
3. Apply systems thinking principles to the engineering design process.
4. Identify criteria and constraints and determine how these will affect the design process.
5. Make two-dimensional and three-dimensional representations of a design solution.
6. Fabricate a prototype or model of a design solution.
7. Evaluate a design by using conceptual, physical, and mathematical models.

Student Assessment Tools and/or Methods:

(See assessment instruments at end of lesson)

1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items

4. Performance Rubrics

Resource Materials:

- Print-Based Sources

1. The Systems Thinking Playbook by Dennis Meadows, Linda Booth Sweeney, Inst for Policy & Social Science; (2001) ISBN: 0966612779
2. The Art of Systems Thinking: Essential Skills for Creativity and Problem Solving by Joseph O'Connor, Ian McDermott, Thorsons Publishers (April, 1997) ISBN: 0722534426
3. The Systems Thinking Approach to Strategic Planning and Management by Stephen G. Haines, CRC Press (June 13, 2000) ISBN: 1574442783

- Audiovisual Materials

1. Systems Thing in Design, PowerPoint presentation, slides 41 to 57 http://www.centerwest.org/projects/energy/payne.html
2. Road Signs Gallery Flash Image
3. What Is the Design Process? QuickTime Video

- Internet Sites

1. Engineering Design, http://www.teachersdomain.org/9-12/sci/engin/design/index.html
2. Highway sign installation and maintenance guidelines, http://www.fhwa.dot.gov/bridge/signinspection04.cfm
3. Aluminum Extruded Panel Signs, http://www.interstatesigns.com/extruded-increment.html

Purpose of Lesson:

To familiarize students with how systems thinking is applied in the design process.

Required Knowledge and/or Skills:

Students should have some understanding of how systems thinking principles provide a conceptual base for addressing the complex issues that confront us by providing ways of viewing the world as a whole and using that view to find the leverage points for fundamental change. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Lesson

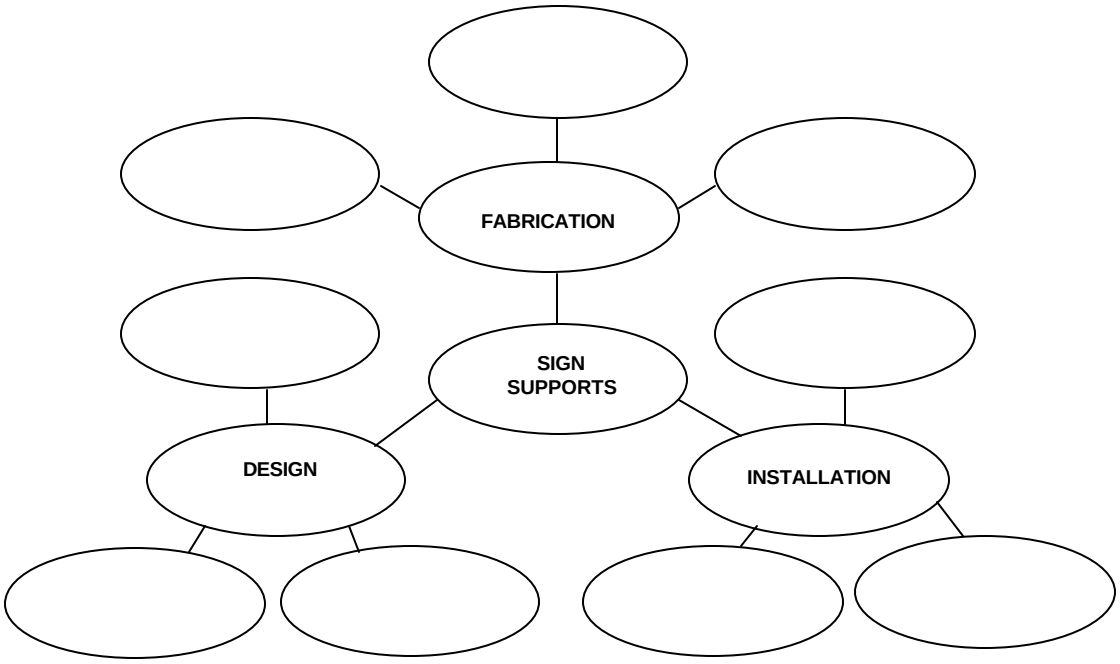
Engagement:

1. The teacher will assess prior knowledge and possible misconceptions related to how systems thinking is applied in the design process.
2. The teacher will show an illustration of a cantilevered sign support that spans a highway and ask students:
   a. To think about what factors must be considered before building a sign support (possible answers: It must be high enough so that trucks won't hit it; it must be strong; it must be stable).
   b. Where have you seen signs and supports like these?
3. The teacher will ask students to observe sign support structures on their way home from school for discussion the following day.

4. At the beginning of the next class session, the teacher will ask the students to work with a classmate to record responses to the following questions:
   a. What type of sign support structures did you see?
   b. Did they cross the road completely or overhang just part of it?
   c. What do you think keeps them from collapsing or falling over?
   d. What keeps the signs from twisting on their support so that they stay in an upright, readable position?

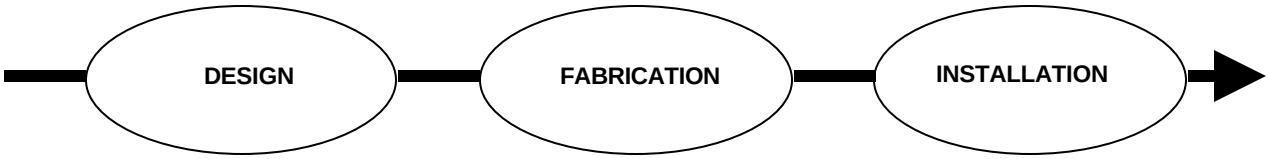
Exploration:

1. The teacher will ask students to imagine that they are the president of a large construction company that designs and fabricates support structures for highway signs.
2. The teacher will state that the total process will involve the design of the supports, the making of the supports and the installation of the supports.
3. The teacher will review some general requirements (criteria and constraints) that influence the design of structures.
4. Students will develop a concept map that identifies factors related to each phase of the task.

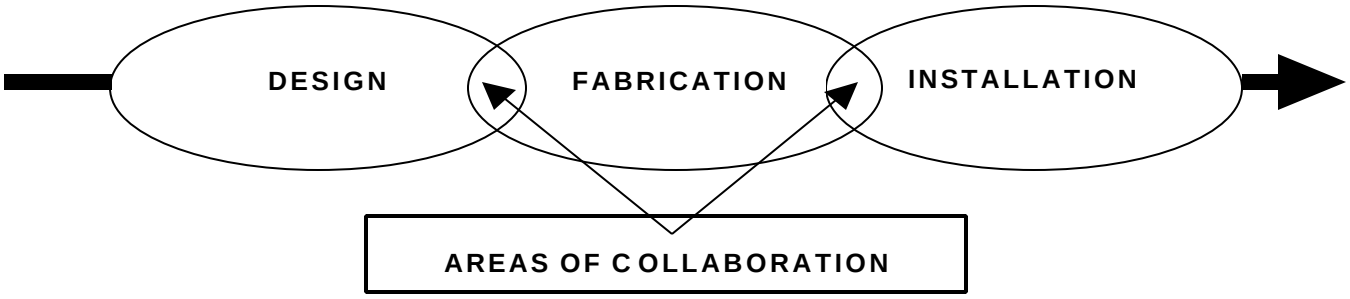


Explanation:

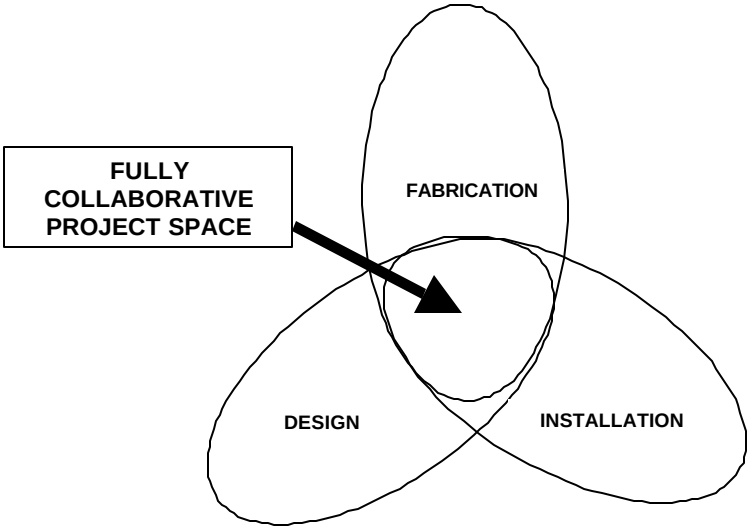
1. Students will share their list of factors that might impact the design, building, and operation of the store.
2. The teacher will assist the students in categorizing the factors according to their relationship to societal, environmental, and economic impact.
3. The teacher will explain that in traditional product development a "linear" approach was employed that dealt with each phase (design, fabrication, and installation) independently and one step at a time.
4. The process can be graphically illustrated as shown below.



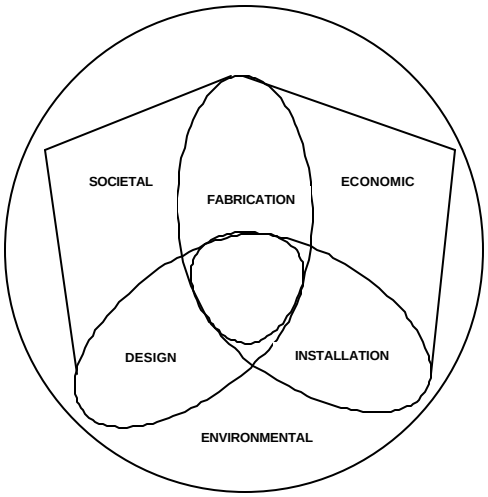
5. The teacher will ask students to think about advantages and disadvantages of this approach.
6. The teacher will explain that a “linear overlapping” approach improved allowed some collaboration (below).



7. The teacher will ask students to think about advantages and disadvantages of this approach.
8. The teacher will state that an improved approach (see below) allows even more collaboration.
9. The teacher will ask students to think about advantages and disadvantages of this approach.
10. The teacher will explain that, ideally, the project path in this approach would take place completely inside the area of collaboration and can be thought of as the “project space.”
11. The teacher will state that this graphic illustrates “Systems-Thinking” as it is applied in the design and development process.
12. The teacher will ask students to recall some other factors that influence design (i.e. economics, society, and the environment).



13. The teacher will explain that economics, society, and the environment must be considered throughout the design process to insure that the project will be effective and accepted. (See graphic at right.)
14. The teacher will explain that:
    a. Some of the societal factors may involve fair labor issues, public health issues, and community issues.
    b. Economic concerns may relate to profitability, consumer relations, and competition.
    c. Environmental concerns may involve ecosystem health.



15. Students will restate any questions that were not answered in the teacher's lecture and clarify any unresolved issues.

Extension:

1. Students will develop a product using a systems-thinking development process.
2. Students will integrate the design, fabrication, and installation planning, taking into account from the start of the project, economic, societal, and environmental factors.
3. Students will design, build, and test a model of a freestanding structure used to support overhead road signs when the wind blows on the sign or when a heavy load is placed on it.
4. Students will conduct a Wind Load Test: Set up the sign support structure, holding it in place by anchoring the column(s) in clay or taping them to a desk and blow air at the sign(s). (If possible, use a fan or a hair dryer on the lowest setting.)
   a. Does the structure blow over or remain standing?
   b. How strong a wind force can it withstand?
5. Students will conduct a Weighted Load Test: Set up the sign support structure again. Select a location farthest from the structure's vertical support(s) and attach a small paper cup by a string, so that the cup hangs straight down but does not touch the "ground."
   a. Load the cup with weights (marbles or coins), one by one.
   b. How much weight can the structure hold before collapsing?
   c. Do the sections look as if they are acting in tension and compression, as predicted in the sketch students presented to the class?
6. Students will conduct research by looking at and discussing images of sign support structures, observing overhead signs in their own environment.

Evaluation:

Students' knowledge, skills, and attitudes will be assessed using rubrics for class participation, group work, graphic organizer, engineering design and systems thinking, brief constructed responses, and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Other Extension Activities:

1. Students will research and report on the American Association of State Highway Transportation Officials (AASHTO) Standard Specifications for Structural Supports for Highway Signs, Cantilevered signal, sign, and light supports are susceptible to fatigue cracking from numerous cycles of wind and other loads. Because these structures are often positioned over major roadways, there is widespread concern regarding their reliability. In rare cases, cantilevered sign supports have failed, crashing into the roadway and presenting a hazard to the traveling public.
2. Students will research and report on Guidelines for the Installation, Inspection, Maintenance and Repair of Structural Supports for Highway Signs.

Laboratory-Classroom Preparation:

The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this

lesson, design tools and equipment, fabrication tools and equipment, and testing tools should be readied.

