GEORGIA'S

Connecting Mathematics and Science to Technology Education

Technology Education

GEORGIA DEPARTMENT OF EDUCATION

Kathy Cox

State Superintendent of Schools

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GEORGIA'S TECHNOLOGY Education

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Connecting Mathematics and Science to Technology Education

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PREFACE

Technology education is the application of math and science for specific purposes, i.e., to make ours lives better or more enjoyable. As part of the school curriculum, technology education teaches students to understand, use and control technology. The curriculum covers the development of the technology and its effects on people, the environment and society. Students learn how to adjust to change, to deal with forces that influence their future and to participate in controlling their future. In the technology education modular laboratory, students develop insights into the application of technological concepts, processes and systems. The program focuses on current and future technology to assist students to become prepared for what they will eventually face when entering the work forces by bring more technologically literate. Therefore, technology education is a comprehensive, action-based educational program concerned with technical means, their evolution, utilization and significance with industry, its organization, personnel, systems, techniques, resources and products and their social and cultural impact. This hands-on program exposes students to experiences and problem-solving approaches in the technologies of communication, construction, manufacturing, transportation and bio-technology as they explore the specifics of robotics, CNC, CAD, electronics, fiber-optics, telecommunication and additional course content areas.

PHILOSOPHICAL RATIONALE

In any culture the primary function of the school is to acquaint the young with the nature in that culture. At its most basic level this is education for survival of the race. In a primitive as in an advanced society, understanding of the technology of that culture is basic to survival. Since the American culture is so characteristically and intensely technological it follows that the primary function of its school is to acquaint the young with the nature of the technological culture. In so doing the curricular offerings must provide students the opportunity to deal with the technology itself.

The American culture as an institution is in principle, if not in practice, committed to assisting the individual in the discovery, development, realization and release of their own talent potential. In effecting this responsibility the school curriculum has Technology Education to assist in the process of self-realization within the context of the technology. It is facilitated by the use of the technology of that culture.

The assumption is made that, through the Technology Education, individual mankind has a native potential for thinking and learning, for reasoning and problem-solving, for imagining and creating and constructing and expressing with hands, materials, tools, machines, ideas and energies. Because he/she exercises these potentials, he/she is able to produce the technology, to use it and to advance it. Every student is seen as having a measure of these native potentials but all do not have the same measure.

The fish from birth is at home in its medium. But mankind is in conflict with the very environment which he/she creates for themselves. One must be able to understand to use wisely, to control and to change what they creates in technology. Technology Education offers to assist mankind by serving as the interpreter of technology for The American school student.

STATEMENT OF PHILOSOPHY

Technology Education is that phase of Education which acquaints students with the origin and development of technology and industry and reflects the technological advances of our culture. This reality is in a constantly changing state due to the impact of technology. It intends to develop attitudes which will help students adjust to the complexities of modern life, both technical and social. Technology Education provides insights into our industrial environment by having students study and experience technology and its techniques.

In a classroom-laboratory, students implement by exploratory means this accumulated knowledge of technology through processes, tools and materials as well as applying English, science and mathematics in solving everyday problems. Technology Education provides concrete physical activity and associated mental experience in situations designed to promote continuous self-expression and self- evaluation. At a level and a pace which allow for a range of individual differences, Technology Education provides the thrill of personal creativity in transforming raw materials into finished products.

SOME GOALS

Humans have historically used communication techniques to transmit information. Mathematics and science is yet another form of this communication as it impacts on the technological process. Every individual must learn to understand and use the basics of math and science since these Areas affect the make –up of all technology to some degree. In today's world, technology is complex and includes but is not limited to the components of research, design, development, math and science communication. As individuals are provided the learning environment in which they can develop basic mathematical and science skills through prescribed activities, they will increase their logic faculties, abilities to solve practical problems and make informed decisions about the technologies around them. Another facet that is an important part of communicating within a technological world is competence in fundamental scientific principles and applications. In many instances, it is a combination of mathematics and science that provide the impetus for technological development. A cogent knowledge of math and science is critical for technological literacy.

Some specific goals of this manual are:

- To research and develop mathematical problem solving activities related to Technology education

- To research and develop science-related problem solving activities related to technology education

- To develop critical thinking skills through technology activities that have math and science connections

- To interpret and use mathematics to solve scientific problems

- To develop problem-solving skills through the practice of mathematics and science activities

- To develop skills and knowledge in math and science as they apply to technology education.

- To assist students toward being able to articulate connections between mathematics, scientific principles, technologies and events affecting ones everyday life.

INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION

Standards for Technological Literacy

1. The characteristics and scope of technology.
2. The core concepts of technology.
3. The relationships among technologies and the connections between technology and other fields.
4. The cultural, social, economic, and political effects of technology.
5. The effects of technology on the environment.
6. The role of society in the development and use of technology.
7. The influence of technology on history.
8. The attributes of design.
9. Engineering design.
10. The role of troubleshooting, research, and development, invention and innovation, and experimentation in problem solving.
11. Apply the design process.
12. Use and maintain technological products and systems.
13. Asses the impact of products and systems.
14. Medical technologies.
15. Agricultural and related technologies.
16. Energy and power technologies.
17. Information and communication technologies.
18. Transportation technologies.
19. Manufacturing technologies.
20. Construction technologies.

GEORGIA PERFORMANCE STANDARDS

Core Employability Skills

BASIC SKILLS

1. Locates, understands, and interprets written information in a variety of formats, including such documents as manuals, graphs, reports, and schedules.
2. Communicates thoughts, ideas, information, and messages in writing and technologically, and creates documents such as letters, directions, manuals, reports, graphs, and flowcharts.
3. Performs and applies numerical concepts and calculations, and solves problems by choosing appropriately from a variety of mathematical techniques using mental, manual, and technological methods.
4. Receives, interprets, and responds to verbal and nonverbal messages in a manner appropriate to a given situation.
5. Organizes ideas and communicates orally in a clear, concise, and courteous manner.

THINKING SKILLS

6. Specifies goals, objectives, constraints, and supporting factors.
7. Identifies problems, alternative solutions, consequences of alternative solutions, and uses appropriate techniques to resolve given problems.
8. Implements a plan of action making modifications as needed to achieve stated objectives.

9 Uses effective learning techniques to acquire and apply new knowledge and skills.

PERSONAL QUALITIES

10. Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control.
11. Chooses ethical courses of action.
12. Takes initiative to accomplish tasks in a timely manner.
13. Exerts a high level of effort and perseveres towards goal attainment.
14. Demonstrates adaptability, dependability, and responsibility and such social behaviors as tolerance, honesty, empathy, and courtesy.

INTERPERSONAL SKILLS

15. Participates and interacts as a team member and leader.
16. Shares knowledge and skills with others.
17. Performs effectively in various environments with people of different ages, genders, cultures, socio-economic backgrounds, attitudes, and abilities.
18. Works to satisfy customer/client expectations.
19. Uses strategies appropriate to a given situation to prevent and resolve conflicts.

RESOURCES

20. Selects goal-relevant activities, prioritizes them, manages time, and prepares and follows schedules.
21. Uses or prepares budgets, makes projections, keeps records, and makes adjustments to meet objectives.
22. Acquires, stores, allocates, and uses materials and space efficiently.

TECHNOLOGY

23. Prevents, identifies, or solves problems with technical or electronic equipment.
24. Operates and maintains technical equipment and the work environment safely following applicable industry regulations and guidelines.
25. Utilizes a variety of technologies.

BUSINESS ASPECTS

26. Demonstrates understanding of basic economic concepts and how they are applied in business functions and activities.
27. Identifies forms of business ownership.
28. Demonstrates understanding of the scope of a business, its place within an industry, and the interrelationship of its parts.
29. Demonstrates understanding of the individual's role, responsibilities, and relationships in the organizational structure of a business.
30. Maintains safety, health, and environmental standards, and addresses ergonomic concerns.

CAREER DEVELOPMENT

31. Makes potential career decisions based upon interests, abilities, and values and formulates appropriate plans to reach career goals.
32. Demonstrates understanding of the relationship between educational achievement and career planning and how career choices impact family patterns and lifestyle.

33. Demonstrates effective skills for seeking and securing employment.

34. Demonstrates understanding of education and career development as a lifelong learning process which requires preparation for change.

21.42500 Introduction to Technology I

Prerequisite: None

COURSE DESCRIPTION: This is the beginning course in the study of Technology and is recommended for students in Grades 9-12. The first course introduces individual, team, and group activities through the use of a modular delivery system. These activities, which are constantly evolving, include but are not limited to the following technologies: Computer Aided Design (CAD), Computer Aided Publishing (CAP), Computer Numerical Control (CNC), Robotics, Electricity, Electronics, Research and Design, Flight, Space, Aerodynamics, Mechanisms, Fluidics, Audio and Video Production (sound, speech, editing, titling), Digital Communication, Computer Animation, Bio-Related Technologies, Technical Presentations with Multimedia, Digital Graphics (animation, photography, video, printing) Weather Monitoring, Computer Architecture(service and repair), Networking, and Alternative Energy. Each laboratory has a minimum of sixteen modules which are chosen from a State approved list and others which reflect local interest and industry operations. Each module places emphasis on reinforcing basic skills, introduces some of the core skill competencies in Technology/Career Education, and provides a basis for narrowing the choice and selection of a potential career cluster.

SAFETY

35. Master relevant safety tests in each technological area.
36. Follow safety manuals, instructions, and requirements in each technological area.
37. Demonstrate appropriate methods of handling and storing tools and materials.

COMPUTER AIDED DESIGN (CAD)

38. Draw a three dimensional XYZ axis on a sheet of paper.
39. Construct drawings (mechanical and architectural) using CAD standards.
40. Scale drawings.
41. Dimension drawings using English and metric systems.
42. Print drawings to a specified scale.

COMPUTER AIDED PUBLISHING (CAP)

43. Select and research a topic to be used as a project.
44. Prepare a storyboard of the selected project.
45. Develop a draft of the project using CAP software.
46. Integrate text and graphics into the project.
47. Utilize spelling and grammar checking software to correct errors.
48. Print and bind the appropriate number of pages of the final project.

COMPUTER NUMERICAL CONTROL (CNC)

49. Identify and define the three axes of the machine.
50. Select a project to be developed.
51. Analyze the requirement of the various movements of the CNC tool and/or table.
52. Load the material to be machined and specify the limits of the cutting tool(s).
53. Use appropriate language and/or pendant to program the machine to produce the required cuts.
54. Use simulation software to check the program for errors and save the final program.
55. Produce the final product.

ROBOTICS

56. Identify and describe the axes and limits of motion for the specified robot.
57. Analyze the process and programming used to produce specific motions.
58. Identify problems to be solved through the use of robotics.
59. Program the robot to produce required motions.
60. Analyze the finished program and modify for efficiency.

ELECTRICITY/ELECTRONICS

61. Examine the sources of electricity.
62. Identify the components of an electrical circuit.
63. Construct a schematic drawing of an electrical circuit.
64. Calculate voltage, current, resistance, and power in series and in parallel circuits using applicable laws.
65. Describe the importance of codes, laws, and standards.
66. Construct a specified electrical/electronic device using a breadboard or computer simulation.

RESEARCH AND DESIGN

67. State the criteria to be reported when evaluating a design project.
68. Select an appropriate topic for a research and design project.
69. Identify the inputs, outputs, processes, and feedback related to the technology system being implemented.
70. Create a design brief and specification statements.
71. Maintain and organize a work record.
72. Apply a technological problem solving process.
73. Analyze and evaluate design.
74. Summarize the results of analysis/evaluation in a written report.
75. Create a multimedia presentation.

FLIGHT/AVIATION

76. Explain the principles of flight.
77. Identify control surfaces of various aircraft.
78. Prepare a flight plan.
79. Use the flight simulator to successfully take off, fly, and land from a predetermined course.
80. Plot the vectors required to reach a specific location with a specified crosswind.
81. Identify the license requirements for operating instructional, private, and commercial aircraft.
82. Design, construct, and flight-test a balsa wood glider.

POWER TRANSFER (Mechanisms and Fluid Power)

83. Interpret formulas and solve problems in power transfer systems.
84. Solve force, pressure, and area problems.
85. Identify how mechanisms can be used to change speed and direction.
86. Identify hydraulic and pneumatic components and symbols.
87. Investigate the compressibility of gasses and liquids.
88. Explain the operation of hydraulic and pneumatic equipment.

VIDEO PRODUCTION

89. Select an appropriate topic for a video production project.
90. Create a storyboard to reflect the selected topic.
91. Develop the script (video clips, titles, sound affects, and storyline).
92. Demonstrate the basic operation and control of the camera and other video equipment.
93. Edit the video using digital or analog editing techniques.
94. Create and present a finished video.

CYBERSPACE COMMUNICATION

95. Identify a topic for a cyberspace communication project.
96. Select the appropriate equipment and materials for the project.
97. Utilize the appropriate hardware and software to complete the project.
98. Use search engines to find selected topics.
99. Form links and arrange graphics into the design.
100. Assemble the various components into the required project.
101. Present the final project.

COMPUTER ANIMATION

102. Select an appropriate topic for a computer animation project.
103. Select and utilize the appropriate hardware and software.
104. Meet requirements for completed sequence.

105. Prepare a storyboard for the required sequence.
106. Select the elements needed to produce the animation sequences.
107. Produce the various elements of the sequences including sound bites and editing
108. Present animation.

BIO-RELATED TECHNOLOGIES (Medical/Health/Plant/Animal/Physiological)

109. Use software models to describe the physiology of the human body.
110. Interpret basic information about vital signs and assesses physical condition of a patient.
111. Calculate cardiac output, heart rate, percentage composition by weight, weight losses or gains from charts.
112. Compare heart rate data to identify the effect of exercise.
113. Interpret X-ray photographs.
114. Investigate techniques in forensic medicine.
115. Design an adaptive device for a handicapped patient.
116. Construct a model of an adaptive device to solve a physical/social prescribed problem.

WEATHER MONITORING

117. Describe factors that drive weather systems.
118. Describe the use of satellites to monitor weather.
119. Identify fronts, clouds, highs and lows, states, bodies of water, tracking radar.
120. Calculate relative humidity.
121. Calculate wind chill using the wind chill index.
122. Convert temperature readings from Fahrenheit to Celsius.
123. Extract forecast information from a weather map.
124. Identify trends from recorded weather data.
125. Graph local weather conditions from ongoing collected data.

COMPUTER ARCHITECTURE (SERVICE AND REPAIR)

126. Disassemble and reassemble the components of a working computer.
127. Identify the components and their sequence inside a working computer.
128. Perform routine preventive maintenance on a computer and its components.
129. Use fault analysis and isolation techniques to repair a malfunctioning computer.
130. Establish appropriate repair procedures for a malfunctioning computer.
131. Prepare necessary paperwork for repair procedure.
132. Write appropriate technical report on a selected repair.
138. Configure network components.
139. Describe wireless network procedures
140. Troubleshoot network using appropriate methods.

NETWORKING

133. Describe a network and differences between networks.
134. Explain Ethernet architecture.
135. Identify physical media in networking.
136. Install an Ethernet card in a computer and connect it to a network.
137. Configure a computer network using appropriate software.
138. Configure network components.
139. Describe wireless network procedures.
140. Troubleshoot network using appropriate methods.

DIGITAL IMAGING (PRINTING)

141. Identify the steps in the digital imaging process.
142. Explain pre-press, production, and post press processes.
143. Select an appropriate image that will utilize the elements of a selected production process.
144. Examine the environmental and societal safety issues involved in the selected production process.
145. Create the necessary artwork and prepare the artwork for production.
146. Select substrate for selected process.
147. Produce single or multiple copies of the artwork.
148. Select and use appropriate post process activities.
149. Assess the quality of the final product.

DIGITAL GRAPHICS (ANIMATION)

150. Describe the process of animation.
151. Create animation from information given in a storyboard.
152. Apply problem-solving techniques to animate a character.
153. Simplify the steps to achieve a fluid animation.
154. Define links between sound and action for realistic animation.
155. Utilize the elements of digital animation in an appropriate topic.

DIGITAL GRAPHICS (PHOTOGRAPHY)

156. Compare and contrast digital photography with other types of photography.
157. Identify and use appropriate hardware and software associated with a digital camera.
158. Prepare a storyboard of required shots and captions.
159. Use appropriate software to manipulate image properties.
160. Utilize the elements of digital photography in an appropriate topic.

TECHNICAL PRESENTATIONS WITH MULTIMEDIA

161. Create a storyboard for a multimedia presentation for a sample product.
162. Identify techniques and skills used in designing content for multimedia presentations.
163. Select and use text, graphics animation, audio, and video in the production of a multimedia presentation.
164. Demonstrate an interactive multimedia presentation.
165. Edit and add voice-overs to screens of a multimedia presentation.

IMPLEMENTATION

The twenty-first century will bring new technologies that will be more complex, mature and versatile than those we utilize today. This reality gives rise to the need for the school curriculum to closely examine and reflect the concept of subject matter integration or connections that are apparent within its content. To establish this connection for the public school subject area of Technology Education, this support manual was developed. Teaching technology to the students in Georgia public schools provides tremendous opportunity for its students to apply knowledge through design, math concepts, science concepts and the use of materials, techniques and processes to solve real-world problems systematically and to gain new knowledge from what they have learned. The manual presents a variety of activities in the systems of biological, informational and the physical to assist the teacher and students to reach the goals of the technology education curriculum by reinforcing the concepts discussed in the technology education laboratory. The manual is also designed as a supplementary resource to likewise accent the presented activities of safety, career awareness, technical terminology, research and information useful in an ever-changing society.

Some suggested uses for this manual are:

- Integrate math, science, reading and writing activities into the curriculum.
- Use worksheet activities in group or individual settings to assist modular assignments.
- Use worksheet activities to continue curriculum excellence when students are absent from the technology education laboratory.
- Utilize presented activities for meaningful student homework assignments.
- Utilize presented activities for enrichment development for all students.

RESEARCH WRITING AND DOCUMENTATION

Research is a foundational component of the Informational, Physical, and Biomedical Systems studied in the Technology Education curriculum. Before a structure can be designed, a product can be manufactured, a new software package is developed or pharmaceutical merchandise is distributed to the public research is conducted. Preliminary research is needed to help prevent initial problems, alleviate any questions or concerns, and necessary to create a safe, useful, and appropriate product.

Research papers are newly created works that consult several sources to answer a question or problem. In a research paper, students are expected to develop a point of view toward the material, take a stand, express some original thoughts, and draw a conclusion from the information gathered and presented. To help present a clear understanding and successfully compose a research paper, the table below compares and contrasts positive and negative components that should be discussed before starting a research paper.

A Research Paper *IS:*	**A Research Paper *IS NOT:***
• Synthesizes discoveries about a topic and judgment, interpretation, and evaluation of those discoveries	• Summary of an article or a book
• Work that shows student's personal and original thoughts and ideas	• Ideas of others, repeated uncritically
• Acknowledges all sources used	• Unsubstantiated personal opinion
• Shows continued writing commitment and growth in the student's educational development	• Copying or accepting another person's work as your own and not acknowledging credit for all sources used

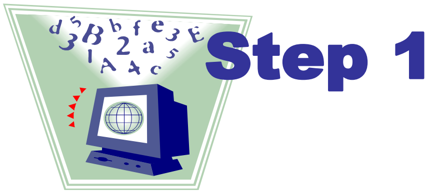
To successfully develop a well-written research paper, the following steps are given:

Step 1: Research topic and gather information.

Step 2: Organize facts, thoughts, and findings into an outline.

Step 3: From the outline, prepare a rough draft, working paper, and final product.

Step 4: Document all sources.



Research and Gather Information

Before any research paper can be composed, information on the selected topic must be collected. Research material can be compiled from of a variety of places including books, journal articles, personal communication, television and video, and the internet. A variety of sources will provide a larger assortment of information on the selected topic and improve research skills.

When using different approaches to gathering information, the following guidelines should be considered:

Source	Guidelines when using this medium
Books Books are documents (hardback or paperback) published to provide basic information on a specific content.	1. Try a content search under specific topic name (i.e. robotics, laser and fiber optics, etc.) 2. If little information is generated under specific topic, use broader base title searches (i.e. manufacturing, communication, etc.) 3. Use full topic name not abbreviations (i.e. CADD instead use Computer Aided Drafting and Design)
Journal Articles Journal articles are popular publications published in the mass media commonly found for sale at newsstands, in bookstores, or through national and international organizations. Journal articles in these types of publications generally are reviewed by the publication source and typically list sources of the information used as background to write the article for further investigation on the subjected discussed.	One of the leading sources for retrieving information on journal articles is Galileo. Galileo is a system wide library services in the state of Georgia that allows libraries to share databases and information through an on-line medium. Galileo can be accessed from the following web address: http://www.galileo.peachnet.edu/ Some tips for using Galileo: 1. Get acquainted with the system. Galileo offers a Where to Begin sections on the home page that provides tips and information on the system. 2. In the content section for Where to Begin, select Finding Scholarly Articles. This section provides basic information on what type of journal articles are available. 3. To become familiar with Galileo journal search options, start a basic journal search with Academic Search Premier. This database search is easy to use and allows for a variety of search options.

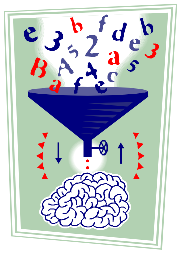
Personal Communication Personal communication can include personal interviews, telephone interviews, or multimedia interviews (teleconferencing, e-mail, etc.)	1. Use community members to help bring real-world experience into the research paper. 2. When conducting an interview, have questions prepared in advanced to avoid. 3. Be prompted, courteous, and give thanks to the person being interviewed.
Internet The Internet is a public, cooperative, and self-sustaining worldwide system of computer networks that allows one user at any one computer to get information and talk directly to users at other computers around the world.	1. Identify important concepts or keywords that describe the research topic. 2. Choose a search engine (i.e. Lycos. AltaVista, MSN search, etc.). 3. Read and understand the search engine's home page for search instructions. Each search engine may have different procedures for conducting a through search. 4. Evaluate the search results and visit generated sites. Don't become discouraged if desired information is not retrieved immediately. 5. Modify search terms if needed. Sometimes different search engines use different key terms for the same content or subject topic (i.e. world wide web and internet will generate different search results).

Individual Student Activity: Assign each student a topic for research from below (or use your own). Have students use a minimum of three different research methods to gather information on the given topic.

Animation
Robotics
Pneumatics
Computers
Computer Aided Drafting
Aviation
Environmental Conservation

Mass Media
Telecommunications
Hydroponics
Desktop Publishing
Electronics
Digital Photography
Hydroelectric Power

Satellites
Automation
Space Travel
Plastics
Genetics
Lasers



Step 2

Organize Information into an Outline

Once information is gathered for the research paper, an organized method of sorting the information into similar sub-topics is suggested. An outline is a simple and effective way to visualize and develop concepts in the research paper. Outlines help organize thoughts and ideas, show connections among ideas, and provide an order to the research paper.

Below is a sample outline:

Basic Computer Terminology

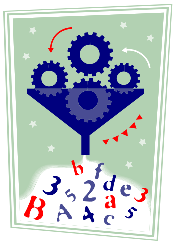
I. Hardware
   A. Internal
      1. CPU
      2. Motherboard
      3. Video Card
   B. External
      1. Monitor
      2. Keyboard
      3. Serial Cable
II. Software
   A. Word Processing Applications
      1. MS Word
      2. Word Perfect
      3. Notepad
III. Computer Safety
   A. Electrical Precautions
   B. Liquid Precautions
   C. Maintenance Precautions

Student Group Activity

In small groups, have students create an outline for one of the following topics: Transportation, Construction, Manufacturing, or Communication.

Individual Student Activity

Have each student develop an outline with the information gathered in Step 1.

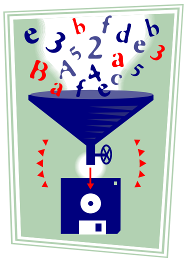


Step 3

Compose the Research Paper

Composing the research paper is not an easy task. Several aspects exist and require careful consideration before the final product. Many different formats exist and can be adapted to fit any individual's writing style or instructor's requirements. The table below is a basic guideline for the parts of a research paper.

Parts of the Research Paper	**Suggestions**
1. Title Page	Title of Paper Name of Author School Name Instructor's Name Date
2. Abstract	This is usually a one to three paragraph summary of the research paper
3. Outline	This helps to visualize the topic presented in the research paper
4. The Paper	This usually consists on three parts: 1. *Introduction paragraph(s)* – states the purpose or topic of the paper and introduces concepts presented throughout the paper 2. *Body Paragraphs* – presents ideas, information and support materials on the research topic 3. *Conclusion Paragraph(s)* – brings the main argument of the paper to a close and summarizing your ideas on the topic
5. Bibliography or Works Cited Page	This page(s) documents all sources used in the research paper



Step 4

Document and Cite all Sources

Documenting sources is an important part to any research paper. Not citing where material or information is obtained from may result in allegations of plagiarism. Citing all resources used in the paper is common courtesy and gives strong support to the ideas presented. There are several methods available for citing or referencing source. The two most widely accepted formats are MLA (Modern Language Association) and APA (American Psychological Association). Colleges and universities throughout the United States commonly accept both of these formats. It is the responsibility of the instructor to select an appropriate method for their classroom requirements.

The table below is a basic guideline for MLA and APA formats:

MLA Format	**APA Format**
http://www.mla.org/ Official website for MLA. Lists tips and answers frequently asked questions concerning MLA format.	http://www.apastyle.org/elecref.html Official website for APA. Lists tips, answers frequently asked questions, and style tips of the week.
http://www.english.uiuc.edu/cws/wworkshop/bibliography/mla/mlamenu.htm This site developed by Illinois University (Urbana Champaign) Writer's Workshop,	http://webster.commnet.edu/apa/apa_index.htm This site developed by Capital Community College, is a guide for writing research papers based on styles recommended by The American Psychological Association.
http://owl.english.purdue.edu/handouts/research/r_mla.html This site developed by Purdue University Online Writing Lab provides basic information and examples on The Modern Language Association format.	http://owl.english.purdue.edu/handouts/research/r_apa.html This site developed by Purdue University Online Writing Lab provides basic information and examples on The American Psychological Association format.

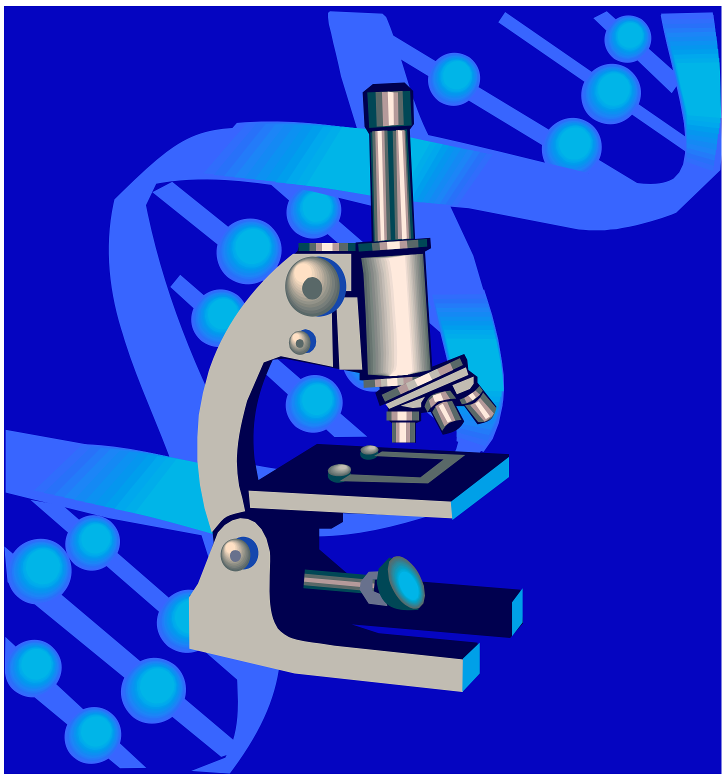
SCIENTIFIC PROCESS/METHOD

Technological literate students are learners as well as users of knowledge. Technological literacy comes with the ability to ask questions about the world that can be answered by using scientific, mathematical and technological knowledge and its techniques. Technological literate students can also develop solutions to problems that they encounter or questions they ask. In developing solutions, technically literate students may use their own knowledge and reasoning abilities, seek out additional knowledge from other sources and engage in empirical investigations of the real world. They can learn by interpreting text, graphs, tables, pictures, or other representations as they go about their investigations in to the research data. They can use knowledge and activities to assist them in formulating descriptions and explanations of real world objects; prediction of future events or observations and the design of systems or courses of action that will enable them to adapt to or modify the world around them. They can take a historical and cultural perspective on concepts, theories and technical data as well as discuss the many relationships among science, technology, math and society. Finally technically literate students can describe the limitations of their own knowledge and technological knowledge in general.

The scientific method or problem-solving process is a powerful instructional strategy that enables students to develop higher-order thinking skills and greater abilities to address real-world problems. The strength of this approach is that it is not just a theoretical structure for instruction, nor a system of forcing the student to conform or confront all of the learning problems in a task. It has as its primary purpose the structure of shifting the focus of the content delivery from the instructor to the student. The student has the mechanism in this process to create and implement solutions to actual problems as found in the workplace. The following seven steps give the student this investigative power:

- Identify the problem.
- Establish what you want to achieve/ design brief.
- Research past solutions to similar problems.
- Brainstorm possible solutions.
- Pick the best solution.
- Build a working model/ prototype.
- Adjust your solution if necessary/ feedback.

BIOLOGICAL



Introduction

The basic building block of technology education is the system. A system is a group of interrelated components designed to collectively achieve a desired goal or goals. Systems can and do exist on many levels. The technologically literate person uses a strong systems-oriented thinking approach as they go about solving technological problems.

Technology is human innovation in action. It involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. The systems that are developed can easily be categorized as biological systems, informational systems and physical systems.

The first system addressed in this document is **Biological Systems**. In this system, the developmental processes include such topic areas as genetic engineering, agricultural cultivation, manipulating the human immune system and improving the predictive technologies for disease. The biological system likewise uses living organisms [or parts of organisms] to make or modify products, to improve humans, plants or animals or to develop micro-organisms for specific use. The biological systems are used in content fields such as agriculture, medicine, sports and genetics. This system is addressed through some of the ITEA Standards of 3,9,10,12,13,14 and 15. The following technology education activities, with their associated mathematical and science connections, are a sampling of the units that can be studied by the student to assist them in understanding the behavior of the system. Once the behavior of a system is understood, the technologically literate person is able to assess the complete system to judge what necessary control adjustments are needed as variables change or inputs become known.

Connecting Mathematics and Science to Technology Education

System: Biological
ITEA Standards: 3, 4, 6, 10, 12, 13, 15
GPS: 1-17, 19, 20-26, 30, 43-48, 75

Name: ______________________________

Bioethics Debate Activity

This activity probes bioethical issues surrounding hormones, specifically BST (bovine somatotropin) and provides a setting for students to engage in problem solving, investigation, and discovery. In this activity, students will investigate and research the growth hormone to collect data and information for debating the pros and cons of the use of BST. Students will develop an overall awareness of the impacts of a bio-related technology and impinge upon his or her interpretations and consciousness to derive a conclusive stand with respect to the bio-related technology.

Math Connections	Science Connections	Technology Connections
Data table	Physiology	Bio-related technology
Charts		Design Processes
Graphs		Troubleshooting
Comparison		Problem-solving
Ratio, Percent, and Proportion		

Introductory Activity

The teacher or instructor should use an introductory activity to illustrate that a person's perspective of an issue may affect individual opinions or decisions.

1. Place an abstract or irregular shaped item in the center of the room and have each Student describe the item from their point of view. Suggestions: An irregular box, an abstract piece of art or even a garden scene will evoke different perspectives.

2. Are their descriptions the same as others given in the class?

3. Discuss what factors affect how one describes the item.

Role of the Teacher

1. Set a date and time for the debate and secure at least a 12 member judges panel. Have back-ups in case of illness or other priorities.
2. Invite parents, teachers and administrators to observe the students in action.
3. Facilitate the activity and give guidance but refrain from dictating solutions or answers.
4. Remain neutral to both teams and DO NOT take either position.
5. Instruct students in developing a PowerPoint presentation and in using Excel to do their bar graphs.
6. Have all the necessary technology available for preparation and delivery of the debate.
7. Set up the classroom formally for the debate.
8. Arrange to have the debate videotaped so that the students can view it later.

INTRODUCTION

Technology can have both positive and negative results. It is important to study the effects of technology and how it impacts humans and the environment. Oftentimes, the long term effects can not be adequately analyzed until damage has already been done. Research is very important in studying both short and long term effects of technology and research findings often bring forth many controversial issues.

One area of controversy is the use of hormones. Research indicates that there are definite safety issues and concerns relating to long term use for humans. These studies have helped people to make informed decisions on whether to continue or discontinue the use of the hormone. However, humans unknowingly still consume hormones indirectly through the foods that they buy and consume.

One of these food products is milk. Many dairy farmers employ the use of the hormone, BST, to increase milk production to increase profits. However, drug companies make a large profit from the sale of the hormone and therefore, the use of the hormone has caused some controversial issues in regards to bioethical concern related to public safety.

What is BST?

Bovine Somatotropin (BST), also known as Recombinant Bovine Growth Hormone (rBGH), is a growth hormone used in the dairy industry to produce more milk than cows would naturally produce. It is a genetically engineered copy of a naturally-occurring hormone produced by cows and it works by altering gene expression of glucose transporters in the cow's mammary gland, skeletal muscle and omental fat. The gene facilitates the repartitioning of glucose to the mammary gland, which in turn produces more milk.

ACTIVITY ASSIGNMENT

Use of BST is a bioethical concern because it raises issues related to public safety. You are to investigate and collect evidence for both the pros and cons of the use of BST. After gaining insight on the subject, you are to make an ethical decision for or against the use of the genetically engineered, hormone technology. You will use the data and information that you have collected to help your team collaborate and prepare to present and argue your team's position to a neutral panel of judges comprised of parents, teachers, administrators, and people from surrounding businesses and industry.

1. Each team will use displays and props to sway opinions not only in the classroom but throughout the school.
2. Each team must prepare a PowerPoint presentation collectively to show their research and knowledge of the subject.
3. Each team must prepare formal opening and closing arguments for the debate.
4. Each team must collect data from 100 different people (50% male and 50% female) to determine public awareness of the use of BST to be used in a bar graph to compare the two data sets.
5. Each team must conduct a survey of a specific group of students comprised of 50 % females and 50% males (names submitted) to predict the outcome of the debate.

Your objective is to be able to debate or argue your position with supporting facts and information that will sway the judges to take your position on the subject. At the end of the debate, the judges will each take a position based on the most convincing evidence that appeals to their conscious.

INSTRUCTIONS

1. Using the Internet, research BST to answer the following questions. Remember that the more information you gather, the better you can support an argument.

   What are the impacts of BST on food safety?

   What are the economic impacts of BST?

   How does the use of BST affect large or small farms?

   What effect does BST have on human physiology?

   Does BST cause cancer?

   What effect does BST have on the behavior of cows?

   What effect does it have on human behavior?

2. Make a chart of the pros and cons of BST. (You will need to know both sides so that you can adequately counteract an opposing argument.)

3. How aware is the public about BST and milk?

   Gather the following data to use in constructing the bar graph to represent public awareness. Develop a method or form to properly record the survey data. Each team member is responsible for collecting an equal portion of the data. Names of students surveyed must be recorded for documentation. (*Students who have already participated in the survey by another team member or by the opponent's team may not be surveyed again.)* After each team member has completed their survey, the data can then be consolidated to use in the bar graph. Your graph must show percentages.

   Survey 100 different students, to see how many are aware of the growth hormone in the milk that they drink. Ask each student the following question:

   Are you aware that BST, a growth hormone is used in cows to increase milk productivity?

4. Do a survey of an adequate number of a specific group of students to make a prediction of the final outcome of the debate. An adequate number is the number that each team decides to survey to make a prediction more reliable. Refer to *Calculating Probability* on the following page to determine the sampling size for your sampling population.

   a. The sampling population must be a specific group (all ninth graders or all tenth graders, etc.) comprised of 50% males and 50% females.

   b. Names must be documented and again, students who have already participated with another team member or with the opponent's team is not eligible.

Calculating Probability

Probability is the basis for estimating the results of many scientific experiments. If you tossed a coin 1000 times, you would probably expect that 50% of the time it would come up heads and the other 50%, it would be tails. It is true that the more tosses you make the greater the probability that the proportion of heads to tails will be about equal. Because large numbers provide results closer to what happens in real life, scientists study large samples to make predictions.

Using a simple method, reliability of test samples can be increased by how many times scientists want to increase the sample's reliability. If a test sample is 30 subjects, to make the sample twice as reliable, a scientist will multiply 2 by itself (2 x 2) and then by the number of test subjects in the sample (4 x 30). In this case, the scientist will need 120 subjects to make the test sample twice as reliable as the original sample.

Constructing a Bar Graph

A bar graph is a picture that displays and compares numerical facts in the form of vertical or horizontal bars. To construct a vertical bar graph, follow these steps:

1. Draw the vertical and horizontal axes.
2. Scale the vertical axis to correspond to the given data.
3. Draw one bar to represent each quantity.
4. Label each bar and the vertical and horizontal axes.
5. Title the graph.

Connecting Mathematics and Science to Technology Education

System: Biological
ITEA Standard: 8, 9, 10, 11, 16
GPS: 1-19, 23-25, 38, 40, 41, 70-74

Name: ______________________________

Chair Design

This activity requires students to design an ergonomically correct chair based on measurements of students in the class. The chair, after being made from cardboard, must be able to support a 250 pound person.

Math Connections	Science Connections	Technology Connections
Area	Ergonomics	Engineering
Measurement		Problem Solving
		Design

Specifications and Limitations

1. The chair must have a seat, backrest, and arms.
2. Measurements for the chair will be based on statistical class data.
3. Required Angles;
   a. Back tilt – 90 to - 105 degrees
   b. Seat lift - 15 degrees
4. There can be no fewer than three (3) legs that touch the ground and the three legs cannot make contact with over 12 square inches of floor space.
5. The chair must support a person weighing 250 pounds.
6. The chair should be comfortable to sit in.
7. The chair is to be made of corrugated cardboard.
S. Any form of tape may be used to secure the cardboard.
9. The chair should be finished with some type and style of fabric so as to be pleasing to the eye.
10. Other materials may be used for padding, covering etc (the basic structure must be corrugated cardboard).

Students will work in teams of four. Each of the team members will be responsible for one of the following jobs:

Structural Engineer

1. The initial design and testing of materials and connections
2. Computations of ultimate strength and safety margin of structure
3. The structural drawings
4. The structural Journal

Ergonomic Engineer

1. Collection and analysis of anthropometric data
2. Dimensions meet all parameters and constraint on all drawings.
3. Dimensions on models
4. Ergonomic Journal

Product Design Engineer

1. Design Sketches (at least 5 thumbnail drawings)
2. Final Chair design solutions and fabrication
3. Chair construction meets all design/comfort criteria and constraints

Draftsman

1. Orthographic drawings (top, front and side views)
2. Isometric sketches and final isometric drawings

Definitions in Ergonomics

Defining what one does in the field of ergonomics confuses many people. Terms such as anthropometry , risk factor , OSHA, MSD, and ANSI often make it more confusing; therefore, it is helpful to give them a list of the following definitions so that they will understand more of what you are explaining.

Administrative Control - Procedures and methods, set up by the employer, that significantly reduce exposure to risk factors by altering the way in which work is performed; examples include employee rotation, job task enlargement, and adjustment of work pace.

ANSI - American National Standards Institute. Is a private, non-profit membership organization that coordinates voluntary standards activities. ANSI assists with standards-developers and standards users from the private sector and government to reach agreement on the need for standards and establish priorities.

Anthropometry - Anthropometry is the branch of the human sciences that deals with body measurements.

Awkward Posture - Posture is the position of the body while performing work activities. Awkward posture is associated with an increased risk for injury. It is generally considered that the more a joint deviates from the neutral (natural) position, the greater the risk of injury.

Cumulative Trauma Disorders (CTDs) - Term used for injuries that occur over a period because of repeated trauma or exposure to a specific body part, such as the back, hand, wrist and forearm. Muscles and joints are stressed, tendons are inflamed, nerves pinched or the flow of blood is restricted. Common occupational induced disorders in this class include carpal tunnel syndrome, epicondylitis (tennis elbow), tendinitis, tenosynovitis, synovitis, stenosing tenosynovitis of the finger, DeQuervian's Syndrome, and low back pain.

Engine*ering Control* - Physical changes to jobs that control exposure to risk. Engineering controls act on the source of the hazard and control employee exposure to the hazard without relying on the employee to take self-protective action or intervention. Examples include: changing the handle angle of a tool, using a lighter weight part, and providing a chair that has adjustability.

Ergonomics - According to Ergoweb: The science of work. Ergonomics removes barriers to quality, productivity, and safe human performance by fitting products, tasks and environments to people.

Ergonomic program - A systematic process for anticipating, identifying, analyzing and controlling ergonomic risk factors.

Force - The amount of muscular effort required to perform a task. Generally, the greater the force, the greater the degree of risk involved. High force has been associated with work-related musculoskeletal disorders at the shoulder and neck, the low back and the forearm, wrist and hand.

Human Factors - A term synonomous with ‘ergonomics’, is the branch of this science that began in the US and focuses on cognitive performance of humans.

Manual Material Handling - Lifting, carrying, and moving materials without mechanical aide.

Musculoskeletal Disorders (MSD) - Injuries and disorders of the muscles, nerves, tendons, ligaments, joints, cartilage and spinal disc; examples include carpal tunnel syndrome, rotator cuff tendonitis, and tension neck syndrome.

NIOSH - National Institute of Occupational Safety and Health. NIOSH is the institution that provides scientific data upon which OSHA makes recommendations.

RSI - Repetitive Strain Injury

RMI - Repetitive Motion Injury

UECTD - Upper Extremity Cumulative Trauma Disorders

WRULD - Work Related Upper Limb Disorder

Occupational Injury - Any injury such as a cut, fracture, sprain, amputation, etc., which results from a work-related event or from a single instantaneous exposure in the work environment. Examples of injuries or disorders that can be work related include:

- Carpal tunnel syndrome (CTS)
- Rotator cuff syndrome
- De Quervain’s disease
- Trigger finger
- Tarsal tunnel syndrome
- Sciatica
- Epicondylitis
- Tendinitis
- Raynaud’s phenomenon
- Carpet layers knee
- Herniated spinal disc
- Low back pain

OSHA - Occupational Safety and Health Administration. The mission of the Occupational Safety and Health Administration (OSHA) is to save lives, prevent injuries and protect the health of America’s workers. To accomplish this, federal and state governments must work in partnership with the more than 100 million working men and women and their six and a half million employers who are covered by the Occupational Safety and Health Act of 1970.

OSHA 200 Log - An OSHA-required form for employers to record and classify occupational injuries and illnesses, and note the extent of each case.

Repetition - Repetition is the number of a similar exertions performed during a task. A warehouse worker may lift three boxes per minute from the floor to a countertop; an assembly worker may make 20 units per hour. Repetitive motion has been associated with injury and worker discomfort. Generally, the greater the number of repetitions, the greater the degree of risk. However, there is no specific repetition limit or threshold value (cycles/unit of time, movements/unit of time) associated with injury.

Risk Factor - Actions in the workplace, workplace conditions, or a combination thereof, that may cause or aggravate a Work Related Musculoskeletal Disorders; examples include forceful exertion, awkward postures, repetitive exertion, and environmental factors such as temperature.

Segmental Vibration (Hand-Arm Vibration) - Vibration applied to the hand/arms through a tool or piece of equipment. This can cause a reduction in blood flow to the hands/fingers (Raynaud's disease or vibration white finger). Also, it can interfere with sensory receptor feedback leading to increased handgrip force to hold the tool. Further, a strong association has been reported between carpal tunnel syndrome and segmental vibration.

Work Related Musculoskeletal Disorders (WMSD, WRMSD) - Injuries and disorders of the muscles, nerves, tendons, ligaments, joints, cartilage and spinal disc due to physical work activities or workplace conditions in the job. Examples include: carpal tunnel syndrome related to long term computer data entry, rotator cuff tendonitis from repeat overhead reaching, and tension neck syndrome associated with long term cervical spine flexion.

History of Ergonomics

Christensen (1987) points out that the importance of a "good fit" between humans and tools was probably realized early in the development of the species. Australopithecus Prometheus selected pebble tools and made scoops from antelope bones in a clear display of selecting/creating objects to make tasks easier to accomplish.

In the work environment, the selection and creation of tools, machines, and work processes continued. Over centuries, the effectiveness of hammers, axes and plows improved. With the Industrial Revolution, machines such as the spinning jenny (a machine that produced yarn to make cloth) and rolling mills (a method of flattening iron ore into flat sheets) were developed to improve work processes. This is the same motivation behind much of ergonomics today.

The association between occupations and musculoskeletal injuries was documented centuries ago. Bernardino Ramazinni (1633-1714) wrote about work-related complaints (that he saw in his medical practice) in the 1713 supplement to his 1700 publication, 'De Morbis Artificum (Diseases of Workers)."

Wojciech Jastrzebowski created the word ergonomics in 1857 in a philosophical narrative, "based upon the truths drawn from the Science of Nature" (Jastrzebowski, 1857).

In the early 1900's, the production of industry was still largely dependent on human power/motion and ergonomic concepts were developing to improve worker productivity. Scientific Management, a method that improved worker efficiency by improving the job process, became popular.

Frederick W. Taylor was a pioneer of this approach and evaluated jobs to determine the "One Best Way" they could be performed. At Bethlehem Steel, Taylor dramatically increased worker production and wages in a shoveling task by matching the shovel with the type of material that was being moved (ashes, coal or ore).

Frank and Lillian Gilbreth made jobs more efficient and less fatiguing through time motion analysis and standardizing tools, materials and the job process. By applying this approach, the number of motions in bricklaying was reduced from 18 to 4.5 allowing bricklayers to increase their pace of laying bricks from 120 to 350 bricks per hour.

World War II prompted greater interest in human-machine interaction as the efficiency of sophisticated military equipment (i.e., airplanes) could be compromised by bad or confusing design. Design concepts of fitting the machine to the size of the soldier and logical/understandable control buttons evolved.

After World War II, the focus of concern expanded to include worker safety as well as productivity. Research began in a variety of areas such as:

- Muscle force required to perform manual tasks
- Compressive low back disk force when lifting
- Cardiovascular response when performing heavy labor
- Perceived maximum load that can be carried, pushed or pulled

Areas of knowledge that involved human behavior and attributes (i.e., decision making process, organization design, human perception relative to design) became known as cognitive ergonomics or human factors. Areas of knowledge that involved physical aspects of the workplace and human abilities such as force required to lift, vibration and reaches became known as industrial ergonomics or ergonomics.

The broad group focus and name duality continues at this time. Contributors to ergonomics/human factors concepts include industrial engineers, industrial psychologists, occupational medicine physicians, industrial hygienists, and safety engineers. Professions that use ergonomics/human factors information include architects, occupational therapists, physical therapists, occupational medicine nurses, and insurance loss control specialists.

The Chair: Rethinking Culture, Body and Design

By Galen Cranz

BERKELEY: While as much as half the world eats, works, relaxes, and entertains without them, why are we in the West so committed to chairs - from La-Z-Boys to prison electric chairs, from strollers to rockers? In her new book, “The Chair: Rethinking Culture, Body and Design.” Galen Cranz, University of California Berkeley architecture professor, explores the history, politics, and physiology of how and why we sit on chairs - often to the detriment of our health. She also analyzes a variety of chairs and proposes a new chair design that is easier on the both.

The book traces the story of the chair from its crudest beginnings in the Neolithic Age to today’s modern office, drawing on social science, design history, modern ergonomics, literature, anecdotes and personal experience.

A sociologist by training and a certified teacher of the type of body work known as the Alexander Method, Cranz argues that the chair was “created, modified, and nurtured” not in response to the requirements of the human body but as a means of indicating differences in status - between lord and subject, man and woman, boss and employee, adult and child. This history, she said, is preserved even in our language, where such terms as chair persons, county seats, and seats on the stock exchange are all metaphors for position, social role and power. “The chair comes to represent a role” wrote Cranz “so that people are careful not to sit in others’ chairs.” Not every culture shares our devotion to the chair, Turkish homes feature raised platforms. Indian divans, Japanese tatami mats, and Chinese heated k’ang are but a few of the other alternatives whose virtues. Cranz said, should not be overlooked.

Ergonomic research, she said, suggests that making chapattis while squatting on the floor is aerobic. The Muslim practice of bending and stretching ritual five times day, she added, is excellent for the spine.

Yet typical of Western attitudes toward such postures are the complaints of an English colonialist in India, in 1852, who thought the local laborers’ fondness for squatting suggested “indolence and inefficiency ....especially irritating to an Englishman” and who referred to raised seats as “one of those natural steps toward a higher civilization.” Ironically, Cranz said., it is we who pay a high price for choosing chair sitting over squatting, kneeling, sitting cross-legged or other postures common outside the West. Our increase in back problems over the last century, she wrote “correlates directly with the increasing number of hours we spend seated.”

One study found chair-sitting to be as great a health risk as lifting weights and excessive vibration. According to Cranz, in the U.S., back pain is second only to the common cold as a reason for missing work, costing an estimated $70 billion annually.

Attempts to address (his epidemic have spawned a small industry, as designers and back specialists seek to create back-friendly chairs.

But the quest for the perfect chair design has remained elusive, Cranz said, because right-angled seating is inherently stressful, and cumulatively deforming to the human body.

From a purist point of view, Cranz said she might argue that chairs should be abandoned. But from a pragmatic point of view, “we need to explore how they can be fixed or at least improved.” she wrote.

In chapters on “The Chair Reformed” and “Beyond Interior Design.” Cranz advocates a design movement, already in nascent form as “the new ergonomics.” that would potentially change workplace, home and urban environments, as well as social relations, in fundamental ways.

Offices should be designed like exercise par courses, she said, offering postural variety and more freedom for workers to move around and alternate tasks.

If the implications of what Cranz calls “body-conscious design” arc daunting. She believes they are also exciting. “There hasn’t been anything original in furniture design since the early 20th century, when modernists started fooling around with materials.” she said.

The book has its origin in her own physical problems, Cranz said. She has successfully addressed scoliosis without surgery, through both work and modifications to her home and office. “But I think I found something of universal significance.” she said.

Brief History of Chair Design

In the beginning, most chairs were made of wood. The nature of wood and wood-working techniques dictated the basic shape of chairs. Over centuries, some chairs and seats evolved which were elegant, practical, and extremely well suited to the human body. in this century, furniture design has changed more radically than at any other time in history. New materials and manufacturing processes have allowed new designs which have not evolved naturally, and are not well adapted to the body. Instead, humans are adapting to the chairs.

At the same time, our lifestyles have changed and many of us now spend large amounts of our lives sitting down. This unnatural lifestyle has lead to deterioration in posture and physical strength and many people now habitually slump. Chairs and seats are built to fit this collapsed posture. But these seats force you to slump and make the situation worse. If you always slump, you will find these seats comfortable - until you develop back trouble. This has lead to confusion about what good sitting posture is.

Although more attention is paid to design and ergonomics than ever before, the combination of shapes based on new technologies, and confusion about natural posture, has resulted in new, experimental seats which have not been used and tested over long periods of time. Yet, these new seats are everywhere, in the home, in public transport, in public buildings. And these seats are contributing to the problem of poor posture and back trouble.

Back Facts

What you sit on affects how you sit, and this may influence how your back feels and works. Back pain is an increasing and major health problem and the cause of the greatest loss of working days. There is an epidemic of back trouble which is costing the NHS £480 million every year. Posture is deteriorating. Poor posture leads to back trouble. Poor seats encourage or even force one into poor posture. Sitting on seats which force you to slump weaken the back, and leave it vulnerable to injury. Slumping and poor posture become the norm. We know that it is important to sleep on a good firm mattress, and to have a good office chair, but we have not made this link in relation to the seats we buy for our homes. We tend to think that sprawling on a very soft sofa is a luxurious, relaxing experience. But too much sprawling can harm us. We don't need to sit bolt upright all the time, but it is important to have good support while relaxing.

Sofas and Armchairs

You don't want to sit bolt upright on a hard chair all the time, you want to relax on a comfy sofa or armchair. But what do you mean by comfortable? To look at, or to sit on for 10 minutes, or to sit on for *3* hours. And what do you mean by relax? What looks comfortable to the eye may not be comfortable to the body. And if a sofa puts you in a collapsed position, you will be in a physiologically stressful situation, not a relaxing one. Furniture follows fashion like everything else. Recent fashion is for very large, very soft sofas. These mould the body into a harmful posture putting strain on the spine, the digestive system, and the breathing.

Everyone now knows that sleeping on an unsupportive mattress isn't good for the body and doesn't provide a restful sleep. Spending hours on an unsupportive sofa or chair doesn't provide us with rest or relaxation either, and it may be doing more serious damage long term.

What to look for in a chair

1. Can you get your posterior in the back of the seat and your feet on the ground at the same time with nothing digging into the back of your knees? If not, the seat is too deep, or perhaps too high off the ground, but this is less likely.

2. Is the backrest raked so far back that you couldn't eat, drink, read, or do anything else that you do on the sofa without hunching forward? And is the backrest high enough so that you can lean against it without strain in the upper body? The angle between the back and the seat should be close to a right angle. Does the back force the spine into exaggerated forward or backward curves? Is the seat a level surface without dips and bumps?

3. Is it too soft without being supportive? This is more difficult. What feels soft and pleasant or a short time can become uncomfortable after longer use. Are there cushions on the sofa and what are they made of? Feathers are too soft for support, and feather cushions need constant plumping to look good and the fabric may wear faster. Foam is the firmest but foam comes in different degrees of firmness and softens after a few months. There are also fiber fillings and combination fillings. The quality of the fabric will also affect the firmness. A

more closely woven, strong material will give a firmer quality to the filling or padding. The cushions should not depress more than 10 cm when you sit on them.

These are the most obvious things to look for in a sofa or armchair, but check what to look for in a seat again.

Is the seat flat or does it dump you in a hole in the middle or tip you to the center, especially if someone else is sitting on the sofa with you? Does the backrest have too much lumbar or neck support built in for you.

You can improve an existing sofa by using small cushions behind your back or shoulders. A piece of wood under the seat cushions can make the seat firmer and more level.

Most popular and easily available brands of sofas and armchairs are too soft and often too deep. Some have lumbar and neck support built in an attempt to be good for the back. Remember that support in the wrong place or too much support can be harmful.

Now it's your turn!

Chair Design Evaluation

Team Members
Structural Engineer ____ Notebook #
Ergonomic Engineer ______________________________________ Notebook #
Production Design Engineer _________________________________ Notebook #
Draftsman ____ Notebook #

Comfort	1	4	8	12	15	_____
Chair	1	4	8	12	15	_____
Angles	1	4	8	12	15	_____
Ergonomic	1	4	8	12	15	_____
Measurements	1	4	8	12	15	_____
Strength	1	4	8	12	15	_____
Appearance	1	4	8	12	15	_____
Teamwork	1	4	8	12	15	_____
Timeliness 0--- 10						_____
					Total	_____

Assessment Scale

1 = Unacceptable: workmanship is unacceptable
4 = Poor: workmanship is poor or incomplete
8 = Acceptable: work is acceptable, but needs modifications
12 = Accomplished: workmanship fulfills all objectives
15 = Mastery: workmanship demonstrates excellence

Chair Design (isometric views)

Draftsman Notebook

Design Sketches

(at least 5 thumbnail sketches)
Product Design Notebook
Engineer

Structural Drawings

(show testing of material & designs)
Structural Engineer Notebook

Ergonomic Information

(show information gathered)

Ergonomic Engineer Notebook #

Connecting Mathematics and Science to Technology Education

System: Biological
ITEA Standard: 3, 5, 15
GPS: 3-9, 15, 16, 23-25, 72

Name: ______________________________

Acres of Farming

In this activity, students will be introduced to the GPS system and will design a small growth system for farming. They will learn the applications of the GPS system to farming in general as well as the applications of math and science of the system specific to farming.

