Radio Reception and Transmission

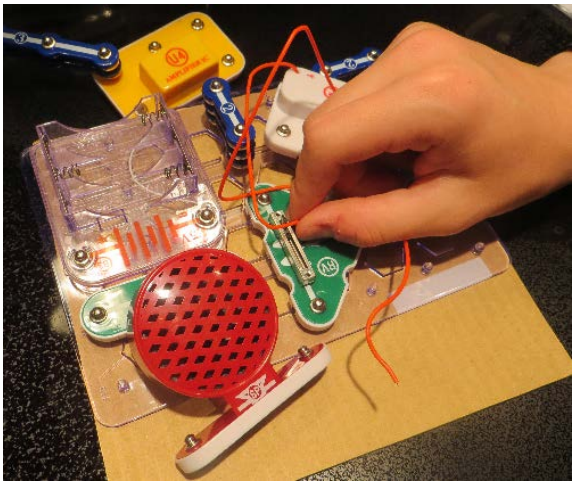
Provided by TryEngineering - www.tryengineering.org

Lesson Focus

Lesson explores the electronics behind radio, and its impact on society. Students work in teams to build and test a radio receiver and optional transmitter from either a snap or soldering kit (depending on level and age). They review challenges encountered in the building and testing process, evaluate their results, and share observations with their class.

Lesson Synopsis

The "Radio Reception & Transmission" lesson explores how radio has impacted society, and impacted communications globally. Students work in teams to construct a working radio receiver that can receive FM broadcasts. An extension is to also build a FM transmitter, or to have an older student team build a transmitter, and partner with younger students who build the radio receiver. Very young students can build a snap kit. Older students will be more challenged to build the radio receiver or transmitter using kits of resistors, capacitors, coils, semiconductors, a PC board, and other parts. Teams build their radio and transmitter, test it, reflect on the challenge, and present their experiences to their class.



Age Levels

8-18. Note: This lesson may be shared where younger students build the radio receiver, and partner with older students who build the radio transmitter.

Objectives

- Learn about engineering design and redesign.
- Learn about circuits and computers.
- Learn about radio receivers and transmitters.
- Learn about teamwork and problem solving.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- engineering design
- computer engineering
- radio
- teamwork

Lesson Activities

Students explore how advances in radio communications have impacted society. Students work in teams to build and test a working FM radio receiver and an FM transmitter. They review challenges encountered in the building and testing process, evaluate whether they are able to both send and receive radio transmission, and share observations with their class.

Resources / Materials

- Teacher Resource Documents (attached)
- Student Resource Sheet (attached)
- Student Worksheet (attached)

Alignment to Curriculum Frameworks

See curriculum alignment sheet at end of lesson.

Internet Connections

- TryEngineering (www.tryengineering.org)
- TryComputing (www.trycomputing.org)
- US National Radio and Television Museum (http://ncrtv.org/)
- History of the BBC (www.bbc.co.uk/historyofthebbc/)
- Museum of Broadcasting (www.museum.tv)
- Radio Museum (International listings and resources) (www.radiomuseum.org)
- National Science Education Standards (www.nsta.org/publications/nses.aspx)
- ITEA Standards for Technological Literacy (www.iteaconnect.org/TAA)

Recommended Reading

- Inventing the Radio (Breakthrough Inventions) (ISBN: 978-0778728399)
- Radio Tubes and Boxes of the 1920's (ISBN: 978-1886606135)
- Wireless: From Marconi's Black-Box to the Audion (Transformations: Studies in the History of Science and Technology) (ISBN: 978-0262514194)

Optional Writing Activity

- Write an essay or a paragraph that examines who invented radio -- there is much controversy on this topic!

Safety Regulations

- In some areas, operating even a very short range FM transmitter without a license may conflict with applicable laws and/or regulations. Check the rules for your area -- often schools are exempt.

