Technological Systems

A Standards-Based Middle School Model Course Guide

MS-3

Engineering byDesign™

Advancing Technological Literacy

A Standards-Based Program Series

Engineering byDesign™

ITEA

INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION
CENTER TO ADVANCE THE TEACHING OF TECHNOLOGY AND SCIENCE
CATTS

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Preface

Engineering byDesign™ – 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 byDesign™ Program, of which the *Technological Systems* guide is one component. The program is described in detail later in the Introduction 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 *Standards for Technological Literacy (STL)*. 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 among 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 middle 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) and its addenda, *Realizing Excellence: Structuring Technology Programs; Developing Professionals: Preparing Technology Teachers; Planning Learning: Developing Technology Curricula; and Measuring Progress: A Guide to Assessing Students for Technological Literacy*. 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 its Technology for All Americans Project (TfAAP) originally 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 byDesign™: 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*
- *Technological Issues: A Standards-Based High School Model Course Guide*
- *Impacts of Technology: A Standards-Based High School Model Course Guide*
- *Engineering Design: A Standards-Based High School Model Course Guide*

Engineering byDesign™: Standards-Based Technological Study Units
Elementary School Resources
- Kids Inventing Technology Series (KITS)

Elementary/Middle School Resources (Grades 5-6)
- Invention, Innovation, and Inquiry (I^3) Units
    - 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 Units
    - Manufacturing Technologies
    - Energy and Power Technologies
    - Construction Technologies
    - Transportation Technologies
    - Information and Communication Technologies
    - Medical Technologies
    - Agriculture and Related Technologies
    - Entertainment and Recreation 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.

The 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 byDesign™ 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 designed for all students, and not based on preparing students with technical skills, they are preparing students for the global workplace by ensuring that they are technologically literate. For more information, please visit www.engineeringbydesign.org.

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 & Media, Business & Finance, Entrepreneurship, Theatre, Science & 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 high school course, Technological Issues, is 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 middle 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 as a model for creating standards-based curriculum.

The **Introduction** section addresses the Engineering byDesign™ 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 *Technological Systems*, course information, and goals and objectives. The use of 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 1-6 provide the units of instruction in detail for use by the classroom teacher. Each unit presents standards-based content for students in the Technological Systems 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 **Appendices** contain 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 byDesign™: Model Program

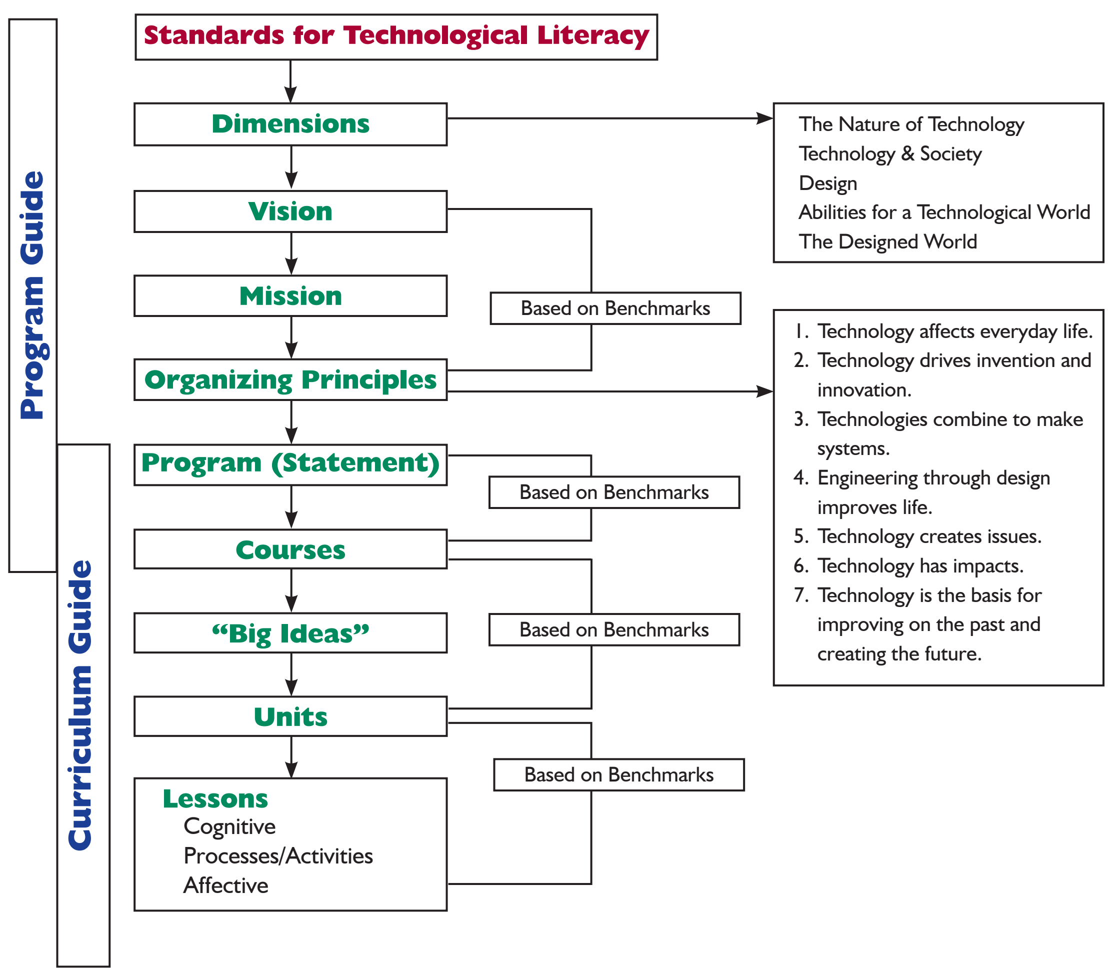
Introduction

Engineering byDesign™ 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 byDesign™
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* and *AETL*, *Realizing Excellence: Structuring Technology Programs* (2005c).**



The Vision – Engineering byDesign™

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 byDesign™

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 byDesign™ 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 byDesign™: 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	18 weeks
7th Grade	Invention and Innovation	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 byDesign™: 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	18 weeks
7th Grade	Invention and Innovation	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: *Technological Systems*	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 on 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: *Technological Systems*	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	18 weeks
Connections to: *Technological Systems*	*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. Students learn how technology, innovation, design, and engineering interrelate and are interdependent.

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	18 weeks recommended
Connections to: *Technological Systems*	*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	**Foundations of Technology**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 10-12
Course Overview	*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 Length	36 weeks recommended
Connections to: *Technological Systems*	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* course 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 *Technological Issues, Impacts of Technology*, and *Engineering Design*.

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. Students learn that, by studying technological issues, there may not be a solution that everyone agrees upon, nor may everyone benefit or receive the cost in the same way. The study of technological issues will not give students the correct answers, but will allow them to develop skills in asking critical questions and understanding alternative viewpoints and their origins, and will give them the confidence to be involved in deciding which technologies to develop, which to use, and how to use them. *Technological Issues* allows students to investigate critical historical and emerging issues affecting the creation, development, use, and control of technology. They will use case studies, simulations, research, design, problem solving, and group discussions and presentations to address complex issues and propose alternative solutions to technological developments. Local, regional, and global governmental, social, and economic policies concerning technology are also studied. The course will focus on the development of knowledge and skills regarding the following aspects of technological issues: 1) recognition, 2) sources, 3) examining, 4) addressing, and 5) predicting.
Course Length	36 weeks recommended
Connections to *Technological Systems*	*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 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.

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. This 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: *Technological Systems*	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 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.

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: *Technological Systems*	*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 byDesign™ Program***, *Engineering Design* provides students with the knowledge and skills to delve deeper into engineering at the post-secondary level.

Overview:
Technological Systems

Overview: Technological Systems

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 dependent upon each other than ever before. Electronic systems are interacting with natural (i.e. bio) systems as humans increasingly use monitoring devices for medical reasons. Electrical systems are interacting with mechanical and fluid power systems as manufacturing establishments become more automated. This course will give students a general background on the different types of systems, but its major concentration will be on the connections between these systems.

Rationale

Oftentimes we break down complicated technologies into smaller systems in order to make more sense of them. These systems include: mechanical, fluid, electrical, thermal, structural, and natural. Through a general observation of technology textbooks, curriculum guides, resource units, vendor modules, etc. at all educational levels, these microsystems are often taught in isolation and never brought back together into the original macrosystem. It seems as though instructors often get bogged down in the fine details of each microsystem. At the same time, systems containing only one of these elements are becoming harder to come by as systems get larger, more automated, more integrated, and seamlessly standardized (i.e. farm equipment consisting of merely a mechanical system vs. current farm equipment consisting of many systems working together). It is the intent of this course to bring these microsystems together and show the implications and power of integration.

Technology is getting easier and easier on the user level; however, on the systems level it is becoming more and more complex. In order to have students understand the "big picture," it is imperative that they understand how microsystems interact and impact each other as a larger system. This course will concentrate on the interaction of all systems as a whole. Though the microsystems are important, at the middle school level it is more appropriate to get students to understand the "big ideas" inherent with technological literacy. As students become more advanced with their technological, mathematical, and scientific studies in high school, as well as hone in on areas of interest, they can dig deeper into the intricacies of the specific microsystems (i.e. electrical, fluid, mechanical, etc.).

This guide presents content and activities in a cornerstone technology education model course for the middle school. This guide 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.

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 dependent upon each other than ever before. Electronic systems are interacting with natural (i.e. bio) systems as humans increasingly use monitoring devices for medical reasons. Electrical systems are interacting with mechanical and fluid power systems as manufacturing establishments become more automated. This course will give students a general background on the different types of systems but its major concentration will be the connections between these systems.
Course Length	12-18 weeks recommended
Connections to: Engineering byDesign™ Program Sequence	*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.

What is Technology?

"Broadly speaking, technology is how people modify the natural world to suit their own purposes. From the Greek word techne, meaning art or artifice or craft, technology literally means the act of making or crafting, but more generally it refers to the diverse collection of processes and knowledge that people use to extend human abilities and to satisfy human needs and wants." (Excerpt from *Standards for Technological Literacy: Content for the Study of Technology*, ITEA, 2000/2002.)

A Rationale for the Study of Technology

Technology is a fundamental aspect of human activity. The acceleration of technological change is a constant in everyone's life. The power and the promise of technology is based on the need for technological literacy—the ability to use, manage, and understand technology. Technological literacy is considered to be critical to the success of individuals, entire societies, and to the Earth's ecological balance. The promise of the future lies not in technology alone, but in the people's ability to use, manage, and understand it.
(Excerpt from *Technology for All Americans: A Rationale and Structure for the Study of Technology*, ITEA, 1996.)

A Rationale for Studying Technology as a System

As stated in the excerpt above regarding technological literacy, "The power and promise of technology is based on the need for technological literacy—the ability to use, manage, and understand technology." With technology becoming more and more sophisticated in nature (i.e. more parts, smaller parts, less visible operations, more integration, etc.) it is becoming very difficult at times to understand what the goal of the particular technology is. It is this confusion that causes the misunderstanding and misuse of technology. A large part of making sense of technology is the ability to establish a systematic way of thinking about it. In order to do this, we break large, complex technologies into systems. A technological system is defined as a group of parts working together to accomplish a task. "With the growing importance of technology to our society, it is vital that students receive an education that emphasizes technological literacy (*Standards for Technological Literacy*, ITEA, 2000/2002)." With this in mind, it is then vital that students receive an education that exposes them to methods of organizing and learning about Technological Systems.

Based on the definition, a technological system could consist of only two parts. For example, a rope and a pulley make up a mechanical system. Keep adding parts and you could end up with an extremely sophisticated system, such as a crane with thousands of parts working together to safely lift thousands of pounds, hundreds of feet in the air. By understanding some basic concepts about all types of systems (i.e. mechanical, fluid power, electrical, etc.), one can group these parts into larger packets of information, thus cutting down on the "complexity" of making sense of the technology. These basic concepts about all technological systems are what we define as "big ideas."

The Importance of the Big Ideas

Big ideas are extremely powerful in that they are what many refer to as enduring concepts. These "big ideas" stay quite static even though the actual technologies themselves are dynamically changing. Therefore, it is important in the field of technology education to create lessons and activities that will enhance a student's ability to develop these powerful "long-lasting" understandings of the nature of technology.

With the vast nature of technology, it is often easy to include too much content when developing curriculum for young people. The big ideas then become muddled in technical content far too advanced for the age of the intended learner. The "big picture" understanding that we want all students to develop becomes secondary in instruction and assessment. The writers of this text used the "big idea" concept when developing this curriculum guide to stay grounded on what is truly important for students to learn. By using this approach to curriculum development, it is the hope of the writers that this document will aid teachers in teaching young people the transferable skills and knowledge needed to successfully use, manage, and understand technology, now and in the future.

The content and structure of this guide is based on these six big ideas:

- A technological system consists of parts working together to accomplish a task.
- People interact with technological systems (they operate, care for, construct, and design them).
- Technological systems are built upon each other.
- Adjustments made to the inputs of a technological system result in changes to the outputs of the system.
- Failure in one aspect of a technological system can cause failure in a larger part of the system.
- Technological systems are becoming more complex in design, less complicated in use.

Technological Systems – Core Concepts of Technology

The "big ideas" are the driving force of instruction, student activities, and assessment methodologies. Students will, however, still be exposed to and learn about the technical side of technological systems. This technical information provides a context for students to develop the big ideas. Along with the big ideas, the following core concepts of technology will also be covered throughout this curriculum guide as they are combined to create technological systems:

- **Electrical** – systems consisting of a series of components designed to control, monitor, or measure the flow of electricity.
- **Magnetic** – systems relying on magnetic fields to provide control, motion, or force.
- **Mechanical** – systems used to take an input motion or force and create a desired output motion or force.
- **Fluid** – systems consisting of a gas or a liquid used to provide linear, reciprocating, or rotational motion.
- **Structural** – systems that resist forces without changing shape, except for that due to the elasticity of the material.
- **Natural** – systems that occur naturally within the environment (i.e. digestive system).
- **Thermal** – those systems dealing with controlling and measuring temperature.

Curriculum Guide Structure

This curriculum guide is organized into the main areas listed below. A brief explanation is given for each.

Introduction

The Introduction section of this guide explains the Engineering byDesign™ Model Program and describes the courses in the ITEA Professional Series.

Overview

The Overview section gives the rationale for the study of technological systems along with the importance of the learner developing enduring concepts about technology.

Assessment

The Assessment section gives an explanation of different forms of assessment and how they can be used to assess students' knowledge of enduring concepts related to technological systems.

Units of Instruction

Units 1-6 cover each of the six big ideas. Within each Unit is the following:

- ***STL* Standards Addressed** – The standards, which relate to the enduring concepts, are listed here.
- **Student Learning Experiences (Benchmarks) Addressed –** The benchmarks students should attain in relation to the national standards are listed here.
- **Big Idea –** The enduring concept taught in this unit is stated here.
- **Acceptable Evidence of Student Understanding –** The types of evidence that can be used to determine student understanding are described here.
- **Student Assessment Criteria –** The rubric presented here will help teachers to evaluate student understanding at the unit level.
- **Overview –** A brief overview of the purpose of the chapter and the concepts involved is given here.
- **Narrative –** In this section, the enduring concept is explained in a "story" format. This section contains real-life examples of how the big idea pertains to technological systems.
- **Teacher Preparation –** This section explains things that the teacher can do to become more familiar with the content being taught in a particular unit.
- **Enduring Experiences –** This section gives a brief explanation of learning activities that lend themselves to developing students' grasp of the big ideas, related to technological systems.
- **Student Learning Activities –** Contained in each unit are complete activities that can be used to develop students' enduring understandings related to technological systems. These activities are very complete in that they include student objectives, activity explanation, material lists, tool lists, fabricating directions, technical drawings, student worksheets, and assessment rubrics. These activities are ready to be printed and given to the student.

Appendices

- **Appendix A – Program Responsibility Matrix (with listing of *STL* Technology Content Standards)**
- **Appendix B – References**
- **Appendix C – Glossaries**

Technological Systems

Assessment

Assessment

Course Assessment

Assessment is not a new concept in education. In fact, for as long as people have been sharing their knowledge and skills with those who follow, there has been some type of measurement of how well learning has taken place. What has changed, indeed what must change, is the means by which we measure students' levels of understanding, and how we utilize this information.

Traditionally speaking, much of the assessment that takes place in kindergarten through twelfth grade is written, and summative in nature. That is, after a unit of study, a group of students is given some type of written "test," to determine how much they have learned. The results of these tests are primarily used to assign grades, or report to parents, administrators, and other stakeholders how well the students have learned the curriculum. There are several significant flaws in this paradigm. First is the heavy reliance on a single assessment tool. Second is how the assessment results are utilized, with limited timely feedback or an opportunity for student improvement only after the results are known.

Keep in mind that technology education is a balance between what students should know and be able to do. If we want to determine a pilot's ability to safely land an airplane, do we rely solely on a written test? If we want an accurate measure of a medical technician's ability to measure vital health statistics, do we verify this with a written test? Obviously, the answer is no. Why then, do we rely so heavily on written assessments in Grades K-12? There are many tools a teacher can use to assess student understanding. No single one of these is better than the others. In fact, the best strategy is to utilize as wide a variety of assessment tools as possible. The following is a brief comparison of evidence-gathering tools (Sterry, 2002, Unpublished). For an in-depth discussion of these evidence-gathering tools, as well as other issues relating to assessment, see *Measuring Progress: A Guide to Assessing Students for Technological Literacy*. (ITEA, 2004)

Tools	Duration	Domains of Knowledge	Technical Competence	Technological Understanding
Scenarios	Medium	Cognitive	Possibly	Yes
Portfolios/Journals	Long	Mainly Cognitive (synthesis) Some Psychomotor & Affective	Possibly	Yes
Models/Prototypes	Medium-Long	Cognitive (synthesis & evaluation) & Psychomotor	Some	Yes
Realizations/ Products/ Projects	Long	Cognitive & Psychomotor; Some Affective	Yes	Yes
Discussions/ Interviews	Short	Cognitive	Little	Yes
Observations	Short	Cognitive, Psychomotor, Affective	Yes	Yes
Plans and Drawings	Medium	Cognitive & Psychomotor	Yes	Yes
Open-Ended Questioning	Medium	Cognitive	Some	Yes
Concept Mapping	Short	Cognitive	Minimal	Yes
Presentations	Short	Cognitive, Psychomotor, Affective	Yes	Yes
Multiple Choice Tests	Short	Cognitive	Yes	Yes
True/False Tests	Short	Cognitive	Yes	Yes
Team Interaction	Long	Cognitive, Psychomotor, Affective	Yes	Yes

Figure 1. Comparison of Evidence-Gathering Tools

> *Firm evidence shows that formative assessment is an essential component of classroom work and that its development can raise standards of achievement.*
>
> *Black & William, 1998*

Formative Assessment

For assessment to be as useful as possible, it should be formative in nature. Classroom assessment becomes formative assessment when the evidence is actually used to adapt the teaching to meet student needs. (Black & William). Numerous studies have shown that innovations, which include the practice of formative assessment, produce significant and substantial learning gains. Formative assessment has several key traits. First, feedback needs to be enhanced between those being taught and the teacher. For assessment to be truly formative, the results have to be used to adjust teaching and learning methods.

The assessment issue is further complicated by a wealth of research that points out that everyday practice of assessment is fraught with problems. The most significant difficulties relating to assessment revolve around three issues. The first is effective learning. Most tests utilized by teachers encourage rote and superficial learning, even while teachers acknowledge they want to develop understanding. The second issue is negative impact. Giving of marks and grades is overempha-

sized, while meaningful advice and true learning are underemphasized. Finally, is the managerial role. Teacher feedback to students appears to serve social and managerial functions. The collection of scores to determine an overall grade is given a higher priority than the analysis of student works to determine learning needs and subsequent modification of teaching strategies.

There are several suggestions for improvement of the formative assessment process. To start, there needs to be a culture of success, along with a belief that all pupils can achieve. Once this has been established, formative assessment can be a powerful tool if it is communicated properly. The teacher needs to clearly identify what can be improved with submitted works. Care must be taken to avoid comments about ability, competition, or comparison with others. Observations and suggestions made to a student need to be about his or her individual work.

Self-assessment and peer assessment are two other powerful tools in the assessment process. One main problem with both of these methods is that pupils can only assess themselves or their classmates when they have a clear picture of the outcomes that their learning is meant to attain. Unfortunately, many learners do not have such a picture and have grown accustomed to the classroom experience as an arbitrary sequence of activities with no overriding rationale. Students' own assessments become objects of discussion, which further promotes reflection on their own thinking that is essential to good learning.

Planning for Classroom Assessment

To monitor student achievement effectively, classroom teachers should begin each unit of instruction with a clear vision of the specific targets their students are to achieve. Beginning with the instructional targets, teachers need to map out how their students will progress to higher levels of technological literacy. In what order will they master more complex understandings of content knowledge? How will they apply these understandings to reason and solve problems? What skills will they master, and in what sequence? What are the achievement products they will be called on to create? This progress assessment map needs to be made visible, and shared with parents and students in an understandable format. (Assessment Training Institute, 2002.)

Understanding Who the Users Are

Many different stakeholders, for a variety of reasons, rely on assessment results. Basically, these stakeholders can be divided into three categories: classroom level, instructional support level, and policy level. Understanding who the stakeholders are, what questions they need answered, and the information needed to answer these questions is essential when developing a comprehensive assessment plan.

Users	Key Questions to be Answered	Information Needed
Classroom Level		
Student	Am I meeting the teacher's standards? What help do I need to succeed? Are the results worth my investment of energy?	Continuous information about individual student attainment of specific instructional requirements
Teacher	Which students need what help? Who among my students should work together? What grade should appear on the report card? Did my teaching strategies work? How do I become a better teacher?	Continuous information about individual student achievement Continuous assessment of group performance
Parent	Is my child succeeding in school? What does my child need to succeed? Is my child's teacher(s) doing a good job? Is this district doing a good job?	Continuous feedback on the student's mastery of required material Clear understanding of required supplies and expectations of the class(es)
Instructional Support Level		
Principal/ Vice Principal	Is instruction in particular areas producing results? Is this teacher effective? What kinds of professional development will help? How shall we spend building resources to be effective?	Periodic assessment of group achievement
Lead Teacher (mentor, support teacher)	What does this teacher need to be good at the job?	Periodic assessment of group achievement
Counselor/ Psychologist	Who needs special support services such as remedial programs? Which students should be assigned to which teachers to optimize results?	Periodic assessment of individual achievement
Curriculum Director	Is our program of instruction effective?	Periodic assessment of group achievement
Policy Level		
Superintendent	Are programs producing student learning? Is the building principal producing results? Which programs need/deserve more resources?	Periodic assessment of group mastery of district curriculum
School Board	Are students in the district learning? Is the superintendent producing results?	Periodic assessment of group achievement
State Dept. of Education	Are programs across the state producing results?	Periodic assessment of group mastery of state curriculum
Citizen/Legislator	Are students in our schools achieving in ways that will allow them to be effective citizens?	Periodic assessment of group mastery of valued targets

Figure 2. Users and Uses of Assessment Results (Assessment Training Institute, 2002)

End-of-Course Assessment Rubric

Achievement Level / Sub-concept	Above Target 3	At Target 2	Below Target 1
What is a System?	Thoughtfully designs, prototypes, and tests a technological system that effectively accomplishes an outcome and includes input, process, output, and feedback components.	Designs, prototypes, and tests a technological system that accomplishes an outcome and includes input, process, output, and feedback components.	Designs, prototypes, and tests a technological system that includes input, process, output, and feedback components but may not accomplish the system's objectives.
How Systems Work	Correctly, safely, and efficiently operates and maintains effective technological systems that process matter (separate, form, combine, and condition) and data (collect/detect, process, and display).	Operates and maintains effective technological systems that process matter (separate, form, combine, and condition) and data (collect/detect, process, and display).	Operates and maintains with minimal effectiveness, technological systems that process matter (separate, form, combine, and condition) and data (collect/detect, process, and display).
How Systems Evolve	Early systems are creatively compared to modern systems; large systems are effectively built from smaller systems; science and mathematics are thoughtfully applied to the development of new technological systems; and outcomes are insightfully assessed to determine their impacts on individuals, society, and the environment.	Early systems are compared to modern systems; large systems are built from smaller systems; science and mathematics are adequately applied to the development of new technological systems; and outcomes are assessed to determine their impacts on individuals, society, and the environment.	Early systems are compared to modern systems; large systems are built from smaller systems; science and mathematics are minimally applied to the development of new technological systems; and outcomes are not well assessed to determine their impacts on individuals, society, and the environment.
Modifying Systems	Conducts comprehensive assessments of system outputs to determine the system's effectiveness, objectively evaluates the outcomes of the system compared to its objectives, makes thoughtful recommendations for improvements, makes promising modifications to the system based on the feedback, and reassesses the outcomes to determine if the system is actually improved.	Conducts assessments of system outputs to determine effectiveness, evaluates the outcomes of the system compared to its objective, makes recommendations for improvement, modifies the system based on the feedback, and reassesses the outcomes to determine if the system is actually improved.	Conducts limited assessments of system outputs to determine effectiveness, reviews the outcomes of the system compared to its objective, makes modest recommendations for improvement, makes minimal adjustments to the system based on the feedback, and does some reassessment of the outcomes to determine if the system is actually improved.
Correcting Systems Failures	Objectively analyzes the problem based on the system's objectives, systematically inspects and tests the subsystems and component parts, appropriately repairs or replaces faulty parts, and re-tests the system to determine if the failure was corrected.	Analyzes the problem based on the system's objectives, inspects and tests the subsystems and component parts, repairs or replaces faulty parts, and re-tests the system to determine if the failure was corrected.	Searches for the problem, inspects the subsystems and component parts, repairs or replaces faulty parts until the problem appears to go away.
Systems in the Future	Gathers data and thoughtfully determines human needs and desires into the short- and long-term future, proposes promising systems to address those needs and wants, speculates about the implementation of these systems, objectively assesses the potential impacts of the proposals, and develops creative scenarios about the world if these technological systems are implemented.	Gathers data to determine human needs in the future, proposes systems to address those needs, speculates about the implementation of these systems, assesses potential impacts of the proposals, and develops scenarios about life if these technological systems are implemented.	Gathers data to determine human needs in the future, proposes systems to address those needs, thinks about how these systems might be implemented, makes statements about the potential impacts of the proposals, and develops a few ideas about life if these technological systems are implemented.