Math Connections	Science Connections	Technology Connections
Area	Environment	Communication
Geometry	Agriculture	Biotechnology
	Chemistry	

Career Connections: Interview with a farmer from Jamaica IL

There is a lot of mathematics in farming! With farming, you have to be able to use different areas of mathematics, such as weights and measures, addition, subtraction, multiplication, division, rates and ratios, geometry and area, interest rates, and taxes. We farmers do quite a bit with conversions. For example, grain has always been sold in bushels. However, when we harvest a field, we know the weight of the corn or soybeans we've brought in. So we use the fact that a bushel of soybeans weighs 60 lbs and a bushel of corn weighs 50 lbs to calculate how much of each we have to sell.

The size of a field is measured in acres. An acre is equal to 160 square rods. (These are very old measures that farming has carried through the years.) A rod is equal to 16-1/2 feet. That means that an acre is 43,560 square feet. All farmers know how long and wide their fields are and use that to convert feet into acres.

When we plant corn, we like to plant about 30,000 seeds per acre. With beans, we plant about 18,000 seeds per acre. There are new planters now that will tell us as we drive through the field how many seeds per acre we are planting. However, it is still good to check how much we've planted by digging up a small area and counting the seeds that have been planted there. Once we know how many seeds per foot are being planted in that row and how close the rows are, we can do the math to figure if we are planting the right amount and if not, we can determine what type of adjustments we need to make.

With fertilizers, we generally spread 200-400 lbs per acre. We run soil tests to determine how much of which fertilizer we need. New spreaders with computers allow us to enter a map of the field that it will use to adjust the amount of fertilizer applied as we drive along. We are also starting to use farm machines that are linked by satellites. These are currently very expensive.

Farmers also have to know mathematics to think about interest rates. There is quite a difference between 6.5% and 14%. We also use mathematics when deciding what to plant and when to sell. We watch the prices. It is kind of strange. If it rains in Brazil, then the price of beans drops. It takes something really good to happen to make the prices go up. But that's farming!

Calculations from the Farm

How big is an acre?

An old unit of measure is the rod. A rod is 16-1/2 feet long. A square rod is a square plot of ground 16-1/2 feet on a side. An acre is 160 square rods.

Questions

1. How many square feet are in one acre?

2. Calculate the area of your classroom. How many classrooms would it take to make an acre?

3. A football field is 160 feet wide and 100 yards from goal line to goal line. How does this area compare to an acre?

4. If the acre field was a square, what would its dimensions be?

5. If an acre field was 1 rod (16-1/2 feet) wide how long would it be? What part of a mile (5280 feet) is this length?

It is common these days for farmers to have fields of 120 acres.

6. What are some possible dimensions for a 120 acre field?

7. If the 120 acre field was square, what would its dimensions be?

When planting corn, it is common for the rows to be 30 inches apart and the goal is to have a corn stalk about every 4 inches.

8. Suppose you have an acre field and plant rows that are 30 inches apart. What is the combined length of all the rows in the acre field?

9. If seeds are planted every 4 inches, how many seeds are needed for an acre field? How many seeds are needed to plant a 120 acre field?

10. In the fall, the farmer hopes to be able to harvest about 175 bushels per acre. A bushel of corn weighs about 56 lb. How much would the corn from a 120 acre field weigh?

11. Using the football as your farm, plot the GPS coordinates for the following crops: corn, beans, and potatoes.

Did you know?

Did you know that farmers use tractors with GPS systems that drive the tractors for them? Today's technology allows farmers to input farm map information into a computer system. Then the computer and tractor take over and plant the crops for them. The system also can determine how many seeds are being planted in each row and how far apart they are spaced.

The system is also used in crop harvesting. The computer system is connected to the combine and as the crops are harvested, calculations are conducted to determine how many bushels per acre are harvested. All of this information is then used to determine how productive an area of farm land is and what can be done to improve crop yields.

After the crops are harvested and calculations are reviewed, the farmer can go back and take soil samples from different areas of a field and have them analyzed to determine what fertilizers need to be added to the soil. This information is added to the computer system and the fertilizer spreader with the same computer system spreads the fertilizers at the appropriate rate in the appropriate area. Technology is increasing our productivity by giving us new and effective tools that work.

To read more about it go to www.dere.com/en_us/ag/servicessupport/ams/feature-article-autotrac-assisted-steering-system.html

Did you know that biotechnology is affecting our grain crop production? By using corn and soy bean seeds that are herbicide resistant farmers are able to use no till techniques that reduce soil erosion and green house gas emissions.

To read more about it go to www.ncga.com/worldofcorn/main/worldofcorn2004.pdf

Design Brief

Farming involves the planning and growing of farm products like corn, beans, and soybeans. Your task is to design and build a growth system of some description that will simulate on a small scale the farming practice of growing farm products. To achieve this project idea, it is suggested that the student think about developing a hydroponics growth system.

Specifications

1. The system design must be approved by the instructor.

2. The system must be operational.

3. All equipment and materials must be supplied by the student because different students will have different designs or solutions to the project.

4. The student should research the Internet and locate such sites as " The Encyclopedia of Hydroponics Gardening" for design ideas and construction instructions.

5. The student is allowed to design their own system if they so choose.

6. The student is to construct the growth system and test out its effectiveness of design.

Connecting Mathematics and Science to Technology Education

System: Biological
ITEA Standard: 15
GPS 1-9, 116

Name________________________________

Waste and Recycling

This activity employs the use of collecting recycling materials so students will develop an awareness of their environment. This activity helps the student to understand the amount of material waste used by households and the importance of recycling.

Math Connections	Science Connections	Technology Connections
Multiplication	Environment	Technology Impacts
Division		Processes of Recycling
Average		

Recycling Process

Collecting and processing secondary materials, manufacturing recycled-content products, and then purchasing recycled products creates a circle or loop that ensures the overall success and value of recycling.

Step 1 - Collection and Processing: Collecting recyclables varies from community to community, but there are four primary methods: curbside, drop-off centers, buy-back centers, and deposit/refund programs.

Regardless of the method used to collect the recyclables, the next leg of their journey is usually the same. Recyclables are sent to a materials recovery facility to be sorted and prepared into marketable commodities for manufacturing. Recyclables are bought and sold just like any other commodity, and prices for the materials change and fluctuate with the market.

Step 2 – Manufacturing:Once cleaned and separated, the recyclables are ready to undergo the second part of the recycling loop. More and more of today's products are being manufactured with total or partial recycled content. Common household items that contain recycled materials include newspapers and paper towels; aluminum, plastic, and glass soft drink containers; steel cans; and plastic laundry detergent bottles. Recycled materials also are used in innovative applications such as recovered glass in roadway asphalt or recovered plastic in carpeting, park benches, and pedestrian bridges.

Step 3 - Purchasing Recycled Products: Purchasing recycled products completes the recycling loop. By "buying recycled," governments, as well as businesses and individual consumers, each play an important role in making the recycling process a success. As consumers demand more environmentally sound products, manufacturers will continue to meet that demand by producing high-quality recycled products.

Recycling Facts and Figures

- In 1999, recycling and composting activities prevented about 64 million tons of material from ending up in landfills and incinerators. Today, this country recycles 28 percent of its waste, a rate that has almost doubled during the past 15 years.
- While recycling has grown in general, recycling of specific materials has grown even more drastically: 42 percent of all paper, 40 percent of all plastic soft drink bottles, 55 percent of all aluminum beer and soft drink cans, 57 percent of all steel packaging, and 52 percent of all major appliances are now recycled.
- Twenty years ago, only one curbside recycling program existed in the United States, which collected several materials at the curb. By 1998, 9,000 curbside programs and 12,000 recyclable drop-off centers had sprouted up across the nation. As of 1999, 480 materials recovery facilities had been established to process the collected materials.

Opportunities

For recycling to work, everyone has to participate in each phase of the loop. From government and industry, to organizations, small businesses, and people at home, every American can make recycling a part of their daily routine. Below are some ways in which businesses, local governments, and citizens can get involved.

Landfilling

Although source reduction, reuse, recycling, and composting can divert large portions of municipal solid waste from disposal, some waste still must be placed in landfills. Modern landfills are well-engineered facilities that are located, designed, operated, monitored, closed, cared for after closure, cleaned up when necessary, and financed to insure compliance with federal regulations. The federal regulations were established to protect human health and the environment. In addition, these new landfills can collect potentially harmful landfill gas emissions and convert the gas into energy.

Assignment

For the next seven days you are to monitor the amount of garbage your family generates. To conduct this activity you will need five large grocery bags. You are going to keep records of your household waste with these paper bags.

You will also need to find a place where you can store you bags for this time period.

Your bags should be labeled:

Paper Items
Examples - newspapers, cardboard boxes, food containers, and any other paper products

Glass Items
Examples - bottles and glass jars

Aluminum Items
Examples - aluminum cans, foil, or any other aluminum products

Plastic Items
Examples - plastic food containers, styrofoam containers, plastic wrap, and any other products that will not decompose

Food Waste Items
Example - food scraps that will decompose

For the next seven days you need to monitor and record, on the cart below, the number of bags of each type that your household accumulates. Round each day off to the nearest fourth of a full bag.

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Paper							
Glass							
Aluminum							
Plastic							
Food							

At the end of the project answer the following questions at the end of the week:

1. How many total bags of trash were produced?

2. How many total bags of each were produced?

   a. ________Paper

   b. ________Glass

   c. ________Aluminum

   d. ________Plastic

   e. ________food

3. How many people live in your house?

4. What is the average amount of trash, per person, produced in you house?

5. How many bags of trash would your household produce in a 6 months?

6. How many bags of trash would your household produce in 2 years?

7. Rank the five categories of waste from highest amount to lowest for your household.

   a. ____________________ (most)

   b. ____________________

   c. ____________________

   d. ____________________

   e. ___________________(least)

8. What could be done to reduce the amount of trash your family produces?

9. Could any of the trash produced in your house be reused? If so, how?

10. What amount of waste produced in your household could be recycled?

Connecting Mathematics and Science to Technology Education

System: Biological
ITEA Standard: 15
GPS 1-9, 110,111, 112

Name: ______________________________

Blood Pressure and Pulse

In this activity students will be introduced to the science and basic concepts of devices that measure pulse and blood pressure. They will study examples of normal and abnormal rates of blood pressure and learn how these items impact the health of individuals.

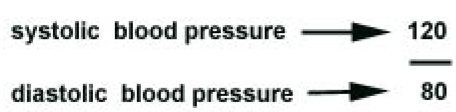
Math Connections	Science Connections	Technology Connections
Averages	Circulatory System	Healthcare
Multiplication	Blood Pressure	Stethoscope
Subtracting	Pulse	Historical Perspective

What is blood pressure?

With each beat of the heart, blood is pumped out of the heart into the blood is pumped out of the heart into the blood vessels, which carry your blood throughout your body. Your blood pressure is a measurement of the pressure or force inside your arteries with each heartbeat.

How is blood pressure measured?

A doctor or nurse can listen to your blood pressure by placing a stethoscope on your artery and pumping up a cuff placed around your arm. The blood pressure is read on a special meter. It is recorded as two numbers:



Systolic blood pressure – the first number; the amount of pressure against the artery walls each time the heart contracts or squeezes blood out of your heart.

Diastolic blood pressure – the second number; the amount of pressure inside your arteries when your heart is at rest, in between heartbeats.

Your blood pressure recording is not always the same. When you are exercising or excited, your blood pressure goes up. If you are at rest, your blood pressure will be lower. This is a normal response to changes in activity or emotion. Age, medications, and changes in position can also affect blood pressure.

What is a normal blood pressure reading?

To decrease the risk of cardiovascular (heart and blood vessel) disease, normal blood pressure, for those not taking blood pressure medications, should be less than 120/80.

What Is High Blood Pressure?

Blood pressure is the force in the arteries when the heart beats (systolic pressure) and when the heart is at rest (diastolic pressure). It's measured in millimeters of mercury (mm Hg). High blood pressure (or **hypertension**) is defined in an adult as a blood pressure greater than or equal to 140 mm Hg systolic pressure or greater than or equal to 90 mm Hg diastolic pressure.

High blood pressure directly increases the risk of coronary heart disease (which leads to heart attack) and stroke, especially along with other risk factors.

High blood pressure can occur in children or adults, but it's more common among people over age 35. It's particularly prevalent in African Americans, middle-aged and elderly people, obese people, heavy drinkers and women who are taking birth control pills. It may run in families, but many people with a strong family history of high blood pressure never have it. People with diabetes mellitus, gout or kidney disease are more likely to have high blood pressure, too.

American Heart Association recommended blood pressure levels

Blood Pressure Category	**Systolic (mm Hg)**		**Diastolic (mm Hg)**
Normal	less than 120	and	less than 80
Prehypertension	120-139	or	80-89
High			
Stage 1	140-159	or	90-99
Stage 2	160 or higher	or	100 or higher

About blood pressure monitors

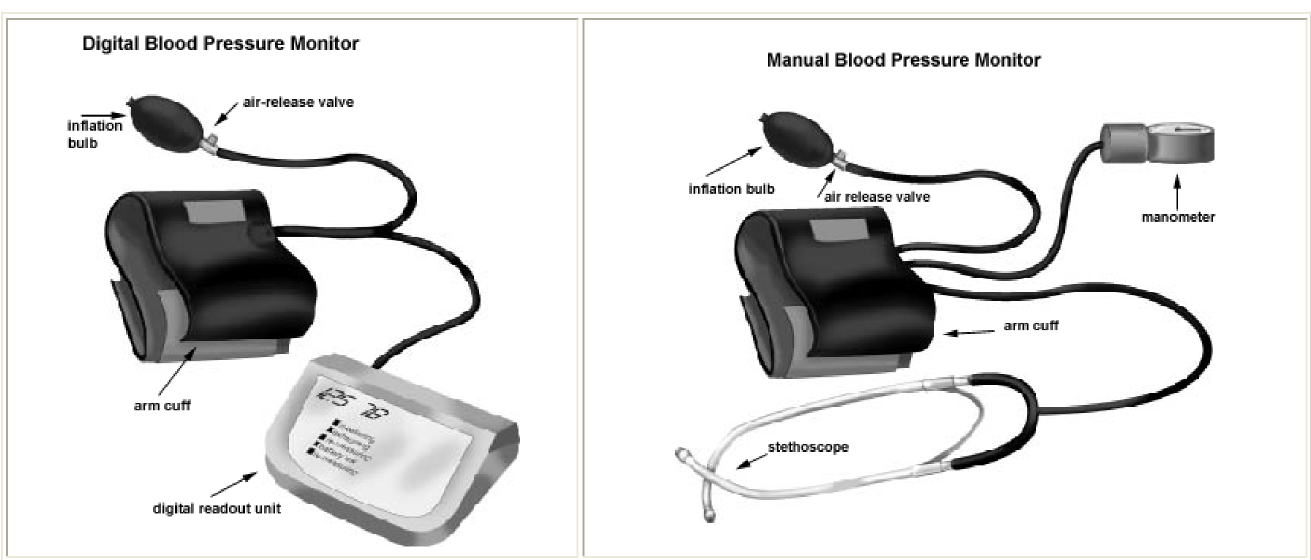
Some people get nervous when they go to their doctor. This causes blood pressure to rise and is called "white coat syndrome." To confirm if your blood pressure is high at other times, you may be asked to:

- Purchase a blood pressure monitor. You will be asked to check your blood pressure at different times of the day and keep a record. You can bring this record with you at your appointments. For more information on blood pressure monitors, go to:
    - Manual Blood Pressure Monitors
    - Digital Blood Pressure Monitors

- Wear a blood pressure monitor. This monitor is attached to your. You will be asked to wear it for 24 hours. The monitor is usually programmed to take blood pressure readings every 15 to 30 minutes all day and night while you go about your normal activities. The doctor will evaluate the results.

Before taking your blood pressure

1. Find a quiet place. You will need to listen for your heartbeat.
2. Roll up the sleeve on your left arm or remove any tight-sleeved clothing, if needed. (It's best to take your blood pressure from your left arm, if possible.)
3. Rest in a chair next to a table for 5 to 10 minutes. (Your left arm should rest comfortably at heart level.)
4. Sit up straight with your back against the chair, legs uncrossed.
5. Rest your forearm on the table with the palm of your hand facing up.



Taking your blood pressure

If you purchase a manual or digital blood pressure monitor (sphygmomanometer), follow the instruction booklet carefully. The following steps provide an overview of how to take your blood pressure on either a manual or digital blood pressure monitor.

Step 1: Locate your pulse
Locate your pulse by lightly pressing your index and middle fingers slightly to the inside center of the bend of your elbow. Here you can feel the pulse of the brachial artery. If you cannot locate your pulse, place the head of the stethoscope (on a manual monitor) or the arm cuff (on a digital monitor) in the same general area.

Step 2: Secure the cuff
(illustration at right: proper positioning of the manual monitor)

A. Thread the cuff end through the metal loop and slide the cuff onto your arm, making sure that stethoscope head is over the artery (when using a manual monitor. (The cuff may be marked with an arrow to show the location of the stethoscope head.)

The lower edge of the cuff should be about 1 inch above the bend of your elbow. Use the velcro wrap to make the cuff snug, but not too tight.

B. Place the stethoscope in your ears. Tilt the ear pieces slightly forward to get the best sound.

Step 3: Inflate and deflate the cuff
If you are using a manual monitor*:

A. Hold the pressure gauge in your left hand and the bulb in your right. (As shown to the right.)

B. Close the airflow valve on the bulb by turning the screw clockwise.

C. Inflate the cuff by squeezing the bulb with your right hand. You may hear your pulse in the stethoscope.

D. Watch the gauge. Keep inflating the cuff until the gauge reads about 30 points (mm Hg) above your expected systolic pressure. At this point, you should not hear your pulse in the stethoscope.

E. Keeping your eyes on the gauge, slowly release the pressure in the cuff by opening the airflow valve counter clockwise. The gauge should fall only 2 to 3 points with each heartbeat. (You may need to practice turning the valve slowly.)

F. Listen carefully for the first pulse beat. As soon as you hear it, note the reading on the gauge. This reading is your systolic pressure.

G. Continue to slowly deflate the cuff.

H. Listen carefully until the sound disappears. As soon as you can no longer hear your pulse beat, note the reading on the gauge. This reading is your diastolic pressure.

I. Allow the cuff to completely deflate.

IMPORTANT: If you released the pressure too quickly or could not hear your pulse DO NOT inflate the cuff right away. Wait one minute before repeating the measurement. Start by reapplying the cuff.

If you are using a digital monitor:

A. Hold the bulb in your right hand
(illustration at right: Proper positioning of the digital monitor. Note: some digital monitors also have automatic cuff inflation)

B. Press the power button. All display symbols should appear briefly, followed by a zero. This indicates that the monitor is ready.

C. Inflate the cuff by squeezing the bulb with your right hand. If you have a monitor with automatic cuff inflation, press the start button.

D. Watch the gauge. Keep inflating the cuff until the gauge reads about 30 points (mm Hg) above your expected systolic pressure.

E. Sit quietly and watch the monitor.

F. Pressure readings will be displayed on the screen. For some devices, values may appear on the left, then on the right. Most devices will also display your pulse rate.

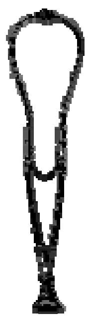
G. Wait for a long beep. This means that the measurement is complete. Note the pressures on the display screen. Systolic pressure appears on the left and diastolic pressure on the right. Your pulse rate may also be displayed in between or after this reading.

H. Allow the cuff to deflate.

IMPORTANT: If you did not get an accurate reading, DO NOT inflate the cuff right away. Wait one minute before repeating the measurement. Start by reapplying the cuff.

Step 4: Record your blood pressure.
Follow your doctor's instructions on when and how often you should measure your blood pressure. Record the date, time, systolic and diastolic pressures.

The Stethoscope



A Stethoscope is an instrument used for listening to sounds produced within the body. The first “stethoscope” was constructed of stacked paper rolled into a solid cylinder shape by Rene’ Laennec, a French physician, in 1816. After great success he would make new models out of wood. Prior to this invention physicians would place their ear to the patient’s chest to hear sounds of the lungs and heart. This type of stethoscope is called a “Monaural” stethoscope due to it having only one earpiece. To make your very own simple working model see the instructions below. Monaural stethoscopes for listening to an unborn baby’s heartbeat are still made today. As time went on many other stethoscopes were developed and made from different materials such as various woods (pine, ebony, cedar), metallic wire tubing, gutta-percha, ivory, metal, and India rubber. In 1829 the Binaural Stethoscopes (two earpiece models) make their debut, but not with much success by a doctor in Dublin.

Pulse Rate

Your pulse is your heart rate, or the number of times your heart beats in one minute. Pulse rates vary from person to person. Your pulse is lower when you are at rest and increases when you exercise (because more oxygen-rich blood is needed by the body when you exercise).

Knowing how to take your pulse can help you evaluate your exercise program. If you are taking heart medications, recording your pulse on a daily basis and reporting the results to your health care provider can help your provider determine if the medications are working properly.

Finding your pulse rate:

1. Place the tips of your index, second and third fingers on the palm side of your other wrist, below the base of the thumb. Or, place the tips of your index and second fingers on your lower neck, on either side of your windpipe.

2. Press lightly with your fingers until you feel the blood pulsing beneath your fingers. You may need to move your fingers around slightly up or down until you feel the pulsing.

3. Use a watch with a second hand, or look at a clock with a second hand.

4. Count the beats you feel for 10 seconds. Multiply this number by 6 to get your heart rate (pulse) per minute.

Check your pulse: _______________ x 6 = ________________
(beats in 10 seconds) *(your pulse)*

What is a normal pulse?	
Age Group	Normal Heart Rate at Rest
Children (ages 6-15)	70-100 beats per minute
Adults (age 18 and over)	60-100 beats per minute

Assignment Brief

Part 1

1. Take your resting pulse rate using the previously described technique or a stethoscope and record you findings (Remember to count the beats you feel for 10 seconds and multiply by six). List anything that could have effected your pulse rate. For example, were you nervous about anything today? Have you been exercising recently?

2. Try jogging in place for about 3 minutes and take your pulse rate once more. Record your findings.

3. What is the difference between your resting and active heart rates?

Part 2

1. Using the blood pressure kit, take your blood pressure and record it below. Is it above average, below average, or normal?

2. Continue taking your blood pressure once a day for the next week. At the end of the week calculate to find your average blood pressure.

A Simple Monaural Stethoscope

Design Brief

Your task is to design and build a simple monaural stethoscope device. The first stethoscope was made from paper, therefore; using the provided paper material: [1] a stack of newspaper or [2] 10 sheets of construction paper or [3] 10 sheets of duplicating paper, you are to design and construct a stethoscope.

Your first step is to do some basic research on the monaural stethoscope to assist you with an understanding of the device and some ideas of design and construction. You might want to develop several prototypes using some thumbnail sketches and then different paper materials to see which design and paper material works best. You then need to test the developed device on a classmate of the same gender on his or her arm artery to see which paper material works best.

Your next task is to design and build a simple monaural stethoscope from wood. As you now know from your research that the second development of such a device was made from wood.

Again, your first step is to do some basic research on the idea to gain some design concepts. After the research, select a 1" diameter dowel rod from the provided material. You will need to cut off a piece that is 12" long in length. Your next step is to decide how you are going to hollow out the center of the 12" rod. A hint here is to keep in mind that you have to have strength in the constructed device so you need to think about how large of a diameter hole one will need to drill for needed structure strength. After you have made the device, you need to test it out on a classmate of the same gender.

Application Questions

1. Which material device worked the best? Why?

   ____

   ____

   ____

2. Can the device you made be made from other types of materials? If so how?

   ____

   ____

   ____

3. How does your device differ from a binaural device used in modern medicine?

   ____

   ____

4. Do you think you could make a binaural device? What material do you think could be used? Why? ____

Connecting Mathematics and Science to Technology Education

System: Biological
ITEA Standard: 1-3, 17
GPS: 1-14, 43, 46, 47

Name: ______________________________

Water Conservation

Students will learn about water conservation and use desktop publishing software and design principles to design flyers to encourage water conservation.

Math Connections	Science Connections	Technology Connections
Percentages	Water conservation	Desktop Publishing
		Design principles

Water Conservation

Water is a fascinating topic. There's so much to learn about the natural water cycle and the pipes and reservoirs that deliver drinking water to our faucets. Explore these pages to discover your role in maintaining healthy streams and rivers and learn responsible ways to use less water in your every day activities.

Water on earth is used over and over in a continuous cycle. This is called THE WATER CYCLE and it is the continuous movement of water from ocean to air and land then back to the ocean in a cyclic pattern. In the water cycle, the sun heats the Earth's surface water, causing that water to evaporate into gas. This water vapor then rises into the earth's atmosphere where it cools and condenses into liquid droplets. These droplets combine and grow until they become too heavy and fall to the earth as precipitation (rain or snow).

When rain falls and snow melts, it collects in streams and rivers forming many watersheds. These watersheds provide much of the water we use. Some of the water seeps into the ground and collects in spaces known as aquifers. Lakes also act as reservoirs that temporarily store this precious resource. Water can move from these places via streams and rivers where it returns to the ocean, is used by people, plants and animals, or is evaporated directly back into the atmosphere.

The human body is 70% water.

Every system in our body uses water. Water is important to our bodies because it makes up 83% of our blood, transports body wastes, lubricates body joints, keeps our body temperature stable, and is a part of cells, which make up all living things.

The earth's surface is covered 75% with water.

Of all that water, 97% of it is salt water. We cannot drink salt water. It is difficult and expensive to remove salt from the water for drinking purposes, but some countries do have plants that do this. They are called "desalinization" plants. Two percent (2%) of the water on earth is frozen in glaciers at the North and South Poles. This frozen water is fresh water and could be melted down and used. However, it is too far away from where people live for this to be practical.

So, when you think about why water is so precious, it is because less than 1% of all the water on earth is fresh water which we can actually use. We use this water not only to nourish our bodies, but for transportation, heating and cooling, industry, and many other purposes.

All living things, including humans, animals, plants, and trees need water to live. Next to the air we breathe, water is our most important necessity. Without water, the earth would be very desolate -- something like the moon.

Flushing toilets represent the largest portion of indoor water use.

Unless they are newer models, most toilets use 3.5 to 7 gallons of water each time they flush. This is to remove a relatively small amount of waste. Modern, high-efficiency toilets use only 1.6 gallons per flush. In most homes, about one-third (33%) of the water used goes to flush toilets.

You can save water by making sure that you don't use the toilet as a trashcan for paper and particles that can be thrown in the garbage can instead. Why waste gallons of precious water if you don't have to?

Many of the actions you can take to conserve are free or low cost. Others, such as buying a new toilet or washing machine will cost initially, but pay for themselves in a few years through utility savings.

You can choose to take a number of actions and reach your goal right away, or you can choose to do a little bit each year for each of the ten years. There is no "typical" way to meet your goal. For some, it may be easy to meet the 1% goal each year. Others may find they have been doing a lot to conserve over the years and need to turn to innovative ways to save more.

Each of us uses water a little differently; some of us water the lawn, many of our homes have water leaks, even more of us have old toilets that use more than 1.6 gallons per flush. Find the opportunities that are right for you, and set your goal to reduce your use. Don't limit yourself to a total of 10%. If you feel you can easily reach 15%…20%, or more, go for it!

Indoor Conservation Tips

- **Flush less often.** Region-wide, this could save more than 3 million gallons each day. Also, don't use the toilet as a wastebasket for tissue and the like. Want to do more? Consider replacing any older toilets in your home with new low-flow models that use 1.6 gallons per flush. Toilets ten years or older may be using three-and-a-half to seven gallons per flush.
- **Shorten your shower by one minute.** Cut back on your shower time and you will rack up big savings in water and energy. If you really want to try and save water, limit your shower time to five minutes or less. Also, install a water-saving showerhead that uses two-and-a-half gallons per minute.
- **Fix leaking faucets and toilets.** Research has shown that an average of 8% (or more) of all home water use is wasted through leaks. Test for a leaking toilet by lifting the lid off the toilet tank and putting a few drops of food coloring into the bowl. Wait a few minutes, then look in the bowl. If the food coloring has made its way there, you have a leak.
- **Wash only full loads** of laundry in your washing machine or full loads of dishes in your dishwasher. You'll not only save water, but energy as well. Want to do even more? Consider purchasing a new water- and energy- efficient clothes washer. $100 rebate are available for qualified models.
- **Turn the water off.** Minimize faucet use when shaving, brushing teeth and washing dishes. Replace older bathroom faucet nozzles (aerators) with new ones that are rated at 1-gallon per minute.
- **Reuse clean household water.** Collect all the water that is wasted while waiting for the hot water to reach your faucet or showerhead. Use this to water on your houseplants or outdoor planters. Do the same with water that is used to boil eggs or steam vegetables.
- **Take showers instead of baths**. A bathtub holds up to 50 gallons of water- much more than a normal shower would use. (A typical shower uses less than 20 gallons.
- **Don't pre-rinse dishes.** Check if your dishwasher can clean dishes without pre-rinsing them. Most newer dishwashers don't require pre-rinsing.

Math Exercises

1. If you use 210 gallons of water a day and you are able to reduce your usage to 90% of this, how much water are you conserving?
2. If you use 2.3 gallons of water every time you flush your toilet and you are able to reduce your usage by 5% of this, how much water would you be using to flush your toilet?
3. If you use 7.7 gallons of water every time you wash a load of clothes and you wash 4 loads a week, how many gallons of water would you use in a year?
4. If you were able to reduce the total amount of water used a year in the above problem by 3.2%, how much water would you save per load?

Desktop Publishing

Desktop Publishing requires imagination, patience, and training. There are many different software packages available for DTP, some for illustration and drawing, others for painting and photo editing, and others for 'page-layout'. Which one you use depends upon the kind of document you are creating, and also on personal preferences. Usually individual 'elements' are created in a program best suited to them, then all these elements are arranged together in a 'page-layout' program.

Design Elements. When designing your piece, avoid using shaded screen backgrounds for separation or emphasis of parts of the page. This looks good on professionally printed materials but for the most part, screens look bad on forms or promotional materials that are laser printed or photocopied. Instead, use simple frames, white space, or a different font to separate a particular element from the rest of your copy. If you must use screened backgrounds, be sure to print the document with a coarse dot pattern so the photocopier is capable of reproducing the dots consistently.

On the same subject, when you're planning on copying scanned photographs, use the maximum coarseness in the halftone screen of your photo. A high quality laser printer might print a photo that looks good with very tiny halftone dots, but the photo will look bad when copied. Set your printer to do halftone photos at no more than 85 lines per inch or you'll be sorry.

Alignment. Avoid using left and right justified text unless your lines of type are long enough to get away with it. Many people think text should be justified both left and right to look professional but this is not true. Many times if your columns of type are very narrow as in the case of a tri-fold brochure, justifying the text will result in large gaps between words making the type look strange and actually making the reader think of these gaps as pauses, such as where a comma might be used. Be sure that your DTP software is set to auto-hyphenate where necessary and left justification looks just fine.

Watch out for widows, words left by themselves on the last line of a paragraph, as above. If you have to, adjust the letter spacing of your paragraph so that the last word will fit on the line above, or rewrite the last sentence to avoid the widow. In some cases it's OK to leave a widow on the last line if it's a long word and the length of the lines is short.

Fonts. Avoid the temptation to use all the fonts (typestyles) you have available on a single printed brochure or flyer. It looks tacky and is the first sign that your piece has been produced by an amateur. Typically you should never use more than three different fonts on a page, and most times two is plenty. Instead, make use of **bold** and *italic* versions of your fonts for prominence, and perhaps another stylized font for headlines. Never, ever <u>underline</u> type. This was done on typewriters for emphasis when there was no other way. With a PC and a desktop publishing program you have the ability to **bold** or *italicize* your type, even make it larger, to emphasize certain words or phrases.

DESIGN BRIEF

With the above information in mind, design a flyer that will promote water conservation using any kind of desktop publishing software available (examples: Word, Microsoft Publisher). Your design must be eye catching and utilize good elements of design. The flyer must include what you are promoting (water conservation), three facts about why it is important to conserve water, and five tips on how to save water.

Connecting Mathematics and Science to Technology Education

System: Biological
ITEA Standard: 1-3, 5, 11, 15
GPS: 1-19

Name: ______________________________

Build a Soda Can Crusher

In this activity, students will build a soda can crusher after learning about the recycling processes for aluminum and other materials. Students will also learn about energy savings and the cost effectiveness of recycling.

Math Connections	Science Connections	Technology Connections
Calculation of	Environment	Problem Solving
Energy Savings	Metal Properties	Manufacturing
		Bio-related technology

Tools, Materials and Supplies

An assortment of materials (examples: scrap lumber, cardboard, metal hinges, jar lids, etc.
Screws, glue
Saws, screwdrivers, utility knives

Background Information

Recycling saves natural resources, energy, the environment and it benefits the economy. Recycling has become an important aspect of our daily lives. By recycling aluminum, we are helping ourselves as well as future generations.

Recycling receiving centers all across the country are where materials collected curbside from residents, businesses, and schools within a region are separated, sorted and prepared to be sent to their next destination. Sorting is done both by machine and by hand. Trucks dump their load of recyclables toward the front of the building. A front-end loader scoops up material and deposits it into a screener. Vibrations cause small pieces of material to drop through the screen so that they can be removed. Larger items vibrate off the screen, and into a six-foot pit in front of the vibrating device. From here, the recyclables are taken up a steep conveyor. At the top of this belt, a powerful magnet removes steel and bi-metal cans. This material is sent down a chute into a hopper. The hopper is filled and emptied into a roll off container outside the recycling center. At the end of the day, steel and bi-metal materials are put into a baler, which compresses them into a solid brick.

Plastics are separated from glass with a series of air clarifiers. These machines use air to lift lighter materials, such as the plastic, while the heavier material, (i.e. glass) continues down the conveyor. The glass is then moved by conveyor into the next sorting station. Green, brown and clear glasses are sorted manually by workers in the sorting station. Conveyors transport separated glass up three separate belts, moving glass outside where it drops into three different storage bins.

Plastics and aluminum move through a trommel screen which again allows for small pieces of material and contaminants to be screened out. These materials move down the belt to the Eddy Current, a set of magnets operating under the conveyor, which create a negative charge, which repels aluminum. The aluminum cans appear to spring off the belt and down a chute, which feeds them into the densifier, another type of equipment, which compresses them into a 40 lb. "biscuit." Biscuits are banded together to form bales. Plastics move down a conveyor and are deposited in a pile. Materials in this pile are taken up another conveyor into a sorting station, where the different types of plastic are separated by hand and sent down different chutes to bins below the sorting station, much like the paper sorting process. Front-end loaders push plastics onto a conveyor, which moves them into a baler, compressing them and securing the bales with wire. Throughout the day, bales of different material are loaded onto tractor-trailers, ready to head to a variety of destinations.

The bales of cans are unloaded at smelting plants and tested for quality and moisture content. After inspection, the bales of cans are broken up in a shredder into small pieces. These shredded cans are then conveyed into a de-lacquering oven to remove the paint and residual moisture. The hot shredded aluminum is then passed over a small screen to remove dirt and contaminants and then fed directly into a furnace where the metal is heated to 1400 degrees Fahrenheit. The cans melt and blend in with the molten metal already in the furnace. Molten aluminum is checked for proper chemistry and then tapped (removed) from the furnace and poured into large molds that cast large blocks. These large rectangular blocks (20 to 40,000 lbs each) are allowed to cool and harden. The block is then passed between two giant steel rollers in a large rolling mill. The sheet is passed through a few more times until it is about 1/2 an inch thick and 1000 feet long. This long sheet is then annealed to soften it and passed through a series of rollers in a finishing mill where it acquires the necessary hardness and thickness. The edges are trimmed in a slitter and the coil is rolled up for shipment to a can manufacturer. The finished coil may be 2 miles long and made from over 1.2 million recycled cans.

The recycling of aluminum beverage cans eliminates waste. It saves energy, conserves natural resources, reduces use of city landfills and provides added revenue for recyclers, charities and local town government. The aluminum can is therefore good news for the environment and good for the economy.

Review Questions

1. How are aluminum cans removed from the pile during the sorting stage at a recycling center?

2. What machine crushes cans into a solid brick?

3. How is plastic removed from glass?

4. Why do aluminum cans appear to spring off the conveyor belt?

5. What is a biscuit when referring to recycling?

6. When the cans arrive at smelting plants, what two things are they tested for?

7. How is paint removed from the aluminum cans?

8. What is molten aluminum?

9. What process is used to soften the metal so it can be rolled?

10. Name five benefits of recycling.

<u>Practice Problems: How much can we save by recycling?</u>

Use the basic facts below to answer the questions that follow:

- There are 365 days in one year.
- There are 7 days in one week and 24 hours in one day.
- There are 52 weeks in one year.
- There are 12 months in one year.
- There are 16 cups in one gallon.
- Recycling one aluminum can saves the energy equivalent of one cup of gasoline.
- Recycling one aluminum can saves enough energy to light a 100-watt light bulb for 3.5 hours (210 minutes).
- Each person generates about 5 pounds of garbage per day.
- Each pound of aluminum makes 32 cans.

1. A technology class decided to collect cans for The Great Aluminum Can Roundup. How many cans will they need to collect if they want to save the "equivalent" energy in 100 cups of gasoline?

2. If each student in your class recycles one aluminum can each day, how much "gasoline energy" would the class save in one week? In one year? How many gallons of gasoline would they have saved?

3. Suppose your class decides to recycle cans for a recycling contest. You set a class goal of 50 cans each week. How much "gasoline energy" will your class save each week?

4. Recycling 50 cans each week would save enough energy to light a room with a 100-watt light bulb for how many minutes?

5. If you recycle one aluminum can each day for one year, you would save enough energy to light a room with a 100-watt light bulb for how many minutes?

6. At the end of 6 weeks, the fourth grade class collected 3,200 cans for recycling. How many pounds of aluminum did they collect?

7. If recyclers pay $.25 per pound of aluminum, how much money can the class earn for 3,200 cans?

8. If a car can go 30 miles on one gallon of gas, how far could it travel on the amount of gasoline saved by recycling 8 aluminum cans each month for one year?

Design Brief: Building a Soda Can Crusher

A great idea for recycling cans is to crush them so that they do not take up as much room. Use any of the provided materials to create the most efficient can crusher. Your goal is to create a crusher that uses the least amount of effort possible to crush cans.

Constraints:

1. The device needs to have two bins one to hold cans before crushing and one to hold cans after crushing.
2. The cans need to automatically feed from the holding bin into the crusher and then automatically feed into the second storage bin after the cans have been crushed.
3. A poker should be added that would cause a decrease in the pressure needed to crush the can.

Connecting Mathematics and Science to Technology Education

System: Biological
ITEA Standard: 15
GPS 1-9, 110,111, 112

Name: ______________________________

Making a Simple Monaural Stethoscope

In this activity, students will make a simple monaural stethoscope after learning about the heart rate and how to take a pulse.

Math Connections	Science Connections	Technology Connections
Estimations	Circulatory System	Healthcare
Multiplication	Pulse	Historical Perspective

Heart Rate

A person's heart rate equals the number of heartbeats during a specified length of time. Your heart rate is often referred to as your pulse rate. The pulse is usually measured at the wrist, but can be measured at the neck, temple, groin, behind the knees, or on top of the foot. These are all areas where an **artery** passes close to the skin.

Once you find the pulse, count the beats for 1 full minute, or for 30 seconds and multiply by 2, or for 10 seconds and multiply by 6 to calculate your heartbeat. Heart beat rates will be different when taken at rest and after exercising. Heart rates taken after exercise should be done within 5 seconds of stopping, because the heart rate declines very quickly after the exercise stops.

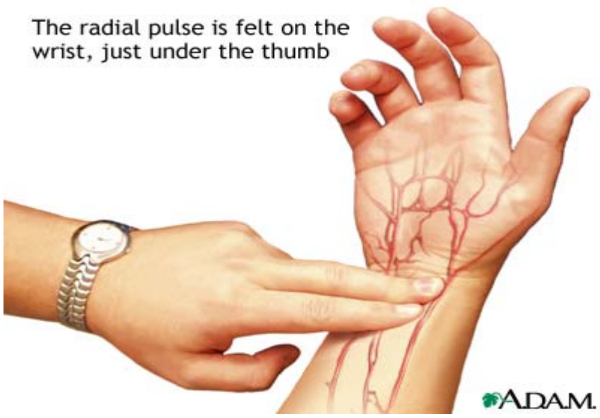
Wrist pulse http://www.nlm.nih.gov/medlineplus/ency/article/003399.htm

To measure the pulse at the wrist, place the index and middle finger over the underside of the opposite wrist, below the base of the thumb. Press firmly with flat fingers until you feel the pulse in the radial artery.

Taking your carotid pulse
http://www.nlm.nih.gov/medlineplus/ency/imagepages/19386.htm

The carotid arteries take oxygenated blood from the heart to the brain. The pulse from the carotids may be felt on either side of the front of the neck just below the angle of the jaw. This "beat" is caused by varying volumes of blood being pushed out of the heart toward the extremities.

Radial pulse
http://www.nlm.nih.gov/medlineplus/ency/imagepages/19395.htm



Arteries carry oxygenated blood away from the heart to the tissues of the body; veins carry blood depleted of oxygen from the same tissues back to the heart. **The arteries are the vessels with the "pulse", a rhythmic pushing of the blood in the heart followed by a refilling of the heart chamber**. To determine heart rate, one feels the beats at a pulse point like the inside of the wrist for 10 seconds, and multiplies this numbers by six. This is the per-minute total.

Target Heart Rate Activity # 1

Normal resting heart rates

Age	**Heart Rate—beats per minute**
Newborn infants	100 -160 beats
Children ages 1 to 10 years	70 to 120 beats
Children over 10 years and adults	60 to 100 beats (average 80-90 per minute)
Well-trained athletes	40 to 60 beats
Mouse	500 beats
Elephant	20 beats
Blue whale	5 beats

Based on the information above answer the following questions

Smaller animals have smaller or larger __________________ hearts.

Smaller animal's hearts beat faster or slower ___________________.

Smaller animals use up energy faster or slower_________________.

Target Heart Rate (THR) Activity #2

People who engage in physical activities need their activity to reach an intensity level that is called the target heart rate. The target heart rate equals reaching the desired number of heart beats per minute. For normal adults the activity should reach an intensity level of between 60% and 90% of their maximum heart rate. A well conditioned person may use a higher target rate for their intensity level. A person with a low fitness level may be able to achieve the desired effect from training with a target heart rate as low as 60 %. Maximum heart rate declines with age. Exercising that does not reach your targeted heart rate will not improve your fitness level. As the circulatory system becomes more efficient with regular exercise, higher levels of activity will be required to reach the target heart zone.

How to calculate your target heart rate (THR) - Target heart rate is determined by subtracting your age from the maximum heart rate of 220 and then multiplying by .60 to .90. Complete the following examples.

20 year old wanting THR of 80 %	
Maximum heart rate	220
Calculation	220 x .80= 160
Target heart rate (THR)	160 beats per minute

Calculate the following:

40 year old wanting THR of 65%	
Maximum heart rate	
Calculation	
Target heart rate (THR)	

Target Heart Rate (THR) Activity # 3

Taking a pulse

Materials needed: Stopwatch, Pencil, Paper, Heart beat worksheet

Divide students into work groups. Review directions given earlier on how to take a pulse/heart beat. Have each students resting heart beat taken and recorded. Next, have the students jog in place for one minute and then take their pulse/heart beat and record the data. This activity could be expanded for children to keep a log of their heart beats at various times of the day, and after various activities. To calculate your pulse/ heart rate: pulse/heart rate for 10 seconds x 6 = pulse/heart rate for 1 minute.

Heart Rate Data

Does activity change your heart rate?	Calculate heart rate for 1 minute (show calculations)
Resting heart rate	
Heart rate after jogging in place	

Heart Rate Calculations

Based on your resting heart rate, calculate the following data. Remember: Pulse/ heart rate (beats) for 10 seconds x 6 = pulse heart rate (beats) for 1 minute. Show calculations.

Resting heart rate (beat)	
Heart beats per minute (see above directions)	
Heart beats per hour (60 minutes per hour)	
Heart beats per day (24 hours per day)	
Heart beats per week (7 days per week)	

Make Your Own Simple Monaural Stethoscope

Design Brief

Using the following materials, you will assemble a monaural stethoscope to experiment on yourself and others:

> 2 small plastic kitchen funnels (funnel opening to be no larger than 3 inches in diameter and with a 1/2 inch diameter spout).
>
> Rubber Tubing 1 piece 18 inches long, 5/8 inch diameter. Rubber or vinyl tubing can be purchased at hardware or home improvement stores in the pond/garden or plumbing department for approx. 15 - 24 cents per foot.

Steps

You may have to find a quiet area to listen to your heart beat, but it will work. Notice how the heart sounds and the speed of the beating.

1. Take your piece of rubber tubing and insert a funnel into each end.

2. Place one end of your “stethoscope” to your ear and the other funnel end over your heart.

   Does it sound different when you are calm?

   How about when you are excited or after exercising?

   Why does that happen?

3. Enlist the help of a parent or grandparent and try your stethoscope with them. Is their heartbeat different than yours?

Activity 2

40 year old wanting THR of 65%	
Maximum heart rate	220 – 40 = 180
Calculation	180 x .65 = 117
Target heart rate (THR)	117 beats per minute

Activity Answers

Activity 1
Smaller hearts
Faster beats
Use energy faster

System: Biological
ITEA Standard: 3, 5, 9, 15
GPS: 1-5, 23-25, 109 - 116

Name: ________________________________

Build a Simple Model of a Human Arm

Students will learn about the skeletal and muscular systems to understand the mechanisms of movement and then apply their knowledge to building a model of a human arm.

Math Connections	Science Connections	Technology Connections
Measurement	Skeletal System	Healthcare
Comparisons	Muscular System	Historical Perspective
Estimation	Physics	Simple Machines
	Biomechanics	Robotics
		Technical Design

How does your body work? This concept is easy to understand when you compare your body to a machine. A machine and your body both perform work and both need fuel to be able to work as shown below.

Compare a machine and your body	**Does it perform work? If yes, what?**	**Does it need fuel? If yes, what?**	**What does fuel do?**
Crane	Yes Lifting heavy weights	Yes Gasoline	Burned in engine to produce energy. Makes crane move
Body	Yes Moving and lifting weights	Yes Oxygen and food	Burned in muscles (body's engine) to produce energy. Moves different parts of the body.

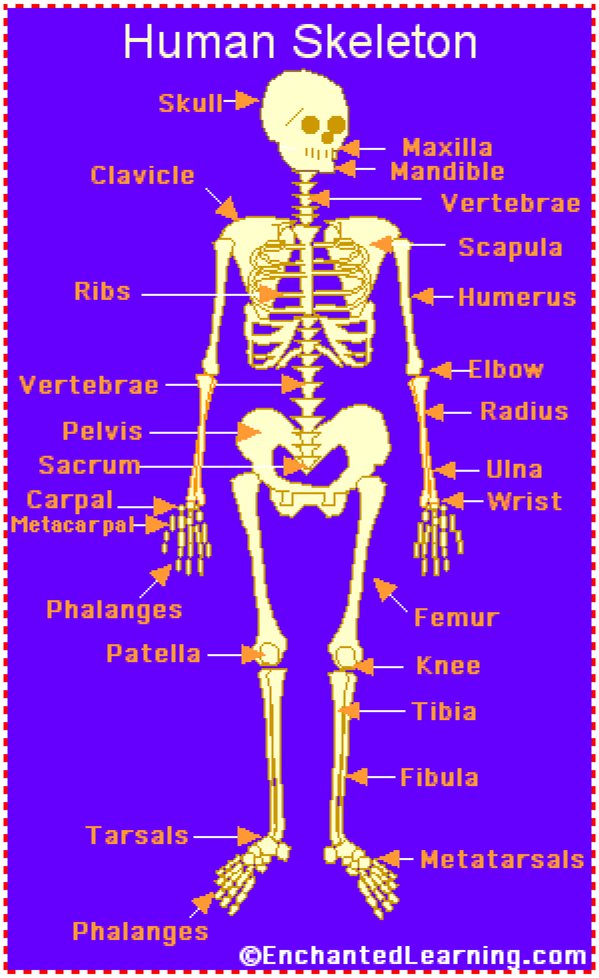
Do you ever think about your bones? Probably not, unless you've been in an accident or had an injury. They are simply a part of your body and you just expect them to work, without being given too much attention. It is only when they break that this changes – we X-ray them, put them in plaster, nurture them, and keep weight off them with crutches.

But bones are important, as they give shape to your body. Without them, you would have looked like an immovable blob. Scary thought, isn't it? Circuses in previous decades often displayed someone they called "A boneless wonder", but this was not someone without bones, just someone who could manipulate their body in such a way as if they were boneless.

How much do you really know about your own bones? Take a look at the following fascinating facts:

- Newborn babies have 300 bones and adults 206. The other 94 bones have not disappeared – they have fused with other bones.
- Twenty-five percent of your bones are made up of water.
- Bones are a protective enclosure for your heart, lungs, brain and other organs and also provide places to attach ligaments, muscles, tendons, etc.
- If you remove the minerals from a bone by soaking it overnight in a 6% solution of hydrochloric acid, it will become so soft you could tie it in a knot.
- Bones are a storehouse for calcium and inside the bones, blood cells are manufactured.
- One person in 20 has an extra rib – and the extra rib is three times as common in men as in women.
- Bones lose strength and mass as well as their ability to manufacture blood cells if you lead a very sedentary life. Exercise increases the blood cell manufacturing ability and the bone mass.
- Over 100 bones, almost half the bones in your body, are in your hands and your feet.
- Your bones are at their thickest at the points of greatest stress and can withstand stresses of about 10,900 kg per 6 cm square.
- No bone in your body is more than 1 mm away from a capillary or tiny blood vessel.
- Your femur is the largest bone in your body and your ear contains the smallest bones in your body.
- Bones act as levers in the body, greatly expanding the capacities of our muscles.
- Where skull bones have joined, there are seams or sutures. These seams start sealing up when we are about 22 and this process continues until we are in our eighties. By taking a look at how far this process has progressed, scientists can determine the age at death of even ancient skeletons.

(Information from The People's Almanac No.2, edited by David Wallechinsky and Irving Wallace).



Your bones are joined to each other at joints. There are many different types of joints, including:

- Fixed joints (such as in the skull, which consists of many bones)
- Hinged joints (such as in the fingers and toes)
- Ball-and-socket joints (such as the shoulders and hips).

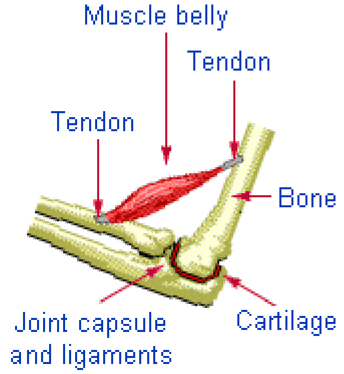
There are some skeletal differences for men and women including:

- A different elbow angle
- Males have slightly thicker and longer legs and arms
- Females have a wider pelvis and a larger space within the pelvis

The bones of the body fall into four general categories:

- Long bones- longer than they are wide and function as levers. These are bones in the upper and lower extremities (arms, hands, and legs).
- Short bones- short, cube-shaped bones of the wrists and ankles
- Flat bones- broad bones for protecting organs and for muscles to attach to. These are the ribs, shoulder girdle, and cranial bones.
- Irregular bones- all bones not listed above. These vary in size and shape and include some of the bones in the vertebrae and the skull.

For your body to move you must have and use muscles, ligaments, and joints. Muscles are attached to the bones, and when they contract, the bones act as levers and the body parts begin to move. The joints' function is to make the bones be able to move in certain directions. The various types of joints allow you to bend your knee, move your arms, and turn your head. Note details in the picture below.



Modified from: DeLisa, Stolov, p. 30

Joints

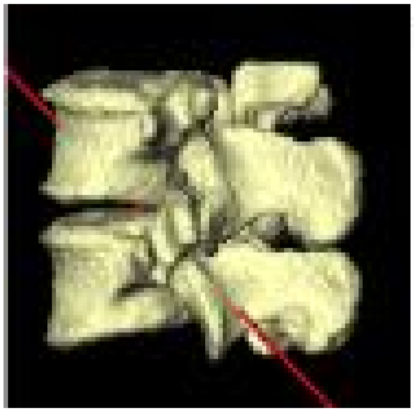
The bones of the body are connected together by joints. Technology advances have allowed joint replacements to be made of metal or plastic. There are many types of joints in the body, with most helping the body parts to move in certain directions. There are some joints that do not allow for movement or only allow for a small amount of movement. Facts about joints:

- Skull joints do not move
- Vertebrae joints move slightly
- Limb joints allow a lot of movement
  Only moves in certain directions
  Greater range of movement = less stability
  More prone to injury
- Knuckle, knees, and elbow joints allow bending only
- Limb joints carrying the most weight are larger so they can carry more weight
  Ankle and knees are larger than arm, wrist, and elbow joints.

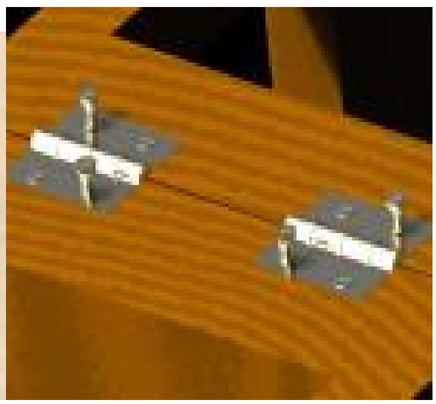
Skeletal System Activity # 1: Comparing your body's major joints to machine parts

Students will learn the various joints of the body and how they relate and function like machine parts.

Pivot Joint – Allows bone to twist from side to side, such as your head

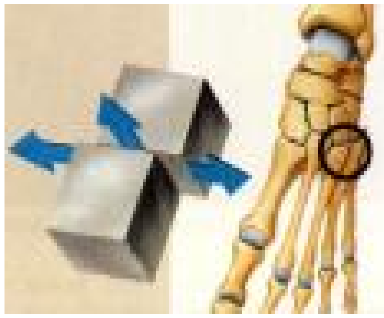


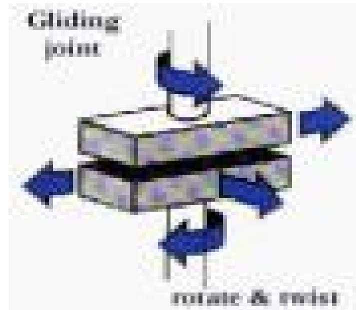

Hinge Joint – Allows movement back and forth in one direction, such as knees and fingers

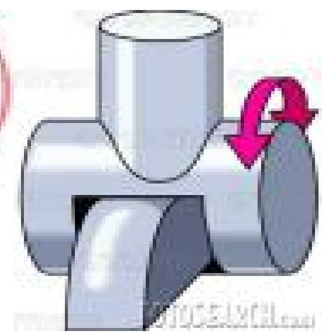
Ball and Socket Joint – Found in shoulder and thigh and allows for great range of movement. Ball shape fits into a fits into a cup shaped socket.


Gliding Joint – Two flat surfaces glide over each other. Allows for limited movement. Can be found in the feet, toes, and vertebrae.