Radio Reception & Transmission

For Teachers: Teacher Resources

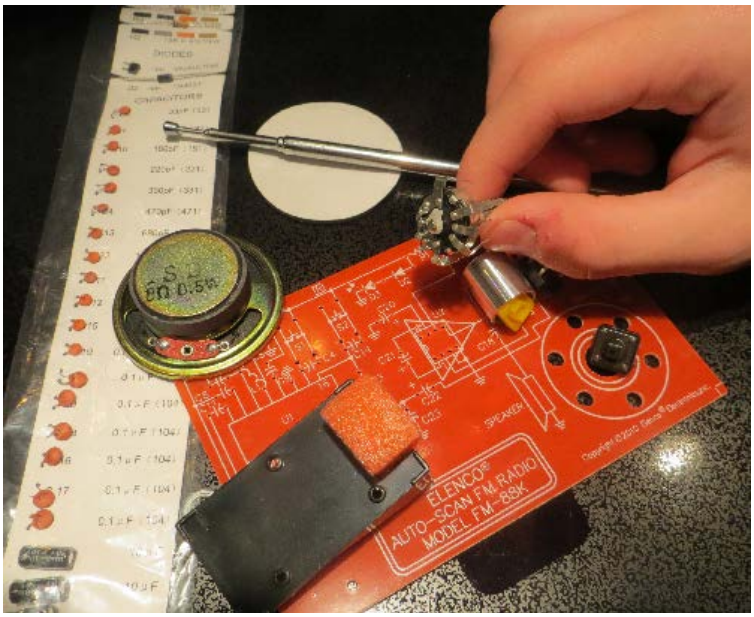
◆ Lesson Goal

The "Radio Reception & Transmission" lesson explores how radio has impacted society, and impacted communications globally. Students work in teams to construct a working radio receiver that can receive FM broadcasts. An extension is to also build a FM transmitter, or to have an older student team build a transmitter, and partner with younger students who build the radio receiver. Very young students can build a snap kit. Older students will be more challenged to build the radio receiver or transmitter using kits of resistors, capacitors, coils, semiconductors, a PC board, and other parts. Teams build their radio and transmitter, test it, reflect on the challenge, and present their experiences to their class.

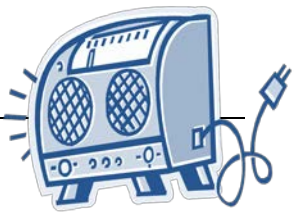
◆ Lesson Objectives

- Learn about engineering design and redesign.
- Learn about circuits and computers.
- Learn about radio.
- Learn about teamwork and problem solving.

◆ Materials



- Student Resource Sheets
- Student Worksheets
- Classroom Materials: 25 or 30 watt soldering unit (all soldering should be under supervision of teacher)
- Younger Student Team Receiver Materials: FM Radio Snap Model Kit ($15-22) (Elenco - www.elenco.com, Model FM88-K; Edmund Scientifics www.scientificsonline.com, Item 3081963; or similar).
- Older Student Team Receiver Materials: Circuit board based FM Radio Model Kit ($15-40) (Elenco - www.elenco.com, Model SCP02; Edmund Scientifics www.scientificsonline.com, Item 3042107; or similar); 9 volt battery, long nose plier, small screwdrivers.
- Older Student Team Transmitter Materials: FM Stereo Transmitter Kit ($18-45) (Ramsey Electronics - www.ramseyelectronics.com, Model FM10C; Carls Electronics www.electronickits.com, Item Low Power FM Transmitter Kit; or similar); batteries, long nose plier, small screwdrivers. Or, purchase individual items and build it all from scratch following instructions such as those found on Jameco's website (www.jameco.com/Jameco/workshop/diy/fmtransmitter.html).



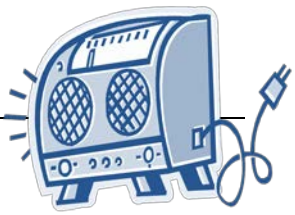
For Teachers:
Teacher Resources (continued)

◆ Procedure

1. Show students the student reference sheets. These may be read in class or provided as reading material for the prior night's homework.
2. To introduce the lesson, consider asking the students how radio transmission is possible. Ask them to consider what components might be inside a radio receiver and how they work. Prompt students to consider radio transmission as well.
3. Consider if your students will be working on the receiver only, or building both a receiver and transmitter. Divide your class into teams of 3-4 students, and consider partnering with an older or younger class at your school where one grade builds the receivers, and an older grade builds the transmitters -- perhaps present the work of both at a parent night or science fair event.
4. Teams of 3-4 students will consider their challenge, and work as a team to build a functional FM radio receiver or transmitter based on age and experience.
5. Student teams test their radio receivers and transmitters, review challenges encountered in the building and testing process, evaluate their results, and share observations with their class.

◆ Time Needed

Two to four 45 minute sessions (some student teams may work on this outside of class).



Student Resource: What is Radio

◆ Radio

Radio is the transmission of signals through free space by electromagnetic waves with frequencies significantly below visible light, in the radio frequency range, from about 3 kHz to 300 GHz. These waves are called radio waves. Electromagnetic radiation travels by means of oscillating electromagnetic fields that pass through the air and the vacuum of space. Information, such as sound, is carried by systematically changing (modulating) some property of the radiated waves, such as their amplitude, frequency, phase, or pulse width. When radio waves strike an electrical conductor, the oscillating fields induce an alternating current in the conductor. The information in the waves can be extracted and transformed back into its original form.