Unit 1
Definition of a System

Unit 1: Definition of a System

Standards for Technological Literacy Standards and Benchmarks

Unit 1 addresses *STL* standards as follows:

- **Standard 1** — **Students will develop an understanding of the characteristics and scope of technology.**
- **Standard 2** — **Students will develop an understanding of the core concepts of technology.**
- **Standard 12** — **Students will develop the abilities to use and maintain technological products and systems.**

Student Learning Experiences

- **Pencil Sharpener** — **Standard 1, Benchmark G; Standard 2, Benchmarks M, N, O and V; and Standard 12, Benchmarks H and K.**
- **Electrical System** — **Standard 1, Benchmarks F and H; Standard 2, Benchmarks M and N; and Standard 12, Benchmark K.**
- **Fluid Power** — **Standard 2, Benchmarks M and V and Standard 12, Benchmark K.**

Big Idea

A system is a group of parts working together to accomplish a task.

Acceptable Evidence of Student Understanding

State in writing; describe verbally, in writing, or graphically; list; script; develop visuals; model; present; critique; brainstorm; sketch; draw; photograph; research; engage experts; visit; interview; plan; organize; construct; envision; combine ideas; chart; graph; examine; test; experiment; animate; simulate; evaluate.

Special note: Please keep in mind that criteria must be developed to measure the evidence that students provide in demonstrating their levels of understanding—what are we looking for and how will we know it when we see it? For example, if students are asked to build a model, how will we know if it's a good one?

When considering achievement levels and helping students to understand how they might improve, it will be necessary to know what we mean by terms such as effectively, efficiently, adequately, creatively, thoughtfully, mostly, clearly, minimally, marginally, correctly, safely, systematically, randomly, logically, thoroughly, introspectively, insightfully, and meaningfully. (See **Appendix C, Acceptable Evidence Glossary**, for definitions.)

Student Assessment Criteria – What is a System?

Achievement Level / Sub-concept	Above Target 3	At Target 2	Below Target 1
Inputs	Inputs are clearly identified as being materials, energy, information, people, tools, and capital and are appropriately selected for the task or purpose of the system.	Inputs are clearly identified as being materials, energy, information, people, tools, and capital and are somewhat appropriately selected for the task or purpose of the systems.	Inputs are mostly identified as being materials, energy, information, people, tools, and capital and are not appropriately selected for the task or purpose of the system.
Processes	Resources are organized and processed efficiently to accomplish the task.	Resources are adequately organized and processed in a reasonably efficient way to accomplish the specified task.	Resources are not well organized or processed in an efficient way to accomplish the specified task.
Outputs	Outputs are such that the task or objective was creatively and effectively accomplished and new knowledge identified with a minimal amount of negative impact.	Outputs are such that the task or objective was adequately accomplished and new knowledge identified with some negative impact.	Outputs are such that the task or objective was minimally accomplished with little regard for negative impacts.
Feedback	Outputs are creatively analyzed, findings are cycled back to the systems input and process functions, and promising adjustments are recommended.	Outputs are adequately analyzed, findings are cycled back to the systems input and process functions, and adjustments are recommended.	Outputs are marginally analyzed, minimal findings are cycled back to the systems input and process functions, and modest adjustments are recommended.

Overview

Virtually all technological inventions and innovations can be thought of as systems. That is, they are a group of parts working together to accomplish a task. This unit will explore the key components of technology systems. Students will learn that systems are not unique to human ingenuity, that they exist in nature, and that natural systems have many similarities with technological systems.

The main goal of this unit is to expose students to a new way of organizing their thinking about technological devices. By looking at technological devices from a systems perspective, many complex systems can be broken down into subsystems, and eventually to the individual part level. In doing so, much of the "magic" and mystery can be removed, and a better understanding of how these systems actually work can be developed. Students will develop an understanding of the universal systems model of inputs, processes, outputs, and feedback. They will construct and work with a variety of systems, including mechanical, electrical, fluid, thermal, chemical, and natural systems.

Narrative

Begin the unit by explaining that systems are not unique to human ingenuity. That is, systems have long existed in nature, and continue to do so, without human intervention. Discuss photosynthesis, digestive systems, and other natural systems. Pay particular attention to the inputs, processes, outputs, and feedbacks associated with these natural systems.

Have students examine a common, everyday technological system, such as a pencil sharpener. In simple terms, lead a discussion, which will categorize what is going on in the *Universal Systems Model*. Students should start to develop an understanding of inputs, processes, outputs, and feedback. Using a variety of simple systems as examples, students should identify or describe the associated inputs, processes, outputs, and feedbacks.

Present the core concepts of technology, along with examples and descriptions of how they are combined to make systems. Show and demonstrate concrete examples of the systems, rather than talking about them in the abstract. Consider linking all of the core concepts into one common system of which they have a basic understanding, such as a car.

1. **Electrical –** systems consisting of a series of components designed to control, monitor, or measure the flow of electricity. Examples: lights, flashlight, radio, ignition.
2. **Magnetic** – systems relying on magnetic fields to provide control, motion, or force. Examples: doorbell, car lock.
3. **Electromagnetic** - systems that are combinations of electrical and magnetic systems. Examples: remote control, garage door opener, radio, microwave oven.
4. **Mechanical –** systems used to take an input motion or force and create a desired output motion or force. Examples: door latch, pulleys, gears, bicycle.
5. **Fluid power –** systems consisting of a gas or a liquid used to provide linear, reciprocating, or rotary motion. Examples: brakes, shock absorbers, log splitter.
6. **Structural –** systems that resist forces without changing shape, except for that due to the elasticity of the material; each element of a structural system must remain in relative position to the other parts. Examples: chair, table, frame, body of car.
7. **Chemical –** systems that rely on the interaction of chemicals to produce energy, or cause changes in other materials. Examples: fuel, battery.
8. **Thermal –** those systems dealing with controlling and measuring temperature. Examples: cooling system, climate control.
9. **Natural –** systems that occur naturally within the environment.

An automobile is a system that consists of many different subsystems.

Teacher Preparation

In order for you to successfully prepare for teaching this unit, you should:

- Gather references dealing with technological systems (i.e., *How Stuff Works* book and Web site, children's technology and science books, invention books, etc.).
- Obtain numerous technological systems for demonstration purposes (toaster, hot glue gun, stapler, remote control).

Enduring Experiences

Students should examine a variety of simple, common systems. The systems should include examples of mechanical, electrical, fluid power, structural, chemical, and thermal systems. They should look at the parts that make up these systems, the intended purpose, and categorize the parts as inputs, processes, outputs, and feedback, according to the universal systems model.

Lesson 1: Mechanical System

Students use a pencil sharpener virtually every day. It is a common mechanical system, and students generally understand what it does. In this activity, they will examine the internal workings of a pencil sharpener. They will identify the parts, then describe each function and explain how they interact with each other.

Lesson 2: Electrical System

Students will fabricate a modular electrical system. This system will allow the inputs, outputs, and controls to be easily interchanged. Through the use of this system, students will expand their knowledge of the types of inputs, outputs, and controls possible in an electrical system. They will identify uses and applications of a variety of inputs, outputs, and controls.

Lesson 3: Fluid-Power System

Students will fabricate a simple fluid-powered lever system. This system can be operated using either liquid or air, thereby introducing the concept of hydraulics and pneumatics. They will explore the differences between these two types of fluid power and identify the basic principles involved in fluid power.

Name: ____________________

Date: ____________________

Hour: ____________________

Technological Systems
Unit 1: Definition of a System

Lesson 1: Mechanical System – Pencil Sharpener

Objectives:
Upon successful completion of this activity you should be able to:
- Sketch a common mechanical system.
- Identify the individual parts of a mechanical system.
- Describe the relationship of parts and how they interact.

Connections:
During this activity you will be applying knowledge from the following areas:
- Mathematics – measurement
- Language Arts – writing

Directions:
You have probably used a pencil sharpener many times. This is an example of a simple mechanical system. Have you ever thought about how it works? Have you ever looked at all the parts that must work together just right to properly sharpen a pencil? In this activity you will be examining all the parts in a mechanical pencil sharpener system, sketching them, identifying them, and describing what they do.

Begin by taking a pencil sharpener apart. As you do, take care that you can put it back together when you are finished. Sketch each part of the pencil sharpener, and identify the part by name. If you do not know the exact name of the part, describe what it does. Describe the function of each part and how it is connected to other parts.

When you are done, put the pencil sharpener back together. Use the pencil sharpener to sharpen your pencil.

Materials Needed

The following materials are needed to construct your mechanical system. Other materials may be substituted when noted.

- Mechanical pencil sharpener
- Ruler
- Sketch paper
- Pencil
- Screwdriver

Part Identification

In the table below, list the parts of your device and describe their size and functions.

Part Name	Function	Size

Use complete sentences to answer the following questions:

1. What are the inputs into the mechanical system?

2. What are the processes involved in the mechanical system?

3. What are the outputs of the mechanical system?

4. Are all of the outputs desirable? If not, explain.

5. What are the controls of the mechanical system?

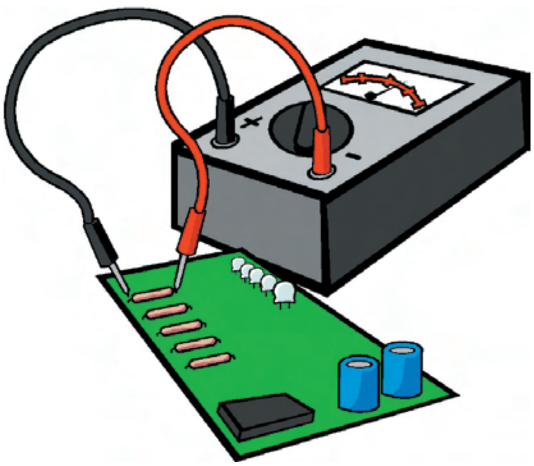
6. Is this an open-loop or closed-loop system?

Grading Criteria – Pencil Sharpener

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Sketch	Accurately depicts the chosen device in complete detail.	Most details are included and drawn accurately.	Sketch does not depict device, missing significant details.	
Parts Labeled	Most parts are accurately labeled.	Some parts are accurately labeled.	Very few parts are labeled correctly.	
Part Identification and Function	Most parts are correctly identified and functions accurately described.	Some parts are correctly identified and functions accurately described.	Very few parts are correctly identified and described.	
Description of Operation	Written and verbal descriptions demonstrate clear understanding of the system's operation.	Written and verbal descriptions skip some key steps in the operation.	Written and verbal descriptions do not demonstrate correct operation of system.	
Systems Concepts	Student accurately categorizes functions of a pencil sharpener according to the universal systems model (inputs, process, outputs, feedback).	Student categorizes functions of a pencil sharpener according to the universal systems model (inputs, process, outputs, feedback) with few errors.	Student cannot accurately categorize functions of a pencil sharpener according to the universal systems model (inputs, process, outputs, feedback).	

Comprehensive Understanding ____/ 15 points

Additional comments:



Name: ____________________

Date: ____________________

Hour: ____________________

Technological Systems
Unit 1: Definition of a System

Lesson 2: Electrical System – Electrical Circuit

Objectives:
Upon successful completion of this activity you should be able to:
- Build a simple circuit.
- Identify a variety of sources of energy in an electrical circuit (inputs).
- Identify a variety of applications of electrical circuits (outputs).
- Identify a variety of controls used in electrical circuits (control).

Connections:
During this activity you will be applying knowledge from the following areas:
- Mathematics – measurement
- Science – electrical principles
- Language Arts – reading for understanding, writing

Directions:
For this activity, you will be building a simple electrical circuit, which will allow you to connect a variety of energy sources, output devices, and control mechanisms.

Tools Required
The following tools are needed to construct your simple electrical system. Other tools may be substituted.
- Phillips head screw driver
- Wire stripper and cutter
- Scissors
- $^{3}/_{16}$" drill bit
- Counter-sinking bit
- Drill press
- Hand roller

Materials Needed

The following materials are needed to construct your electrical system. Other materials may be substituted when noted.

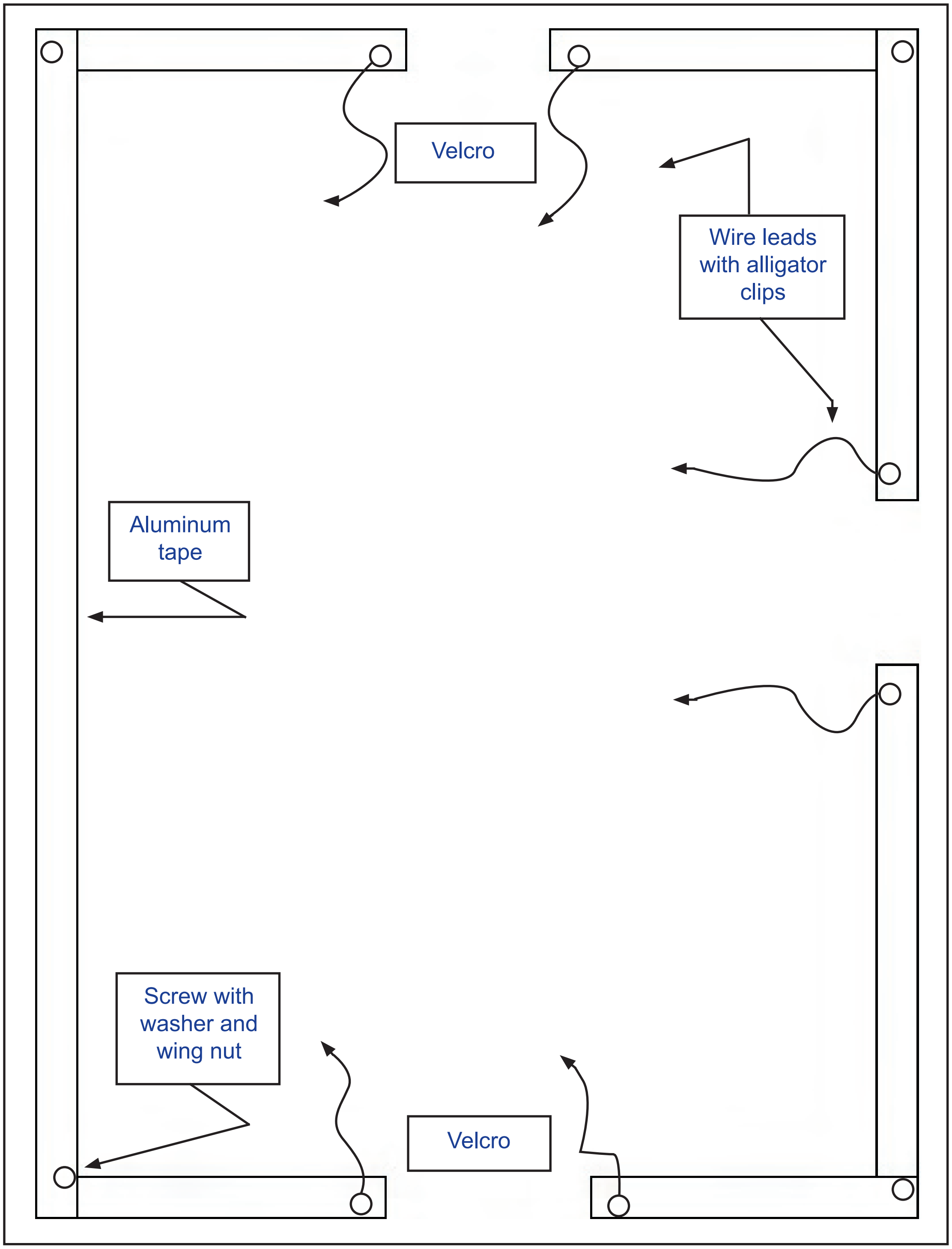
- 10” by 16”acrylic base
- 45” self-sticking aluminum tape
- (10) #8 by ¾” flathead screws
- (10) #8 wing nuts
- (10) 3⁄16” flat washers
- (6) wire leads with alligator clips
- (3) 1½” pieces of self adhesive hook & loop strips

Fabricating Instructions

Follow the instructions below to safely construct your electrical system.

1. Attach the self sticking aluminum tape around the edge of the base according to the following:
    - Stay ¾” away from edge of base all the way around.
    - Leave (3) 2” gaps in the tape as shown in the diagram on page 33.
    - Overlap the tape at each corner.
    - Roll tape firmly in place with hand roller. **Do not rub tape down with your hand. It is sharp on the edges, and can cut you.**
2. Drill a 3⁄16” hole through the tape where it overlaps at each corner, and ½” from each opening.
3. Countersink each hole **from the bottom** so the head of the screw is flush with the bottom.
4. Cut your wire leads to 5” long.
5. Strip 5⁄8” of insulation off the end of each lead.
6. Working one hole at a time, insert a screw from the bottom, place a flat washer over it, then tighten a wing nut on top of that.
7. Bend the stripped end of the wire leads into a “U” shape.
8. Loosen the wing nuts on each side of the gaps in the aluminum tape.
9. Place a wire lead under the flat washer on each side of the gap, and retighten the wing nuts.
10. Stick one piece of hook strip tape 1” in front of each gap in the aluminum tape.

Electrical System Base



Get Ready to Use It

It is now time to operate your electrical system with a variety of input sources of energy, output devices, and control mechanisms.

From your instructor, obtain the following:
(Note: Some of the devices may be substituted.)

Device	Device Code
Input energy sources:	
• Double A battery holder with batteries	I.1
• Quadruple A battery holder with batteries	I.2
• 9V battery	I.3
• Hand generator	I.4
• Solar cell	I.5
• Variable power supply	I.6
Output devices:	
• Lamp holder, with lightbulb	O.1
• Piezo electric buzzer	O.2
• Motor	O.3
• NiChrome wire mounted to base	O.4
• Mini electric fan	O.5
Control mechanisms:	
• Momentary push-button switch	C.1
• On-off push button switch	C.2
• Micro switch	C.3
• Pressure switch	C.4
• Thermal switch	C.5
• Magnetic switch and magnet	C.6

Operating Instructions

Complete the circuits described below, according to the device code referenced above. After completing each electrical system, answer the questions and describe your observations.

A. Input Device: I.1; Output Device: O.1; Control mechanism: C.1

1. Is the light on when you complete the circuit?

2. If you push the button, what happens?

3. If you let go of the button what happens?

B. Input Device: I.2; Output Device: O.1; Control mechanism: C.2

1. Is the light on when you complete the circuit?

2. If you push the button, what happens?

3. If you let go of the button, what happens?

4. Is the light the same as in the previous system? Explain why you think it changed.

C. Input Device: I.3; Output Device: O.1; Control mechanism: C.4 (connect to white and black wires)

1. Is the light on when you complete the circuit?

2. If you push in on the hydraulic (syringe) plunger, what happens?

3. If you pull out on the hydraulic (syringe) plunger, what happens?

4. Is the light the same as in the previous system? Explain why you think it changed.

Circuits of Your Own Design

You will now connect a variety of circuits with the class time remaining. Try to use many different inputs, outputs, and controls. After you have connected the circuit, operate the control mechanism, and describe the operation of the system.

Input Device Code:	**Output Device Code:**	**Control Code:**
System Description:		
Input Device Code:	**Output Device Code:**	**Control Code:**
System Description:		
Input Device Code:	**Output Device Code:**	**Control Code:**
System Description:		
Input Device Code:	**Output Device Code:**	**Control Code:**
System Description:		

System Applications

Use complete sentences to complete the following:

Can you think of some good uses for these different inputs, outputs, and controls? In the space provided, identify the type of input, output, or control, and describe what you think would be a good use for this device, or where you have seen something similar.

Can you think of any other types of inputs, outputs, or controls for electrical systems that you haven't used in this activity?

Grading Criteria – Electrical Circuit

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Electrical System Assembly	Parts are correctly assembled, and satisfactory operation is likely.	Parts are incorrectly assembled, but correct operation is still possible.	Parts are assembled in a way that correct operation is unlikely.	
Electrical Systems Operation	Teacher-designed systems are correctly operated, and in-depth observations are made and recorded.	Teacher-designed systems are correctly operated, but observations are inaccurate, or not recorded.	Teacher-designed systems are incorrectly operated, and observations are not made or recorded.	
Electrical Systems Design	Student designs and operates a variety of electrical systems, using a wide range of inputs, outputs, and controls. Detailed observations are made and recorded.	Student designs and operates several different circuits but does not use several of the inputs, outputs, and controls. Observations and recording lack depth of understanding.	Few circuits are designed and operated. Many of the inputs, outputs, and controls are not used. Observations and recording are inaccurate, or not done.	
Identification of Electrical Systems Applications	Student demonstrates an exceptional understanding of a variety of applications, electrical system inputs, outputs, and controls.	Student demonstrates a limited understanding of applications, electrical system inputs, outputs, and controls.	Student has little understanding of electrical system inputs, outputs, and controls.	

Comprehensive Understanding ____/ 15 points

Additional comments:

Name: ______________________

Date: ______________________

Hour: ______________________

Technological Systems
Unit 1: Definition of a System

Lesson 3: Fluid-Power System – Fluid-Powered Lever

Objectives:
Upon successful completion of this activity you should be able to:
- Build a fluid-powered lever.
- Differentiate between hydraulic and pneumatic systems.
- Identify a variety of applications of fluid-powered systems.

Connections:
During this activity you will be applying knowledge from the following areas:
- Mathematics – measurement
- Science – fluid-powered systems, force
- Language Arts – reading for understanding, writing

Directions:
For this activity, you will be building a fluid-powered lever, which will allow you to observe hydraulic and pneumatic systems in action.

Tools Required
The following tools are needed to construct your simple electrical system. Other tools may be substituted.
- Saw
- Drill
- Disk sander

Materials Needed

The following materials are needed to construct your fluid-powered lever system. Other materials may be substituted when noted.

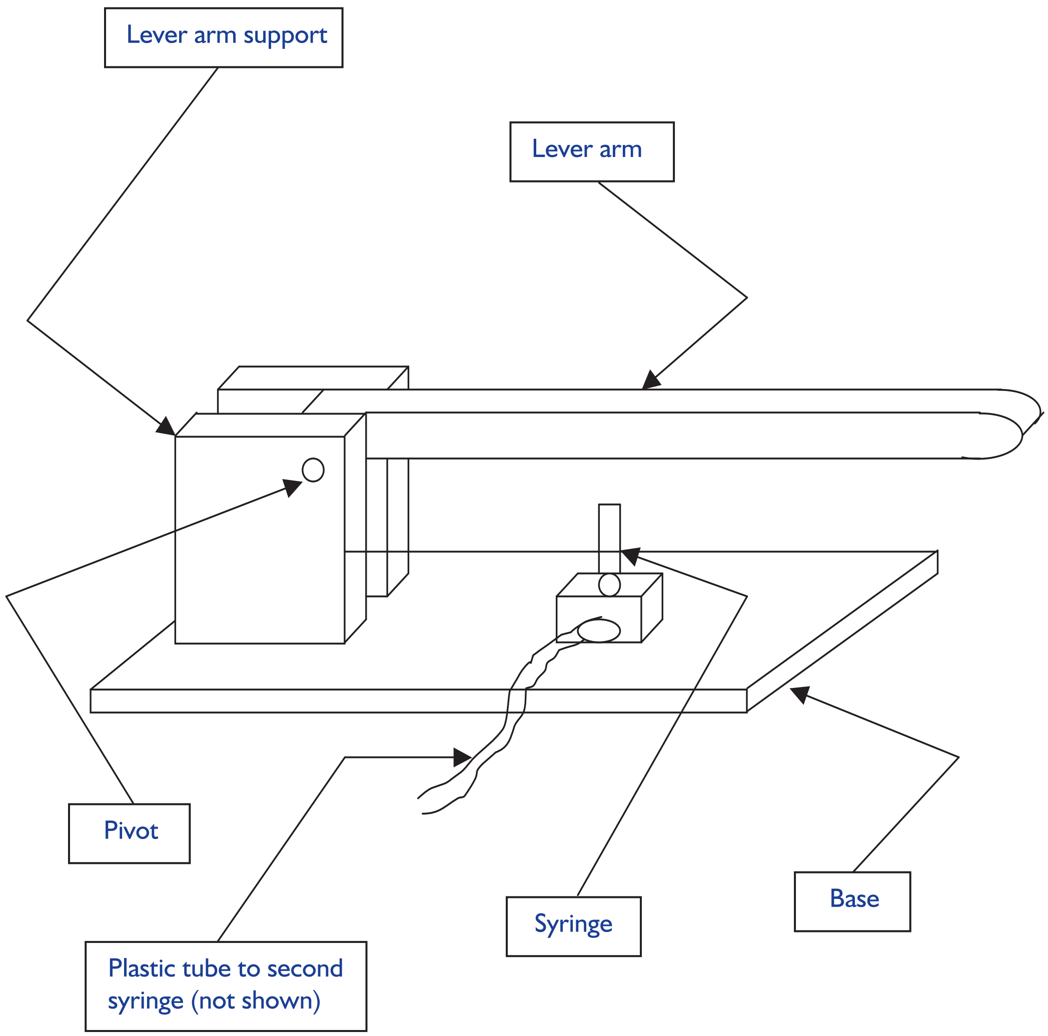
- 10” by 17”wood base
- (2) ¾” by 7 ½” by 8 ½” pivot supports
- (1) 4” piece of 2 by 4
- (1) 1 ½” by 2” by 18” lever arm
- (2) syringes (hydraulic syringes – may be enhanced by two different size syringes)
- (1) 6” piece of ⅛” flexible plastic tubing
- 9 ½” self sticking hook and loop fastener
- 3” piece of ¼” dowel

Fabricating Instructions

Follow the instructions below to safely construct your fluid-powered lever system.

1. Cut the wood pieces to correct sizes.
2. Using the disk sander, round the edges as shown.
3. Drill a ¼” hole through the pivot arm and both pivot supports.
4. Drill a hole the same size as the body of the syringe approximately 2” deep in the top edge of the 2 by 4.
5. Drill a ¼” hole the rest of the way through the 2 by 4, so it is centered in the first hole.
6. Drill a ¾” hole in the face of the 2 by 4 so it intersects the ¼” hole.
7. Drill four ¾” holes in the bottom edge of the pivot arm, spaced as shown in the diagram on page 40.
8. Screw through the bottom of the base into the vertical pivot supports, leaving a 1½” space between them.
9. Insert the pivot arm between the vertical pivot supports, aligning all three ¼” holes.
10. Apply one part of the hook-and-loop fastener to the base, being careful to align it with the pivot arm.
11. Apply the other part of the hook-and-loop fastener to the bottom of the 2 by 4 block.
12. Attach the plastic tube to the end of one of the syringes.
13. Insert one syringe into the hole in the top of the 2 by 4, working the tube so it comes out the ¾” hole in the side.
14. Attach the other syringe to the other end of the plastic tube.

Hydraulic Lever Diagram



Using Your Fluid-Powered Lever System

When you think of a fluid, what do you think of? List four different fluids.