Tools/Materials/Equipment:

- Computers with simulation programs
- Library resources
- Graphic tools, materials, and equipment
- Design tools
- Fabrication tools and equipment
- Testing apparatus

Laboratory-Classroom Safety and Conduct:

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared Minimal effort to participate	Prepared for class, attempts to answer teacher generated questions	Well prepared for class, attempts to answer teacher generated questions and adds additional information to class when relevant
Curiosity	Rarely demonstrates curiosity	Usually demonstrates curiosity	Consistently demonstrates curiosity
Motivation For Learning	Rarely demonstrates motivation for learning	Usually demonstrates motivation for learning	Consistently demonstrates motivation for learning
Use of Time	Gives up easily, is not engaged Has difficulty remaining on task	Makes good use of class time to work on assignments and projects	Makes excellent use of class time to work on assignments and projects

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Contributions	Seldom cooperative Does little work Rarely offers useful ideas	Cooperative Works at assignments Usually offers useful ideas	Always willing to help and do more Does more than required Routinely offers useful ideas
Cooperation	Rarely listens to, shares with, or supports the efforts of others Often is not a good team member	Usually listens to, shares with, and supports the efforts of others Does not cause problems in the group	Always listens to, shares with, and supports the efforts of others Tries to keep people working together
Focus on the task	Does not focus on the task and what needs to be done Lets others do the work	Focuses on the task and what needs to be done most of the time.	Almost always focused on the task and what needs to be done Self-directed

Assessment Instruments – Graphic Organizer

Category	Below Target	At Target	Above Target
Arrangement of Concepts	Main concept not clearly identified; subconcepts don't consistently branch from main idea	Main concept easily identified; most subconcepts branch from main idea	Main concept easily identified; subconcepts branch appropriately from main idea
Links and	Linking lines not always pointing	Most linking lines connect	Linking lines connect related

Linking Lines	in correct direction; linking words don't clarify relationships between concepts; hyperlinks don't function or fail to enhance the topic	properly; most linking words accurately describe the relationship between concepts; most hyperlinks effectively used	terms/point in correct direction; linking words accurately describe relationship between concepts; hyperlinks effectively used
Graphics	Graphics used inappropriately and excessively; graphics poorly selected and don't enhance the topic; some graphics are blurry and ill-placed	Graphics used appropriately most of the time; most graphics selected enhance the topic, are of good quality, and are situated in logical places on the page	Graphics used appropriately; greatly enhance the topic and aid in comprehension; are clear, crisp, and well situated on the page
Content	Contains extraneous information; is not logically arranged; contains numerous spelling and grammatical errors	Reflects most of the essential information; is generally logically arranged; concepts presented without too many excess words; fewer than three misspellings or grammatical errors	Reflects essential information; is logically arranged; concepts succinctly presented; no misspellings or grammatical errors
Text	Font too small to read easily; more than four different fonts used; text amount is excessive for intended audience	Most text is easy to read; uses no more than four different fonts; amount of text generally fits intended audience	Easy to read/appropriately sized; no more than three different fonts; amount of text is appropriate for intended audience; boldface used for emphasis
Design	Cluttered design; low in visual appeal; requires a lot of scrolling to view entire diagram; choice of colors lacks visual appeal and impedes comprehension	Design is fairly clean, with a few exceptions; diagram has visual appeal; four or fewer symbol shapes; fits page well; uses color effectively most of time	Clean design; high visual appeal; four or fewer symbol shapes; fits page without a lot of scrolling; color used effectively for emphasis
Knowledge Gained	Student demonstrates a lack of knowledge about the content and the processes used to create the poster	Student can accurately answer most questions related to content and the processes used to create the poster	Student can accurately answer all questions related to content and the processes used to create the poster

Assessment Instrument– Engineering Design and Systems Thinking

Category	Below Target	At Target	Above Target
Defining the Problem	Rephrases the problem with limited clarity	Rephrases the problem clearly	Rephrases the problem clearly and precisely
Requirements	Does not take into account requirements placed on the development of a product or system	Takes into account several requirements placed on the development of a product or system	Takes into account numerous requirements placed on the development of a product or system
Trade-offs	Does not consider trade-offs in the design process	Makes trade-offs recognizing the need for careful compromises among competing factors.	Makes effective trade-offs that enhance the usefulness and acceptability of the product
Simulation Tools	Simulation tools not used to explore alternative courses of action	Simulation tools used to explore alternative courses of action	Simulation tools used effectively to explore alternative courses of action and enhance design performance
Optimization	Does not use the process of optimization	Applies the process of optimization to make the design or system as effective as possible within the given criteria and constraints	Effectively uses the process of optimization to make the design or system as effective as possible within the given criteria (desired specifications) and constraints (limits on the design process)

Refining the design	Refinement based on testing and evaluation is not evident	Refinements made based on testing and evaluation results	Significant improvement in the design is made based on prototype testing and evaluation
Creating or making it	Finished solution (product) fails to meet specifications	Finished solution (product) meets specifications	Finished solution (product) exceeds specifications
Communicating processes and results	Solution presented with limited accuracy Limited supporting evidence on how the solution meets the task criteria	Solution presented accurately Some supporting evidence on how the solution meets the task criteria	Solution presented concisely with clarity and accuracy Extensive supporting evidence on how the solution meets the task criteria

Assessment Instrument – Brief Constructed Response Items

1. Explain that applying systems thinking to the design and development requires managers to address societal, environmental, and economic impacts throughout the process.
2. Explain that when systems thinking is applied to the design and development process, potential costly conflicts and incompatibilities and can be avoided.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Assessment Instrument – Extended Response Items

1. Describe the benefits of applying systems thinking principles in the design process.

Category	Below Target	At Target	Above Target
Context and Argument	Context inappropriate Argument unsatisfactory	Context appropriate Argument satisfactory	Context appropriate Argument satisfactory Clearly stated thesis included
Evidence	Evidence is largely missing or generalized	Ample and appropriate evidence provided	Abundant, relevant specifics (names, events, legislation, court decisions, etc.) provided Includes obscure, but important evidence Thorough chronology
Analysis	Minimal analysis or fallacious reasoning	Organizes argument and uses data to support conclusions Recognizes causation, change, and continuity	Well-reasoned cause and effect arguments Fully explained conclusions Refers to views of others
Historical Accuracy	Many errors	May have a few errors Mistakes may slightly hinder argument, but do not detract from the overall accuracy	Virtually error free; minor mistakes do not compromise argument
Thoroughness	Covers question superficially May not complete all tasks	Covers entire question, but may be slightly imbalanced	Covers all areas of question in approximate proportions to their importance
Presentation	Inconsistent organization	Uses clear language	Uses clear, appropriate, and

	Grammatical errors cloud argument to a major degree	Well organized Contains few grammatical errors	precise language Cohesive organization Very few grammatical errors

Chapter 8 – Systems Thinking: Putting It All Together

Lesson 3 - Reviewing The Big Ideas

Lesson Duration: Two (2) hours

Standards:

- Students will develop an understanding of the core concepts of technology. (ITEA/STL-2)
- Students will develop an understanding of common themes. (Systems) (AAAS-BSL)
- Students will develop an understanding of data analysis and probability. (NCTM - MSE)
- Students will develop and evaluate inferences and predictions that are based on data. (NCTM - MSE)

Benchmarks:

ITEA – Benchmarks for Technological Literacy	AAAS - Benchmarks for Science	NCTM – Benchmarks for Mathematics
• Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. • New technologies create new processes. • Management is the process of planning, organizing, and controlling work. • Humans devise technologies to reduce the negative consequences of other technologies. • Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.	• A system usually has some properties that are different from those of its parts, but appear because of the interaction of those parts. • Understanding how things work and designing solutions to problems of almost any kind can be facilitated by systems analysis. • The successful operation of a designed system usually involves feedback. • Even in some very simple systems, it may not always be possible to predict accurately the result of changing some part or connection.	• Develop an understanding of large numbers and recognize and appropriately use exponential, scientific, and calculator notation; • Understand the differences among various kinds of studies and which types of inferences can legitimately be drawn from each • Understand how basic statistical techniques are used to monitor process characteristics in the workplace.

Learning Objectives:

Students will:

1. Explain how knowledge of the history of technology helps people understand the world.
2. Describe the interrelationships that exist among technologies and between technology and other fields of study.
3. Describe how engineering, the systematic application of mathematical, scientific, and technical principles, produces tangible end products that meet our needs and desires.
4. Explain some of the techniques used in modern manufacturing technologies that produce quality goods at low prices, enhancing the quality of life for many people.
5. Explain how cultural norms, environmental conditions, and the requirements of enterprises and institutions impact the process of designing and erecting structures.
6. Describe how advancements in the processing and controlling of energy resources have been an enabling factor in the development of technology.
7. Explain why information and communications technologies have proven to be a critical resource for competitive economic growth.
8. Explain that systems thinking principles provide a conceptual base for addressing the complex issues that confront.

Student Assessment Tools and/or Methods:
(See assessment instruments at end of lesson.)
1. Selected Response Items
2. Brief Constructed Response Items
3. Extended Response Items
4. Performance Rubrics

Resource Materials:
- Print-Based Sources
- Standards for Technological Literacy: Content for the Study of Technology, International Technology Education Association, (2000) ISBN 1-887101-02-0
- Teaching Technology - High School: Strategies for Standards-Based Instruction, Cat. No. P173 International Technology Education Association, (2000)
- Advancing Excellence in Technological Literacy: International Technology Education Association, (2003) ISBN 1-887101-03-9

- Audiovisual Materials
1. Technology Education: A Global Imperative, Cat. No. V018, International Technology Education Association
2. The 10 Gallon Bet – Video, Cat. No. V021, International Technology Education Association
3. A World-Class Education, Cat. No. V015, International Technology Education Association

- Internet Sites
1. Standards for Technological Literacy, http://www.iteawww.org/TAA/Publications/STL/STLMainPage.htm
2. Advancing Excellence in Technological Literacy, http://www.iteawww.org/TAA/Publications/AETL/AETLMainPage.htm
3. Inclusion of Special Needs Students & the 20 Standards for Technological Literacy, International Technology Education Association http://www.waza-inc.com/inclusion/Mainpage1.htm

Purpose of Lesson: To review the "Big Ideas" addressed in the Foundations of Technology course.

Required Knowledge and/or Skills: Students should have some understanding of how systems thinking principles provide a conceptual base for addressing the complex issues that confront us by providing ways of viewing the world as a whole and using that view to find the leverage points for fundamental change. They should have some basic graphic and research skills. In the engagement and exploratory phases of instruction, the teacher will identify student misunderstandings and/or misconceptions about the influence of technology on science.

Lesson 8-3

Engagement:
1. The teacher will assess prior knowledge and possible misconceptions related to the "Big Ideas" addressed in the Foundations of Technology course.
2. The teacher will remind students that technology is how humans modify the world around them to meet their needs and wants and to solve problems.

3. The teacher will ask students to think about the greatest problem that we face today.
4. Students will identify and justify their selections.
5. The teacher will ask students to think about whether their problem can be addressed through technology (modifying the world around them).
6. Students will list things they have learned in this course that might help them solve the problem they identified.

Concepts, understandings, or ideas I have learned in this course that might help me address the problem	**Skills that I have developed in this course that might help me address the problem**

Exploration:

1. The teacher will state that the ability to interact successfully with technology and to make informed decisions about the technology is part of what we call "Technological Literacy."
2. The teacher will ask students to take the items from their chart and organize their items according to the following categories.

Using Technology	**Assessing and Technology**	**Designing Technology**	**Producing Technology**

Explanation:

1. Students will share information from their charts.

2. The teacher will state that the things you did in this course were designed to help students acquire an understanding of some "Big Ideas" related to technology.
3. The teacher will review the "Big Ideas" addressed and activities completed in the Foundations of Technology course.