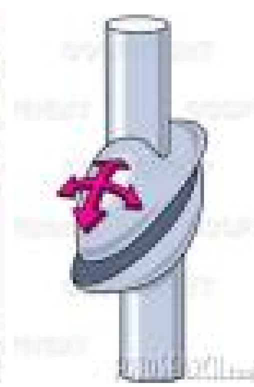


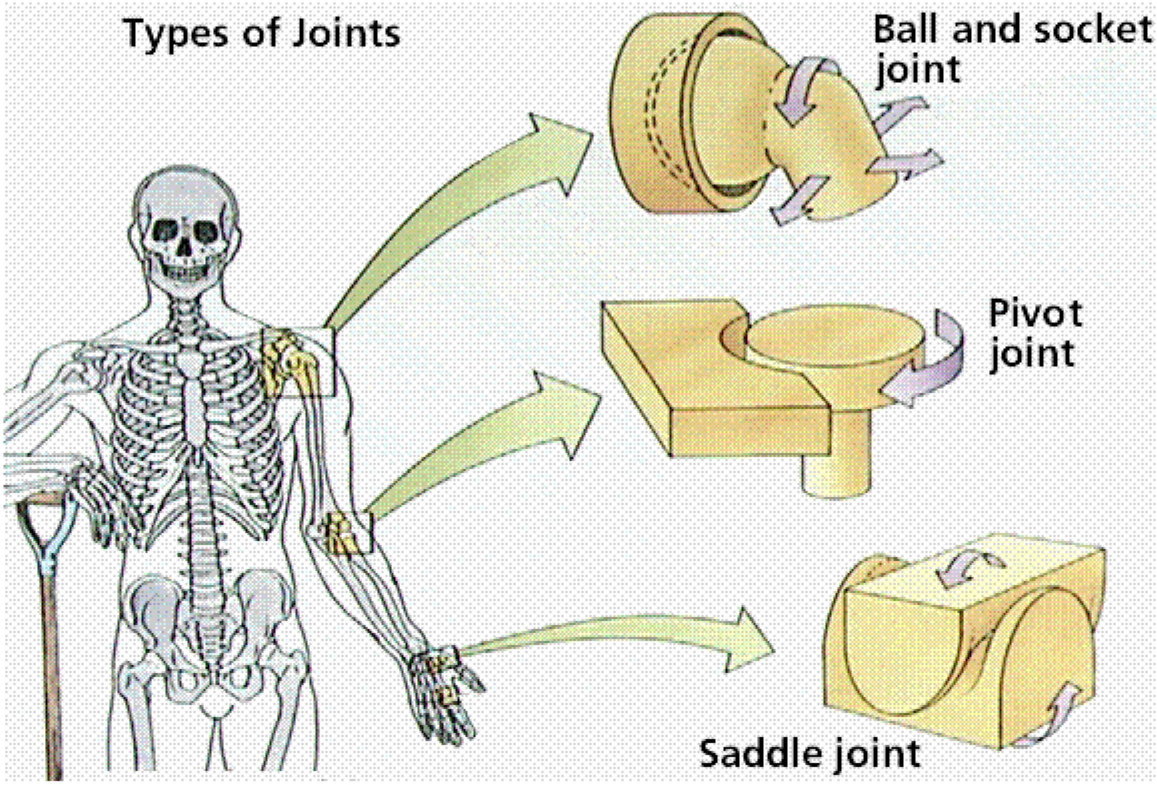


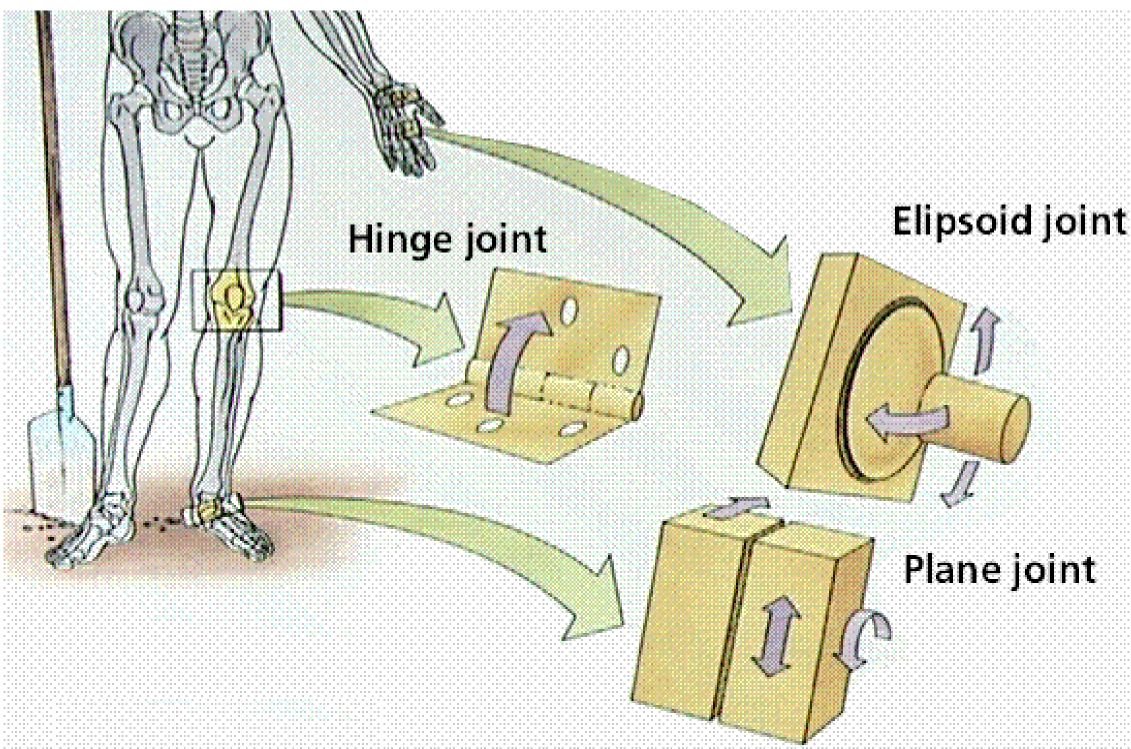
Saddle Joint – Allows movement in two directions. It is a wrist bone that fits over a saddle shaped bone at the end of the thumb.



Ellipsoid Joints – Allows movement both back and forth and sideways. For example, it is where the wrist fits into a hollow area at the end of the forearm bones.




Types of Joints
Ball and socket joint
Pivot joint
Saddle joint


Hinge joint
Elipsoid joint
Plane joint

Skeletal System: Joints - Activity #1 Worksheet

Name ____ Date_____________________

Directions: Use the space provided to answer the following questions. Use the back of this sheet if necessary.

Describe how the following joints move and where they can be found.

Joint	How does it move?	Where is it found?
Hinge Joint		
Ball and socket joint		
Pivot joint		
Saddle Joint		
Gliding joint		
Elipsoid joint		

Complete the table below on joints by entering the correct letter in the blank box

A. Allows movement in three planes
B. Gliding
C. Hinge
D. Skull

Type of joint	Location	Type of Movement
Immoveable or fixed		None
	Vertebrae, wrist	Slightly moveable
Ball and Socket	Hip, shoulder	
	Elbow, knee	Moveable in one plane only

Directions: Do the following to compare the movement of the hinge and ball-and-socket joints.

1. Move your arm without moving the upper arm at the shoulder. What type of movement is allowed by the hinge joint of the elbow?

____

____

2. Now move your entire arm, concentrating on the variety of movements permitted by the ball-and-socket joint of the shoulder. What types of movements were possible?

____

____

3. How does the movement of the hinge joint of the elbow compare with the movement of the ball-and-socket of the shoulder?

____

____

The knees and hips joints are similar to the arms and shoulders. The hinge joint represents which type joint?

____

____

Which joint represents the ball-and-socket joint?____

5. Why would a ball-and-socket joint at the knees create problems for walking?

____

____

6. The elbow is an example of which kind of joint?
   a. ball-and-socket
   b. hinge
   c. pivot
   d. fixed

7. The joint between the shoulder and upper arm is an example of which kind of joint?
   a. ball-and-socket
   b. hinge
   c. pivot
   d. fixed

8. The bones of the skull are an example of which kind of joint?
   a. ball-and-socket
   b. hinge
   c. pivot
   d. fixed

Skeletal System Activity # 2: Levers

Students will learn about the skeletal system and the study of levers. Students will be able to identify and define the various types of levers, and the related counterpart in the skeletal system. Students will gain an understanding of how the body works like a machine. Students will complete the activity quiz at the end of the review.

Bones as Levers

How are your bones like machines? Your bones act as levers when the muscle pulls on a bone and makes it move.

- Most of the bones in your arms and legs are **levers.** These levers are powered by muscles.
- A lever is a rigid rod able to rotate about a fixed point known as a fulcrum, formed by the **joint**. Any **force** applied to the lever is called the **effort**.
- A force that resists the motion of the lever, such as the downward force exerted by a weight on the bar, is called the **load** or the **resistance**.
- The contraction of the muscles is the **effort** and the part of the body concerned is known as the **resistance** or **load.**
- Bones of the body act as levers (a mechanical device) which create a mechanical advantage of **strength** or **speed**.
- Each of these levers can be found in your body and you can tell the classes of levers apart by:
    - The force you apply (or the effort you make).
    - An opposing force such as a weight, which is usually called the load.
    - The pivot point, or fulcrum of the action.

Types of Levers in the Body

Levers are classified according to the positions of the fulcrum, effort, and load or resistance. There are three classes of levers (first and second class have a mechanical advantage over third class). In each type of lever, notice where the fulcrum is located compared to the effort and the load. In your body, the effort is the force that your muscles apply to the lever:

- First Class Lever: The fulcrum is between the force and the weight.
- Second Class Lever: The weight is between the fulcrum and the force.
- Third Class Lever: The force is located between the fulcrum and the weight. Increase distance and speed but not force. The body is mostly third class levers.

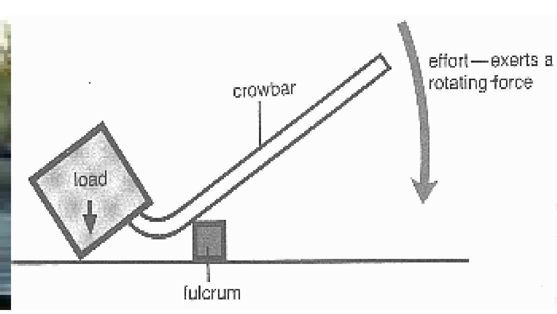
Parts of Levers

- Effort: Force that moves the lever
- Point of effort: Point where effort is applied to lever
- Load: Force to be moved
- Point of resistance: Point of attachment of the load
- Force arm or effort arm: Distance between the fulcrum and the point of effort
- Load arm: Distance between the fulcrum and the point of resistance

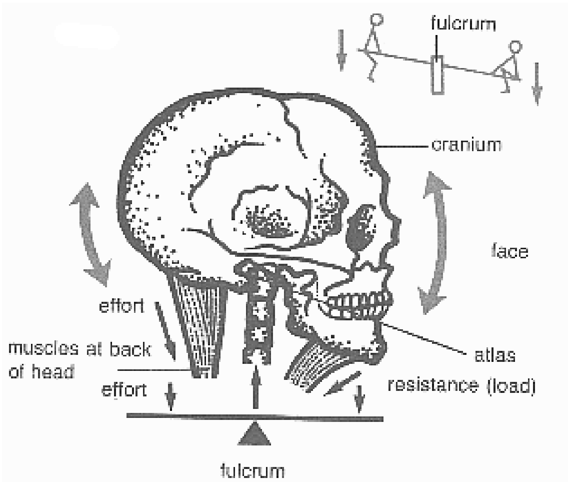
- Moment of force: Rotating force exerted when force is applied to lever

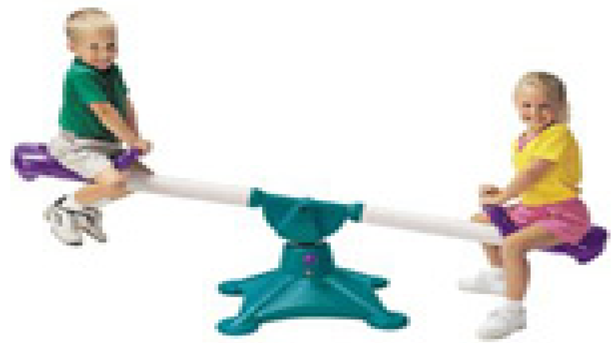
	First Class Lever- fulcrum lies between the effort and the load	**Second Class Lever- load lies between the fulcrum and the effort**	**Third Class Lever- effort lies between the fulcrum and the load**.
Machine lever	Scissors Crowbars Teeter-totters	Wheelbarrow	Car door handle, spring on screen door
Body lever	Joint between skull and vertebrae--nodding of head. When a bent arm is straightened	Achilles tendon pushing or pulling across heel of foot. Our feet when we stand on our toes and lift our heels off the ground. Leverage allows us to walk.	Elbow joint When the biceps contracts, allowing us to lift something in our hand.
Advantage	Strength or speed, depending on where the fulcrum is located. Overcomes the resistance.	Strength. Overcome the resistance.	Speed of movement rather than strength. Obtain rapid movement

Movement of the levers is possible because of joints and the contraction of muscles which are attached to the levers. A lever is an inflexible or rigid rod that is able to rotate about a fixed point called the fulcrum.

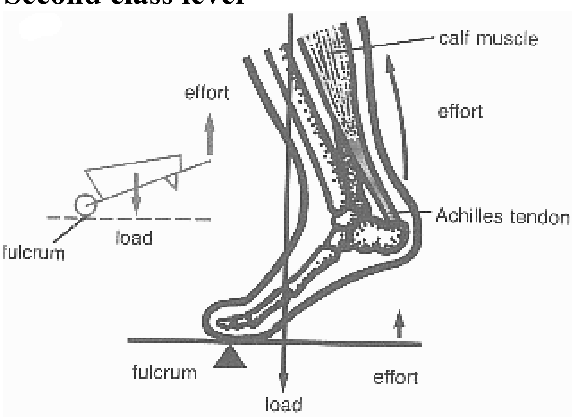


First class lever

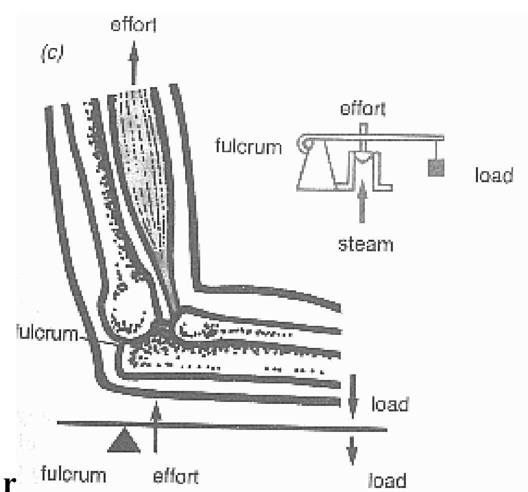




Second class lever



Third class lever



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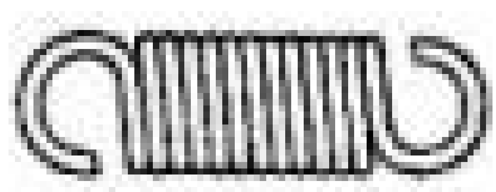


Skeletal System: Levers - Activity #2 Worksheet

Name ____ Date______________________

Directions: Complete the following questions.

1. A first class lever has the _____________ in the middle.

2. Give an example of a first class lever: ______________________________

3. Draw a diagram of a first class lever:

4. A second class lever has the _______________ in the middle.

5. Give an example of a second class lever:____________________________________

6. Draw a diagram of a second class lever:

7. A third class lever has the ________________ in the middle.

8. Give an example of a third class lever: ______________________________

9. Draw a diagram of a third class lever:

10. What advantage is gained for each type of lever?

____

____

____

____

____

11. What type of levers is found most often in the human body?

____

12. Muscles _______________ to make movement possible.

13. Describe each of the following – use reference material if necessary:

a. Effort_______________________________________

b. Extension____________________________________

c. Force____

d. Force arm____________________________________

e. Fulcrum______________________________________

f. Joint____

g. Levers_______________________________________

h. Limbs____

i. Load____

j. Resistance___________________________________

k. Tendon_______________________________________

l. Weight arm___________________________________

Skeletal System Activity #3: Measuring Using Body Parts

Students will learn to measure items in the classroom using their body's bones as the measuring devise. Students will convert the non standard measurements into inches, feet, etc. Students will work with a partner and each will complete the worksheet below (rulers will be needed). Students will observe that everyone has a different measurement, and will see how technology has made measuring more uniform.

Non-standard units of measurement using the body's bones:

- Cubit: The length from your elbow to your fingertips
- Span: The width of your outstretched fingers
- Fathom: The width of your arms when outstretched
- Pace: The width of the body's step when walking

1. How many inches are in your body's cubit? ____________________________________

2. How long is the teacher's desk?

    - in cubits? ____
    - in inches?____
    - in feet? ____

3. Calculate your height in cubits. Show your work.________________________________

4. How many inches wide is the bone span of your hand?
    ____

5. How wide is your fathom?
    ____

6. How many paces is it from your desk to the blackboard? __________ Inches?_____ Feet?_______ Show calculations.

Skeletal System Activity #4: Building a Working Arm

Students will perform experiments to learn how the arm works as a lever and then construct a model of a working robotic arm. Students will learn how muscles, joints, and bones all work together to act as a lever. Students may work in a team of two or work individually.

Muscles move bones through mechanical leverage. When muscles contract, they make the bone act as a lever with the joint serving as the fulcrum. Do the following to understand the movement concept:

1. Hold an object in your hand with your arm straight down at your side
2. Place your finger on the muscle and bones so you can feel how they move
3. Raise your arm until it is at a 90 degree angle
4. Next, raise your hand toward your shoulder and then lower it back down

You are now ready to begin the design process for construction of the arm model. Conduct research on the internet or other available resources.

Materials:

- Craft sticks – 2 for each arm
- Rubber bands – 2 large and 2 small for each arm
- Scissors or cutting tool to notch the craft sticks

Procedure

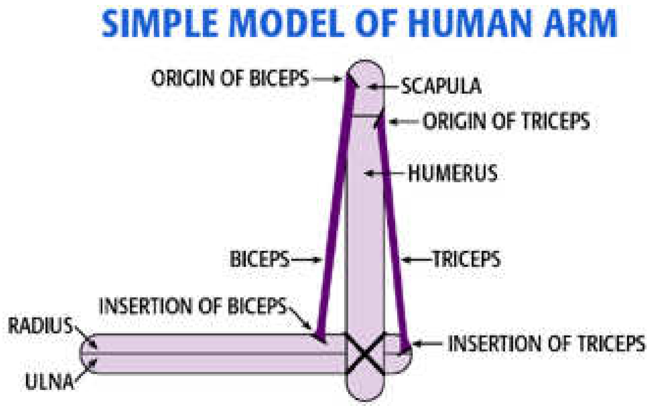
1. To simplify things, have only two "bones" in your model. One will represent the scapula and humerus; the other will represent the radius and ulna. (Build a more complex model if desired.)

2. Wrap the two small rubber bands around the craft sticks to secure the bones at the elbow joint but allow the joint to move.

3. Cut two small notches in each craft stick to represent the origin and insertion of each muscle. Using rubber bands to represent muscles, attach two muscles, the biceps and triceps, to your model arm.

4. Make sure your model works. That is, when you pull on a muscle (contract it), the arm moves in the way the real arm would.

5. Label the parts of your model.



Compare your model to an anatomical design as you answer the following:

When pulled, rubber bands stretch and store energy, then return to a relaxed shape. How does this action, shown by the rubber bands in your model, compare to the way real muscles work?

____

____

____

The elbow joint in your model had to be held together but still move. How does the human body hold joints together to allow them to move?

____

____

____

Skeletal System Activity #5: Build a Model of a Arm with Bones and Joints

Design Brief

You will build a model of an arm to see how joints and muscles work. Like all models, it will be like the real thing in some ways and very different in others. Spend some time investigating your own arm. How is it made? In what ways can it move?

MATERIALS NEEDED: 3 skill sticks, Styrofoam ball, 1 bottle cap, masking tape

Procedure

1. Mark the three skill sticks as shown in Figure 1. Note that some of the markings are made on the underside of the stick (humerus, ulna, and scapula). Break the sick where shown. Note that E stands for "elbow" and H for "hand".

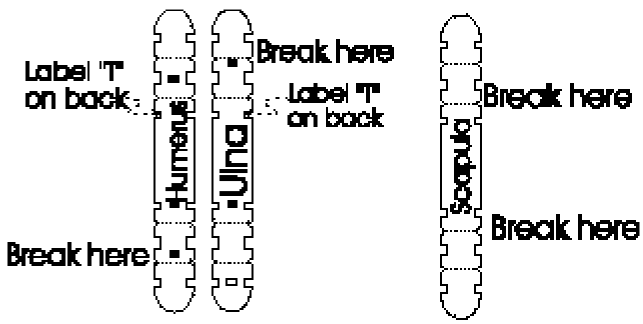


Figure 1

2. Assemble the **shoulder joint** as shown in Figure 2 using Styrofoam ball, bottle cap (socket), and tape. Note how the shoulder ball fits into the bottle cap. Tape the scapula to bottle cap top.

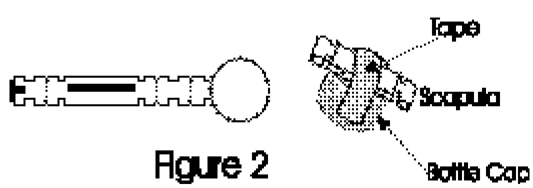


Figure 2

3. Now assemble the **elbow** as shown in Figure 3. Be sure to leave space between the humorous and the ulna about the thickness of a skill stick.

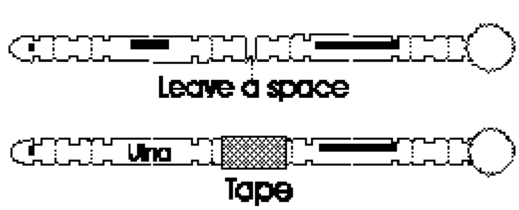


Figure 3

Questions (Research answers if necessary.)

1. What bone is missing from this model?

2. What type of motion does this missing bone allow?

3. Describe each joint:

JOINT	TYPE	TYPE OF MOTION
Shoulder		
Elbow		

Note: See copyright information below for this activity adaptation.

BODY BASICS

Connecting Mathematics and Science to Technology Education

System: Biological
ITEA Standard: 1-3, 8, 10, 19
GPS: 1-19, 43-47, 67-75

Name: ______________________________

Car Safety: The Crash Car Derby

In this activity, students will learn about general car safety for humans. As they learn these concepts, they will be required to demonstrate what they have learned by designing and building a car that will protect its passenger (a raw egg) from being damaged in a head-on crash.

Math Connections	Science Connections	Technology Connections
Measuring Time	Physics	Construction
Measuring Distance		Design process
Calculation Speed		Bio-related technology
		Transportation

Tools, Materials and Supplies

Assorted materials for the vehicle (selected and provided by the student)
An assortment of tools, eggs, bicycle inner tube for testing, and rulers provided by instructor

Information

Crash Testing. Crash test dummies have been the subject of public service announcements, cartoons, parodies, even the name of a band. Real crash test dummies, however, are true life-savers as an essential part of automotive crash tests. Even though cars get a little safer each year and fatality rates are declining, car crashes are still one of the leading causes of death and injury in the United States. The dummy's job is to simulate a human being during a crash, while collecting data that would not be possible to collect from a human occupant. All frontal crash tests in the United States are conducted using the same type of dummy, the Hybrid III dummy. This guarantees consistent results.

Crash Test Dummy. A dummy is built from materials that mimic the physiology of the human body. For example, it has a spine made from alternating layers of metal discs and rubber pads. The dummies come in different sizes and genders. The dummy most commonly used in crash testing weighs 170 lbs and is 70 inches (5 ft 10 inches) tall which is the size of the average man. The dummies contain three types of instrumentation: accelerometers which measure the acceleration in a particular direction, load sensors which measure the amount of force on different body parts during a crash, and movement sensors which are in a dummies chest and measure how much the chest deflects during a crash.

Seatbelts. According to a recent research report from the National Highway Traffic and Safety Administration, seatbelts save 13,000 lives in the United States each year. Meanwhile, the NHTSA estimates that 7,000 U.S. car accident fatalities would have been avoided if the victims had been wearing belts. While seatbelts do occasionally contribute to serious injury or death, nearly all safety experts agree that buckling up dramatically increases your chances of surviving an accident. According to the NHTSA, seatbelts reduce the risk of death for a front seat car occupant by about 50 percent. The basic idea of a seatbelt is very simple: It keeps you from flying through the windshield or hurdling toward the dashboard when your car comes to an abrupt stop. This happens because of a force known as inertia.

Inertia. Inertia is an object's tendency to keep moving until something else works against this motion. To put it another way, inertia is every object's resistance to changing its speed and direction of travel. Things naturally want to keep going. If a car is speeding along at 50 mph, inertia wants to keep it going 50 mph in one direction. Anything that is in the car, including the driver and passengers, has its own inertia, which is separate from the car's inertia. The car accelerates riders to its speed. Imagine that you're coasting at a steady 50 mph. Your speed and the car's speed are pretty much equal, so you feel like you and the car are moving as a single unit. But if the car were to crash into a telephone pole, it would be obvious that your inertia and the car's were absolutely independent. The force of the pole would bring the car to an abrupt stop, but your speed would remain the same. Without a seatbelt, you would either slam into the steering wheel at 50 mph or go flying through the windshield at 50 mph. Just as the pole slowed the car down, the dashboard, windshield or the road would slow you down by exerting a tremendous amount of force. If you hit the windshield with your head, the stopping power is concentrated on one of the most vulnerable parts of your body. It also stops you very quickly, since the glass is a hard surface. This can easily kill or severely injure a person. A seatbelt applies the stopping force to more durable parts of the body over a longer period of time.

Earlier Cars. Year after year automakers have made faster and faster cars capable of transporting more and more people from place to place. In the 1940's, 50's and 60's automobiles were "made to last" with rigid (stiff) frames, bulky body's made from thick sheet metal. No seat belts, metal dashboards, big steering wheels with small shafts in the center were standard. These cars survived a crash pretty well, unfortunately the people didn't. Starting as early as the 60's, automotive engineers began to design cars to protect the passengers in a crash. Seat belts, 5 mph bumpers, and lighter weight materials were introduced.

Modern Cars. Today's passenger cars advertise "crumple zones" that protect their passengers in head-on and rear-end crashes. They are called crumple zones because the ends of the lighter weight automobiles are designed to crumple up on impact, taking some of the energy away from the passengers during the crash. Think of it like how you would catch a fastball barehanded or how a shock absorber works.

Race Cars. Race cars were a moving test platform for several new concepts. A radical idea was to sacrifice the vehicle to protect the passenger. Indianapolis 500 cars are designed to disintegrate in crashes. Each part that separates from the main body of the race car takes with it a part of the energy that the vehicle had. Drivers have walked away from 200 mph crashes because of this.

Car Safety: Crash Car Derby

Design Brief

You are to apply safety mechanisms in the design and production of a vehicle that will protect its passenger, a raw egg, from being damaged in a head-on crash. You may use any household items that will not present a safety hazard to you or others during construction and testing, except for aerosol cans. WARNING! Aerosol cans present a safety hazard for you and others. If you are not certain about a material or item being a safety hazard, ask your instructor.

You will need to complete the Crash Derby Worksheet for Mathematics Connections and Science Connections. The Mathematics Connections can not be completed until your vehicle is tested. However, the Science Connections brochure will be due on the same date as the materials are due.

Limitations

1. You may not use pre-existing cars.
2. Size limits: The car MUST be within these specifications:
    a. Height - 3"-4" tall
    b. Width - 3"-4" wide
    c. Length - 4"-6" long
3. Cars must have wheels that roll.

Project Date and Time Limits

You will be required to complete your vehicle in one class period; therefore, it is critical that you plan to have your materials or items for constructing the vehicle on this date, _______________. Your Science Connections brochure is also due at this time.

Testing Procedure

1. The test device is a bicycle inner tube cut so that it becomes a big rubber band.
    a) Stretch the tube between table legs, one inch above floor level.
    b) Face the test device ten feet from a brick wall.
    c) Place color dots on the floor starting 12" from the straight inner tube line and continuing at two inch intervals away from the rear of the test device on a center line perpendicular to the inner tube.
2. Egg must be placed in a sealable plastic bag and into the car immediately before the test.
3. Car must be designed so that a quick check can be made (within ten seconds) to see if the egg survived the crash.
4. The car must make contact with the wall to qualify.
5. If the egg survives the initial impact, you will receive full credit and advance to the next dot back until it cracks.

Crash Derby Worksheet

Mathematics Connections

Determine the speed of your vehicle on impact of the wall.

Step 1 Measure the distance from the front of your car on the testing track to the wall in inches: _________________inches.

Step 2 Use a stopwatch to time your car as it travels down the testing track and stop the time as soon as your car hits the wall:________________ seconds

You will convert inches and seconds to miles per hour (mph).

Step 3 Convert distance to miles.

12 inches = l foot 1 mile = 5,280 feet

Distance from Step 1:_____ / 12 = _____ feet /5,280 = _____ miles

Step 4 Convert the time to hours.

60 seconds = 1 minute 60 minutes = 1 hour

Time from Step 2:_____/ 60 =_____minutes /60 =_____ hours

Step 5 Divide the number of miles by the time in hours.

_____ miles / _____ hours = __________ mph

Science Connections

All new automobiles are required to have airbags as an additional means of safety. You are going to create a brochure explaining how air bags work and how they assist in saving lives. Be sure to include information about how an airbag inflates and the physics concepts that transpire as an air bag prevents serious injury. Make sure that you include your name on the brochure as part of your design of the brochure.

Connecting Mathematics and Science to Technology Education

System: Informational
ITEA Standard: 1-3, 15
GPS: 1-14, 117

Name: ______________________________

Construct a Psychrometer

In this activity, students will be introduced to some basic concepts on humidity. As they learn the different aspects of this part of our atmosphere, these concepts are re-inforced and demonstrated with the student constructing a psychrometer device which measures moisture content or relative humidity.

Math Connections	Science Connections	Technology Connections
Measurement	Weather	Bio-related technology
Temperature conversion	Atmosphere	Construction
Data collection		
Chart		

Humidity

Humidity refers to the amount of moisture in the air. You might be surprised to know that the air in our atmosphere has water in it. Lots of water!

Water in the atmosphere exists in 3 main states.

1. WATER VAPOR
2. CLOUD DROPLETS *(SOMETIMES FROZEN ICE CRYSTALS)*
3. LIQUID RAIN DROPS *(SOMETIMES FROZEN!)*

There are different ways to measure and express the amount of water in the air. Two ways are relative humidity and dew point. Imagine we have a blob of air with moisture in it and the temperature of this air is 80 degrees. How do we determine how much moisture is in the blob of air?

Relative Humidity. The relative humidity tells how much water the air is holding compared to how much it could hold at a certain temperature. If our blob of air has a relative humidity of 50% then that means it is holding half of the amount of water a blob of air 80 degrees could hold. The relative humidity can change if the moisture changes or if the temperature changes.

Dew Point. The dew point is a much better indicator of moisture in the air and is referred by most meteorologists. The dew point is the temperature at which the air will be holding all the moisture it can, if cooled. In other words, t*he dew point is the temperature at which the relative humidity reaches 100%.*

If our 80 degree, moisture holding blob of air is cooled, it will eventually reach a temperature at which it can no longer hold the water vapor. Remember that warm air holds more moisture than cool air. Therefore, the blob of air forms a cloud, releasing the moisture when it is cooled to 50 degrees, then 50 degrees is the dew point of the blob of air. *Note that the dew point does not depend on the temperature like relative humidity!*

Psychrometers

A psychrometer is an instrument commonly used in laboratories to measure relative humidity. It is also referred to as a wet-bulb and dry-bulb thermometer.

This instrument consists of two similar thermometers that are mounted side by side. The dry bulb has its bulb exposed to the air. The wet bulb is wrapped in an absorbent material such as muslin, which is immersed in water and serves as a wick. When the wet bulb is taken out of the water, it cools by evaporation of the water. If the bulb is whirled around to hasten evaporation, it is called a *sling psychrometer*. If air is forced past the bulb, it is referred to as an *aspirated or ventilated psychrometer.*

The amount of evaporation, and consequent cooling of the thermometer, depends on the humidity in the atmosphere—the drier the atmosphere, the faster the water evaporates. Using this data and humidity tables or calculations, the dew point (the temperature to which air would have to be cooled for saturation to occur) can be determined, and from it, the relative humidity.

Create an Psychrometer

Design Brief

You are to demonstrate your understanding of the atmosphere and humidity by constructing and using your own psychrometer.

Materials

- tape
- water
- 2 identical thermometers
- gauze (2" X 2")
- rubber band
- piece of cardboard (8" X 11")

Procedures

Step 1 Wrap the gauze around one of the bulbs and tie it firmly in place with a rubber band.

Step 2 Wet the gauze.

Step 3 Place the thermometers side by side with the two bulbs just hanging over the edge of a desk or table.

Step 4 Use the cardboard to fan the thermometers. (Be careful not to bump or hit the thermometer while they are taped down or they could break).

Step 5 Fan vigorously until the temperature of the thermometer with the wet bulb stops going down.

Step 6 Develop a Relative Humidity chart. The left column represents the dry bulb reading and the numbers across the top represent the difference between the wet and dry bulb reading.

Step 7 Record the temperature readings on both thermometers.

Step 8 Subtract the wet bulb temperature from the dry bulb temperature and record the difference.

Step 9 Look at the Relative Humidity chart that you developed in Step 6. Follow your dry bulb temperature across and follow your difference column down until they intersect.

Step 10 Record the number at this point.________________ The number you have recorded is the relative humidity of your room.

Step 11 Find the Relative Humidity of another room (i.e. an empty classroom).

Any difference?__________ Why?____

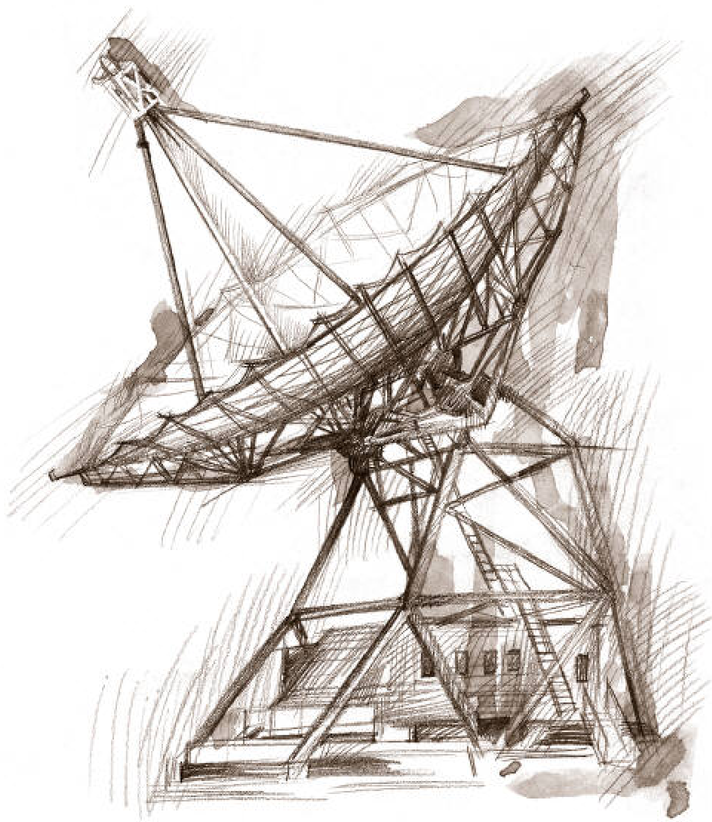
____

Find the relative humidity outdoors. ____

Step 12 Convert measured Fahrenheit temperatures to Celsius and record on the following chart:

Fahrenheit	**Celsius**

INFORMATIONAL



Introduction

The basic building block of technology education is the system. A system is a group of interrelated components designed to collectively achieve a desired goal or goals. Systems can and do exist on many levels. The technologically literate person uses a strong systems-oriented thinking approach as they go about solving technological problems.

Technology is human innovation in action. It involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. The systems that are developed can easily be categorized as biological systems, informational systems and physical systems.

The second system addressed in this document is **Informational Systems**. In this system, the developmental processes include basic data manipulation and enhancing actions such as encoding and decoding. Informational systems likewise are concerned with processing, storing and using data. Knowledge of and experience with these components of the informational system gives students the ability to quantify, qualify and interpret data as a basis for developing new knowledge. They can study the informational system as it provides the interface between human and human, between human and machines and between machines and machines. This system is addressed through some of the ITEA Standards of 3,10, and 17. The following technology education activities with their associated mathematical and science connections are a sampling of the units that can be studied by the student to assist them in understanding the behavior of the system. Once the behavior of a system is understood, the technologically literate person is able to assess the complete system to judge what necessary control adjustments are needed as variables change or inputs become known.

Connecting Mathematics and Science to Technology Education

System: Informational
ITEA Standard: 8, 9, 10, 19
GPS: 1 - 34, 46, 39, 40, 42, 72, 73

Name: ________________________

Design and Construct a Cereal Box

Students are to design and construct a cereal box or container for a new kind of cereal that targets a specific age group. This activity employs a variety of problem solving skills in the design of a cereal box that must meet a stated design challenge. This activity can be done as an individual project or as a team project.

Math Connections	Science Connections	Technology Connections
Area	Mass	Design Processes
Surface area	Environment	Manufacturing
Circumference	Pollution	Problem-solving
Volume	Material science	Communication
Measuring lengths		
Data table		
Prediction		

Tools, Materials and Supplies
Measuring tools: Rulers, compasses, protractors, cloth measuring tape, scientific scales (grams/ounces)
Calculators
2 sheets of poster board per team
glue sticks
hot glue guns and hot glue sticks
30 assorted shapes and sizes of packaging (*cubes, cylinders, rectangles, etc*.); include odd shapes. *Suggestions: Pringles container, soda can, soda bottle, cereal box, detergent boxes, liquid detergent containers, gift boxes, hat box, etc.*

Other materials: Paper, wax paper, plastic wrap, cellophane, colored pencils and markers, paint, cartoon/coloring books, scissors, clip art, glue sticks, wrapping paper, gift bags, drawing tools, glue, etc.

Software: graphic and CAD software
Internet resources: www.kelloggs.com
www.generalmills.com
www.boxtops4education.com
www.epa.gov

Determining Volume, Area, Circumference and Surface Area

1. Select 5 packages, from each category of shapes that the teacher has provided for you.

2. Sketch and identify each of the geometric shapes that you have selected. Make each drawing size approximately 3″ x 3″.

3. Make a table similar to the following table to record your data.

	Shape	Area	Circumference	Volume
Pkg #1				
Pke #2				
Pkg #3				
Pkg #4				
Pkg #5				

3. Given the formulas in Table 1 below, determine the circumference, area, and volume for each of the packages that you selected wherever it is applicable.

	Area	Circumference	Volume	Surface Area
Square	$A = s^2$			
Rectangle	$A = lw$			
Parallelogram	$A = bh$			
Triangle	$A = ½\, bh$			
Trapezoid	$A = ½\, (b_1 + b_2)h$			
Circle	$A = \pi r^2$	$C = 2\pi r$		
Cylinder			$V = \pi r^2 h$	$SA = 2\pi r(r + h)$
Rectangular prism			$V = lwh$	$SA = 2lw + 2hw + 2lh$
General prisms			$V = Bh$	SA = sum of the areas of the faces

Table 1

<u>Design Brief</u>

You are part of a design team at a large cereal company. Your company has developed a new cereal for a targeted age group. You and your team must design a container or box for marketing the cereal as well as construct the prototype for a presentation to the company president, your instructor, and its board of directors, the class. You will prepare a one-page report that describes the following considerations in your design.

There are many factors that must be considered in the design and the manufacturing of a container or box: function, consumer appeal, information, and environmental impact.

One of the most important factors is that the container must be *functional*. It must be appropriate for the contents and durable enough to protect the contents in shipment and storage. Packaging must also provide for maintaining freshness of its contents. The package should be easy to handle and store. Last, the packaging must be cost-effective so that the company makes a projected profit.

Another important design factor to be considered is marketing and advertising. The package must be attractive and appealing to the consumer so that they will purchase it over another brand.

Next, the package must communicate information about the contents and nutrition to the consumer.

Last, considerations must be made with respect to how the manufacture of the package will impact the environment, in both the materials and the processes as well as in the disposal of the container.

Preparation

1. Conduct research using the resources given and other resources to learn how major cereal companies approach the design problem.

2. Use the Internet to learn about the Fair Packaging and Labeling Act of 1966 and how it is applied to labeling contents.

3. Visit the United States Environmental Protection Agency website and/or contact them to gain insight to environmental issues in packaging.

4. Disassemble other cereal boxes to discover how they are designed and glued to get ideas how to design, cut and assemble your container.

5. Learn how to use graphic or CAD software to design logos and/or graphics for your cereal box.

Design Specifications

6. Construction must be precision and container must have defined edges.

7. Your cereal box must include the following:

    - Graphics
    - Color
    - Company logo
    - Brand
    - UPC code
    - Nutritional information
    - List of ingredients
    - Content Weight
    - Other consumer information
    - Re-closable lid or flap
    - All sides must contain information, text and graphics.

Connecting Mathematics and Science to Technology Education

System: Informational
ITEA Standard: 3, 6, 7, 12, 15
GPS: 1, 3, 9, 23-25

Name: ______________________________

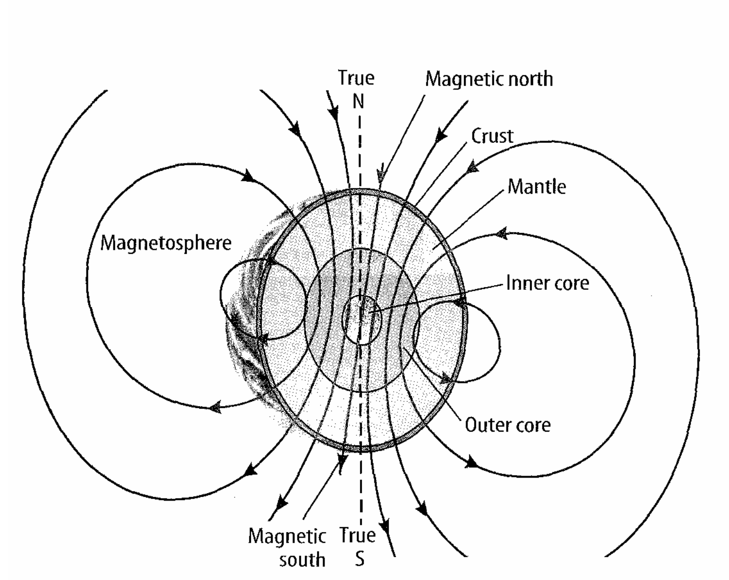
Earth's Magnetism and Navigation

This worksheet will give students information about the Earth's Magnetism and how earthly inhabitants use its magnetic fields. Students will learn how animals use magnetism to navigate. They will also be introduced to the Global Positioning Technology system now available to aid humans in navigation.

Math Connections	Science Connections	Technology Connections
Area	Magnetism	Navigation
Angles	Polarity	Problem Solving
Graph	Directions	Communication
Translation/Conversion		

Earth's Magnetic Field

The Earth has a magnetic field. The region of space affected by Earth's magnetic field is called the magnetosphere. The origin of Earth's magnetic field is thought to be deep within Earth in the outer core layer. One theory is that movement of molten iron in the outer core is responsible for generating Earth's magnetic field. The shape of Earth's magnetic field is similar to that of a huge bar magnet tilted about 11º from Earth's geographic north and south poles.



Nature’s Magnets Honeybees, rainbow trout, and homing pigeons have something in common with sailors and hikers. They take advantage of magnetism to find their way. Instead of using compasses, these animals and other have tiny pieces of magnetite in their bodies. These pieces are so small that they may contain a single magnetic domain. Scientist have shown that some animals use these natural magnets detect Earth’s magnetic field. They appear to use Earth’s magnetic field, along with other clues like the position of the Sun or stars, to help them navigate.

Earth’s Changing Magnetic Field

Earth’s magnetic Poles do not stay in one place. The magnetic pole in the north today, is in a different place from where it was years ago. In fact, not only does the position of the magnetic pole move, but Earth’s magnetic field sometimes reverses directions. For example, 700 thousand years ago, a compass needle that now points north would point south. During the past 20 million year Earth’s magnetic field has reversed direction more than 70 times. The magnetism of ancient rocks contains a record of these magnetic field changes. When some types of molten rock cool, magnetic domains of iron in the rock line up with Earth’s magnetic field. After the rock cools, the orientation of these domains is frozen into position. Consequently, these old rocks preserve orientation of Earth’s magnetic field as it was long ago.

The Compass

How can humans detect and measure Earth’s magnetic field? The compass is a useful tool for finding and mapping magnetic fields. A compass has a needle that is free to turn. The needle itself is a small magnet with a north and a south magnetic pole. A magnet placed close to a compass causes the needle to rotate until it is aligned with the magnetic field line that passes through the compass, as shown in Figure 8.

Earth’s magnetic field also causes a compass needle to rotate. The north pole of the compass needle points toward Earth’s magnetic pole that is near the geographic North Pole. Unlike poles attract, so this magnetic pole is actually a magnetic south pole. Earth’s magnetic field is like that of a bar magnet with the magnet’s South Pole near Earth’s North Pole.

Finding the Magnetic Declination

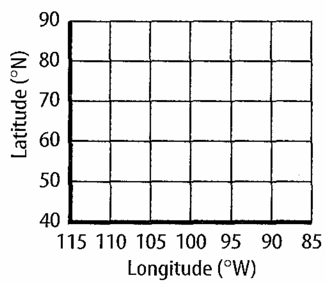
The north pole of a compass points toward the magnetic pole rather than true north. Imagine drawing a line between your location and the North Pole, and a line between your location and the magnetic pole. The angle between these two lines is called the magnetic declination. Sometimes knowing the magnetic declination can be important if you need to know the direction to true north, rather than to the magnetic pole. However, the magnetic declination changes depending on your position.

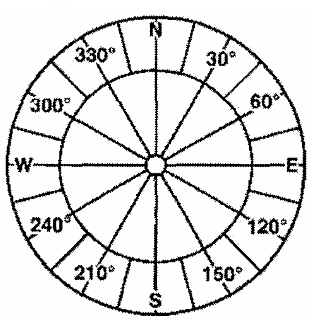
Identifying the Problem

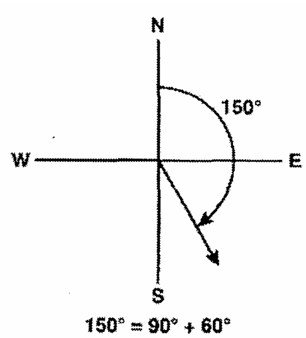
Suppose your location is at 50° N and 110º W. You wish to head true north. The location of the North Pole is at 90° N and 110º W, and the location of the magnetic pole is at about 80° N and 105º W. What is the magnetic declination angle at your location?

Solving the Problem

1. Label a graph like the one shown below.
2. On the graph, plot your location, the location of the magnetic pole, and the location of the North Pole.
3. Draw a line from your location to the North Pole and a line from your location to the magnetic pole.
4. Using a protractor, measure the angle between the two lines.







There are 360 degrees in a complete rotation. The directions north, east, south, and west are shown on the compass at the left.

To find the direction a boat or airplane is heading, measure clockwise from north around the compass.

The example shows a heading of 150 degrees.

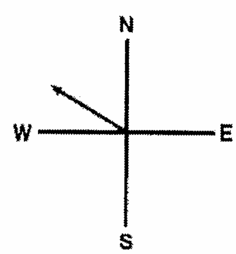
Materials

- Protractor

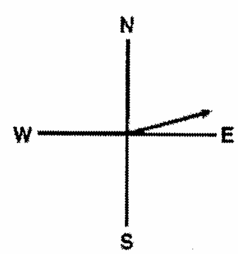
Directions

Use a protractor. Write the compass heading in degrees for each diagram on the lines provided.

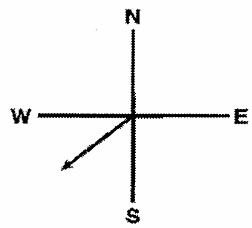
1. ___________



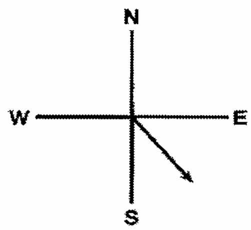
2. ___________



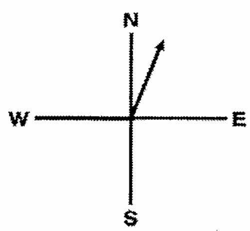
3. ____________



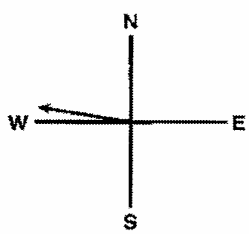
4. ______________



5. __ ___________

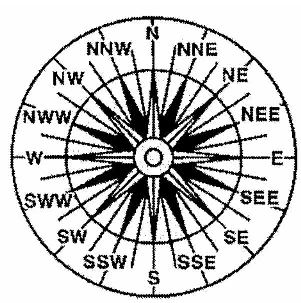


6. ______________



The drawing below is called a compass rose. Use the compass rose to translate each direction into degrees.

7. East ___________
8. North ____________
9. Northeast (NE) ____________
10. Southwest (SW) ________ _____
11. South _____ ______
12. Southeast (SE) _ ___________
13. Northwest (NW) __________
14. North northeast (NNE) ____________



Why GPS?

Trying to figure out where you are and where you're going is probably one of man's oldest pastimes. Navigation and positioning are crucial to so many activities and yet the process has always been quite cumbersome. Over the years all kinds of technologies have tried to simplify the task but every one has had some disadvantage. Finally, the U.S. Department of Defense decided that the military had to have a super precise form of worldwide positioning. And fortunately they had the kind of money ($12 billion!) it took to build something really good.

What is GPS?

The Global Positioning System (GPS) is a worldwide radio-navigation system formed from a constellation of 24 satellites and their ground stations. GPS uses these "man-made stars" as reference points to calculate positions accurate to a matter of meters. In fact, with advanced forms of GPS you can make measurements to better than a centimeter
In a sense it's like giving every square meter on the planet a unique address.
GPS receivers have been miniaturized to just a few integrated circuits and so are becoming very economical. And that makes the technology accessible to virtually everyone.

These days GPS is finding its way into cars, boats, planes, construction equipment, movie making gear, farm machinery, even laptop computers. Soon GPS will become almost as basic as the telephone. Indeed many people think it just may become a universal utility.

Here's how GPS works in five logical steps:

1. The basis of GPS is triangulation' from satellites.

2. To 'triangulate,' a GPS receiver measures distance using the travel time of radio signals.

3. To measure travel time, GPS needs very accurate timing which it achieves with some tricks.

4. Along with distance, you need to know exactly where the satellites are in space. High orbits and careful monitoring are the secret.

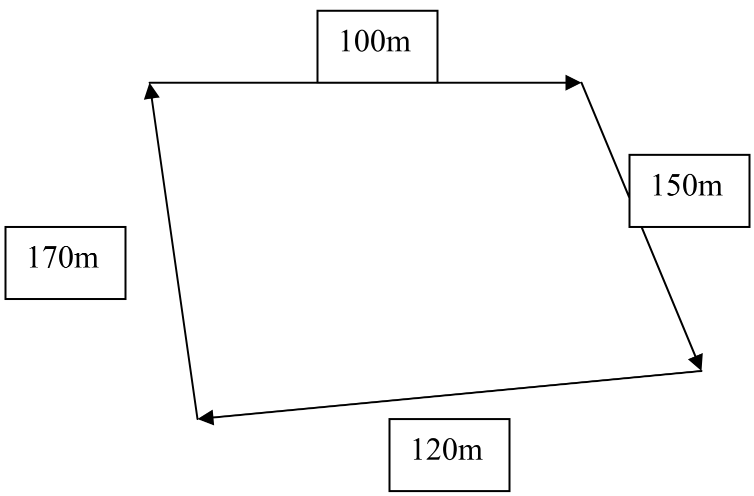
5. Finally you must correct for any delays the signal experiences as it travels through the atmosphere.

The result is the Global Positioning System, a system that's changed navigation forever.
Global Positioning System technology allows you to navigate much like you would if you were using a compass. Most GPS receivers have a navigate mode. While using this mode the receiver gives you a screen that looks like a compass. The *Off Road* screen will give you a direction arrow to your destination.

Design Brief

Go outside and select a starting point on the ground. Using a compass walk in a direction or magnetic azimuth of your choice, pace off 100 meters then place a mark. Turn and pace off another 100+- meters at another magnetic azimuth, place a mark. Turn and pace off another 100 meters at a chosen azimuth and place another mark. Now turn an azimuth back to your start point and count the paces. Now you can have your students calculate the perimeter of your polygon and they can also determine different azimuths and practice using the compass.

Now using a GPS receiver, enter your above turn points as a waypoint and demonstrate how to navigate with a GPS receiver. You can also calculate your rate of travel and distance traveled.



Calculate the following.

Perimeter ________

Area ____________

Connecting Mathematics and Science to Technology Education

System: Informational
ITEA Standard: 17, 3
GPS 1-10, 61, 62

Name: ______________________________

Build an Electronic Device

In this activity, students will learn basic electronic theory and then apply their knowledge to build an electronic device.

Math Connections	Science Connections	Technology Connections
Using Formulas	Electric Power	Electricity/Electronics
Calculations	Series Circuits	

Materials

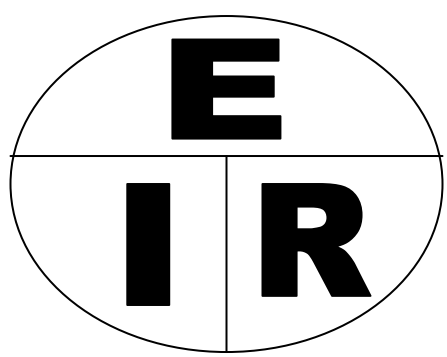
Instructor will provide tools and a kit containing the materials for constructing an electronic device.

Basic Electrical Concepts

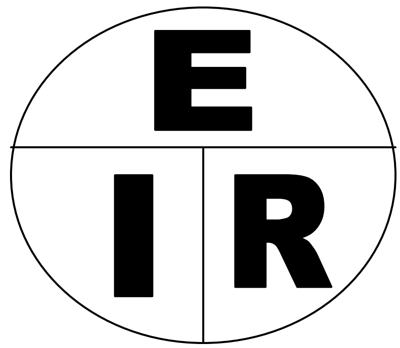
Ohm's Law - There is a way to figure out the amount of Volts, Amps, and Ohms in a circuit. Voltage, amperes and resistance are all connected to an electrical circuit. Because of this connection, we can calculate any one of the three if we know the values of the other two.

The formula to calculate these values is called Ohm's Law. According to Ohm's Law,

> **E = I x R**, where E=Electromotive force (Voltage), I=Current (Amperage), and R=Resistance (Ohms). Based on this, a series circuit that has a total current of 2 Amps and a total resistance of 30 Ohms will have a voltage drop of 60 volts.



Use Ohms Law to calculate the missing value within the following circuits.



1) E=3
I=12
R=_______________

2) E=5
I= _______________
R=15

3) E= _______________
I=20
R=10

4) E=40
I=13
R=_______________

5) E=_______________
I=17
R=20

Coulomb's Formula:

$$F = K\frac{Q1 \text{ x } Q2}{\text{D squared}}$$

F = Force (Neutrons)
K = Constant 9x 10 to the 9th power (for air or vacuum)
Q = change in units or charge (coulombs)
D = Distance between changed bodies (meters)

Flow of one coulomb per second = one ampere

$$I = Q/T$$

I = current in amperes
Q = change in coulombs
T= time in seconds

Watts

Unit of Power = Watts
1 watt = amount of work done with 1 ampere
power = E (voltage) x I (current)

Basic Electrical Concept Problems

Using the formulas and knowledge acquired, solve the following problems:

1. A circuit conducts 15 amperes when 41.5 volts are applied. What is the resistance in the circuit? What power is dissipated in the circuit? What is the G?

2. An electric heater is rated at 5 kilowatts and is designed to be operated on 240 volts. What is the R of this heater? What is the current through the heater?

3. What voltage is required to force 400 milliamps through 56 ohms? What power would be dissipated in the resistor?

4. How many coulombs would be above circuit conduct in a time of 5 seconds?

5. What voltage is required for a 4 ohm resistor to dissipate a power of 575 milliwatts? For a power of 10 watts?

6. A 50 ohm resistance conducts 4.5 amperes. What is the power dissipated? What voltage will be required?

7. A certain electric motor furnishes 2.4 horsepower. What is the watts of the motor?

8. What is the current through the above motor if the electromotive force applied is 120?

9. A 1500 watt hair dryer is operating on 120 volts. What is the current in amperes? What is the resistance of the hair dryer? What is the BTU's of heat output? What does it cost to operate this hair dryer for 1 month (30 days) if it is to operate 5 minutes daily and the cost of electricity is 8 cents per kilowatt hour?