____

____

____

____

Are all of the fluids you listed liquids? ______________________ Actually, a fluid can be either a liquid or a gas. If the system uses a liquid, it is called a hydraulic system. The most common liquid used in hydraulic systems is some type of oil, but other liquids may be used. For our activities, we will use water. If the system uses a gas, it is called a pneumatic system. The most common gas used in pneumatic systems is air.

Pneumatic Procedure:

Your lever system should already be set up, with air in both cylinders, and the connecting tube. If not, do so at this time.

1. Position the 2 by 4 so the cylinder in it lines up with hole #1 on the lever arm.
2. Push the hand-held cylinder all the way in.
3. How far does the end of the lever arm move? ____________________________
4. Repeat the procedure with the weight hanging on the end of the lever.
5. How far does the end of the lever arm move? ____________________________
6. Move the 2 by 4 to each of the other hole positions, and repeat the procedure, with and without the weight attached. Record your results in the table below.

Position #	Distance without weight	Distance with weight	Difference	% Difference (col. 3 ÷ col. 1)
#1				
#2				
#3				
#4				

1. Why do you think there was a difference between the distance traveled with weight and without?

2. Can gasses be compressed—that is, can more air be forced into the same amount of space? Explain why or why not. Can you think of any examples?

Hydraulic Procedure:
You now need to get all of the air out of the system and replace it with water. If you need help doing this, ask the instructor.

1. Position the 2 by 4 so the cylinder in it lines up with hole #1 on the lever arm.
2. Push the hand-held cylinder all the way in.
3. How far does the end of the lever arm move? ___________________________
4. Repeat the procedure with the weight hanging on the end of the lever.
5. How far does the end of the lever arm move? ___________________________
6. Move the 2 by 4 to each of the other hole positions, and repeat the procedure, with and without the weight attached. Record your results in the table below.

Position #	Distance without weight	Distance with weight	Difference	% Difference (col. 3 ÷ col. 1)
#1				
#2				
#3				
#4				

1. Was there as much of a difference between the distance traveled with and without the weight when you used water (hydraulic system) as opposed to when you used air (pneumatic system)?

2. Can liquids be compressed—that is, can more water be forced into the same amount of space? Explain why or why not. Can you think of any examples?

3. Can you think of any examples where hydraulic and pneumatic systems are used to do work for us? Try to think of as many examples as you can. Discuss your answers with one or two classmates.

Grading Criteria – Fluid-Powered Lever

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Fabrication	Parts are cut to the correct size, and holes are correct size and location.	Most parts are correct size, and most holes are correct size.	Enough parts are incorrect to the point where correct operation is unlikely.	
Assembly	Parts are correctly assembled, and satisfactory operation is likely.	Parts are incorrectly assembled, but correct operation is still possible.	Parts are assembled in a way that correct operation is unlikely.	
Pneumatic operation	Procedure is followed correctly, and accurate measurements are taken and recorded.	Slight variation in the procedure occurred, and/or measurements are not entirely accurate or recorded incorrectly.	Operation does not follow correct procedure, and/or measurements are not close, or not recorded.	
Hydraulic operation	Procedure is followed correctly, and accurate measurements are taken and recorded.	Slight variation in the procedure occurred, and/or measurements are not entirely accurate or recorded incorrectly.	Operation does not follow correct procedure, and/or measurements are not close, or not recorded.	
Identification of systems	Student demonstrates an understanding of a variety of applications of hydraulics and pneumatics.	Student demonstrates a limited understanding of applications of hydraulics or pneumatics.	Student has little understanding of either hydraulics or pneumatics.	

Comprehensive Understanding ____/ 15 points

Additional comments:

Unit 2
Systems Interaction

Unit 2: Systems Interaction

Standards for Technological Literacy Standards and Benchmarks

Unit 2 addresses *STL* standards as follows:

- **Standard 8** — **Students will develop an understanding of the attributes of design.**
- **Standard 10** — **Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.**
- **Standard 11** — **Students will develop the abilities to apply the design process.**
- **Standard 12** — **Students will develop the abilities to use and maintain technological products and systems.**

Student Learning Experiences

- **How Things Work** — **Standard 11, Benchmark J and Standard 12, Benchmarks H and K**
- **Keep it Running** — **Standard 10, Benchmark F and Standard 12, Benchmark I and K**
- **Continuity Tester** — **Standard 11, Benchmark L and Standard 12, Benchmark I**
- **Designing a Structural System** — **Standard 8, Benchmarks E, F, and G; Standard 10, Benchmark G; and Standard 11, Benchmarks J and L.**

Big Idea

People interact with technological systems (they operate, care for, construct, and design them).

Acceptable Evidence of Student Understanding

State in writing; describe verbally, in writing, or graphically; list; script; develop visuals; model; present; critique; brainstorm; sketch; draw; photograph; research; engage experts; visit; interview; plan; organize; construct; envision; combine ideas; chart; graph; examine; test; experiment; animate; simulate; evaluate.

Special note: Please keep in mind that criteria must be developed to measure the evidence that students provide in demonstrating their levels of understanding—what are we looking for and how will we know it when we see it? For example, if students are asked to build a model, how will we know if it's a good one?

When considering achievement levels and helping students to understand how they might improve, it will be necessary to know what we mean by terms such as effectively, efficiently, adequately, creatively, thoughtfully, mostly, clearly, minimally, marginally, correctly, safely, systematically, randomly, logically, thoroughly, introspectively, insightfully, and meaningfully. (See **Appendix C, Acceptable Evidence Glossary**, for definitions.)

Student Assessment Criteria – How Systems Work

Achievement Level / Sub-concept	Above Target 3	At Target 2	Below Target 1
Design	A potentially effective system is designed that accurately identifies the input, process, output, and feedback components to accomplish a specified purpose.	A system is designed that has some potential and is somewhat accurate in identifying the input, process, output, and feedback components to accomplish a specified purpose.	A system is designed that has limited potential and is marginally accurate in identifying the input, process, output, and feedback components to accomplish a specified purpose.
Build	Using a potentially effective design, a prototype is constructed and tested for a system that correctly incorporates input, process, output, and feedback components and successfully accomplishes a specified purpose.	Using a potentially effective design, a prototype is constructed and tested for a system that correctly incorporates input, process, output, and feedback components that, to a limited degree, accomplishes a specified purpose.	Using a potentially effective design, a prototype is constructed and tested for a system that mostly incorporates input, process, output, and feedback components but does not successfully accomplish a specified purpose.
Operate	Correctly, safely, and with efficiency, operates systems that process matter (separate, combine, condition, form) and data (collect, process, display).	With some degree of correctness, safety, and with limited efficiency, operates systems that process matter (separate, combine, condition, form) and data (collect, process, display).	With a minimal degree of correctness, safety, and efficiency, operates systems that process matter (separate, combine, condition, form) and data (collect, process, display).
Maintain	Creatively anticipates and specifies, with an accurate understanding of its function, the maintenance requirements with regard for cleaning, lubricating, sharpening, updating, monitoring, or otherwise servicing a system to keep it operating effectively and protected against potential failure.	Specifies, with a somewhat accurate understanding of its function, the maintenance requirements with regard for cleaning, lubricating, sharpening, updating, monitoring, or otherwise servicing a system to keep it operating effectively and protected against potential failure.	Minimally specifies, with a limited understanding of its function, the maintenance requirements with regard for cleaning, lubricating, sharpening, updating, monitoring, or otherwise servicing a system to keep it operating effectively and protected against potential failure.

Overview

The main goal of this unit is to teach students about the different ways in which humans interact with technological systems. In this unit, students will operate, maintain, construct, and design systems. Key concepts covered in this unit include troubleshooting, the design process, safe use of tools, material processing techniques, reading technical manuals, and modeling and prototyping.

Narrative

In society there are four different levels in which people interact with systems. Everyone operates technological systems in their daily lives. Many people fix and maintain systems at home and in the workplace. Some people construct systems either as a hobby or a career. Even fewer design

(invent and innovate) systems to be used by others to solve technological problems. The following examples show this hierarchy of people interacting with systems.

Take for example an automobile. Virtually all adults operate automobiles as a means of transportation (operate). Many people perform maintenance either on their own vehicles or in a career as a technician (care for). Some people work in manufacturing occupations, fabricating and assembling these vehicles (construct). A fewer number of people are involved in the design of new vehicles (design).

Another example of the levels at which people interact with a system is construction technology. Most people live in some type of constructed shelter such as apartments, houses, etc. (operate). Many people perform a variety of maintenance tasks either on their own homes or as a job (care for). A large number of people are employed in constructing new structures (construct). Some people design new structures for others to build and utilize (design).

Teacher Preparation

In order for you to successfully prepare for teaching this unit, you should:

- Gather references dealing with technological systems (i.e. *How Stuff Works* book and Web site, children's technology and science books, invention books, etc.).
- Obtain numerous technological systems for demonstration purposes (toaster, hot glue gun, stapler, remote control).
- Make a list of local businesses that fall under the different categories of operating, maintaining, constructing, and designing technological systems (i.e. Jiffy Lube, Smith Engineering, etc.).
- Obtain owner's manuals for different technological systems.

Enduring Experiences

Operating a System

Lesson 1: How Things Work

By the middle school level, students have already been exposed to operating many different technological systems through their everyday encounters. For this activity, students will select one of these devices, sketch it, label its parts and their functions, and list the steps in using it to complete a task. At the same time, students will describe the outcomes if the steps are not performed in the correct order.

Other Ideas: Depending on the facility and available equipment, students may also be expected to operate and explain the proper use of different technological devices according to instructions given by the manual, instructor, etc. Examples may include, but are not limited to, programming a VCR, taking pictures with a digital camera, using a power tool, etc.

Care For

Lesson 2: Keep it Running

Preventative and scheduled maintenance greatly extends the life of most technological systems. The ability to understand and perform tasks such as cleaning, lubricating, and adjusting these systems can prevent or postpone costly systems failure. During this activity, students will read an owner's manual for a given system and outline the user-performed maintenance tasks. After completing this task, given a list of various system problems, students will identify corrective measures that could have prevented or will repair the problem.

Other Ideas: Depending on the facility and available equipment, students may also perform regularly scheduled maintenance procedures on the given piece of equipment. Examples may include cleaning a VCR, lubricating a simple piece of equipment, using a virus scan or defragging a computer, and cleaning and lubricating a fishing reel.

Construct

Lesson 3: Building a Continuity Tester

A continuity tester is a device used to check and troubleshoot electrical circuits. In this activity students will be constructing a simple electrical circuit, which works as a continuity tester. Students will use this device in future activities.

Design

Lesson 4: Designing a Structural System

The ability to implement the design process is a key factor in becoming technologically literate. A structural system is designed to resist forces without changing shape, except that which is due to the elasticity of the material. Common structures include houses, buildings, bridges, roadways, etc. During this activity, students will be designing, building, and testing a model structure.

Name: ____________________

Date: ____________________

Hour: ____________________

Technological Systems
Unit 2: Systems Interaction

Lesson 1: How Things Work

Objectives:
Upon successful completion of this activity you should be able to:
- Diagram a technological system.
- List, in order, the steps for operating the system.
- Describe the outcomes if the system is used incorrectly.

Connections:
During this activity you will be applying knowledge from the following areas:
- Mathematics – spatial reasoning
- Language Arts – technical writing

Directions:
For this activity, you are to select one of the devices listed below (if you have an idea of a different device, you must get it approved by the instructor). Sketch the device on a separate piece of paper, label its parts and their functions, and list the steps in using it to complete the designed task. Describe what could happen if the steps are not performed in the correct order.

Technological Devices:

Hairdryer	Stapler	Toaster	Alarm clock
TV remote	CD player	Hand drill	Video game controller
Blender	Mixer	Telephone	Vacuum cleaner
Curling iron	Fire extinguisher	Flashlight	Car jack
Vending machine	Rivet gun	Lawn mower	Hedge trimmer
Coffee maker	Bicycle	Microscope	Sewing machine
Washing machine	Tire pump	Three hole punch	

The technological device I chose is the ____________________.

Sketch

In the space provided below, sketch your technological device and label all the parts.

Part Identification

In the table below, list the parts of your device and describe their function.

Part Name	Function

Description of Operation

In the space provided below, list, in order, the steps involved to properly use the technological device.

Incorrect Operation

What types of things might happen if this technology is used incorrectly or if the operation steps are performed out of order? (Think of safety, systems failure, etc.)

Grading Criteria – How Things Work

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Sketch	Accurately depicts the chosen device in complete detail.	Most details are included and drawn accurately.	Sketch does not depict device, missing significant details.	
Parts Labeled	Most parts are accurately labeled.	Some parts are accurately labeled.	Very few parts are labeled correctly.	
Part Identification and Function	Most parts are correctly identified and their functions accurately described.	Some parts are correctly identified and their functions accurately described.	Very few parts are correctly identified and described.	
Description of Operation	Description demonstrates clear understanding of the systems operation.	Description skips some key steps in the operation.	Description does not demonstrate correct operation of system.	
Incorrect Operation	Student understands a variety of consequences of incorrect operation.	Student understands some consequences of incorrect operation.	Student demonstrates little understanding of consequences of incorrect operation.	

Comprehensive Understanding ____/ 15 points

Additional comments:

Name: ______________________

Date: ______________________

Hour: ______________________

Technological Systems
Unit 2: Systems Interaction

Lesson 2: Keep it Running

Objectives:
Upon successful completion of this activity you should be able to:
- Outline proper maintenance procedures found in technical manuals.
- Forecast problems in technological systems.
- Identify a maintenance procedure to prevent a malfunction in a technological system.

Connections:
During this activity you will be applying knowledge from the following areas:
- Language Arts – technical writing, reading

Directions:
During this activity, your instructor will give you various instruction manuals (i.e. automobile manual) to different technological systems. Your task is to read the manual and outline the preventative maintenance steps. You will then be given a list of various systems malfunctions or failures. Your task is to determine preventative measures that could have kept the malfunction from happening or prolonged the life of the system. Use the templates on the next pages to help.

Manual Review

(Make copies of this sheet for each manual reviewed.)

The name of my technological system is the: ______________________________.

The company that made the product is called: ______________________________.

Circle yes or no if the product has a warranty (YES / NO).

If yes, how long does the warranty last? ____________________

What does the warranty cover?

____

____

____

____

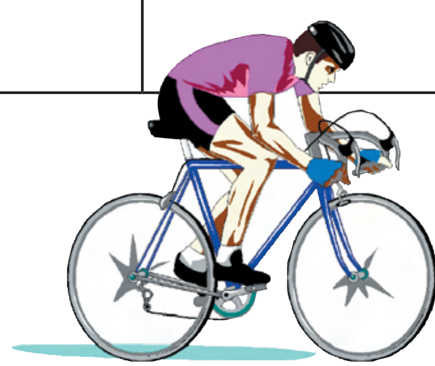
After reviewing the manual for your technological device, identify the maintenance tasks and explain the reasons why the tasks need to be done in order to prevent or postpone costly system malfunctions later.

Maintenance Task	Why Task Needs to be Done

Preventative Maintenance

Most people are familiar with a bicycle. A bicycle is a transportation system used to get us from one location to another. There are many things that can go wrong with a bicycle. However, preventative maintenance can prolong the time until a failure happens. In the table below is a list of failures or problems that can happen to a bicycle. Your task is to explain what could have been done to prevent the problem. Be thorough in your explanation.

Failure/Problem	Preventative Maintenance
Flat tire	
Chain falls off	
Rusty chain	
Loose seat	
Pedal squeaks	
Gears do not switch	
Handbrakes do not stop well	
Bike does not steer straight	



Grading Criteria – Keep It Running

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Ability to Interpret Owner's Manual	Accurately outlines all information in owner's manual.	Outlines most details in owner's manual.	Does not accurately outline details in owner's manual.	
Ability to Forecast Systems Failure	Demonstrates a clear understanding of possible systems failures.	Demonstrates some understanding of possible systems failures.	Does not recognize possible systems failures.	
Ability to Understand Maintenance Need	Demonstrates clear understanding of maintenance need.	Demonstrates some understanding of maintenance need.	Does not understand maintenance need.	

Comprehensive Understanding ____/ 9 points

Additional comments:

Name: ______________________

Date: ______________________

Hour: ______________________

Technological Systems
Unit 2: Systems Interaction

Lesson 3: Building a Continuity Tester

Objectives:
Upon successful completion of this activity you should be able to:
- Use tools, materials, and machines safely to fabricate a simple system.
- Follow assembly instructions to successfully build a system.

Connections:
During this activity you will be applying knowledge from the following areas:
- Science – electricity
- Mathematics – measurement

Directions:
During this activity you will be constructing a simple electrical system. This system consists of a variety of parts. When these parts work together properly, they allow you to check the conductivity of a material and the continuity of an electrical circuit. The materials needed and the steps in constructing a continuity tester and test stand are described below and on the next page.

Tools Required
The following tools are needed to construct a continuity tester and stand. Other tools may be substituted.

- Wire cutters
- Bandsaw, handsaw, or any other saw that can be used to cut PVC pipe
- Hand drill or drill press
- Phillips screwdriver
- Needle-nose pliers

Materials Needed
The following materials are needed to construct a continuity tester and test stand. Other materials may be substituted when noted.

Tester

- ½ inch PVC pipe (large enough inside diameter to fit AA or AAA battery)
- PVC endcaps (2 per tester)
- (1) 2-inch panhead wood screw (1 per tester)
- Small bolt, nut, and washer (suggest number 8, ½ inch long)
- Wire (single strand from telephone cable works well)
- Alligator clip
- Christmas tree light bulb

Stand

- ⅛” acrylic, 3” x 9”

Fabricating Instructions
Follow the instructions below to safely construct a continuity tester and stand.

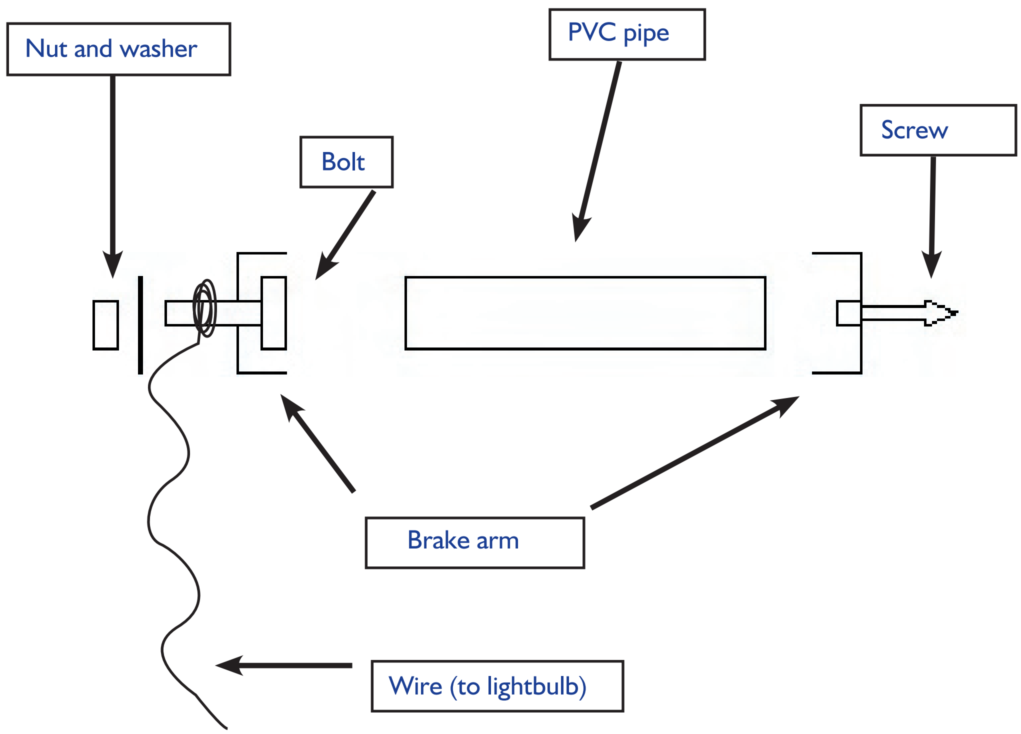
Tester

1. Cut PVC pipe to length of battery.
2. Drill small hole (1 smaller than diameter of screw, other hole large enough for #8 bolt) in end of each PVC end cap.
3. Thread screw in one end cap from inside out.
4. Insert bolt into other end cap from inside out.
5. Wrap wire around end of bolt.
6. Put on washer and tighten nut.
7. Connect other end of wire to lightbulb.
8. Connect alligator clip to other lead of lightbulb.

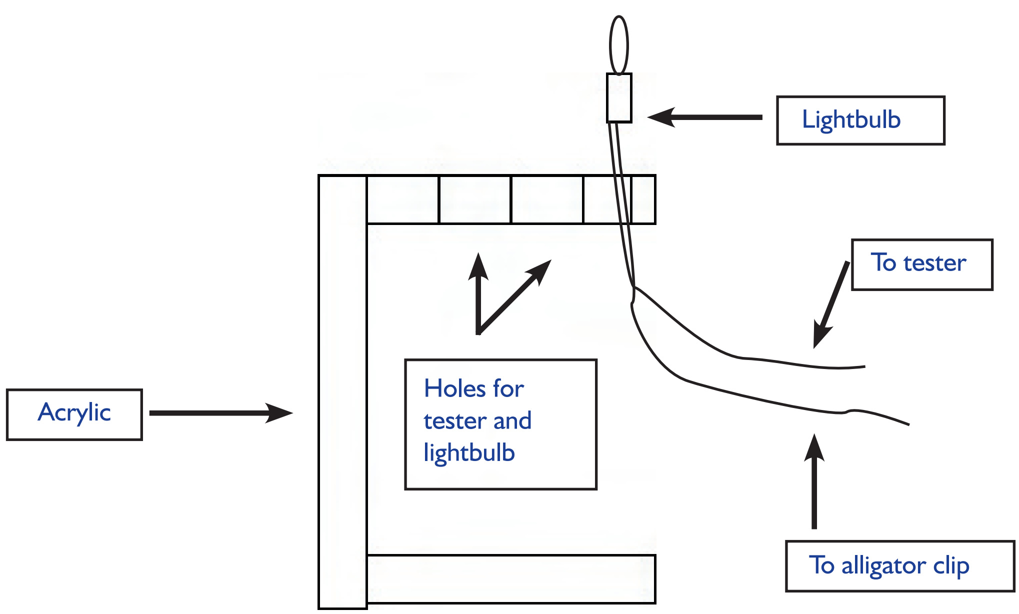
Stand

1. Cut a 3” x 9” piece of acrylic.
2. Drill hole in top piece large enough for continuity tester to fit through.
3. Drill small hole in front of large hole for Christmas tree lightbulb to fit in.
4. Bend acrylic to create 3”x 3”x 3”.
5. Attach felt pad to bottom.

Tester Diagram



Stand Diagram (side view)



Using Your Continuity Tester

Now that you have constructed an electrical system, it is time to put it to work. Your instructor has given you a variety of different materials. Some materials are conductors and some are insulators. Insulators do not allow the flow of electrical current. Conductors do allow the flow of electrical current. Your task is to test each of the materials with your continuity tester to see if they are conductors or insulators. Do this by hooking an alligator clip to one end of the material and then touching the other end with the screw tip.

CAUTION: HIGH DOSES OF ELECTRICAL CURRENT CAN CAUSE SERIOUS INJURY OR DEATH!

NEVER PUT CONDUCTIVITY TESTER INTO AN ELECTRICAL OUTLET!

Recording your Results

In the table below, put a check in the insulator column if the material does not conduct current. If the material does conduct current and the lightbulb lights, put a check in the conductor column.

Material	Conductor	Insulator
Copper wire		
Aluminum foil		
Glass rod		
Screwdriver		
Plastic pen		
Spring		
Paper clip		
Paper		
Clothing		
Yarn		
Wood strip		
Stapler		
Cup of water		
Piece of ceramic tile		

Now that you have done conductivity tests on the materials given to you by your instructor, it is time you do some testing yourself. Your task is to find five different objects around the room. Test to see if parts of those devices are made out of a material that conducts electrical current. Record your results in the table on the next page.

CAUTION: HIGH DOSES OF ELECTRICAL CURRENT CAN CAUSE SERIOUS INJURY OR DEATH!

NEVER PUT CONDUCTIVITY TESTER INTO AN ELECTRICAL OUTLET

Device	Part	Material

Reflection

Use complete sentences to answer the following:
Now that you have tested the conductivity of different materials, what kind of materials do you think make good conductors? What about insulators?

A continuity tester is a technological system (parts working together to perform a task). Besides testing to see if a material conducts electrical current, can you think of specific uses for a conductivity tester?

Technological systems can fail for many reasons. List as many reasons as you can that could cause your continuity tester to malfunction (stop working).

Grading Criteria – Building a Continuity Tester

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Use of Tools to Process Materials	Tester is built to fabricating specifications and functions properly.	Most fabricating specifications were met. Tester functions properly.	Tester is poorly constructed and/or does not function properly.	
Differentiates Between Insulators and Conductors	Accurately identifies materials as conductors or insulators (within 95% accuracy).	Some materials are accurately identified (within 85% accuracy).	Very few materials are identified correctly.	
Material Identification	Student accurately identified conductive part of device.	Some conductive parts were identified accurately.	Very few parts were correctly identified and described.	
Characteristics of Conductors	Student demonstrates clear understanding of conductive material.	Student understands what material is conductive, but does not necessarily know why.	Student does not understand characteristics of a conductive material.	
Systems Malfunction	Student understands a variety of failures that could cause the tester to malfunction.	Student understands some of the failures that could cause the tester to malfunction.	Student demonstrates little understanding of systems malfunction.	

Comprehensive Understanding ____/ 15 points

Additional comments:

Name: ____________________

Date: ____________________

Hour: ____________________

Technological Systems
Unit 2: Systems Interaction

Lesson 4: Designing a Structural System

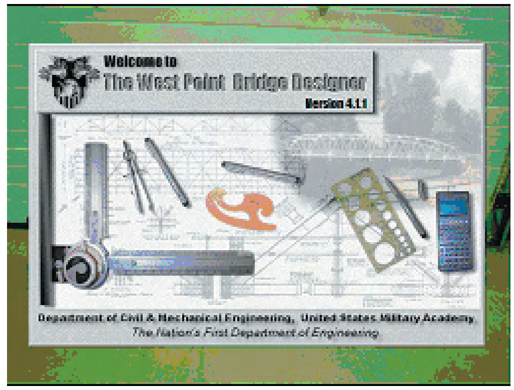
Objectives:
Upon successful completion of this activity you should be able to:
- Design a structural system using computer-aided design (CAD) software.
- Use engineering data to analyze constraints on technological systems.
- Diagram parts of your structural system.
- Test and critique your design.