UNITS OF STUDY	LESSONS	EXTENSION ACTIVITIES
UNIT 1 **The History Of Technology** **Big Idea** - Knowledge of the history of technology helps people understand the world around them by seeing how people of all times and places have increased their capability by using their unique skills to innovate, improvise, and invent.	Lesson 1 - Getting Familiar with the Big Idea	Develop a **timeline** of a major technological achievement.
	Lesson 2 - Exploring Historical Periods of Technological Evolution	Create a **poster** highlighting representative artifacts and processes from one of the technological time periods.
	Lesson 3 - Analysis of the Historic Significance of Technological Advancements	Develop a **graphic organizer** for a selected technological development that identifies the social, cultural, political, and economic impacts.
	Lesson 4 - Research Activity: Influence of Technology on History	Develop a **research report** on the historical impact of a selected technological advancement.
UNIT 2 **Relationships Among Technologies and Connections with Other Fields of Study** **Big Idea** - Understanding that interrelationships exist among technologies and between technology and other fields of study enhances our ability to use, assess, design, and produce technology.	Lesson 1 - Getting Familiar with the Big Idea	Write a **newspaper opinion column.** Design and fabricate a **bulletin board display.** Analyze the **graph.**
	Lesson 2 - Technology Triggers a Scientific Revolution	Research and develop a **multimedia presentation** on a selected 20th century scientific advancement.
	Lesson 3 - The Discovery of Neptune	Read the **vignette** and complete the exercise at the end.
UNIT 3 **Engineering Design** **Big Idea** - Engineering, the systematic application of mathematical, scientific, and technical principles, produces tangible end products that meet our needs and desires.	Lesson 1 - Getting Familiar with the Big Idea	Develop an **oral presentation** on one of the "Greatest Engineering Achievements of the 20th century."
	Lesson 2 - The Design Process: Transforming an Idea into a Final Product or System.	Use the engineering design process to **solve a problem.**
	Lesson 3 - Engineering Resources (Core Technologies)	Use the engineering design process to **solve a problem.**
	Lesson 4 - An Introduction to Mechanical Technology	Use the engineering design process to **solve a problem.**
	Lesson 5 - An Introduction to Electrical Technology	Use the engineering design process to **solve a problem.**
	Lesson 6 - Reverse Engineering	**Reverse engineer a product.**
	Lesson 7 - An Introduction to Fluid Technology	Use the engineering design process to **solve a problem.**
	Lesson 8 - An Introduction to Thermal Technology	Use the engineering design process to **solve a problem.**

	Lesson 9 - An Introduction to Optical Technology	Conduct research and write a **newspaper article.**
	Lesson 10 - An Introduction to Materials Technology	Create a **timeline** on the development and impact of a material.
UNIT 4 **Manufacturing Technologies** Modern manufacturing technologies produce quality goods at low prices, enhancing the quality of life for many people.	Lesson 1 - Getting Familiar with the Big Idea	Research, design and fabricate a **display** depicting a primary manufacturing process.
	Lesson 2 - What's New In Manufacturing?	Develop a **concept map that** illustrates the common attributes of an integrated manufacturing process.
	Lesson 3 - "Stuff" We Use to Make "Things"	Design and fabricate a **three-dimensional model or display panel** that illustrates the processing of the material
Unit 5 – Construction Technology Construction is the systematic process of erecting structures to meet human needs and desires. It reflects cultural norms, environmental conditions, and the requirements of enterprises and institutions.	Lesson 1 - Getting Familiar with the Big Idea	Research and develop a **multimedia presentation** on construction.
	Lesson 2 - Bridge Building	Create a structural model, test a design, and **optimize the design of a truss bridge.**
	Lesson 3 - Construction Management	Develop a **display** documenting the design process for their bridge.
UNIT 6 **Power and Energy** Advancements in the processing and controlling of energy resources have been an enabling factor in the development of technology.	Lesson 1 - Getting Familiar with the Big Idea	Design a **Web page** on "Electrification and Quality of Life."
	Lesson 2 - Energy and Cars: What Does the Future Hold?	Research and present an **oral report** on automobile energy sources and attitudes toward energy use from 2000 to 2050.
	Lesson 3 - The Great Energy Debate	Conduct a **mock hearing (debate)** of the U.S. Senate Committee for Energy and Natural Resources.
UNIT 7 **Information and Communication Technologies** Information and communications technologies that process information in digital form have revolutionized society's information handling capacity and have proven to be a critical resource for competitive economic growth.	Lesson 1 - Getting Familiar with the Big Idea	Write a **friendly letter** describing the communications technologies they use and how they affect their lives. Create a **graphic organizer** that describes how information technologies enhance an enterprise.
	Lesson 2 - Communication Systems	Create a **brochure** about one of the four types of communication systems.
	Lesson 3 - The Global Positioning System (GPS)	Create **GPS graphics** that will pinpoint their location using a map and a drawing compass.

UNIT 8 **Systems Thinking: "Putting It All Together"** Systems thinking principles provide a conceptual base for addressing the complex issues that confront us by providing ways of viewing the world as a whole and using that view to find the leverage points for fundamental change.	Lesson 1 - Getting Familiar with the Big Idea	**Solve an engineering design problem** and optimize the design using simulation and mathematical modeling.
	Lesson 2 - Systems Thinking and the Design Process	**Develop a product** using a systems-thinking development process.
	Lesson 3 - Reviewing The Big Ideas	Write a **letter** to a student who will take the same course the next semester that "summarizes the material covered, topics and strategies that were worthwhile, and those that caused problems and provide a general introduction to the course.

4. The teacher will explain that the quizzes, tests, and other assessment instruments used were designed to document your achievement of the goals for the course.
5. The teacher will congratulate students for their efforts and achievements and discuss science, mathematics, and technology courses that they might take in the future.
6. Students will restate any questions that were not answered in the teacher's lecture and clarify any unresolved issues.

Extension:

1. The teacher will describe what he or she has learned related to teaching technique used in the course and new insights that the instructor gained about the subject material.
2. The teacher will explain that this year's students can help the teacher plan for next year by sharing their thoughts on the course.
3. Students will write a letter to a student who will take the same course the next semester. The letter summarizes the material covered, topics and strategies that were worthwhile, and those that caused problems and provide a general introduction to the course.

Evaluation:

Students' knowledge, skills, and attitudes will be assessed using rubrics for class participation, concept map, friendly letter, brief constructed responses and extended constructed responses summarizing the lesson. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Laboratory-Classroom Preparation: The laboratory should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, and research activities. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, design tools and equipment, fabrication tools and equipment, and testing tools should be readied.

Tools/Materials/Equipment:

- Computers with simulation programs
- Library resources

- Graphic tools, materials, and equipment
- Design tools
- Fabrication tools and equipment
- Testing apparatus

Laboratory-Classroom Safety and Conduct:

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.
2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

Assessment Instrument – Class Participation

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared Minimal effort to participate	Prepared for class, attempts to answer teacher generated questions	Well prepared for class, attempts to answer teacher generated questions and adds additional information to class when relevant
Curiosity	Rarely demonstrates curiosity	Usually demonstrates curiosity	Consistently demonstrates curiosity
Motivation For Learning	Rarely demonstrates motivation for learning	Usually demonstrates motivation for learning	Consistently demonstrates motivation for learning
Use of Time	Gives up easily, is not engaged Has difficulty remaining on task	Makes good use of class time to work on assignments and projects	Makes excellent use of class time to work on assignments and projects

Assessment Instrument– Friendly Letter

Category	Below Target	At Target	Above Target
Layout/Design	Letter appears busy or boring. Text may be difficult to read. May have some grammar and or punctuation indicating it is a friendly letter.	The letter is eye-catching and attractive. Text is easy to read. Grammar, style, and punctuation are indicative of a friendly letter.	The letter is creatively designed with easily read text. Grammar, style, and purpose all excellent for a friendly letter.
Information, style, audience, tone	Some information is provided, but is limited or inaccurate.	Information is well written and interesting to read.	Information is accurate and complete, is creatively written, and is cleverly presented.
Accurate Parts of the Friendly Letter	Most friendly letter elements (the heading, the salutation, the body, the closing, and the signature) out of place or missing.	Some friendly letter elements (the heading, the salutation, the body, the closing, and the signature) may be missing.	Letter is complete with all required elements (the heading, the salutation, the body, the closing, and the signature).
Grammar, Punctuation, and choice of words for the friendly letter	Information mislabeled or missing. Inaccurate punctuation or grammar.	Style, purpose, audience, grammar, and punctuation all fair and indicative of a friendly letter.	Excellent job on presentation, style, grammar, and punctuation.

Assessment Instrument – Extended Response Items

1. Explain how knowledge of the history of technology helps people understand the world.

2. Describe the interrelationships that exist among technologies and between technology and other fields of study.
3. Describe how engineering, the systematic application of mathematical, scientific, and technical principles, produces tangible end products that meet our needs and desires.
4. Explain some of the techniques used in modern manufacturing technologies that produce quality goods at low prices, enhancing the quality of life for many people.
5. Explain how cultural norms, environmental conditions, and the requirements of enterprises and institutions impact the process of designing and erecting structures.
6. Describe how advancements in the processing and controlling of energy resources have been an enabling factor in the development of technology.
7. Explain why information and communications technologies have proven to be a critical resource for competitive economic growth.
8. Explain that systems thinking principles provide a conceptual base for addressing the complex issues that confront us.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the text and/or the question	Response demonstrates an understanding of the text	Response demonstrates an understanding of the complexities of the text
Focus	Lacks transitional information to show the relationship of the support to the question	Addresses the demands of the question	Exceeds the demands of the question
Use of Related Information	Uses minimal information from the text to clarify or extend meaning	Uses some expressed or implied information from the text to clarify or extend meaning	Effectively uses expressed or implied information from the text to clarify or extend meaning

Appendix A

Program Responsiblity Matrix - Technology/Science/Mathematics

KEY:
A: this standard/benchmark will be used to develop student understanding
B: conceptional understanding is transferable if supported
C: prior knowledge

		172	232	217	186	172	256	176	186	197	Foundations of Technology			
	4 = Benchmark must be covered in detail, lessons and assessments cover this content 3 = Benchmark is covered, but topics and lessons do not center on them 2 = Topics and lessons refer to previous knowledge and integrate content covered 1 = Topics and lessons refer to previous knowledge	K-2	3-5	Exploring Technology	Invention & Innovation	Systems	Foundations	Impacts	Issues	Engineering Design	Science *AAAS* Stds/Benchrks		Mathematics *NCTM* Stds/Benchrks	
The Nature of Technology														
STL-1	**Understanding the characteristics & scope of technology**	**8**	**12**	**11**	**16**	**9**	**8**	**11**	**10**	**11**				
A	The natural world and human-made world are different.	4												
B	All people use tools and techniques to help them do things.	4												
C	Things that are found in nature differ from things that are human-made in how they are produced and used.		4											
D	Tools, materials, and skills are used to make things and carry out tasks.		4											
E	Creative thinking and economic and cultural influences shape technological development.		4											
F	New products and systems can be developed to solve problems or to help do things that could not be done without the help o technology.			4	4	4								
G	The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.			2	4	2								
H	Technology is closely linked to creativity, which has resulted in innovation.			3	4									
I	Corporations can often create demand for a product by bringing it onto the market and advertising it.			2	4	3								
J	The nature and development of technological knowledge and processes are functions of the setting.						2	3		4				
K	The rate of technological development and diffusion is increasing rapidly.						2	4	3					
L	Inventions and innovations are the results of specific, goal-oriented research.						2	2	3	4	2/P	C		
M	Most development of technologies these days is driven by the profit motive and the market.						2	2	4	3				
STL-2	**Understanding the core concepts of technology**	**20**	**28**	**13**	**29**	**35**	**21**	**14**	**20**	**23**				
A	Some systems are found in nature, and some are made by humans.	4												
B	Systems have parts or components that work together to accomplish a goal.	4												
C	Tools are simple objects that help humans complete tasks.	4												
D	Different materials are used in making things.	4												
E	People plan in order to get things done.	4												
F	A subsystem is a system that operates as a part of another system.		4											
G	When parts of a system are missing, it may not work as planned.		4											
H	Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time.		4											
I	Tools are used to design, make, use, and assess technology.		4											
J	Materials have many different properties.		4											
K	Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing.		4											
L	Requirements are the limits to designing or making a product or system.		4											
M	Technological systems include input, processes, output, and, at times, feedback.			4	4	4								
N	Systems thinking involves considering how every part relates to others.				3	4								
O	An open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.					4								
P	Technological systems can be connected to one another.			2	3	4								
Q	Malfunctions of any part of a system may affect the function and quality of the system.				4	4								
R	Requirements are the parameters placed on the development of a product or system.				4	4								
S	Trade-off is a decision process recognizing the need for careful compromises among competing factors.				4									
T	Different technologies involve different sets of processes.			2	4	3								
U	Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.			2	3	4								
V	Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change.			3		4								
W	Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems.									4				
X	Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.						4		3				3N, P 14M, 22C	A
Y	The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.						3		3		58/K	B		
Z	Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.						3	3	3	2	39/M	C		
AA	Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.						3		3	4	58/I 58/L	B		
BB	Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.							2	2	4				
CC	New technologies create new processes.						4	2			5/E	B		
DD	Quality control is a planned process to ensure that a product, service, or system meets established criteria.							4		4				
EE	Management is the process of planning, organizing, and controlling work.						4		3	2				
FF	Complex systems have many layers of controls and feedback loops to provide information.							3	3	3				

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Program Responsiblity Matrix - Technology/Science/Mathematics