10. What is the current of a 7 watt night light operating on 120volts? What is the current of a 100 watt light bulb operating on 120 volts? Which on these light bulbs offer the most electrical resistance? What will it cost to operate each bulb for 1 month (30 days), eight hours per day? (8 cents per KW)

11. A 100,000 BTU air conditioner operates for 1 month (30 days), eight hours per day. This air conditioner operates on 120 volts. What is the current through the AC? What power is dissipated by the AC? What will it cost to operate this AC for 1 month (30 days), eight hours per day? What would it cost to operate this AC if it were a 240 volt AC instead of a 120 volt AC?

12. What is the G of a 100 watt, 10 volt lamp?

13. What is the current of a circuit having a G of .1 mhos and a power of 10 watts?

Design Brief

Your task is to build a continuity tester. Any continuity tester will do to complete this activity. The student is to contact the instructor for necessary parts or kit to do this project. Continuity testers are typically just a buzzer that sounds when the circuit path under test is " made complete". When you use a kit , it has assembly instructions that contain a description on how to use your continuity tester as well as let you know how to install a red LED which lights up with the buzzer sound. It should also be remembered that when you use an LED , it has a PN junction which causes polarity needing to be observed.

Connecting Mathematics and Science to Technology Education

System: Informational
ITEA Standard: 17, 3
GPS: 1-10, 61, 62

Name: ______________________________

RESISTOR COLOR CODE

In this activity, students will discover the concepts behind the color code used in electronic devices and then apply this knowledge in a practical hands-on project.

Math Connections	Science Connections	Technology Connections
Using Formulas	Electric Power	Electricity/Electronics
	Series Circuits	

DIRECTIONS: Answer the 7 questions below. Crack the resistor color band code and place the correct answers to the right in the space provided. All the answers must be in Ohms (Ω). Each question must have three (3) answers.

Example: Red, Red, Brown, Gold

2 2 x 10 = 220 Ω

5% of 220Ω = 0.05 x 220 = 11Ω
220 - 11 = 209Ω
220 + 11 = 231Ω

Range 209Ω to 231Ω________________

1) Gold, Blue, Green, Brown ____________________________________
____
____
____
Range ____________________________________

2) Black, Silver, Black, Brown ____________________________________
____
____
____
Range ____________________________________

3) Gold, Blue, Gray, Black ______________________

____

____

____

Range______________________

4) Brown, Gold, Yellow, Violet ______________________

____

____

____

Range______________________

5) Blue, Red, Silver, Black ______________________

____

____

____

Range______________________

6) Violet, Gray, Silver, Red ______________________

____

____

____

Range______________________

7) Red, Gold, Red, Gold ______________________

____

____

____

Range______________________

<u>Resistor Color Band Chart</u>

Color	First Band	Second Band	Third Band (Multiplier)	Fourth Band
Black	0	0	1	
Brown	1	1	10	
Red	2	2	100	
Orange	3	3	1,000	
Yellow	4	4	10,000	
Green	5	5	100,000	
Blue	6	6	1,000,000	
Violet	7	7	10,000,000	
Gray	8	8	100,000,000	
White	9	9	0.10	
Gold			0.01	5% or 0.05
Silver				10% or 0.10
None				20% or 0.20

There is sometimes a fifth color band. This indicates how long the resistor should work before it fails.

<u>Design Brief:</u>

The student can best learn the color code of component parts by constructing an electronic device. They will also learn the importance of correct component value and place of that value in the electronic circuit. Any electronic device will do the job in this activity. The student is to contact the instructor for the parts or kit to be used in this hands- on experiment of concept reinforcement.

Connecting Mathematics and Science to Technology Education

System: Informational
ITEA Standard: 3, 5, 8, 11, 12, 15
GPS: 1-4, 6-9, 23-25, 40-42

Name: ____________________________

Measuring and Estimating for Landscape Design

Science and technology involve measuring. Therefore, a basic skill in technology education is the ability to estimate and make accurate measurements. This activity will teach students the difference between estimating and measuring, how to measure and to estimate lengths, how to communicate measurements, and to be aware of the different types of linear and angular measurement. Hands-on activities involving various landscaping tools enable students to obtain experience in drawing, measuring, and designing basic landscapes. This activity is a great enhancement to the design world of agriculture and landscape.

Math Connections	Science Connections	Technology Connections
Angles	Agriculture	Problem Solving
Area	Soil	Landscape Design
Perimeter		
Scale Conversions		

Materials
Assorted rulers, yardsticks, tape measures

Information for the teacher for the Estimating and Measuring Scavenger Hunt Activity

1. Begin the lesson by reviewing estimating and measuring length. Some strategies are to estimate a part of a larger object and using this estimated length to estimate the rest of the object, comparing the length to a known length like how tall they are, or estimating the shortest and longest length and getting a range of the object.

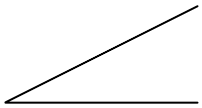
2. Next, have two students measure the object separately. The students need to determine what units they will use to measure the object. Should they use feet or inches, or meters or centimeters. After they have made their measurements make the point that the unit used depends on the size of the object being measured. A book's dimensions would likely be measured in inches or centimeters, while a chalkboard would be measured in feet or meters. Compare the measurements to the estimates done previously.

3. Group the students and distribute the estimating and measuring worksheet. While the students will work together to answer the questions, each should complete their own sheet. The sheet is designed to be completed in one class period.

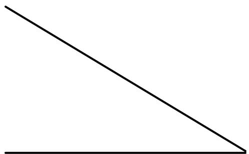
Measuring Angles

Directions: Using a protractor measure the following angles.

1.________

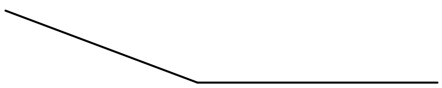


2.________

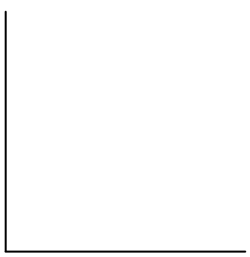


3.________

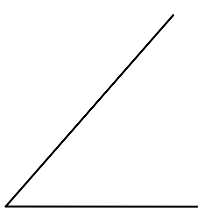
4.________



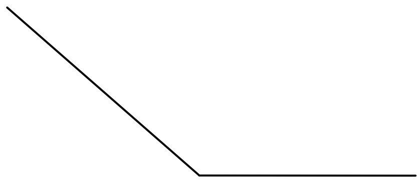
5.________



6.________



7._______



Converting Scales

Use the tools located in your drafting kit to draw the following.

1. A line 45 feet long to the scale of 1”=10’.
2. A line 25 feet long to the scale of 1”=20’.
3. A line 10 feet long to the scale of 1”=10’.
4. A line 80 feet long to the scale of 1”=20’.
5. A line 30 feet long to the scale of 1”=10’.
6. A line 45 feet long to the scale of 1”=20’.
7. A line 15 feet long to the scale of 1”=10’.
8. A line 10 feet long to the scale of 1”=20’.
9. Create a circle with a 40-foot diameter drawn to the scale of 1”=20’.

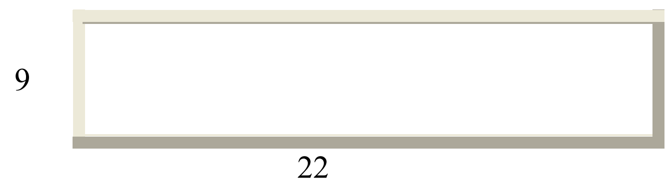
10. Create a circle with a 20-foot diameter drawn to the scale of 1”=10’.

11. Create a circle with a 80-foot diameter drawn to the scale of 1”=20’.

<u>Area & Perimeter of a Rectangle</u>

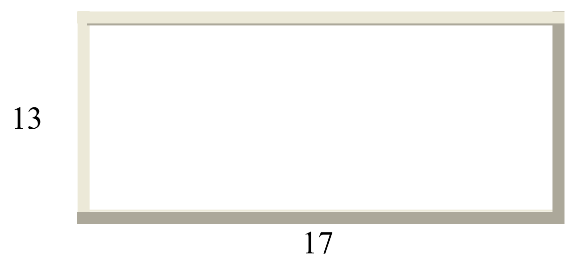
Directions: Find the area and perimeter of each rectangle. Each rectangle would represent your lawn.

1.



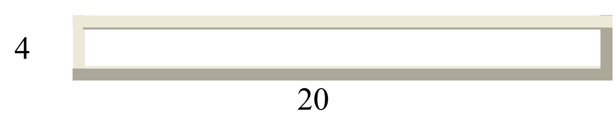
Area = **Perimeter =**

2.



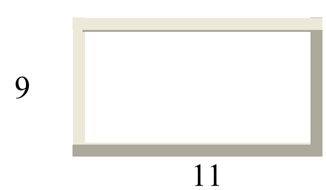
Area = **Perimeter =**

3.



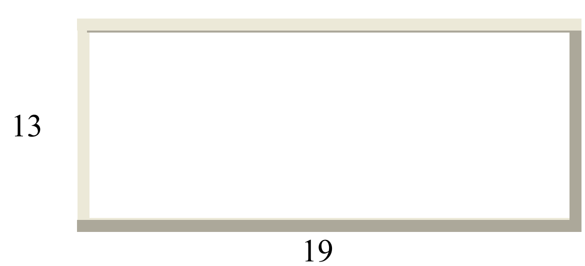
Area = **Perimeter =**

4.



Area = **Perimeter =**

5.



Area = **Perimeter =**

Answers To Area / Perimeter of a Rectangle Worksheets

Area	Perimeter
1. 198 2. 221 3. 80 4. 99 5. 247	1. 62 2. 60 3. 48 4. 40 5. 64

Estimating and Measuring Scavenger Hunt Activity

Use the hints to find objects in the classroom estimate its length and then measure the length using the appropriate units.

Hint	Object	Estimate	Exact Measurement
1. Object more than 6 feet long.			
2. Object between 8 and 10 feet long			
3. Object between 2 and 3 feet long			
4. Object that is twice as long as it is thick			
5. Object twice as tall as it is long			
7. Object that is less than a foot long			
8. Object that is less than 4 inches long			
9. Two things where one object is twice the length of the other	1. 2.	1. 2.	1. 2.
10. Two things that add up to about 2 feet	1. 2.	1. 2.	1. 2.

12. If you can measure, why would you need to estimate anything?

13. Suppose there was no such thing as inches. How would things smaller that a foot be measured?

14. How many cars lined up bumper to bumper would it take to be 1 mile long.

15. Describe three jobs where the ability to make accurate measurements is essential.

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System: Informational
ITEA Standard: 1,5,15
GPS: 1-9, 23-25, 121-124

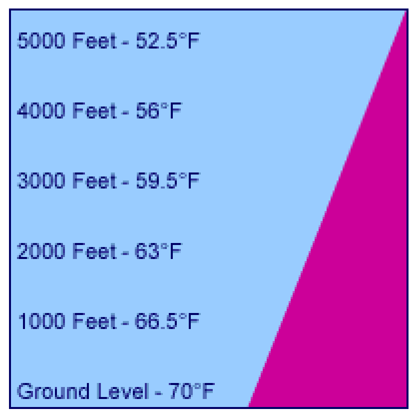
Name: ______________________________

Meteorology Math

In this activity, students will collect data and then analyze the data with respect to various weather conditions on earth.

Math Connections	Science Connections	Technology Connections
Data Collection/Analysis	Temperatures	Problem Solving
Mean, Median, Mode	Weather Patterns	

Background Information



The higher above the earth you are, the cooler it gets. This is because the atmosphere is warmed by the heat from the earths surface – the sun's energy must hit the surface of the earth before its turned into heat energy.

On average, for each 1000 feet above earth's surface, the temperature is cooler by 3.5 degrees Fahrenheit.

For example, if the temperature is 70 degrees at ground level, it will be 66.5 degrees at an elevation of 1000 feet.

For each 1000 feet decrease in elevation (getting closer to the ground), the temperature increases by 3.5 degrees.

1. Temperature at 6000 feet if temperature at ground is 30 degrees.

2. Temperature at surface if temperature at 1000 feet is 77.5 degrees.

3. Temperature at 2000 feet if temperature at surface is 50 degrees.

4. Temperature at surface if temperature at 10,000 feet is 20 degrees.

5. Temperature at 1000 feet if temperature at 2000 feet is 55 degrees.

6. Temperature at 3000 feet if temperature at ground is 30 degrees.

7. Temperature at 4000 feet if temperature at 1000 feet is 50 degrees.

8. Temperature at surface if temperature at 5,000 feet is 45 degrees.

9. Temperature at surface if temperature at 1,000 feet is 35.5 degrees.

10. Temperature at surface if temperature at 3,000 feet is 40 degrees.

Calculating wind direction, time, temperatures and precipitation

1. Katie's weather station recorded a high temperature of sixty-six degrees Fahrenheit. Jasmine's weather station recorded a high temperature that was eight degrees warmer than Katie's. What did Jasmine's weather station record as the high temperature?	2. Emory's weather station recorded a high temperature of sixty-one degrees Fahrenheit. Mark's weather station recorded a high temperature that was five degrees colder than Steven's. What did Amanda's weather station record as the high temperature?

3. In the morning, the wind was blowing fourteen miles per hour southeast. By the afternoon, the wind was blowing eighteen miles per hour stronger, but in the exact opposite direction. What is the direction and the speed of the wind in the afternoon?	4. Last week, there were two cloudy days, three rainy days, and the rest of the week was sunny. How many days last week were sunny?

5. The current temperature is 84 degrees Fahrenheit. On the same day in 1978, the record high temperature was set at 99 degrees Fahrenheit. How much warmer must it get for the temperature to break the record in 1978?	6. It snowed 12 inches on Sunday, 5 inches on Monday, and 10 inches on Tuesday. On Wednesday two inches of snow melted. How much snow is left?

7. On Friday, sunrise as at 6:50 a.m. Five days earlier on Sunday, sunrise was three minutes earlier. What time was sunrise on Sunday?	8. Yesterday’s high temperature was 23 degrees Fahrenheit warmer than yesterday’s low temperature. If yesterday’s high temperature was 81 degrees Fahrenheit, what was yesterday’s low temperature?

9. It rained one-quarter of an inch on Monday, one-fifth of an inch on Tuesday, and half of an inch on Wednesday. How many inches did it rain altogether?	10. A total of ten and two-tenths inches of rain have fallen this year. The normal amount of rain to have fallen by this time is twenty-eight and ninety-four hundredths inches. How much below normal is this year's rainfall?

11. In May, the weather was sunny for ten days, cloudy for eleven days, and rainy the rest of the month. In June, the weather was sunny for eight days, cloudy for sixteen days, and rainy the rest of the month. In July, the weather was sunny for eleven days, cloudy for twelve days, and rainy the rest of the month. How many days did it rain all together in May and June?	12. On Friday, the temperature was negative eight degrees Fahrenheit. On Saturday, the temperature rose twenty-five degrees Fahrenheit. What was the temperature on Saturday?

13. Yesterday, Washington's high temperature of 64 degrees Fahrenheit was 55 degrees Fahrenheit warmer than Calgary's high temperature. The difference between Calgary's low temperature and Calgary's high temperature was 11 degrees Fahrenheit. What was Calgary's low temperature?	14. It snowed 3 inches on Wednesday and 4 inches on Thursday. There are still 3 ½ inches of snow on the ground. How much snow has melted?

15. Monday's sunrise is at 6:54 a.m. and sunset at 9:34 p.m. During the next week, the sun will rise two minutes earlier each day and will set one minute later. Assuming clear skies, how many hours of sunlight will we have from Monday through Thursday?	16. It snowed 17 inches each month for four months. What was the total amount of snow?

17. The average monthly precipitation during the past six months was 1.68 inches. If this trend continues, how much precipitation will fall during the coming year?	18. The average weekly rainfall during the past 23 weeks was 8 mm. During this period, what was the total rainfall in centimeters?

19. At 1:45 p.m., a storm that is 81kilometers away is approaching at a speed of 37 kilometers per hour. Approximately what time will the storm arrive?	20. The speed of four tornadoes was 84 mph, 96 mph, 101 mph, and 95 mph. What was the average speed of the tornadoes?

Temperatures

Russell and Anna each live in a different city. Each Monday for eleven weeks, they recorded the high temperature. The data below is the high temperature, in Fahrenheit, that they recorded.

Russell's data: 52, 52, 46, 49, 50, 45, 49, 49, 55, 52, 55, and 53.

Anna's data: 69, 69, 71, 69, 77, 74, 74, 71, 70, 63, 60, and 59.

All calculations should be rounded to the nearest tenth.

1. What is the range of temperatures in Russell's data?	2. What is the mean, median, and mode for Russell's data? for Anna's data?
3. If you combined the data for both cities, what would be the mean, median, and mode for the combined data?	4. Russell added one more week to his data. The median of all of his data is now 50.6, rounded to the nearest tenth. What was the new temperature value that Russell added to the data?

5. Using Russell's data, what was the mean temperature in Celsius?	6. Anna calculated the median to be 70, however he forgot to include one number when calculating the median. Which number did Anna forget?
7. What is the variance and standard deviation of Russell's data?	8. What is the variance and standard deviation of Anna's data?
9. What would be a good prediction for the high temperature the next two weeks in Anna's city? Why?	10. If you could spend the next month in either city, whom would you want to visit? Why?

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System: Informational
ITEA Standard: 3, 17
GPS: 1-14, 92

Name: ______________________________

Electromagnets

Students will construct an electromagnet out of some wire, a nail, and a small battery. Students will then have an opportunity to study the use of electromagnets in electronic devices such as televisions and VCRs.

Math Connections	Science Connections	Technology Connections
Time Measurement	Magnetism	Electromagnet Construction Video Technology

How magnets work

Natural magnets usually contain the metals iron or nickel, but they can also be made from the metals cobalt, samarium, dysprosium, and gadolinium. These same metals, even when they are not magnets, are still attracted by magnets.

But magnetic materials do not have to be metals. They can be non-metals whose atoms or molecules have their electron orbits in certain arrangements. In fact, that is how we believe magnets work. The electrons in the atoms of all materials create magnetic fields because of their orbits. In most materials, the orbits and their magnetic fields are randomly oriented and thus create no permanent magnetic field. But in certain materials, called ferromagnetic, the electron orbits and their magnetic fields line up in a row and thus create a permanent magnet.

Television and computer screens have magnets inside of them that make them work. These cathode ray tubes have an electron gun in the neck of the tube that shoots a stream of electrons toward the screen. Normally these electrons travel in a straight line and strike the screen at a central spot.

But powerful electromagnets in the tube's neck deflect the electrons toward the top or bottom and left or right sides of the tube. The inside of the screen has a special coating that glows when the stream of electrons strikes it. In this way, magnets help us see images on the TV screen.

Computer storage disks are coated with an iron material that stores tiny magnetic fields in a pattern, and that is how we store data on the computer disks.

Also, videotape uses a similar material with iron compounds that allows magnetic fields to be stored in patterns on the tape so we can watch our favorite programs and movies.

Design Brief

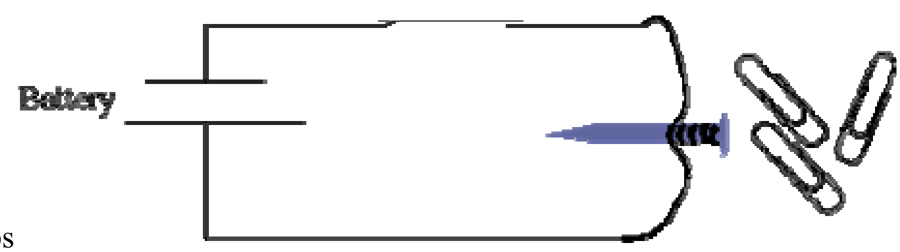
Students will construct an electromagnet using the materials listed below. They will then have an opportunity to experiment with a video or audio tape to see the rolls magnets play in recording on a tape.

Tools, Materials and Supplies

Insulated wire
A nail
Small battery
Compass

Step 1

1. Wrap some of the insulated wire around a nail
2. Attach the wire ends to the small battery

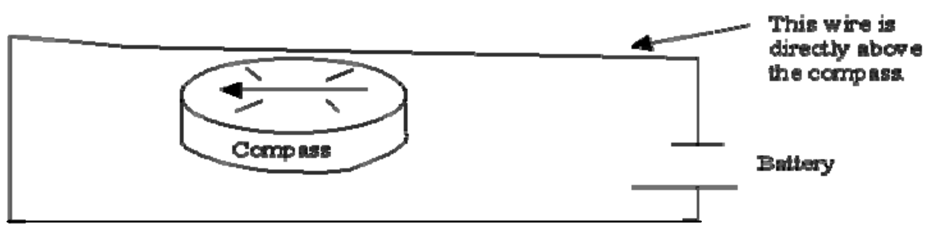


After completing this, you will see that the nail will suddenly become magnetized (paper clips may be used to demonstrate this). You have just crated an electromagnet.

Now, reverse the wires connecting to the battery.

Does the electro magnet pick up the paper clips?_____________________________

Put a compass near your electromagnet and you will find that one end of the nail registers north and the other, south. Now, reverse the battery.



What happens to the direction of the needle? ____

Why? ____

If you put an alternating current through the wire (current that oscillates from positive to negative), your magnetic field will oscillate north to south. Every electrical oscillation will create a magnetic oscillation.

Step 2

1. Put some iron filings on a sheet of plastic or paper.
2. Your electro magnet under the sheet.
3. Move the electromagnet father away from the sheet. And then closer.

How does this affect the filings? ____
____

This is what happens while recording onto a video. Tapes consist of a plastic strip coated with powder like metal particles. These particles become tiny magnets when the strip passes by the recording head (a source of magnetism). When this happens, the tiny particles are attracted to the recording head depending on the strength of the signal. The particles become arranged in a pattern that is then translated into image and sound.

Use a video or audiotape, pre-selected by your teacher. View the material on the tape. When finished, run a very strong magnet, provided by your teacher over the tape and play it again.

What has happened?____

Why? ____

Mathematical Calculations

1. If you had a video tape that would record for 1, 3, or 5 hours, what is the greatest number of *That's so Raven* episodes (this is a 30 minute show) could you record on this tape?

    ____

2. If the video tape passed the recording tape 10 inches per second, how much time will it take for 250 inches to pass?

    ____

Connecting Mathematics and Science to Technology Education

System: Informational
ITEA Standard: 1-3, 7, 8, 17
GPS: 1-19, 156-160

Name: ______________________________

Creating a Digital Collage

Photography is becoming a part of our everyday lives. This activity will take a look at how film cameras work and how they have evolved into digital photography. Students will then use a digital camera to create an electronic collage of their interests.

Math Connections	Science Connections	Technology Connections
Calculating Resolution	Optics (physics)	Communication
Calculating Photo Size	Chemistry	Design

Tools, Materials and Supplies
Digital Camera, Computer, Printer

Software: Photo Editor, Desktop Publishing program

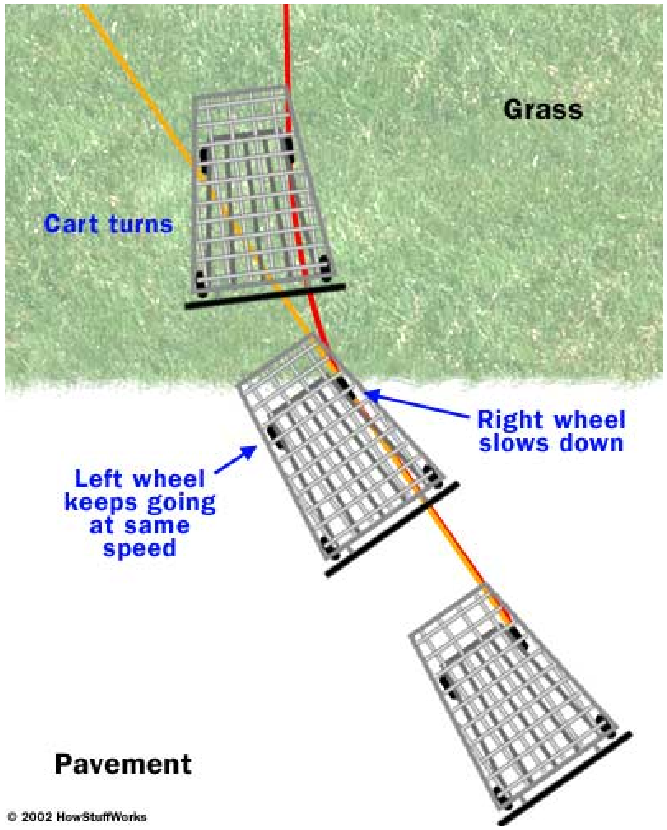
Background Information

Photography is undoubtedly one of the most important inventions in history. It has truly transformed how people envision the world. Now we can "see" all sorts of things that are actually many miles away from us. Photography lets us capture moments in time and preserve them for years to come. The basic technology that makes all of this possible is fairly simple. A still film camera is made of three basic elements: an optical element (the lens), a chemical element (the film) and a mechanical element (the camera body itself).

The optical component of the camera is the lens. At its simplest, a lens is just a curved piece of glass or plastic. Its job is to take the beams of light bouncing off of an object and redirect them so they come together to form a real image -- an image that looks just like the scene in front of the lens.

But how can a piece of glass do this? The process is actually very simple. As light travels from one medium to another, it changes speed. Light travels more quickly through air than it does through glass, so a lens slows it down.

When light waves enter a piece of glass at an angle, one part of the wave will reach the glass before another and so will start slowing down first. This is something like pushing a shopping cart from pavement to grass, at an angle. The right wheel hits the grass first and so slows down while the left wheel is still on the pavement. Because the left wheel is briefly moving more quickly than the right wheel, the shopping cart turns to the right as it moves onto the grass.



The effect on light is the same -- as it enters the glass at an angle, it **bends** in one direction. It bends again when it exits the glass because parts of the light wave enter the air and speed up before other parts of the wave.

After the film is loaded it is time to take pictures. But first we have to set the other camera controls. These settings depend on film speed and lighting. Film speeds are set according to the ISO rating listing on the film canister. The size of the shutter opening will determine the amount of light that will strike the film. This opening is called the aperture. The aperture size is indicated by a number called the f-stop. The higher the f-stop, the smaller the aperture. A smaller aperture (or opening) means less light will strike the film. Once all the pictures have been taken it is time to develop the film.

To begin developing the film you first need the following items: an exposed roll of film, a developing tank, a film reel, a darkroom, and developing chemicals. The most difficult part of film developing is loading the film reel. This is because exposed film must be loaded in complete darkness. A darkroom is normally used for this procedure. Once in total darkness, the film canister is opened. The film is loaded onto the reel and then the loaded reel is placed into the developing tank.

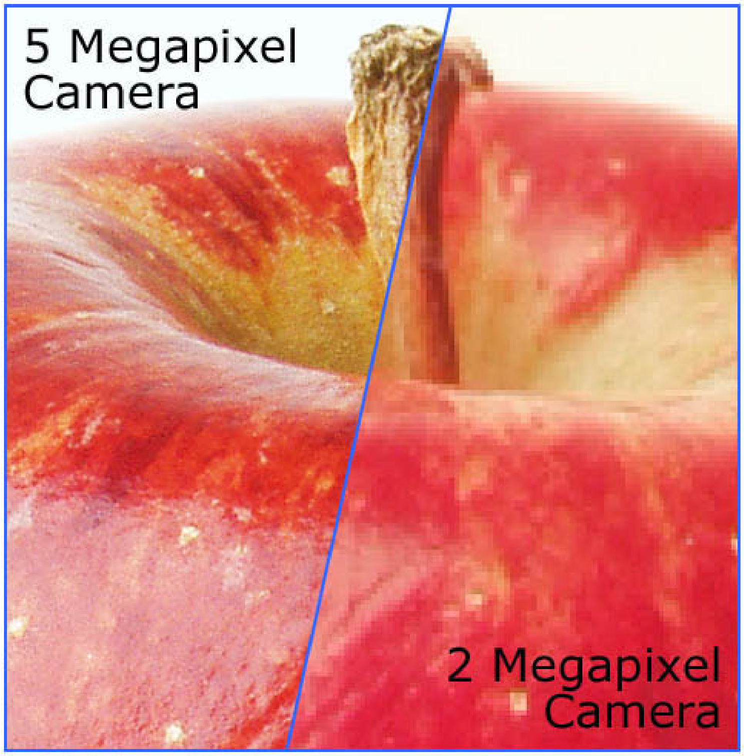
Three chemicals are needed to develop the film: the developer solution, the stop bath solution, and the fixer solution. The developer solution is the chemical that reveals the image on exposed film. The stop bath solution creates a chemical reaction with the developer solution stopping the developer from developing any further. The fixer solution is a chemical that makes the developed image on film permanent. These chemicals must be added to the film for certain time limits to ensure proper developing. The chemicals cause chemical reactions which result in the exposing of the parts of the film that have the image on them. The non-image sections do not absorb the chemicals. Once the chemicals have been applied and washed out, the film needs to dry completely.

Making a photographic print is a two step process. First, the negative must be enlarged. Next, it must be developed into a photograph using the same chemicals used in the film processing procedure. This process is referred to as printing.

Now that digital cameras have emerged into today's technological society, film is slowly becoming obsolete. We have moved from film and darkrooms to storage cards and megapixels. All digital cameras have a built-in computer and all of them record images in a completely electronic form. Let's say you want to take a picture and e-mail it to a friend. To do this, you need the image to be represented in the language that computers recognize- bits and bytes. Essentially, a digital image is just a long string of 1s and 0s that represent all the tiny colored dots (pixels) that collectively make up the image. At its most basic level, this is all there is to a digital camera. Just like a conventional camera, it has a series of lenses that focus light to create an image of a scene. But instead of focusing this light onto a piece of film, it focuses it onto a semiconductor device that records light electronically. A computer then breaks this electronic information down into digital data.

Megapixels, resolutions, dpi and ppi; it almost sounds like a foreign language or some encrypted military code. Relax, because deciphering the language of pixels is far easier than anything spoken. Digital cameras have steadily increased in image quality since first coming on the market, and will likely continue to do so. Knowing something about resolution proves helpful when editing your digital images, as well as printing them out for family and friends. Pixels are tiny squares of color, grouped together, to form the digitized image we see on a computer screen. If you use the zoom tool in any image editing program to look at your photo, as you zoom in, you'll begin to see your picture turn into squares. The closer in you zoom, the less like a picture it seems, and more like a Rubik's cube of varying colors. One "megapixel" is 1 million of these pixels. As a general rule in the digital world, the more pixels an image has, the more detail. A digital camera is able to process a certain amount of information through its lens and record it onto a removable media card. The information stored to this media card is essentially made up of digital pixels. A 2 Megapixel (MP) camera can process and record images that consist of 2 million pixels apiece. Similarly, a 5 Megapixel (MP) camera can process and record images that consist of 5 million pixels apiece. Why is this important? Simply put, the more pixels that can be recorded by a camera, the greater the image resolution, and the greater the image resolution, the better the image quality. The image below compares an apple that was photographed by two different digital cameras, 5 MP and 2 MP. Here, we've magnified a section of each result for comparative purposes.

As you can see, the difference in detail, or resolution, is quite obvious.



Right now, there are two main types of storage media in use today. Some cameras use 1.44-MB floppy disks, and some use various forms of Flash memory that have capacities ranging from several megabytes to 1 gigabyte. The main difference between storage media is their capacity: The capacity of a floppy disk is fixed, and the capacity of Flash memory devices is increasing all the time. This is fortunate because picture size is also increasing constantly, as higher resolution cameras become available.

The two main file formats used by digital cameras are TIFF and JPEG. TIFF is an uncompressed format and JPEG is a compressed format. Most cameras use the JPEG file format for storing pictures, and they sometimes offer quality settings

Design Brief

You are to create a one page document using Microsoft Photo Editor and a desktop publishing program (a blank slide in PowerPoint may be used) depicting their hobbies and interests. You must have at least 5 digital pictures of various sizes arranged on the single page document.

Begin by creating a sketch using paper and pencil. Decide what you are going to take pictures of and how the pictures will fit together on the page.

Use a digital camera and take ten pictures of items that represent your hobbies and interests. (You want to be able to choose the best).

Use photo editor software to adjust the sizes of the different pictures so that they fit onto the page. The sizes of the pictures should correspond to their importance in your life.

Import the photos into a desktop publishing program and arrange them on the page. Print your final result.

Review Questions:

1. What are the three basic elements of a still film camera?
2. What is the function of a lens?
3. Why does light bend when it enters a lens at an angle?
4. The shutter opening is called a(n) _______________?
5. What is the f-stop?
6. How does the f-stop relate to the aperture?
7. Define the following terms:
   - Developer Solution
   - Stop Bath Solution
   - Fixer Solution
8. What is printing?
9. What is a pixel?
10. How many pixels are in 1 megapixel?
11. What are the two main types of storage media in use today?
12. Which of the two types of storage media is better and why?
13. What are the two main file formats?
14. Which file format produces uncompressed pictures?
15. Which file format is used by the majority of cameras?

Calculating Resolution

You are going to use the given resolution (shown in pixels) to calculate the megapixel setting used on the camera. Next you will determine what size the picture will print depending on the quality of the printer used. Refer to the example line in the chart below.

To calculate megapixels**:**

Multiply the two numbers given and then divide by 1 million.
Round your answer to the nearest whole number.

Example
2,048 x 1,536 = 3,145,728/1,000,000 = 3.145728 = 3 megapixels

To calculate the size:

Divide the first number of the resolution by the Quality number (dpi).
Round to the nearest tenth.
Repeat the process for the second resolution number

Examples for low quality: 2,048 ÷ 300 dpi = 6.8”
1,536 ÷ 300 dpi = 5.1”

Complete the rest of the chart for Lines 1- 5.

	Printer Quality:	300 Dpi (Low Quality)	400 Dpi (Medium Quality)	600Dpi (High Quality)
Example	3 megapixels 2,048 x 1,536	6.8” x 5.1”	5.1” x 5.1”	3.4” x 2.6”
Line 1	**A.**_________ 2,272 x 1,704	**B** _____________	**C**_______________	**D**_______________
Line 2	**E.**_________ 2,592 x 1,944	**F**_______________	**G**_______________	**H**_______________
Line 3	**I.**_________ 3,008 x 2,000	**J**_______________	**K**_______________	**L**_______________
Line 4	**M.**_________ 3,000 x 2,400	**N**_______________	**O**_______________	**P**_______________
Line 5	**Q.**________ 3,264 x 2,448	**R**_______________	**S**_______________	**T**_______________

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ITEA Standard: 8, 9, 10, 19
GPS: 1 - 34, 46, 39, 40, 42, 72, 73

Name: ______________________________

Ship and Shop Box

In this activity, students will take on the task of a design team to solve a breakage problem for a manufacturing company. The design team must design an ornament display box and shipping container that will solve the problem of shipping and handling breakage. Students will use a variety of problem solving skills to meet the design challenge. This activity is best done as a 3-4 member team with each member of the team having specifically assigned objectives.

Math Connections	Science Connections	Technology Connections
Area	Mass	Design Processes
Surface area	Environment	Manufacturing
Circumference	Pollution	Problem-solving
Dimensioning	Material science	Communication
Measurement		

Tools, Materials and Supplies
Rulers, compasses, protractors, cloth measuring tape
Scientific scales (grams/ounces)
Calculators
Scissors
Colored legal sized file folders, poster board
Clear transparency sheets
Glue sticks
Transparent tape
Glue guns and glue sticks
Ornaments
Software: Graphic and CAD software

SCENARIO

The Case of the Break. The Classy Cricket Company designs and manufactures collectible ornaments for all occasions. The delicate ornaments are very laborious making them expensive to manufacture. The demand has been very good but the company's profit margin remains low because of losses resulting from breakage. The company decided to hire the Mad Hatters Consulting Firm to investigate why the breakage is occurring and to help them solve the problem.

Investigation by the Mad Hatters. The Mad Hatters began their investigation by observing how the large boxes, although not heavy, were handled from the point of the loading dock of the manufacturing plant to the unloading dock at the retail stores. While Classy Cricket's shipping and handling crew handled the company's merchandise very effectively and with great ease, it was observed very quickly that the retail stores' unloading crew was not trained as well and could not handle the large boxes as easily without dropping an occasional box which caused some of the breakage.

This still did not account for all of the breakage—so the Mad Hatters further investigated the problem by placing a video camera where the ornaments were shelved. In spite of having one of each of the different ornaments displayed so that consumers would not open the boxes, the video revealed that 85% of the customers opened one or more of the ornament boxes to examine the ornament. Occasionally a customer dropped an ornament breaking it. Occasionally an ornament slipped out of a partially closed box that had been previously opened and would break. But most of the time, the boxes were accidentally knocked off the shelf when customers were browsing and the box did not adequately protect the ornament. It was determined that this caused most of the breakage of the ornaments.

Next, the Mad Hatters investigated why customers were insistent on taking the ornaments out of the box although they could see the display ornament. When interviewing customers, it was soon determined that customers simply wanted to examine the quality of the ornament before purchasing and that they like to compare it to one or more before making a final decision. Many customers remarked that they would not buy an ornament without physically examining it.

The Mad Hatters finished its investigation and sent a report back to the company with suggestions for solutions to the problem.

The consulting firm offered the following solutions to minimize breakage to increase the company's profit margin.

1. To minimize breakage in shipping and handling, scale down the size of the shipping boxes so that the boxes could be handled easily and safely.

2. To minimize consumers' handling of the fragile ornaments, redesign the ornament container so that customers can view and examine the quality of the ornament without taking the ornament out of the box.

3. To minimize the breakage from shelf accidents, redesign the ornament container so that it provides more protection for the fragile ornament.

Upon receiving the report from the Mad Hatter Consulting Firm, the Classy Cricket Company decided to bring in an outside design team to design and construct the boxes to solve the shipping and handling problems.

DESIGN BRIEF

Your team will be competing with other design teams for the contract with the Classy Cricket Manufacturing Company. Your team must meet the design challenge of designing and constructing a prototype of the display box and provide recommendations and information necessary for a shipping container for the ornaments based on the three suggestions provided by the Mad Hatter Consulting Firm. At least four aspects of design and construction must be considered: *function, cost, communication, and environmental impact*. You must address the following questions in your presentation to the company's board of directors.

Function. One of the most important factors is that the container must be functional. It must be appropriate for the contents and durable enough to protect the contents in shipment and storage. The package should be easy to handle and store.

- What is the maximum size for the shipping container for handling and storage?
- How many ornaments can be shipped safely in one container?

Cost. The packaging must be cost-effective so that the company makes a projected profit. Packaging must protect the contents.

- What kind of packaging should be used?
- How much will the packaging cost?
- How much are shipping costs?
- How does the cost of smaller shipping boxes compare to the cost of the larger shipping boxes?
- Are there any costs considerations related to the environment that will affect the company?

Communication. Another important design factor to be considered is marketing and advertising. The package must be attractive and appealing to the consumer and it must communicate information about the contents.

Environment. Considerations must be made with respect to how the manufacture of the package will impact the environment, in both the materials and the processes as well as in the disposal of the container. Packaging must be environmental friendly.

- What is the decomposition rate of the boxes?
- Can the boxes be recycled?

Criteria for Designing and Constructing the Display Box

The following are guidelines that you must consider when designing and constructing your display box.

1. The display prototype must pass rigorous testing by the Classy Cricket Company's shipping and handling department. The shipping and handling department has setup testing in which the display box containing the ornament must be able to survive a fall of at least 12 feet. Testing will continue at varying increments of additional heights to establish which design team's box provides the best safety factor (i.e. the one that survives the greatest height has the best safety factor.)

2. The display box must be designed so that it has at least *three* viewing windows with sides at least *two inches* in length.

3. The display box must be designed so that it has a lid that opens and closes so that a customer can take it out of the box if they choose to examine the ornament. The lid must close securely to keep the ornament from tumbling out of the box.

4. The display box must be aesthetically inviting (consumer appeal). Construction must be precision and container must have defined edges. Details and graphics that will appeal to the customer will also help sell the ornaments. This is a plus for the design team.

5. The size of the display box can not be greater than four inches in any direction as the cost of shipping increases dramatically beyond this size.

6. The company desires that the display box be a one-piece design as it is more cost-effective for them to buy one machine that can cut the entire box design in one step than it is for them to buy two or more. A one piece design will also require less employees to assemble the box which makes it more cost-effective.

7. Each team must provide a cost analysis of all the material used in making the prototype.

8. Each team must research the environmental impact of making and deposing of their display box.

Shipping Container

1. What are the dimensions of the proposed shipping container?
2. What are the shipping costs of the proposed shipping container?
3. What is the volume of the shipping container?
4. How many of your ornament packages can fit into the shipping container?
5. What is the cost of the shipping container?
6. Are there any associated environmental fees for the shipping container?
8. What is the weight of the shipping container with and without the contents?

Preparation Suggestions

1. Use the Internet and other sources to learn how packaging companies approach the design problem.

2. Access the Internet resource, www.epa.gov , to learn about environmental issues.

3. Disassemble other boxes to discover how they are designed and glued to get ideas how to design, cut and assemble your container.

4. Learn how to use graphic or CAD software to design your box.

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Connecting Mathematics and Science to Technology Education

System: Informational
ITEA Standard: 1-3, 8, 17
GPS: 1-19, 161-164

Name: ______________________________

Multimedia and Advertising

Every time we turn on the television we see multimedia. This unit will take a look at how video cameras work and how audio travels through the air to our ears. Students will then use a digital camera and a video camera to create an advertisement that combines video, still pictures, and music.

Math Connections	Science Connections	Technology Connections
Time Calculations	Physics of Audio	Communication
Calculating Ratings		Design

<u>Tools, Materials and Supplies</u>
Digital Camera with basic movie capabilities, Computer
Video Editing Software

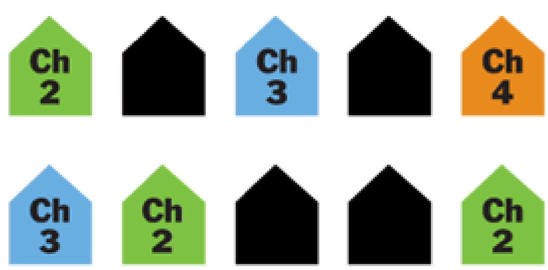
<u>Background Information</u>

Video Cameras - The camera component's function is used to receive visual information and interpret it as an electronic video signal. The VCR component is exactly like the VCR connected to your television: It receives an electronic video signal and records it on video tape as magnetic patterns. The viewfinder, receives the video image as well, so you can see what you're shooting. Viewfinders are actually small, black-and-white or color televisions, but many modern camcorders also have larger full-color LCD screens. There are many formats for analog camcorders, and many extra features, but this is the basic design of most all of them. The main variable is what kind of storage tape they use. Digital camcorders have all these same elements, but have an added component that takes the analog information the camera gathers and translates it to bytes of data. Instead of storing the video signal as a continuous track of magnetic patterns, it records the picture and sound as 1s and 0s. Digital camcorders are so popular because you can copy 1s and 0s very easily without losing any of the information you've recorded. Analog information, on the other hand, "fades" with each copy -- the copying process doesn't reproduce the original signal exactly. Video information in digital form can also be loaded onto computers, where you can edit it, copy it, e-mail it, and manipulate it.

The Physics of Audio - Sound and music are parts of our everyday sensory experience. Sound is a compression wave which means it travels by bunching up and stretching the atoms it moves through. Sound waves have a frequency, which is the number of compression pulses that go past a fixed point in a given amount of time. The frequency of audible sound is measured in hertz, or cycles per second. Sound waves have a wavelength, which is the physical distance between compression pulses. The wavelength is inversely proportional to the frequency. Sound waves also have amplitude, which is the amount of air that gets moved with each pulse of pressure. In general, you perceive the frequency of the wave as a particular pitch. You perceive the amplitude of the wave as loudness. Length, thickness, tension, and density of the string material all affect the pitch of a given string. Longer, thicker, denser, and looser strings all vibrate more slowly than shorter, thinner, less dense, and tighter strings. Slower vibration means lower pitch; faster vibration means higher pitch. The different pitches on most stringed instruments are obtained either by having many strings of different lengths, as on a harp, or by changing the vibrating length of strings by stopping them at different points, as on a violin or guitar. When dealing with wind instruments, a longer instrument will produce a lower pitch which is why a tuba makes a lower sound than a flute.

Television Ratings - In the U.S., the term "TV ratings" immediately makes people think of "Nielsen" because Nielsen Media Research has become the national measurement service for the television industry in the United States. Nielsen measures the number of people watching television shows and makes its data available to the television and cable networks, advertisers and the media. Nielsen uses a technique called statistical sampling to rate the shows - the same technique that pollsters use to predict the outcome of elections. Nielsen creates a "sample audience" and then counts how many in that audience view each program. Nielsen then uses the sample to estimate the number of viewers in the entire population watching the show. Nielsen relies mainly on information collected from TV set meters that it installs, and then combines this information with huge databases of the programs that appear on each TV station and cable channel.

How to Calculate Ratings: Rating (RTG or AA%) - The estimate of the size of a television audience relative to the total universe, expressed as a percentage. The estimated percent of all TV households or persons tuned to a specific station. In the example below, three of the 10 homes in the universe are tuned to channel 2. That translates to a 30 rating.



1) HUT $\frac{6}{10}$ $\frac{\text{Households Using TV}}{\text{Total TV households}}$ = **60**

2) Rating $\frac{3}{10}$ $\frac{\text{Channel 2 households}}{\text{Total TV households}}$ = **30**

3) Share $\frac{3}{6}$ $\frac{\text{Channel 2 households}}{\text{Households Using TV}}$ = **50**

or Rating=Share x HUT

Share (SHR) - The percent of the Households Using Television (HUT) or Persons Using Television (PUT) which are tuned to a specific program or station at a specified time. Using the example above, Channel 2 is being viewed in three of the six homes using television. That means it has a 50 share of audience.

Gross Rating Points (GRPs) or Target Rating Points (TRPs) - The sum of all rating points achieved for a particular period of time and/or schedule of commercials or spots (called Gross Impressions when expressed as the sum of all exposures to a given time period or spot schedule). The chart at the bottom of the page illustrates reach and frequency. Each home shows which days the set was in use during the time a commercial or spot aired. Since each home comprises 10% of the universe of 10 homes, each represents a 10 rating every time the spot airs. By adding these ratings we arrive at the total of 150 Gross Rating Points.

Reach (Cume) - The number of different or unduplicated households or persons that are exposed to a television program or commercial at least once during the average week for a reported time period. During the course of the schedule illustrated below, seven different households were exposed to the commercial at least once. Since each home represents 10 % of the universe, this makes the reach or cume 70%.

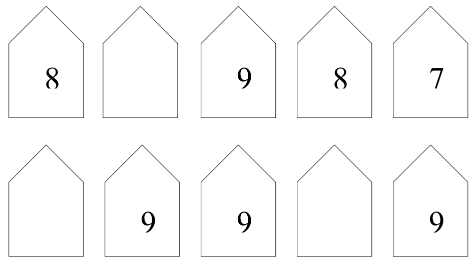
Frequency - Average number of times a household or a person viewed a given television program, station or commercial during a specific time period. In our example, the Gross Rating Points achieved (150) is divided by the percent of homes reach (70) to determine the frequency of 2.1.

4) GRPs	Monday = 20 Rtg Tuesday = 30 Rtg Wednesday = 40 Rtg		Thursday = 30 Rtg Friday = 30 Rtg Total = 150 GRPs	
5) Reach	$\frac{7}{10}$	$\frac{\text{Channel 2 households}}{\text{Total TV households}}$	= **70**	
6) Frequency	$\frac{150}{70}$	$\frac{\text{GRPs}}{\text{Reach}}$	= **2.1**	

or GRPs=Reach x Frequency

Now that you know how ratings work, you can see how the top shows are rated by visiting: http://www.nielsenmedia.com/ratings/broadcast_programs.html

Practice Problems



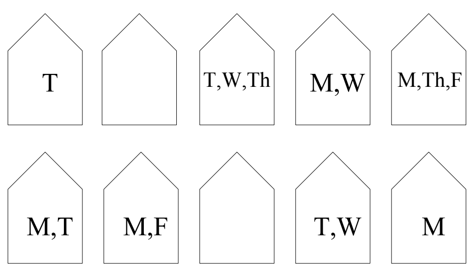
Sample Channels a Neighborhood is Watching on Monday Night

Calculate the following using the diagram above:

1. HUT =

2. Rating of:
   a. Channel 7 =
   b. Channel 8 =
   c. Channel 9 =

3. Share of:
   a. Channel 7 =
   b. Channel 8 =
   c. Channel 9 =



Nights that the Sample Neighborhood Watches Channel 9

Calculate the following using the diagram above:

4. GRPs:

   a. Monday =
   b. Tuesday =
   c. Wednesday =
   d. Thursday =
   e. Friday =

5. Reach =

6. Frequency =

Review Questions

1. What is the purpose of the component function of a video camera?

2. How does the VCR component work?

3. What component of a video camera is actually a small television?

4. How does a digital video camera work?

5. What are the advantages of digital camcorders over analog camcorders?

6. What kind of wave is a sound wave?

7. What does frequency of a wave mean?

8. What units are used to express frequency?

9. What is the amplitude of a wave?

10. Does a longer or shorter instrument produce a lower pitch?

Design Brief

We see advertisements in every aspect of our lives. You are to create a one minute long advertisement for a product of your choosing using video editing software. You must have at least five digital pictures, two video clips, and music incorporated into the ad.

Begin by creating a basic storyboard using paper and pencil. Decide what your topic is going to be, what you are going to take pictures and video of, and what music best represents the product you are advertising.

Use a digital camera and take ten pictures of the product you are trying to advertise. (You want to be able to choose the best).

Use a camcorder to film a couple video segments that could potentially be used in your ad.

Select appropriate music. The music must be clean and appropriate for school; get your teacher's approval.

Use video editing software to combine your pictures, video, and music. Drag the clips around the timeline so that they are in the correct order. Add transitions between your clips and text explaining what you are advertising and how someone can purchase it. Make sure everything adds up to be sixty seconds (within one second above or below). Once you have everything set the way you want it, export your movie so that it can be viewed on any computer.

Connecting Mathematics and Science to Technology Education

System: Informational
ITEA Standard: 1-3, 8, 17
GPS: 1-19, 43-47, 61-66

Name: ______________________________

Creating a Simple Crystal Radio

In this activity, students will learn how radios work. Then they will construct a simple crystal radio using instructor supplied materials.

Math Connections	Science Connections	Technology Connections
Time measurement	Radio waves	Construction technology
Distance	Sine waves	Design processes
Speed	Frequency	Communication technology
Units		Problem solving

Tools, Materials and Supplies

1 sturdy plastic bottle
50 feet of enamel coated magnet wire
1 Germanium diode
1 telephone handset
1 set of alligator jumpers
Approximately 50 to 100 feet of stranded insulated wire

Background Information

"Radio waves" transmit music, conversations, pictures and data invisibly through the air, often over millions of miles -- it happens every day in thousands of different ways! Even though radio waves are invisible and completely undetectable to humans, they have totally changed society. Whether we are talking about a cell phone, a baby monitor, a cordless phone or any one of the thousands of other wireless technologies, all of them use radio waves to communicate.
In the early days of radio, the transmitters were called spark coils, and they created a continuous stream of sparks at much higher voltages. The high voltage creates large sparks like you see in a spark plug, and they could transmit farther. Today, a transmitter like that is illegal because it spams the entire radio spectrum, but in the early days it worked fine and was very common because there were not many people using radio waves.

It is incredibly easy to transmit with static. All radios today, however, use continuous sine waves to transmit information. The reason that we use continuous sine waves today is because there are so many different people and devices that want to use radio waves at the same time. If you had some way to see them, you would find that there are literally thousands of different radio waves (in the form of sine waves) around you right now -- TV broadcasts, AM and FM radio broadcasts, police and fire radios, satellite TV transmissions, cell phone conversations, GPS signals, and so on. It is amazing how many uses there are for radio waves today. Each different radio signal uses a different sine wave frequency, and that is how they are all separated.

Any radio setup has two parts: the transmitter and the receiver. The transmitter takes some sort of message, encodes it onto a sine wave and transmits it with radio waves. The receiver receives the radio waves and decodes the message from the sine wave it receives.

Math Connections: FM Radio Station Frequencies

FM radio stations all transmit in a band between 88 megahertz (millions of cycles per second) and 108 megahertz. This band of frequencies is completely arbitrary and is based mostly on history and whim. Inside that band, each station occupies a 200-kilohertz slice, and all of the slices start on odd number boundaries. So there can be a station at 88.1 megahertz, 88.3 megahertz, 88.5 megahertz, and so on. The 200-kilohertz spacing, and the fact that they all end on odd boundaries, is again completely arbitrary and was decided by the FCC. In Europe, the FM stations are spaced 100 kilohertz apart instead of 200 kilohertz apart, and they can end on even or odd numbers.

Design Brief

You are to construct a basic crystal radio using the materials provided. To help you, a brief suggestion and description of what has been used has been included with the list of component parts that follow. You are also to complete the science assignment to turn in with your project.

Materials

- A sturdy plastic bottle. I have used the plastic bottle that hydrogen peroxide comes in, or the bottles that used to contain contact lens cleaner. They are about three inches in diameter, and 5 to 7 inches long. Shampoo bottles also work, but you will want to get the ones with thick walls, rather than the thin flimsy ones. This will make it easier to wind wire around them.

- About 50 feet of enamel coated magnet wire. Most common gauges (wire diameters) will work, but thicker wire is easier to work with, something like 22 gauge to 18 gauge. This can be bought at Radio Shack (part number 278-1345), or you can take apart an old transformer or electric motor that is no longer needed. You can also use vinyl coated wire such as Radio Shack part number 278-1217, which in some ways is easier to use than enamel coated wire (it is easier to remove the insulation).

- A Germanium diode. Most stores that sell electronic parts have these. They are called 1N34A diodes (Radio Shack part number 276-1123). These are better for our radio than the more common silicon diodes, which can be used but will not produce the volume that Germanium diodes will. We also carry it in our catalog.

- A telephone handset. You listen to this radio just like you listen to the phone. If you have an old telephone sitting around, or can find one at a garage sale, you are set. Or you can buy the handset cord (Radio Shack part number 279-316) and borrow the handset from your home phone (using it for the radio will not harm it).

- A set of alligator jumpers. Radio Shack part number 278-1156, or you can find them anywhere electronics parts are sold.

- About 50 to 100 feet of stranded insulated wire for an antenna. This is actually optional, since you can use a TV antenna or FM radio antenna by connecting our radio to one of the lead-in wires. But it's fun to throw your own wire up over a tree or on top of a house, and it makes the radio a little more portable.\

Instructions

Step 1
Use a sharp object like a nail or an ice pick to poke four holes in the side of the bottle. Two holes should be about a half an inch apart near the top of the bottle, and will be matched at the bottom of the bottle with two more just like them. These holes will hold the wire in place.

Step 2
Thread the wire through the two holes at the top of the bottle, and pull about 8 inches of wire through the holes. If the holes are large and the wire is loose, it is OK to loop the wire through the holes again, making a little loop of wire that holds snuggly.

Step 3
Now take the long end of the wire and start winding it neatly around the bottle. When you have wound five windings on the bottle, stop and make a little loop of wire that stands out from the bottle. Wrapping the wire around a nail or a pencil makes this easy. Continue winding another five turns, and another little loop. Keep doing this until the bottle is completely wrapped in wire, and you have reached the second set of holes at the bottom of the bottle.

Step 4
Cut the wire so that at least 8 inches remain, and thread this remaining wire through the two holes like we did at the top of the bottle.

Step 5
Remove the insulation from the tips of the wire, and from the small loops we made every 5 turns (these loops are called 'taps'). If you are using enameled wire, you can use sandpaper to remove the insulation. You can also use a strong paint remover on a small cloth, although this can be messy and smelly. Don't remove the insulation from the bulk of the coil, just from the wire ends and the small loops. If you are using vinyl coated wire, the insulation comes off easily with a sharp knife.

Step 6

Attach the Germanium diode to the wire at the bottom of the bottle. It is best to solder this connection, although you can also just twist the wires together and tape them, or you can use alligator jumpers (Radio Shack part number 278-1156) if you are really in a hurry.

Step 7

Cut one end off of the handset cord to remove one of the modular telephone connectors. There will be four wires inside. If you are lucky, they will be color coded, and we will use the yellow and black wires. If you are ***not*** lucky, the wires will be all one color, or one will be red and the others will be white. To find the right wires, first strip off the insulation from the last half inch of each wire. Then take a battery such as a C, D, or AA cell, and touch the wires to the battery terminals (one wire to plus and another to minus) until you hear a clicking sound in the handset earphone. When you hear the click, the two wires touching the battery are the two that go to the earphone, and these are the ones we want.