Connections:
During this activity you will be applying knowledge from the following areas:
- Mathematics – measurement, arithmetic, data gathering
- Science – strength of materials, forces

Directions:
During this activity you will be designing a structural system. This system consists of a variety of parts. When these parts work together properly, they resist forces. A bridge is a structure that resists both live loads (i.e. cars, trucks, people, wind, snow, etc.) and dead loads (the weight of the materials). A bridge that is designed properly not only resists these loads, but does it efficiently (strong enough at a low price) and is aesthetically pleasing (looks nice). During this activity you will be designing an aesthetically pleasing bridge that will hold the greatest load possible using the least amount of materials. The materials needed and the steps in designing your structural system are described below and on the next page.

Tools Required
During this activity you will be using the West Point Bridge Designer computer program. This program was developed by Colonel Stephan J. Ressler, P.E., Ph.D., from the Department of Civil and Mechanical Engineering at the USMA (United States Military Academy). The program demonstrates how engineers use a computer as a tool for designing structures. It is free for educational purposes and can be downloaded at http://bridgecontest.usma.edu/.

http://bridgecontest.usma.edu/



Design Instructions

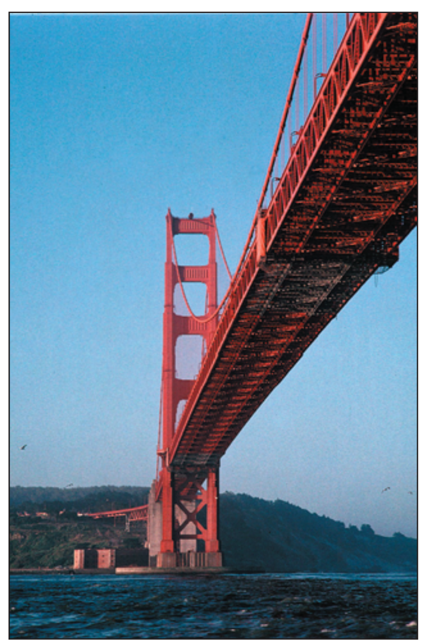
The following instructions are copied directly from the West Point Bridge Designer program. After reading, open up the program and begin designing your structural system based on the criteria given to you by your instructor.

Introduction

When you use the West Point Bridge Designer, you will experience the engineering design process in simplified form. You will design a highway bridge in much the same way that practicing civil engineers design real highway bridges. The West Point Bridge Designer gives you complete flexibility to create designs using any shape or configuration you want. Creating the design is fast and easy, so you can experiment with many different alternative configurations as you work toward the best possible solution to each project. The process you will use is quite similar to the process used by practicing civil engineers as they design real structures. Indeed, the West Point Bridge Designer itself is quite similar to the computer-aided design (CAD) software used by practicing engineers, and it will help you in the same way that CAD software helps them—by taking care of the heavy-duty mathematical calculations so that you can concentrate on the creative part of the design process.

Design Steps

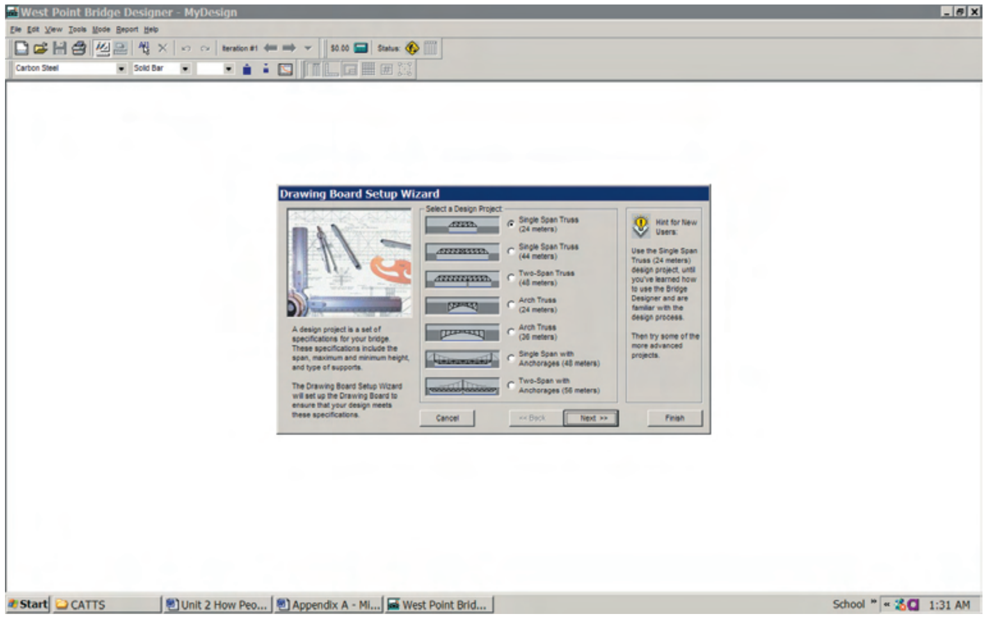
1. You will be presented with a requirement to design a steel truss bridge to carry a two-lane highway across a river. There are seven different design projects to choose from. Each offers a unique set of site conditions that you will need to consider in your design.
2. You will develop a design for your bridge by drawing a picture of it on your computer screen.
3. Once your first design attempt is complete, the West Point Bridge Designer will test your bridge to see if it is strong enough to carry the specified highway loads. This test includes a full-color animation showing a truck crossing your bridge. If your design is strong enough, the truck will be able to cross it successfully; if not, the structure will collapse.
4. If your bridge collapses, you can strengthen it by changing the types of steel and the sizes of the structural components that make up the bridge, or by changing the configuration of the bridge itself.
5. Once your bridge can successfully carry the highway loading without collapsing, you can continue to refine your design, with the objective of minimizing its cost while still ensuring that it is strong enough to carry the specified loads.



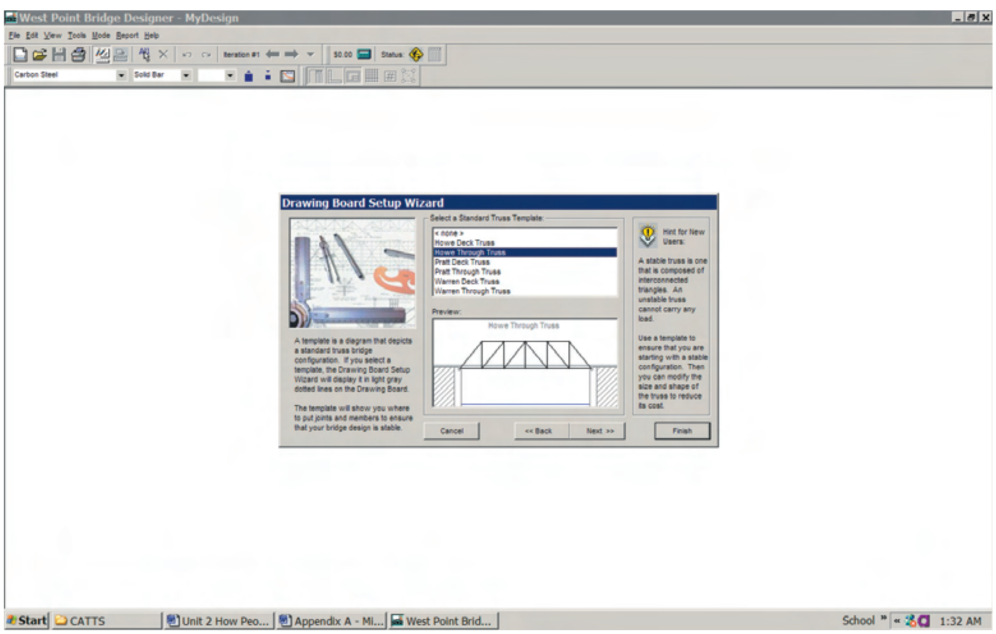
Design Criteria

Your instructor will give you the following design criteria. Use this information to set up the West Point Bridge Designer software.

The Design Project we will be using is the ______________________.



The Truss Template we will be using is the _____________________.

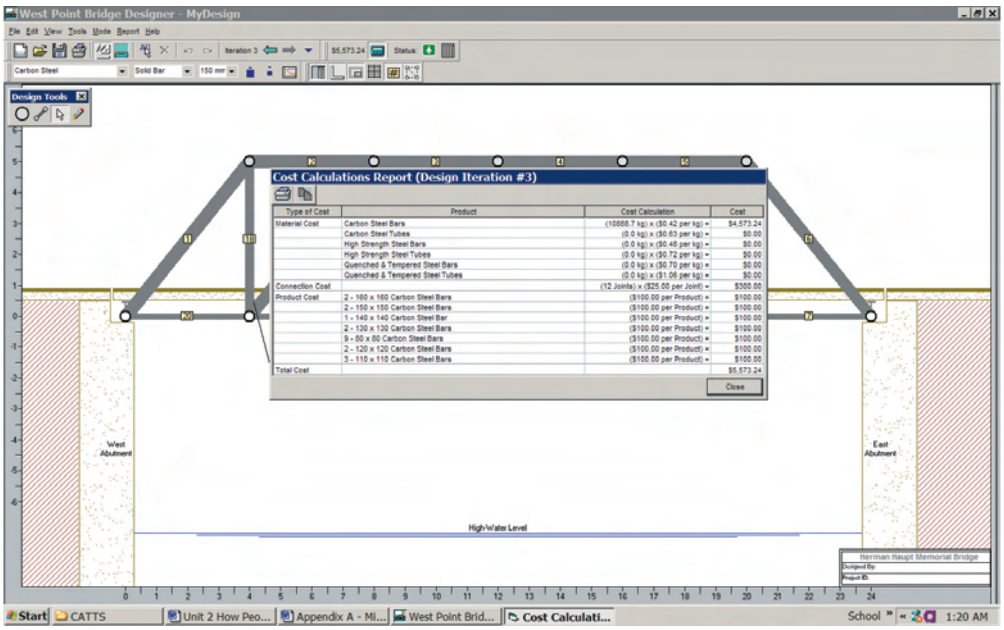


You are to use this criterion to begin engineering your bridge. The object is to design a bridge that meets the given criteria for the lowest cost possible. Begin by designing your bridge so the simulated truck can cross without failure. Once you have done that, move on to the next section, titled Reflection.

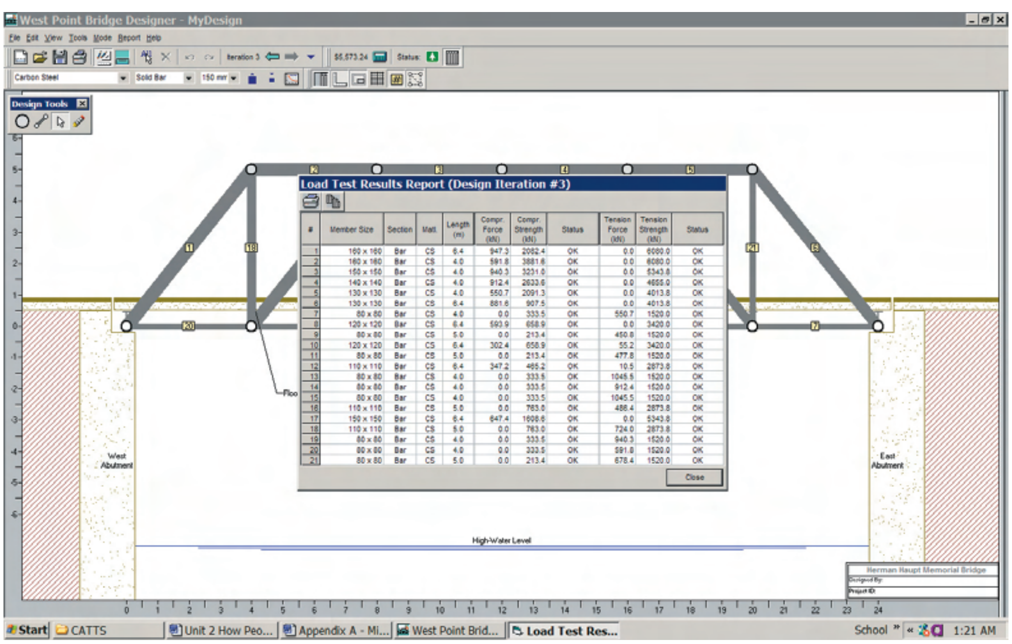
Reflection

Now that you have designed a structural system, it is time to assess your design. Print off your Cost Calculations and Load Test Results sheets. The Cost Calculations sheet represents the material costs to build your bridge. In a technological system, this is known as an INPUT. The Load Test Results sheet represents the total forces each member of the bridge can withstand. In a technological system, this is known as an OUTPUT.

Cost Calculations Data Sheet
(Inputs)



Load Tests Results Sheet
(Outputs)



Data Analysis

After reviewing your Load Test Results sheet, specifically the compression and tensile strength data, which members could you change to decrease the costs of your bridge? What is the minimum strength needed? Fill in the table below with your answers.

Truss Member No.	Current Member Strength (Tension or Compression in kN)	Minimum Strength Needed (Tension or Compression in kN)

Now that you have compared the status of the members that you currently have in your bridge design against the data on the minimum strength needed in these members, it is time to make changes to your design to make it more cost-effective. Making your bridge cost-effective requires you to change or decrease the inputs into your structural system while still maintaining the desired outputs.

There are two methods of reducing the costs of the inputs to your structural system. In the blanks below, describe these two methods.

1. One way of making my bridge more cost-effective is to….

____

____

____

____

2. Another way of making my bridge more cost-effective is to….

____

____

____

____

Redesign

Use the data in the table above and your two methods of reducing the cost to go back and redesign your bridge. Print off a final copy of the Costs Calculations Data Sheet and the Load Tests Results Sheet. Use the information from the tables to answer the following questions.

1. The final cost of my bridge was ______________________.
2. By using the data table and analyzing the engineering constraints, I saved __________ __________ dollars on the cost of my bridge.
   (cost of design 1 – cost of design 2 = money saved)
3. What if there were a shortage of high-strength/low-alloy steel, and you could not afford to use it in your bridge design? Could you still make a bridge that holds the weight of the truck? ______________ If so, how would your bridge be different than your initial design? What output issues would you have to take into consideration? Explain your answer in detail below.

____

____

____

____

____

You now need to print off your bridge design and label the parts of your bridge. You will turn in this **assignment packet** with all **four engineering data sheets** and your labeled **bridge design blueprint** to your instructor.

Grading Criteria – Designing a Structural System

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Use of CAD Program to Design Structural System	Student successfully designed bridge to all engineering specifications.	Student designed bridge to meet most engineering specifications.	Student was unable to use program to design bridge.	
Ability to Use Engineering Data to Enhance Design	Student redesigned structure to optimum efficiency.	Student redesigned structure to be more efficient than original.	Student did not redesign structure to be more efficient than original.	
Ability to Label Parts of Structural System	Student accurately labeled all parts of structural system.	Student accurately labeled most parts of structural system.	Very few parts of the structural system were labeled correctly.	
Ability to Understand Constraints and Impacts of Designing Systems	Student demonstrates clear understanding of constraints and impacts involved in designing systems.	Student understands some constraints and impacts involved in designing systems.	Student does not understand constraints and impacts involved in designing systems.	

Comprehensive Understanding ____/ 12 points

Additional comments:

Unit 3
Systems Evolution

Unit 3: Systems Evolution

Standards for Technological Literacy Standards and Benchmarks

Unit 3 addresses *STL* standards as follows:

- **Standard 2** — **Students will develop an understanding of the core concepts of technology.**
- **Standard 3** — **Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.**
- **Standard 10** — **Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.**

Student Learning Experiences

- **Mix-and-Match** — **Standard 2, Benchmark P and Standard 10, Benchmark G**
- **Inventing the Telegraph** — **Standard 2, Benchmark P and Standard 10, Benchmark G**
- **Inventing the Telegraph – Building a Fax Machine** — **Standard 2, Benchmark P; Standard 3, Benchmark F; and Standard 10, Benchmark G.**

Big Idea

Technological systems are built upon each other.

Acceptable Evidence of Student Understanding

State in writing; describe verbally, in writing, or graphically; list; script; develop visuals; model; present; critique; brainstorm; sketch; draw; photograph; research; engage experts; visit; interview; plan; organize; construct; envision; combine ideas; chart; graph; examine; test; experiment; animate; simulate; evaluate.

Special note: Please keep in mind that criteria must be developed to measure the evidence that students provide in demonstrating their levels of understanding—what are we looking for and how will we know it when we see it? For example, if students are asked to build a model, how will we know if it's a good one?

When considering achievement levels and helping students to understand how they might improve, it will be necessary to know what we mean by terms such as effectively, efficiently, adequately, creatively, thoughtfully, mostly, clearly, minimally, marginally, correctly, safely, systematically, randomly, logically, thoroughly, introspectively, insightfully, and meaningfully. (See **Appendix C, Acceptable Evidence Glossary**, for definitions.)

Student Assessment Criteria – How Systems Evolve

Achievement Level / Sub-concept	Above Target 3	At Target 2	Below Target 1
Serving a Need	Early systems are creatively compared to modern systems, with creative projections for how future systems may evolve to satisfy human needs such as food, shelter, security, health, entertainment, transportation, and communication.	Early systems are adequately compared to modern systems, with some projections for how future systems may evolve to satisfy human needs such as food, shelter, security, health, entertainment, transportation, and communication.	Early systems are limited in comparison to modern systems, with few projections for how future systems may evolve to satisfy human needs such as food, shelter, security, health, entertainment, transportation, and communication.
Influence of Other Subject Matter	Related scientific and mathematical concepts are effectively used as the underpinnings and tools that are essential to the development of modern technological systems. Technology is illustrated as a means of advancing science.	Related scientific and mathematical concepts are used to a small degree as the underpinnings and tools that are essential to the development of modern technological systems. Technology is described as a means of advancing science.	Related scientific and mathematical concepts are used little as the underpinnings and tools that are necessary to the development of modern technological systems. Technology is described as a means of advancing science.
Interfacing Systems	Several simple systems are used in combination to design, prototype, and test a more complex system, using more than a few component parts to creatively accomplish a specified task.	A few simple systems are used in combination to design, prototype, and test a more complex system, using more than a few component parts to adequately accomplish a specified task.	Just two simple systems are used in combination to design, prototype, and test a more complex system, using more than a few component parts to partially accomplish a specified task but with minimal effectiveness.
Assessing Impacts	Simple, complex, old, new, and future systems are creatively and thoroughly assessed for effectiveness, spin-offs, trade-offs, benefits, shortcomings, short- and long-term results, and overall impacts on individuals, the global community, and the environment.	Simple, complex, old, new, and future systems are adequately assessed for effectiveness, spin-offs, trade-offs, benefits, shortcomings, short- and long-term results, and overall impacts on individuals, the global community, and the environment.	Simple, complex, old, new, and future systems are minimally assessed for effectiveness, spin-offs, trade-offs, benefits, shortcomings, short- and long-term results, and overall impacts on individuals, the global community, and the environment.

Overview

The main goal of this unit is to show students the patterns of systems development and the connections between these systems. Key concepts covered in this unit include innovation, forecasting, and product development.

Narrative

Throughout history, many technological devices and systems have been developed by modifying or adding to existing technological devices or systems. This is the process we refer to as innovation. Innovations often follow patterns and trends in the development of new materials, different processing techniques, and different needs and requirements of the society. Examples of systems that have been built upon each other include:

- Rock –> club –> spear –> bow and arrow –> crossbow
- Bicycle –> glider –> airplane –> jet
- Wheel –> scooter –> rollerskates –> rollerblades
- Telegraph –> telephone –> network –> computer –> intranet –> Internet

As we build upon these systems, they often become more complex in nature, as they can contain more parts. It is essential that these new parts work together with the existing parts for the system to operate properly. With this in mind, a large emphasis is placed on the proper integration and standardization of new parts in a system. A technologist is able to understand different systems and even forecast the integration of these systems into larger systems.

Teacher Preparation

In order to successfully prepare for teaching this unit, the teacher should:

- Research historical technologies in textbooks, timelines, encyclopedias, etc.
- Gather references for student research.
- Understand the six technical communications concepts (encoding, transmitting, receiving, storing, retrieving, and decoding) and how it pertains to the telegraph and fax machine.

Enduring Experiences

Lesson 1: Mix-and-Match

By the middle school level, students have already been exposed to operating many different technological systems through their everyday encounters. Students may use these systems, yet not be able to break down their development or forecast new applications of the system. During Unit 2, *How People Interact With Systems*, students were required to diagram a technological system and identify the parts. During this activity, students will work together and combine their systems to innovate a new technology.

Lesson 2: Inventing the Telegraph

The telegraph is one of the most important technologies ever invented. One of the reasons it was so important is that it started the development of communications networks. Today it is hard to imagine the world without communications networks such as cable television, telephones, and the Internet. During this activity you will be inventing a telegraph system. In your next activity you will innovate the telegraph and build a fax machine.

Lesson 3: Innovating the Telegraph – Building a Fax Machine

As stated above, the telegraph was an extremely important technology because it sparked the beginning of telecommunications networks. It was also important since many other technological systems were developed by innovating the basic idea of the telegraph. For example, add a microphone and a speaker to the telegraph and you have a telephone system. Add even more components and you have a phone with an answering machine that can store your message. Another innovation of the telegraph that allows you to store information is the fax machine. A fax machine transmits an electric impulse over a distance and then turns the electric impulse into text on a piece of paper. During this activity you will be innovating the telegraph system by adding components to construct a fax machine.

Name 1: ______________________

Name 2: ______________________

Date: ______________________

Hour: ______________________

Technological Systems
Unit 3: Systems Evolution

Lesson 1: Mix-and-Match

Objectives:
Upon successful completion of this activity you should be able to:
- Combine two or more technologies to make a new technology.
- Describe how the parts of the system are going to work together.
- List the benefits and the problems that would arise with the integration of two or more technologies into a larger system.

Connections:
During this activity you will be applying knowledge from the following area:
- Language Arts – technical writing

Directions:
For this activity, you will be using the previous assignment, How Things Work, from Unit 2: How People Interact With Systems. Your teacher will match you up with a partner. As a team, you will modify and combine the technological devices you diagrammed to form a new system of parts that work together to accomplish a new or modified task.

Technological Devices:
The technological devices we are going to combine include a ________________ and a ________________.

New Innovation:
The new innovation we are creating is called the ____________________.

Sketch

In the space provided below, sketch your new technological device and label all the parts.

Parts Used

In the table below, list the parts of your devices in the first two columns. In the third column list the parts you are going to use for you new system. In the fourth column describe the functions of the parts in the new system.

Part names for the ___________	Part names for the ___________	Parts used in the new system	Function of the part in the new system

Function of The New System

In the space provided below, describe the function or the task that the new system performs.

Grading Criteria – Mix-and-Match

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Sketch	Accurately depicts the chosen device in complete detail.	Most details are included and drawn accurately.	Sketch does not depict device, missing significant details.	
Parts Labeled	Most parts are accurately labeled.	Some parts are accurately labeled.	Very few parts are labeled correctly.	
Part Identification and Function	Most parts are correctly identified and functions accurately described.	Some parts are correctly identified and functions accurately described.	Very few parts are correctly identified and described.	
Description of Operation	Written and verbal descriptions demonstrate clear understanding of the systems operation.	Written and verbal descriptions skip some key steps in the operation.	Written and verbal descriptions do not demonstrate correct operation of system.	
Incorrect Operation	Student understands a variety of consequences of incorrect operation.	Student understands some consequences of incorrect operation.	Student demonstrates little understanding of consequences of incorrect operation.	

Comprehensive Understanding ____/ 15 points

Additional comments:

Name 1: ____________________

Name 2: ____________________

Date: ____________________

Hour: ____________________

Technological Systems
Unit 3: Systems Evolution

Lesson 2: Inventing the Telegraph

Objectives:
Upon successful completion of this activity you should be able to:
- Use tools to process materials into a useful technological system.
- Describe how the parts of an electrical system work together.
- Understand how a telegraph performs the communications concepts of encoding, transmitting, receiving, and decoding.
- Transmit a message from sender to receiver.

Connections:
During this activity you will be applying knowledge from the following areas:
- Science – electricity
- Mathematics – measurement

Directions:
During this activity you will be constructing a simple electrical system known as a telegraph. This system consists of a variety of parts working together to accomplish a task. When these parts work together properly, they allow you to communicate a message over a distance. The materials needed and the steps in constructing a telegraph are listed below.

Tools Required
The following tools are needed to construct a telegraph system. Other tools may be substituted when noted.
- Bandsaw (used to cut plastic or wood)
- Portable electric drill or drill press
- Phillips screwdrivers
- Needle-nose pliers
- Wire strippers
- Hot glue guns

Materials Needed

The following materials are needed to construct a telegraph. Other materials may be substituted when noted.

- ½ inch PVC pipe (large enough inside diameter to fit AA battery)
- PVC endcaps (two per telegraph)
- Small bolts, nuts, and washers (suggest number 8, ½ inch long)
- Wire (single strand from telephone cable works well)
- Aluminum tape (a 3M product) (optional for replacing some wire)
- 1.5-3 volt piezo electric buzzer (can be purchased at Radio Shack for around $1.50)
- Christmas tree lightbulbs
- Electrical tape
- AA batteries
- Morse code sheet (included with this activity)

Fabricating Instructions

Follow the instructions below to safely construct a telegraph.

Battery Holder (fabricating instructions much like continuity tester)

1. Cut PVC pipe to length of battery.
2. Drill small hole (large enough for #8 bolt) in end of each PVC end cap.
3. Insert bolt into end caps from inside out.
4. Wrap wire around end of bolt.
5. Put on washers and tighten nuts.

Sending Unit (base for holding battery holder, switch, and Morse code sheet)

1. Cut piece of ⅛" polycarbonate or acrylic into 6" x 8" rectangle
2. Drill ¼" holes for attaching switch
3. Form material using either a vice (polycarbonate) or a strip heater (acrylic) to look like the drawing on the next page.
4. Attach Morse code sheet with Scotch tape.

Switch (you will be creating a momentarily closed, pushbutton switch)

1. Cut piece of ⅛" polycarbonate into 1" x 6" strip.
2. Drill ¼" hole in one end.
3. Form material with a vice to look like the drawing on the next page.
4. Wrap switch with aluminum tape.