KEY:
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		K-2	3-5	Exploring Technology	Invention & Innovation	Systems	Foundations	Impacts	Issues	Engineering Design	Foundations of Technology		Science *AAAS* Stds/Benchrks	Mathematics *NCTM* Stds/Benchrks
		172	232	217	186	172	256	176	186	197				
STL-3	**Understanding the relationships among technologies and connections with other fields of study**	**4**	**8**	**6**	**9**	**9**	**16**	**6**	**7**	**10**				
A	The study of technology uses many of the same ideas and skills as other subjects.	4												
B	Technologies are often combined.		4											
C	Various relationships exist between technology and other fields of study.		4											
D	Technological systems often interact with one another.			3	2	2								
E	A product, system, or environment developed for one setting may be applied to another setting.				4	3								
F	Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.			3	3	4								
G	Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.						4			4				
H	Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.						4	3		3	7/K 5/D	C		
I	Technological ideas are sometimes protected through the process of patenting.						4		3	3				
J	Technological progress promotes the advancement of science and mathematics.						4	3	4		7/L 5/F	C		
Technology and Society														
STL-4	**Understanding the cultural, social, economic and political effects of technology**	**4**	**8**	**14**	**14**	**3**	**0**	**15**	**11**	**8**				
A	The use of tools and machines can be helpful or harmful.	4												
B	When using technology, results can be good or bad.		4											
C	The use of technology can have unintended consequences.		4											
D	The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology's development and use.			4	3	3								
E	Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.			4	3									
F	The development and use of technology poses ethical issues.			3	4									
G	Economic, political, and cultural issues are influenced by the development and use of technology.			3	4									
H	Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.							4						
I	Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.							4	3	3				
J	Ethical considerations are important in the development, selection, and use of technologies.							3	4	3				
K	The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.							4	4	2				
STL-5	**Understanding the effects of technology on the environment**	**4**	**8**	**8**	**4**	**9**	**4**	**21**	**19**	**11**				
A	Some materials can be reused and/or recycled.	4												
B	Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment.		4											
C	The use of technology affects the environment in good and bad ways.		4											
D	The management of waste produced by technological systems is an important societal issue.			4		3								
E	Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.				1	4								
F	Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another.			4	3	2								
G	Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing and recycling.							4	3	2				
H	When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.							3	4					
I	With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making.							3	4					
J	The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.							4		3				
K	Humans devise technologies to reduce the negative consequences of other technologies.						4	3	4	3				
L	Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment.							4	4	3				

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		K-2	3-5	Exploring Technology	Invention & Innovation	Systems	Foundations	Impacts	Issues	Engineering Design	Foundations of Technology		Science *AAAS* Stds/Benchrks	Mathematics *NCTM* Stds/Benchrks
		172	232	217	186	172	256	176	186	197				
STL-6	**Understanding the role of society in the development and use of technology**	**4**	**8**	**13**	**15**	**2**	**5**	**3**	**11**	**9**				
A	Products are made to meet individual needs and wants.	4												
B	Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes.		4											
C	Individual, family, community, and economic concerns may expand or limit the development of technologies.		4											
D	Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.			4	3									
E	The use of inventions and innovations has led to changes in society and the creation of new needs and wants.			3	4									
F	Social and cultural priorities and values are reflected in technological devices.			3	4	2								
G	Meeting societal expectations is the driving force behind the acceptance and use of products and systems.			3	4									
H	Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values.						2		3	3				
I	The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures.							3	4	3				
J	A number of different factors, such as advertising, the strength of the economy, the goals of a company, and the latest fads contribute to shaping the design of and demand for various technologies.						3		4	3				
STL-7	**Understanding the influence of technology on history**	**4**	**4**	**6**	**14**	**4**	**27**	**20**	**15**	**4**				
A	The way people live and work has changed throughout history because of technology.	4												
B	People have made tools to provide food, to make clothing, and to protect themselves.		4											
C	Many inventions and innovations have evolved by using slow and methodical processes of tests and refinements.			3	4									
D	The specialization of function has been at the heart of many technological improvements.			3	4									
E	The design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.				2	4								
F	In the past, an invention or innovation was not usually developed with the knowledge of science.				4									
G	Most technological development has been evolutionary, the result of a series of refinements to a basic invention.						4			2				
H	The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials.							4	3	1				
I	Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.							4	3	1				
J	Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how.						4		2		8/K	C		
K	The Iron Age was defined by the use of iron and steel as the primary materials for tools.						4		3		8/K	C		
L	The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society.						4	3			8/K	C		
M	The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology.						4	3			8/K 3/O	C		
N	The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time.						4	3			8/K 57/C,D,E	C		
O	The Information Age places emphasis on the processing and exchange of information.						3	3	4		8/K	C		
Design														
STL-8	**Understanding the attributes of design**	**8**	**8**	**9**	**12**	**0**	**13**	**2**	**8**	**15**				
A	Everyone can design solutions to a problem.	4												
B	Design is a creative process.	4												
C	The design process is a purposeful method of planning practical solutions to problems.		4											
D	Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.		4											
E	Design is a creative planning process that leads to useful products and systems.			3	4									
F	There is no perfect design.			3	4									
G	Requirements for a design are made up of criteria and constraints.			3	4									
H	The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, te						4	2	2	4	8/M	B	8 J,K,M 11 S,V, W,AA	A
I	Design problems are seldom presented in a clearly defined form.						3		3	3				
J	The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.						3			4	8/J 8/O	B		
K	Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.						3		3	4				

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		K-2	3-5	Exploring Technology	Invention & Innovation	Systems	Foundations	Impacts	Issues	Engineering Design	Foundations of Technology			
		172	232	217	186	172	256	176	186	197	Science *AAAS* Stds/Benchrks		Mathematics *NCTM* Stds/Benchrks	
STL-9	**Understanding engineering design**	**8**	**12**	**10**	**11**	**2**	**13**	**0**	**2**	**16**				
A	The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.	4												
B	Expressing ideas to others verbally and through sketches and models is an important part of the design process.	4												
C	The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.		4											
D	When designing an object, it is important to be creative and consider all ideas.		4											
E	Models are used to communicate and test design ideas and processes.		4											
F	Design involves a set of steps, which can be performed in different sequences and repeated as needed.			4	4									
G	Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.			4	3	2								
H	Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.			2	4									
I	Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.						4			4	58/J	A	3 N,P 12J-M	A
J	Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.						3			4	58/J	A		
K	A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.						3			4				
L	The process of engineering design takes into account a number of factors.						3		2	4	8/J 8/L	B		
STL-10	**Understanding the role of troubleshooting, R&D, etc. in problem-solving**	**8**	**12**	**9**	**10**	**6**	**12**	**0**	**15**	**9**				
A	Asking questions and making observations helps a person to figure out how things work.	4												
B	All products and systems are subject to failure. Many products and systems, however, can be fixed.	4												
C	Troubleshooting is a way of finding out why something does not work so that it can be fixed.		4											
D	Invention and innovation are creative ways to turn ideas into real things.		4											
E	The process of experimentation, which is common in science, can also be used to solve technological problems.		4											
F	Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.			3	2	4								
G	Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it.			3	4	2								
H	Some technological problems are best solved through experimentation.			3	4									
I	Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.						4		4	3				
J	Technological problems must be researched before they can be solved.						2		3	2	7/K	C		
K	Not all problems are technological, and not every problem can be solved using technology.						3		4	2				
L	Many technological problems require a multidisciplinary approach.						3		4	2	5/F 8/O	C	18 A-D 20 A-D	A
Abilities for a Technological World														
STL-11	**Abilities to apply the design process**	**12**	**16**	**15**	**20**	**2**	**24**	**2**	**6**	**19**				
A	Brainstorm people's needs and wants and pick some problems that can be solved through the design process.	4												
B	Build or construct an object using the design process.	4												
C	Investigate how things are made and how they can be improved.	4												
D	Identify and collect information about everyday problems that can be solved by technology, and generate ideas and requirements for solving a problem.		4											
E	The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many.		4											
F	Test and evaluate the solutions for the design problem.		4											
G	Improve the design solutions.		4											
H	Apply a design process to solve problems in and beyond the laboratory-classroom.			3	4									
I	Specify criteria and constraints for the design.			3	4									
J	Make two-dimensional and three-dimensional representations of the designed solution.			3	4									
K	Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.			3	4									
L	Make a product or system and document the solution.			3	4	2								
M	Identify the design problem to solve and decide whether or not to address it.						4	2	3	4				
N	Identify criteria and constraints and determine how these will affect the design process.						4		3	3				
O	Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.						4			3	59/K 59/I	B		
P	Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.						4			3	59/J	B	6 C,F 18 B-D	A
Q	Develop and produce a product or system using a design process.						4			3				
R	Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.						4			3	65/L,M 65/P,Q	B	6 C 11 S 20 A-D	A

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		172	232	217	186	172	256	176	186	197				
STL-12	**Abilities to use and maintain technological products and systems**	**12**	**16**	**8**	**9**	**13**	**13**	**7**	**1**	**15**				
A	Discover how things work.	**4**												
B	Use hand tools correctly and safely and be able to name them correctly.	**4**												
C	Recognize and use everyday symbols.	**4**												
D	Follow step-by-step directions to assemble a product.		**4**											
E	Select and safely use tools, products, and systems for specific tasks.		**4**											
F	Use computers to access and organize information.		**4**											
G	Use common symbols, such as numbers and words, to communicate key ideas.		**4**											
H	Use information provided in manuals, protocols, or by experienced people to see and understand how things work.			**4**	**3**	**3**								
I	Use tools, materials, and machines safely to diagnose, adjust, and repair systems.				**3**	**4**								
J	Use computers and calculators in various applications.			**4**	**3**	**2**								
K	Operate and maintain systems in order to achieve a given purpose.					**4**								
L	Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.						**3**	**4**	**1**	**3**	65/L&M 65/P&Q	B		
M	Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.						**3**			**3**	64/R	C		
N	Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision.									**3**				
O	Operate systems so that they function in the way they were designed.						**3**			**3**				
P	Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate						**4**	**3**		**3**			3 K 5N, 6C 20 A-D	A
STL-13	**Abilities to assess the impact of products and systems**	**8**	**12**	**9**	**6**	**16**	**3**	**15**	**10**	**9**				
A	Collect information about everyday products and systems by asking questions.	**4**												
B	Determine if the human use of a product or system creates positive or negative results.	**4**												
C	Compare, contrast, and classify collected information in order to identify patterns.		**4**											
D	Investigate and assess the influence of a specific technology on the individual, family, community, and environment.		**4**											
E	Examine the trade-offs of using a product or system and decide when it could be used.		**4**											
F	Design and use instruments to gather data.			**3**		**4**								
G	Use data collected to analyze and interpret trends in order to identify the positive or negative effects of a technology.				**3**	**4**								
H	Identify trends and monitor potential consequences of technological development.			**3**		**4**								
I	Interpret and evaluate the accuracy of the information obtained and determine if it is useful.			**3**	**3**	**4**								
J	Collect information and evaluate its quality.						**3**	**3**	**4**	**3**	41/J 41/K	C	12 M 14 H	A
K	Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment.							**4**	**3**	**2**				
L	Use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology.							**4**		**2**				
M	Design forecasting techniques to evaluate the results of altering natural systems.							**4**	**3**	**2**				

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		172	232	217	186	172	256	176	186	197				
The Designed World														
STL-14	**Understanding of and abilities to select and use medical technologies**	**12**	**12**	**13**	**4**	**8**	**4**	**9**	**8**	**0**				
A	Vaccinations protect people from getting certain diseases.	4												
B	Medicine helps people who are sick to get better.	4												
C	There are many products designed specifically to help people take care of themselves.	4												
D	Vaccines are designed to prevent diseases from developing and spreading; medicines are designed to relieve symptoms and stop diseases from developing.		4											
E	Technological advances have made it possible to create new devices, to repair or replace certain parts of the body, and to provide a means for mobility.		4											
F	Many tools and devices have been designed to help provide clues about health and to provide a safe environment.		4											
G	Advances and innovations in medical technologies are used to improve healthcare.			3	4									
H	Sanitation processes used in the disposal of medical products help to protect people from harmful organisms and disease, and shape the ethics of medical safety.			4										
I	The vaccines developed for use in immunization require specialized technologies to support environments in which a sufficient amount of vaccines are produced.			3		4								
J	Genetic engineering involves modifying the structure of DNA to produce novel genetic make-ups.			3		4								
K	Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained.						4	3						
L	Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psycho							3	4					
M	The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures.							3	4					
STL-15	**Understanding of and abilities to select and use agricultural and biotechnologies**	**8**	**12**	**16**	**0**	**4**	**4**	**4**	**14**	**3**				
A	The use of technologies in agriculture makes it possible for food to be available year round and to conserve resources.	4												
B	There are many different tools necessary to control and make up the parts of an ecosystem.	4												
C	Artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals.		4											
D	Most agricultural waste can be recycled.		4											
E	Many processes used in agriculture require different procedures, products, or systems.		4											
F	Technological advances in agriculture directly affect the time and number of people required to produce food for a large population.			4										
G	A wide range of specialized equipment and practices is used to improve the production of food, fiber, fuel, and other useful products and in the care of animals.					4								
H	Biotechnology applies the principles of biology to create commercial products or processes.			4										
I	Artificial ecosystems are human-made complexes that replicate some aspects of the natural environment.			4										
J	The development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food.			4										
K	Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products.								3					
L	Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering.						4		3					
M	Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.							4	4					
N	The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna.								4	3				
STL-16	**Understanding of and abilities to select and use energy and power technologies**	**8**	**8**	**14**	**2**	**8**	**20**	**6**	**3**	**6**				
A	Energy comes in many forms.	4												
B	Energy should not be wasted.	4												
C	Energy comes in different forms.		4											
D	Tools, machines, products, and systems use energy in order to do work.		4											
E	Energy is the capacity to do work.			4										
F	Energy can be used to do work, using many processes.			2		4								
G	Power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.			4										
H	Power systems are used to drive and provide propulsion to other technological products and systems.				2	4								
I	Much of the energy used in our environment is not used efficiently.			4										
J	Energy cannot be created nor destroyed; however, it can be converted from one form to another.						4				15/I 15/J	C		
K	Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.						4				15/I 15/J	C		
L	It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings.						4	4						
M	Energy resources can be renewable or nonrenewable.						4	2	3	3	22/J 39/P	B		
N	Power systems must have a source of energy, a process, and loads						4			3				