The 'wires' in the handset cord are usually fragile copper foil wrapped around some plastic threads. This foil breaks easily, sometimes invisibly, while the plastic threads hold the parts together making it look like there is still a connection. I recommend carefully soldering the handset wires to some sturdier wire, then taping the connection so nothing pulls hard on the copper foil.

Step 8

Attach one handset wire to the free end of the Germanium diode. Solder it if you can. Attach the other wire to the wire from the top of the bottle. Soldering this connection is a good idea, but it is not necessary.

Step 9

Clip an alligator jumper to the antenna. Clip the other end to one of the taps on the coil.
Clip another alligator lead to the wire coming from the top of the bottle. This is our 'ground' wire, and should be connected to a cold water pipe or some other metal object or wire that has a good connection to the earth.

At this point, if all went well, you should be able to hear radio stations in the telephone handset. To select different stations, clip the alligator jumper to different taps on the coil. In some places, you will hear two or more stations at once. The longer the antenna is, the louder the signal will be. Also, the higher you can get the antenna the better.

Step 10

Now that your radio works, you can make it look better and make it sturdy by mounting it on a board or in a wooden box. Machine screws can be stuck into holes drilled in the wood to act at places to attach the wires instead of soldering them.

Assignment for Science Connection

Create a single page poster explaining the science of radio waves. Be sure to include the following terms: frequency, pitch, wavelength, and amplitude. Your poster should also include pictures and/or diagrams that help to illustrate the concepts.

Connecting Mathematics and Science to Technology Education

System: Informational
ITEA Standard: 1, 3, 7, 9, 10, 11,
GPS: 2, 3, 7, 8, 35, 36, 37,

Name: ______________________________

Construct a Periscope Device

In this activity, students will learn about innovation and invention. Students will also learn about the Law of Reflection and demonstrate their understanding by developing a periscope to assist them in looking over a wall that they could not otherwise see over without climbing or using a ladder.

Math Connections	Science Connections	Technology Connections
Measurement	Law of Reflection	Construction
Angles	Angle of reflection	Design Processes
Distance	Angle of incidence	

Invention and Innovation

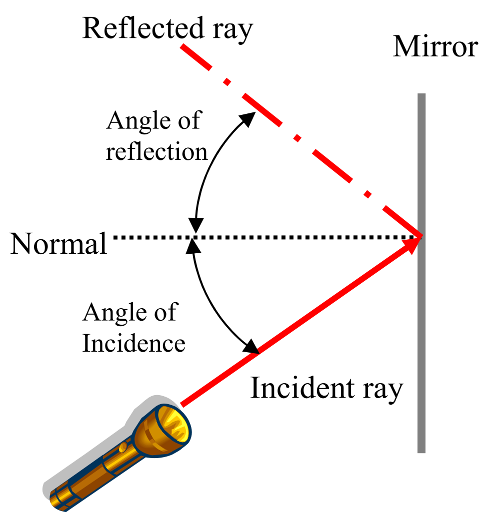
Humans have created new artifacts and structures throughout their history. Many of the artifacts were created out of necessity the others out of want to make life easier. The process they used is often called "invention and innovation." Invention is the process of creating a new and unique idea, product, or process. Innovation is the process of adding value to an existing product by changing one or more of its features.

The act of invention is a mental process that combines human creativity and imagination with discovery and formal research. The inventive process starts with recognition of a need, want, or desire. That is why it is often said that, "necessity is the mother of invention," because the best inventions solve routine problems and needs. Our need to communicate motivated people to create the alphabet and invent writing instruments, the telegraph, radio, television and communication satellites. There are a number of reasons that people invent things: some people are personally challenged; others are socially challenged to invent for societal benefits; and others are motivated to invent or innovate for profit. The economic incentive is a strong force in modern invention as devising a useful and popular item can be financially rewarding to the inventor.

Today, most inventive work occurs under the guided environment of a research institution. From corporate facilities to university laboratories, invention is a direct result of structured investigations. Few modern inventions are "accidentally" discovered by a single person.

The Law of Reflection

When a light ray strikes a surface and is reflected, the reflected ray obeys the law of reflection. Imagine a line drawn perpendicular to the surface where the light ray strikes. This line is called the normal to the surface. The incoming ray and the normal form an angle called the angle of incidence. The reflected light ray forms an angle with the normal called the angle of reflection. According to the law of reflection, the angle of incidence is equal to the angle of reflection. This is true for any surface, no matter what the material.



Angle of incidence is always equal to the angle of reflection.

Law of Reflection Experiment

A light ray strikes the surface of a plane mirror and is reflected. Conduct the following experiment to learn how a plane mirror reflects light and to understand the relationship between the direction of the incoming light ray and the direction of the reflected light ray.

Materials

1) Flashlight
2) Protractor
3) Metric ruler
4) Scissors
5) Tape
6) Small plane mirror, at least 10 cm. on a side
7) Black construction paper
8) Modeling clay
9) White unlined paper

Procedure

1. With the scissors, cut a slit in the construction paper and tape it over the flashlight lens.

2. Place the mirror at one end of the unlined paper. Push the mirror into the lump of clay so it stands vertically, and tilt the mirror so it leans slightly toward the table.

3. Measure with a ruler to find the center of the bottom edge of the mirror and mark it. Then use the protractor and the ruler to draw a line on the paper perpendicular to the mirror from the mark. Label this line P.

4. Using the protractor and the ruler, draw lines on the paper outward from the mark at angles of 30°, 45°, and 60° to line P.

5. Turn on the flashlight and place it so the beam is along the 60° line. This is the angle of incidence. Locate the reflected beam on the paper, and measure the angle this angle in your data table. This is the angle of reflection. If you cannot see the reflected beam, slightly increase the tilt of the mirror.

6. Repeat step 5 for the 30°, 45°, and P lines.

Questions

1. What happened to the beam of light when it was shined along line P?

____

2. What can you infer about the relationship between the angle of incidence and the angle of reflection?

____

3. How can you use this new discovery to help you in constructing your periscope?

____

Estimating the Distance of Sight

If you have ever watched a submarine movie, you've probably seen the captain of the submarine look through a periscope. Have you ever wondered how far the captain could see?

Under ideal conditions, the equation that approximates the distance that one can see is $d = 1.5\sqrt{h}$, *d = distance, h = height in feet of the observer above the surface.* Viewing conditions on Earth are typically less than ideal.

Problems

1. A submarine captain is looking through a periscope that is 1 foot above the water. How far is the captain able to see? ____

2. An airplane is flying at an altitude of 5.5 miles. When looking out the window, how far would an observer be able to see? (5,280 feet = 1 mile) ________________________

3. The Sears Tower in Chicago is 1,464 feet tall. If the observation deck is located at a height of 1,350 feet above ground, how far would a person on the observation deck be able to see? ____

4. A sailor is standing in the crow's nest of a sailing ship 120 feet above the surface of the water. (The crow's nest is an observation area located high above a ship's mast.) What is the sight distance of the sailor?___________________________

5. While using a periscope, a submarine captain sights a rowboat that is floating at a distance of 1.84 miles from the ship. How far is the periscope above water? ___________________

6. When looking out the window of an airplane an observer is able to see a distance of 150 miles. At what height is the airplane flying?

7. Using your new periscope and your maximum range distance, determine the height of you and your periscope. ___________________

Construct a Periscope Device

Design Brief

You are to develop a device that will allow you to look over an open wall that is too high for you to see over without climbing or using a ladder. The device needs to be a highly portable device that extends your vision up and over the wall. Think in terms of how a submarine uses a periscope to help you design your device. You are to record adequate notes about your design and the construction process so that your design can be reproduced.

Materials

Masking or clear tape
Glue
Paper clips
Poster board
2 Small mirrors

Problem-solving

1. Clearly define the problem.
2. Gather information by researching periscopes and major inventors/inventions using any available research tool.
3. Design and construct two to three different models of periscopes making notes of your construction steps.
4. Present your designs and models for review.
5. Choose the best design and model, revising if necessary.
6. Use and evaluate the device.
7. Suggest ways for improving the device.

Instruction Manual Assignment

Develop an instruction manual on how to operate and use your device. Be sure to include its capabilities and any limitations by:

- Measuring how far away you can clearly see a fellow student on a clear day.
- Measuring the angle that you placed each mirror and determine how each mirror placement helped to focus your periscope.

Connecting Mathematics and Science to Technology Education

System: Informational
ITEA Standard: 1-3, 15
GPS: 1-14, 117

Name: ______________________________

Hurricanes: Wind Speed and Air Pressure

In this activity, students will be introduced to some basic concepts on hurricanes. Students will then build two simple weather technologies to determine wind speed and barometric pressure which will help them gain a better understanding of this powerful force of nature.

Math Connections	Science Connections	Technology Connections
Angles	Weather	Weather technology
Unit Conversion		Communication
Data collection/charts		Construction

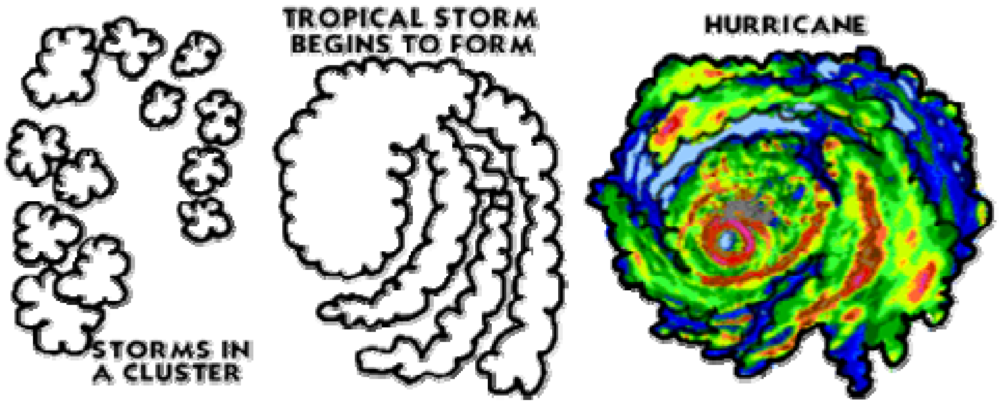
Hurricanes

A hurricane is a severe storm of tropical origin, in which the winds have reached or surpassed 74 miles per hour. At this point, the hurricane is given a name, for example Hurricane Camille *(1968)*, Andrew *(1992)*. A hurricane is a powerful storm that measures several hundred miles in diameter. Hurricanes have two main parts. The first is the eye of the hurricane, which is a calm area in the center of the storm. Usually, the eye of a hurricane measures about 20 miles in diameter, and has very few clouds. The second part is the wall of clouds that surrounds the calm eye. This is where the hurricane's strongest winds and heaviest rain occur.

Hurricanes are born over warm, tropical oceans. Hurricanes are fueled by water vapor that is pushed up from the warm ocean surface, so they can last longer and sometimes move much further over water than over land. The combination of heat and moisture, along with the right wind conditions, can create a new hurricane.

Radar Imaging

The colors in hurricane radar images indicate the amount of rain falling in a given area as you can see in the picture below. Each raindrop reflects the energy from the radar. Therefore, the more raindrops in a certain area, the brighter the color in the radar image of that area. Simply, the radar image is really measuring the amount of moisture in the air. The brighter the color on the radar image, the greater amount of moisture is in the air. The bright red color around the eye indicates the area of heaviest rainfall. The green colored area has a moderate amount of rain, while the blue areas represent the least amount of rain.



Storm Classifications

Tropical Cyclone Classification	
Tropical Depression	20-34 kts
Tropical Storm	35-64 kts
Hurricane	65+kts or 74+mph

Saffir-Simpson Scale

Saffir-Simpson Scale for Hurricane Classification				
Strength	**Wind Speed** *(Kts)*	**Wind Speed** *(MPH)*	**Pressure** *(Millibars)*	**Pressure**
Category 1	65- 82 kts	74- 95 mph	>980 mb	28.94 "Hg
Category 2	83- 95 kts	96-110 mph	965-979 mb	28.50-28.91 "Hg
Category 3	96-113 kts	111-130 mph	945-964 mb	27.91-28.47 "Hg
Category 4	114-135 kts	131-155 mph	920-944 mb	27.17-27.88 "Hg
Category 5	>135 kts	>155 mph	919 mb	27.16 "Hg

Weather Planes

It is almost impossible to determine the intensity of a storm based on satellite photos alone. In order to get that information, some planes are designed to fly right into the eye of the storm. These planes measure temperature, moisture, air pressure, wind speed, and wind direction. When these "hurricane hunters" think the storm may reach land within 24 hours, they issue a hurricane warning. If a warning is issued, people who live near the sea are warned to evacuate.

Hurricanes Names

All hurricanes are given names. Names help us identify storms and track them as they move across the ocean. More than one hurricane can occur at a given time and names help distinguish which hurricane is being referenced.

For hundreds of year, hurricanes in the West Indies were named after a particular Saint's day on which the hurricane occurred. An Australian meteorologist began giving women's names to tropical storms before the end of the 19th century. In 1953, the U.S. National Weather Service, which is the federal agency that tracks hurricanes and issues warnings and watches, began using female names for storms. In 1979, both women and men's names were used. One name for each letter of the alphabet is selected, except for Q, U and Z. For Atlantic Ocean hurricanes, the names may be French, Spanish or English, since these are the major languages bordering the Atlantic Ocean where the storms occur.

Who decides what names are used each year? The World Meteorological Organization uses six lists in rotation. The same lists are reused every six years. The only time a new name is added is when a hurricane is very deadly or costly. Then the name is retired and a new name is chosen.

Hurricane Names for Atlantic Storms (2002 - 2007)

2002	2003	2004	2005	2006	2007
Arthur	Ana	Alex	Arlene	Alberto	Andrea
Bertha	Bill	Bonnie	Bret	Beryl	Barry
Cristobal	Claudette	Charley	Cindy	Chris	Chantal
Dolly	Danny	Danielle	Dennis	Debby	Dean
Edouard	Erika	Earl	Emily	Ernesto	Erin
Fay	Fabian	Frances	Franklin	Florence	Felix
Gustav	Grace	Gaston	Gert	Gordon	Gabrielle
Hanna	Henri	Hermine	Harvey	Helene	Humberto
Isidore	Isabel	Ivan	Irene	Isaac	Ingrid
Josephine	Juan	Jeanne	Jose	Joyce	Jerry
Kyle	Kate	Karl	Katrina	Kirk	Karen
Lili	Larry	Lisa	Lee	Leslie	Lorenzo
Marco	Mindy	Matthew	Maria	Michael	Melissa
Nana	Nicholas	Nicole	Nate	Nadine	Noel
Omar	Odette	Otto	Ophelia	Oscar	Olga
Paloma	Peter	Paula	Philippe	Patty	Pablo
Rene	Rose	Richard	Rita	Rafael	Rebekah
Sally	Sam	Shary	Stan	Sandy	Sebastien
Teddy	Teresa	Tomas	Tammy	Tony	Tanya
Vicky	Victor	Virginie	Vince	Valerie	Van
Wilfred	Wanda	Walter	Wilma	William	Wendy

Build a Wind Meter Box

Design Brief

You are to build a simple device called a wind box to measure the speed of developing strong winds. Hurricanes are noted for developing strong winds that can be measured.

Materials

1 shoe box
A piece of thin cardboard
A protractor
A fine point permanent-ink pen
1 roll of sticky tape
A knitting needle
A piece of plastic film

Procedure

Step 1: Using the protractor and the permanent –ink pen, mark the angles for a wind-speed scale at 5 degree intervals between zero and 90 degrees on the plastic film.

Step 2: Cut the ends off the shoe box and lid and stick them together [box and lid]. Cut a hole in one side of the box, near to one end and stick the scale inside so it is displayed through the hole.

Step 3: Push the knitting needle through a small hole that is made by the needle and located to the right top of the box and to the right of the film scale. Wiggle the needle about until it rotates freely. Cut out a cardboard flap, slightly smaller than the end of the box and stick it to the needle on the inside of the box.

Step 4: Hold the box so the flap faces into the wind. Look at the angle of the flap and work out the wind speed from the chart below.

Angle [degrees]	Km/h		Angle [degrees]	Km/h
90	0		50	28 – 30
85	8 – 11		45	31 – 33
80	12 – 14		40	34 – 36
75	15 – 17		35	37 – 39
70	18 – 20		30	40- 43
65	21 – 23		25	44 – 48
60	24 – 25		20	49 -54
55	26 - 27			

Note: To convert km/h to mph, multiply by 0.621.

Build a Simple Barometric Device

Design Brief

Hurricanes are noted for developing strong amounts of air pressure.You are to build a simple device to measure the air pressure which is measured in millibars.

Materials

A large narrow plastic bottle
Two rubber bands
A small piece of cardboard
A wood measuring scale in millibars
A small plastic bowl
A container of some water

Procedure

Step 1: Cut a 2.5 cm[1”] strip of thin cardboard and draw a scale along one edge. Attach the cardboard to the bottle using the rubber bands.

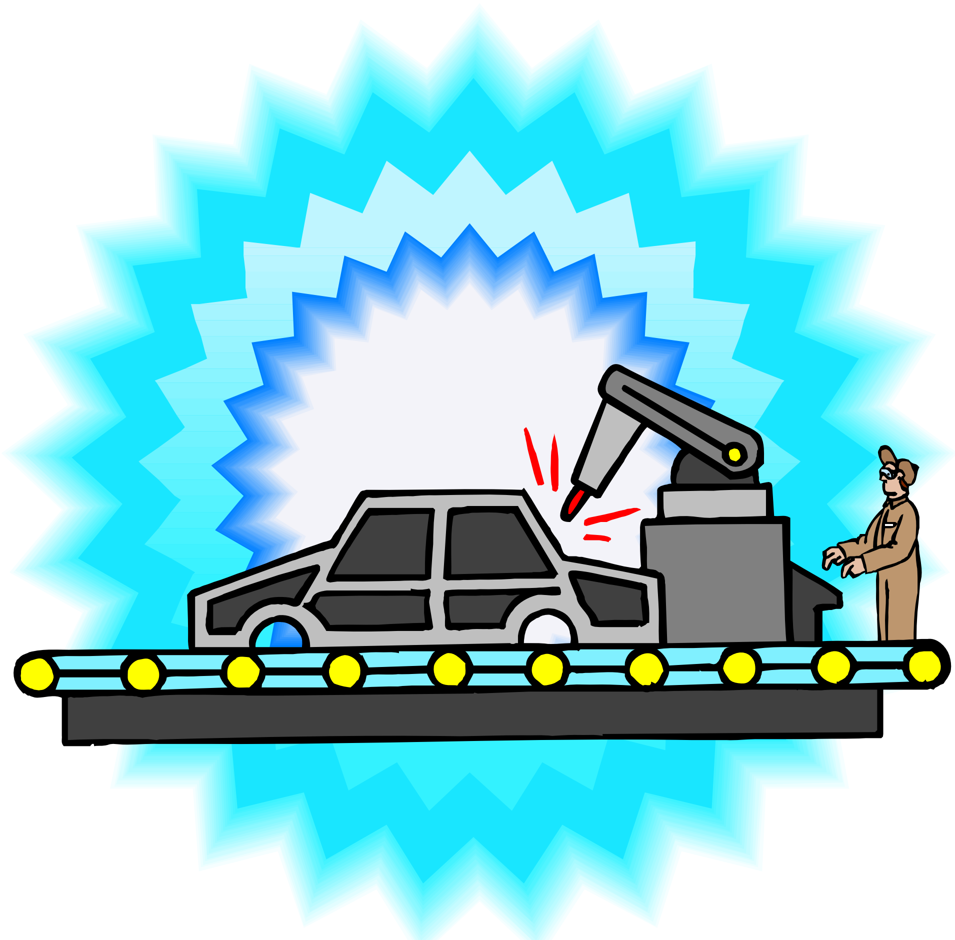
Step 2: Fill the bottle with some water so it is three-quarters full. Also fill the bowl nearly to the top with water.

Step 3: Place your hand over the top of the bottle and turn it upside down. Put your hand into the bowl so that the neck of the bottle is under the water. Remove your hand from the bottle and stand it in the bowl.

Step 4: The water level in the bottle will rise and fall with the air pressure as more or less air pushes down on the water in the bowl.

Step 5: Mark the water level on the day you make the barometer in millibars and then mark it again on different days of the week. Record your readings in chart form.

PHYSICAL



Introduction

The basic building block of technology education is the system. A system is a group of interrelated components designed to collectively achieve a desired goal or goals. Systems can and do exist on many levels. The technologically literate person uses a strong systems-oriented thinking approach as they go about solving technological problems.

Technology is human innovation in action. It involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. The systems that are developed can easily be categorized as biological systems, informational systems and physical systems.

The final system addressed in this document is **Physical System**. In this system, the developmental processes include those activities that are used to carry out the plans, create solutions, or to test ideas that are generated through a design process. The development of physical systems likewise involves many of the common manufacturing, production, transportation and construction processes. Specifically, the physical systems are those that are tangible and made of physical resources. Students study this system as a means of understanding how changing the form of materials can increase their value in society. This system is addressed through some of the ITEA Standards of 3,8,9,11,16,18,19 and 20. The following technology education activities with their associated mathematical and science connections are a sampling of the units that can be studied by the student to assist them in understanding the behavior of the system. Once the behavior of a system is understood, the technologically literate person is able to assess the complete system to judge what necessary control adjustments are needed as variables change or inputs become known.

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA: 3, 8-11, 19
GPS: 2, 7, 12-13, 17, 35-37, 67, 72-73

Name:_______________________________

Engineering CO2 Cars

In this activity, students will design and build a CO_2 vehicle. As they do this, they will also study the science of motion and how motion effects a vehicle's aerodynamics and vice-versa.

Math Connections	Science Connections	Technology Connections
Measuring Distance	Chemistry	Problem Solving
Compute Average Speed	Newton's Third Law	Drafting
Mass	Friction	Tools, materials, &
processes	Aerodynamics	Engineering Design

Introduction

The first thing students want to know when they start to design their CO2 cars is "how do I design my car to go fast?' or "which design is faster?" Are shorter cars better? Longer cars? There are really no clear-cut answers to what is best. Short cars and long cars win races. Heavier cars and lighter cars win races. The short answer? The best design is the one that wins races. Usually, this best design is a compromise between various engineering principles. Really good designs built poorly can lose to so-so designs built well. However, while there is no "one best" design, there are indicators of a good design:

1) clean aerodynamics
2) a high level of craftsmanship

The best way to make a fast CO2 car is learn how they work; what engineering principals are involved, and the parameters of the design envelope that the car must meet.

While CO2 cars are referred to as dragsters, they are really more similar to rocket powered cars. Dragsters have motors that drive a transmission that imparts rotational force to the tires. Therefore they need sticky tires and spoilers that force the car into the ground to give it more traction. Rocket powered cars use thrust, much like a jet airplane to give them forward motion. They do not need sticky tires, and spoilers and air intakes just hang out in the air stream and slow them down. While spoilers are cool looking they do nothing to make a car faster. CO2 cars use Newton's third law: **"for every action, there is an equal and opposite reaction."**

The CO_2 canisters used to propel the cars have compressed carbon dioxide gas stored inside them. When the end of the canister is pierced by the starting pin, the gas is released. Gas is released forcefully in one direction, and the car is pushed in the opposite direction.

Engineering is always a tradeoff between desirable traits. When trying to fix one problem, often other problems are created. So the solution has to be a compromise between problems. Often none of the problems is solved completely; the solution is to find a balance between the problems.

Engineering Principles

Engineering Compromise #1 – Mass: A lighter car has less mass, and therefore will go faster, all other factors being equal. That's true, but other factors are rarely equal. These cars will have to be raced multiple times. A lightly built car will likely break or be destroyed after racing just a few times. The forces put on the cars as they race, sudden acceleration, cars hitting each other, and coming to a sudden stop tend to make lightly built cars break. And while a bent axle can be replaced, a car that is in splinters cannot be glued back together in anything close to its original condition. So light is good, but only until a point.

> <u>Engineering Tradeoff</u>
> Advantages:
> Cars with less mass go much faster.
> Disadvantages:
> Cars with less mass are less durable.

Engineering Compromise # 2 – Drag: Drag occurs when a fluid (air, water) flows past a solid object (a car) and slows it down through surface friction. How do you overcome drag? Think of jet fighters or rockets; you want to make the cars as aerodynamically clean as possible. Minimize the car area that faces into the wind. Hide the wheels if possible. The down side is that it takes a lot of skill and time to make a perfectly smooth surface or create wind screens for the wheels.

> <u>Engineering Tradeoff</u>
> Advantages:
> Aerodynamic cars create less drag so they go faster.
> Disadvantages:
> Aerodynamically clean cars require more skill and time to build.

Engineering Principle #3 – Friction: Friction cannot be eliminated, but it can be reduced. The primary areas of friction in CO_2 powered cars are between the wheels and the ground, between the axles and the car body, and between the eyehooks and the fish line track. First, make sure the tires are free from any defects by carefully sanding or cutting them away. Make sure they are not rubbing on the car body! Use washers between the wheels and the car body. Add a dry lubricant such as powdered graphite in the axle holes. Use a straw as a wheel bearing so that the axle does not rub against the rough wood. Sand away any imperfections on the axles. Make sure that the eyehooks are aligned properly. Poorly aligned eyehooks cause the line to build up friction.

Engineering Tradeoff
Advantages: A friction filled requires less skill and care to build and is slow.
Disadvantages: Reducing friction takes a lot of extra effort, time and patience, but results in a faster car

Engineering Principle #4 -The Design Envelope: When engineers design cars or airplanes or anything else there are limits on the design. Limits include the manufacturing technology, labor skill, materials, or cost. They also include maximum and minimum dimensions for the object. It takes a certain amount to space to put an engine or a transmission in a car. The Mars Rover had to fit into a set of dimensions for the trip to Mars. NASCAR has a set of specifications that cars must meet or they will be disqualified. CO2 cars also have a set of minimum and maximum dimensions, called a Design Envelope. Having a set of specifications simulates what real engineers have to work with in the design process, forcing the students to work within a framework.

The Design Envelope levels the playing field so that all competitors know what is expected in the way of dimensions. It also helps to keep the cars safe. Some students design their cars so that they just meet the minimum requirements, minimizing their weight. Others make their cars longer and as wide as possible so it tracks straight down the track and maximizes stability. Both approaches are valid. But all cars must meet the design envelope, or they will be disqualified from racing.

Engineering Tradeoff
Advantages:
Cars that follow a design envelope compete fairly and safely.
Disadvantages:
Cars that do not meet the design envelope may go faster, but will be disqualified from competing.

Building CO2 Cars

While there are many ways for students to build a CO2 car, it is good to have a basic outline for the main steps followed. Variables in the building process range from what kind of tools are available in the shop, the skill level of the students, and how much time is available for the project.

Design Phase

Students typically want to just take a block of wood, and a vague sense of what they are doing, and head into the shop "design on the fly." This seat pants approach is inadvisable if the students want a) build something they can be proud of b) stay within the design envelope c) not make mistakes that will necessitate starting over again. They need to follow an organized design approach were they first come up with as many ideas as possible, then refine a few of their ideas, and finally draw a detailed plan of the car they want to build.

A good strategy used to develop many ideas quickly is thumbnail sketches. Thumbnails are simply small (about the size of a thumbnail) sketches without too much detail. They don't need to be great works of art, but they need to convey a basic idea of a shape. Thumbnails are a brainstorming activity; the idea is to capture an idea on paper before you can forget it. Worry about the details later. Just think about what a fast car might look like and get it on paper, then move on to the next one. The best way to come up with a good idea is to have lots of ideas, then pick out the best. Use the thumbnail sheet for this activity. The students should complete 20 thumbnails each. Ideally they would draw a top and a side view for each idea (1 thumbnail). Send them back if they just come a few ideas with small variations. Use the grading scale to minimize subjectivity.

Once they have 20 quality ideas the students pick 3 of these ideas for development. These ideas should be sketch quality, but should be neat and have more detail. Use these sketches to refine ideas and to discuss the finer points of the design with classmates. They should fit into the dimensions of the wood block blank that the car will be cut from and conform to the design envelope. While it would be better if these drawings are made with instruments (straight edges and curves), it is not absolutely necessary.

The final stage of the Design Phase is the creation of the working drawing. The students pick one of the designs developed in the rough sketches and create a full size drawing. This is the drawing that will be used to cut the wood block. This drawing needs to have full details and drafting quality lines. The lines should be done with drafting instruments, including the curved surfaces, which can be drawn with templates or French curves. The students should show their drawings to their classmates to get their input. Some flaws that are not apparent to the designer might be obvious to another student. A final check should be done by the teacher, who will look for flaws and give the drawing a grade, then make a copy of the drawing for the student to put the car into production.

Build Phase

Once the students have completed the design phase they will be given a copy of their drawing and a wood blank. Keep the original working drawing for two reasons: 1) in case the student has to start over she can get another copy, 2) to compare with the finished project when grading. The first operation is to cut out the design and tape it to the wood blank. The most important thing is to make sure that the CO_2 hole on the blank lines on with the CO_2 holes on the drawings**.** Once the patterns are taped into place the rest of the build process can proceed.

Before any wood is cut the axle holes should be drilled. It is much easier to drill the holes first because the sides are flat and provide a better surface for drilling. Use a 1/8" drill or a 3/16" drill if using a straw as a bearing sleeve. If using a drill press, make sure the platform is square with the drill by using a square or drafting triangle. If the holes are crooked the car will be slow and it will not track straight. Use a punch or a nail to mark the place to be drilled. This helps the drill "find" the correct place. Make sure that the front and back holes are lined up. Having accurately drilled holes is most important to having a fast car. After getting the axle holes drilled the blank is ready for cutting.

Typically, the side view should be cut first. Using a band saw carefully cut out the side view. Use relief cuts on circular cuts, and to keep from having to back the saw out. If a band saw is not available a coping saw is a cost effective substitute. Try to cut slightly to the outside of the paper pattern especially in areas that are running close to the limits of the design envelope. This keeps the car from being sanded into an illegal shape later on. It is much better to cut big and sand down than to cut to limits and then sand beyond where is wanted.

Next, cut the top view. Make sure that the CO2 hole and the axle holes in the top view line up with the actual holes on the wood blank. If there are curves on the top view it will be necessary to cut the top pattern in places so that it can be "stretched out." Good locations for stretching include long straight places in the middle of the car, areas where the car narrows, and at the axle holes. It's a good idea to keep the area around the axle holes flat so that pressure points don't develop between the wheel and the car body. As in cutting the side view, be careful to cut outside the pattern to give room for sanding.

Once the car has been cut from the wood blank, it can be shaped. This process involves using a rasp or sandpaper to smooth and round the car to its finished shape. A good file can be made by gluing sandpaper to a flat stick of wood or plastic. Make sure that the right tools are available. Metal files should not be used for wood. Use wood putty to fill in holes or saw marks. As the shaping process is being finished, a light coat of primer can be used to identify surface imperfections not noticeable to the eye. Automotive glazing putty can be used to fill small holes and saw marks.

Finishing Phase

Painting the car starts off with a light coat of primer. It is better to use several light coats with a light sanding in between than 1 heavy coat. Heavy coats just waste the primer. Use brush on or spray primer and allow it to dry overnight, then use fine sandpaper to lightly sand surface imperfections out of the primer. Be careful not to sand the primer off. Primer will not fill in holes; that's what putty is for. However, the more putty used, the heavier the car will turn out, and the slower it will be in a race. Once the surface is smooth it is ready for paint.

Spray paint will allow for a smoother surface, although brush on paint will work if that's what is available. Again, several light coats work better than one heavy coat. Heavy coats take longer to dry, therefore more likely to collect dust, and are more prone to form drips (running) than light coats. Its easy to use too much paint when using spray cans. Keep the nozzle about 8"-12" from the car, use short strokes, and keep the can moving will avoid most painting mistakes. If you are using a multi-color paint scheme start with lightest color and add darker colors on top. Light colors (like white, yellow, light blues; etc.) have a hard time covering darker colors. Use the same type of paint for the different colors so that the paints are compatible with each other. Some paints will lift off other paints, and your car will be left with a nasty "crinkle-coat" finish. Make sure that the paint is completely dry before putting on the masking or the masking might lift off the paint from the previous coats. To prevent paint from seeping under tape the first coats must be smooth and light coats should be applied. A single heavy coat is more likely to seep under the masking, ruining the design. Allow the paint to dry completely (at least overnight) before putting any decals on and proceeding with assembly.

Assembly Phase

The axles will need to be custom cut to length for a particular car which is the width of the car at the axle hole plus 1" for the two wheels. When cutting the axle material it is easy to put on too much pressure and bend the axle. Let the saw do the work rather than forcing the saw through the metal. Use a file or a grinder to remove metal burrs from the ends and make the axle smooth. Be careful not to create any flat spots on the axle.

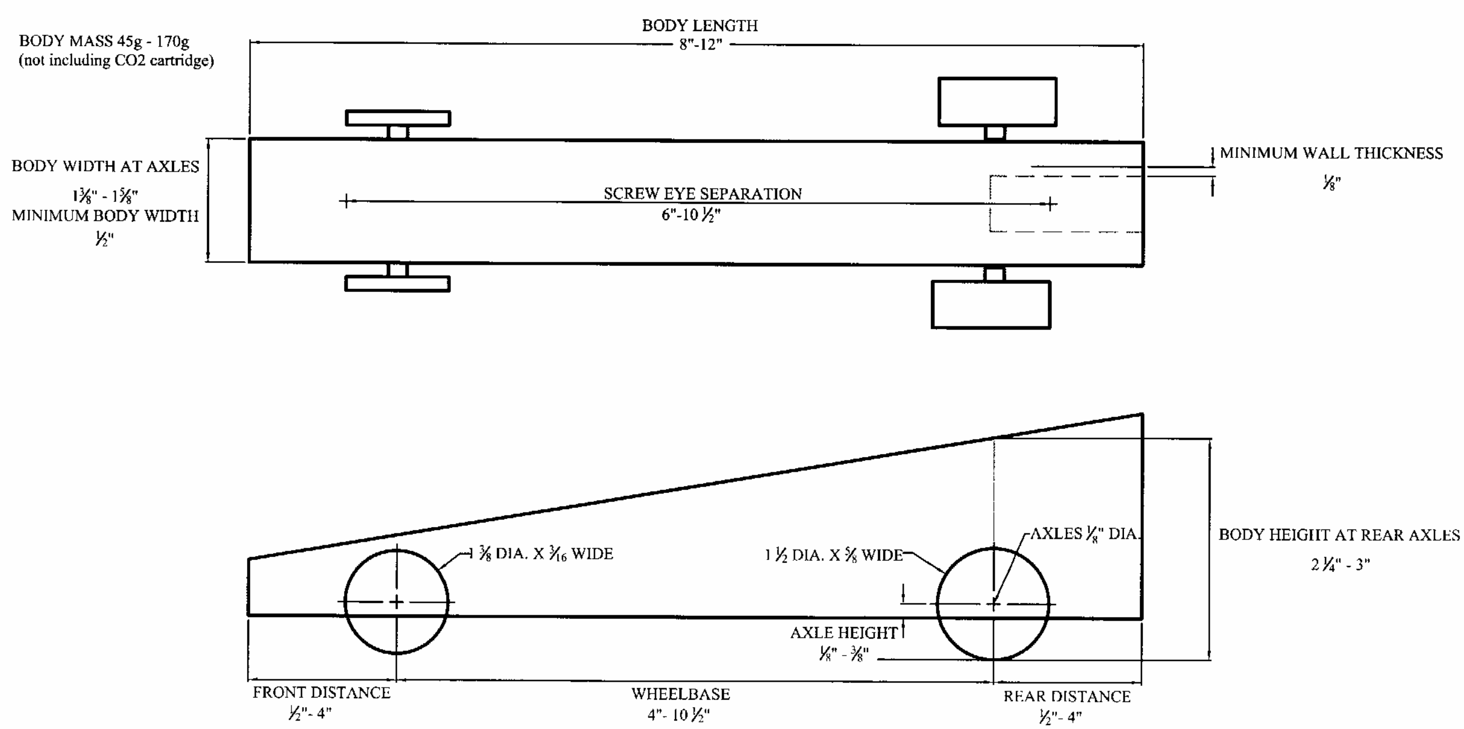
If you are using a straw for a bearing sleeve cut it to the exact width of the body at the axle hole. It should not stick out at all or it introduces friction and slows the car down. Use wood glue to glue the sleeve in place being careful not to get any glue inside the straw, and wipe off any excess glue on the outside of the holes. Another way to create bearing for the axles is to use a two 1/8" pieces of flexible tubing on either end of the axle. Leave out the straw sleeves if using this method.

The eye hooks should be opened slightly with a pair of pliers so that they will just barely snap onto the fish line race track. If it goes on too easily, slightly close the gap. Loose fitting eye hooks could contribute to a disastrous crash if the car leaves the track. Place the screw eyes as near but slightly offset from the axle holes. If the screw gets touches the axle it will obviously slow the car down. Also, make sure that the eye does not contact the ground. When installing the screw eyes into the car make sure they are in the absolute center of the car body, and lined up with each other so that they do not cause the fish line to rub against the eyes, and slow the car down.

Attach one wheel to the axle. It will be tight, but do not use a hammer, just put it on with finger pressure. Put pressure on the center of the hub, as opposed to the tire, so that the wheel spokes don't get bent. Next put on a washer (brass is best) to go between the wheel and car body. Put some dry powdered graphite in the axle hole to reduce friction, and slip in the axle/wheel assembly. Put another washer on the other side of the car and finally the second wheel. Put pressure on the hubs to snug up the wheels onto the axle, then slightly back off so that the wheels are not tight against the car body.

Testing Phase

This is the last phase before the car is ready for racing. Spin the wheels to see if they wobble. Push the car along a flat surface to see if it curves on way or the other. If they do bend them in the opposite direction until they spin as true and the car tracks as straight as possible. Inspect the screw eyes and make sure they line up with each other. Check the wheels looking for any defects and sand them off. The car is now ready to race. Good Luck!!



Name:	Desi Envelope	Date:	Grade:

Thumbnail Sketches **Name**________________________

CO2 Car Design **Date** _________**Period**__________

Thumbnails are small (about the size of a thumbnail) simple sketches without too much detail. They don't need to be great works of art, but they need to convey a basic idea of a shape. Thumbnails are a brainstorming activity; the idea is to capture an idea on paper before you can forget it. Worry about the details later. Just think about what a fast car might look like and get it on paper, then move on to the next one. The best way to come up with a good idea is to have lots of ideas, then pick out the best.

1.	2.	3.	4.
5.	6.	7.	8.
8.	10.	11.	12.

Grading Rubric:

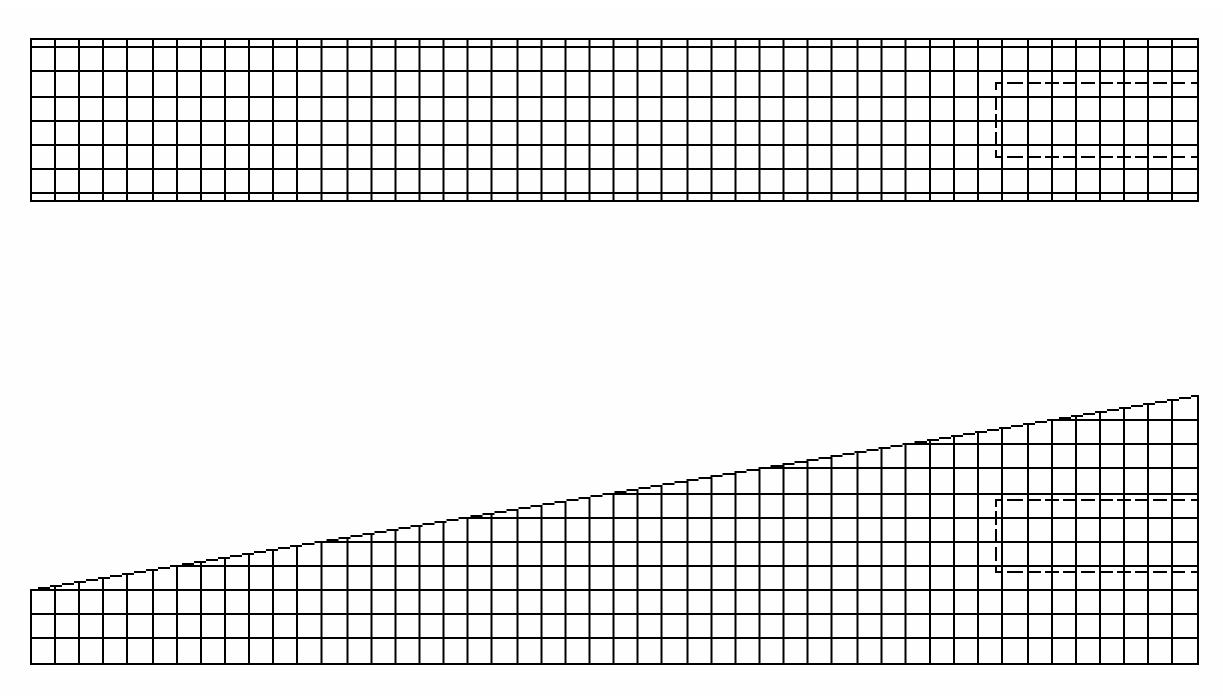
	Points		
__HIGH QUALITY IDEAS	2	1	__MANY POOR IDEAS
__CREATIVE/ORIGINAL	2	1	__MANY SIMILAR IDEAS
__20 GOOD IDEAS	2	1	__FEW GOOD IDEAS
__CONSISTENT EFFORT	2	1	__MORE EFFORT NEEDED
__SHOWS THOUGHT	2	1	__SHOWS LITTLE THOUGHT
__NEAT WORK	2	1	__SLOPPY WORK
__CLEAN PAPER	2	1	__MESSY PAPER
__DIRECTIONS FOLLOWED	2	0	__DID NOT FOLLOW DIRECTIONS
__TURNED IN ON TIME	2	0	__TURNED IN LATE
__NAME/DATE/PERIOD	2	0	__NO NAME/DATE/PERIOD

Total Points________

Rough Sketches Name________________________

CO2 Car Design Date _________Period__________

Pick 3 of ideas from the Thumbnails sheet for development. These rough sketches should be sketch quality, but should be neat and have more detail. Use them to refine ideas and to discuss the finer points your design with classmates. They should fit into the dimensions of the wood block blank that the car will be cut from and conform to the design envelope. You should finish by using drafting instruments to get distinct, high quality lines.



Grading Rubric:

	Points		
__HIGH QUALITY DRAWING	1	0	__LOW QUALITY DRAWING
__GOOD LINE QUALITY	1	0	__POOR LINE QUALITY
__VIEWS LINE UP	1	0	__VIEWS DON'T LINE UO
__CREATIVE/ORIGINAL	1	0	__MORE EFFORT NEEDED
__SHOWS THOUGHT	1	0	__SHOWS LITTLE THOUGHT
__NEAT WORK	1	0	__SLOPPY WORK
__CLEAN PAPER	1	0	__MESSY PAPER
__DIRECTIONS FOLLOWED	1	0	__DID NOT FOLLOW DIRECTIONS
__TURNED IN ON TIME	1	0	__TURNED IN LATE
__NAME/DATE/PERIOD	1	0	__NO NAME/DATE/PERIOD

Total Points________

CO2 Car **Name**____________________________

Grading Rubric **Date**________**Class**_______

Engineering

Overall Car (105 points total)

	No		Maybe					Yes
• The engineering principle of Mass has been considered: Total mass________g	3	4	5	6	7	10	13	15
• The engineering principle of Friction has been considered: (wheels, eyelets)	3	4	5	6	7	10	13	15
• The engineering principle of Drag has been considered: (aerodynamics)	3	4	5	6	7	10	13	15
• Axle is cut to proper length	3	4	5	6	7	8	9	10
• Axle holes are square with the body	3	4	5	6	7	8	9	10
• Design involves advanced ideas, construction, or detail:	3	4	5	6	7	8	9	10
• Design is thoughtful, not haphazard or block-like:	3	4	5	6	7	8	9	10
• Body is free of structurally weak areas:	3	4	5	6	7	8	9	10
• Body shape matches the original design drawing:	3	4	5	6	7	8	9	10

• Deduction for using extra car blanks (7 pts X # of bodies over 1) DEDUCTION = ______

Craftsmanship and Quality (70 points total)

	No		Maybe					Yes
• Preparation for painting was done properly:	3	4	5	6	7	8	9	10
• Overall finish is defect free:	3	4	5	6	7	8	9	10
• Special details (multi-color, decals, painting hubs) are included:	3	4	5	6	7	8	9	10
• Finished project maintains original design:	3	4	5	6	7	8	9	10
• Top view of car is symmetrical on both sides:	3	4	5	6	7	8	9	10
• Attention to detail is evident:	3	4	5	6	7	8	9	10
• Project was completed by due date:	3	4	5	6	7	8	9	10

Design Envelope (110 points total)

	No	Close	Yes
Body Mass (with wheels, hardware) 45g – 170g	3	5	10
Body Length is 8” to 12”.	3	5	10
Wheel base is 4-1/8” to 10-1/2”.	3	5	10
Distance from front of car to axle hole is ½” to 4”.	3	5	10
Distance from rear or car to axle hole is ½” to 4”.	3	5	10
Body width at front wheels is 1-3/8” to 1-5/8”.	3	5	10
Body width at back wheels is 1-3/8” to 1-5/8”.	3	5	10
Body width is a minimum of ½”.	3	5	10
Body height at rear axle is 2-1/4” to 3”.	3	5	10
Minimum power plant wall thickness is 1/8”.	3	5	10
Axle placement is 1/8” to 3/8” above bottom of car.	3	5	10

Work Ethic (100 points total)

	No		**Some**		**Yes**
Student worked consistently during class period:	20	40	60	80	100

Performance Test (100 points total)

1st place 100 points	4th place 88 points	9th place 79 points	14th place 74 points
2nd place 96 points	5th place 86 points	10th place 78 points	15th place 73 points
3rd place 92 points	6th place 84 points	11th place 77 points	16th place 72 points
	7th place 82 points	12th place 76 points	17th place 71 points
	8th place 80 points	13th place 75 points	>18th place 70 points

*Did not participate 0 points

CO2 Car Average Speed WS **Name**_________________________

Class_______ **Date**____________________

Directions:
Compute the average speed of your CO2 car in miles per hour (mph) by following the directions and filling in this worksheet. Use a calculator to help with the mathematics. Round answers to 2 decimal places (0.00).

1. Record your car's race times from the heats we conducted in class. Record as many races as you participated in.

   1. _____________sec
   2. _____________sec
   3. _____________sec
   4. _____________sec
   5. _____________sec

2. Add all the times in boxes 1-5 together for the Total Time:
   TOTAL TIME = ____________sec

3. Divide the TOTAL TIME by the number of races to find the average time.
   AVERAGE TIME = _____________sec

4. Record the track length in feet. TRACK LENGTH = _____________ft

5. Divide the track length by the average time to find the average feet per second (f/s).
   AVERAGE FEET/SEC = ______________f/s

6. Multiply average f/s by 60 to get average feet per minute (f/m).
   AVERAGE FEET/MIN = _____________f/m

7. Multiply average f/m by 60 to get average feet per hour.
   AVERAGE FEET/HOUR = _____________f/h

8. Divide average f/h by 5280 (1 mile = 5280 ft) to calculate average speed in miles per hour AVERAGE MILES/HOUR= ___________mph

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standard: 8,9,10,19
GPS: 1-3, 5, 7 – 13, 15 -16, 22, 25, 39, 43, 73

Name: ______________________________

Golf Ball Catapult Problem Solving Activity

This activity is a problem solving activity that limits students to a specific materials list and employs the application of simple machines on a student-designed catapult powered by rubber bands. In this activity, students will learn about the history and evolution of catapults, types of catapults and how they are used today. Using math and science principles, students will learn how to control and manipulate their device for a desired distance, velocity, and specified target.

Math Connections	Science Connections	Technology Connections
Angles	Projectiles	Problem-solving
Trigonometry	Mass/Force	Technological Design
Data table	Gravity	Troubleshooting
Comparison	Hooke's Law	Materials
Graphs	Kinetic energy	

Materials Provided by the Teacher

The teacher will provide 6 – (3½" x ¼") rubberbands to ensure equal power advantage, golf balls and the five weights needed for the experiment for Hooke's Law. Each weight should double in mass so that the student can prove Hooke's Law more readily. Students will need a scientific scale for measuring the mass of the weights and their golf ball.

Materials Provided by the Student

Students will provide their own materials but are confined to the following materials. These items are unlimited but cannot exceed the size specifications of the device.
string, large or small popsicle/craft sticks, drinking straws, paper clips, *standard* metal coat hangers, *empty* soda bottles, *cardboard* egg crates, styrofoam egg containers, any clear tape but NO duct tape or opaque tape, paper clips, any glue or adhesive which include soldering or welding, plastic picnic *eating* utensils

History and Evolution of Catapults

Since the beginning of time, humans have applied innovative ideas and designs to devices to extend human capabilities. One such device was the catapult. The first catapult was a sling shot followed by the bow and arrow used by hunters and warriors in early time. Although greatly improved, hunters and hobbyists still use the bow and arrow today. Construction of more powerful catapulting machines followed the bow and arrow. These machines gave great advantage to an attacking army during enemy siege. Although these machines are no longer used for military advantage, the same basic concepts are employed in many technologies today. Using the Internet or any available resource, find the answers to the following questions:

1. Define catapult.

    ____

    ____

2. List the three types of catapults and briefly describe each one.

    ____

    ____

    ____

    ____

    ____

    ____

    ____

    ____

    ____

3. Choose one of the three types of catapults and research information for that catapult to answer the following questions.

    Name of catapult selected _________________________

4. What was the purpose for this type of catapult? ________________________________

    ____

5. Is this type of catapult used today? ________ If so, for what purpose.

    ____

    ____

6. Describe the original design.

____

____

7. Was the original design changed or modified? _______If so, how and why did it change?

____

____

8. Are there other technologies that make use of this device? Give an example.

____

9. Make a sketch or provide a picture of your selected catapult in the space below and label or describe the parts.

<u>Using Scientific Principles in the Design and Function of a Catapult</u>

Matter has some universal elastic properties, whether it be rubber bands, concrete or steel. Hooke's Law states that force is proportional to stretch and is expressed by the formula F = kd. F is the force applied, k is the constant of elasticity and d is distance of the stretch of a material. You will use Hooke's Law to determine the constant value for the rubber bands that you will be using to power your catapult. This activity will help you discover and understand the relationship between the elasticity of the rubber bands, the force applied to them, and the distance they traveled. You can then apply your gained knowledge to the construction of your catapult.

10. Using five different weights, attach a rubber band to a defined point and suspend each mass.

11. Measure and record the distance of the stretch respective to each of the masses in the chart below. You will need to weigh each mass on the scientific scales.

	mass	distance	k (constant)
m_1			
m_2			
m_3			
m_4			
m_5			

12. Calculate *k*, the elasticity constant, for your rubber bands and record in the chart above.

13. Was the stretch of the rubber band proportional to the size of the mass as Hooke's Law implied? ________

14. When you applied a mass with twice the weight of m_1, did the stretch double? ______

15. Using graph paper, draw and plot a graph representing the distance measured in relationship to the masses (mass vs. distance). Label the graph.

16. Use the graph to help you predict how the distance of the stretch of the rubber band be affected when smaller or larger masses are applied.

    What will happen if you use a smaller mass? ____________________________________

    ____

    What will happen if you use a larger mass? _____________________________________

    ____

17. Experiment with the rubber bands by twisting them and then apply the mass to see how this changed its elasticity. What happened? ______________________________________

    ____

<u>How to find the velocity of the golf ball</u>

The elastic potential energy of the rubber band is when it is stretched and set but has not been released. Potential energy is represented by the equation: PE = ½ kx^2, where k is the constant for elasticity and x is the distance stretched. Since you know k from the previous activity, you can now predict the potential energy of the stretch according to your placement from a fixed point on your device.

18. Using a scientific scale, determine the mass of your golf ball that you will be using to launch your catapult.

    Mass = _______________

Once you release the rubber band the potential energy or work that is done by the elastic properties is converted into kinetic energy represented by KE = ½ mv^2, where m is the mass and v is the velocity. Velocity is the only unknown variable but you can find it by using the following deductions and the given formulas for potential energy and kinetic energy.
Since potential energy is converted to kinetic energy once the rubber band is released from its set point, then PE = KE. If PE = ½ kx^2 and KE = ½ mv^2, then ½ kx^2 = ½ mv^2. Put in the known information and solve to find the velocity.

$$\tfrac{1}{2} kx^2 = \tfrac{1}{2} mv^2$$

Determining the angle at which to set your device

The angle at which you launch your golf ball is very important. This angle must be between 0 degrees (horizontal) and 90 degrees (vertical). If you launch the golf ball at 0 degrees, then you would be at ground level and if you launch it vertically, straight-up, then the golf ball would come straight back down, so it makes sense that the angles are between 0 and 90 degrees.
As you are building your catapult, you will need to factor in varying angles at which to set the rubber bands for launching. This is important as this will allow you varying degrees of adjustment to obtain different distances and heights that you may need during launching and competition.

Newton's Second Law of Motion

The amount of force you will need to hit your target can be determined by using Newton's Second Law → F= ma but since calculating acceleration gets rather complicated in ballistic projectiles, you will use the trial and error method for manipulating the force for your catapult. It's important that you recognize that you are using Newton's Second Law of Motion although you are using the trial and error method. You can control your force by using varying degrees of stretch for the rubber band and this will depend on the placement of the set point and the angle at which you set. The extent of the stretch of the rubber band determines the force and hence is the relationship between Hooke's Law and Newton's Second Law of Motion.

Determining the distance the golf ball will travel

A projectile (golf ball) is any object that has been launched in the air and moves freely with only the influences of gravity and air resistance. Gravity is a constant downward acceleration with the value of 9.81m/s^2 and it affects the projectile from the instant of release. The effect of air resistance is often relatively small or difficult to predict in combination with surface drag, speed, and direction. To predict the distance an object will travel, the following formula can be used: $y = x \tan\theta - (9.81\text{m/s}^2 / 2 \times v^2/\cos^2\theta)$, where θ is the angle of launch, x is the distance it will travel, and v is the velocity. Otherwise, you will have to use trial and error to chart your distances.

Design Brief

You are to design a catapult device using **only** the materials that have been listed above. No other materials will be acceptable. The height of the arm can not exceed 20 inches with the lever in its highest position. The device must be able to catapult a golf ball over a one meter wall from a distance of 2 meters. The golf ball must land in a 2 feet square, netted backboard set above the one meter wall. The device must be designed such that it can be set or cocked before release of the golf ball. Any intended enhancements or additions to the catapult must be shown as part of the design when the project is checked before testing.

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standard: 8, 9, 10, 20
GPS: 1 – 3, 5, 7 – 10, 12 -20, 22 – 25, 43, 72, 73, 84 – 85, 87

Name: ______________________________

Hot-Air Balloon Project

In this activity, students construct a hot-air balloon after learning about the history of air balloons and the scientific principles that make them float.