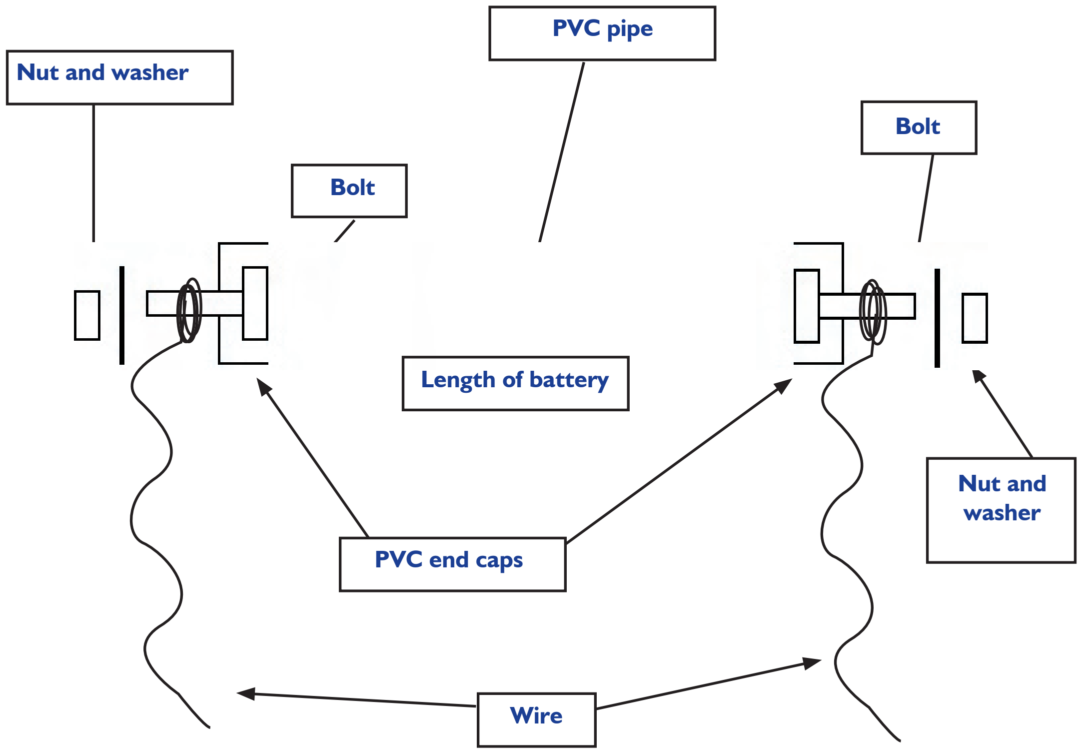
Receiving Unit (base for holding piezo electric buzzer)

1. Cut piece of ⅛" polycarbonate or acrylic into 6" x 8" rectangle, just like sending unit.
2. Form material using either a vice (polycarbonate) or a strip heater (acrylic) to look like the drawing on page 83.
3. Use hot glue to attach piezo electric buzzer.
4. Attach Morse code sheet with scotch tape.

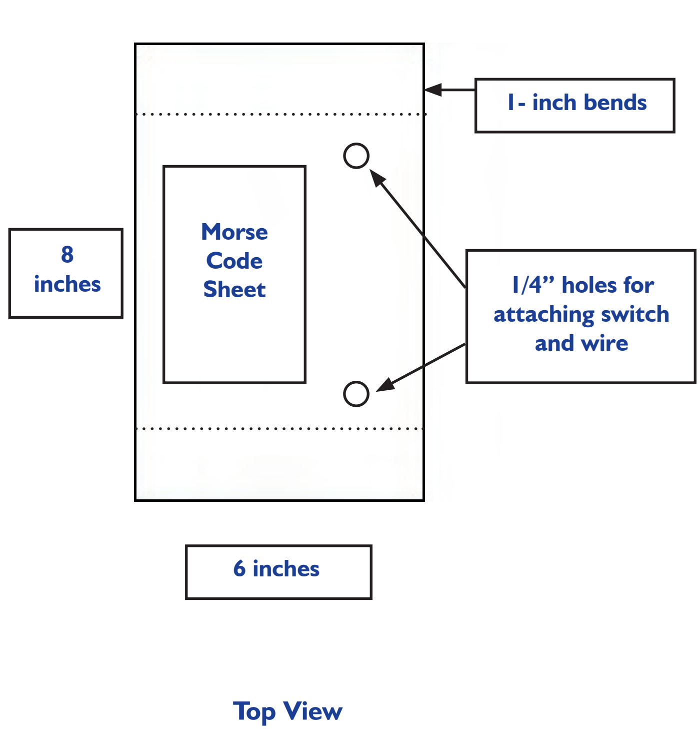
Wiring

1. Cut pieces of telephone cable to approximately eight feet long.
2. Strip ends of wire.
3. Cut one piece of telephone cable to approximately six inches.
4. Wire a simple series circuit between switch, battery holder, and piezo buzzer as shown in the diagram on page 83.

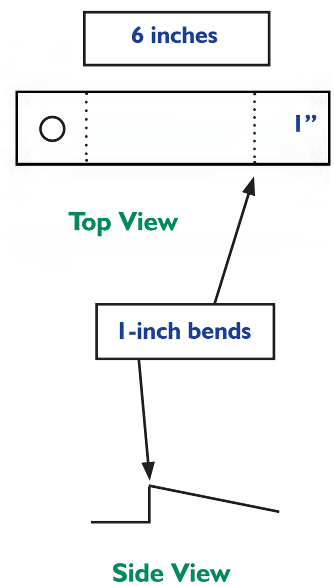
Battery Holder



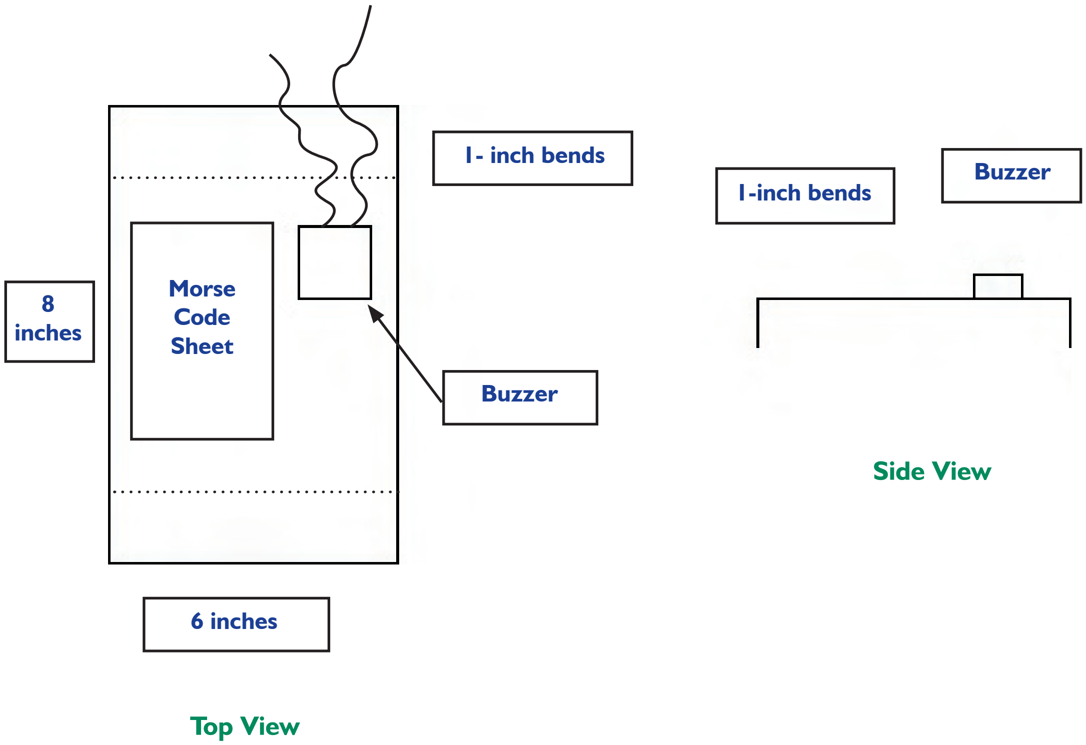
Sending Unit



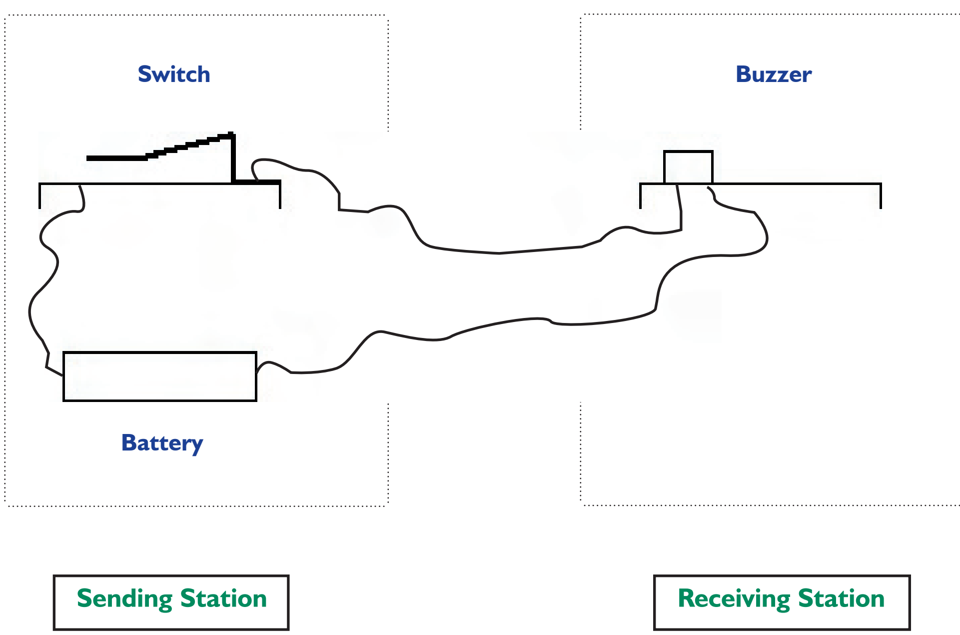
Switch



Receiving Unit



Wiring Diagram



Morse Code Sheet

A •—	B —•••	C —•—•	D —••
E •	F ••—•	G ——•	H ••••
I ••	J •———	K —•—	L •—••
M ——	N —•	O ———	p •——•
Q ——•—	R •—•	S •••	T —
U ••—	V •••—	W •——	X —••—
Y —•——	Z ——••		

A •—	B —•••	C —•—•	D —••
E •	F ••—•	G ——•	H ••••
I ••	J •———	K —•—	L •—••
M ——	N —•	O ———	p •——•
Q ——•—	R •—•	S •••	T —
U ••—	V •••—	W •——	X —••—
Y —•——	Z ——••		

Samuel Morse

Using Your Telegraph

Now that you have constructed an electrical communication system, it is time to put it to work. If your system is functioning properly, your telegraph should make a buzzing sound when you depress the switch. If this is not working, use the continuity tester you built earlier to help troubleshoot and diagnose the system failure. Once your telegraph is functioning properly, your task is to encode (put information into desired format) a message from the sending station to your partner at the receiving station. Do this by transmitting the messages listed in the "Challenge" below. Have your partner record the messages in the recording section.

Recording Your Results

Your instructor will give half the class (the senders) five short sentences. Write them in the blanks provided below. Your challenge is to transmit the messages to your partner using Morse code (short and long beeps). Your partner should decode the messages and write them in the blanks provided below (use a piece of scratch paper if needed). Once you have completed the sentences, you will switch with your partner and he/she will be the sender and you will be the receiver. Repeat the process above and record your results.

Challenge

The five sentences I will be encoding and transmitting to my partner include (instructor secretly gives to students who are sending messages):

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

The five sentences I will be decoding include (decipher your messages in the blanks below):

1. ______________________________
____
____
2. ______________________________
____
____
3. ______________________________
____
____
4. ______________________________
____
____
5. ______________________________
____
____

Reflection

You just built an electrical system called a telegraph. This system contains many different parts that work together to complete a task. In the table below, list the parts of the telegraph system as well as their purposes.

Part Name	Purpose

In the space below, describe the process of sending a message from the sender to the receiver. Use the terms encoding, transmitting, receiving, and decoding in your explanation.

Grading Criteria – Inventing the Telegraph

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Use of Tools to Process Materials	Telegraph is built to fabricating specifications and functions properly.	Most fabricating specifications were met. Telegraph functions properly.	Telegraph is poorly constructed and/or does not function properly.	
Component Identification	Student accurately identified parts of the system.	Some parts were identified accurately.	Very few parts are correctly identified.	
Component Purpose	Student accurately explained purposes of parts.	Student explained some purposes of the parts correctly.	Student did not explain purposes accurately.	
Communication Process	Student demonstrates clear understanding of communications processes.	Student partially understands communications processes.	Student does not understand communications processes.	

Comprehensive Understanding ____/ 12 points

Additional comments:

Name 1: ___________________________

Name 2: ___________________________

Date: ___________________________

Hour: ___________________________

Technological Systems
Unit 3: Systems Evolution

Lesson 3: Innovating the Telegraph – Building a Fax Machine

Objectives:
Upon successful completion of this activity you should be able to:
- Use tools to process materials into a useful technological system.
- Modify your telegraph system and create a fax machine.
- Explain what it means to innovate.
- Describe how a fax machine can transmit information from one location to another using the following technical communications concepts: encoding, transmitting, receiving, storing, retrieving, and decoding.

Connections:
During this activity you will be applying knowledge from the following areas:
- Science – electricity
- Mathematics – measurement, graphing

Directions:
During this activity you will be building upon the telegraph that you made in the last activity to produce a new technological system called the fax machine. This process is called innovation. Much like the telegraph, this technological device will allow you to transmit a message over a distance. The fax machine, however, will allow you to send a stored text message. The materials needed and the steps in innovating your telegraph are listed below.

Tools Required
The following tools are needed to modify your telegraph into a fax machine. Other tools may be substituted when noted.
- Bandsaw (used to cut plastic or wood)
- Portable electric drill or drill press
- Phillips screwdrivers
- Needle-nose pliers
- Wire strippers
- Hot glue guns

Materials Needed

The following materials are needed to modify your telegraph onto a fax machine. Other materials may be substituted when noted.

- Small bolts, nuts, and washers (suggest number 8, ½ inch long)
- Wire (single strand from telephone cable works well)
- Aluminum tape (a 3M product) (optional for replacing some wire)
- Christmas tree lightbulbs
- Electrical tape
- Foam board

Fabricating Instructions

Follow the instructions below to safely modify your telegraph into a fax machine.

Switch

(You will be creating a momentarily closed, pushbutton switch.)
You will be adding another switch to the sending unit of your telegraph. This switch works the same way as the switch on you telegraph; however, it will be connected to a lightbulb instead of a buzzer.

1. Cut piece of ⅛” polycarbonate into 1” x 6” strip.
2. Drill ¼” hole in one end.
3. Form material with a vice to look like drawing on the following page.
4. Wrap switch with aluminum tape.

Sending Unit

1. Remove the Morse code sheet from your telegraph.
2. Drill two ¼” holes for the switch you made above. (This is the same process as the original switch on the telegraph; however, this time the holes are on the left side of the sending unit.)
3. Using a small bolt and nut, attach the switch to the base and insert one bolt for the switch contact.

Receiving Unit

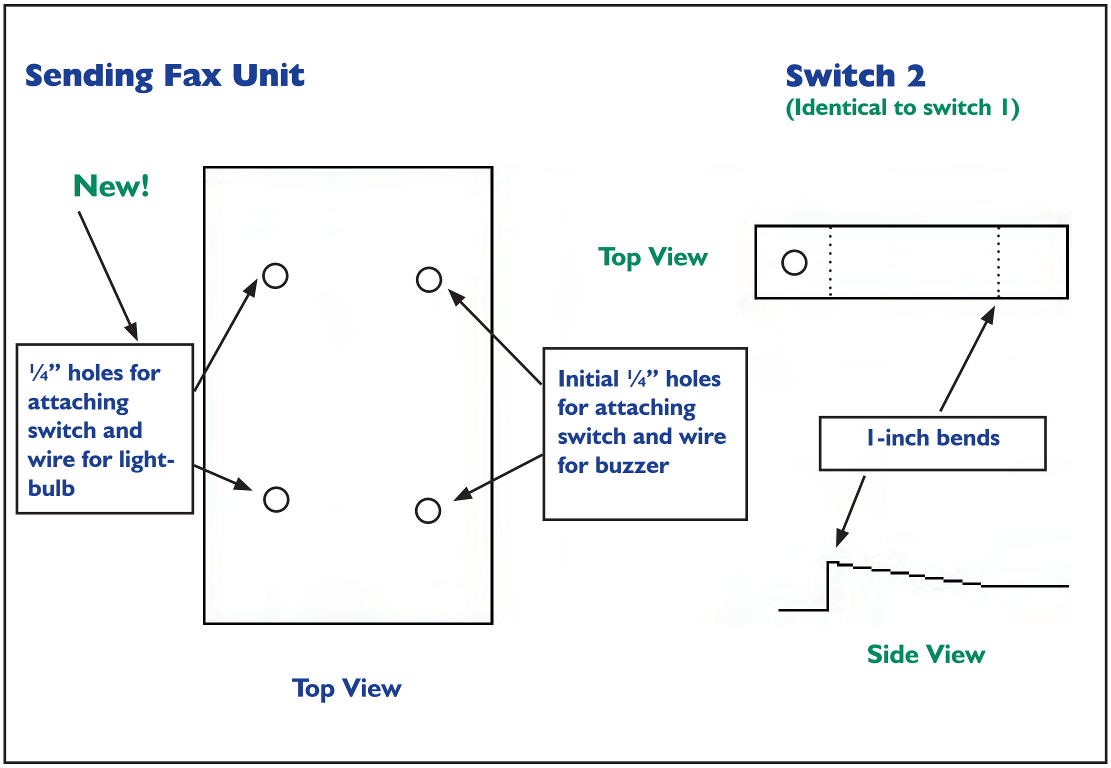
1. Drill a 5⁄16” diameter hole next to the piezo buzzer.
2. Insert one small Christmas tree lightbulb.

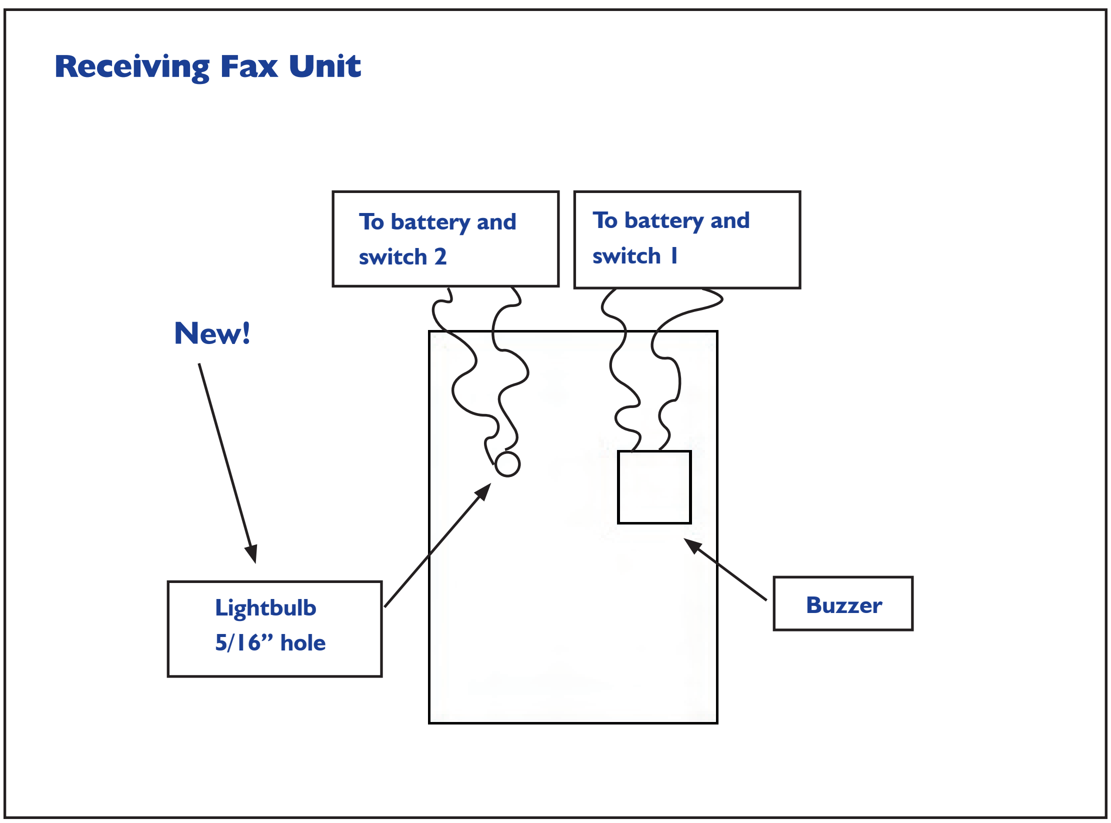
Wiring

1. Cut two wires to approximately eight feet long.
2. Strip ends of wire.
3. Wire two simple series circuits, one between the switch, battery holder, and piezo buzzer, and one between the other switch, battery holder, and lightbulb as shown in the diagram on page 91.

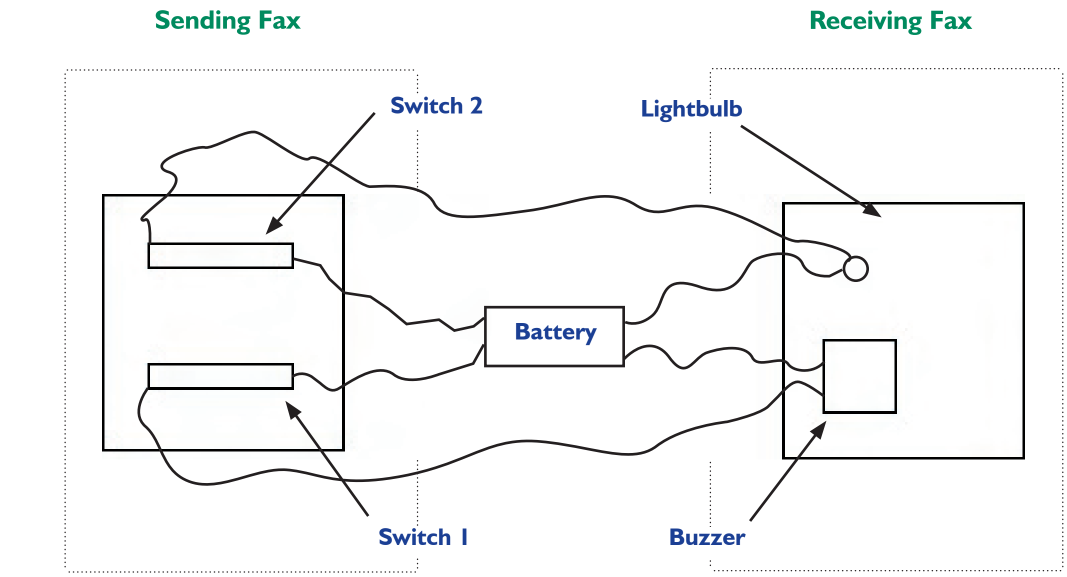
Decoding Pad

1. Cut two 10” x 10” foam board squares for each fax machine.
2. Cut 1” strips and hot glue to foam board as shown in the diagram on page 91.
3. Using a ruler, mark and number 1” increments on top, bottom, and side 1” strips as shown in the diagram on page 91.

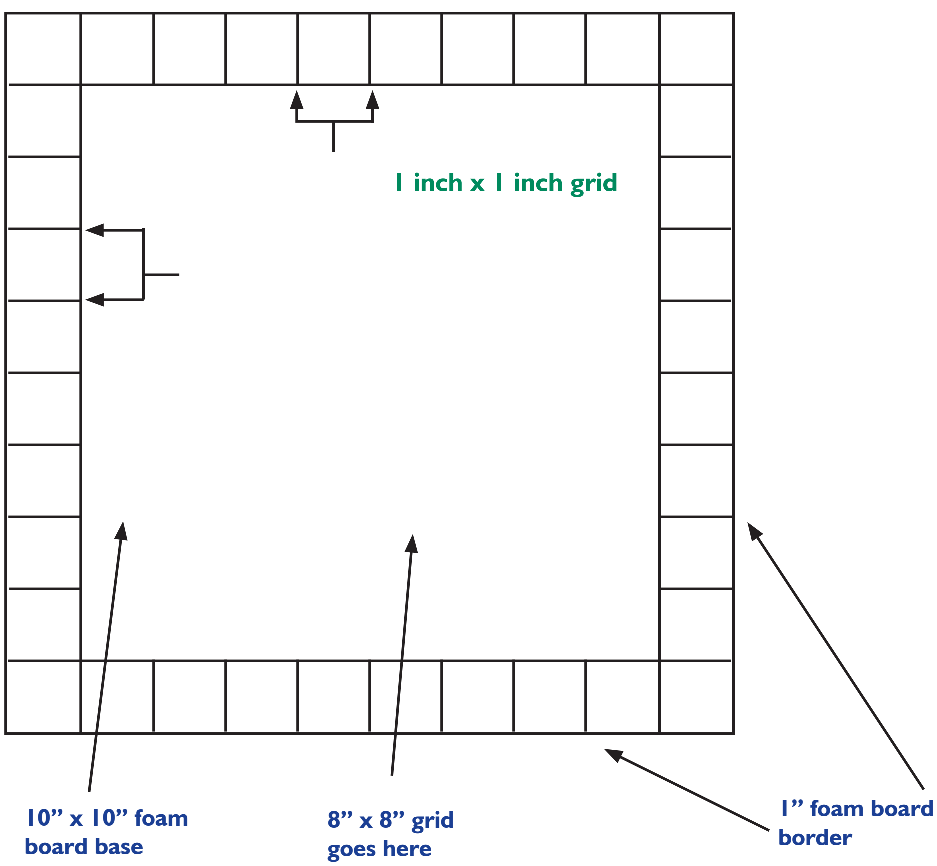

Sending Fax Unit
Switch 2
(Identical to switch 1)
New!
¼" holes for attaching switch and wire for light-bulb
Initial ¼" holes for attaching switch and wire for buzzer
Top View
1-inch bends
Side View
Top View


Receiving Fax Unit
To battery and switch 2
To battery and switch 1
New!
Lightbulb 5/16" hole
Buzzer

Wiring Diagram



Encoding/Decoding Pad (x 2 per fax machine)



Using Your Fax Machine

Now that you have modified your telegraph, it is time to put it to work. If your system is functioning properly, your telegraph should make a buzzing sound when you depress switch No. 1, and the light should come on if you push down on switch No. 2. If this is not working, use the continuity tester you built earlier to help troubleshoot and diagnose the system failure (start at the battery supply and work your way through the circuit). Once your telegraph is functioning properly, your task is to encode (put information into desired format) a message from the sending fax machine to your partner at the receiving fax machine. Follow the directions below to transmit your message.