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		172	232	217	186	172	256	176	186	197				
STL-17	**Understanding of and abilities to select and use information and communication technologies**	**12**	**16**	**13**	**4**	**11**	**23**	**6**	**4**	**7**				
A	Information is data that has been organized.	4												
B	Technology enables people to communicate by sending and receiving information over a distance.	4												
C	People use symbols when they communicate by technology.	4												
D	The processing of information through the use of technology can be used to help humans make decisions and solve problems.		4											
E	Information can be acquired and sent through a variety of technological sources, including print and electronic media.		4											
F	Communication technology is the transfer of messages among people and/or machines over distances through the use of technology.		4											
G	Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations.		4											
H	Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human.			3		4								
I	Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination.			3		4								
J	The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.			4										
K	The use of symbols, measurements, and drawings promotes clear communication by providing a common language to expres ideas.			3	4	3								
L	Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.						4			2				
M	Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.						4				40/K	C		
N	Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.						3	3	4		24/N 47/J	C		
O	Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.						4							
P	There are many ways to communicate information, such as graphic and electronic means.						4	3		2			6 C	A
Q	Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.						4			3				
STL-18	**Understanding of and abilities to select and use transportation technologies**	**12**	**8**	**4**	**3**	**15**	**8**	**12**	**8**	**3**				
A	A transportation system has many parts that work together to help people travel.	4												
B	Vehicles move people or goods from one place to another in water, air, or space and on land.	4												
C	Transportation vehicles need to be cared for to prolong their use.	4												
D	The use of transportation allows people and goods to be moved from place to place.		4											
E	A transportation system may lose efficiency or fail if one part is missing or malfunctioning or if a subsystem is not working.		4											
F	Transporting people and goods involves a combination of individuals and vehicles.			4		3								
G	Transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.					4								
H	Governmental regulations often influence the design and operation of transportation systems.				3	4								
I	Processes, such as receiving, holding, storing, loading, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently.					4								
J	Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.						4	3						
K	Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another.						4	3	2					
L	Transportation services and methods have led to a population that is regularly on the move.							2	4					
M	The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques							4	2	3				

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		172	232	217	186	172	256	176	186	197				
STL-19	**Understanding of and abilities to select and use manufacturing technologies**	**8**	**12**	**16**	**4**	**4**	**18**	**19**	**6**	**11**				
A	Manufacturing systems produce products in quantity.	4												
B	Manufactured products are designed.	4												
C	Processing systems convert natural materials into products.		4											
D	Manufacturing processes include designing products, gathering resources, and using tools to separate, form, and combine materials in order to produce products.		4											
E	Manufacturing enterprises exist because of a consumption of goods.		4											
F	Manufacturing systems use mechanical processes that change the form of materials through the processes of separating, forming, combining, and conditioning them.			4										
G	Manufactured goods may be classified as durable and non-durable.			4										
H	The manufacturing process includes the designing, development, making, and servicing of products and systems.					4								
I	Chemical technologies are used to modify or alter chemical substances.			4										
J	Materials must first be located before they can be extracted from the earth through such processes as harvesting, drilling, and mining.			4										
K	Marketing a product involves informing the public about it well as assisting in selling and distributing it.				4									
L	Servicing keeps products in good operating condition.							4						
M	Materials have different qualities and may be classified as natural, synthetic, or mixed.						4	3		4	17/L 38/P	B		
N	Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time.						4	2	2	2				
O	Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.						4		2		38/M	C		
P	The interchangeability of parts increases the effectiveness of manufacturing processes.						2	4		3				
Q	Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products.							4						
R	Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it.						4	2	2	2				
STL-20	**Understanding of and abilities to select and use construction technologies**	**8**	**12**	**10**	**0**	**12**	**20**	**4**	**8**	**8**				
A	People live, work, and go to school in buildings, which are of different types: houses, apartments, office buildings, and schools.	4												
B	The type of structure determines how the parts are put together	4												
C	Modern communities are usually planned according to guidelines.		4											
D	Structures need to be maintained.		4											
E	Many systems are used in buildings.		4											
F	The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function.			4										
G	Structures rest on a foundation.			3		4								
H	Some structures are temporary, while others are permanent.			3		4								
I	Buildings generally contain a variety of subsystems.					4								
J	Infrastructure is the underlying base or basic framework of a system.						4	2		2				
K	Structures are constructed using a variety of processes and procedures.						4		3					
L	The design of structures includes a number of requirements.						4		3	3				
M	Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use.						4	2		3				
N	Structures can include prefabricated materials						4		2					

Appendix B

References and Suggested Readings

Preface

American Association for the Advancement of Science. (1993). *Benchmarks For Science Literacy*. New York: Oxford University Press.

International Technology Education Association. (2002). *Measuring Progress: A Guide To Assessing Students For Technological Literacy*. Reston, VA.

International Technology Education Association. (2000). *Standards For Technological Literacy: Content For The Study Of Technology*. Reston, VA.

National Academy of Engineering/National Research Council. (2002). *Technically Speaking: Why All Americans Need to Know More About Technology*. Washington, DC: National Academy Press.

Introduction to Course Guide

International Technology Education Association. (2002). *Measuring Progress: A Guide To Assessing Students For Technological Literacy*. Reston, VA.

International Technology Education Association. (2001). *Teaching Technology: High School Strategies For Standards-Based Instruction*. Reston, VA.

Leypoldt, M. (1974). *40 Ways To Teach In Groups*. Valley Forge: Judson Press.

Chapter One

Basalla, George. (1989) *The Evolution of Technology*. Cambridge University Press, ISBN: 0521296811

Hellemans, Alexander. (2004) *The History of Science and Technology*. Houghton Mifflin, ISBN: 0618221239

Karwatka, D. (1996). *Technology's Past: America's Industrial Revolution and the People Who Delivered the Goods*. Ann Arbor, MI: Prakken Publications, Inc.

Kranzberg, M. & Pursell, C.W. Jr., editors. (1967). *Technology in Western Civilization*. New York: Oxford University Press.

Pacey, Arnold. (1991) *Technology in World Civilization: A Thousand-Year History*. The MIT Press. ISBN: 0262660725

Pytlik, E. et.al. (1978). *Technology, Change and Society*. Worcester, MA: Davis

Publications, Inc.
Williams, T. (1987). *The History of Invention: From Stone Axes to Silicon Chips*. New York: Facts on File Publications.

Chapter Two

Fauvel, John and Gray, Jeremy. (1996) *A History of Mathematics: A Reader.* Math. Assoc. Amer.
Peel Board of Education Teachers. (1996) *Mathematics, Science, & Technology Connections, Teachers Helping Teachers Series.* ISBN: 1-895579-37-6, 1996.
Pytlik, E. et.al. (1978). *Technology, Change and Society.* Worcester, MA: Davis Publications, Inc.
Trefil, James S. et. al. (2001) *The Encyclopedia of Science and Technology,* Taylor & Francis Group

Chapter Three

Florman, Samuel C. (1996) *The Existential Pleasures of Engineering* (Thomas Dunne Book) St. Martin's Griffin; ISBN: 0312141041
Garner, Geraldine. (2002) Careers in Engineering, 2nd Ed. McGraw-Hill; ISBN: 0071390413
Petroski, Henry. (1992) To Engineer is Human: The Role of Failure in Successful Design, Vintage; Reprint Edition, ISBN: 0679734163
Todd, R. et.al. (1996). *Introduction to Design And Technology*. Cincinnati: Thomson Learning Tools.
Voland, G. (1999). *Engineering By Design*. Reading, MA: Addison-Wesley.

Chapter Four

Biotechnology unzipped: Promises & Realities. Washington, DC: Joseph Henry Press.
Groover, Mikell. P. (2001) *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*, Wiley, ISBN: 0471400513
Lindsey, Diane et. al. (2005) *Career Ideas For Teens In Manufacturing*, Facts on File ISBN: 0816052948
Miller, William B. (1993) *All I Need to Know About Manufacturing I Learned in Joe's Garage*, Bayrock Pr, ISBN: 0963043935
Todd, R. et.al. (1996). *Introduction To Design And Technology*. Cincinnati: Thomson Learning Tools.
Voland, G. (1999). *Engineering By Design*. Reading, MA: Addison-Wesley. Grace, E. (1997).

Chapter Five

Gordon, J.E. (2003) *Structures: Or Why Things Don't Fall Down*. Da Capo Press; Reprint Edition (2003) ISBN: 0306812835

Salvadori, Mario, et. al. (1990) *The Art of Construction: Projects and Principles for Beginning Engineers and Architects.* Chicago Review Press; 3rd Edition (1990) ISBN: 1556520808

Schodek, Daniel L. (2003) *Structures and Buildings*, 5th Edition, Prentice Hall; (2003) ISBN: 0130488798

Chapter Six

Bradley, Robert. (2004) Energy: The Master Resource. Kendall Hunt Pub Co, ISBN: 0757511694

Cassedy, Edward S. and Grossman, Peter Z. (1998) *Introduction to Energy: Resources, Technology*, Cambridge University Press; 2nd Edition (1998) ISBN: 0521637678

Christensen, John W. (1996) *Global Science: Energy, Resources, Environment*, Kendall Hunt Pub Co; ISBN: 0840374836

Chapter 7

Dodd, Annabel Z. (2001) *The Essential Guide to Telecommunications* (3rd Edition) Prentice Hall PTR; 3rd Edition, ISBN: 0130649074

Stair, Ralph. (2003) *Principles of Information Systems*, Sixth Edition. Course Technology; 6th Edition, ISBN: 0619064897

Tavani, Herman T. (2003) *Ethics and Technology: Ethical Issues in an Age of Information and Communication Technology*, Wiley; 1st Edition, ISBN: 0471249661

Chapter 8

Gharajedaghi, Jamshid. (1999) *Systems Thinking: Managing Chaos and Complexity: A Platform for Designing Business Architecture.* Butterworth-Heinemann, 0750671637

Richmond, Barry. (2000) *The "Thinking" in Systems Thinking: Seven Essential Skills* Pegasus Communications, 188382348X

Weinberg, Gerald M. (2001) *An Introduction to General Systems Thinking.* Dorset House Publishing Company, Incorporated; 1st Edition 0932633498

Appendix C

Glossary of Terms

Accuracy: Degree of conformity of a measure to a standard value.

Adhesion: The process of fastening two parts by the application of a third material such as glue, epoxy, etc.

Agriculture: The raising of crops and animals for food, feed, fiber, fuel, or other useful products.

Alloy: A substance composed of two or more metals or of a metal and a nonmetal intimately united usually by being fused together and dissolving in each other when molten.

Analog: Of, relating to, or being a mechanism in which data is represented by continuously variable physical quantities.

Annealing: The process of softening metal for improved machinability or cold working by heating it to its critical temperature, holding it there until the temperature is uniform, then cooling it slowly at a controlled rate.

Artifact: A human-made object.

Assembly: Consisting of individual parts fitted together to create a final product

Automation: A machine or system that operates with minimal human control: using automated machines as control for production.

Bernoulli's Law: A change in the velocity of a fluid caused by a constriction produces an opposite change in pressure.

Bioengineering: Engineering applied to biological and medical systems, such as biomechanics, biomaterials, and biosensors. Bioengineering also includes biomedical engineering as in the development of aids or replacements for defective or missing body organs.

Biotechnology: The technology of using, adapting, and altering organisms and biological processes for a desired outcome—one of the nine core technologies.

Bonding: Adhering materials with cement or glue.

Boyle's Law: The volume of a gas at a constant temperature is inversely proportional to its pressure.

Brainstorming: A method of shared problem solving in which all members of a group spontaneously and in an unrestrained discussion generate ideas.

Build: To make something by joining materials or components together into a composite whole.

CAD (computer-aided design or computer-aided drafting): 1. (Design) The use of a computer to assist in the process of designing a part, circuit, building, etc. 2. (Drafting) The use of a computer to assist in the process of creating, storing, retrieving, modifying, plotting, and communicating a technical drawing.

CAM: A mechanical device used to change simple rotary motion into a more complex motion.

Capital: One of the basic resources used in a technological system. Capital (money) is the accumulated finances and goods devoted to the production of other goods.

Center of Gravity: The point at which the entire weight of a body may be considered as concentrated so that if supported at this point the body would remain in equilibrium in any position—same location as center of mass.

Ceramic: A compound of metallic and nonmetallic elements, for which the inter-atomic bonding is predominantly ionic.

Charles' Law: The volume of a gas at a constant pressure is directly proportional to its temperature.

Closed-loop system: A system that uses feedback from the output to control the input.

Cohesion: The process of fusing two like materials for the purpose of fastening. Examples include friction welding, spot welding, electron beam welding and laser welding).

Cold forming: The process of working metal into shape below the temperature of recrystallization. Cold forming improves the strength; machinability, dimensional stability, and surface finish of metals.

Combining: The joining of two or more materials by such processes as fastening, coating, and making composites.