Math Connections	Science Connections	Technology Connections
Units conversion	Archimedes' Principle	Design Processes
Geometry	Equilibrium	Construction
Measuring lengths	Density	Modeling
	Buoyancy	Troubleshooting
	Specific gravity	

Materials and Supplies

Archimedes' Principle experiment: spring balance, kitchen scales, a stone, measuring cup or beaker

Density demonstration: brick, 2″x 4″x 8″ block ; oil, water, small clear container, small bottle, small balloon, small heat source

Hot-air balloon construction: 40 sheets of assorted colors of 20″ *x* 26″ tissue paper, scissors, medium size glue stick, soft-leaded pencil, colored pencils, measuring tools (ruler, yardstick, meter stick, 48" level if available), wire coat hanger or 36″ length wire, 4 ft. of 8″ diameter stove pipe with pipe reducer, large coffee can, kerosene, rags, and a fire extinquisher

History of Hot-air Balloons

1. Using any resource available, define balloon. ____________________________________

   ____

   ____

2. Use the Internet and/or other resources to investigate the history of lighter-than-air vehicles.

3. Who is credited with inventing the hot-air balloon? ______________________________

4. Who is credited for the first recorded flight of a hot-air balloon? ____________________

5. When was the first passenger-carrying hot-air balloon launched?____________________

6. Who were the voyagers for the first test flight? __________________________________

7. When was the first recorded manned flight?__________________

8. Where did the first manned flight take place? _____________________

9. How was the first manned flight fueled? ________________________

10. What invention made prolonged flights possible? ________________________________

11. Who developed this invention and in what year? ______________________ ________

12. What gas was used in early gas balloons? ______________________________________

13. What caused the Hindenburg disaster in 1937? __________________________________

14. Name two gases used for balloon flight? _______________________________________

15. What is a serious drawback to using hydrogen for balloon flights? __________________

16. What were some uses of hot-air balloons in the past? _____________________________

17. Name two primary uses for hot-air balloons today?

    a) ________________________

    b) ________________________

18. Name three atmospheric conditions that are measured using a hot-air balloon.

    a) ________________________

    b) ________________________

    c) ________________________

Understanding and Investigating Scientifics Principles Effecting Flight

Objects can float in a liquid such as water. Objects can also float in a gas or in a gas mixture - as in the atmosphere. Liquids and gases are fluids because they do not have a defined shape; therefore, objects can float in liquids and gases.

Archimedes' Principle

19. Use any reference or resource available and state Archimedes' Principle.

    ____

    ____

20. Obtain the materials needed from your teacher to prove Archimedes' Principle.

21. Attach the stone to the spring balance with a string and record the weight of the stone.

22. What is the weight of the stone in grams? ________________ in ounces? ____________

23. Hold the balance scale so that the stone is suspended in the middle of the glass cup and pour water into the cup until it is at the top of the container.

24. Record the weight of the stone again. ___________ grams ____________ ounces

25. Determine the buoyancy by finding the difference between the two weights. __________

26. Notice where the water level is with the weight still suspended in the water.

27. Remove the weight and observe that the water level has decreased.

28. What did you observe? ____

29. What caused the displacement of the water? _________________________________

30. Using the scales provided, weigh the measuring cup of water and record the weight of the water and the cup. ___________ grams _____________ ounces

31. Fill the cup to the top with more water, then weigh and record this measurement. ______________

32. Find the weight difference between the two containers of water. ____________________

33. Does the difference in the weight of the water equal the buoyant force that you measured in step 25? ____________

34. If not, you were not careful enough in the experiment and you will need to redo it.

Buoyancy
Use any available resource to determine the answers.

35. Define buoyancy. ____

36. In steps 21 -25, you determined that there was a difference in the weight of the stone out of the water than when it was weighed in the water. What was the difference in the weights? _________________

37. Investigate and explain why the weight of the stone was less in the water.
____

38. Drop the stone in a glass of water. Did it sink? ______

39. Is the buoyant force of a liquid always strong enough to lift a solid body? ____________

Density
Whether a body will sink or float depends on its density. As you discovered in step 38, some solid bodies will sink when placed in a liquid.

40. Using any available resource, define density.____________________________________

____

41. Obtain the brick and wood block from your instructor.

42. Weigh the brick and record its weight. _____________ lbs ____________ ounces

43. Weight the wood block and record its weight. ________ lbs ___________ ounces

44. Do both the brick and the block take up the same space? _______

45. If so, then why does the brick weigh more than the block? _________________________

46. If you had a large object and a small object both having the same weight, what could you conclude about the smaller object? ____

47. Obtain a clear glass container and pour about an inch of water into the container, then pour about an inch of oil into the container.

48. What happened? ____

49. Which liquid has greater density, water or oil? ___________________________________

50. Do liquids have different densities? ____________

51. Does density depend on weight? _________

52. If so, do fluids (gases) have different densities? _____________

Specific Gravity

Specific gravity is directly related to the changes in density in the atmosphere. The change in density in the atmosphere will have a great effect on the altitude that a gas or hot-air balloon can gain.

53. Use any available resource to define specific gravity. _____________________________

____

54. When determining specific gravity, the density of liquids or solids is compared to the density of __________.

55. Is the air thinner or denser at higher altitudes? ___________________________________

What Makes a Hot-Air Balloon Rise

In winter months when heat is necessary to keep warm, you have most likely observed that the hot air will rise and the cool air is pushed down. This is because hot air rises because hot air is less dense than cool air. This means that the gas particles are spread out and that there are fewer gas particles in a cubic foot (volume) of hot air as opposed to cold air. Using hot air is a practical approach to flying hot-air balloons as it cost is minute compared to hydrogen and helium.

56. Use any available resource to define ambient air.________________________________

57. Use any available resource to define equilibrium. ________________________________

58. Obtain a small soda bottle and a small balloon.

59. Snap the balloon over the bottle neck.

60. Did the balloon rise or go limp?

61. Place the bottle in a small container of hot water over a small heat source.

62. What happens as the water warms the air in the bottle? ___________________________

63. Do the gas molecules expand or contract? ___________________________

64. If the air expands, does the air within the bottle and balloon decrease in density or increase in density?_______________

65. The gas inside a lighter-than-air balloon must have less ___________ than the air that surrounds the balloon in order for the balloon to float.

66. The air surrounding a hot-air balloon is called _________ air and it must have a greater ____________ than the air inside the balloon for the balloon to float.

67. As long as the balloon's internal air has less density than the ambient air, the balloon will _________.

68. What will happen when the air in the balloon and the ambient air reach an equilibrium?

____

69. If the inside and outside air density is the same, why does the balloon sink? __________

____

Archimedes' Principle says that the buoyant force is equal to the weight of the fluid pushed aside. The fluid that is pushed aside is displaced. The displacement of the air by the size of a balloon has a direct relationship to the amount of weight it will carry into the air. This means that the larger the balloon, the greater the displacement. Therefore, the buoyancy is greater and the balloon can carry a greater load.

70. Given the information above, how can the buoyancy of a balloon be changed to cause the balloon to rise or fall. ____

You have now completed the first section of the activity. You will now proceed to the instructions for constructing a hot-air balloon. You will need a partner for this project.

Construction of a Hot-Air Balloon

Now that you have learned about the scientific principles affecting fluids or gases and what causes hot air to rise, you are now ready to construct a hot-air balloon. After constructing the balloon, you will launch it and watch it disappear in the skies.

1. Obtain colored pencils and a design worksheet representing the eight panels of your balloon from your instructor.

2. Match the colored pencils to the colors of tissue that are available for your project.

3. Notice that the design worksheet has eight individual panels lying side by side. There are 8 tissue panels. Each panel consists of 5 pieces of tissue. This layout represents each of the panels that you will assemble for your balloon. The purpose of the design sheet is to help you place the tissue pattern so that no two pieces of the same colored tissue touch on any side, except at the diagonal corners. You will also use it as your guide as you assemble the individual tissues into a panel.

4. You must use at least two colors for your design. You may use more than two colors but be careful in the layout because you have an even number of tissue pieces.

5. On the design sheet, indicate which end of the panel will be the bottom and which end will be the top so that you will be consistent once you start building the panel.

6. After deciding on your colors, color in your pattern and then count the number of tissues you will need for each color.

7. Obtain the tissue paper and make sure that you have exactly 40 pieces as you will not be given additional tissue if you come up short or if you make thoughtless errors when cutting the tissue.

8. In addition to the tissue paper, you will need a ruler, a meter stick, a glue stick, scissors and a soft-leaded pencil before beginning to work.

9. Measure your tissue to make sure that it is the correct size of 20″ *x* 26″. If it is not the correct size, then you will need to cut it to size.

10. Use your ruler to mark increments along the side or top of the tissue and then lay a straight edge along these marks, drawing a straight line and cut the tissue to the size that is stated above. Make sure that you make straight cuts as you want your balloon be a quality project.

11. Using your pattern guide, select the 5 pieces of tissue for your first panel.

12. You will assemble your balloon beginning at the bottom. Lay the first piece of tissue on the work surface. Mark a glue line across the top of the tissue by laying the meter stick venly along the top edge. Then use the soft-leaded pencil to mark a line so that you have about an inch from the top edge all the way across.

13. Have your partner hold one side of the paper firm to the work surface while you gently pull the tissue tight so that you can slide the glue stick from your partner's side back to you easily. Stay within the line and top edge with the glue. Make sure that you apply enough glue so that the tissue will not come apart after you have the balloon assembled.

14. Take the second tissue and carefully match its bottom edge on top of the glue along the glue line of the first piece of tissue.

15. Draw a glue line at the top edge and apply glue in the same manner as the first making sure that you stay within the boundary of the line and top edge of the tissue.

16. Take the third piece of tissue and place it on top of the glue.

17. Repeat until all 5 pieces of tissue have been glued to the panel.

18. With your partner at one end of the work surface and you at the other end of the panel, turn the panel over so that the inside of the panel is on top. (*You glued on top of the outside, the brightest or shiny side of the tissue.*)

19. Fold the panel lengthwise and crease slightly so that the fold remains in place. *(You can accomplish folding easily if you will step backward while your partner remains stationary pulling the panel straight and tight gently as you move backward.)*

20. At the bottom of the balloon panel, lay a meter stick at the center corner of the panel *at the crease fold*. **Make very certain that you are at this position on the panel.** Align the other end of the meter stick diagonally across two pieces of tissue to the open seam on the other side at its corner.

21. With the meter stick in position, draw a line from the crease fold corner at the top of the panel to the corner of the second piece of tissue at the open side seam.

22. Using a pair of scissors, begin cutting along the line from the folded corner at the crease to the open side seam. If you drew your diagonal line correctly, you will have cut off two separate pieces of tissue. Save this paper until you have completely finished your balloon as you will need it to make a patch for the top and for repairs.

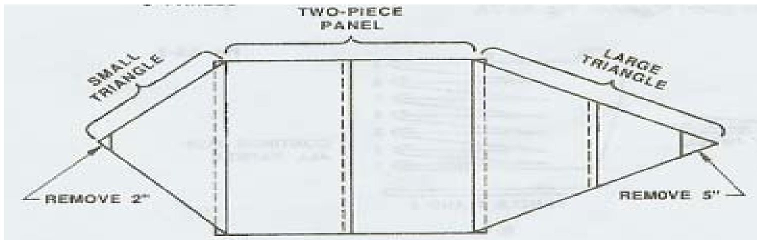
23. Using a ruler, measure 5″ down from the pointed end and cut the tip off.

24. At the other end of the panel, draw a diagonal line from the crease fold corner to the open side seam to the corner of the first tissue.

25. Again, cut along this line beginning from the crease fold corner to the open side seam. If you cut this correctly, you will again have two separate pieces of tissue paper. Save these scraps in case you need them for repairs.

26. Measure 2″ from the point and cut the tip off.

27. Your panel should now look like the following except that you have already removed the ends.



28. Mark the panel as #1.

29. Turn the panel so that the outside of the panel is exposed.

30. Positioning yourself at the bottom of the balloon panel (the large triangle), draw a glue boundary line around the edges of the right side to the top of the balloon. Use the meter stick as a guide for drawing the line. This will be helpful to you later when you glue the panels together.

31. Repeat steps 11 – 30 for the remaining panels.

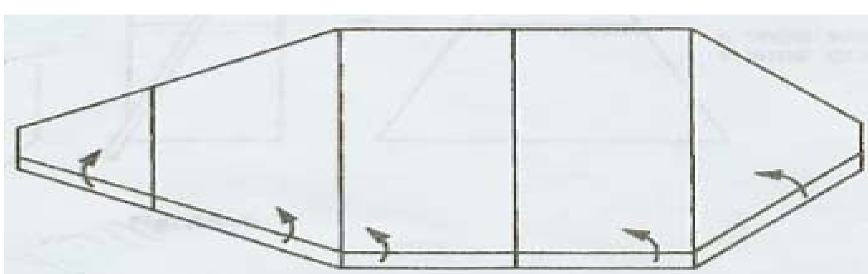
32. After assembling all 8 panels, place panel #1 on the work surface so that the inside of the panel is exposed.

33. Place panel #2 so that the inside is facing down on top of panel #1.

34. Work on the side that the glue boundary lines have been drawn.

34. Understand that you will only glue one side of panel #1 together leaving the other side open until all of the other panels have been joined. You will work only on one side of the work surface as you are joining the panels together.

35. Slide panel #2 over about an inch so that panel #1 can be folded over to the glue line as shown below.



36. You will glue the side in sections, beginning with the middle section.

37. Next glue the small triangle section and then the large triangle section.
DO NOT GLUE THE OTHER SIDE.

38. Take the top panel and fold it in half as you are pulling it toward you, overlapping the edge by 1".

39. Place the 3rd panel on top and glue that panel to panel #2. Now, panel #2 is joined on both sides. One side is joined to panel #1 and the other side is joined to panel #3.

40. Fold the top panel in half again overlapping the edge 1" as you are pulling it toward you.

41. Continue this procedure until all panels have been glued together.

42. After the last panel has been glued, do not fold it in half. Move to the other side of the work surface and join the first panel to the last panel in the same manner.

43. Use the large scraps to make 2 - 10″ circles to cover the hole in the top of the balloon.

44. Carefully open the top of the balloon (the small triangles) and flatten the top so that one of the circles can be fitted and glued on the inside of the hole. Do not glue the patch to the inside of the balloon!

45. Glue the second circle on top of the first circle sealing the raw edges of the balloon.

46. The bottom of the balloon will also have a hole but this is where you will fill the balloon with hot air.

48. Shape the metal wire or the coat hanger so that it has a handle on two sides with an 8″ diameter circle between them.

49. Cut two strips in each of the panels at the bottom of the balloon.

50. Place the bottom of the balloon through the hanger and glue the tabs over the hanger leaving the handles free.

51. On a 3″ *x* 5″ piece of paper, write the name of your balloon to identify your balloon (since you can not use your name), the name, address, and telephone number of your school and your teacher's name. Write the following: "Please let us know if you find this balloon. Thank you."

52. If a heat gun is available, you can test your balloon for leaks; otherwise, examine the balloon carefully for any tears or other damage. Repair if necessary. Fold the balloon neatly and put in a storage container until the balloon can be launched into the atmosphere.

53. Weather conditions will dictate when your balloon can be launched. The balloon must be launched in a large open area when the wind speed is less than 5mph and there is no humidity.

54. The stove pipe should have several holes drilled at the bottom for better draft and when it is placed over the can, it should be elevated about an inch from the ground surface. This can be achieved with blocks or pipe supports.

55. Use a large coffee can, roll an old towel loosely or rags to fill the can.

56. Make sure a fire extinguisher is handy.

57. For safety precautions, your teacher will perform the rest of the activity with respect to soaking the rags with kerosene and ignition while wearing fire resistant gloves for protection.

58. Have a few students help hold the balloon up while it is filling with hot air as the teacher will be holding the balloon on the heat source for you.

59. Release the balloon when it begins to lift and watch it soar into the atmosphere.

60. Extinguish the fire and dispose properly of the fuel can and charred rags.

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standard: 8, 9, 10, 19
GPS: 1 -3, 5, 7 – 10, 15 – 20, 22 – 23, 25, 67, 72 – 74, 83

Name: ____________________________

Transportation Engineering with a Mousetrap

This activity employs the application of simple machines on a student-designed vehicle that is powered by a mousetrap. Students predict the performance of the vehicles using math and science principles and then apply the knowledge learned to manipulate the speed and distance it will travel by changing the length of a lever, the diameter of a wheel or axle, a gear ratio, or other variables.

Math Connections	Science Connections	Technology Connections
Circumference	Simple machines	Problem-solving
Ratios	Torque	Modeling
Measuring angles and lengths	Newton's laws	Troubleshooting
Data collection and graphing		Design Processes

Materials and Supplies

Pre-packaged mouse vehicle kit or equivalent parts to assemble the vehicle.
Calculator
Foam cutter
Drill press, 3 mm drill bit
Low temperature glue gun and glue sticks
Elmer's white or wood glue
Measuring tools: ruler, yard/meter sticks, flexible measuring tapes, string, 50 ft steel tape measure

Determining and Applying Specifications

1. Using any of the measuring tools provided, determine the specifications for the different vehicle parts and complete the Table 1.

Part	Diameter (inches)	Diameter (decimal)	Initial Weight (oz.)	Gross Weight (oz.)
Rear wheel			--------	--------
Front wheel			--------	--------
Axle			--------	--------
Vehicle	----------	---------		3.36 oz

Table 1

2. Using the formula for circumference, determine the circumference of the wheels and axle ***rounding*** it to the nearest hundredth. *(If you do not know the formula for circumference, look it up in your math textbook or use any reference tool available.)*

   a) *Formula for circumference is __________________________.*

   b) *Circumference of rear wheel = ____________________ inches.*

   c) *Circumference of front wheel =____________________ inches.*

   d) *Circumference of axle = ____________________ inches.*

3. Use a string to measure the circumference of the wheel and then measure the string.

   a) What is the measured value of the rear wheel circumference? _________in

   b) What is the measured value of the front wheel circumference? ________in

4. How do the calculated circumference and the measured circumference compare?

   a) Rear wheel: ____

   b) Front wheel: ____

5. What is the relationship between circumference and revolution of a wheel?

   ____

6. How far will the vehicle travel in one revolution of the rear wheel? ______________in

7. How far will the vehicle travel in one revolution of the front wheel? ______________in

8. Which wheel will determine the distance the mousetrap vehicle travels, the rear wheel or the front wheel?

   ____

9. Complete Table 2 by calculating the values for the distance the vehicle will travel respective to the number of revolutions indicated in Table 2.

Remember that you are working with feet and inches units. The following equations will be helpful in helping you convert inches to feet and hundredths of a foot to inches

1) $\text{feet} = \dfrac{\text{total number of inches}}{\#\text{ inches in one foot}}$ *2) hundredths of a foot x 12 = inches*

Round Row 1 values (total inches) to the nearest hundredth.
Round Row 2 values (total feet) to the nearest hundredth.
Round Row 3 values (ft. – in.) to the nearest inch.
In Row 4, round the values in Row 3 to feet.

		Revolutions of Wheel										
	Distance	2	3	4	5	6	7	8	9	10	11	12
1	total inches											
2	total feet											
3	ft. – in.											
4	feet											

Table 2

10. What is the decimal diameter of the rear axle? ___________

11. What is the ratio of the rear axle to the rear wheel? ______________________________

12. How many times does the rear wheel rotate when the rear axle rotates one time? _______

13. If the rear axle rotates 10 times, how many times does the rear axle rotate? __________

14. How much string will wrap around the rear axle one time? ______ in (nearest hundredth)

15. How far will the vehicle travel when the rear axle rotates 10 times?

a) _________in b) ft. ____in.____ c) ________ft

16. Calculate how much string you will need for the axle to rotate the given number of times indicated in Table 3 and calculate the distance the vehicle will travel.

	Axle Rotations						
	6	9	12	15	18	21	24
Amount of string							
Distance vehicle will travel							

Table 3

17. If the string is wrapped around the axle 10 times, will the axle rotate 10 times if the string is pulled all the way? __________
Explain your answer. ____

____

The above calculations and understanding what makes the wheel travel will help you determine how much of a powerstroke that you will want to use for your vehicle design. What is a powerstroke? In this case, a power stroke for the mousetrap can be defined as the distance of a string pull. The string is attached to the end of the lever or arm of the mousetrap.

Observe the mousetrap arm (Fig. 1) and string movement in (Fig. 2) below.

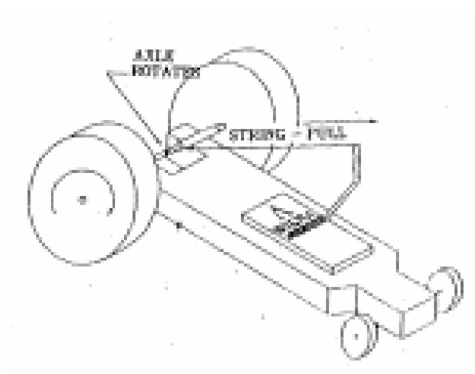


Fig. 1

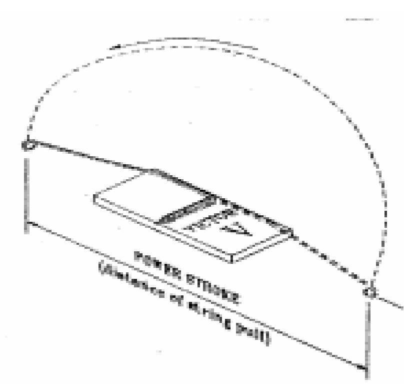


Fig. 2

With the mousetrap arm or lever set at one end of the trap, release of the arm or lever will pull the string 180° to the opposite end of the trap. The distance between these points is the power stroke of the mousetrap.

18. Refer to Fig. 2 and determine the power stroke for each of the arm lengths listed in Table 4 below and then calculate how much string is needed for each of the powerstrokes, how many times the axle will rotate, and the distance the vehicle will travel.

	Length of Arm or Lever					
	2″	**4″**	**6″**	**8″**	**10″**	**12″**
Powerstroke						
String Amount						
Axle rotations						
Projected distance						

Table 4

19. Which power stroke will make the vehicle travel farther? _____________

20. Which power stroke will make the vehicle travel the least distance? _____________

21. Which power stroke, do you think, will make the vehicle travel slower? _____________

22. Which power stroke might make it faster? _________________

Just how much of a power stroke will be your decision for your design but to help you make that decision, you will need to understand the principles of force. One kind of force is called *torque*, which is a force causing rotation. The force of a rotating device such as a wheel or a wrench is measured by torque. Torque is normally measured in ft/lbs or in/lbs.

How to Determine Vehicle Power

See figures 3 and 4 below. Each show a wrench with different radii fitted over a nut. The nut is the fixed point and the handle of the wrench is the arm. In the figure below, it is called a radius because when it is turned one full rotation, it makes a circle. Turning this wrench around the fixed point requires a force to make the fixed point (nut) turn. This force is called torque. The longer an arm or the radius, the easier it is to move a fixed point. Force is the ratio of torque divided by the radius, thus the formula is $\boldsymbol{F = t/r}$.

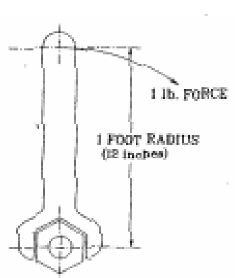


Fig. 3

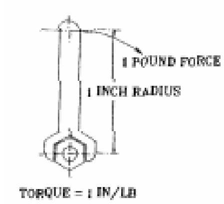


Fig. 4

On a mousetrap, shown in Fig.5, torque lessens as the spring unwinds. When the mousetrap's arm or lever is set, the torque is 3.21 in/lbs at 0° as it begins the rotation. At 90° or perpendicular to the base, the torque is 2.00 in/lbs and at its final destination of 180° degrees, the torque decreases to 0.68 in/lbs.

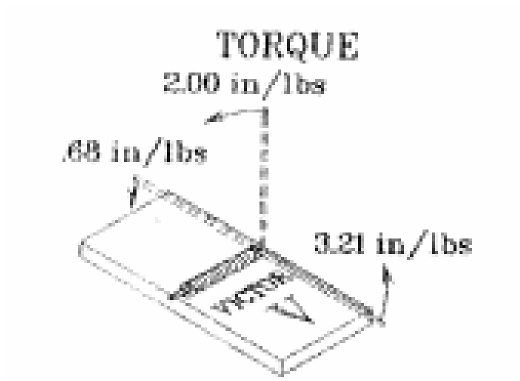


Fig. 5

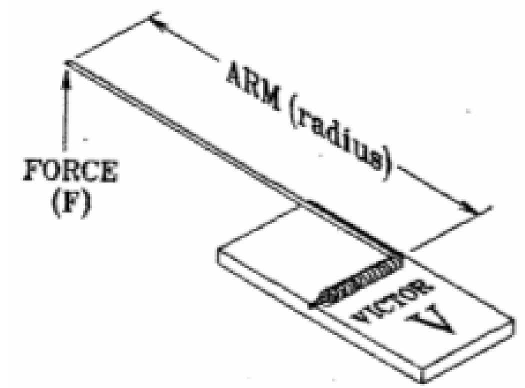


Fig. 6

23. What is the maximum torque of the mousetrap arm? ______________________

24. What is the least torque of the mousetrap arm? ____________________

25. Using the formula given above, find the force (F) exerted by the mousetrap arm for each of the radii listed in Table 5 at the different positions of the mousetrap. Give the answer in both pounds and ounces.

Position	**F (lb)**	**F (oz)**	**r** *(See Fig. 6)*	**t** *(See Fig. 5)*
0°			4″	
90°			4″	
180°			4″	
0°			6″	
90°			6″	
180°			6″	
0°			8″	
90°			8″	
180°			8″	
0°			10″	
90°			10″	
180°			10″	

Table 5

26. Which arm has the greatest force (pull)? ____________________

How to Determine Wheel Force

Force (wheel) $= F_w$
Force (axle) $= F_a$
radius (wheel) $= r_w$
radius (axle) $= r_a$

$$r_w \, x \, F_w = r_a \, x \, F_a \quad \rightarrow F_w = \frac{r_a \, x \, F_a}{r_w}$$

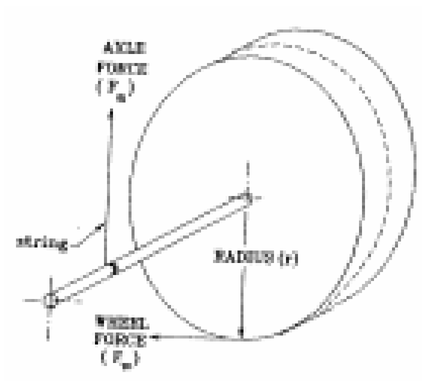


Fig. 5

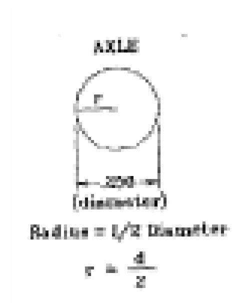


Fig. 6

27. What is the radius of the axle? ________________ *(See Fig.6)*

28. What is the radius of the wheel? _______________

29. Refer to Table 5 and recall that force is equal to torque divided by the radius from the set point. When the mousetrap arm or lever is set, what is the force being applied to the axle for the following:

    4″ arm or lever? _______________

    6″ arm or lever? _______________

    8″ arm or lever? _______________

    10″ arm or lever? ______________

    12″ arm or lever? ______________

30. Complete Table 6 by listing all the known values and then solving for F_w.

Arm	F_w (oz)	r_a	F_a	r_w
4″				
6″				
8″				
10″				

Table 6

31. Compare the values in Table 6.

32. Which arm has the least force? ________________

33. Which arm has the greatest force? ______________

34. What is the difference in the largest force and the least force? ______________

34. The greatest speed would result from which arm? _____________

35. Refer to Step 18. Which arm would result with the greatest distance? ____________

36. Using all of the information that you have calculated and collected, which powerstroke will you use for your vehicle? ____________________

37. Explain why you would use this powerstroke. __________________________________

____

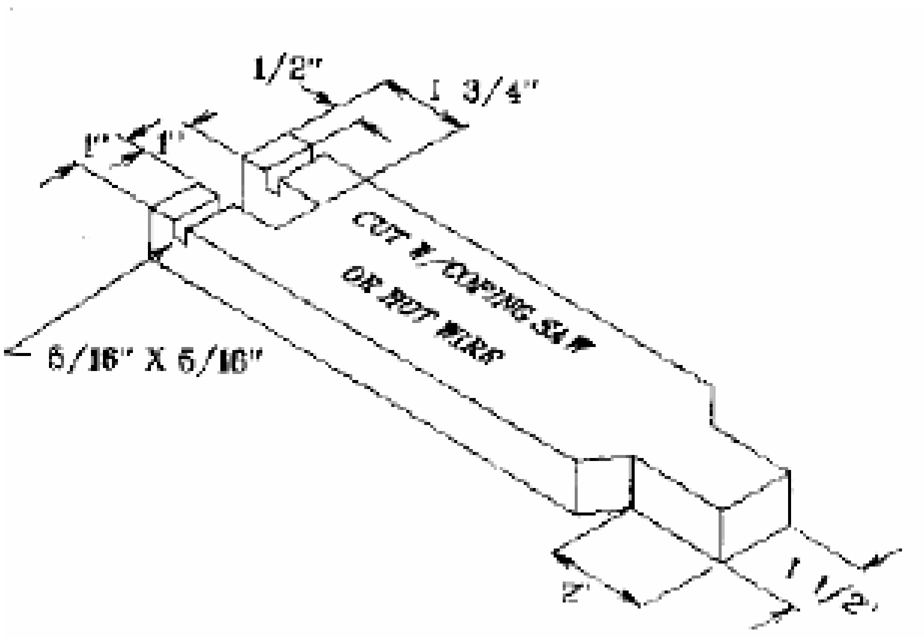
38. You have now acquired the knowledge to apply to the design and engineering of your mousetrap vehicle to obtain the greatest distance. Read and study the steps carefully before taking any action so that you can engineer the best possible vehicle.

Construction of the Mousetrap Vehicle

Use the following graphical instructions to assemble your vehicle. You will need to use the foam cutter to shape the vehicle.

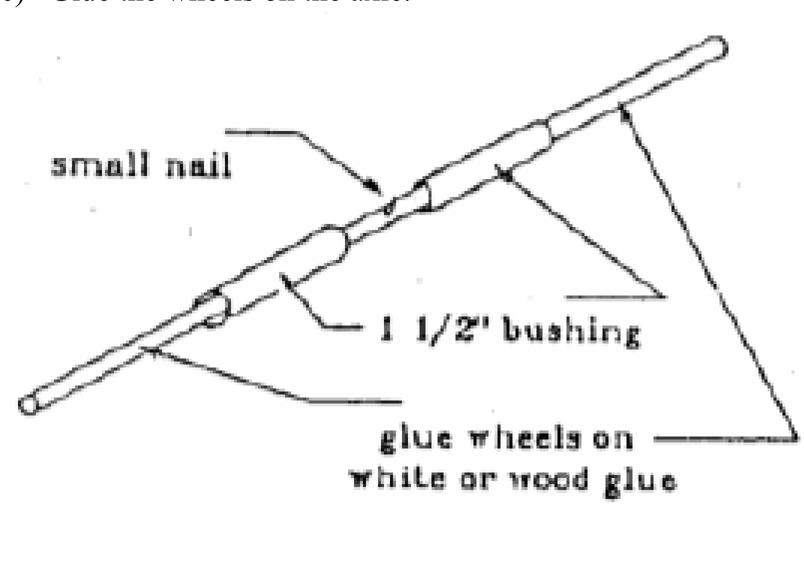
Step 1

Instead of cutting the axle space as shown in Step 1, an alternate method for positioning the axle bearing is to drill a hole but this must be done before you make any cuts in the body so that you have a flat surface for drilling a straight hole.



Step 2

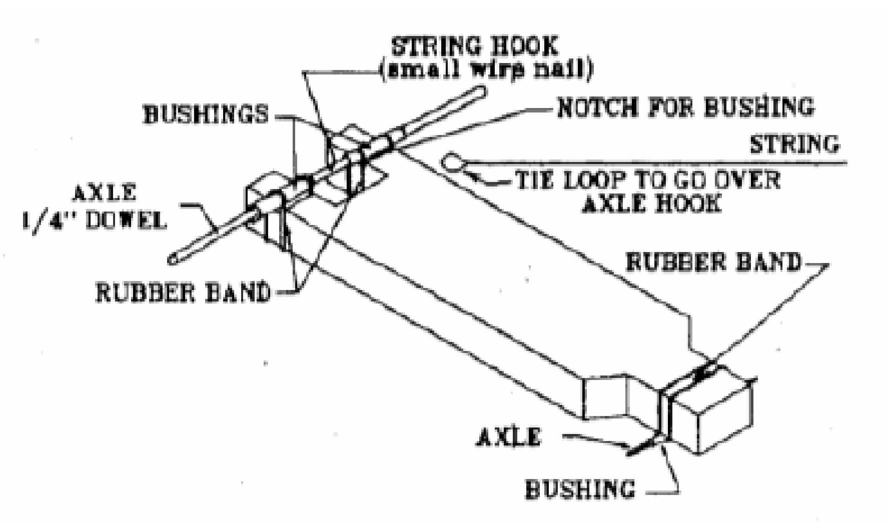
a) Tap a small nail into the center of the dowel to secure the string.
b) Cut out the bushing and slide onto the axle.
c) Glue the wheels on the axle.

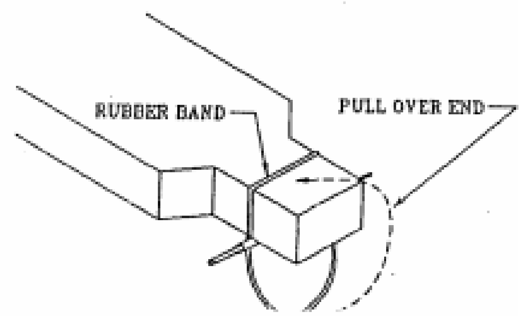


Step 3

Pull the small rubber bands over the top, then around the axle and back over the top as shown on the front of the vehicle. Do the same thing for the rear axle.

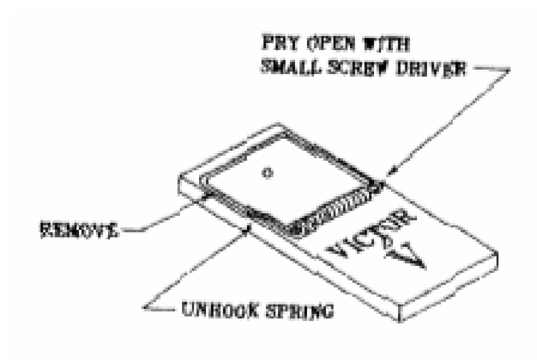
If you decided to drill your holes instead of using the rubberbands to stabilize the axle bushing, you will need to put some glue on the outside of the straw and then push it into the hole. Do not get any glue on the axle as you want the axle to move and turn freely in the bushing. It would be wise to wait until the glue dries before sliding the axle into the bushings.





Step 4

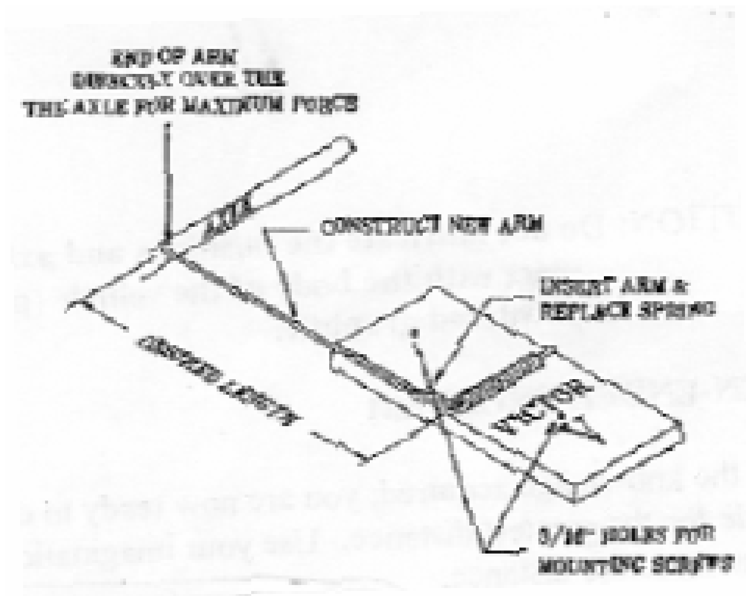
Remove the original mousetrap arm from the spring.



Step 5

a) Replace it with the arm that you have chosen for your vehicle.

b) Drill 3/16″ holes in the base of mousetrap.

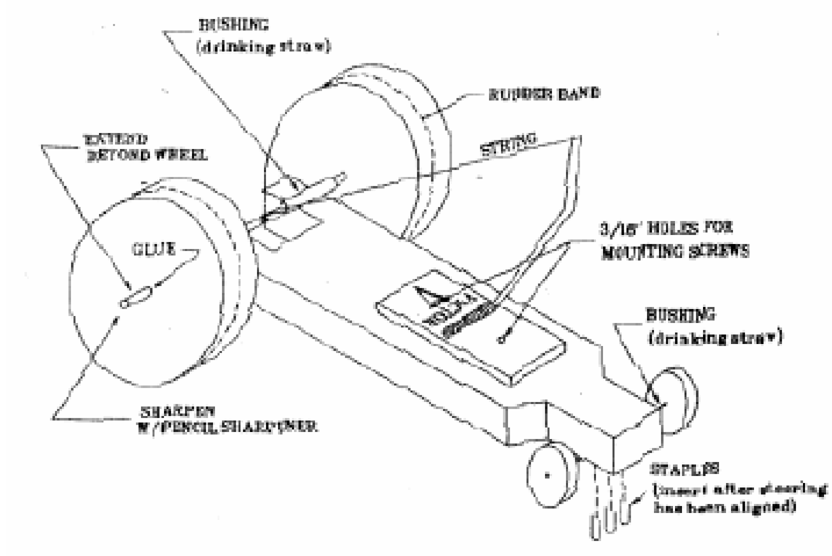


Step 6

a) Mount the mousetrap on top of the body using the screws. You could also use cool temperature glue sticks to help hold the mousetrap onto the body before screwing.

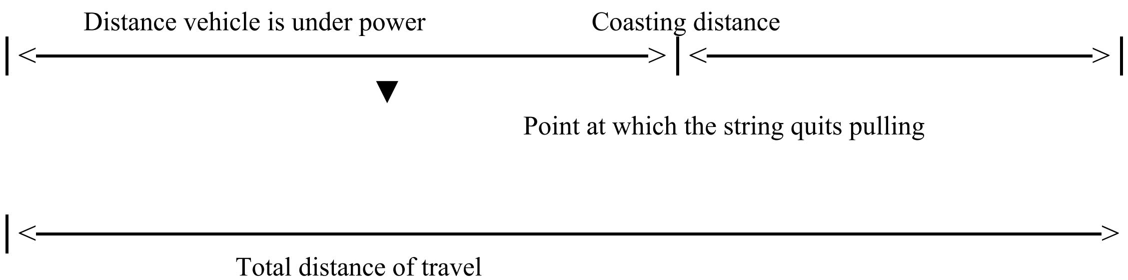
b) Insert staples underneath front to keep the rubber band in place.

c) Place the large rubberbands on the wheels for traction.



39. You will need a 25 – 50 feet smooth-surfaced straightway to race your vehicle. For lubrication of the bushing and axle, use soap or powdered graphite only.

40. Use the following guide line for gathering the remaining engineering data.



40. Gather the following data to complete the Engineering Data table, Table 7. *You will only need to use the values for the size arm that you used on your vehicle.*

Engineering Data

	Calculated	**Actual**	**Difference**
Distance under power = d_1			
Total distance = d_2			
Momentum w/o power = $d_2 - d_1$	-----------------------		
Time under power = t	-----------------------		
Speed (ft/sec) ft/sec = d_1/t	-----------------------		
Wheel force = F_w			
Gross vehicle weight	3.36 oz (given)		

Table 7

41. Collect data from at least one other student who used a different arm length and then construct a similar table to Table 7 to compare the different results. Use the space below.

42. What was the size of the arm for the other student's vehicle? ________

43. Which vehicle coasted the furthest? ________________

44. Which vehicle had the greatest speed? ____________________

45. Which vehicle had the greatest wheel force? ________________

46. Does speed have a direct relationship with wheel force? _________

47. Does speed have a direct relationship with the coasting distance? ________

48. Whose vehicle weighed less? __________________

49. What effect did the weight have on the speed?
____

50. What specifically did you learn by doing this activity?
____
____
____
____

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standard: 1, 2, 3, 4, 9, 11
GPS: 1-5, 6-9, 20-23,

Name: ______________________________

Paper Platform

In this activity, students will construct a paper platform that will support X number of pounds using only the given materials and design criteria.

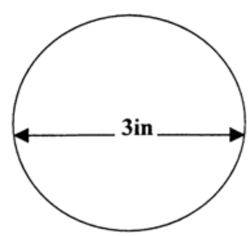
<u>Math Connections</u>	<u>Science Connections</u>	<u>Technology Connections</u>
Measurement	Forces	Problem Solving
Ratio	Equilibrium	Modeling
		Engineering Design
		Structures

<u>Materials</u>
6 Index cards
12 inches of masking tape

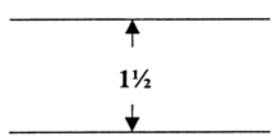
<u>Design Criteria</u>

You are design a platform using the given materials. Your platform must adhere to the following limitations:

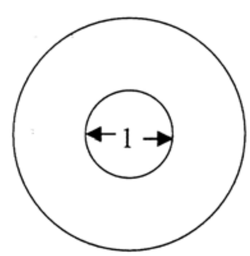
1. Be at least 3 inches across at the narrowest point.



2. Stand at least 1½ inches high.



3. Have at least a 1 inch hole (opening) in the middle of the device.



Structural Efficiency (SE)

The winning device will be decided by a structural efficiency ratio. The lightest holding device that supports the most weight wins!

MLS = Maximum Load Supported

$$SE = \frac{MLS}{\text{Mass of Holding Device}} + \frac{MLS}{10} =$$

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standard: 3, 8, 9, 10, 11, 12, 16, 18, 20
GPS: 1-9, 23-25,

Name: ______________________________

Simple Machines

The objective of this activity is to design a mechanical device that accomplishes an easy task while demonstrating the principles of the six simple machines in an inventive and fun way.

Math Connections	Science Connections	Technology Connections
Problem Solving	Physics	Design Processes
	Structures	Engineering Design

Introduction

Machines make work easier but do not change the amount of work that is done. Machines either change the amount of force you exert, the distance over which you exert your force, or change the direction in which you exert your force:

> *Multiplying force* - less force is required but it must be applied over a longer distance;
> *Multiplying distance*- more force is required but work is applied over a shorter distance;
> *Changing direction* **-** changes direction not the force required or distance applied.

Mechanical Advantage

The mechanical advantage of a machine is the number of times the force exerted is multiplied by the machine.

$$\text{Mechanical advantage} = \frac{\text{Output force}}{\text{Input force}}$$

If the mechanical advantage is greater than 1, the machine multiplies force.
If the mechanical advantage is less than 1, the machine multiplies distance.

Efficiency

Efficiency compares the output work to the input work and is expressed as a percent. Machines can lose efficiency to frictional forces. Efficiency is never greater than 100%.

$$\text{Efficiency} = \frac{\text{Output work}}{\text{Input work}} \times 100\ \%$$

Simple Machines

List the 6 simple machines and give one example of each.

Simple Machine	Example
______________________	_________________________
______________________	_________________________
______________________	_________________________
______________________	_________________________
______________________	_________________________
______________________	_________________________

1. In your own words, define the term work.

2. Give an example of a complex machine. List 2 of the simple machines found in this complex machine.

3. The hammer is what type of simple machine? In the picture below, label the load (resistance), fulcrum and effort.

4. What simple machine would be used to lift a couch in a 3rd story apartment? Explain why you chose this simple machine.

Pulley

1. What is a pulley?____

2. How does it work?____

4. Does it change the direction of applied force? ________________________

5. What is the advantage to using a pulley?____________________________

6. List some common uses of a pulley.

Wedge

1. What is a wedge? ____

____

____

2. How does it work? ____

____

____

3. Does it change the direction of applied force? ____________________________

____

____

4. What is the advantage to using a wedge? ____________________________

____

____

5. List some common uses of a wedge.

____

____

____

____

____

____

Inclined plane

1. What is an inclined plane?____

2. How does it work? ____

3. Does it change the direction of applied force?__________________________________

4. What is the advantage to using an inclined plane (How does it affect the work equation)?

5. List some common uses of an incline plane.

Screw

1. What is a screw? ____

____

____

2. How does it work? ____

____

____

3. Does it change the direction of applied force?______________________________

____

____

4. What is the advantage to using a screw?______________________________

____

____

5. List some common uses of a screw.

____

____

____

____

____

____

Lever

1. What is a lever? ____

____

____

2. How does it work?____

____

____

3. Does it change the direction of applied force?______________________________________

____

____

4. What is the advantage to using a lever?____

____

____

5. List some common uses of a lever.

____

____

____

____

____

____

Wheel and Axle

1. What is a wheel and axle?____

2. How does it work?____

3. Does it change the direction of applied force?______________________________

4. What is the advantage to using a wheel and axle?____________________________

5. List some common uses of a wheel and axle.

Design Brief

Using all the principles of the six simple machines, you are to design and construct a mechanical “Rube Goldberg” device. The device must be self-powered, i.e. no sources of electrical power including batteries are to be used. Rubber bands, springs, or mousetraps may be used to utilize potential and stored energy but hand cranking or pouring of counterweight material into the device will not be allowed. The device must be capable of repeated demonstrations without long setup times between trials.

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA: 1-3, 8-10, 19
GPS: 3, 15-17, 23-25, 58, 64

Name: ______________________________

Robotics: Choosing the Right Motor

Robotics organizes content in a way that integrates the application of math, science and technology. A robotics project promotes technological literacy, and introduces students to working in related competencies such as project planning, research, problem solving, resource management, systems design, and working as a team. Robotics allows teachers to introduce applied physics and mathematics in context and in a motivating format that makes students want to learn.

Math Connections	Science Connections	Technology Connections
Equations	Electromagnetism	Robotics
Ratios	Physics	Engineering
		Design

Electric Motors

Electric DC motors do most of the work on a robot. Motors and the power they supply move arms and drive train components and whatever other tasks the robot is designed to do. They provide the muscle for lifting and moving the bot. It is important to know how electric motors work because they cannot be fully utilized unless their strengths and their limitations are known.

Electric motors convert electrical power into mechanical power. Electric power in a battery does little in the way of physical work, but use the battery to run a motor converting the electrical energy into mechanical motion and there is some very apparent physical work.

The more electrical power put into a motor, the more mechanical power comes out. The more the trigger is pulled, the more electricity is supplied to the motors and the stronger the motor runs. The amount of mechanical power that comes out of the motor is proportional to the voltage that is supplied to it. Speed controllers are devices that allow control of the amount of electricity that is supplied to the motors. Motors can also be controlled by a relay, which simply turns the motor on and off at the full voltage delivered by the battery.

A DC motor will slow down as the load of the motor increases. Loads are outside forces that act on the motors shaft. As the forces acting against the motors motion increase, the slower the motors shaft rotates, and the stronger the motor pushes back. If a motor is used to power a crane, it will lift a load. The heavier the load is, the slower the shaft rotates, and the harder the motor pulls at the load. If the load is increased eventually the motor will stop turning and it will stall.

The Physics of Motors

Electrical Power (W) = Voltage (V) X Current (A)

Mechanical Power (Nm/s) = Force (N) X Velocity (m/s)
= Torque X Angular velocity

Power measures the net force applied to an object and how fast the object moves. With motors power measures how strong and how fast the motor is spinning. If either force or velocity is zero, then power is zero as well. Similarly, if either force or velocity is low, then the mechanical power will be low. Maximizing both force and velocity maximizes the mechanical power out of the system. The same thing applies to electric power. If either voltage or current is zero, then electrical power is zero. If either voltage or current is low, then the power will be low.

Velocity = Distance/Time	Measures speed
Angular Velocity = Rotation/Time	Measures rotational speed
Torque = Force X Radius	Measures rotational force

Useful Unit Conversions:

1lbs.	=	4.45 N
1 in	=	0.0254 meters
1 foot	=	0.3048 meters
1 in-lb	=	0.11 Nm
1 Watt	=	1 Nm/s (conversion between electrical and mechanical power)
1 RPM	=	0.104 Rad/s

Velocity of falling objects = 9.8 m/s

Other useful equations:

Force	=	Mass X Velocity
Power	=	Force (N) X Velocity (m/s)
Power	=	Torque (Nm) X Angular Velocity (Rad/Sec)
Electrical Power	=	Voltage X Current

Motor Curves

Terms defined:

Stall torque – The highest amount of torque a motor can generate, the point at which the motor quits tuning. The motor will stop when facing too much load. This number tells how much load is too much.
Stall current – The amount of current drawn when the motor is stalled. Also, it is the maximum amount of current that the motor can draw.
Free speed – The speed of the motor with no load; the fastest possible speed output by the motor.
Gear box ratio – The amount of gear reduction supplied by the supplied gear box with the motor.
Maximum motor power – The maximum amount of power a motor can generate.

Motor curves help to compare the performance characteristics of motors such as torque, power, and current. Other important points on the graph are the stall torque, stall current, free speed, peak power. All of these factors determine the optimal power range to operate the motor. Some motors come with a spec sheet and a graph and some don't. For the ones that don't you have to generate a graph from the specs.

These are the curves that need to be looked at:

1. Current vs. torque – (current curve) As the load (torque) increases, the current increases in a direct linear relationship. Torque is measured in Nm, and current is measured in amps. So as the motor is run harder and harder, the current goes up.

2. Speed vs. torque – (speed curve) As the load (torque) increases, the speed decreases in an inverse linear relationship. Speed is measured in RPMs. So as the torque increases, the motors speed decreases.

3. Power vs. torque – (power curve) This curve shows the relationship between power, and speed and torque. At the beginning of the curve, power is zero because torque (F) is zero ($P = F \times V$). At the end of the curve, power is again zero because the motor is stalled and has no speed (V). Maximum power happens at the peak of the curve when the torque is ½ stall torque, and when the speed is ½ free speed. Running the motor beyond this point (adding more current) turns into heat, which should to be avoided. Some motors have thermal protection and as they heat up the power will dramatically reduce or shut off completely. Motors without thermal protection can fail if run beyond maximum power for too long.

The most important information about the electric motors from the graph is the speed torque curve. It describes the behavior of a motor under load. The more load, the slower it goes, until the motor stalls out. At no load, the motor is spinning at free speed, and under extremely amount of load, the motor is stalling and not spinning at all. Also, as the load increases, the current it draws increases. Drawing too much current will trip the breakers, or it will heat the motors until they fail.

The curve shows where the optimal range on the speed torque for the motor. This range is near the power peak, or the efficiency peak of the curve. The range can be accomplished by using gear ratios on whatever component you are using that motor on, and choose how much load it's going to reflect back to the motors. This idea will be discussed later.

<u>Drawing and Labeling the Graphs</u>

Label the axes with the numbers supplied in the spec sheet that comes with the motor. The bottom axis is labeled "torque," and ranges from zero to the stall torque from the specs in Newton meters. The left vertical axis is labeled "speed" and ranges from zero to the amount of free speed in the specs in RPMs. The right axis is labeled "current" and ranges from zero to stall current listed in the specs in amps.

To draw each curve:

1. <u>Speed vs. torque</u> – Draw a straight line from (0 torque, free speed) to (tall torque, 0 speed.

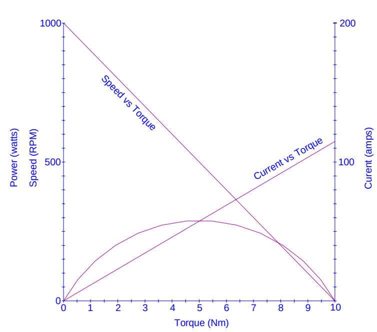
2. <u>Current vs. torque</u> – Draw a straight line from (0 torque, 0 current) to (stall torque, stall current)

3. <u>Power vs. torque</u> – Draw an upside down parabola, with the ends at (0 torque, 0 power) and (stall torque, 0 power). The peak is at (1/2 stall torque, max motor power. Motor power is calculated using the equation:

   Motor Power = ½ Free Speed X ½ Stall Torque

   Free Speed in Rad/s (1 RPM = 0.104 Rad/s)
   Stall Torque in Nm (1in-lbs = 0.11 Nm)

**Free speed and stall torque are proportional to voltage. The specs should say at what voltage they were generated.



Draw the motor curves using the specifications below.

Approx data 12V	Gearbox Ratio	Gearbox Efficiency	Stall Torque	Stall Current	Free Speed	Free Current	Peak Power
1. Bosch, motor	-	-	0.65	114 A	20,000 RPM	2.5 A	340 W
2. Bosch, high gear	20:1	0.8	10 N-m	114 A	1,000 RPM	2.5 A	260 W
3. Bosch, low gear	64:1	0.7	29 N-m	114 A	300 RPM	2.5 A	230 W
4. Chiaphua Motor	-	-	2.22 N-m	107 A	5,500 RPM	2.3 A	321 W
5. Fisher-Price motor	-	-	.36 N-m	57 A	15,000 RPM	?	140 W
6. Fisher-Price, motor/gearbox	147:1	0.65	35 N-m	57 A	100 RPM	?	91 W
7. Taigene Van Door Motor	-	-	35 N-m	40 A	75 RPM	?	69 W
8. Globe, motor only	-	-	.21 N-m	21 A	11,500 RPM	.82 A	63 W
9. Globe, motor/gearbox	117:1	0.77	19 N-m	21 A	100 RPM	.82 A	50 W
10. Keyang Seat Motor	-	-	2 N-m	20 A	600 RPM	?	31 W
11. Valeo Window Motor	-	-	12 N-m	20 A	70 RPM	?	22 W

Note: 141.6 oz-in = 1 N-M used for the Chiaphua motor.

Calculating power requirements and choosing a motor

It is important to look at what the robot needs to when choosing the right motor for the job. It might be moving the robot, picking up objects, pushing things around, or even lifting itself up to a certain height. In any case the different tasks need to be separated individually, and then figure out what is needed power, time and distance wise to achieve the objective. The formula for calculating this is Power = Force X Velocity.

Example 1: A robot that weighs 130 lbs needs to be lifted 1 foot in a. 2 seconds; or b. 4 seconds. How much power is required?

First some dimensional analysis:

$$\frac{130\text{ lbs}}{1} \times \frac{1\text{ kg}}{2.2\text{ lbs}} = 59.09\text{ kg} \qquad \frac{1\text{ ft}}{1\text{ ft}} \times 0.3048\text{ m} = 0.3048\text{ meters}$$

Calculate what the force is:

$$F = mV = (59.09\text{ kg})(9.8\text{ m/s}) = 580\text{ N}$$

Then solve for power:

1a. $P = FV = (580\text{ N})(0.3048\text{ m/2 s}) = 88\text{ Watts}$
1b. $P = FV = (580\text{ N})(0.3048\text{ m/4 s}) = 44\text{ Watts}$

Example 2: A powered arm has to lift a 5 lb ball 7ft to the top of a goal. Lift time for the arm is 6 seconds, and the design calls for an arm that is 3.5 feet long and weighs 20 lbs that will lift the ball by rotating the arm 180 degrees. How much power is required?

Equations needed are: Torque = Force X Distance; Angular Velocity = Rotation/Time;
Power =Torque X Angular Velocity.

Dimensional analysis:

$$\frac{5\text{ lbs}}{1} \times \frac{1\text{ kg}}{2.2\text{ lbs}} = 2.27\text{ kg} \qquad \frac{20\text{ lbs}}{1} \times \frac{1\text{ kg}}{2.2\text{ lbs}} = 9.09\text{ kg}$$

$$\frac{3.5\text{ ft}}{1} \times \frac{0.3048\text{ m}}{1\text{ ft}} = 1.07\text{ m} \qquad \frac{1.75\text{ ft}}{1} \times \frac{0.3048\text{ m}}{1\text{ ft}} = .53\text{ m}$$

There are two torques: the torque from the ball, and the torque from the arm.

Torque of the ball = $(22.7\text{ kg})(9.8\text{ m/s}) \times 1.07\text{ m}$ (distance from center of rotation)
Torque of the arm = $(9.09\text{ kg})(9.8\text{ m/s}) \times 0.53\text{ m}$ (distance of the arm's center of mass from the center of rotation)

Total torque = torque of ball + torque of arm = (22.25 kg)(1.07 m) + (89.08 kg)(0.53 m)
= 23.81 Nm + 47.21 Nm
= 71.02 Nm

Angular Velocity = Rotation / Time = 180 degrees / 6 seconds
= 5 RPM / 60 seconds
= 0.5 Rad/second

Power = Torque X Angular Velocity = 71 Nm X 0.5 Rad/s
= 35.5 Watts

Gears

Gears are basically wheels that have teeth. Gears and sprockets can be used to reduce speed and increase torque, or to go the other way and increase speed and reduce torque if required. Electric motors provide power but spin fast, so usually gearing has to reduce speed and increase torque. For drive trains, typically the smaller gear is on the motor aperture, with the larger gear linked to the drive wheel.