Transmitting Directions

1. *Sender* – fill in the squares on your grid paper to represent a number or letter (for the number "one" you would fill in the middle vertical squares).
2. *Receiver* – place a blank grid sheet in your foam decoding station.
3. *Sender* – start at the 0,0 square and perform one of the following steps:
   - if the square is not filled in, depress the buzzer switch to instruct the decoder to move to the next cell.
   - if the square is filled in, press the light switch to instruct the decoder to put an X in the square.
4. *Sender* – once you are done with the first row, go down to the second row.
5. *Sender* – go through the entire grid until the letter is transmitted to the decoder.
6. *Receiver* – once finished, go back and fill in the boxes with an X in them….What letter or number was communicated?

Recording Your Results

Once you have completed transmitting one word, you will switch with your partner and he/she will be the sender and you will be the receiver. Repeat the process above and record your results on a separate piece of paper.

Reflection

Congratulations! First you invented the telegraph, now you have modified it and have created a functioning fax machine. You are truly an innovator! Now it is time to find out what you learned about the advancements of technological systems.

Many technological systems are built upon each other. Often, additional parts or components are added to the original technology. What additional components did you add to your telegraph to make it into a fax machine?

____

____

____

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____

____

____

____

Do these components make the system **more** or **less** complicated in design? Why?

What system do you think was easier to use—the telegraph or the fax machine? Which system allowed you to transfer the message more accurately?

Many other technological systems are built upon each other. In the table below, write the name of an original technological system in the first column and a technology that was built upon that system in the second column.

Original Technology	New Technology

Grading Criteria – Inventing the Telegraph – Building a Fax Machine

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Use of Tools to Process Materials	Fax machine is built to fabricating specifications and functions properly.	Most fabricating specifications were met. Fax machine functions properly.	Fax machine is poorly constructed and/or does not function properly.	
Component Identification	Student accurately identified additional components of new system.	Some new components were identified accurately.	Very few parts are correctly identified and described.	
Systems Design vs. Use – Sophistication Trade-off	Student demonstrates clear understanding of sophistication trade-off.	Student partially understands systems sophistication trade-off.	Student does not understand systems sophistication trade-off.	
Characteristics of Systems Development	Student demonstrates clear understanding of the characteristics of systems development.	Student partially understands systems development.	Student does not understand characteristics of systems development.	

Comprehensive Understanding ____/ 12 points

Additional comments:

Unit 4
Systems Adjustments

Unit 4: Systems Adjustments

Standards for Technological Literacy Standards and Benchmarks
Unit 4 addresses *STL* standards as follows:

- **Standard 2** — **Students will develop an understanding of the core concepts of technology.**
- **Standard 3** — **Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.**

Student Learning Experiences

- **Piloting an Airplane** — **Standard 2, Benchmarks N, S, and V; and Standard 3, Benchmark D.**
- **Calibrating a Catapult** — **Standard 2, Benchmarks N, S, and V; and Standard 3, Benchmark D.**

Big Idea
Adjustments made to the inputs of a technological system result in changes to the outputs of the system.

Acceptable Evidence of Student Understanding

State in writing; describe verbally, in writing, or graphically; list; script; develop visuals; model; present; critique; brainstorm; sketch; draw; photograph; research; engage experts; visit; interview; plan; organize; construct; envision; combine ideas; chart; graph; examine; test; experiment; animate; simulate; evaluate.

Special note: Please keep in mind that criteria must be developed to measure the evidence that students provide in demonstrating their levels of understanding—what are we looking for and how will we know it when we see it? For example, if students are asked to build a model, how will we know if it's a good one?

When considering achievement levels and helping students to understand how they might improve, it will be necessary to know what we mean by terms such as effectively, efficiently, adequately, creatively, thoughtfully, mostly, clearly, minimally, marginally, correctly, safely, systematically, randomly, logically, thoroughly, introspectively, insightfully, and meaningfully. (See **Appendix C, Acceptable Evidence Glossary**, for definitions.)

Student Assessment Criteria – Modifying Systems

Achievement Level / Sub-concept	Above Target 3	At Target 2	Below Target 1
Monitoring / Assessing Outputs	Conducts a comprehensive assessment (gathering, recording, and analysis) of data regarding the outputs of a system to determine the extent to which the initial objective was accomplished, new knowledge was generated, the effects the outputs have had on the organization, agency, or institution, and the impacts these outputs have had on individuals, society, and the environment.	Conducts an adequate assessment (gathering, recording, and analysis) of data regarding the outputs of a system to determine the extent to which the initial objective was accomplished, new knowledge was generated, the effects the outputs have had on the organization, agency, or institution, and the impacts these outputs have had on individuals, society, and the environment.	Conducts a limited assessment (gathering, recording, and analysis) of data regarding the outputs of a system to determine the extent to which the initial objective was accomplished, new knowledge was generated, the effects the outputs have had on the organization, agency, or institution, and the impacts these outputs have had on individuals, society, and the environment.
Evaluating Outcomes	Conducts a comprehensive review of the assessment findings to determine the overall positive and negative effects of the system's outputs. The resulting evaluation provides feedback in the form of creative and promising recommendations for improvement to the system's input, process, and assessment components.	Conducts a review of the assessment findings to determine the overall positive and negative effects of the system's outputs. The resulting evaluation provides feedback recommendations for improvement to the system's input, process, and assessment components.	Conducts a review of the assessment findings to determine the positive and negative effects of the system's outputs. The resulting evaluation provides feedback, with few recommendations for improvement to the system's input, process, and assessment components.
Adjusting Inputs, Processes, and Assessment	Determines and makes creative and appropriate adjustments to the system based on the evaluation recommendations, with substantial effects on the system. This could include changes in the inputs, execution of the processes, techniques for monitoring and assessment, and the quality of the evaluation recommendations.	Determines and makes appropriate adjustments to the system based on the evaluation recommendations, with some effects on the system. This could include changes in the inputs, execution of the processes, techniques for monitoring and assessment, and the quality of the evaluation recommendations.	Determines and makes few adjustments to the system based on the evaluation recommendations, with minimal effects on the system. This could include changes in the inputs, execution of the processes, techniques for monitoring and assessment, and the quality of the evaluation recommendations.
Reassessing Outcomes	Operates the adjusted system, collects meaningful new assessment data, introspectively analyzes those data, and re-evaluates the system to determine the extent to which the adjustments caused the system to function more effectively.	Operates the adjusted system, collects new assessment data, analyzes those data, and re-evaluates the system to determine the extent to which the adjustments caused the system to function more effectively.	Operates the adjusted system, collects marginally useful assessment data, analyzes those data with few insights, and re-evaluates the system to determine the extent to which the adjustments caused the system to function more effectively.

Overview

The main goal of this unit is to teach students to understand that adjusting the input variables to a technological system directly reflects the state of the output of the system. In this unit, students will be exposed to different technological systems and be given the option to adjust the input variables and observe the change in outputs. Students will then be challenged to predict the adjustments needed to obtain a specific, desired output. Key concepts covered in this unit include forecasting, technological trade-offs, optimization, safe use of tools, and material processing techniques.

Narrative

In today's age, we are given infinite options for changing the way our technological systems operate and perform. With all these options available to us, it is crucial that we understand how to optimize our choices to most efficiently obtain the desired outputs. Take, for example, a heating system in a house. We can adjust the thermostat to receive the desired output temperature. Is it better to leave the temperature at a constant level, or is it better to turn the thermostat down when not needed and crank it up when you get home? Different decisions on the adjustments may determine if the output is desired, undesired, optimum, or wasteful.

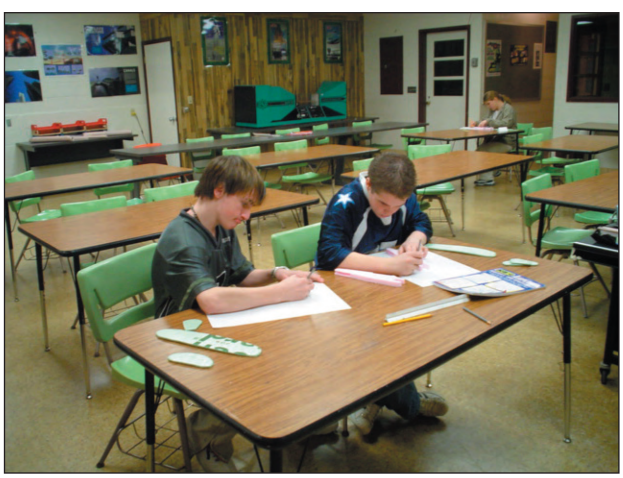
Another example deals with the use of a computer scanner. The output quality of the image is directly reflected by the adjustments made to the scanning resolution setting in the scanning software. What output image quality is required for the application? Some applications may be better suited for an image with less resolution and, therefore, less memory space (i.e., a Web page). Other applications may require a higher quality image to present more clarity (i.e., picture in a newspaper or book). By understanding that adjustments to the input of a technological system result in changes in the outputs, students can begin to formulate how to make these adjustments optimum for the desired application.

Teacher Preparation

In order to successfully prepare for teaching this unit, the teacher should:

- Gather various systems examples and make a table comparing adjustment made vs. output changed (i.e. automobile – accelerate more, use more fuel).
- Obtain a technological system and demonstrate to students how adjustments in inputs affect the outputs (i.e. set a toaster at different settings and show students the different outputs).

Enduring Experiences

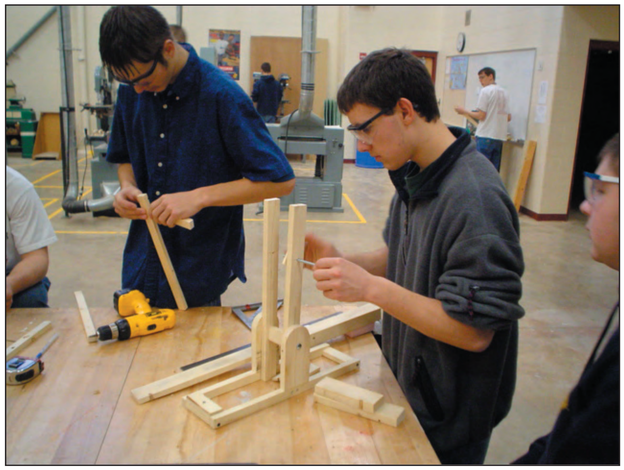


Lesson 1: Piloting an Airplane

During this activity, students will be fabricating a foam model airplane. This airplane will be connected to a center control stand, which will allow them to adjust the amount of voltage (thrust) going to the electric motor in the plane. By making this adjustment, students can increase or decrease the amount of thrust of their airplanes, thus increasing or decreasing the amount of lift.

Lesson 2: Calibrating a Catapult

During this activity, students will be fabricating a small wooden catapult. The design of this catapult incorporates a total of 625 different adjustment options. After construction, students will have the opportunity to calibrate their catapults to launch a projectile at targets at specified distances. This activity will allow students to adjust their technological system to receive the desired outputs.



Name: ______________________

Date: ______________________

Hour: ______________________

Technological Systems
Unit 4: Systems Adjustments

Lesson 1: Piloting an Airplane

Objectives:
Upon successful completion of this activity you should be able to:
- Use tools, materials, and machines to safely fabricate a simple system.
- Follow assembly instructions to successfully manufacture a system.
- Explain how changing the inputs to a technological system changes the outputs.

Connections:
During this activity you will be applying knowledge from the following areas:
- Science – forces, electricity
- Mathematics – measurement

Directions:
During this activity you will be manufacturing an airplane. An airplane is a technological system that consists of many parts working together to accomplish a task. When these parts work together properly, they allow you to change such outputs as airspeed, altitude, direction, etc. The materials needed and the steps in fabricating your airplane are described below.

Tools Required
The following tools are needed to fabricate your airplane. Other tools may be substituted when noted.
- Hot wire cutter
- Hot glue gun
- Scissors
- Wooden airplane templates

Materials Needed

The following materials are needed to fabricate your airplane:

- Polystyrene foam insulation – usually pink or gray
- ¼" polystyrene foam sheathing (usually green)
- Hot glue sticks
- Small brads

Fabricating Instructions

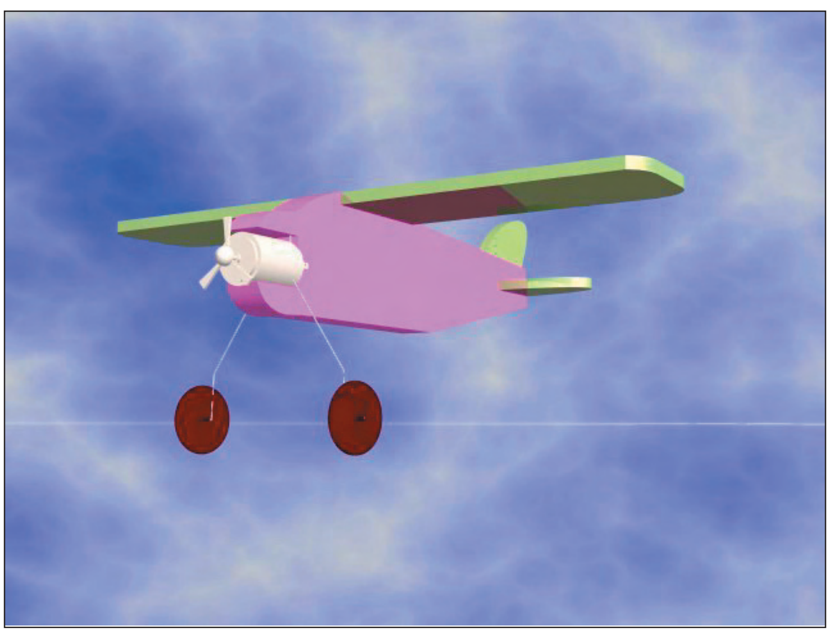
Follow the instructions below to safely manufacture your airplane.

1. Pin the fuselage pattern, provided by your instructor, to your piece of pink foam.
2. Using the hot wire cutter, cut out the fuselage by running the hot wire against the edge of the template.

CAUTION: HOT WIRE CUTTERS CAN BURN – DO NOT TOUCH WIRE.

3. Evenly place the wing, rudder, and elevator templates on the piece of green foam.
4. Trace around the templates with a marker.
5. Using scissors, cut out the wing, rudder, and elevator.
6. Hot glue the airplane together.

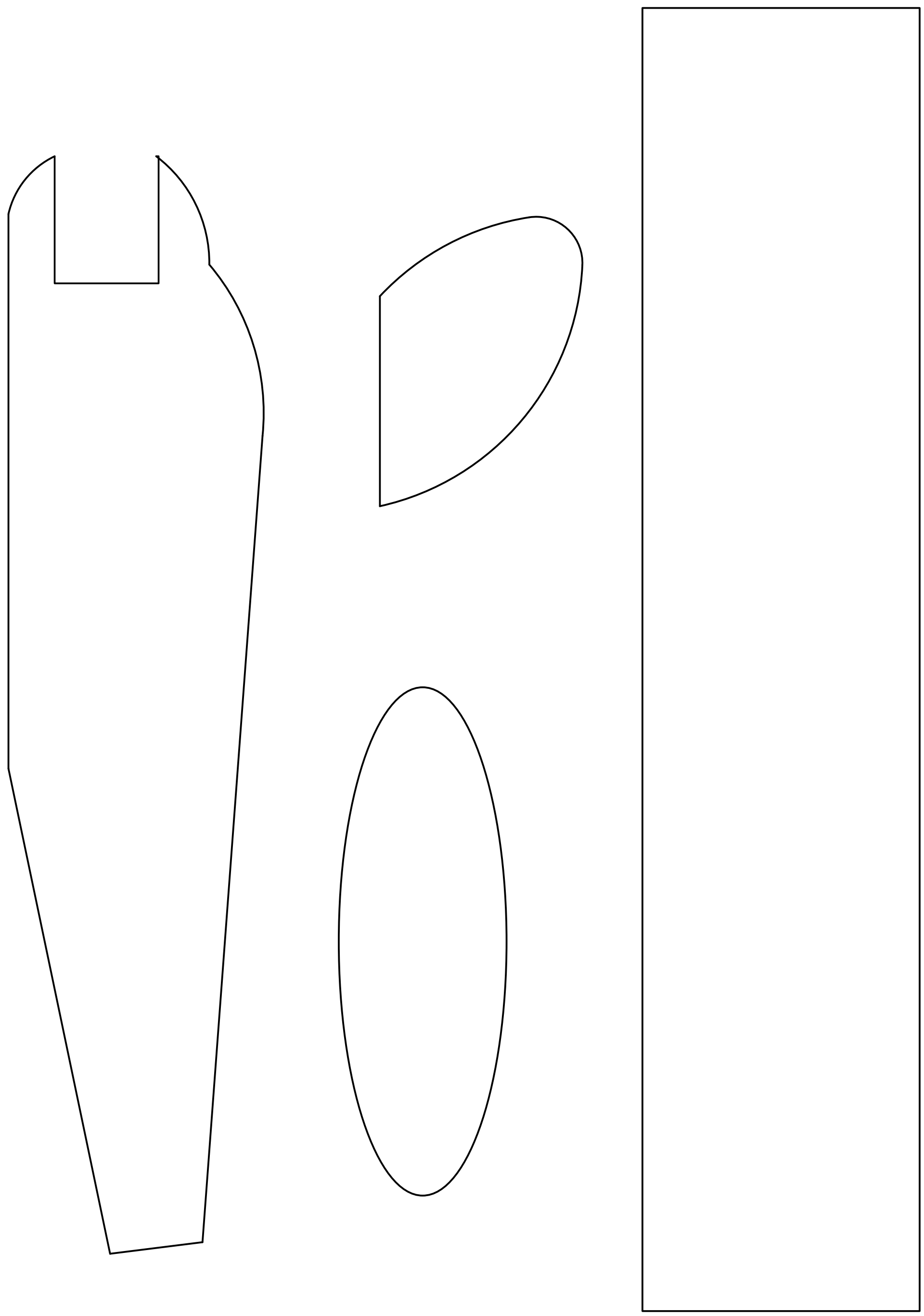
CAUTION: HOT GLUE GUNS AND GLUE CAN BURN –
DO NOT TOUCH TIP OF GLUE GUN.



This is how your airplane should look when it is completed.

Airplane Templates

The following templates should be scaled so that the fuselage is approximately 11.5 inches long and the main wingspan is approximately 14 inches long.



Flying Your Airplane

Now that you have built your airplane, it is time to fly it. In order for you to fly your airplane, your instructor had to also build a technological system. This system is called the *Control Stand*. The control stand allows you to change the input voltage going to the electric motor in your airplane. By changing the voltage, you can change the speed of your motor, thus producing more thrust. When you increase thrust in an airplane, you also increase the amount of lift, thus changing the altitude of your airplane.

Your instructor will help you insert the motor mount into your airplane. Once this is done and you are ready to fly, slowly change the input voltage to your airplane by adjusting the dimmer switch. Once you are flying, vary the input voltage to the airplane and observe the outcomes.

Reflection

You have now flown your airplane and observed how the flight pattern changes when you vary the input voltage. It is now time to reflect on those observations and form a conclusion about your technological system.

- As you increase the input voltage into the electric motor propelling your airplane, the propeller spins ____________________ (faster or slower or the same).
- As the propeller spins faster, the airplane ____________________ (moves faster or moves slower or stays the same) around the circle.
- As the airplane moves faster, its output altitude (distance off the ground) _________ ___________ (gets higher or gets lower or stays the same).
- If you keep the input voltage the same, the output altitude __________________ (gets higher or gets lower or stays the same).
- As you decrease the input voltage into your airplane, the output altitude _________ ___________ (gets higher or gets lower or stays the same).

What would happen if you were to add weights to your airplane? Would you need more speed or less speed or the same speed to get your airplane off the ground? Explain your response.

____

____

____

____

You changed the input variable voltage to make your airplane go faster or slower and ultimately ascend and descend. If you were to make the wire supplying your airplane with voltage longer, would your airplane go ____________________ (higher or lower or stay the same)? Explain your response.

____

____

____

____

Transfer: Changes in Inputs vs. Changes in Outputs

An automobile is another technological transportation system just like your airplane. If you change the input controls, you get different outputs. In the table below, describe the output results if you adjust the input controls of the automobile. Be as descriptive as possible.

Input Control	Output Result
Accelerator pedal	
Windshield wiper switch	
Seat adjustment button	
Radio station button	
Steering wheel	
Brake pedal	
Turn signal	
Headlight button	
Steering column tilt button	
Volume control	
Fan switch	
Cruise control	

Grading Criteria – Piloting an Airplane

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Use of Tools to Process Materials	Airplane is built to fabricating specifications.	Most fabricating specifications were met.	Airplane is poorly constructed.	
Reflection	Student correctly identified most changes in outputs of airplane.	Student correctly identified some changes in outputs of airplane.	Student identified very few output changes in the airplane correctly.	
Transfer	Student accurately explained most results of changing inputs.	Student accurately explained some results of changing inputs.	Student did not explain changes in inputs accurately.	

Comprehensive Understanding ____/ 9 points

Additional comments:

Name: ____________________

Date: ____________________

Hour: ____________________

Technological Systems
Unit 4: Systems Adjustments

Lesson 2: Calibrating a Catapult

Objectives:
Upon successful completion of this activity you should be able to:
- Use tools, materials, and machines safely to fabricate a simple system.
- Follow assembly instructions to successfully build a system.
- Adjust the input variables of a technological system to control desired outputs.
- Forecast the necessary inputs of a system to obtain the desired outputs.

Connections:
During this activity you will be applying knowledge from the following areas:
- Science – forces, simple machines
- Mathematics – measurement

Directions:
During this activity you will be constructing a mechanical system to use the potential energy in rubber bands to create kinetic energy in the lever arm of a catapult. This system consists of a variety of parts. When these parts work together properly, they allow you to launch projectiles a given distance from your catapult. The materials needed and the steps in constructing your catapult are described below.

Tools Required
The following tools are needed to construct a catapult. Other tools may be substituted.
- Band saw, scroll saw, handsaw, or any other saw that can be used to cut pine
- Portable electric drill or drill press and drill bits
- Phillips screwdriver

Materials Needed

The following materials are needed to construct your catapult. Other materials may be substituted.

- 1” x 6” pine boards
- Various length drywall screws
- Hinges
- Eyehooks
- ⅝” wooden dowel
- ¼” wooden dowel
- ¼” bolt 3” long and wing nut

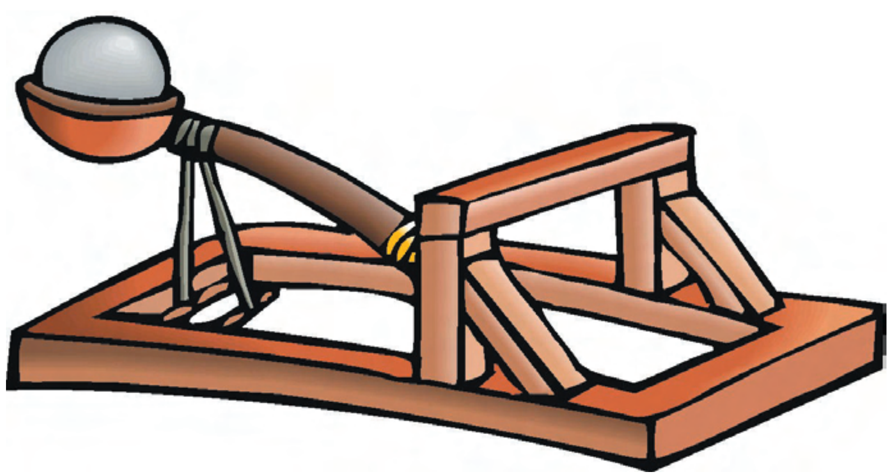
Fabricating Instructions

Follow the instructions below to safely construct your catapult.

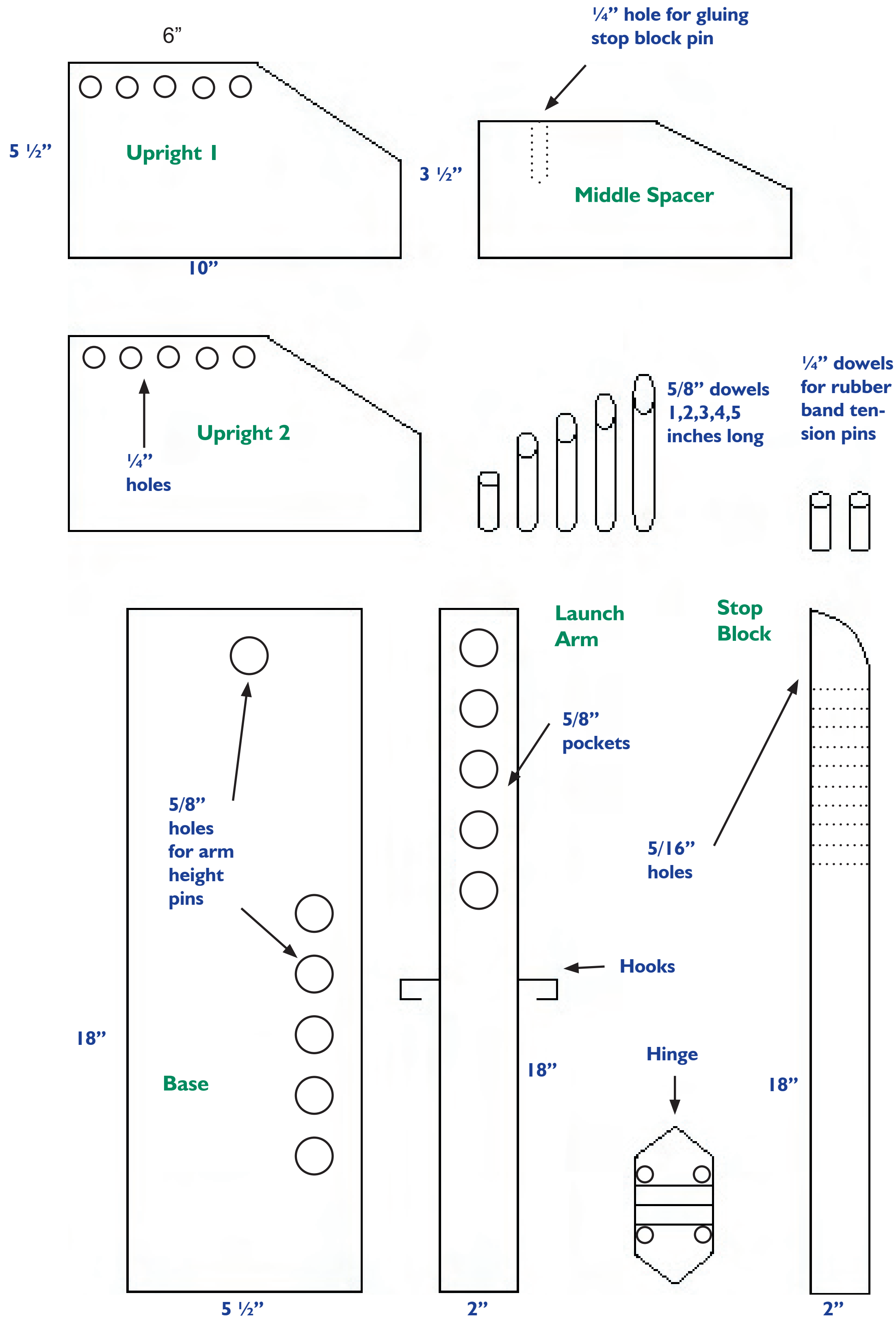
1. Cut pine base to 18”.
2. Cut three uprights.
3. Cut 1 ½” off top of one upright for middle spacer.
4. Cut two, 1 ½” x 18” wood strips for catapult arm and stop block.
5. Drill ¼” holes in middle spacer and stop block for adjustor pin.
6. Cut head off ¼” bolt and glue into middle spacer hole.
7. Screw uprights to base.
8. Drill ¼” holes 1” apart on uprights for adjusting rubber band tension.
9. Cut two, ¼” to 2 inches for connecting rubber bands.
10. Drill hole in base for arm height dowels.
11. Cut five, ⅝” dowels to 1, 2, 3, 4, 5 inches for arm height.
12. Drill arm height storage holes.
13. Screw hooks into side of launch arm.
14. Screw hinge to launch arm and base.