Communication: The successful transmission of information through a common system of symbols, signs, behavior, speech, writing, or signals.

Communication system: A system that forms a link between a sender and a receiver making possible the exchange of information.

Component: A part or element of a whole that can be separated from or attached to a system.

Composite: A multiphase material formed from a combination of materials that differ in composition or form, remain bonded together, and retain their identities and properties.

Compound: A substance of two or more elements in fixed proportions. Compounds can be decomposed into their constituent elements.

Compression: The effect of a force, which tends to shorten an object in the direction of the force. Such a force is called a compressive force, and the object it acts on is said to be in compression. For example, the towers of a suspension bridge are in compression.

Computer aided drafting (CAD): The use of a computer to create drawings.

Computer Numeric Control (CNC): A combination of a computer, a digital control system and a machine tool that enables the machine to accept standard codes and automatically make parts.

Concurrent: Occurring at the same time; running parallel; acting in conjunction.

Conditioning processes: Processes (using force, heat, cold, electricity, etc.) in which the internal structure of a material is changed to alter its properties to make it stronger or improve its function or appearance.

Conduction: (Thermal definition) The transfer of heat energy by physical contact.

Conservation: The preservation and protection of the environment and the wise use of natural resources.

Constraint: A limit to the design process. Constraints may be such things as appearance, funding, space, materials, and human capabilities.

Construction: The systematic act or process of building, erecting, or constructing buildings, roads, or other structures.

Control: An arrangement of chemical, electronic, electrical, and mechanical components that commands or directs the management of a system.

Control system: An assemblage of control apparatus coordinated to execute a planned set of actions.

Convection: The transfer of heat energy by moving a heated substance from one place to another.

Core technologies: The building blocks of technology systems including mechanical, structural, electrical, electron, fluid, thermal, optical, material, and bio technologies.

Creative thinking: The ability or power used to produce original thoughts and ideas based upon reasoning and judgment.

Criterion: A desired specification (element or feature) of a product or system.

Critical thinking: The ability to acquire information, analyze and evaluate it, and reach a conclusion or answer by using logic and reasoning skills.

Culture: The beliefs, traditions, habits, and values controlling the behavior of the majority of the people in a social-ethnic group. These include the people's way of dealing with their problems of survival and existence as a continuing group.

Current: The total amount of electrons flowing through a circuit per unit time; measured in Amperes (one coulomb of electrons passing a single point per second).

Curriculum: The subject matter that teachers and students cover in their studies. It describes and specifies the methods, structure, organization, balance, and presentation of the content.

Curriculum development: The process of planned development of curriculum pedagogy, instruction, and presentation modes.

Custom production: A type of production in which products are designed and built to meet the specific needs and wants of an individual.

Data: Raw facts and figures that can be used to draw a conclusion.

Data processing system: A system of computer hard-ware and software to carry out a specified computational task.

Decision-making: The act of examining several possible behaviors and selecting from them the one most likely to accomplish the individual's or group's intention. Cognitive processes such as reasoning, planning, and judgment are involved.

Decode: To convert a coded message into understandable form using ordinary language.

Density: Mass per unit volume.

Design: An iterative decision-making process that produces plans by which resources are converted into products or systems that meet human needs and wants or solve problems.

Design brief: A written plan that identifies a problem to be solved, its criteria, and its constraints. The design brief is used to encourage thinking of all aspects of a problem before attempting a solution.

Design Constraints: Requirements and limitations under which the design process takes place.

Design principle: Design rules regarding rhythm, balance, proportion, variety, emphasis, and harmony, used to evaluate existing designs and guide the design process.

Design process: A systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to solve a problem or satisfy human needs and wants and to winnow (narrow) down the possible solutions to one final choice.

Design proposal: A written plan of action for a solution to a proposed problem.

Desktop Publishing: Creating and publishing a document using a PC and output device such as a laser printer.

Destructive Testing: Material or product testing in which information is learned about the material/product via careful measurements and recordings as the material/product is destroyed.

Develop: To change the form of something through a succession of states or stages, each of which is preparatory to the next. The successive changes are undertaken to improve the quality of or refine the resulting object or software.

Diagnose: To determine, by analysis, the cause of a problem or the nature of something.

Digital: An information system whose signals have only two states, 1 (closed) or 0 (open).

Dimension: Numerical value used on a drawing to describe size, shape, or geometric characteristic.

Discipline: A formal branch of knowledge or teaching (e.g., biology, geography, and engineering) that is systematically investigated, documented, and taught.

Drawing: A work produced by representing an object or outlining a figure, plan, or sketch by means of lines. A drawing is used to communicate ideas and provide direction for the production of a design.

Drilling: To bore or drive a hole in. A machining process that produces a hole.

Ductility: The amount of plastic strain that a material can withstand before fracture. Ductile materials generally have a yield point in the stress-strain curve.

Dynamics: The behavior of matter when in motion; (physics) the study of why objects move.

Economy: The system or range of economic activity, such as production, distribution, and consumption in a country, region, or community that manages domestic affairs and resources.

Educational technology: Using multimedia technologies or audiovisual aids as a tool to enhance the teaching and learning process.

Efficient: Operating or performing in an effective and competent manner with a minimum of wasted time, energy, or waste products.

Electrical: Of, relating to, or operated by electricity.

Electrical technology: The technology of producing, storing, controlling, transmitting and getting work from electrical energy—one of the nine core technologies.

Electromagnet: A core of magnetic material surrounded by a coil of wire through which an electric current is passed to magnetize the core

Electronic technology: The technology of using small amounts of electricity for controlling: detecting; and information collecting, storage, retrieving, processing, and communicating—one of the nine core technologies.

Encode: To change a message into symbols or a form that can be transmitted by a communication system.

Energy: The ability to do work. Energy is one of the basic resources used by a technological system.

Engineer: A person who is trained in and uses technological and scientific knowledge to solve practical problems.

Engineering: The profession of or work performed by an engineer. Engineering involves the knowledge of the mathematical and natural sciences (biological and physical) gained by study, experience, and practice that are applied with judgment and creativity to develop ways to utilize the materials and forces of nature for the benefit of mankind.

Engineering design: The systematic and creative application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.

English system: (U.S. Customary System) A measurement system in which the foot is the fundamental unit for length and pound is the fundamental unit for weight.

Ergonomics: The study of workplace equipment design or how to arrange and design devices, machines, or workspace so that people and things interact safely and most efficiently. Also called human factors analysis or human factors engineering.

Equilibrium: A state of balance due to the equal action of opposing forces in a structure.

Ethical: Conforming to an established set of principles or accepted professional standards of conduct.

Ethics: a. A set of moral principles or values b. a theory or system of moral values (the present-day materialistic ethic) c. plural but singular or plural in construction: the principles of conduct governing an individual or a group (professional ethics) d. a guiding philosophy.

Experimentation: 1. The act of conducting a controlled test or investigation. 2. The act of trying out a new procedure, idea, or activity.

Fact: A statement or piece of information that is true or a real occurrence.

Fastening: The joining of two or more parts or materials through the application of mechanical devices, adhesive materials or a cohesive process.

Fatigue: The failure or decay of mechanical properties after repeated applications of stress. Fatigue tests give information on the ability of a material to resist the development of cracks (which eventually bring about failure) as a result of a large number of cycles.

Feedback: Using all or a portion of the information from the output of a system to regulate or control the processes or inputs in order to modify the output.

Ferrous: Related to iron (derived from the Latin ferrum); iron base alloys.

Figure: A written symbol, other than a letter, representing an item or relationship, especially a number, design, or graphic representation.

Finishing: The final processes applied during the production of a part (examples include coating, de-burring, blast finishing, coloring, cleaning, etc.).

Fluid: The medium used to transfer power can be a liquid or a gas.

Fluid technology: The technology of using fluid, either gaseous (pneumatics) or liquid (hydraulics) to apply force or to transport materials—one of the nine core technologies.

Force: A push or pull exerted by one object on another.

Forecast: A statement about future trends, usually as a probability, made by examining and analyzing available information. A forecast is also a prediction about how something will develop usually as a result of study and analysis of available pertinent data.

Forging: The working of a piece of metal into a predetermined shape by applying pressure or impact blows. Forging increases the strength of a part by compressing and aligning the surface to the shape of the die.

Forming: The process that changes the shape and size of a material without cutting it.

Friction: A force that opposes the motion or intended motion of a body in contact with another body.

Gear: A wheel with teeth that will allow the transfer of power when coupled to another gear.

Generator: A device that converts mechanical energy to electrical energy.

Graph: A diagram (as a series of one or more points, lines, line segments, curves, or areas) that represents the variation of a variable in comparison with that of one or more other variables.

Graphics: A graphic representation (as a picture, map, or graph) used especially for illustration.

Guidance system: A system that provides information for guiding the path of a vehicle by means of built-in equipment and control.

Hardening: The process by which a piece of metal is hardened by heating it to or above the critical temperature, then cooling it rapidly, usually by quenching in an oil or water solution.

Hardness: The measure of a material's resistance to deformation by surface indentation or by abrasion.

Heat Engine: Device that converts the energy of heat into mechanical energy.

Human wants and needs: Human wants refers to something desired or dreamed of and human needs refers to something that is required or a necessity.

Hydraulic fluid: A liquid that is used in hydraulic systems to transfer energy; usually an oil-based substance.

Impact: The effect or influence of one thing on another. Some impacts are anticipated, and others are unanticipated.

Inclined plane: A flat sloping surface along which an object can be pushed or pulled; a plane surface that makes an oblique angle with the plane of the horizon—one of six simple machines.

Industrial Revolution: A period of inventive activity, beginning around 1750 in Great Britain. During this period, industrial and technological changes resulted in mechanized machinery that replaced much of which was previously manual work. The Industrial Revolution was responsible for many social changes, as well as changes in the way things were manufactured.

Information: One of the basic resources used by technological systems. Information is data and facts that have been organized and communicated in a coherent and meaningful manner.

Information Age: A period of activity starting in the 1950s and continuing today in which the gathering, manipulation, classification, storage, and retrieval of information is central to the workings of society. Information is presented in various forms to a large population of the world through the use of machines, such as computers, facsimile machines, copiers, and CD-ROMs. The Information Age was enhanced by the development of the Internet; an electronic means to exchange information in short periods of time, often instantaneously.

Information system: A system of elements that receive and transfer information. This system may use different types of carriers, such as satellites, fiber optics, cables, and telephone lines, in which switching and storage devices are often important parts.

Infrastructure: 1. The basic framework or features of a system or organization. 2. The basic physical systems of a country's or a community's population, including transportation and utilities.

Innovation: An improvement of an existing technological product, system, or method of doing something.

Input: Something put into a system, such as resources, in order to achieve a result.

Instructional technology: The use of computers, multimedia, and other technological tools to enhance the teaching and learning process. Sometimes referred to as educational technology.

Integration: The process of bringing all parts together into a whole.

Internet: The worldwide network of computer links, begun in the 1970s, which today allows computer users to connect with other computer users in nearly every country, and speaking many languages.

Invention: A new product, system, or process that has never existed before, created by study and experimentation.

Iron Age: The period of human culture characterized by the smelting of iron and its use in industry beginning after the Bronze Age somewhat before 1000 BC in western Asia and Egypt.

Irrigation system: A system that uses ditches, pipes, or streams to distribute water artificially.

Iterative: Describing a procedure or process that repeatedly executes a series of operations until some condition is satisfied. An iterative procedure may be implemented by a loop in a routine.

Kinetic energy: The energy possessed by a body as a result of its motion.

Laboratory-classroom: The formal environment in school where the study of technology takes place. At the elementary school, this environment will likely be a regular classroom. At the middle and high school levels, a separate laboratory with areas for hands-on activities, as well as group instruction, could constitute the environment.

LASER: Light Amplification by the Stimulated Emission of Radiation. A device that produces a concentrated beam of light.

Lever: A rigid piece that transmits and modifies force or motion when forces are applied at two points and it turns about a third; specifically: a rigid bar used to exert a pressure or sustain a weight at one point of its length by the application of a force at a second and turning at a third on a fulcrum.

Literacy: Basic knowledge and abilities required to function adequately in one's immediate environment.

Machine: A device with fixed and moving parts that modifies mechanical energy in order to do work.

Magnetism: A force that exists around magnets that attracts ferrous materials and is used in motors and generators.

Maintenance: The work needed to keep something in proper condition; upkeep.

Management: The act of controlling production processes and ensuring that they operate efficiently and effectively; also used to direct the design, development, production, and marketing of a product or system.

Malleability: Capable of being altered or controlled by outside forces or influences.

Manufacturing: The process of making a raw material into a finished product; especially in large quantities.

Manufacturing system: A system or group of systems used in the manufacturing process to make products for an end user.

Marketing: The act or process of offering goods or services for sale.

Mass production: The manufacture of goods in large quantities by means of machines, standardized design and parts, and, often, assembly lines.

Material: The tangible substance (chemical, biological, or mixed) that goes into the makeup of a physical object. One of the basic resources used in a technological system.

Materials technology: The technology of producing, altering, and combining materials—one of the nine core technologies.

Mathematics: The science of patterns and order and the study of measurement, properties, and the relationships of quantities; using numbers and symbols.