Gearing are also used to change the direction of rotation and motion, and to transfer motion from one location to another. The gear or sprocket on the motor shaft transfers power to another gear or sprocket and from there to a wheel or arm. Motion is transferred through the system.

Gears work by transmitting load (force) at the teeth. Sprockets transfer load with a chain. The load comes from the motor driving the gear creating torque. The bigger the gear is, the longer the 'lever arm," the greater the torque. When one gear is driving another gear, the force from the teeth of the first gear pushes the teeth on the second gear. The bigger gear creates more torque from the output of the smaller gear. Using different combinations of gears produces different amounts of torque, whether it is greater or smaller. Using gears or sprockets can multiply torque from the motor by 2, 4, or 16 times or reduce torque and increase speed by the same factors.

The number of teeth is proportional to the gear radius so the ratio can be calculated by dividing the number of teeth by the number of teeth on the drive gear (the gear on the motor). If an 8 tooth gear is driving a 32 tooth gear, then 32/8 reduces to a 4:1 ratio. For every 4 turns of the smaller gear, the larger gear turns once. For the reduction in speed the larger gear has 4 times the torque of the smaller gear. The same ratios also apply to sprockets.

Using the correct gear ratio optimizes the force and the velocity that comes out of the system. If the motor has no load on it will spin at free speed. The more force that is put against the motor, the more it pushes back, and the slower it spins. If the motor is pushed at ½ the stall torque, it will push back at ½ stall torque, and will spin at ½ of free speed. This information is found on the speed-torque curve. Controlling how much force reaches the motor by using the correct gear ratio controls how much force the motor is putting out, how fast it is spinning, and how much power the motor is drawing.

If a motor is moving a 2 foot arm with a 1:1 ratio, and the arm is pushed with 10 lbs of force, then the motor will push back with 10lbs X 2 ft = 20 ft lbs of torque. At a 2:1 ratio with the arm pushed with the same 10 ft lbs of force, the motor needs only 10 ft lbs of torque to push back with, because the 2:1 ratio is multiplying the motors torque by 2. The motor feels 20 ft lbs of torque at 1:1, and 10 ft lbs of torque at the 2:1 ratio. Ratios control how much torque reaches the motor.

Efficiency

Due to friction, gears and sprockets do not transfer 100% of the power to the end destination. The efficiency of the system is reduced depending on the type of gears used and the precision of the component assembly. Generally, the more gears in a system, the more friction there will be, and the less efficient the entire assembly. Another factor in efficiency is the type of gear involved. Spur gears are quite efficient in that they transfer 90-95% of the power sent through them. On the other hand worm gear systems transmit as little as 10-60%. Here are some other power transmission systems and their efficiency rating:

Spur gears	90-95%
Chain and sprocket	85-95%
Cables and pulleys	0-98%
Rack and gear	50-80%
Twist cables	30-70%
Worm gear	10-60%
Nut on a thread	10-60%

While the "ideal" ratio might be 4:1, the effective ratio is always going to be less.

Solving the Problem

Putting everything together involves taking power calculations, motor characteristics, and gear ratios to solve a given problem. The problem that needs to be solved on any robot is how to design a drive train or an arm to maximize the efficiency of the components. It comes down to what motor has enough power to do the job, and how can it be set up with the other components to do the required task.

1. Calculate power requirements
   Use the list of motors from the motor curves section.
   In example #2 a 3.5 ft 20 lb arm lifts a 5 lb ball 7 ft in the air by rotating it 180 degrees. The calculations show that it will take 35.5 watts to lift the ball in 6 seconds.

2. Choose the right motor.
   A more powerful motor will certainly do the job, but it would waste power in this application, so a smaller motor would be a better fit. However, it's nice to have a little spare power, so a 50 watt motor will do the job.

3. <u>Calculating working torque and applying a gear ratio</u>

Max torque required is when the arm is straight out from the pivot point, halfway between straight down (0 ft) and straight up (7 ft).

Total torque	=	torque of ball + torque of arm
	=	(22.25 kg)(1.07 m) + (89.08 kg)(0.53 m)
	=	23.81 Nm + 47.21 Nm
	=	71.02 Nm

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standard: 3, 7, 18
GPS: 1-14, 76, 77, 83

Name: ______________________________

Rockets

Students will construct a soda bottle rocket using a copy of Pitsco Bottle Rocket instructions. Students will then have an opportunity to launch his/her rocket and be required to answer some questions relating to Newton's Laws of Motion.

Math Connections	Science Connections	Technology Connections
Measurement	Thrust	Transportation technology
Formulas	Newton's laws	Construction
	Mass	
	Force	

Tools, Materials and Supplies

Ruler
Marker
Sandpaper
Plastic 20oz soda bottle
Cone and fin patter sheet
Ping Pong ball
String
Fin material
Cardboard tube
2 rocket nose caps
Glue gun with glue sticks
Pitsco AquaPort Launcher
Pitsco Bottle Rocket Book

Design Brief

Working with a partner, the student will construct a soda bottle rocket using the materials and supplies stated above. After construction, students will have an opportunity to launch their rockets using the Pitsco AquaPort Launcher. Each student will be required to record various data on his/her rocket and launch. In addition, students will answer questions related to this project using Newton's First and Second Laws of Motion.

Preparation

Newton's first law of motion states that every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.

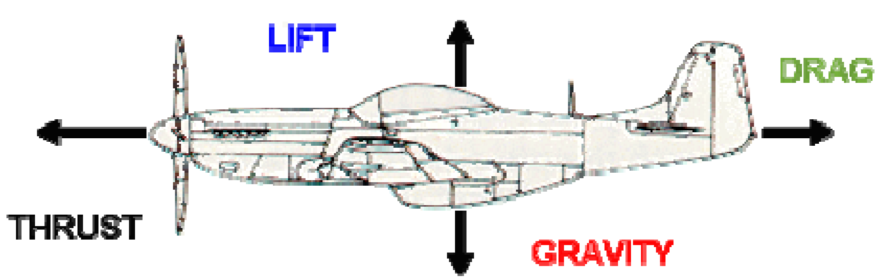
Newton's second law of motion states that the relationship between an object's mass m, its acceleration a, and the applied F is $F = ma$. Acceleration and force are vectors. The direction of the force vector is the same as the direction of the acceleration vector.

History Related To Newton's Laws of Motion. One of the first devices to successfully employ the principles essential to rocket flight was a wooden bird. In the writings of Aulus Gellius, a Roman, there is a story of a Greek named Archytas who lived in the city of Tarentum, now a part of southern Italy. Somewhere around the year 400 B.C., Archytas mystified and amused the citizens of Tarentum by flying a pigeon made of wood. It appears that the bird was suspended on wires and propelled along by escaping steam. The pigeon used the action-reaction principle that was not to be stated as a scientific law until the 17th century.

About three hundred years after the pigeon, another Greek, Hero of Alexandria, invented a similar rocket-like device called an aeolipile. It, too, used steam as a propulsive gas. Hero mounted a sphere on top of a water kettle. A fire below the kettle turned the water into steam, and the gas traveled through pipes to the sphere. Two L-shaped tubes on opposite sides of the sphere allowed the gas to escape, and in doing so gave a thrust to the sphere that caused it to rotate.

Just when the first true rockets appeared is unclear. Stories of early rocket like devices appear sporadically through the historical records of various cultures. Perhaps the first true rockets were accidents. It is certain that the Chinese began to experiment with the gunpowder-filled tubes. At some point, bamboo tubes were attached to arrows and launched with bows. Soon it was discovered that these gunpowder tubes could launch themselves just by the power produced from the escaping gas. The true rocket was born.

The Forces of Flight: Lift, Thrust, Drag, and Gravity. The force that pushes an object up is called lift, the force that pulls an object down is called gravity, the force that pulls the airplane forward is called thrust, and the force that pushes against the airplane is called drag.



Sites to Visit

1. Visit the Rocketry Through the Ages website at http://history.msfc.nasa.gov/rocketry/ to gain more background knowledge of rocket history.

2. Visit the Glenn Learning Technologies Project website and/or contact them to gain insight to the forces of flight and practice using Newton's Laws of Motions.

Using Newton's Laws of Motion

Directions: The formulas below relating to Newton's First and Second Law of Motion complete the following questions. Be sure to show all work.

d= v t

- **d** is the distance traveled
- **v** is the rate of motion (velocity)
- **t** is the time

Example Problem: d = v t
d = (343 m/s) (1.25 s)
d = 429 m

F= ma

- **F** is the unbalanced force
- **m** is the object's mass
- **a** is the acceleration that the force causes

Example Problem: F = ma
m = F/a
m = 600n/15 m/s2
m = 40 kg

Applied Problems

1. Weigh your rocket and record its mass in grams.

2. If your rocket traveled 60 km/hr along a straight line, how many meters does it travel in 20 seconds?

3. Let's say that your rocket has an acceleration of $3 m/s^2$. Find the net force acting on your rocket. Use the weight of your rocket for mass.

4. A bag of groceries resting on the floor has a mass of 6 kg. When an unbalanced horizontal force of 60 Newtons acts on it, what will be its acceleration?

5. If a force of 4 Newtons is applied to your rocket, what is its acceleration?

6. If your rocket was traveling at 25 meters per second for duration of 15 seconds, how far did your rocket travel?

Connecting Mathematics to Technology Education

System: Physical
ITEA: 8-10
GPS: 6-7, 13, 15-17, 67, 71-74

Name: ______________________________

Delta Dart Aerodynamics

This activity introduces students to flight. Students will learn about aerodynamics, parts of an airplane and the basics of flight by constructing a Delta Dart airplane using a kit. The students will be then be challenged to configure the airplane so that it flies in specified flight paths and to correct the plane from flying in undesirable flight paths. The basic idea is to get the plane to stay aloft as long as possible using flight principles learned in this activity.

Math Connections	Science Connections	Technology Connections
Measuring	Aerodynamics	Structures
Geometry	Lift Theories	Troubleshooting

Materials Needed

1 Delta Dart Class pack (about $40 for 35 kits)
Cardboard or plywood work surfaces
Stick Glue
Wood Glue or White Glue
Delta Dart Grading Rubric (included)
Aeronautics Review Worksheets 1 and 2 (included)
Lift Theories Worksheet
Internet Access

Information

The Delta Dart airplane uses balsa and tissue construction and a rubber band with a propeller as a power supply. It is inexpensive and easy to build. There are a limited number of balsa pieces that need to be cut and glued into place, but the plans make the build easier than most other kits. Student builders will take 2-3 hours to build the plane, but experienced builders can put one together in 30 minutes. It is a fairly robust plane compared to other models, and will take repeated hard landings, but will break especially if it hits an obstacle under power.

Instructions for the Teacher

1. Introduce the topic by going over basic aerodynamics with the class in a lecture format, or make packets and have the students use them to answer the questions and do the vocabulary in Aerodynamics 1 WS. (1-2 class periods)

2. Once the students have completed Step 1 give out the kits. It's good to stay a little ahead of the class and build one as an example. The instructions that come with the kits are good but many students have difficulty reading and following directions. Having a model to follow helps these students successfully complete their planes. Reserving the rubber bands and propellers until the students actually need them will reduce mischief and broken planes. (build time 2-3 hours)

3. Grade the plane with the rubric before the students start to fly.

4. Fly the planes. They can be flown indoors in a large room like a gym and outdoors, but it needs to be a light wind day. Allow opportunities for the students to trim and repair the planes between flying sessions. The students should try to trim the plane so flight time is maximized.

5. The questions could be answered best at the end of the activity when the students have the experience of building, flying and trimming the planes.

PARTS OF AN AIRPLANE

On any visit to the local airport you are likely to see a wide variety of airplane configurations and designs. While all these airplanes can look quite different, all have component parts that are really very similar and serve similar purposes. Typically, an airplane has five major components:

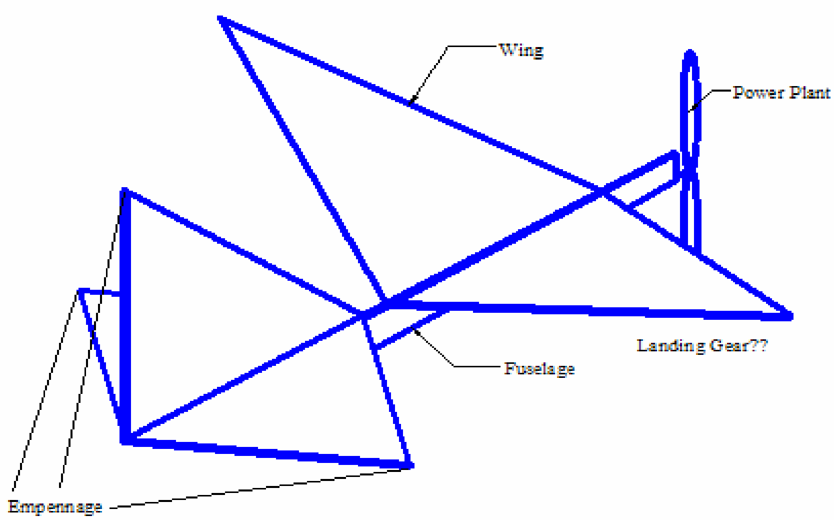
Fuselage. The fuselage provides a place for the controls of the aircraft, the pilot, and if large enough, passengers and cargo. It also provides a common attachment point for the other major components.

Wing. Wings provide the aircraft with lift, the force that makes airplanes fly. They can be attached to the top, bottom or middle of the fuselage. They must be extremely strong but lightweight structures. Wings also have the control surfaces, called ailerons and flaps attached to the trailing edges. Ailerons are located on the outward part of the wing and turn the plane, moving in opposite directions. Flaps are located closest to the fuselage, and are used during takeoffs and landings, moving together in the same direction.

Empennage. The empennage or tail assembly consists of the vertical stabilizer, and the horizontal stabilizer. These surfaces act like feathers on an arrow to keep the airplane on a straight path through the air. The rudder is attached to the back of the vertical stabilizer, and turns the nose of the aircraft left and right. The elevator is attached to the back of the horizontal stabilizer and moves the nose up and down controlling the altitude of the plane.

Landing gear. The landing gear supports the airplane when it is on the ground, and absorbs force when the aircraft lands. Landing gear can be fixed, so that it is always extended, or retractable, so that it can be put away during flight to reduce air resistance.

Power plant. The power plant may be an engine-propeller configuration, or it may be a turbo prop or a jet. Power plants can be located at the front or rear of an airplane, or located on the wings. Besides providing forward thrust for the airplane, the power plant provides electricity for the instruments and heat for the cabin occupants.

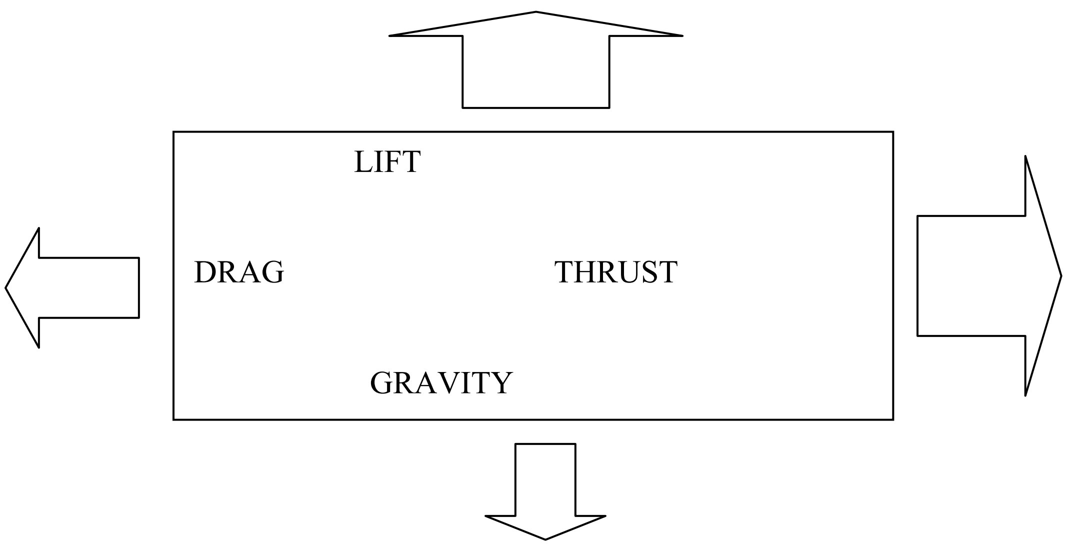


Aerodynamics

Aerodynamics is the study of objects in motion through the air. Large airliners, small model airplanes, kites, rockets, or a baseball thrown by a major league pitcher all are affected by aerodynamics.

The same scientific laws and principles that allow a full size airplane to fly also apply to model airplanes. These forces must be properly managed for any airplane to fly, whether it is a balsa and rubber band powered model, or a full sized, jet-powered transport, such as a Boeing 747. Four forces basic must be managed: lift, thrust, gravity, and drag.

1. Lift – the wings job is to create **lift** which keeps the airplane **up** in the air.
2. Thrust – the airplanes motor creates **thrust** which pulls the airplane **forward**.
3. Gravity – the mass of the airplane is affected by **gravity** which pulls the airplane **down**.
4. Drag – the friction of air on the surfaces creates **drag** which holds the airplane **back**.



For the airplane to fly the forces of lift and thrust must be greater than the forces of drag and gravity. It must lift the weight of the airplane, the fuel, passengers and cargo. Most of the lift is generated by the wings**,** but other surfaces such as the horizontal stabilizer and fuselage can generate lift as well. The Delta Dart does not actually have an airfoil to create lift. It flies because its nose-up flight attitude presents the bottom side of the wing to the air flow and pushes the airflow downward. Larger and heavier aircraft must generate lift with airfoils.

To generate lift the airplane must be pushed through the air. Thrust is provided by propellers or jet engines. Propellers are simply wings that rotate and pull the plane forward. On a rubber band powered airplane, the faster the propeller turns, the greater the thrust produced, but also the faster the power supplied by the rubber band will be used up.

Friction between the airplane's skin and the surrounding air creates drag, which resists the forward motion of the plane. Drag opposes thrust, and slows down a planes motion through the air. Trim tabs placed on the Delta Dart to create a desired flight path will increase drag and shorten flight times.

Weight is the force that opposes lift, and is caused by the gravitational force of the Earth. Airplanes are designed with light weight materials and structures so that their weight is held to a minimum. Reducing the weight increases aircraft performance.

Lift results when a moving fluid (air) is turned by a surface. On an airplane, lift can be generated by any surface, but mostly comes from the wings. Wings have shaped surfaces known as airfoils that turn a flow. But any surface can generate a lift, whether it is an airfoil or a flat surface such as the Delta Dart's wing. The moving fluid moves in one direction and lift is generated in the other direction according to Newton's Third Law of action-reaction forces.
Lift is a mechanical force. It is produced by the direct contact of a fluid with a solid object. If there is no contact, there is no lift. Also, there must be motion between the fluid and the solid object. If there is no motion, there is no lift.

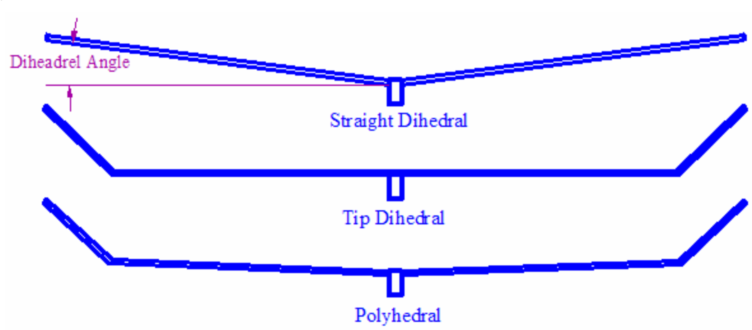
This explanation for what causes lift might be different from what you have learned in the past. Many explanations for lift are misleading or are over simplifications. For a more detailed look at what causes lift and incorrect explanations of lift, complete the Internet Lift WS activity.

Stability

We have talked about the basic structure of an airplane and what keeps it in the air moving forward. An airplane must also be controlled so that is stable and capable of making turns, and go up and down. An airplane is said to be in stable flight when it is flying straight and level without any tendency to pull in one direction or another.

The vertical and horizontal stabilizers at the rear of an airplane provide stability much like the tail feathers of an arrow keep the arrow flying straight. These surfaces keep the nose pointed in the direction of travel, and keep the attitude of the airplane at the correct angle of attack.

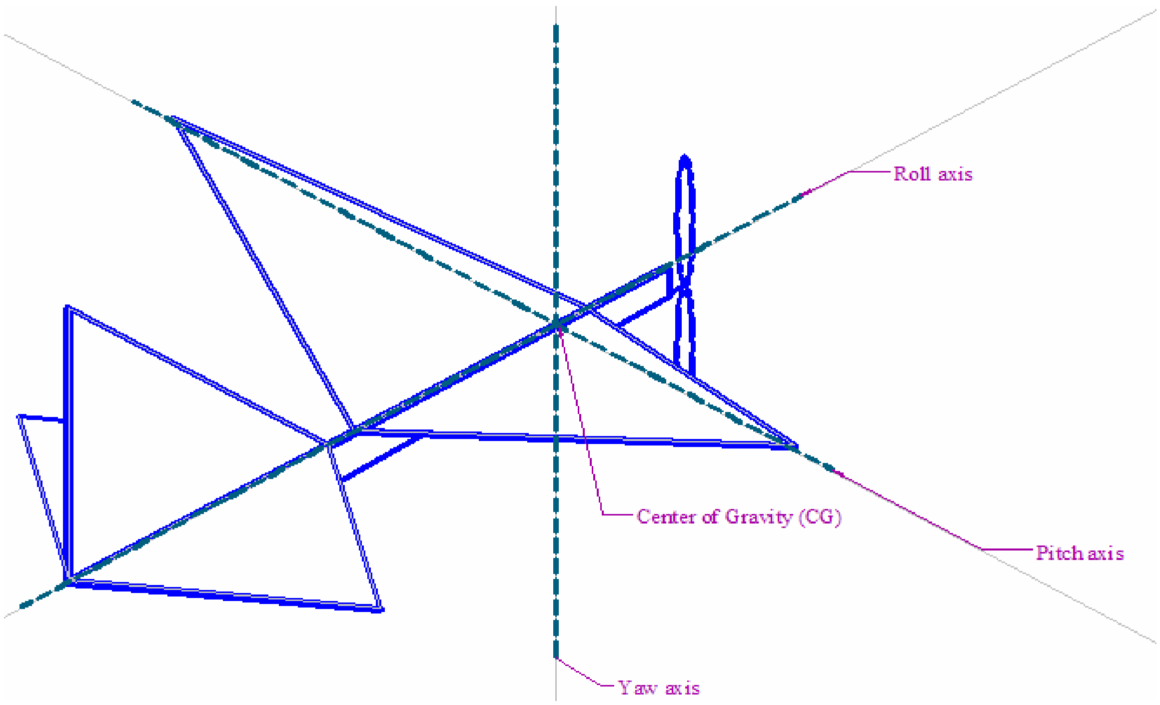
Another stability factor is the dihedral of the wings. Dihedral is the upward angle that the wings are inclined when viewed from the front. Dihedral angle and type can vary according to the type of airplane and what it is used for. Passenger aircraft tend to have a positive dihedral as pictured below. Military and aerobatic aircraft might have a neutral or negative dihedral to increase their maneuverability.



Control

The movements of an airplane are about three axes. The terms used to describe airplanes movements are yaw, pitch and roll. Yaw describes movements to the right or left, pitch describes movements up and down, and roll describes bank, or lean to the right or left.

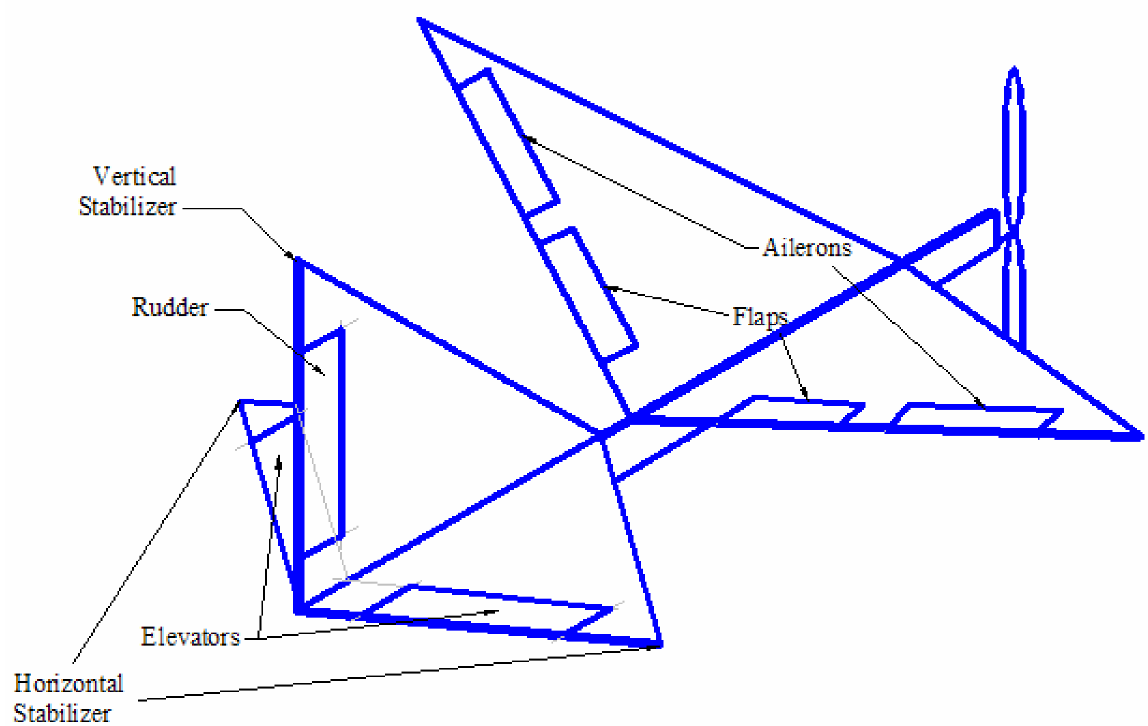
The center of gravity or CG is the point that the yaw, pitch, and roll axis intersect. On most planes the CG is slightly forward to achieve stability in normal, level flight. If the CG is too far to the rear the airplane will tend to want to fly with its nose too far up, which will result in a stall. If the CG is too far forward the airplane will dive.



Yaw is controlled by the rudder, which is located on the back of the vertical stabilizer. The rudder hinges right and left. Move the rudder right, the tail moves left and the nose of the plane moves right. Move the rudder left, the tail moves right and the nose moves left.

Pitch is controlled by the elevator, which is located on the back of the horizontal stabilizer. If the elevator moves up, the tail goes down and the nose pitches up. Move the elevator down, the tail goes up and the nose pitches down.

Roll is controlled by the ailerons, which are located on the back of the wings. The ailerons pivot up and down, but move opposite each other. If one is down, then the other goes up. They make the airplane bank into turns and are used with the rudder to change the direction of flight. If the combination is left up/right down the airplane will turn counterclockwise, or left. If the ailerons are left down/right up, the airplane will turn clockwise or right relative to the pilot's position.



The Delta Dart airplane has none of these control surfaces, but they can be added later depending on how the model flies. Delta Darts are known as "free flight" models. Their flight path is determined by adjustments made to control surfaces prior to the flight. A common flight characteristic is for the model to continuously stall. Stalls are caused by the plane climbing too steeply for the available power. Once it cannot go up any further, the nose drops, the plane dives, picks up speed and starts to climb again until it stalls and repeats the process. Another typical flight is a dive. The flight path is at a continuously downward angle until it contacts the ground. The last common flight pattern is the spiral dive. The plane dives while flying in a circle. All of these flight paths are considered undesirable, because they decrease flight times, but they can be corrected by adjusting the trim of the plane.

Adjusting the Flight Path

Some Delta Darts fly just as intended immediately. They require no further adjustments. Most however, need to have some corrections to fly as intended. Correcting the way an airplane flies is known as trimming the airplane. In general, the idea is to trim the model so that it stays in the air as long as possible. If the plane is flown indoors in a large room such as a gym, the flight path will need to be circular. Outdoors the flight path could be circular, or it could be a more of a straight line. Outdoors it is possible to find thermals, or rising columns of air, which can dramatically increase the time aloft, and the model could actually go out of sight.

Proper launch technique is important for a successful flight. If the plane is thrown with too much force it will stall immediately and have to recover, which will decrease its performance. Hold the plane by the fuselage with one hand and the propeller with the other. Release the propeller first, and then immediately toss the plane forward with a flick of the wrist. Again, don't throw it hard, it would be better just to release it without throwing at all.

There are two ways to adjust the planes trim once it is built. One way involves adding weight to the nose or the tail. If the plane climbs and stalls, add clay to the nose. If it dives, add clay to the tail. Adding clay means adding weight, which will degrade overall performance, but is necessary for a good flight path. For this reason it is important to get the wings glued on a close as to balanced as possible. Add the least amount of clay possible to correct the CG. Another way is to add the appropriate trim tabs to the trailing edges of the control surfaces. Only add the tabs that are needed. Remember, anything that adds weight to the plane or adds drag will decrease performance.

When flying indoors it is sometimes desirable to adjust the flight path so that the plane flies in a smaller circle to avoid walls. It can also correct the climbing and stalling condition without having to add weight to the plane. This can be accomplished by bending the prop slightly in the direction you wish the plane to turn. Alternately, add a rudder trim tab to the vertical stabilizer. Post-it notes make great trim tabs.

DESIGN BRIEF

You are to construct an airplane by following the instructions in the kit. Your challenge will be to keep the plane aloft for as long as possible by configuring the airplane so that it flies in specified flight paths or to correct the plane from flying in undesirable flight paths.

After you have flown your airplane, you will apply your knowledge by answering the following questions on the worksheets.

Lift Theories WS
Delta Dart Airplanes

Name____________________________

Many explanations for how lift is generated are incorrect and over simplify a complex interaction of forces. The Beginner's Guide to Aerodynamics is a "textbook" of information prepared at NASA Glenn Research Center to help you better understand aerodynamics. Type in http://www.lerc.nasa.gov/WWW/K-12/airplane/short.html to gain access the Aerodynamics Index. Open the slides called What Is Lift?, Incorrect Theory #1, Incorrect Theory #2, and Incorrect Theory #3 and read the explanations on lift and the popular incorrect theories on how lift is produced. Then using the information found in these slides, complete the following questions below designed to demonstrate your understanding of the theories.

1. Compare and contrast the incorrect lift theories #1 and #3.

2. Contrast the incorrect lift theories #2 and #3.

3. Which theory(ies) cannot explain why airplanes can fly upside down?

4. Which theory(ies) cannot explain why the upper surface of a wing has an effect on lift?

5. Which theory(ies) cannot explain why the air flowing past the lower surface of a wing has an effect on lift?

6. Explain the correct theory of lift in your own words.

Aerodynamics Review Worksheet 1 Name__________________________

Delta Dart Airplanes

Answer the following questions:

1. Name the major parts of an airplane and describe the function of each.

2. What are the four forces that affect powered flight? Describe each.

3. Compare and contrast the impact of the four forces that affect powered flight on a passenger aircraft and a military fighter jet. How are these forces managed differently in each design?

4. In your own words restate Bernoulli's Principle as it relates to generating lift on a plane's wings.

5. How does dihedral angle contribute to the stability of an aircraft?

Aerodynamics Review Worksheet 2 Name__________________________

Delta Dart Airplanes

Flight Configurations

1. How could you modify the design of the Delta Dart so that you can change its center of gravity without adding weight to its nose of tail?

2. What are the three axes of control? What direction does each axis affect?

3. What are the major control surfaces on an airplane, and how does each control surface affect a plane’s flight.

4. Describe what a stall is. Why do airplanes stall?

5. When in flight your Delta Dart continuously stalls. How can you trim the aircraft to correct this condition?

6. When in flight your airplane dives until it hits the ground. How can you trim the aircraft to correct this condition?

7. When in flight your airplane goes into a shallow spiral dive. How can you trim the aircraft to correct this condition?

Delta Dart Rubric — **Name____________________**
Technology I — **Class________**

Fabrication (100 points)

Paper is properly joined to wood	no 3 4 5 6 7 8 9 10
Wood joints are trimmed correctly and glued	no 3 4 5 6 7 8 9 10
Wood joints are firmly joined	no 3 4 5 6 7 8 9 10
Wings are approximately 1-1/4” from front edge of fuselage	no 3 4 5 6 7 8 9 10
Wings are firmly attached to fuselage	no 3 4 5 6 7 8 9 10
Dihedral angle is correctly formed	no 3 4 5 6 7 8 9 10
Propeller is properly balanced	no 3 4 5 6 7 8 9 10
Eyelet is securely attached to fuselage	no 3 4 5 6 7 8 9 10
Rubber band is attached properly	no 3 4 5 6 7 8 9 10

Craftsmanship (40 points)

Glue is not used as a structural element.	no 3 4 5 6 7 8 9 10
There is no excess glue on paper	no 3 4 5 6 7 8 9 10
There is no space between wood joints	no 3 4 5 6 7 8 9 10
Airplane is symmetrical about central axis	no 3 4 5 6 7 8 9 10
Plane completed on time. .	no 3 4 5 6 7 8 9 10

Work Ethic (100 points) — 20 40 60 80 100

Flight Characteristics (100 points)

_____Plane flies in a climbing turn
_____Plane flies level in a straight line
_____Plane flies in a straight line but does not climb
_____Plane flies poorly or dives into the ground
_____Plane continuously stalls

If the airplane is trimmed correctly it will fly in a climbing turn and do one or two complete circles before it comes back down. How will you trim your aircraft so that it flies in a climbing turn? Describe below:

____
____
____
____
____
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____
____
____
____

Sources

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System: Physical
ITEA Standard: 1, 2, 3, 18, 20
GPS: 1-19

Name: ______________________________

The Paper Roller Coaster

Every time you experience the thrills and chills of a roller coast, do you ever stop and think about how a roller coaster actually works? You are going to learn about the physics involved in roller coasters and then create a model out of basic materials.

Math Connections	Science Connections	Technology Connections
Physics Calculations	Physics	Construction

Tools, Materials and Supplies

1. 1 - 18" x 24" cardboard or poster board base
2. 24 - 3" x 5" index cards
3. 6 sheets of 8 1/2" x 11" copy paper
4. 24 strands of dry spaghetti
5. 1 ping-pong ball
6. 1 roll masking tape

Scissors
Ruler

Background Information

At first glance, a roller coaster is something like a passenger train. It consists of a series of connected cars that move on tracks. But unlike a passenger train, a roller coaster has no engine or power source of its own. For most of the ride, a roller coaster is only moved by the forces of inertia and gravity. The only exertion of energy occurs at the very beginning of the ride, when the coaster train is pulled up the first hill (called the lift hill).

The purpose of this initial ascent is to build up a sort of reservoir of potential energy. The concept of potential energy, often referred to as energy of position, is very simple: As the coaster gets higher in the air, there is a greater distance gravity can pull it down. You experience this phenomenon all the time -- think about driving your car, riding your bike or pulling your sled to the top of a big hill. The potential energy you build going up the hill can be released as kinetic energy, energy of motion, as soon as you start coasting down the hill.

The same thing happens in a roller coaster. When the coaster is released at the top of the first hill, gravity takes over. Gravity applies a constant downward force on the cars. The coaster tracks serve to channel this force -- they control the way the coaster cars fall. If the tracks slope down, gravity pulls the front of the car toward the ground, so it accelerates. If the tracks tilt up, gravity applies a downward force on the back of the coaster, so it decelerates.

Since an object in motion tends to stay in motion (Newton's first law of motion), the car will maintain a forward velocity even when it is moving up the track, opposite the force of gravity. When the coaster ascends one of the smaller hills that follows the initial lift hill, its kinetic energy changes back to potential energy. In this way, the course of the track is constantly converting energy from kinetic to potential and back again. This fluctuation in acceleration is what makes roller coasters so much fun.

In most roller coasters, the hills decrease in height as you move along the track. This is necessary because the total energy reservoir built up in the lift hill is gradually lost to friction between the train and the track, as well as between the train and the air. When the train coasts to the end of the track, the energy reservoir is almost completely empty. At this point, the train either comes to a stop or is sent up the lift hill for another ride.

Following is a list of physics terms associated with roller coasters that you need to become familiar with:

acceleration - Objects that are changing their speed or their direction are said to be accelerating. The rate at which the speed or direction changes is referred to as acceleration. Some amusement park rides (such as roller coasters) are characterized by rapid changes in speed and or direction. These rides have large accelerations. Rides such as the carousel result in small accelerations; the speed and direction of the riders change gradually.

balanced and unbalanced forces - A balanced force results whenever two or more forces act upon an object in such a way as to exactly counteract each other. As you sit in your seat at this moment, the seat pushes upward with a force equal in strength and opposite in direction to the force of gravity. These two forces are said to balance each other, causing you to remain at rest. If the seat is suddenly pulled out from under you, then you experience an unbalanced force. There is no longer an upward seat force to balance the downward pull of gravity, so you accelerate to the ground.

centripetal force - Motion along a curve or through a circle is always caused by a centripetal force. This is a force that pushes an object in an inward direction. The moon orbits the earth in a circular motion because a force of gravity pulls on the moon in an inward direction toward the center of its orbit. In a roller coaster loop, riders are pushed inwards toward the center of the loop by forces resulting from the car seat (at the loop's bottom) and by gravity (at the loop's top).

energy - Energy comes in many forms. The two most important forms for amusement park rides are kinetic energy and potential energy. In the absence of external forces such as air resistance and friction (two of many), the total amount of an object's energy remains constant. On a coaster ride, energy is rapidly transformed from potential energy to kinetic energy when falling and from kinetic energy to potential energy when rising. Yet the total amount of energy remains constant.

force - A force is a push or a pull acting upon an object. Forces result from interactions between two objects. Most interactions involve contact. If you hit the wall, the wall hits you back. The contact interaction between your hand and the wall results in a mutual push upon both objects. The wall becomes nicked (if hit hard enough) and your hand hurts. Bumper cars experience mutual forces acting between them due to contact during a collision. Some forces can act from a distance without actual contact between the two interacting objects. Gravity is one such force. On a free fall ride, there is a force of gravitational attraction between the Earth and your body even though the Earth and your body are not in contact.

friction - Friction is a force that resists the motion of an object. Friction results from the close interaction between two surfaces that are sliding across each other. When you slam on your brakes and your car skids to a stop with locked wheels, it is the force of friction that brings it to a stop. Friction resists the car's motion.

g - A g is a unit of acceleration equal to the acceleration caused by gravity. Gravity causes free-falling objects on the Earth to change their speeds at rates of about 10 m/s each second. That would be equivalent to a change in speed of 32 ft/s in each consecutive second. If an object is said to experience 3 g's of acceleration, then the object is changing its speed at a rate of about 30 m/s every second.

gravitational force - Any two objects with mass attract each other with a type of force known as a gravitational force. The strength of this force depends upon the mass of the two objects and the distance between them. For objects with masses as large as the earth and the sun, these forces are sizeable and have tremendous influence upon the subsequent motion. For objects such as two persons sitting in a theater, the force of gravitational attraction is so small that it is insignificant. In order for such persons to increase the force of attraction between them, they must add to their mass (maybe by eating more popcorn). Objects on the earth experience noticeable attractions with the earth due to the earth's large mass.

inertia - Inertia is a tendency of an object to resist change in its state of motion. More massive objects have more inertia; that is, they have more tendency to resist changes in the way they are moving. An elephant has a lot of inertia, for example. If it is at rest, it offers a large resistance to changes in its state of rest, and so it's difficult to move an elephant. On the other hand, a pencil has a small amount of inertia. It's easy to move a pencil from its state of rest. More massive objects have more inertia and thus require more force in order to change their state of motion.

kinetic energy - Kinetic energy is the energy possessed by an object because of its motion. All moving objects have kinetic energy. The amount of kinetic energy depends upon the mass and speed of the object. A roller coaster car has a lot of kinetic energy if it is moving fast and has a lot of mass. In general, the kinetic energy of a roller coaster rider is at a maximum when the rider reaches a minimum height.

mass - The mass of an object is a measurement of the amount of material in a substance. Mass refers to how much "stuff" is there. Elephants are very massive, since they contain a lot of "stuff."

momentum - Momentum pertains to the quantity of motion that an object possesses. Any mass that is in motion has momentum. In fact, momentum depends upon mass and velocity, or in other words, the amount of "stuff" that is moving and how fast the "stuff" is moving. A train of roller coaster cars moving at a high speed has a lot of momentum. A tennis ball moving at a high speed has less momentum. And the building you are in, despite its large mass, has no momentum since it is at rest.

Newton's First Law of Motion - An object at rest or in uniform motion in a straight line will remain at rest or in the same uniform motion unless acted upon by an unbalanced force. This is also known as the law of inertia.

Newton's Second Law of Motion - The acceleration of an object is directly proportional to the total unbalanced force exerted on the object, and is inversely proportional to the mass of the object (in other words, as mass increases, the acceleration has to decrease). The acceleration of an object moves in the same direction as the total force. This is also known as the law of acceleration.

Newton's Third Law of Motion - If one object exerts a force on a second object, the second object exerts a force equal in magnitude and opposite in direction on the object body. This is also known as the law of interaction.

potential energy - Potential energy is the energy possessed by an object because of its height above the ground. The amount of potential energy possessed by an object depends on its mass and its height. A roller coaster car is initially hauled by a motor and chain system to the top of a tall hill, giving it a large quantity of potential energy.

speed - Speed is a measurement of how fast an object is moving. Fast-moving objects can cover large distances in a small amount of time. They are said to have a high speed. A roller coaster car moving at 60 miles per hour would be able to cover a distance of 60 miles in one hour if it could maintain this pace.

velocity - The velocity of an object refers to the speed and direction in which it moves. If you drive north to your work place and your speedometer reads 35 miles per hour, then your velocity is 35 miles per hour in a northward direction. Velocity is speed with a direction and is important in understanding bumper car collisions.

weight - Weight is a measurement of the gravitational force acting on an object. The weight of an object is expressed in pounds in the U.S. A 180-pound person is experiencing a force of gravitational attraction to the earth equal to 180 pounds.

weightlessness - Amusement park rides often produce sensations of weightlessness. These sensations result when riders no longer feel an external force acting upon their bodies. At the top of the tower of a free-fall ride, a 100-pound rider would feel 100 pounds of force from the seat pushing as an external force upon her body. The rider feels her normal weight. Yet, as she falls from the tower, the seat has fallen out from under her. She no longer feels the external force of the seat and subsequently has a brief sensation of weightlessness. She has not lost any weight, but feels as though she has because of the absence of the seat force. In this context, weightlessness is a sensation and not an actual change in weight.

Practice Problems

Kinetic Energy = ½ mass(speed of object)^2
1 Joule is equivalent to 1 kg*(m/s)^2
Power = Work / Time
Power = Force * Velocity
Power = (Force * Displacement) / Time

1. Determine the kinetic energy of a 1000-kg roller coaster car that is moving with a speed of 20.0 m/s.

2. If the roller coaster car in the above problem were moving with twice the speed, then what would be its new kinetic energy?

3. A 750-kg compact car moving at 100 km/hr has approximately 290 000 Joules of kinetic energy. What is the kinetic energy of the same car if it is moving at 50 km/hr?

4. Two technology students, Will N. Andable and Ben Pumpiniron, are in the weightlifting room. Will lifts the 100-pound barbell over his head 10 times in one minute; Ben lifts the 100-pound barbell over his head 10 times in 10 seconds. Which student does the most work? Which student delivers the most power? Explain your answers.

5. During the Personal Power lab, Jack and Jill ran up the hill. Jack is twice as massive as Jill; yet Jill ascended the same distance in half the time. Who did the most work? Who delivered the most power? Explain your answers.

6. When doing a *chin-up*, a physics student lifts her 40-kg body a distance of 0.25 meters in 2 seconds. What is the power delivered by the student's biceps?

7. An escalator is used to move 20 passengers every minute from the first floor of a department store to the second. The second floor is located 5-meters above the first floor. The average passenger's mass is 60 kg. Determine the power requirement of the escalator in order to move this number of passengers in this amount of time.

Review Questions

1. What two forces control a roller coaster after the initial climb?

2. What is the difference between potential and kinetic energy?

3. What role does gravity play in the movement of roller coaster cars along the track?

4. Why do most roller coaster hills decrease in height during the length of the ride?

5. Explain Newton's three laws of motion. How do they compare? How do they differ?

6. What is the difference between speed and velocity?

7. What is the difference between weight and mass?

8. What is a force? What is an example of a force?

9. What is the difference between balanced and unbalanced forces?

10. What is a "g"?

Constructing a Paper Coaster

Design Brief

Students will design and construct a device that will control the fall of a ping-pong ball, allowing the ball to roll as quickly as possible.

Materials (Team of 2 or 3 students)
1 - 18" x 24" cardboard or poster board base
24 strands of dry spaghetti
24 - 3" x 5" index cards
1 ping-pong ball
6 sheets of 8 1/2" x 11" copy paper
1 roll masking tape

Tools
Scissors
Ruler

Constraints

1. You may use only the materials provided
2. The ball must start in one corner of the base and, change directions at least 3 times.
3. The ball must come to a resting point at any corner other than the one it started from.
4. There must be a triggering mechanism that can be released to start the ball. The triggering mechanism must be able to be reset for multiple tests.

Instructions

1. Sketch the design/plan for your device.
2. Attain needed materials from your instructor.
3. Construct your device.

Testing

1. A stopwatch will used to time the fall of each ball.
2. Once the ball has begun its journey, no one may touch the ball.
3. Students will be allowed to place the ball at the starting position and release the starting mechanism.
4. Each device will have three attempts and each time will be recorded.
5. Time will begin when the ball is released from point A and end when the ball stops at point B.
6. Appearance and construction will be considered in grading.

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standard: 1, 2, 3, 20
GPS: 1-19

Name: ______________________________

The Straw Tower

In this activity, students will gain an understanding of the basic history and construction principles for skyscrapers and tower development. Students will apply learned knowledge to build a tower using straws.

Math Connections	Science Connections	Technology Connections
Geometry	Physics	Construction
Trigonometry	Metallurgy	
Ratios		

Tools, Materials and Supplies

1. 100 - Plastic Straws per team
2. Straight Pins (many)
3. 1- Tennis Ball for Testing

Background Information

Throughout the history of architecture, there has been a continual quest for height. Thousands of workers toiled on the pyramids of ancient Egypt, the cathedrals of Europe and countless other towers, all striving to create something awe-inspiring. People build skyscrapers primarily because they are convenient -- you can create a lot of real estate out of a relatively small ground area.

Up until relatively recently, we could only go so high. After a certain point, it just wasn't feasible to keep building up. In the late 1800s, new technology redefined these limits. Suddenly, it was possible to live and work in colossal towers, hundreds of feet above the ground.

The main obstacle in building upward is the downward pull of gravity. Imagine carrying a friend on your shoulders. If the person is fairly light, you can support them pretty well by yourself. But if you were to put another person on your friend's shoulders (build your tower higher), the weight would probably be too much for you to carry alone. To make a tower that is "multiple-people high," you need more people on the bottom to support the weight of everybody above.

This is how "cheerleader pyramids" work and it's also how real pyramids and other stone buildings work. There has to be more material at the bottom to support the combined weight of all the material above. Every time you add a new vertical layer, the total force on every point below that layer increases. If you kept increasing the base of a pyramid, you could build it up indefinitely. This becomes infeasible very quickly, of course, since the bottom base takes up too much available land. In normal buildings made of bricks and mortar, you have to keep thickening the lower walls as you build new upper floors. After you reach a certain height, this is highly impractical. If there's almost no room on the lower floors, what's the point in making a tall building?

Using this technology, people didn't construct many buildings more than 10 stories -- it just wasn't feasible. But in the late 1800s, a number of advancements and circumstances converged, and engineers were able to break the upper limit -- and then some. The social circumstances that led to skyscrapers were the growing metropolitan American centers, most notably Chicago. Businesses all wanted their offices near the center of town, but there wasn't enough space. In these cities, architects needed a way to expand the metropolis upward, rather than outward.
The main technological advancement that made skyscrapers possible was the development of mass iron and steel production. New manufacturing processes made it possible to produce long beams of solid iron. Essentially, this gave architects a whole new set of building blocks to work with. Narrow, relatively lightweight metal beams could support much more weight than the solid brick walls in older buildings, while taking up a fraction of the space. With the advent of the Bessemer process, the first efficient method for mass steel production, architects moved away from iron. Steel, which is even lighter and stronger than iron, made it possible to build even taller buildings.

The central support structure of a skyscraper is its steel skeleton. Metal beams are riveted end to end to form vertical columns. At each floor level, these vertical columns are connected to horizontal girder beams. Many buildings also have diagonal beams running between the girders, for extra structural support. In this giant three-dimensional grid -- called the super structure -- all the weight in the building gets transferred directly to the vertical columns. This concentrates the downward force caused by gravity into the relatively small areas where the columns rest at the building's base. This concentrated force is then spread out in the substructure under the building. In a typical skyscraper substructure, each vertical column sits on a spread footing. The column rests directly on a cast-iron plate, which sits on top of a grillage. The grillage is basically a stack of horizontal steel beams, lined side-by-side in two or more layers (see diagram, below). The grillage rests on a thick concrete pad poured directly onto the hard clay under the ground. Once the steel is in place, the entire structure is covered with concrete.

This structure expands out lower in the ground, the same way a pyramid expands out as you go down. This distributes the concentrated weight from the columns over a wide surface. Ultimately, the entire weight of the building rests directly on the hard clay material under the earth. In very heavy buildings, the base of the spread footings rest on massive concrete piers that extend all the way down to the earth's bedrock layer.

One major advantage of the steel skeleton structure is that the outer walls -- called the curtain wall -- need only to support their own weight. This lets architects open the building up as much as they want, in stark contrast to the thick walls in traditional building construction. In many skyscrapers, especially ones built in the 1950s and '60s, the curtain walls are made almost entirely of glass, giving the occupants a spectacular view of their city.

Once you get more than five or six floors, stairs become a fairly inconvenient technology. Skyscrapers would never have worked without the coincident emergence of elevator technology. Ever since the first passenger elevator was installed in New York's Haughwout Department Store in 1857, elevator shafts have been a major part of skyscraper design. In most skyscrapers, the elevator shafts make up the building's central core.

Figuring out the elevator structure is a balancing act of sorts. As you add more floors to a building, you increase the building's occupancy. When you have more people, you obviously need more elevators or the lobby will fill up with people waiting in line. But elevator shafts take up a lot of room, so you lose floor space for every elevator you add. To make more room for people, you have to add more floors. Deciding on the right number of floors and elevators is one of the most important parts of designing a building.

Building safety is also a major consideration in design. Skyscrapers wouldn't have worked so well without the advent of new fire-resistant building materials in the 1800s. These days, skyscrapers are also outfitted with sophisticated sprinkler equipment that puts out most fires before they spread very far. This is extremely important when you have hundreds of people living and working thousands of feet above a safe exit.

Architects also pay careful attention to the comfort of the building's occupants. The Empire State Building, for example, was designed so its occupants would always be within 30 feet (ft) of a window. The Commerzbank building in Frankfurt, Germany has tranquil indoor garden areas built opposite the building's office areas, in a climbing spiral structure. A building is only successful when the architects have focused not only on structural stability, but also usability and occupant satisfaction.

Math Connections: Estimating the Height of a Tall Tower

There are several different techniques you can use depending on where the tower is located. These same techniques can be used to measure trees in your yard, mountains, tall buildings in downtown areas and so on. Following are three of the most commonly used techniques:

First Technique - If the tower is sitting in the middle of a flat field, probably the easiest technique is to use its shadow on a sunny day. Take a broomstick, a hammer and a measuring tape with you. Pound the broomstick into the ground a few inches so it stands up on its own. If you are patient, you can wait until the length of the broomstick's shadow is equal to the length of the visible broomstick and then go measure the length of the tower's shadow. The length of the shadow tells you the height of the tower directly.

If you are impatient, you can:

1. Measure the length of the broomstick's shadow.
2. Calculate the ratio of the broomstick's shadow length to the broomstick's height.
3. Measure the tower's shadow.
4. Apply the ratio to discover the tower's height.

Example

If the broomstick's shadow measures 3 feet and the actual length of the broomstick measures 4 feet, then the ratio of the broomstick shadow's to the actual length of the broomstick is 3:4 or ¾ . Suppose the length of the tower's shadow is 60 feet and x represents the actual height of the tower, then $3/4 = 60/x$, so $3 * x = 4 * 60$ or $3x = 240 \rightarrow x = 80$ feet. The actual height of the tower is 80 feet.

Second Technique - For the second technique you need a drinking straw, a protractor, some scotch tape and a measuring tape. Tape the drinking straw to the protractor at the 45 degree angle mark. Hold the protractor with its flat side level with the horizon and then sight through the drinking straw. Walk a distance away from the tower until you can see the top of the tower through the straw. Since you are sighting the top of the tower at a 45-degree angle, your distance from the tower is equal to the height of the tower. Measure your distance from the tower and you know its height.

Third Technique - For the third technique you need a protractor, drinking straw, tape measure and a calculator that will handle trigonometric functions. Stand somewhere where you can easily measure your distance to the tower. Sight through the drinking straw and find the top of the tower, and then measure the angle between the straw and the horizon using the protractor. Let's say the angle is 55 degrees, and the distance to the base is 200 feet, then the equation is:

Height of tower = distance from tower * tan(angle)
Height of tower = 200 feet * tan(55 degrees) = 200 feet * 1.43 = 286 feet

In this example, the height of the tower is 286 feet. Don't forget to add the height of the protractor when you measure the angle to the height of the tower.

Estimate the following using either procedure

1. The height of your school

2. The height of a tree in the schoolyard

3. The height of the school's flagpole

4. The height of a telephone pole

5. The height of one of the goal posts on the football field.

Science Connections: Metallurgy

As you have read in the background information above, mass steel production has been the major technological advancement allowing us to continually build taller, safer skyscrapers.

Assignment: Create a PowerPoint presentation explaining how steel is produced. Be sure to begin with the mining of iron ore and continue step by step through the process.

Constructing a Paper Coaster

Design Brief

Students will build a straw tower as tall as possible that can support the weight of a tennis ball.

Materials (Per Group)

100 - Plastic Straws
Straight Pins (many)
1 Tennis Ball (for testing)

Constraints

1. The students will use only the materials provided.
2. The students may not cut the straws.
3. The tower must support the tennis ball for 30 seconds.

Procedure

1. Groups of 3 students work best.
2. The students will draw a design for their tower.
3. The students will then obtain 100 straws and a container of pins from the instructor.
4. The students will build their structure.
5. The instructor will test the towers at the end of the allotted time frame (usually 3 to 5 days).

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standard: 1-3, 11, 16, 20
GPS: 1-14

Name: ______________________________

Insulation

Whether you live in Maine or South Georgia, your home will be more comfortable and energy efficient with the right insulation. Insulation helps reduce the costs of heating and cooling your home. Here's how: Heat travels. In the winter, heat flows out; in the summer, heats flow in. A properly insulated home reduces heat flow, using less energy in the winter for heating and less energy in the summer for cooling. That could mean money in your pocket. In this activity students will gain an understanding of how heat transfers and how to calculate the R-Value of insulation. They will then have an opportunity to experiment with this new knowledge by testing and analyzing insulation materials using ice cubes and plastic cups.

Math Connections	Science Connections	Technology Connections
Measurement	Heat Transfer	Insulators
Using formulas	Radiation	Construction
	Conduction	
	Convection	

How Heat is Transferred

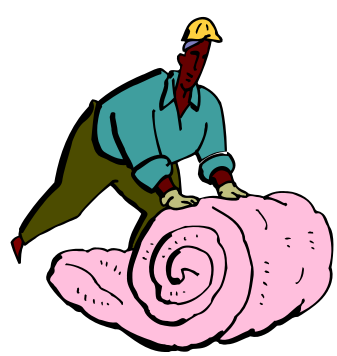
Since 50% to 70% of the energy used in the average home in North America is for heating and cooling. It makes sense to use thermal insulation to reduce the energy consumed and increase comfort and save money.

The performance of any thermal insulation system depends on how well it reduces heat flow. Heat moves from warm locations to cool locations in three ways:

· By radiation from surface to surface through an air space,

· By conduction through solid or fluid materials,

· By convection which involves the physical movement of the air.