Using Your Catapult

Now that you have fabricated your catapult, it is time to put it to work. If your system is functioning properly, you will be able to change the input variables and receive different output results. The input variables of your catapult include: rubber-band tension, projectile position, arm height, and release position. By adjusting these variables, you will be able to launch your projectile the correct distance to hit a given target.



Catapult Design



Launch Directions

You will be launching your catapult in a large, safe area. You are to set your inputs at the values given in the data table below. After you launch the projectile, record the distance it flew in the column labeled *Distance*. Repeat this procedure for all the given input values.

CAUTION: NEVER LAUNCH YOUR CATAPULT AT SOMEONE!

Launch Data Table

	Input Variables				*Output Results*
Shot Number	**Rubber Band Tension**	**Projectile Tension**	**Arm Height**	**Release Position**	**Launch Distance (feet)**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Reflection

Now that you have had the opportunity to test your catapult, it is time to make some conclusions. Which combination of input variables gave you the greatest horizontal output distance?

Input Variables				Output Results
Rubber Band Tension	Projectile Position	Arm Height	Release Position	Launch Distance (feet)

Which input variable gave you the shortest horizontal output distance?

Input Variables				Output Results
Rubber Band Tension	Projectile Position	Arm Height	Release Position	Launch Distance (feet)

Challenge

Your instructor will now place three different targets at 10, 15, and 20 feet at which you will launch projectiles. Using the data you obtained earlier, set the input variables to the correct values in order to receive the desired launch distance. You will receive three attempts at each target. Fill in the table below for the given distances. Also record your accuracy by measuring how far the projectile landed from the target.

Input Variables				Output Results	
Rubber Band Tension	Projectile Position	Arm Height	Release Position	Launch Distance (feet)	Accuracy (how far from target)
				10	
				10	
				10	
				15	
				15	
				15	
				20	
				20	
				20	

Grading Criteria – Calibrating a Catapult

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Use of Tools to Process Materials	Processing techniques were performed properly and accurately.	Most processing techniques were performed properly and accurately.	Catapult is poorly constructed.	
Ability to Follow Directions	Catapult is built to fabricating specifications.	Most fabricating specifications were met.	Catapult specifications were not met.	
Catapult Performance	Catapult functions properly most of the time.	Catapult functions properly some of the time.	Catapult does not function properly.	
Ability to Adjust System for Optimum Output Results	Student demonstrates clear ability to adjust system for optimum results.	Student demonstrates some ability to adjust system for optimum results.	Student does not demonstrate ability to adjust system for optimum results.	

Comprehensive Understanding ____/ 12 points

Additional comments:

Unit 5
Systems Failure

Unit 5: Systems Failure

Standards for Technological Literacy Standards and Benchmarks

Unit 5 addresses *STL* standards as follows:

- **Standard 2** — **Students will develop an understanding of the core concepts of technology.**
- **Standard 10** — **Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.**
- **Standard 12** — **Students will develop the abilities to use and maintain technological products and systems.**

Student Learning Experiences

- **Hydraulic Brake** — **Standard 2, Benchmark Q; Standard 10, Benchmark F; and Standard 12, Benchmark I.**
- **What's Broken Now?** — **Standard 2, Benchmark Q; Standard 10, Benchmark F; and Standard 12, Benchmark I.**

Big Idea

Failure in one aspect of the system can cause failure in a larger part of the system. Also, the more parts there are, the more possible chances exist for system failure.

Acceptable Evidence of Student Understanding

State in writing; describe verbally, in writing, or graphically; list; script; develop visuals; model; present; critique; brainstorm; sketch; draw; photograph; research; engage experts; visit; interview; plan; organize; construct; envision; combine ideas; chart; graph; examine; test; experiment; animate; simulate; evaluate.

Special note: Please keep in mind that criteria must be developed to measure the evidence that students provide in demonstrating their levels of understanding—what are we looking for and how will we know it when we see it? For example, if students are asked to build a model, how will we know if it's a good one?

When considering achievement levels and helping students to understand how they might improve, it will be necessary to know what we mean by terms such as effectively, efficiently, adequately, creatively, thoughtfully, mostly, clearly, minimally, marginally, correctly, safely, systematically, randomly, logically, thoroughly, introspectively, insightfully, and meaningfully. (See **Appendix C, Acceptable Evidence Glossary**, for definitions.)

Student Assessment Criteria – Correcting Systems Failures

Achievement Level / Sub-concept	Above Target 3	At Target 2	Below Target 1
Analyzing the Failure	Systematically determines what the system was designed to do, what it is not doing, which subsystem or part is likely to be malfunctioning, or if the operator might be at fault.	Approaches the problem in a disorganized way, but with some success, to determine what the system was designed to do, what it is not doing, which subsystem or part is likely to be malfunctioning, or if the operator might be at fault.	Unable to approach the problems in an organized way and has little success in determining what the system was designed to do, what it is not doing, which subsystem or part is likely to be malfunctioning, or if the operator might be at fault.
Troubleshooting the System	Approaches the problem logically, inspects and tests the subsystems and parts that are likely to be malfunctioning, checks for poor maintenance and misuse, and takes operator error into consideration.	Randomly replaces subcomponents and parts without first inspecting and testing those that are likely to be malfunctioning, checks for poor maintenance and misuse, and takes operator error into consideration.	Randomly replaces subcomponents and parts without first inspecting and testing those that are likely to be malfunctioning, does not check for poor maintenance and misuse, and does not take operator error into consideration.
Correcting the Malfunction	Systematically replaces subsystems and parts that are determined to be malfunctioning.	Randomly replaces subsystems and parts without first, through testing, determining those that are likely to be malfunctioning.	Has difficulty following a logical process of replacing subsystems and parts without first, in a logical way, determining those that are likely to be malfunctioning.
Testing the Modified System	Operates the system effectively, with good insight, determines the extent to which it is accomplishing the purpose for which it was originally designed. If the system does not pass this test, the failure or malfunction needs to be re-analyzed.	Operates the system and adequately determines the extent to which it is accomplishing the purpose for which it was originally designed. If the system does not pass this test, the failure or malfunction needs to be re-analyzed.	Operates the system and, with minimal effect, determines the extent to which it is accomplishing the purpose for which it was originally designed. If the system does not pass this test, the failure or malfunction needs to be re-analyzed.

Overview

The failure of a system can often have disastrous results. Consider the space shuttle program for example. It has experienced many successful missions and undoubtedly extended humankind's understanding of the universe. It also has experienced the most profound result of system failure (loss of human life). In the two catastrophes involving the shuttle program, both were caused by a relatively simple, seemingly benign, part failure.

These two historical disasters graphically depict the two key aspects of system failure. That is, failure in one part of a system can cause failure in a larger part of the system or cause the entire system to fail altogether. Secondly, the more parts in the system, the greater the chance for partial or total failure.

Students will learn how the integrity of a system is equally dependent on all of the parts that make up the system. They will explore the causes of system failure and diagnose, troubleshoot, and propose corrective measures for malfunctioning systems.

Narrative

It has been said that a chain is only as strong as its weakest link. As discussed earlier, a system can be defined as a group of parts working together to accomplish a task. Much like a chain with many links connected together, a system may have many parts working together. And just as a chain is only as strong as its weakest link, a system is only as reliable as its most vulnerable part.

If one or more parts in a system fail to accomplish specific task(s) reliably, the entire system ceases to work as intended. A variety of considerations should be taken into account when designing the system components, including: functionality, quality, safety, ergonomics, appearance, economics, and environmental considerations.

Begin the unit by demonstrating a simple system failure. A chain can be used, with one link weakened. Stress the chain until failure occurs. Discuss the results (i.e., not all of the parts failed, yet the overall system—the chain—no longer performs its task as intended). Discuss some possible results of system failure. What could happen if the chain were being used to hold a load of logs on a truck for transportation?

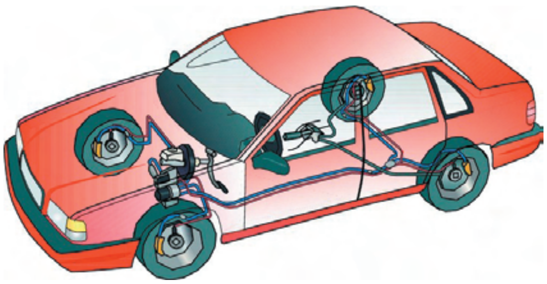
Enduring Experiences

Lesson 1: Hydraulic Brake

Students will fabricate a hydraulic brake system. After completion, they will diagnose possible causes and explore the consequences of system failure.

Lesson 2: What's Broken Now?

Students will identify a familiar system that has failed to perform its task as designed. They will discover the cause of the failure and explore suggestions for prolonging the life of the system.



Name: ____________________

Date: ____________________

Hour: ____________________

Technological Systems
Unit 5: Systems Failure

Lesson 1: Hydraulic Brake

Objectives:
Upon successful completion of this activity you should be able to:
- Predict causes of system failure.
- Identify consequences of system failure.

Connections:
During this activity you will be applying knowledge from the following areas:
- Mathematics – measurement
- Science – simple machines, electrical principles

Directions:
The brakes on a car are a system that we all use every day. Few people actually think about the importance of this system performing its task properly and reliably. For this activity, you will be building a hydraulic brake and analyzing causes and consequences of system failure.

Tools Required
The following tools are needed to construct your simple electrical system. Other tools may be substituted.
- Saw
- Drill
- Disk sander

Materials Needed

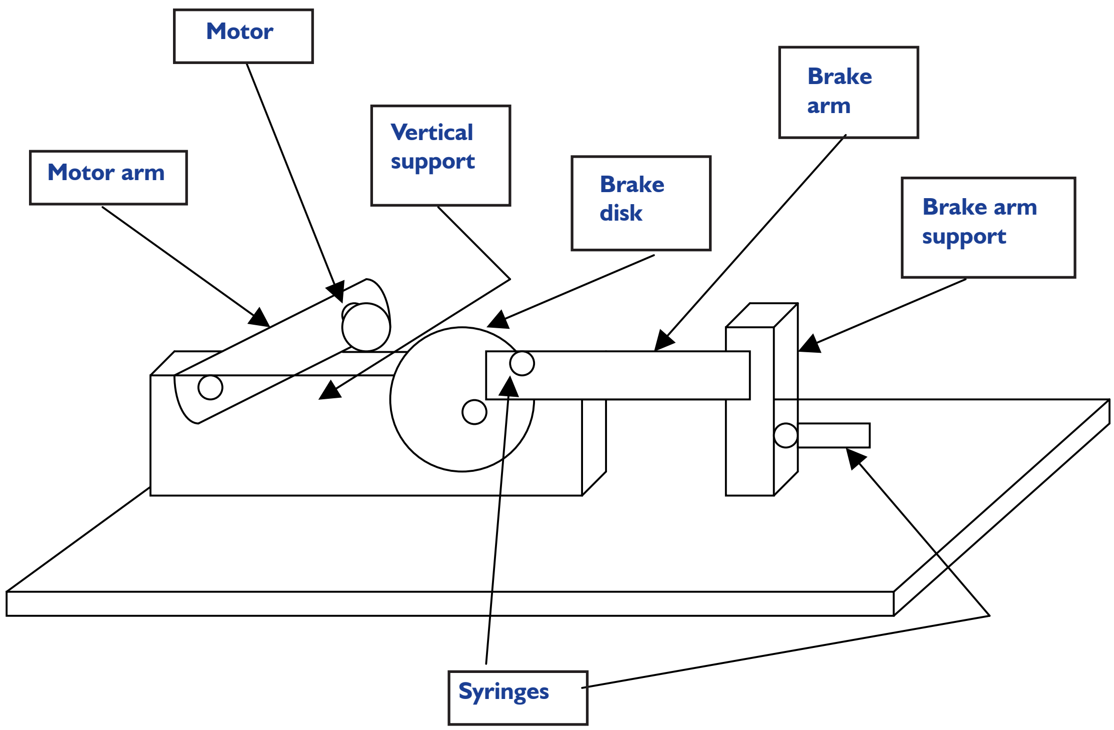
The following materials are needed to construct your hydraulic brake system. Other materials may be substituted when noted.

- 10” by 17” base
- 5” by 10” vertical support
- 1 ½” by 1 ½” by 6” brake arm support
- ¾” by 1 ½” by 6” brake arm
- ¾” by 2” by 5” motor arm
- Compact disk
- Plastic bushing to convert CD to wheel
- Two syringes
- Small electric motor (approximately 1” diameter body)
- Small wheel to fit motor shaft (a foam model car wheel works well)
- Two ¼” bolts with wing nuts
- Axle bushing
- 9-volt battery holder and battery
- Push button switch
- Approximately four feet of 18 gauge wire

Fabricating instructions

Follow the instructions below to safely construct your hydraulic brake system.

1. Cut your base, vertical support, brake arm support, brake arm, and motor arm to size if this hasn’t been done for you.
2. Round the corners of your brake arm and motor arm.
3. Drill a ¼” pivot hole through one end of the brake arm; do the same with the motor arm.
4. Drill a ¼” pivot hole through the brake arm support.
5. Drill a hole the same size as your syringe body through the other end of your brake arm.
6. Drill a hole the same size as your other syringe body through the brake arm support so it does not go through the same sides as the pivot hole.
7. Drill a hole for the axle bushing in the vertical support.
8. Assemble pieces.
9. Wire electrical system, including battery holder, switch, and motor.


Motor
Motor arm
Vertical support
Brake disk
Brake arm
Brake arm support
Syringes

Get Ready to Use It

In Unit One, you built and operated a fluid-powered lever. The same energy principles are used in a hydraulic brake. You are going to operate your brake system with both air and liquid as a fluid. After you have operated the system a few times, look at the system and predict ways in which it could fail.

1. Which fluid do you think will be more effective at stopping the wheel? Explain your answer.

2. In the table below, identify which parts you think could cause the system to stop working the way it should, and how these parts could cause system failure.

Part name:	How could this part cause system failure?

3. If this brake system were on a car, what could the consequences be if the system failed in any of the ways you described above?

Grading Criteria – Hydraulic Brake

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Brake System Assembly	Parts are correctly assembled, and satisfactory operation is likely.	Parts are incorrectly assembled, but correct operation is still possible.	Parts are assembled in a way that correct operation is unlikely.	
Brake Systems Operation	Brake system is correctly operated, and in-depth observations are made and recorded.	Brake system is correctly operated, but observations are inaccurate or not recorded.	Brake system is incorrectly operated, and observations are not made or recorded.	
Causes of Failure	Student identifies a wide range of causes of system failure and demonstrates an understanding that any one of the parts could cause system failure.	Student identifies a variety of causes of system failure, but does not fully understand that failure in any part can cause system failure.	Student has a limited ability to identify causes of system failure.	
Consequences of Failure	Student demonstrates an exceptional understanding of consequences of system failure.	Student demonstrates a limited understanding of possible consequences of system failure.	Student has little understanding of what happens when a system fails.	

Comprehensive Understanding ____/ 15 points

Additional comments:

Name: ______________________

Date: ______________________

Hour: ______________________

Technological Systems

Unit 5: Systems Failure

Lesson 2: What's Broken Now?

Objectives:

Upon successful completion of this activity you should be able to:

- Identify causes of system failure.
- Identify alternatives for preventing system failure.

Connections:

During this activity you will be applying knowledge from the following area:

- Language Arts – reading for understanding, writing

Directions:

Find a technological system that no longer works the way it should. The system you choose should have parts that you can see. It is fine if you need to do some simple disassembly in order to see these parts. Once you have selected your system, determine why it no longer works. Can you think of anything that could have been changed to prevent or prolong the system from failing?

The technological system I selected is:

____

I think the system failed because:

____

What changes could be made to make the system last longer?
(Hint: Think about a new shape, size, material type, etc.)

____

Do you think these changes would affect the cost of the system? ________________

If these changes increased the cost of the system by 20%, would it be worth it? (Explain your answer.)

Grading Criteria – What's Broken Now?

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Chosen System	Chosen technological system has a defect that can easily be identified and explained.	Chosen technological system has a defect that may be difficult either to identify or explain.	Chosen technological system either has no defect, or has a defect that will not be possible to identify or explain.	
System Disassembly	System is disassembled in a logical and orderly fashion, allowing for defect to be identified and explained.	System is disassembled in an unorganized fashion, but the defect can still be identified and explained.	System is disassembled in a way that does not allow for the original defect to be identified or explained.	
Causes of Failure	Student accurately predicts the cause of system failure.	Student predicts causes of system failure, with some inaccuracy.	Student has a limited ability to identify causes of system failure.	
Preventing Failure	Student describes a variety of acceptable ideas for preventing or postponing system failure.	Student demonstrates a limited understanding of possible methods for postponing or preventing system failure.	Student has little understanding of what can be done to prevent system failure.	

Comprehensive Understanding ____/ 15 points

Additional comments:

Unit 6
System Trends

Unit 6: System Trends

Standards for Technological Literacy Standards and Benchmarks

Unit 6 addresses *STL* standards as follows:

- **Standard 2** — **Students will develop an understanding of the core concepts of technology.**
- **Standard 3** — **Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.**
- **Standard 7** — **Students will develop an understanding of the influence of technology on history.**

Student Learning Experiences

- **Let's Take Some Pictures** — **Standard 2, Benchmark P; Standard 3, Benchmark D; and Standard 7, Benchmark D.**
- **You Used to Do It How?** — **Standard 2, Benchmark P; Standard 3, Benchmark D; and Standard 7, Benchmark D.**

Big Idea

Systems are becoming more complex in design, less complicated in use.

Acceptable Evidence of Student Understanding

State in writing; describe verbally, in writing, or graphically; list; script; develop visuals; model; present; critique; brainstorm; sketch; draw; photograph; research; engage experts; visit; interview; plan; organize; construct; envision; combine ideas; chart; graph; examine; test; experiment; animate; simulate; evaluate.

Special note: Please keep in mind that criteria must be developed to measure the evidence that students provide in demonstrating their levels of understanding—what are we looking for and how will we know it when we see it? For example, if students are asked to build a model, how will we know if it's a good one?

When considering achievement levels and helping students to understand how they might improve, it will be necessary to know what we mean by terms such as effectively, efficiently, adequately, creatively, thoughtfully, mostly, clearly, minimally, marginally, correctly, safely, systematically, randomly, logically, thoroughly, introspectively, insightfully, and meaningfully. (See **Appendix C, Acceptable Evidence Glossary**, for definitions.)

Student Assessment Criteria – Systems in the Future

Achievement Level / Sub-concept	Above Target 3	At Target 2	Below Target 1
Emerging Needs	Gathers data and creatively examines trends, economic developments, the global geo-political climate, emerging technology, advances in science, and other factors to determine the human needs of the future.	Gathers some information and reviews trends, economic developments, the global geo-political climate, emerging technology, advances in science, and other factors to determine the human needs of the future.	Gathers limited information and does not effectively review economic developments, the global geo-political climate, emerging technology, advances in science, and other factors to determine the human needs of the future.
Responsible Solutions	Proposes creative and futuristic technological systems that may solve emerging human needs, while anticipating needs that are not yet apparent.	Proposes, with little imagination, technological systems that may solve emerging human needs while anticipating needs that are not yet apparent.	Proposes, with little imagination, technological systems that may solve emerging human needs, with no anticipation for needs that are not yet apparent.
Efficient Applications	Realistically, but futuristically, proposes how global solutions might be implemented, using a variety of technological scenarios.	Proposes how global solutions might be implemented, using a variety of technological scenarios.	Proposes how global solutions might be implemented, using a limited number of technological scenarios.
Assessing Impacts	Objectively gathers data, analyzes those data creatively, and insightfully explains the positive and negative effects of a series of potential solutions to global technological issues.	Gathers data, analyzes those data, and explains the positive and negative effects of a series of potential solutions to global technological issues.	Gathers data, analyzes those data, and explains the positive and negative effects of a minimal number of potential solutions to only a few global technological issues.
Projecting a Future	Develops thoughtful and well documented technological futures, using sociological trends, scientific discoveries, and potential technological developments.	Develops somewhat thoughtful and adequately well documented technological futures, using sociological trends, scientific discoveries, and potential technological developments.	Develops poorly thought out technological futures, with limited use of sociological trends, scientific discoveries, and potential technological developments.

Overview

The main goal of this unit is to teach students to recognize and be able to forecast trends in the development of technological systems. In this unit, students will be exposed to different technological systems of a certain age and then compare them to the same technological systems of today. Key concepts covered in this unit include forecasting, predicting, trends, etc.

Narrative

Some technological devices are fairly easily understood, while others are not. The mechanical pencil sharpener, for example, is fairly simple. It is relatively easy to see what each part is doing and how they interact with each other. With other systems, the operation is not as clear, as in a complex electronic circuit. How, for example, does a microchip know what it is supposed to do?

Enduring Experiences

Lesson 1: Let's Take Some Pictures

Students will fabricate a simple pinhole camera system. Once completed, they will take two sets of pictures, one using their pinhole camera, and the other using a digital camera. They will compare the quality of the pictures, the ease of use of these two systems, and the complexity of design.

Lesson 2: You Used to do it How?

Students will select a common activity that requires the use of a technological system. They will describe how they use current technological systems in this activity. They will also interview the past two generations (i.e. parents and grandparents) to see how technological systems have changed over time. They will also predict how technological systems may change in the future with regard to the activity they have chosen.

Name: ______________________

Date: ______________________

Hour: ______________________

Technological Systems
Unit 6: System Trends

Lesson 1: Let's Take Some Pictures

Objectives:
Upon successful completion of this activity you should be able to:
- Describe how technological systems have become more complex in design and less complex to use.
- Describe the photographic process.

Connections:
During this activity you will be applying knowledge from the following areas:

- Science – principles of light and photography
- Language Arts – reading for understanding, writing

Directions:
You will be building a simple pinhole camera. After completing your project, you will take pictures and develop them. You will also take pictures with a digital camera, compare these two technological systems, and describe the trends in the advancement of photography equipment.

Activity and graphics courtesy of Eastman Kodak Company.

What is a Pinhole Camera?

A pinhole camera is a small, light-tight can or box with a black interior and a tiny hole in the center of one end. (See illustrations that follow.) You can design it to accept roll or sheet film. The two ends of the camera are parallel. The end opposite the pinhole is flat so that the film is held in a flat plane. The pinhole has a cover to prevent light from entering the camera when you aren't taking a picture.

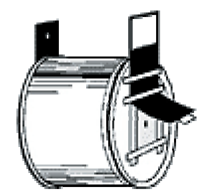
Fabricating Instructions

Follow the instructions below to safely construct your photographic system.

How to Make and Use a Pinhole Camera

Can or Box Pinhole Camera

When you make a pinhole camera to accept roll or sheet film, use a small, light-tight can or box as the camera body.



Pinhole camera made from a can.

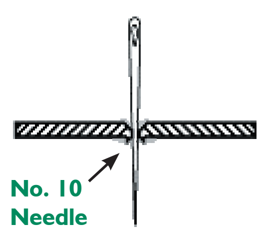
You can use any can that has a tight-fitting top. A two-pound coffee can makes a good pinhole camera. You can use a clean paint can, a vegetable shortening can, a peanut can, or even a cylindrical oatmeal box. If the can you use has a plastic lid, you can paint the lid black. Be sure to paint it inside and out; then before using it, check to make sure no paint has chipped off. Chipped or peeling paint on the lid will allow light to enter the camera and ruin your pictures.

Paint the inside of the camera body with dull black paint or line it with black paper to prevent light reflections.

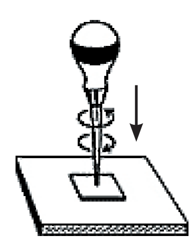
The Pinhole

With a noncartridge camera, make the pinhole in the end opposite the removable end. It's easier to attach the film to the removable end. You can make the pinhole in the box or the can itself, but it's much easier to make it in a separate piece of heavy black paper or thin metal. Then fasten this piece over a larger hole cut in the center of the permanent end of the can or box. Heavy-duty aluminum foil or the backing paper from Kodak roll film is good for this purpose.

For a camera with the pinhole three to six inches from the film, you'll get the best results if the pinhole is about $\frac{1}{75}$ inch in diameter. You can make a hole this size by pushing a No. 10 sewing needle through the paper or metal to a point halfway up the needle shank. (See illustration.) You'll get a smoother hole if you rotate the needle as you push it through. If you're using aluminum foil or paper, sandwich it between two lightweight cards while you make the pinhole. This will help you make a smoother, rounder hole.



You can also make a good pinhole in soft aluminum sheet metal. Place the aluminum on a hard surface (such as tempered hardboard). Make a small hole in the aluminum with an awl or an ice pick. Don't press too hard—the tip should just barely break through the surface. (See illustration.) The hole will be ragged. Enlarge and smooth it by pushing a No. 10 needle into it from the indented side. You can smooth the rough edges with very fine sandpaper and then open the hole with the tip of the needle. You can use the same method to make the



pinhole directly in the metal of the can by working the hole through from inside the bottom of the can.

If you make the pinhole in a separate piece of black paper or metal, you should now make a hole ¼ inch or more in diameter in the center of one end of the camera body. Then tape your pinhole in position over the center of the hole.

You can check your pinhole to make sure it's perfectly round by looking through the back of the camera. To see if the image is clearly visible, aim the camera toward a printed page to determine if you can see the letters clearly.