Mechanical: A form of energy, which uses motion to do work.

Mechanical fastener: A mechanical device such as a nail, screw, bolt, etc., that is used to fasten two parts together.

Mechanical technology: The technology of putting together mechanical parts to produce, control, and transmit motion—one of the nine core technologies.

Medical technology: Of or relating to the study of medicine through the use of and advances of technology, such as medical instruments and apparatus, imaging systems in medicine, and mammography. Related terms: biomedical engineering and medical innovations.

Message: 1. The information sent by one source to another, usually short and transmitted by words, signals, or other means. 2. An arbitrary amount of information whose beginning and end are defined or implied.

Metal: An opaque lustrous elemental chemical substance that is a good conductor of heat and electricity and, when polished, a good reflector of light; most elemental metals are malleable, ductile, and are generally denser than the other elemental substances; metals are structurally distinguished from nonmetals by their atomic bonding and electron availability; the electron band structure of metals is characterized by a partially filled valence band; the "free electrons" lost from the outer shells of metallic atoms are available to carry an electric current; the defining property of a metal is that it is an element with a positive thermal coefficient of resistively, meaning the electrical resistively of a metal continuously increases as temperature increases.

Metric system: A measuring system in which the meter is the fundamental unit of length and gram is the fundamental unit of weight.

Micro-processing system: A computer made up of integrated circuits that are capable of high-speed electronic operations.

Microprocessor: A complex digital chip that performs the computer functions of arithmetic, logic, and supervision.

Middle Ages: The period in European history between antiquity and the Renaissance, often dated from AD 476 to 1453.

Milling: A process of cutting or material removal, which combines a rotating cutter and a traversing worktable allowing for processes such as slotting, facing and pocketing.

Mock-up: A full-sized structural model built accurately to scale chiefly for study, testing, or display.

Model: A visual, mathematical, or three-dimensional representation in detail of an object or design, often smaller than the original. A model is often used to test ideas, make changes to a design, and to learn more about what would happen to a similar, real object.

Moment: The tendency to rotate about a point determined by the product of a force multiplied by the distance from this force to this point.

Motor: A device used to convert electrical energy to mechanical energy.

Multimedia: Information that is mixed and transmitted from a number of formats (e.g., video, audio, and data).

Natural material: Material found in nature, such as wood, stone, gases, and clay.

Network: An interconnected group or system. The Internet is a network of computers.

Nonrenewable: An object, thing, or resource that cannot be replaced.

Nuclear energy: Nuclear energy is the energy associated with nuclear bonding of the nucleus of an atom. (Nuclear energy is the energy, E, represented in the famous equation $E=mc^2$. The mass in this equation is not the mass of the nucleus. The mass of an atom's nucleus is actually less than the sum of the mass of the individual protons and neutrons within the nucleus. The difference between these masses is known as the "mass defect," and is the "m" in the $E=mc^2$. In addition, "c" is the speed of light.)

Nuclear power: Power, the source of which is nuclear fission or fusion.

Ohm's Law: The relationship of voltage, current, and resistance in a circuit $I=V/R$, $V=IR$, $R=V/I$

Open-loop system: A control system that has no means for comparing the output with input for control purposes. Control of open-loop systems often requires human intervention.

Optical: Of or relating to the science of optics or vision.

Optical technology: The technology of producing light, controlling light, using light for information collection, processing, storage, retrieval, and communication and using light to do work.

Optimization: An act, process, or methodology used to make a design or system as effective or functional as possible within the given criteria and constraints.

Output: The results of the operation of any system.

People: One of the basic resources in a technological system. Humans design, develop, produce, use, manage, and assess products and systems.

Plan: A set of steps, procedures, or programs, worked out beforehand in order to accomplish an objective or goal.

Plastics: Any of numerous organic synthetic or processed materials that are mostly thermoplastic or thermosetting polymers of high molecular weight and that can be made into objects.

Political: Of or relating to the structure and affairs of a government, state, or locality and their related politics.

Pollution: The changing of a natural environment, either by natural or artificial means, so that the environment becomes harmful or unfit for living things; especially applicable to the contamination of soil, water, or the atmosphere by the discharge of harmful substances.

Portfolio: A systematic and organized collection of a student's work that includes results of research, successful and less successful ideas, notes on procedures, and data collected.

Potential energy: The energy of a particle, body, or system that is determined by its position or structure.

Power: Force over time. Measured in feet, pounds, Newtons, meters, or watts.

Power system: A technological system that transforms energy resources to power.

Pressure: The force generated when energy is applied to a fluid; force per unit area.

Problem solving: The process of understanding a problem, devising a plan, carrying out the plan, and evaluating the plan in order to solve a problem or meet a need or want.

Process: The action of going through several steps to reach a desired goal.

Produce: To create, develop, manufacture, or construct a human-made product.

Product: A tangible artifact produced by means of either human or mechanical work, or by biological or chemical processes.

Production system: A technological system that involves producing products and systems by manufacturing (on the assembly line) and construction (on the job).

Propulsion system: A system that provides the energy source, conversion, and transmission of power to move a vehicle.

Prototype: A full-scale working model used to test a design concept by making actual observations and necessary adjustments.

Pump: A device that converts mechanical energy to fluid energy.

Qualitative: Of, relating to, or involving the measurement of quality or kind without extensive mathematical analysis

Quality assurance: The use of quality control techniques associated with a process.

Quality control: A system by which a desired standard of quality in a product or process is maintained. Quality control usually requires feeding back information about measured defects to further improvements of the process.

Quantitative: Relating to, or expressible in terms of quantity, typically displayed in a line graph.

R-Value: A numeric expression of thermal insulation. R-values are the reciprocals of U-values.

Radiation: (Thermal definition) Transfer of heat by temporarily transforming the heat (kinetic motion of an objects atoms or molecules) into electromagnetic waves (in the infrared part of the EM spectrum). These waves then travel until absorbed by another object and transferred back into atomic/molecular kinetic energy, which is heat.

Receiver: The part of a communication system that picks up or accepts a signal or message from a channel and converts it to perceptible forms.

Recycle: To reclaim or reuse old materials in order to make new products.

Reliability: The probability of satisfactory operation of the product in a given environment over a specified time interval.

Renaissance: The transitional movement in Europe between medieval and modern times beginning in the 14th century in Italy, lasting into the 17th century, and marked by a humanistic revival of classical influence expressed in a flowering of the arts and literature and by the beginnings of modern science.

Renewable: Designation of a commodity or resource, such as solar energy or firewood, that is inexhaustible or capable of being replaced by natural ecological cycles or sound management practices.

Requirements: The parameters placed on the development of a product or system. The requirements include the safety needs, the physical laws that will limit the development of an idea, the available resources, the cultural norms, and the use of criteria and constraints.

Research: Careful or diligent search; studious inquiry or examination; especially: investigation or experimentation aimed at the discovery and interpretation of facts,

revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws; the collecting of information about a particular subject.

Research and development (R&D): The practical application of scientific and engineering knowledge for discovering new knowledge about products, processes, and services, and then applying that knowledge to create new and improved products, processes, and services that fill market needs.

Resistance: The ratio of the potential difference across an electrical component to the current passing through it. It is thus a measure of the component's opposition to the flow of electric charge. In general, the resistance of a metallic conductor increases with temperature whereas the resistance of a semiconductor decreases with temperature.

Resource: The things needed to get a job done. In a technological system, the basic technological resources are: energy, capital, information, machines and tools, materials, people, and time.

Risk: The chance or probability of loss, harm, failure, or danger.

Robotics: The specialized field of engineering and computer science that deals with the design and application of robots.

Sanitation: The design and practice of methods for solving basic public health problems, such as drainage, water and sewage treatment, and waste removal.

Scale: A proportion between two sets of dimensions used in developing accurate, larger or smaller prototypes or models of design ideas.

Schematic: A drawing or diagram of a chemical, electrical, or mechanical system.

Science: The study of the natural world through observation, identification, description, experimental investigation, and theoretical explanations.

Scientific inquiry: The use of questioning and close examination using the methodology of science.

Sender: A person or equipment that causes a message to be transmitted.

Semiconductor: Materials whose electrical conductivity can be precisely altered by appropriate manufacturing processes.

Separating: The process of using machines or tools to divide materials.

Service: 1. The installation, maintenance, or repairs provided or completed by a dealer, manufacturer, owner, or contractor. 2. The performance of labor for the benefit of another.

Shear: Force that acts parallel to the surface of the material

Simple Machine: Any of various elementary mechanisms formerly considered as the elements of which all machines are composed and including the lever, the wheel and axle, the pulley, the inclined plane, the wedge, and the screw.

Sketch: A rough drawing representing the main features of an object or scene and often made as a preliminary study.

Skill: An ability that has been acquired by training or experience.

Society: A community, nation, or broad grouping of people having common traditions, institutions, and collective activities and interests.

Solution: A method or process for solving a problem.

Spring: A mechanical device that stores energy by expansion or contraction due to pressure, force or stress applied, that will release energy and return to shape when the force or stress is removed.

Stone Age: The first known period of prehistoric human culture characterized by the use of stone tools.

Strain: The elongation of a material under stress divided by the material's length prior to stress; symbol: "epsilon."

Stress: A material's internal resistance to force; symbol: "sigma;" calculated by dividing the force in the material by the area of the material that is subjected to the force.

Structural system: A system comprised of the framework or basic structure of a vehicle.

Structure: Something that has been constructed or built of many parts and held or put together in a particular way.

Structural technology: The technology of putting parts and materials together to create supports, containers, shelters, connectors, and functional shapes—one of the nine core technologies.

Subsystem: A division of a system that, in itself, has the characteristics of a system.

Symbol: An arbitrary or conventional sign that is used to represent operations, quantities, elements, relations, or qualities or to provide directions or alert one to safety.

Synthetic material: Material that is not found in nature, such as glass, concrete, and plastics.

System: A group of interacting, interrelated, or interdependent elements or parts that function together as a whole to accomplish a goal.

Systems-oriented thinking: A technique for looking at a problem in its entirety, looking at the whole, as distinct from each of its parts or components. Systems-oriented thinking takes into account all of the variables and relates social and technological characteristics.

Technical writing: Treating a document with the goal of providing clear and concise information, rather than entertainment or story telling; a technical document/report incorporates diagrams and multi-media information to provide technical information.

Technological literacy: The ability to use, manage, understand, and assess technology.

Technology: 1. Human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. 2. The innovation, change, or modification of the natural environment to satisfy perceived human needs and wants.

Technology education: A study of technology that provides an opportunity for students to learn about the processes and knowledge related to technology that are needed to solve problems and extend human capabilities.

Technological transfer: The process by which products, systems, knowledge, or skills, developed under federal research and development funding, is translated into commercial products to fulfill public and private needs.

Thermal technology: The technology of producing, sorting, controlling, transmitting and getting work from heat energy.

Thermodynamics: The study of thermal energy as it moves from one substance to another.

Thermoplastic: A material capable of being repeatedly softened by increases in temperature and hardened by decreases in temperature.

Tolerance: The difference between the maximum and minimum dimensions allowed within the design of a product.

Tool: A device that is used by humans to complete a task.

Torque: A turning or twisting force that produces or tends to produce rotation or torsion

Torsion: The twisting or wrenching of a body by the exertion of forces tending to turn one end or part about a longitudinal axis while the other is held fast or turned in the opposite direction.

Toughness: The energy required to break a material, which is equal to the area under the stress-strain curve. The toughest materials are those with very great elongations to break accompanied by high tensile strengths. Such materials nearly always have yield points.

Trade-off: An exchange of one thing in return for another; especially relinquishment of one benefit or advantage for another regarded as more desirable.

Transmit: To send or convey a coded or non-coded message from a source to a destination.

Transportation system: The process by which passengers or goods are moved or delivered from one place to another.

Trend: 1. A tendency; 2. A general direction.

Trend analysis: A comparative study of the component parts of a product or system and the tendency of a product or system to develop in a general direction over time.

Trial and error: A method of solving problems in which many solutions are tried until errors are reduced or minimized.

Troubleshoot: To locate and find the cause of problems related to technological products or systems.

Voltage: The electromotive force in a circuit.

Volume: The amount of space occupied by a three-dimensional object as measured in cubic units.

Watt's Law: The mathematical relationship expressing that power is the product of voltage and current.

Welding: The process of joining metal together by heating to the fusion point.

Weight: The gravitational pull (force) on an object.

Wheel and Axle: 1. A simple machine in which a larger diameter wheel requires less force to turn than a smaller diameter axle (e.g. valve handles, steering wheel); 2. A simple machine that turns rotary motion into linear motion whereby increasing the diameter of the wheel, the linear distance traveled for one revolution of the axle can be increased; 3. a rotating lever

Work: The transfer of energy from one physical system to another expressed as the product of a force and the distance through which it moves a body in the direction of that force.

FOUNDATIONS OF TECHNOLOGY
END OF COURSE EXAM

Directions: Circle the T or F in the column to the left of each true (T) or false (F) statement.