R-Value

When buying insulation, look for the "R-value." "R" means resistance to heat flow. The higher the R-value, the greater the insulation power. The R-value must be disclosed for most insulation products. For instance, if you buy loose-fill insulation with an R-value of 38 from Company A, it will have the same insulating power as loose-fill insulation with an R-value of 38 from Company B. You also can compare the R-value of one type of insulation to another, such as loose-fill to blanket.

Several factors affect the R-value your home needs:

- Where you live - You'll need a higher R-value if you live in the Northeast than if you live in Southern California.
- How your home is built - For example, is it a single-level or multi-level structure? Do you have cathedral ceilings? Is there a basement or is your home built on a slab?
- How you heat and cool your home - Do you have a furnace, a central air conditioner, or a heat pump?

It's more efficient to use insulation with higher R-values in the attic and in rooms with cathedral ceilings than in wood frame walls and basements or crawl spaces with walls

The FTC is responsible for enforcing the R-value Rule. The Rule ensures that you get information about the R-value of your insulation before you buy it, have it installed, or buy a new home. Manufacturers must label their packages of insulation; installers and retailers must provide fact sheets; and new home sellers must include this information in sales contracts.

Calculating R-Value

Building materials and insulation have a “U” value, which is the total heat conductance or transfer of heat. The “R” or resistance value is also used to identify how well something is insulated. The formula for calculating R-value is R=1/U.

To find the amount of heat loss a material has, use the formula U=1/R.

To calculate the total ‘U’ for a combination of materials, use the formula:

Total U = 1/ R1+R2+R3

Design Brief

In this activity, students are to create environments for ice cubes using a variety of insulation materials. After doing this, students will then test to determine which material used as insulation was best by calculating the difference in the amount of water collected after a determined period of time from each cube.

Materials

Strips of newspaper

Strips of cloth

Plastic sandwich bags (sealable)

Scissors

Ice cubes

Plastic cups

Foam packing material

Measuring cup

Procedure

1. Place 2 ice cubes in 4 different plastic bags and seal after squeezing the air out of them.

2. Package each plastic bag in a plastic cup using a different insulation material for each one. Be sure that you surround the bag completely with material. The 4th cup should have not insulation.

3. Place all cups in a warm place and leave them there for 30 minutes.

4. After this period of time has passed, retrieve the plastic bag from the insulated container you created, measure the water in each bag, and record that amount.

Questions

1. Which material worked best as an insulator?______________________________

2. Could you have packaged the materials differently that would maximize their insulating capabilities? If so, how?
____
____
____

3. Calculate the difference in the amount of water that drained from your best-insulated container and your insulated container. _________________________________

4. If the newspaper had a U value of 3, what would be its R-value? ___________

5. If the cloth had a U value of 2, what would be its R-value? _______________

6. If the foam had a U value of 5, what would be its R-value? ________________

7. If you were to insulate a container with all 3 materials, what would be the total U value?
____

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standard: 3, 10, 11
GPS: 236, 251, 252, 253, 277

Name: _____________________________

Diving and Surfacing Submarines

In this activity, students will build and test a model of a submarine. Students will develop an understanding of the scientific principles that allow a vehicle to successfully submerge and return to the surface.

Math Connections	Science Connections	Technology Connections
Measurement	Buoyancy	Design
Surface area	Density	Construction
Volume	Archimede's Principle	Transportation technology
	Mass	

Introduction

Submarines play a key role in our countries national defense and are used widely as a research platform. Have you ever wondered how a submarine successfully dives and resurfaces? Submarines use large tanks called buoyancy tanks to assist in this process.

When you look at a boat floating on top of the water you are looking at an example of buoyant force. As the boat sinks into the ocean it displaces water. When the boat displaces the amount of water equal to its entire weight, it stops sinking and a large part of the boat remains out of the water. Water is a lot heavier than the combination of steel, people, and air that make up a boat. Therefore most of the boat remains above the water.

A submarine floats for the same reason a boat does. But with a submarine you want to be able to sink and surface quickly. It is therefore important for designers that the density of the submarine be close to the density of water. Then design a way for the submarine to change density. The submarines have ballast tanks that allow them to change density rapidly. The main ballast tank is located in the hull. The auxiliary and trim tanks are in the interior of the submarine.

The submarines pilot can fill the ballast with water or air. When the tanks are filled with air the submarine is light enough to float. This is termed positive buoyancy. Fill the tanks with water and the submarine becomes heavier and begins to sink. If the amount of water and air is perfectly balanced a submarine can hover in mid-ocean. This is termed as neutral buoyancy.

Terms and formulas to know

Positive buoyancy is when tanks are full of air so that a submarine is light enough to float.

Displacement is the weight or volume of air, water, or other fluid displaced by an object.

Buoyant force is the upward force exerted on an object immersed in a fluid.

Archimedes Principle states that the buoyant force on an object is equal to the weight of the fluid displaced by the object.

Density is the physical property of matter that can be found by dividing the matter's mass by its volume.

Density = mass / volume

Weight of water = 62 lbs per cubic ft

Design Brief

You will construct a model of a submarine and its ballast tanks. The model will demonstrate buoyancy and Archimedes principle. You will dive, surface, and hover your submarine at neutral buoyancy. You will also measure and calculate the amount of water displaced by your model. Follow the procedures below to construct and test your submarine.

Materials needed

Large plastic bottle
Sand
Plastic funnel
Two small plastic bottles
Awl
Scissors
Ruler
Two plastic straws
Rubber bands
Modeling clay
Two small bulldog clips

Procedures

1. Fill the large plastic bottle with sand with the funnel. Fill it until it sinks in a tank of water. Test the bottle to find out the right amount of sand.

2. Make a large hole about ½" across in the side of two small bottles. On the other side make a small hole, big enough to fit a plastic straw.

3. Attach the two small bottles to either side of the large bottle using rubber bands. Twist the small bottles so that the small hole on each one points upward.

4. Push a plastic straw into each small hole so that a bit pokes through. Seal around the base of the straws with modeling clay to make a water tight seam.

5. Put a small bulldog clip about halfway down each straw. The clips need to be strong enough to squash the straw and stop air from being forced out by the water.

6. Put your model submarine in a tank of water. With the clips on, it should float. Remove the clips and water will flood the buoyancy tanks. The submarine will sink.

7. To make the submarine surface again, blow slowly into both straws at once. The air will force the water out of the buoyancy tanks, and the submarine will rise to the surface.

8. When your model submarine has resurfaced, keep blowing slowly into the tanks. Replace each bulldog clip, and your model submarine will remain floating on the surface.

9. Final adjustments: This submarine model may sink bow first or stern first. If this is the case, level it by shaking the sand evenly inside the bottle.

Questions

What can you do to make this model work better.

What other materials can you use to get similar results?

Try some different approaches using the above principles and discuss your results.

Solve the following math problems.

1. The USS Jimmy Carter was commissioned on February 12, 2005. This submarine is the third and last of the *Seawolf*-class submarine. The displacement of the USS Jimmy Carter is 12,139 tons fully loaded with supplies and crew.

   a. What is its density?

   b. How much water is displaced when it is fully submerged?

2. Referring to your model, measure how many inches the water level rises when your model is fully submerged.

   a. Calculate the surface area of your model.

   b. Calculate the volume of your ballasts.

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standard: 1-3, 5, 15, 18
GPS: 1-19

Name: ______________________________

The Cardboard Boat Race

In this activity, a team of three students will construct a two-person cardboard boat. After learning about buoyancy, students will apply their knowledge by constructing a boat that will stay afloat.

Math Connections	Science Connections	Technology Connections
Surface Area	Buoyancy	Construction
Measurement	Archimedes Principle	Design
Displacement	Weight	

Tools, Materials and Supplies

Cardboard
Duct Tape
Utility Knife
Tape Measure
Stop Watch

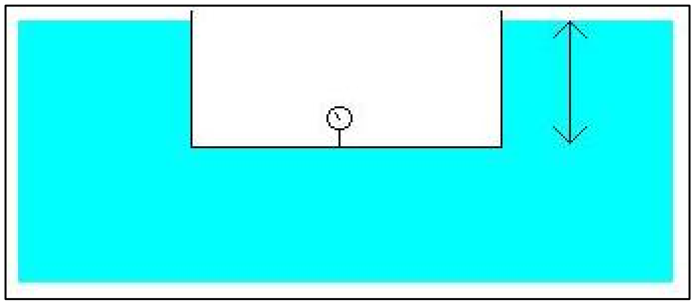
Background Information

Buoyancy is defined as the tendency or capacity to remain afloat in a liquid or rise in air or gas. What causes an object to float? The standard definition of floating was first recorded by Archimedes and goes something like this: An object in a fluid experiences an upward force equal to the weight of the fluid displaced by the object. So if a boat weighs 1,000 pounds, it will sink into the water until it has displaced 1,000 pounds of water. Provided that the boat displaces 1,000 pounds of water before the whole thing is submerged, the boat floats.

It is not very hard to shape a boat in such a way that the weight of the boat has been displaced before the boat is completely underwater. The reason it is so easy is that a good portion of the interior of any boat is air. The average density of a boat -- the combination of the building material (wood, steel, etc.) and the air is very light compared to the average density of water. So very little of the boat actually has to submerge into the water before it has displaced the weight of the boat.

The next question to ask involves floating itself. How do the water molecules know when 1,000 pounds of them have gotten out of the way? It turns out that the actual act of floating has to do with pressure rather than weight. If you take a column of water 1 inch square and 1 foot tall, it weighs about 0.44 pounds depending on the temperature of the water. That means that a 1-foot-high column of water exerts 0.44 pounds per square inch (psi).

If you were to submerge a box with a pressure gauge attached (as shown in this picture) into water, then the pressure gauge would measure the pressure of the water at the submerged depth:



If you were to submerge the box 1 foot into the water, the gauge would read 0.44 psi. What this means is that the bottom of the box has an upward force being applied to it by that pressure. So if the box is 1 foot square and it is submerged 1 foot, the bottom of the box is being pushed up by a water pressure of (12 inches * 12 inches * 0.44 psi) 62 lbs/ft^3. This just happens to exactly equal the weight of the cubic foot of water that is displaced! It is this upward water pressure pushing on the bottom of the boat that is causing the boat to float. Each square inch (or square centimeter) of the boat that is underwater has water pressure pushing it upward, and this combined pressure floats the boat.

Review Questions

1. What is the definition of buoyancy?____

____

2. According to Archimedes, what is the definition of float?

____

____

3. When will a fifty pound boat stop sinking in the water?

____

____

4. Why is it so easy to shape a boat so that it will easily float?

____

____

5. How does the average density of a boat compare to the average density of water?

____

____

6. What is the actual act of floating caused by?

____

____

<u>Determining Weight Displacement</u>

Before your team designs and constructs your boat, your team will need to do some planning with respect to Archimedes Principle, surface area of your boat, depth of the boat, and weight load of the boat. Using the information given above, calculate the following:

1. Surface area of your boat ___________________________
2. Weight load of the boat ___________________________
3. Depth of the boat ___________________________
4. Displacement of water ___________________________

Building a Cardboard Boat

Design Brief

Teams of three students are to design and build a boat made completely from corrugated cardboard and standard duct tape that will carry two members of their team the length of a designated swimming pool in as short a time as possible.

Constraints

- You may only use the provided cardboard and duct tape
- For this challenge, a boat is defined as a vessel with at least 3 sides and a bottom.
- Paddles/oars must also be made from cardboard and duct tape.
- Where the crew sits CAN NOT BE ENCLOSED (the boat crew must be able to get in and out of the boat easily).
- SURFBOARD style designs are NOT ALLOWED. Consider "staying dry" as part of the challenge.
- You may not use duct tape to completely wrap or encase the boat.
- Duct tape is only allowed to reinforce seams and such.
- Boats will be graded based on fastest time and best design.
- Be sure to recycle all cardboard after the race.

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standard: 1-3, 20
GPS: 1-14, 39, 40

Name: ______________________________

Skateboarding

After learning about the physics associated with skateboarding, students will construct a miniature skateboarding park out of various materials.

Math Connections	Science Connections	Technology Connections
Circumference	Work	Construction
Radius	Energy	Problem Solving
Area of a circle	Centripetal force	

Skateboarding History

The skateboard wasn't invented by just one person. It was a way to practice water surfing without water. The first skateboarding wheels were made for rough terrain. After the skateboards were outlawed, the parks were closed down. Then the street wheel was invented but the inventor is unknown.

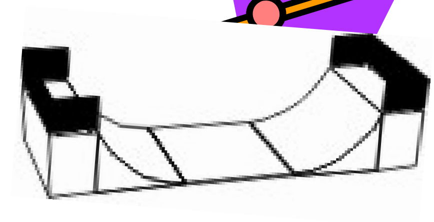
Definitions for Skateboarding

Below are a few terms that have to first be understood in order to learn about the physics of skateboarding.

- Half pipe: a U-shaped ramp of any size, usually with a flat section in the middle
- Centripetal force: a force that keeps a body moving in a circular path
- Rotational inertia: a measure of an object's resistance to being turned, depending on both the mass of the object and how that mass is distributed
- Work: force applied over a distance—for example, you do work when you push a box across the floor. No work is done when you push on a locked door because work done on an object or system results in an increase in the energy of that system.

Skating in a half-pipe

Skateboarders in half-pipes have a need for speed.
The faster they go, the higher they can rise out of the pipe. Achieving greater heights is not only impressive on its own; it's necessary for pulling off acrobatic tricks.



On flat ground, the conventional method for gaining speed is to push off with one foot, but half-pipes present a much more elegant option for the speed-hungry skater. It's called pumping.

To pump in a half-pipe, a skater first drops down into a crouch while traversing the flat bottom of the U-shaped pipe. Then, as she enters the sloped part of the ramp, called the transition, she straightens her legs and rises up. By raising her center of mass just at the beginning of the ramp's arc, the skater gains energy and thereby increases her speed.

Pumping in a half-pipe is closely related to pumping on a swing. To get the swing to go higher, you lift your legs as you pass through the bottom of the swing's arc, then drop them at the top of the arc. Each time you do this, you gain a little energy and swing a little higher.

From a physics point of view, the extra speed that comes from both kinds of pumping is a result of the equivalence of work and energy. As you move into the bottom of the arc, centripetal force makes it harder than normal for you to raise yourself. The net work you perform in lifting yourself is equivalent to a net energy gain. This energy gain translates into extra speed and greater height at the top of the swing or ramp.

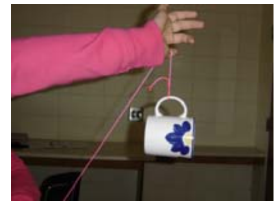
Try this simple demonstration. It shows how lifting an object can increase the height of its swing.

1. Tie a few feet of string to the handle of a plastic coffee mug (or any other unbreakable object onto which you can tie a string). Tie the string good and tight so the mug doesn't fly off when you swing it.

2. Holding the free end of the string in your left hand, enclose the string in a loose fist with your right hand, leaving enough space at the center of your fist for the string to slide freely. The mug should now be dangling below your right hand.

3. With a small push or kick, start the mug swinging slightly.

4. Keeping your right hand perfectly still, pull the string sideways with your left hand to lift the mug just after it passes through the bottom of its arc. Then, when the mug is at the top of its swing, let the mug drop back down by releasing some of the string.



5. If you continue to lift and drop the mug this way, you'll find you can get it to swing higher and higher. This method of adding energy is the same one used by skaters moving on the curved surface of a half-pipe.

Math Application

1. If a half-pipe has a radius of 20 feet, what is its diameter?__________________________

2. What is the area of a half-pipe if it has a diameter of 30 feet?________________________

3. What would be the circumference of a half-pipe if the radius is 16 feet?______________

Design Brief

Create a skateboarding half- pipe out of materials provided by your teacher (example: cardboard, foam board, clay, glue) that can be used with a "finger" skateboard (3 ¾" x 1"). The half-pipe must be your own design and fit on a 30" x 20" base. It needs to be accurately scaled. You must include coping on both sides that is wide enough for the mini skateboard.

Questions

1. What is the radius of your half-pipe?________________

2. What is the diameter?__________________

3. What is the area of two of them combined?_________________

4. What is the circumference of two of them combined?__________________

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standard: 8, 9, 10, 18, 20
GPS: 1-5, 23–25, 50–53, 67-75

Name: ______________________________

Hovercraft Vehicles

In this activity, students will build a couple of simple hovercrafts that will allow them to understand the concepts of design, construction, and how a hovercraft works. There are many hovercraft activities for students to design and construct. They range from very sophisticated and complex ones to relatively simple ones. More complex models can be constructed from cardboard or plywood, and use a motor from a vacuum cleaner engine to provide the air supply.

Math Connections	Science Connections	Technology Connections
Measurement	Friction	Transportation Systems
Averaging	Newton's Law of Motion	Design
	Speed	Construction
	Drag	

Background Information

The hovercraft was invented by Christopher Cockerell in 1956. His idea was to build a vehicle that would move over the water's surface by floating on a layer of air. The air would reduce friction between the water and vehicle. He tested his invention by putting a smaller can inside a larger can, and used a hairdryer to blow air into them. The downward thrust produced was greater when one can was inside the other, rather than air just being blown into one can. Experiments on hovercrafts began as a way to try to reduce the drag that was placed on boats as they traveled through the water.

A hovercraft is an amphibious vehicle that moves (or floats) on a small cushion of air and can operate on water or land. Hovercraft vehicles have large fans that create a pocket of air under the vehicle. This force of air allows the vehicle to rise off the surface of land or water, and to actually float on the air cushion under it. The air cushion eliminates almost all friction between the vehicle and the surface it is on. Most people can relate to the floating on air principle by thinking of an air hockey game. The air blows up from under the table, and the hockey puck travels by floating on air across the table.

A small hovercraft would have at least one engine attached to the fan on it. Most hovercraft, however, use a dual engine system where one large engine is used for thrust and another, smaller engine is dedicated to lift. This allows the craft to remain hovering while the thrust engine is turned off. Larger, commercial craft may use as many as six or eight engines for power of the lift and thrust systems. Engines are usually diesel or gas turbines.

Hovercrafts have a large skirt around them to trap the air underneath them. This air cushion underneath the hovercraft is called the plenum chamber. This plenum chamber is formed by the bottom of the craft and the skirt material. Inside this chamber, the air flow forms a ring of air that circulates around the base of the skirt. This ring helps to insulate the air cushion from the air outside the skirt. The outside air will have a lower air pressure than the air under the skirt inside the plenum chamber. This ring of air also keeps the air under the craft from escaping thus allowing the vehicle to float on air. Most large commercial hovercraft vehicles are propelled by a large propeller attached to the back of the vehicle. Hovercraft vehicles can be propelled by a variety of sources including: air propellers, screw propellers, and water jets.

Large commercial hovercraft vehicles are steered by rudders attached to the propeller's housing. These would be similar in concept to an airplane rudder. Other hovercrafts use 'puff ports' or dual thrust fans that turn on and off to turn in the direction desired. These thrusts of air are similar to the way canoes change directions by moving water around with the paddles.

Hovercraft vehicles can provide water transportation for trips that are short in distance. Technology has allowed these vehicles to progress so they are now being used as a transportation system across the English Channel. Hovercraft vehicles are not used to travel over large bodies of water because they have a very limited air-generating capacity. Hovercraft vehicles are also used as rescue vehicles and small versions can be used as recreational vehicles. Hovercrafts can travel on land, but are not allowed on public streets and do not require a driver's license. Some examples of hovercraft types are shown below:

Single person hovercraft

Recreational hovercraft

Remote control hovercraft

Hovercrafts on land

Hovercrafts should not be confused with hydrofoils. A hydrofoil is a boat type vessel that skims over the water at a high speed. The hull of this boat stands on wing-shaped structures called hydrofoils. As the boat gains speed the hydrofoils lift the boat up and off the surface of the water. Hydrofoils are also used as commercial ferries. Hydrofoils can be propelled by water jets and propellers.

The pictures below show how a hovercraft and a hydrofoil look different.

Hovercraft

Hydrofoil

Hovercraft Activity # 1

Name ____ Date ___________________

1. How does a commercial hovercraft change directions?

____

____

____

2. Since hovercrafts can travel on land are they allowed on public streets?

____

____

____

3. Do hovercrafts require a driver's license?

____

____

____

4. How many engines would a hovercraft need?

____

____

____

5. Where does the hovercraft get its air?

____

____

____

6. Why does a hovercraft need a skirt?

____

____

____

Hovercraft Activity #2: Build a Balloon and Tray Hovercraft

This activity will allow students to understand the principles of how a hovercraft works and how to build their own hovercraft. Prior to beginning this activity there should be a class discussion on friction and drag, and how a hovercraft minimizes both of these. Have someone use a larger tray so students can observe the difference. Students can research hovercrafts on the internet. Students can work in small groups.

Materials

- Styrofoam food trays- large and small, no larger than 8 ½ by 5 ½
- Pencil
- Balloon
- Paper clip
- Ruler

Procedure

1. Use the pencil to make a hole in the middle of the tray.

2. Blow up the balloon.

3. Hold the end tightly, or put a paperclip around the end.

4. Push the end of the balloon through the hole in the tray.

5. Place hovercraft tray on a smooth, flat surface (the tray should be upside down on the table).

6. Release the end of the balloon. This can be done in a controlled fashion by loosening the paperclip so only a small amount of air is released at a time.

7. Tray should begin to glide away when given a push.

8. Measure distances each tray moves and record data.

Activity #2 Worksheet: Balloon and Tray Hovercraft

Name ____ Date ____________________

1. Can you hear the air escaping from under the tray?________________________________

2. Can you feel the air escaping from under the tray? ________________________________

3. Does the big tray move much?____________ How far did it move?_________________

4. How far did the smaller tray move?____

5. Did the smaller tray move in just one direction?__________________________________

6. Based on internet research, write about the hovercraft, its history, and how it works.

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

7. What is friction and drag?

____

____

8. Describe how friction and drag are minimized by the way a hovercraft works.

____

____

____

9. Complete the following data:

	Tray Length	Tray width	Tray height	Distance traveled
Small tray				
Large tray				

10. Explain why the trays moved differently.

____

____

____

11. Who invented the hovercraft? _______________________________

12. What forms the “skirt” of the hovercraft in this experiment?

____

____

13. Why is a “skirt” necessary on a hovercraft? What would happen if there were no “skirt”?

____

____

____

Hovercraft Activity # 3: Build a CD and Balloon Hovercraft

This activity will allow students to understand the principles of how a hovercraft works and how to build their own hovercraft. Prior to beginning this activity there should be a class discussion on friction and drag, and how a hovercraft minimizes both of these. Have some students use thread spools and some use the film canister so students can observe the difference. Students can research hovercrafts on the internet. Students can work in small groups.

<u>Materials</u>

- Compact disc (CD)
- Empty film canister from 35 mm film or large empty spool thread
- Glue
- Balloon
- Ruler

<u>Procedure</u>

1. Make a hole, with a pencil, through the center of the film canister and its cap
2. Cover the top of the thread spool or film cap with glue
3. Line up the CD holes with the holes in the spool or the film canister
4. Securely Glue CD to spool or canister
5. Allow to dry (about an hour)
6. Place CD or spool hovercraft on flat surface and gently push (repeat)
7. Record observations- Distance traveled, average distance
8. Blow up balloon and keep air from escaping (twist end)
9. Stretch balloon over spool or canister (do not let air escape)
10. Place hovercraft on flat surface, release the balloon, and gently push the vehicle (repeat three times)

    1. Record observations: Distance traveled__________________

       Average distance__________________

Activity #3 Worksheet: Balloon and CD Hovercraft

Name ____ Date ___________________

Record of Observations				
	Distance first push	Distance second push	Distance third push	Average distance traveled
Hovercraft without balloon				
Hovercraft with balloon				
Hovercraft from film canister				
Hovercraft from thread spool				

Did the hovercraft travel further with or without the balloon? Explain why.

____

____

____

Which hovercraft style traveled the farther? Explain your answer and ideas of why.

____

____

____

Activity adapted from http://www.ceismc2.gatech.edu/bp/cars/hovrcrft/hover.htm

Answers to Activity #1 Worksheet

1. A rudder system
2. No
3. No
4. A minimum of one
5. Fans attached to an engine blow the air under the hovercraft
6. To trap the air underneath them and provide an air cushion under the vehicle

General Answers

- The smaller tray should float just above the flat surface.

- The smaller tray should move in different directions as the air escapes.

- The larger tray should move little, if any.

- The smaller tray moves easier since it contains a smaller volume of trapped air than the larger tray.

- For the larger tray, there is a larger volume of trapped air under the tray so the air released from the balloon raises the pressure only slightly. This causes the larger tray to move slightly, if any. The downward thrust is smaller per unit area which supports the weight of the tray.

- The balloon hovercraft simulates how a hovercraft works--A hovercraft works by being propelled forward by the downward thrust of air being propelled backwards through special vents or by propellers mounted on top of the craft.

- The craft is steered by rudders which direct the back thrust or by propellers which produce a sideways thrust. The balloon just travels without guidance since the model has no rudders.

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standards: 2, 3, 5, 11, 16, & 20
GPS: 21.47100 1-25, 29–52, 57, 62, 63, 64, 65, 68, 77

Name:______________________________

Residential Wiring

This activity is used to teach students standard load calculations, so that they can determine the sizes of the service entrance panel, service entrance conductors, and the grounding electrode conductors. Various floor plans will be used in this activity.

Math Connections	Science Connections	Technology Connections
Graph Reading	Electricity	Engineering
Percentages	Energy	Construction
Calculations	Physics	

Introduction

Before starting the activity, we must first understand what electricity is and how we harness and transmit power from the power plant to a home. Using any resource your instructor will allow, answer the following questions.

Atomic Theory

Define the following terms:

1. Atom
2. Matter
3. Electron
4. Neutron
5. Proton
6. Nucleus
7. Atomic Number
8. Electricity
9. Current
10. Electromotive Force
11. Ohm
12. Watt
13. Conductor
14. Valence Electrons
15. Law of Centrifugal Force
16. Insulators
17. Semiconductors
18. Molecules
19. Element
20. Amp
21. Electrical Circuit
22. Volt
23. Resistance
24. Ohm's Law

Answer the following questions:

1. Describe the Atomic Theory:

2. What are the 6 methods for producing electricity? Explain each type.

3. Describe the Law of Charges?

4. What the 5 effects that are caused by electricity?

5. How many valence electrons will a conductor have?

6. Before current can flow the circuit must be ________?

7. What is a short circuit?

8. Using Ohm's Law perform the following calculations:

24 volts, 2.5 amps	= _________	ohms	
36 volts, 1.25 ohms	= _________	amps	
2.5 amps, 0.67 ohms	= _________	volts	

9. Using the Power formula, perform the following calculations:

24 volts, 4.6 amps	= _________	watts	________	ohms
80 watts, 18 volts	= _________	amps	________	ohms
75 watts, 3.6 amps	= _________	volts	________	ohms
120 watts, 2.5 amps	= _________	volts	________	ohms
2.4 ohms, 12.4 amps	= _________	volts	________	watts

Now that you have an understanding of the atomic theory, electrical terminology, and scientific formulas associated with basic electricity, we may continue exploring how electricity is produced and then transmitted into your home from a power plant.

The Law of Conservation of Energy, which was discovered in 1842 by Julius Robert Mayer, states, "Energy is neither created nor destroyed." This law proves that energy can only change forms. With this in mind, in order to produce electricity, we must take some other energy source and convert it to electricity. This is the job of a power plant. There are three main types of power plants: nuclear, fossil fuel, and hydroelectric.

Nuclear Power Plants - Uranium is used as a fuel in a nuclear power plant. The energy released through the splitting of a uranium atom, also known as atomic fission produces heat energy. This heat boils water, which converts to steam. The steam is then channeled to a turbine. Connected to the turbine is a drive shaft that is also connected to a generator. Therefore as the turbine spins one end of the shaft, the other end of the shaft turns the generator, which produces electricity.

Fossil Fuel Power Plants - Fossil fuel power plants are very similar to nuclear power plants with one exception. Coal, oil, or natural gas is burned to heat the water into steam instead of splitting uranium atoms to produce heat.

Hydroelectric Power Plants - Damming a river or lake, and directing the water through parts of the dam to a number of turbines produces hydroelectric power. This method of producing power is very environmentally sound.

Alternative Energy - Other sources of producing energy are out there. However, it is difficult to produce as much electricity from these alternative solutions as it is with the above-mentioned forms. Solar energy, geothermal energy, biomass, and wind energy are a few alternative methods that are used to produce electricity.

Electricity leaves the power plant moving down high voltage transmission lines, these are easily recognizable since extremely tall towers support the lines. The lines carry the electricity to a sub-station. It is here that the voltage is stepped-down or reduced for industrial and residential uses. From here the electricity travels through power lines to residences, businesses, and industrial sites. Once at the site the electricity will flow through a transformer that steps down the voltage even more so that it meets requirements for the site. A residence will have a 240-volt power supply. From this point the wire will travel to the electrical meter, and then into the service panel of the home.

ACTIVITY ONE

The National Electrical Code sets the electrical requirements, rules, and practices that must be used when designing and constructing a home, business, industrial site, or civic setting. The graphs that you will be working with come straight from the 2002 NEC Codebook. It is very important that these graphs are used correctly when answering questions

National Electrical Codes

Summary of Table 220.3(A): Dwelling Units-(Homes) - 3 volt-amperes per square foot

Summary of Article 220.16 (A): Appliance Circuits- Each dwelling shall possess at least 2 small appliance circuits (outlets) that are 1,500 volt-amperes each. 1,500 VA x 2 appliance circuits = 3,000 VA

Summary of Article 220.16 (B): Laundry Circuit- Each laundry circuit that is installed shall have a load of not less than 1,500 volt-amperes. Most homes have only one-laundry rooms, therefore only one laundry circuit is needed per home.

Summary of Article and Table 220.19: Ranges – If you have one range and kW rating falls over 8 ¾ but not over 12 kW use column C for the number appliances and it is already calculated. Use the kW rating in Column C. If the rating of the range or ranges is above 12 kW, see note 1. If you have one range larger than 12 kW use note 1. Note 1 states: "If the rating of the range is over

12 but less than 27 kW, subtract the rating from 12 kW, increase the amount in column C for the given number of ranges by 5% per kW over 12 kW." Example: If you have a 14 kW range: You have 2 kW over the 12 kW rating, increase the 8000 VA from Column A by 10% (5% per kW over 12 kW). You now have a demand load of 8800 volt-amperes.

Table 220.19

Number of Appliances	Column A (Less than 3 ½ KW rating)	Column B (3 ½ kW to 8 ¾ kW rating)	Column C Maximum Demand (kW) (See notes) (Not over 12 kW rating)
1	80	80	8
2	75	65	11
3	70	55	14
4	66	50	17
5	62	45	20

"Note 1: Over 12 kW through 27 kW ranges all of same rating. For ranges individually rated more than 12 kW but not more than 27 kW, the maximum demand in Column C shall be increased 5 percent for each additional kilowatt of rating or major fraction thereof by the rating of individual ranges exceeds 12 kW.

Summary of Article 220.17: Non-Coincident Loads (heating/AC) – Use only the largest of the two at 100%.

Summary of Article 220.18: Electric Clothes dryer – The minimum load for a dryer is 5,000 watts or the nameplate rating, whichever is larger. Therefore if the nameplate rating is 4,500 watts, 5,000 should be used; however, if the nameplate rating is 6,500 watts then the nameplate rating should be used.

Summary of Articles 220-14 and 430-24: Use the largest of all motor loads such as the refrigerator, freezer, well pump, disposal, or pool pump. Do not use items such as water heater (no motor), dishwashers, or microwave due to the fact that they have very small motors, mainly heating load). Use the largest motor times 25%.

Summary of Table Table 310-16 (75 deg. Copper Column only):

Size AWG (Wire Size)	75^{o} C Copper (allowable capacity)
6	65
4	85
3	100
2	115
1	130
1/0	150
2/0	175
3/0	200
4/0	230
250	255
300	285
350	310
400	335
500	380

Summary of Table 250-66:

Size of Service Entrance Conductor	Size of Grounding Electrode Conductor
2 or smaller	8
1 or 1/0	6
2/0 or 3/0	4
Over 3/0 through 350	2
Over 350 through 600	1/0
Over 600 through 1100	2/0

By performing the following calculations you will compute load calculations needed to find the sizes for the service panel, service entrance conductor, and grounding electrode conductor.

Standard Calculations

Eight Steps

1. General Lighting Load
2. Ranges
3. Dryers
4. Non-Coincident (Heating and Air Conditioning
5. Appliance Load
6. Motor Load
7. Total Steps 1-6
8. Divide total VA (volt-amps) by 240 volts to convert to Amps.

Step 1: General Lighting

1A- Use outside dimensions of the building excluding open porches, garages, or unused or unfinished area not adaptable for future use.
1B- Multiply square feet x VA per square foot from Table 220-3A
1C- Add the two small appliance circuits (per kitchen) x 1500 VA each. Code 220-16A
1D-Add the laundry circuit x 1500 VA. Code 220-16B
1E- Total 1B-1D and subject to demand factors in Table 220-11. 1st 3000 @ 100%, 3001-120,000 @35%, and remainder over 120,000 @ 25%. (If the total is 120,000 or below: Set aside 3000 VA at 100% and subtract that 3000 from the total. Multiply the balance by 35% and add this back to the 3000VA.) (If the total is over 120,000 VA: subtract 120,000 from the total, multiply this number by 25%, then set aside 3000 at 100% . Subtract that 3000 from 120,000 and multiply the balance x 35%. Add both products back to the 3000 VA.)

Step 2: Ranges   Article 220-19 and Tables 220-19

If you have one range and the kW rating falls over 8 ¾ kW but not over 12kw use column C for the number of appliances and it is already calculated. Use the kW rating in Column C

If the rating of the range or ranges is above 12 kW, see note 1. If you have one range larger than 12 kW use note 1. Note 1 states if the rating of range is over 12 but less 27 kW, subtract the rating from 12 kW, increase the amount in column C for the given number of ranges by 5% per kW over 12. Example: 14 kW range: You have 2 kW over 12, increase the 8000 VA from column A by 10%. You now have a demand load of 8800 VA.

Step 3: Dryers   Article 220-18 and Table 220-18

Use nameplate rating or 5,000 whichever is greater. If you have a 4 kW dryer, use 5,000, but if you a 6kW use 6,000. From 1-4 dryers, use 100% of the rating.

Step 4: Noncoincident Loads (Heating or Air Conditioning)

Use only the largest at 100%

Step 5: Appliance Load   Article 220-17

Any appliance not listed in steps 1-4 will be used in step 5. Examples include Water heaters, refrigerators, freezers, disposals, dishwashers, well pumps, pool pumps, compactors, microwaves, and fans.

Use nameplate rating and total. If you have four or more, multiply the total by 75%

Step 6: Motor Load   Articles 220-14 and 430-24

Use the largest motor load such as the refrigerator, freezer, well pump, disposal, or pool pump. Do not use items such as water heaters (no motor), dishwashers (very small motor, mainly heating load), microwave (very small motor). Use the largest motor X 25%.

Step 7   Total steps 1-6.

Step 8   Divide by 240 volts to convert to Amps

Size service Panel First (200A, 225A, 300A, 400A, or 600A)
Size service Entrance Conductors Table 310-16 75 degree column. (based on service panel size).
Size Grounding Electrode Conductor Table 250-66 (based on service entrance conductor size)

Example Problem

Home	= 55 ft long X 40 ft. wide
1 Range	= 14 kW
Dryer	= 5 kW
A/C	= 25 kW
Heat	= 20 kW
Refrigerator	= 650 W
Freezer	= 750 W
Deep well pump	= 4.5 kW
Attic Fan	= 1250 watts
Microwave	= 2070 VA
Dishwasher	= 2100 VA

Water Heater 4.5 kW

Solution

1A -55' x 40'	= 2200 square feet
1B - 2200 sq. ft x 3	= 6600 VA
1C- 2 appliance circuits x 1500 VA	= 3000 VA
1D- 1 laundry circuit x 1500 VA	= 1500 VA
1E- 6,000 + 3,000 + 1,500	= 10,500 VA

Step 1		Step 2		Step 3
10,500	--	3,000 X 100% = 3,000	--	6,500 X 35%= 2275
- 3,000				
6,500				

Step 4
3,000 + 2,275 = 5,275 VA = General Lighting Load

Ranges – Table 220-19
1 range @ 14,000 Watts

12,000	Column "C", Row 1 = 8kw
- 14,000	8kW X 10% (5% per kW over 12 kW) = 800 W
2,000 W over 12 kW	8,000W + 800 W =8,800 W.

Dryer – Table 220-18
5,000 Watts

Non-coincident Load (Heating or A/C, take the largest figure of the two)
25,000 Watts

Appliance Load (Add the appliances that you haven't used and multiply the total by 75%)

Refrigerator = 650 W	Water Heater 4.5 kW	Total = 15820
Freezer = 750 W	Dishwasher = 2100 VA	X 75%
Deep well = 4.5 kW	Microwave = 2070 VA	11865 W
Attic Fan = 1250 watts		

Motor Load
(Find the largest rated motor and multiply by 25%, do not use dishwasher, microwave, or water heater since they have small motors.)

Deep Well Motor – 4,500 Watts X 25% = 1125 W

Total
(Add up each of the totals from the general lightning load down to the motor load)

GLL	=	5,275
Ranges	=	8,800
Dryers	=	5,000
Non-coincident load	=	25,000
Appliance load	=	11,865
Motor load	=	1,125
Total		57,065

Divide total by 240 V = 237. 77 Amps

Service Panel Size (Sizes 200A, 225A, 300A, 400 A, or 600A. The panel should always be larger than your total amperage = 300 A service Panel)

Service Entrance conductor (based on service panel size) = 350 AWG Copper wire
Grounding Electrode conductor (based on service entrance conductor size) = Size 2 AWG

Problems

Problem #1

Home	= 48 ft long X 38 ft. wide
1 Range	= 12 kW
Dryer	= 6 kW
A/C	= 23 kW
Heat	= 21 kW
Refrigerator	= 625 W
Freezer	= 680 W
Deep well pump	= 4250 W
Attic Fan	= 1350 watts
Microwave	= 1980 VA
Dishwasher	= 2000 VA

Water Heater 3.8 kW

Problem #2

Home	= 46 ft long X 35 ft. wide
1 Range	= 11 kW
Dryer	= 6.5 kW
A/C	= 22 kW
Heat	= 20 kW
Refrigerator	= 675 W
Freezer	= 730 W
Deep well pump	= 4050 W
Microwave	= 1875 VA
Dishwasher	= 1925 VA

Water Heater 3.5 kW

Problem #3

Home	= 54 ft. long X 45 ft. wide
1 Range	= 15 kW
Dryer	= 6 kW
A/C	= 26 kW
Heat	= 23 kW
Refrigerator	= 780 W
Freezer	= 830 W
Deep well pump	= 4.9 kW
Attic Fan	= 1325 watts
Microwave	= 2200 VA
Dishwasher	= 2150 VA
Water Heater	= 4.3 kW
Pool Pump	= 3.2 kW

ACTIVITY TWO

Design Brief

The students are to wire a single pole switch and a three-way switch each to a light fixture.

Materials

Your instructor should have these materials readily available for you to use.

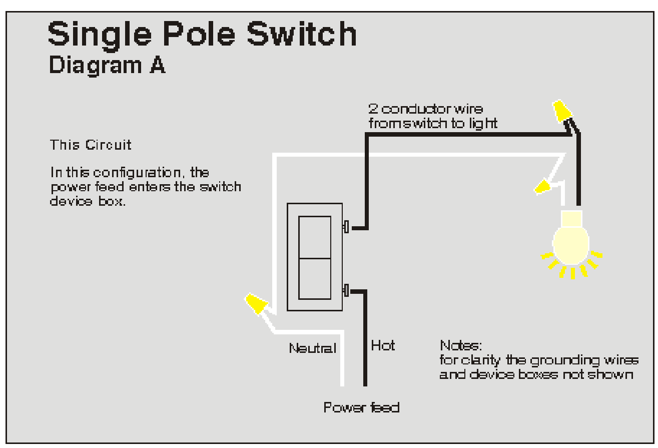
1 Single Pole Switch
2 Porcelain Base Lampholders
2 Three way Switches
8 ft.- 12-2 wire
2 Octagonal Electrical Boxes
6 ft - 12-3 wire
3 Electrical Switch Boxes
2 40-60 Watt Light Bulbs
Needle Nose Pliers
Wire Strippers
Wire cutters
Screwdrivers (Flat and Phillips Head)

Note for Instructor

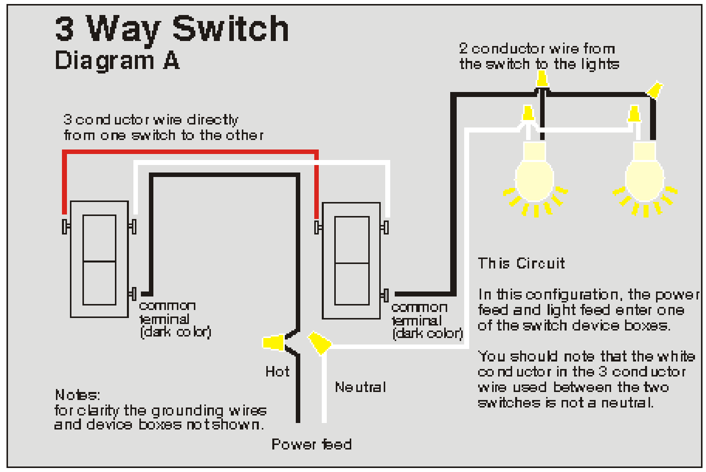
You will need to create a power line with 12-2 wire (approximately 18-24 inches long) one end will have a male plug that fits a standard three-prong receptacle, the other end containing and inch of stripped wire.

Single Pole Switch

A single pole switch is used when only one switch is needed to turn a light source on or off. The switch itself contains two terminals usually found on the same side. When installing the switch make sure the switch reads "ON" before mounting, if you look at it and you read "NO" you should turn the switch around. The neutral wire (white) is not connected to the switch it is coupled directly to neutral wire from the light fixture. The hot wire from the power source is connected to the bottom terminal of the switch, which leaves the top terminal of the switch for the hot wire of the light fixture.



Three Way Switch



A 3-way switch is used mainly in hallways, on staircases, and in long rooms. A 3-way switch makes it possible to have two switches control a light source or a series of lights in a room. From the diagram you can tell that a different type of wire is used to wire these switches than is used to wire a single pole switch. This type of wire would most commonly be a 12-3 wire and a 12-2 wire. 12 is the size of the wire, and the -2 or -3 refers to the amount of wires are in the bundle. In the diagram above the power source is fed directly into the switches. The hot wire from the power source is a 12-2 wire. The red, black and white wires are 12-3 wire. The switches are also different from single pole switches. A three-way switch has three terminals. Two of the terminals should look alike, either brass or silver, and the third terminal should be dark colored. If all three terminals look alike the company should have printed the word “common” near one of the terminals. The hot wires are always attached to the common terminals. Basically in this diagram a 12-3 wire connects the switches, and there is a 12-2 wire coming from the power source, and a 12-2 wire coming to the other switch from the light source. The neutral wire from the light sources couples directly with neutral from the power source.

Connecting Mathematics and Science to Technology Education

System: Physical
ITEA Standards: 8-12
GPS: 1-25; 67-75

Name: ______________________________

Egg Drop Engineering

In this activity, students construct a capsule to protect an egg from a 20' drop. They must learn engineering concepts behind packaging and scientific concepts that will make the capsule environmental friendly.

Math Connections	Science Connections	Technology Connections
Measurement	Material Science	Design Processes
Geometry	Airfoils	Construction
Formulas	Pressure	Troubleshooting
	Force	Engineering Principles
		Problem Solving

Materials and Supplies

Egg drop capsule construction: biodegradable and recyclable materials, large eggs, markers, ruler, testing site approximately 20 feet high.

Science Connections: Use the Internet to research possible materials to meet the requirements of biodegradable and/or recyclable materials for the capsule.

Teacher Information: On the official testing day, the instructor should contact their local power company to request them to bring their sky bucket truck out to drop the students finished capsules.

History of Packaging

1. Using the Internet, investigate the history of packaging and explain how technology has influenced the packaging industry.

   ____

   ____

   ____

   ____

2. What materials have been used to ensure the safety of items being shipped?

3. What materials are used today that make packaging environmentally friendly?

4. What has been the largest change in packaging over the past 20 years?

5. What has been the most challenging aspect of shipping over the past 20 years?

6. What limitations are placed on packaging and items being shipped today?

Understanding and Investigating Mathematical Concepts

1. What is the most common shape that is used to ship items and why?

2. What is the strongest shape and why?

3. What would be the advantages and disadvantages of creating packages to match the shape of the items being shipped?

4. What is done today to ensure the safety of the various shaped items being shipped in square boxes?

____

____

Understanding and Investigating Scientific Concepts

1. Using the Internet, define the following terms:

Biodegradable:____

____

Recyclable:____

____

Airfoils:____

____

Force:____

____

Impact:____

____

Pressure:____

____

2. List the problem solving steps:

____

____

____

____

____

____

3. Using the above steps, formulate a list of items that you may use to build your capsule.

_______________________________________ _______________________________________

_______________________________________ _______________________________________

_______________________________________ _______________________________________

4. When a person places an egg in their hands with the ends of the egg in the palm of each hand, their fingers interlocked and apply pressure on the egg will the egg break? _______

Why or why not?____

____

5. Using the above information, formulate a list of ideas for the following:

shape of your capsule

____

____

____

placement of the egg inside the capsule

____

____

____

placement of the packing materials around the egg

____

____

____

You have now completed the research portion of this project and should have sufficient information to solve the "Egg Drop Engineering" challenge. Using the design process, complete the challenge.

EGG DROP ENGINEERING
Homework Project

This homework is designed to enhance your problem solving skills and give you an opportunity to highlight your engineering skills. It will also provide your parents an opportunity to work with you to complete the activity.

Directions: Read all directions carefully and make sure you adhere to all requirements and limitations! You are to complete the writing assignment after you have tested your egg drop capsule.

Objective: To design a capsule that will prevent a raw chicken egg from breaking when dropped from a height of 20 feet.

Assignment due date: The written assignment and capsule are due ______________________.
(You must turn in your capsule, entry form, and report.)

Grading: Total Points: 500 points
(Report = 200 points; Entry form = 100 points; Capsule = 200 points.)

Testing: On the scheduled date, he N.C.S.E.F. will test your capsule in front of the board members using a sky lift from ___________________Power Company. First, the capsule will be dropped at a height of 20 feet. Surviving capsules will be dropped at 30 feet. For capsules that survive 30 feet, the height will be increased until the egg cracks. ***No testing at school!***

<u>Awards</u>

	Survival	Non-survival
Best engineered	50	25
Lightest	50	25
Smallest	50	25
Best decorated	25	15
Most School Spirited	25	15

EGG DROP ENGINEERING

Design Problem

The National Chicken Space Embryo Foundation is looking to reach other planets. The goal is to get all chickens off the earth to protect them from the bipedal carnivores. The N.C.S.E.F. needs your help! The chickens have used all their mathematical, scientific and engineering skills to solve the problems associated with take off. Unfortunately it is the problems associated with touch down that they haven't been able to….well, err, crack!

The chickens of the world will bestow on the creator of a successful landing capsule all the accolades and honors that their species possible can afford. (Reminder: Don't get too excited over the honors stuff, I mean they're just flightless barnyard fowl. Right?) You have trained all semester for just this sort of engineering mission. And remember the fate of the worlds' chickens, not to mention your grade for this project, hangs in the balance. Good luck!

Limitations

1. No exterior dimension may exceed 4 inches
2. Container weight with egg may not exceed 1 lb.
3. Student number and period must be on the container
4. Container must have 2 or more colors added to it.
5. Container may not have an airfoil (no parachutes!)
6. No food items may be used – including water.
7. The egg may not be coated or covered with anything
8. Container may not be made of wood, glass, or metal.
9. Your instructor will provide the egg for the day of testing – bring an empty capsule!
10. The interior MUST be all biodegradable materials
11. The exterior MUST be all recyclable materials.

Writing Assignment

The N.C.S.E.F. is looking to hire a new safety engineer and has asked all of its candidates to complete the "Egg Drop Engineering" assignment. Upon completion, candidates must provide written evidence of their engineering skills, based on the assignment, along with evidence of why you should be considered the best candidate as the new safety engineer.

EGG DROP ENGINEERING

Official Entry Form

Name: ______________________________ **Period______________**

Please describe in FULL detail the materials you chose in the construction of your capsule AND explain how it will protect your egg.

When my egg drop capsule hits the ground the egg will not break because……

____

____

____

____

____

____

____

____

____

____

____

Inside the square draw a cross section of your egg capsule.

EGG DROP SCORE SHEET

NAME:________________________________

CRITERIA	SCORE	SCORE	SCORE	SCORE	POINTS EARNED
ENTRY FORM 100	100	50	25	0	
APPEARANCE 40	2+ Color Adds 40	1 Color Add 20	Black & White Add(s) 10	No Add 0	
SIZE 20	4x4 (-) 20	1" (-) Over14	1.5" Over 8	More than 1.5" Over 0	
RECYCLABLE 20	All Exterior 20	85% Exterior 14	75 % Exterior 8	50% Exterior 0	
BIODEGRADABL E 20	All Interior 20	85% Interior 14	75% Interior 8	50% Interior 0	
SKY DROP 100	Egg Survived 100			Egg Died 50	
REPORT 200	Format 40	Spelling 30	Grammar 30	Content 100	
TOTAL SCORE	(Possible Total	Score = 400)			

Connecting Mathematics and Science to Technology

System: Physical
ITEA Standards: 2-6, 12-14
GPS: 2-16, 20-25, 30

Name:______________________________

MagLev Vehicle

In this activity, students will learn about magnetic levitation (maglev) technology and then apply their knowledge in constructing a maglev vehicle.

Math Connections	Science Connections	Technology Connections
Measurement	Magnetism	Engineering
Speed	Ohm's Law	Design processes
Tables/Charts		Problem solving

Magnetic Levitation Technology

A magnetic levitation train or maglev is a train-like vehicle that is suspended in the air above a single track, and propelled forward using the repulsive and attractive forces of magnetism. There is no friction between the track and the vehicle because there is not any physical contact between them and the only friction is that between the carriages and the air. Because there is no friction, maglev trains can travel at very high speeds (up to 400 mph)) with reasonable energy consumption and noise levels. This speed is far greater than conventional rail transport. Maglev s technology is very feasible for mass transit and plans are being developed to use maglev trains for fast travel to airports and urban areas. This would lessen traffic congestion and streamline arrivals and departures from the airports.

The capability of high speed makes maglev transportation potential competition to airliners in many routes but certainly not all routes; however, the high cost of constructing maglev lines has limited their commercial application.

There are three primary types of maglev technology systems: Electrodynamic Suspension (EDS), Electromagnetic Suspension (EMS), and Inductrack.

- *Electrodynamic Suspension.* EDS relies on superconducting magnets. On the train, these magnets generate a magnetic field. Propulsion coils on the guide way are used to exert a force on these magnets to make the train move forward. The propulsion coils exert a force on the train in the same way that an electric motor works. An alternating current flowing through the coils causes a continuously varying magnetic field that moves the train forward along the track. The magnets on the train line up with this field which moves the train forward.

- *Electromagnetic Suspension.* In the EMS system, the bottom of the train wraps around a steel guideway. Electromagnets attached to the train's undercarriage are directed up toward the guideway, which levitates the train about 1 cm. above the guideway and keeps the train levitated even when it is not moving. Other guidance magnets embedded in the train's body keep it stable during travel. (In Germany, engineers have developed an EMS maglev train called Transrapid. They have demonstrated that it can reach 300 mph with people aboard.)

- *Inductrack.* Inductrack is a completely passive magnetic levitation train system, using only unpowered loops of wire in the track and permanent magnets on the train to achieve levitation. The only power required is to push the train forward.

Figure 1 is an illustration of a guide way.

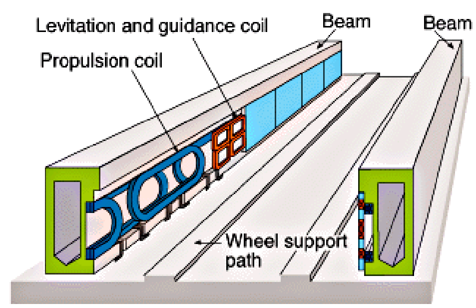


Figure 1

Magnetism

Magnetism is a phenomenon by which materials exert an attractive or repulsive force on other materials. Magnetic forces are fundamental forces that arise due to the movement of electrical charge. Every atom contains one or more electrons which are negatively charged. In many materials (such as wood, glass, plastic, ceramic, etc), the electrons are tightly bound to the atoms causing little to no movement of the electrons which is why these materials do not conduct electricity and exhibit little magnetic properties. However, most metals (gold, silver, copper, aluminum, iron, etc) have electrons that can detach from their atoms and move around freely. These loose electrons make it easy for electricity to flow and have strong magnetic properties. Some materials that are well known to exhibit easily detectable magnetic properties are iron, some steels, and the mineral lodestone.

Ohm's Law

Ohm's law is directly related to electricity and hence electromagnetism. Ohm's law is an equation that describes the relationship between current, voltage, and resistance and is given as:

Current (amps) = Voltage (volts)/ Resistance (ohms) or $I = E/R$.

For a given force (voltage), more current flows through a good conductor than a poor conductor. Resistance opposes the flow of current and the unit of resistance is an ohm, a measure of how well a material conducts electricity.

Maglev Vehicle

Design Brief

You and your teammates are to design and construct a maglev vehicle that will transport a load of as many pennies as possible, as quickly as possible, using the fewest number of magnets. Cost is always a major factor and consideration in a new technology. Therefore, the more magnets that you use, the more costly your vehicle!

Specifications and Constraints

1. Maglev vehicle must be less than 12" long
2. Maglev vehicle must be 2.5" wide
3. Vehicle must transport as many pennies as quickly as possible with the least number of magnets.

Material List

Stopwatch
Measuring tape
Glue gun
pennies
rectangular ceramic magnets with center hole
small plastic or paper cup
thin plastic sheeting
wooden strips, 1-2" wide
Box fan
Foam board sheets/blocks
Wooden dowel
plywood
ruler
string
graph paper

General Procedure

- Conduct research on the Internet about magnetic levitation technology.

- Consider where the sails are placed, the number of magnets you plan to use, where the magnets will be located and where and how the pennies will be loaded on your vehicle. You may or may not use sails but you do have to consider a power source for moving it along the track. It can also be self-propelled or electrified.

- *Determine the north and south poles of your magnets.* This can be done by hanging the magnets by a thread and allowing it to rotate until the magnet stops. When it stops, the magnet will have aligned itself with the Earth's magnetic poles. Use a marker to place a dot on the north-facing side.

- *Determine how many magnets to use for the greatest payload.* For this, you will need to measure the distance between the magnets to determine how much load is required to close the gap and make the magnets touch. Take several measurements between no load and full load. Full load is when the magnets touch. Use the table to chart the distance of the gap and the penny payload with the two magnets, then add another magnet and repeat the process. Repeat with a fourth magnet. Make sure that you record your information on the chart as you will use this information to decide the number of magnets that you will be using for your vehicle.

- In testing, you will need to measure the distance traveled by your maglev vehicle and the total time from start to stop so you can determine the speed in mph of your maglev vehicle.

- You will need to include a photograph or drawing of your final design.

Testing

You will test your vehicle on a track provided by your instructor. The track is 8 feet long and 2-9/16 inches wide with north-facing magnets facing up. The track will have starting and ending points, 12" from each end.

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Activity adapted from *Technology Education: Learning by Design* by Michael Hacker and Dave Burghardt

Maglev Worksheet

1. Chart the distance of the gap between the magnets from no load to full load as you are loading the payload.

Number of Magnets	Gap Distance	Number Of Pennies
2		

Number of Magnets	Gap Distance	Number Of Pennies
3		

Number of Magnets	Gap Distance	Number Of Pennies
4		

Number of Magnets	Gap Distance	Number Of Pennies
5		

2. Using a sheet of graph paper, graph the points for the gap distance and payload.

3. What is the speed of your vehicle? ______________________

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