The Shutter and Viewfinder

The shutter for the camera can be a flap of opaque dark paper hinged with a piece of tape. You can use a small piece of tape to hold the shutter closed while you aren't taking a picture.

A viewfinder for a pinhole camera, while usually not necessary, can be made of cardboard or wire. The larger frame should be slightly smaller than the film size and located directly above the pinhole at the front of the camera. If the film isn't square, the viewfinder should have its longer dimension parallel to the longer dimension of the film. The small frame is a sighting peephole directly above the film and squarely behind the center of the large frame.

When you aim your camera at subjects closer than five feet, tip the camera up slightly to allow for parallax—the difference between the view you see through the viewfinder and the image recorded on the film. This effect is caused by the separation between the viewfinder and the pinhole.

Loading a Can or Box Pinhole Camera

You can load the camera either with film or fast photographic paper. Paper is easier to handle since you can load it into the camera under a safelight. If you don't have a safelight, you can work by the light of a flashlight covered with several thicknesses of red cellophane paper placed six to eight feet away. Most film, on the other hand, must be handled in total darkness. Your choice of film or paper may depend in part on the exposure times. Paper, because it is less sensitive to light than film, will probably require an exposure of about two minutes for sunlit subjects. Film may require only one or two seconds for subjects in sunlight.

If you decide to use paper, try KODABROMIDE Paper F (glossy), No. 2, Single Weight. You can obtain this paper in the 4 x 5-inch size available in 100-sheet packages, or 5 x 7-inch size in 25-sheet packages from your photo dealer (corners may have to be trimmed to fit a cylindrical camera). If you use film, you can cut up a roll of KODAK TRI-X Pan Film or KODAK T-MAX 400 Profesional Film, 120 size, into 2 3/8-inch squares or 2 3/8 x 3 1/2-inch pieces. This must be done in total darkness, of course. At night a closet will probably be dark enough if lights in adjoining rooms are turned off. Sheet film, such as KODAK Tri-X Pan Professional Film, is easier to use because it's flat.

A camera made from a two-pound coffee can will take a 2 ¼ x 3 ¼-inch piece of film or photographic paper. You can use a 3 ¼ x 4 ¼-inch piece if about ½ inch is clipped from each corner of the film or paper. A camera made from a one-gallon paint can will take a 4 x 5-inch piece of film or paper.

When you have the size of paper or film you need, tape it firmly to the inside of the end of your camera opposite the pinhole. The emulsion should face the pinhole. The emulsion side of photo-

graphic paper is the shiny side. The emulsion on roll film is on the inside of the curl. Sheet film is identified by notches cut into one of the shorter sides. When you hold the film in a vertical position with the notches in the top edge toward the right side, the emulsion is facing you. Another way to determine the emulsion side of either paper or film is to touch both sides with a moistened finger. The emulsion side will feel slightly tacky. Test near the edge to avoid a fingerprint in the center of the picture. You will need to tape down the four corners if you use cut-up roll film or paper. Taping two diagonal corners will work for sheet film. Close the camera, making sure the shutter is closed.

Exposure

To get clear, sharp pictures, you must keep your camera very still while the shutter is open. Use tape or a lump of modeling clay to hold your camera to a table, windowsill, chair, rock, or other firm support. Lift the black paper to uncover the pinhole and keep the pinhole uncovered for the recommended time. Cover the pinhole with the black paper between exposures.

The following table gives exposure recommendations for a can or box pinhole camera. These recommendations are approximate. It's a good idea to make three different exposures for each scene, as explained above, to be sure you'll get a good picture.

KODAK Film or Paper	Bright Sun	Cloudy Bright
TRI-X Pan, T-MAX 400, or ROYAL Pan Film 4141	1 or 2 seconds	4 to 8 seconds
(ESTAR Thick Base)	2 to 4 seconds	8 to 16 seconds
T-MAX 100 Film	2 minutes	8 minutes
KODABROMIDE Paper, F2		

Processing and Printing

Print film negatives in the usual way. If you use KODABROMIDE Paper to make your picture, make the camera exposure long enough to allow the resulting paper negative to be a little darker than an ordinary photographic print. Dry the paper negative and make a contact print from it in the normal way, with the emulsion (picture) side of the paper negative toward the emulsion (shiny) side of the printing paper.

Kodak, Kodabromide, Royal, T-Max, and Tri-X are trademarks.

Directions for the pinhole camera courtesy of Eastman Kodak Company. More information can be found online at www.kodak.com/global/en/consumer/education/lessonPlans/pinholeCamera/

1. Are the parts of the pinhole camera easy to see and identify? Explain your answer.

2. Explain how the pinhole camera works to take pictures.

In the space below, sketch your pinhole camera, label the parts, and describe what each part does.

Part name	**What the part does**

1. Are the parts of the digital camera easy to see and identify? Explain your answer.

2. Explain how the digital camera works to take pictures.

3. Which one is easier to use to take good quality pictures?

4. Which camera is more complex in design?

5. Can you think of other systems that have become easier to use, and/or more complex in design?

Technological System	**How did it become easier to operate?**	**How did it become more complex in design?**

Grading Criteria – Let's Take Some Pictures

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Photographic System Assembly	Parts are correctly assembled, and satisfactory operation is likely.	Parts are incorrectly assembled, but correct operation is still possible.	Parts are assembled in a way that correct operation is unlikely.	
Photographic Systems Operation	Camera is correctly operated, including loading film, exposing film, and developing negatives. In-depth observations are made and recorded.	Camera is correctly operated, but observations are inaccurate, or not recorded.	Camera is incorrectly operated, and observations are not made or recorded.	
Sketch	Accurately depicts the camera in complete detail and proportion.	Most details are included and drawn accurately. Proportion may be slightly off.	Sketch does not depict device, missing significant details, or proportionally incorrect in a significant way.	
Part Identification and Function	Most parts are correctly identified and function accurately described.	Some parts are correctly identified and function accurately described.	Very few parts are correctly identified and described.	
Comparison of Systems	A detailed comparison is made between the pinhole camera and a digital camera, including ease of use and complexity of design.	A comparison is made between the pinhole camera and a digital camera. A clear understanding of the evolution of the camera relative to complexity of design and ease of use is not evident.	Little or no evidence of an understanding of the difference in complexity of design or ease of use between a pinhole camera and a digital camera.	

Comprehensive Understanding ____/ 15 points

Additional comments:

Name: ____________________________

Date: ____________________________

Hour: ____________________________

Technological Systems
Unit 6: System Trends

Lesson 2: You Used to Do It How?

Objectives:
Upon successful completion of this activity you should be able to:
- Describe how technological systems have become more complex in design and less complex to use.
- Explain the developmental trends of a specific technological system over time.

Connections:
During this activity you will be applying knowledge from the following areas:

- Language Arts – reading for understanding, writing
  - o Verbal communication skills
  - o Research

Directions:
Select a common activity that requires the aid of some type of technological system. You can select an activity from the list below, or think of one on your own. Describe what the technology is like that you use to complete this activity. Interview at least one person from each of the two previous generations, such as your parents and grandparents. Find out what the technology was like that they used to do the same activity when they were your age.

- Talk to someone on the phone
- Cook a meal
- Ride a bicycle
- Watch television
- Play games
- Solve math problems
- Send a friend a written message
- Travel across country
- Go fishing
- Recreational activities
- Listen to music

Grading Criteria – You Used to Do It How?

Proficiency Levels / Sub Concepts	Target 3	Draft 2	Unacceptable 1	Proficiency
Interview Development	A thorough set of questions is developed and correctly written, which will lead to a successful inquiry into system evolution.	A large set of questions is developed and correctly written, with few mistakes, and/or minor gaps in the information to be gathered.	Few questions are developed and written, and major gaps are evident in the information to be gathered.	
Interviewing Others	Interviews are conducted, and information is recorded in a complete, thorough, and easy-to-understand format.	Interviews are conducted, and information is recorded in a complete, and easy-to-understand format with few gaps in information or detail.	Interview is conducted with significant gaps in information collected, or recorded in a hard-to-understand format.	
Research	Thorough research of available resources is conducted and documented relating to the evolution of the chosen system.	Research is conducted and documented, with minor omissions of information or documentation.	Little or no research is evident in documentation provided.	
Description of Technological System Evolution	Accurately details the evolution of the chosen system over the specified time period, detailing significant developments.	Details the evolution of the chosen system over the specified time period, with few gaps in significant developments.	Description of system evolution has major gaps in significant developments, or inaccuracies of information.	

Comprehensive Understanding ____/ 12 points

Additional comments:

Appendices

Appendix A – Program Responsibility Matrix

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
		172	232	217	186	172	256	176	186	197
The Nature of Technology										
STL-1	**Understanding the characteristics and 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 of 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-directed research.						2	2	3	4
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				

		K-2	3-5	Exploring Technology	Invention & Innovation	Systems	Foundations	Impacts	Issues	Engineering Design
		172	232	217	186	172	256	176	186	197
	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**									
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	
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	
Z	Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.						3	3	3	2
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
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		
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
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
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	
	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

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		K-2	3-5	Exploring Technology	Invention & Innovation	Systems	Foundations	Impacts	Issues	Engineering Design
		172	232	217	186	172	256	176	186	197
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
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

		K-2	3-5	Exploring Technology	Invention & Innovation	Systems	Foundations	Impacts	Issues	Engineering Design
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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**	
K	The Iron Age was defined by the use of iron and steel as the primary materials for tools.						**4**		**3**	
L	The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society.						**4**	**3**		
M	The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology.						**4**	**3**		
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**		
O	The Information Age places emphasis on the processing and exchange of information.						**3**	**3**	**4**	
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, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.						**4**	**2**	**2**	**4**
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**
K	Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.						**3**		**3**	**4**
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**
J	Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.						**3**			**4**
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**

		K-2	3-5	Exploring Technology	Invention & Innovation	Systems	Foundations	Impacts	Issues	Engineering Design
		172	232	217	186	172	256	176	186	197
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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
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
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
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
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
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								

		172	232	217	186	172	256	176	186	197
	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
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
M	Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.						3			3
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
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
K	Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the 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
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 health care.			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						

		K-2	3-5	Exploring Technology	Invention & Innovation	Systems	Foundations	Impacts	Issues	Engineering Design
		172	232	217	186	172	256	176	186	197
	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									
I	The vaccines developed for use in immunization require specialized technologies to support environments in which a sufficient amount of vaccines is 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 psychology.							**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**			
K	Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.						**4**			
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**
N	Power systems must have a source of energy, a process, and loads.						**4**			**3**

		K-2	3-5	Exploring Technology	Invention & Innovation	Systems	Foundations	Impacts	Issues	Engineering Design
		172	232	217	186	172	256	176	186	197
	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									
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 express 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**			
N	Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.						**3**	**3**	**4**	
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**
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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		K-2	3-5	Exploring Technology	Invention & Innovation	Systems	Foundations	Impacts	Issues	Engineering Design
		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.			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 as 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
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	
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

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Appendix C – Glossaries

Acceptable Evidence Glossary

Adequately – Sufficient for a specific requirement; also, barely sufficient or satisfactory.

Clearly – In a clear manner (easily heard, easily visible, free from obscurity or ambiguity, easily understood, unmistakable).

Correctly – 1. Conforming to an approved or conventional standard. 2. Conforming to or agreeing with fact, logic, or known truth. 3. Conforming to a set figure. 4. Conforming to the strict requirements of a specific ideology.

Create – 1. To make or bring into existence something new. 2. To invest with a new form, office, or rank; to produce or bring about through a course of action or behavior. 3. Cause, occasion. 4. To produce, through imaginative skill; to design.

Creatively – Marked by the ability or power to create; given to creating.

Effectively – In an effective manner (producing a decided, decisive effect [result]).

Efficiently – Producing desired effects; productive without waste.

Insightfully – Exhibiting or characterized by insight (the power or act of seeing into a situation; the act or result of apprehending the inner nature of things or of seeing intuitively).

Introspectively – Behaving with introspection (a reflective looking inward; an examination of one's own thoughts and feelings).

Logically – Employing or behaving in accordance with logic (capable of reasoning or of using reason in an orderly, cogent fashion).

Marginally – Close to the lower limit of qualification, acceptability, or function; barely exceeding the minimum requirements.

Meaningfully – 1. Having meaning or purpose; full of meaning, significant.

Mimimally – Relating to or being a minimum: the least possible; barely adequate.

Mostly – For the greatest part; mainly.

Randomly – 1. Lacking a definite plan, purpose, or pattern. 2. Being or relating to a set (or to an element of a set) each of whose elements has equal probability of occurrence.

Safely – Free from harm or risk; unhurt; secure from threat or danger, harm, or loss; affording safety or security from danger, risk, or difficulty.

Systematically – 1. Presented or formatted as a coherent body of ideas or principles. 2. Methodical in procedure or plan; marked by thoroughness and regularity.

Thoroughly – 1. Carried through to completion. 2. Marked by full detail; painstaking; complete in all respects.

Thoughtfully – 1. Absorbed in thought. 2. Characterized by careful, reasoned thinking. 3. Given to or chosen or made with heedful anticipation of the needs and wants of others.

Appendix C – Glossaries
Technological Systems Glossary

Alternative energy source – Any source or resource of energy that is renewable through natural processes, can be renewed artificially, or that is regulated as practically inexhaustible. Includes solar, wind, geothermal, biomass, and wood resources. Also referred to as renewable energy.

Alternative fuel – Transportation fuel other than gasoline or diesel. Includes natural gas, methanol, and ethanol.

Alternative technology – A technology option that is different than the commonly accepted technology for a specific application (e.g. hybrid car).

Application – Putting general knowledge and skills to specific use.

Appropriate technology – Part of an international movement to introduce technology that considers in great detail the user and the region/location of the application.

Assessment – 1. An evaluation technique for technology that requires analyzing benefits and risks, understanding the trade-offs, and then determining the best action to take in order to ensure that the desired positive outcomes outweigh the negative consequences. 2. An exercise, such as an activity, portfolio, written test, or experiment that seeks to measure a student's skills or knowledge in a subject area. Information may be collected about teacher and student performance, student behavior, and classroom atmosphere.

Assessment principles – The basic truths, laws, or assumptions held in the use of assessment. The assessment principles that are in current use should enhance student learning, provide coherency of programs and courses, identify expectations, ensure developmental appropriateness, and be barrier-free.

Attributes of design – Design characteristics that specify that design be purposeful, iterative, creative, and involve many possible solutions.

Authentic assessment – An assessment method that directly examines student performance on tasks that are directly related to what is considered worthy and necessary for developing technological literacy. Traditional assessment, by contrast, relies on indirect or stand-in tasks or questions that are more efficient and simplistic than they are helpful in determining what students actually know and can do.

Benchmark – 1. A written statement that describes specific developmental components by various grade levels (K-2, 3-5, 6-8, and 9-12) that students should know or be able to do in order to achieve a standard. 2. A criteria by which something can be measured or judged.

Benefit – A positive outcome for the application of a technological device or process; during an application not all people involved benefit, and some can benefit at different times.

Best practices – What works and does not work in the laboratory-classroom.

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.

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.

By-product – Something produced in the making of something else; a secondary result; a side effect.

CAD (Computer-Aided Design or 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.

Category – As used in *Standards for Technological Literacy: Content for the Study of Technology* – the large organizers for the study of technology. The categories are: The Nature of Technology, Technology and Society, Design, Abilities for a Technological World, and The Designed World.

Checklist – An evaluative tool, which could be in many forms, from a simple listing to a formal quarterly report of progress.

Closed-loop system – A system that uses feedback from the output to control the input.

Combining – The joining of two or more materials by such processes as fastening, coating, and making composites.

Communicate – To exchange thoughts and ideas.

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.

Complex system – A system consisting of interconnected or interwoven parts that interact in such a way as to produce a global output that cannot always be predicted.

Component – A part or element of a whole that can be separated from or attached to a system.

Consequence – An effect that naturally follows and is caused by a previous action or condition; referred to as an outcome.

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.

Content standard – A written statement about what students should know and be able to do.

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.

Core concepts – A set of ideas that make up the basis for the study of technology. The core concepts of technology as identified in *STL* are systems, resources, requirements, optimization and trade-offs; processes, and controls.

Cost/benefit analysis – Does the cost justify the product? A company would add up the benefits of a course of action, and subtract the costs associated with it.

CNC (Computer Numerical Control) – Programmable systems that automatically control the manufacturing process.

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 by using logic and reasoning skills.

Cumulative assessment – Assessment that is summative and usually occurs at the end of a unit, topic, project, or problem.

Cybernetics – Study of automatic control systems: the science or study of communication in organisms, organic processes, and mechanical or electronic systems.

Data – Raw facts or figures that can be used to draw a conclusion.

Data processing system – A system of computer hardware 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.

Design – An iterative decision-making process in which plans are produced and implemented to devise an effective solution to problems or to meet identified needs and wants.

Design parameters – Criteria or constraints to the design of a technological device or process based on factors such as economics, material properties, users, safety issues, and others.

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.

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.

Discovery – An insight into the existence of something previously unknown. The act of finding out something new.

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.

Effective – Produces the desired results with efficiency.

Efficient – Operating or performing in an effective and competent manner, with a minimum of wasted time, energy, or waste products.

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 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.

Evaluation – 1. The collection and processing of information and data in order to determine how well a design meets the requirements and to provide direction for improvements. 2. A process used to analyze, evaluate, and appraise a student's achievement, growth, and performance through the use of formal and informal tests and techniques.

Experiment – 1. A controlled test or investigation. 2. Trying out a new procedure, idea, or activity.

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.

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.

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.

Formalized assessment – Assessment that is strictly standardized to allow for accurate comparisons.

Formative assessment – Ongoing assessment in the classroom. It provides information to students and teachers to improve teaching and learning.

Group project – Specific organized work or research by two or more individuals who interact with and are influenced by each other.

Hands-on – Experiences or activities that involve tacit doing as a means of acquiring, or a complement to acquiring, knowledge and abilities.

Human adaptive systems – Systems that exist within the human-made and natural world, including ideological, sociological, and technological systems.

Impacts – The results of the design, application, or use of technological devices or processes that can be positive or negative, expected or unexpected, and can show up in different regions or in different times.

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.

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.

Innovate – To renew, alter, or introduce methods, ideas, procedures, or devices.

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.

Intelligent transportation system – Proposed evolution of the entire transportation system involving the use of information technologies and advances in electronics in order to revolutionize all aspects of the transportation network. These technologies include the use of the latest computers, electronics, communications, and safety systems to provide traffic control, freeway and incident management, and emergency response.

Invention – A new product, system, or process that has never existed before, created by study and experimentation.

Irrigation system – A system that uses ditches, pipes, or streams to distribute water artificially.

Just-in-Time (JIT) manufacturing – A systems approach to developing and operating a manufacturing system in which manufacturing operation component parts arrive just in time to be picked up by a worker and used.

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.

Macrosystem – A comprehensive, all-inclusive system.

Maintenance – The work needed to keep something in proper condition; upkeep.

Mathematics – The science of patterns and order and the study of measurement, properties, and the relationships of quantities; using numbers and symbols.

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.

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.

Mass production – The manufacture of goods in large quantities by means of machines, standardized design and parts, and often, assembly lines.

Measurement – Collecting data in a quantifiable manner.

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.

Micro-processing system – A computer made up of integrated circuits that is capable of high-speed electronic operations.

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.

Multimeter – An instrument that reads and measures the values of several different electrical parameters such as current, voltage, and resistance.

Multimedia – Information that is mixed and transmitted from a number of formats (e.g., video, audio, and data).

Network – An interconnected group or system. The Internet is a network of computers.

Noise – An outside signal that interrupts, interferes, or reduces the clarity of a transmission.

Non-biodegradable – The inability of a substance to be broken down (decomposed) and therefore retaining its form for an extended period of time.

Non-durable goods – Items that do not last and are constantly consumed, such as paper products.

Nonrenewable – An object, thing, or resource that cannot be replaced.

Nuclear power – Power, the source of which is nuclear fission or fusion.

Open-loop system – A control system that has no means for comparing the output with the input for control purposes. Control of open-loop systems often requires human intervention.

Optimization – 1. An act, process, or methodology used to make a design or system as effective or functional as possible within the given criteria and constraints. 2. A technological design process that strives to meet all the design criteria for a product with the least amount of costs (economic, environmental, safety).

Output – The results of the operation of any system.

Patent – 1. Protection for the intellectual property of inventions and innovations, allowing the creators to benefit from their efforts and allow the continuation of the creative process. 2. A document issued from the government granting the exclusive right to produce or sell an invention for a certain period of time.

Peer assessment – An assessment method that involves the use of feedback from one student to another student, both students being of similar standing (grade level).

Plan – A set of steps, procedures, or programs worked out beforehand in order to accomplish an objective or goal.

Portfolio – An organized set of student materials that documents research, designs, thinking processes, and activities associated with an experience.

Potential energy – The energy of a particle, body, or system that is determined by its position or structure.

Power – 1. The amount of work done in a given period of time. 2. The source of energy or motive force by which a physical system or machine is operated.

Power system – A technological system that transforms energy resources to power.

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 – 1. Human activity used to create, invent, design, transform, produce, control, maintain, and use products or systems; 2. A systematic sequence of actions that combines resources to produce an output.

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.

Product safety – The responsibility of technological designers to develop products that are safe to operate, use repetitively, or dispose of when the useful life of the product is over.

Production system – A technological system that involves producing products and systems by manufacturing (on the assembly line) and construction (on the job).

Project – A teaching or assessment method used to enable students to apply their knowledge and abilities. These may take many forms and are limited by time, resources, and imagination.

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.

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.

Rating factor – Criteria used by designers to evaluate the effectiveness of a technological product or process by comparing like products or processes and optimizing the design based on which has the highest overall indication using all rating factors.

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 – Capable of being relied on; dependable; may be repeated with consistent results.

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 – Systematic, scientific, documented study.

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.

Resources – 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.

Risks – Used by technological designers to predict any types of loss (negative impact) to those who will use the product or will be impacted by its use; based of the costs (not just economic) and the probability of the occurrence of a negative impact.

Risk/benefit analysis – Does the benefit of building the product outweigh the negative societal impact? Risk = probability of event x cost of event.

Rubric – An assessment or evaluative device based on the identified criteria taken from the content standards. Points or works are assigned to each phase or level of accomplishment. This method gives feedback to the students about their work in key categories, and it can be used to communicate student performance to parents and administrators.

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. Understanding the natural world.

System – A group of interacting, interrelated, or interdependent elements or parts that function together as a whole to accomplish a goal.

Scientific inquiry – The use of questioning and close examination using the methodology of science.

Self-assessment/Self-reflection – An assessment method that encourages individuals to evaluate themselves; for example, in terms of their learning or teaching.

Sender – A person or equipment that causes a message to be transmitted.

Separating – The process of using machines or tools to divide materials.

Side effect – A peripheral or secondary effect, especially an undesirable secondary effect. Some side effects become the central basis for new developments.

Simulation – 1. A method of instruction that attempts to re-create real-life experiences. 2. A modeling tool that allows designers to evaluate a system or process by mimicking the process (using software or other tools) and changing parameters and predict what happens or make refinements.

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.

Space – 1. The continuous expanse beyond the earth's atmosphere, as in space exploration. 2. The area alloted for a specific purpose, as in classroom space.

Standard – A written statement or statements about what is valued that can be used for making a judgment of quality.

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.

Student assessment – A systematic, multi-step process of collecting evidence on student learning, understanding, and abilities and using that information to inform instruction and provide feedback to the learner, thereby enhancing student learning.

Student presentation/demonstration – An assessment method that involves student explanation and communication of their understanding of key ideas, concepts, and principles and abilities of processes, techniques, and skills.

Study of technology – Any formal or informal education about human innovation, change, or modification of the natural environment.

Subsystem – A division of a system that, in itself, has the characteristics of a system.

Support system – 1. A network of personnel or professionals that provides life, legal, operational, maintenance, and economic support for the safe and efficient operation of a system, such as a transportation system. 2. The technical system that supports the operation of a system, as in a life-support system on board the Shuttle.

Suspension system – A system of springs and other devices that insulates the passenger compartment of a vehicle from shocks transmitted by the wheels and axles.

Sustainable – 1. Of or relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged. 2. Relating to a human activity that can be sustained over the long term, without adversely affecting the environmental conditions (soil conditions, water quality, climate) necessary to support those same activities in the future.

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.

System – A group of interacting, interrelated, or interdependent elements or parts that function together as a whole to accomplish a goal.

Systems-oriented – Looking at a problem in its entirety, looking at the whole as distinct from each of its parts or components, taking into account all of the variables and relating social and technological characteristics.

Teamwork – A cooperative effort by the members of a group or team to achieve a common goal.

Technological issues – Issues that arise from the applications of technology into human social and economic systems, which result in a variety of benefits, costs, risks, and limitations.

Technological literacy – The ability to understand, use, manage, and assess technology.

Technological literacy standard – A written statement that specifies the knowledge (what students should know) and process (what students should be able to do) students should possess in order to be technologically literate.

Technological transfer – The process by which products, systems, knowledge, or skills, developed under federal research and development funding, are translated into commercial products to fulfill public and private needs.

Technology – 1. The innovation, change, or modification of the natural environment to satisfy perceived human needs and wants.
2. Human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities.

Technology assessment – Evaluating the potential impacts of applying a technology, positive or negative, expected or unexpected, prior to its implementation to reduce possible technological issues.

Technology education – 1. A school subject specifically designed to help students develop technological literacy. 2. The study of technology that provides an opportunity for learning about the processes and knowledge related to technology that are needed to solve problems and extend human capabilities.

Technology program – Everything that affects student attainment of technological literacy, including content, professional development, curricula, instruction, student assessment, and the learning environment, implemented across grade levels as a core subject of inherent value.

Tolerances – Allowed amount of variation from the standard or from exact conformity to the specified dimensions, weight, etc., as in various mechanical operations.

Tool – A device that is used by humans to complete a task.

Trade-off – An exchange of one thing in return for another; especially relinquishment of one benefit or advantage for another regarded as more desirable.

Trade-offs – Technological design parameters that have more than one impact, which often contradict each other causing the designer to make decisions based on best-case scenarios.

Trademark – A protection of intellectual property that covers any words, names, symbols, or devices (such as packages) that identify the producer, often protected for marketing purposes, which include product names, logos, and packaging.

Transistor – A solid-state electronic device; a small, low-powered, solid-state electronic device consisting of a semiconductor and at least three electrodes, used as an amplifier and rectifier and frequently incorporated into integrated circuit chips.

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 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.

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.

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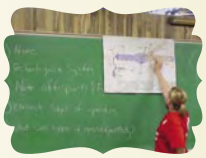
Technological Systems

A Standards-Based Middle School Model Course Guide



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