T	F	1.	Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.
T	**F**	2.	Genetic materials can be used in manufacturing processes.
T	**F**	3.	Computer-integrated manufacturing systems separate functions that traditionally have been integrated
T	**F**	4.	An artificial leg is an example of biotechnology.
T	F	5.	In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.
T	**F**	6.	In computer-integrated manufacturing (CIM) systems, prototypes can be prepared and tested quickly.
T	**F**	7.	Science usually affects society more directly than technology because it solves practical problems and serves human needs.
T	**F**	8.	A door latch is an example of mechanical technology.
T	**F**	9.	Different kinds of materials respond differently to electric forces.
T	**F**	10.	Developments in mathematics seldom stimulate innovations in science and technology.
T	F	11.	A bridge is an example of structural technology.
T	**F**	12.	Engineers use the language of mathematics to express mathematical ideas precisely.
T	**F**	13.	The value of any given technology will be the same for any group of people and at any point in time.
T	**F**	14.	The two broad categories of communication are resources processing and product manufacturing.
T	F	15.	Some materials are made from combinations of mechanical, thermal, chemical and electrochemical processes
T	**F**	16.	Flashlights are examples of mechanical technology.
T	F	17.	Most industrial materials are made using a mechanical, thermal, chemical, and electrochemical processes.
T	**F**	18.	A hot water heater is an example of biotechnology.
T	**F**	19.	Manufacturing is the process of converting industrial materials into products.
T	**F**	20.	Research and development involves promoting and selling a product.

T	F	21.	The Industrial Revolution happened first in the United States because that country made practical use of science, had access by sea to world resources and markets, and had an excess of farm workers willing to become factory workers.
T	**F**	22.	A swimming pool is an example of structural technology.
T	**F**	23.	The usefulness of a model can be tested by comparing predictions to actual observations.
T	F	24.	A telescope is an example of optical technology.
T	**F**	25.	Laser surgical instruments make use of fluid technology.

Place the letter of the correct answer in the box at left of statement.

	26.	New technologies _____ processes. A. create new B. replicate old C. bypass all D. ignore new
.	27.	The process of planning, organizing, and controlling work is _____. A. Management B. Optimization C. Technology D. Innovation
	28.	Technology _____occurs when a new user applies an existing innovation developed for one purpose to a different function. A. assessment B. evolution C. advancement D. transfer
	29.	Technological _____ often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. A. trade-offs B. innovation C. traps D. constraints

	30.	Technological ideas are sometimes protected through the process of _____. A. design B. optimization C. patenting D. copywriting
	31.	Technological progress _____ the advancement of science and mathematics. A. inhibits B. prolongs C. restrains D. promotes
	32.	Humans devise technologies to _____ the negative consequences of other technologies. A. increase B. reduce C. communicate D. transform
	33.	Most technological development has been _____, the result of a series of refinements to a basic invention. A. evolutionary B. obsolete C. negative D. instantaneous
	34.	Early in the history of technology, the development of many tools and machines was not based on scientific knowledge but on _____. A. technological know-how B. mathematics C. social science D. philosophy
	35.	The Iron Age was defined by the use of iron and steel as the primary materials for _____. A. buildings B. tools C. jewelry D. furniture

	36.	The Middle Ages saw the development of many technological devices that produced _____ effects on society. A. short-term B. minimal C. long-lasting D. negligible
	37.	A time of rebirth of the arts and humanities. A. Stone Age B. Renaissance C. Industrial Revolution D. Dark Ages
	38.	The _____ saw the development of continuous manufacturing. A. Stone Age B. Renaissance C. Industrial Revolution D. Dark Ages
	39.	The _____ process is a systematic, iterative approach to problem solving that promotes innovation and yields designs. A. feedback B. design C. assessment D. investigation
	40.	Established design principles are use to _____ existing designs, to collect data, and to guide the design process. A. clarify B. identify C. review D. evaluate
	41.	A specific problem-solving approach that is used to prepare devices and systems for the marketplace. A. Engineering B. Science C. Research and development D. Advertising

	42.	It is important to determine whether a design problem is _____. A. socially acceptable B. worthy of being solved. C. environmentally neutral. D. economically beneficial.
	43.	Identifying criteria and specifying _____ provides a basis for what a design should be and what the limits are. A. feedback B. controls C. inputs D. constraints
	44.	A working model used to refine a design concept. A. Prototype B. Portfolio C. Network D. By-product
	45.	Checking the design solutions against criteria is central to the _____ process. A. forecasting B. evaluation C. risk management D. troubleshooting
	46.	Sometimes items can be produced in single quantity, while others can be made in batches or _____ production. A. dimensional B. laboratory C. volume D. experimental
	47.	In the design process, the final results should be compared to the original goals, _____, and constraints. A. sketches B. models C. processes D. criteria

	48.	Used to access, retrieve, and process data in order to communicate. A. Computers B. Prototypes C. Models D. Portfolios
	49.	Medical technologies include prevention and rehabilitation. A. conservation B. management C. experimentation D. rehabilitation
	50.	Has applications in such areas as agriculture, pharmaceuticals, food and beverages, and medicine. A. Biotechnology B. Recycling C. Geology D. Physics
	51.	Energy cannot be created or destroyed; it can be _____from one form to another. A. synthesized B. optimized C. converted D. communicated
	52.	Its major forms include thermal, radiant, electrical, mechanical, chemical, and nuclear. A. energy B. power C. force D. resistance
	53.	It is impossible to build an engine that does not exhaust thermal energy to the surroundings. A. model B. problem solution C. engine D. process

	54.	Alternate and sustainable energy sources are being developed and tested in order to replace or supplement _____ sources. A. renewable B. environmental C. biological D. non-renewable
	55.	Power systems must have a source of energy, _____, and loads. A. a generator B. a process C. power D. resources
	56.	Information and _____technologies include inputs, processes, and outputs associated with sending and receiving information. A. biotechnologies B. mechanical C. communication D. medical
	57.	Can be transferred from human to human, from human to machine, from machine to human, and from machine to machine. A. Information B. Photochemical processes C. Interconnected components D. Measurements
	58.	Information and communication systems can be used to inform, _____ , entertain, control, manage, and educate. A. maintain B. experiment C. persuade D. build
	59.	Made up of a source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. A. Biotechnology systems B. Transportation systems C. Communication systems D. Medical systems

	60.	There are many ways to communicate information, such as _____ and electronic means. A. nonlinear B. open-loop C. alternative D. graphic
	61.	Symbols, measurement, and _____ are used to communicate technological information. A. forces B. conventions C. supplements D. controls
	62.	Transportation plays a vital role in the operation of _____. A. other technologies B. ecosystems C. subsystems D. prototypes
	63.	The use of different types of transportation as part of an interconnected system that can move people and goods easily. A. Integration B. Partnerships C. Intermodalism D. Triangulation
	64.	Materials have different qualities and can be classified as _____, synthetic, or mixed. A. normal B. biological C. natural D. formed
	65.	Goods that are designed to operate for a short period of time. A. Durable B. Non-Durable C. Synthetic D. Non-Renewable

	66.	May be classified into types, such as customized production, batch production, and continuous production. A. Power and energy systems B. Transportation systems C. Communication systems D. Manufacturing systems
	67.	Involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it. A. Prototyping B. Marketing C. Assessing D. Modeling
	68.	The underlying base or basic framework of a system. A. Criteria B. Infrastructure C. Design D. Climate
	69.	Structures are constructed using a variety of _____ and procedures. A. outputs B. demands C. processes D. cultural priorities
	70.	Laws, codes, and professional standards are examples of _____ that regulate the design and construction process. A. inputs B. outputs C. criteria D. requirements
	71.	Structures require _____, alteration, or renovation periodically to improve them or to alter their intended use. A. regulation B. maintenance C. automated systems D. regeneration

	72.	Some sections of building projects can be prefabricated to _____. A. reduce cost B. reduce inventory C. increase cost D. save materials
	73.	There are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, _____, and good arguments. A. the earth B. technology C. logic D. safety
	74.	The early Egyptian, Greek, Chinese, Hindu, and Arabic cultures are responsible for many _____ and technological inventions. A. resources B. relationships among fields of study C. scientific and mathematical ideas D. transformations
	75.	Modern science is based on traditions of thought that came together in Europe about _____ years ago. A. 50 B. 500 C. 5,000 D. 50,000
	76.	Developments in science or technology often _____ in mathematics by presenting new kinds of problems to be solved. A. create confusion B. inhibit innovations C. stimulate innovations D. restrain innovation
	77.	The process used to minimize the likelihood of unwanted side effects of a new technology. A. Optimization B. Risk analysis C. Specification D. Technology transfer

	78.	Complex systems have layers of _____. A. constraints B. controls C. criteria D. collaboration
	79.	To reduce the chance of system failure, _____ is often conducted using small-scale models, computer simulations, analogous systems, or just the parts of the system thought to be least reliable. A. a time-and-motion study B. an impact study C. a design process D. performance testing
	80.	The disordered motions of its atoms or molecules in a material. A. Heat energy B. Solar energy C. Electrical energy D. Geothermal energy
	81.	Transformations of _____ usually produce some energy in the form of heat, which spreads around by radiation or conduction into cooler places. A. light B. temperature C. energy D. power
	82.	Written records and photographic and _____devices enable human beings to share great amounts of information and misinformation A. hydraulic B. pneumatic C. electronic D. medical
	83.	Manufacturing processes have been _____ by increases in the forces that can be applied and the temperatures that can be reached. A. hampered B. enhanced C. changed D. complicated

	84.	The availability of electronic controls that make operations occur more rapidly and consistently improves the _____. A. manufacturing processes B. design process C. evaluation process D. engineering process
	85.	Increased knowledge of the molecular structure helps in the design and synthesis of new _____ for special purposes. A. processes and procedures B. tools and machines C. solutions D. materials
	86.	At present, all fuels have advantages and disadvantages so that society must consider the _____ among them. A. constraints B. trade-offs C. criteria D. similarities
	87.	As technologies that provide privacy in communication improve, so do those for _____ privacy. A. invading B. securing C. minimizing D. increasing
	88.	Exploring the logical consequences of a set of instructions and a set of data. A. Assessing B. Designing C. Computer modeling D. Controlling
	89.	The _____ increased the productivity of each worker but it also increased child labor and unhealthy working conditions, and it gradually destroyed the craft tradition. A. Scientific Revolution B. Industrial Revolution C. Renaissance D. Age of Reason
	90.	Understanding how things work and designing solutions to problems of almost any kind can be facilitated by _____. A. brainstorming B. data processing C. automation D. systems analysis

	91.	The successful operation of a designed system usually involves feedback. A. innovation B. decoding C. feedback D. support systems
	92.	Computers have greatly improved the power and use of _____ by performing computations that are very long, very complicated, or repetitive. A. machine tools B. mathematical models C. transportation systems D. data collection
	93.	Engineers create and use representations to organize, record, and communicate mathematical ideas. A. the scientific method B. representations C. feedback D. specifications

Match the terms in Column II with the statements in Column I.

		Column I	**Column II**	
	94.	Unorganized facts	A	Data
	95.	Organized data	B	Communication
	96.	Information applied to a task	C	Decoder
	97.	The sending and receiving of information	D	Encoder
	98.	A device that changes a message into a form that can be transmitted	F	Information
	99.	A device that sends a signal (encoded message)	G	Knowledge
	100.	A device that acquires a signal (encoded message)	H	Receiver
	101.	A device that changes a coded message into an understandable form.	I	Storage
			J	Transmitter

Match the terms in Column II with the statements in Column I.

	102.	A mindset for understanding how things work	A	Automation
	103.	Involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development	B	Complex systems
	104.	Useful in enhancing or optimizing designs	C	Management
	105.	The processes used to make a design or system as effective as possible	D	Optimization
	106.	A planned process designed to ensure that a product, service, or system meets established criteria	F	Quality control
	107.	Have many layers of controls and feedback loops to provide information about a system	G	Requirements
	108.	Human innovation in action	H	Simulation and mathematical modeling
	109.	A decision process recognizing the need for careful compromises among competing factors	I	Systems thinking
	110.	The process of planning, organizing, and controlling work	J	Technology is
			K	Trade-off

Match the terms in Column II with the statements in Column I.

	111.	The technology of putting together mechanical parts to produce, control, and transmit motion	A	Biotechnology
	112.	The technology of producing, storing, controlling, transmitting and getting work from electrical energy	B	Electrical Technology
	113.	The technology of using small amounts of electricity for controlling; detecting; and information collecting, storing, retrieving, processing and communicating	C	Electronic Technology
	114.	The technology of putting parts and materials together to create supports, containers, shelters, connectors, and functional shapes	D	Fluid Technology
	115.	The technology of using fluid, either gaseous (pneumatics) or liquid (hydraulic) to apply force of transport	E	Materials Technology
	116.	The technology of producing light; using light for information collecting, storing, retrieving, processing and communicating; and using light to do work	F	Mechanical Technology
	117.	The technology of producing, storing, controlling, transmitting and getting work from heat energy	G	Optical Technology

	118.	The technology of using, adapting, and altering organisms and biological processes for a desired outcome.	H	Structural Technology
	119.	The technology of producing, altering, and combining materials.	I	Thermal Technology