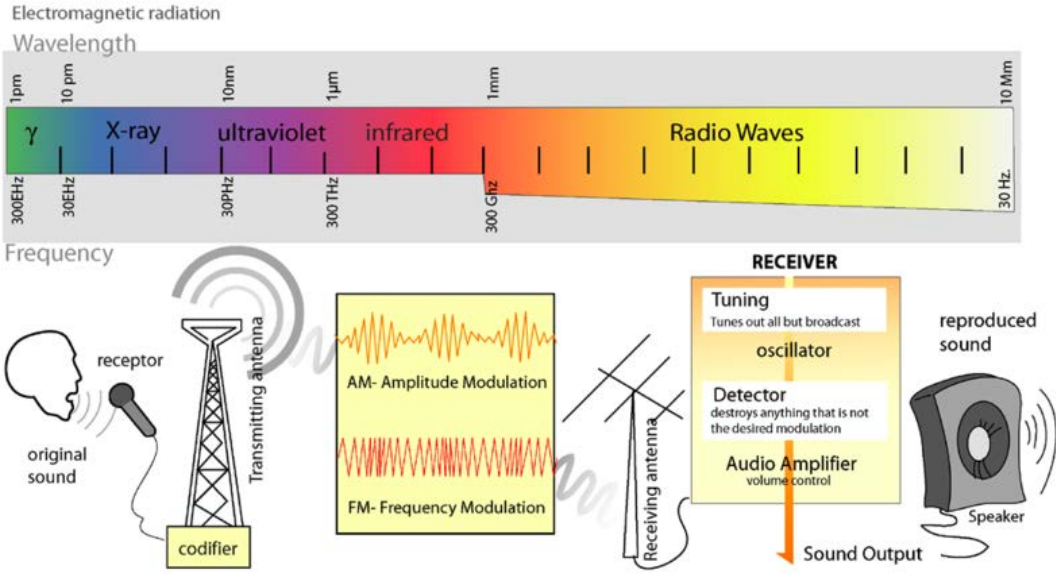
◆ Radio Bands

Radio frequencies occupy the range from a few hertz to 300 GHz, although commercially important uses of radio use only a small part of this spectrum. Other types of electromagnetic radiation, with frequencies above the RF range, are microwave, infrared, visible light, ultraviolet, X-rays and gamma rays. (See table.)

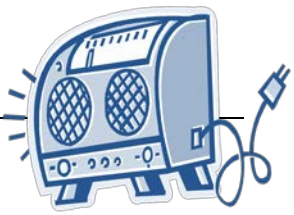
Name	Wavelength	Frequency (Hz)	Photon Energy (eV)
Gamma ray	less than 0.01 nm	more than 10 EHZ	100 keV - 300+ GeV
X-Ray	0.01 to 10 nm	30 PHz - 30 EHZ	120 eV to 120 keV
Ultraviolet	10 nm - 400 nm	30 EHZ - 790 THz	3 eV to 124 eV
Visible	390 nm - 750 nm	790 THz - 405 THz	1.7 eV - 3.3 eV
Infrared	750 nm - 1 mm	405 THz - 300 GHz	1.24 meV - 1.7 eV
Microwave	1 mm - 1 meter	300 GHz - 300 MHz	1.24 meV - 1.24 µeV
Radio	**1 mm - km**	**300 GHz - 3 Hz**	**1.24 meV - 12.4 feV**

◆ Applications

Early uses of radio were focused on maritime applications -- for sending telegraphic messages using Morse code between ships and land. Broadcasting began from San Jose, California in 1909, and became feasible in the 1920s, with the widespread introduction of radio receivers, particularly in Europe and the United States. Today, radio takes many forms, including wireless networks and mobile communications of all types, as well as radio broadcasting. Within the history of radio, many people were involved in the invention of radio technology that continues to evolve in modern wireless communication systems today.



(Note: Source for some content on this page is http://en.wikipedia.org/wiki/Radio)

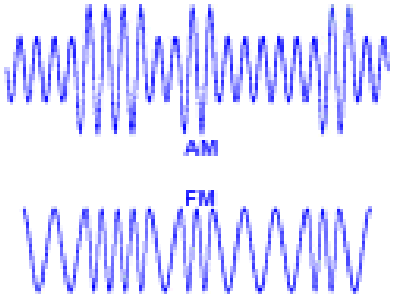


Student Resource: How Does a Radio Work?

◆ How Does a Radio Work?

Radio signals are made up of two kinds of waves: “audio” (or sound) waves represent the sounds being sent to the audience and radio frequency waves travel with these sound waves to "carry" them to radios in homes and car, for example. All waves have three parts: a wavelength, an amplitude and a frequency. Each of these parts can be changed to carry information.

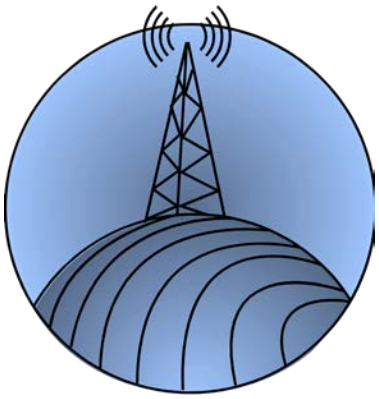
◆ What is the difference between AM radio and FM radio?



AM stands for “amplitude modulation” – a type of signal. With AM, the amplitude of the combined audio frequency and radio frequency waves varies to match the audio signal. AM radio can develop problems with interference. This makes it hard to hear the radio show. Interference can be caused by many sources. For example, sparks discharge when a car is started, in electric motors in all sorts of electrical appliances, and even lightning. All of these things can produce interference to AM radio. As you can see, there is a lot of background noise that changes the amplitude of the radio wave signal. This creates the random crackling noises call static.

FM stands for “frequency modulation”- a type of radio transmission, the frequency of the combined waves change to reproduce the audio signal. For example, higher frequency is associated with the peak amplitude in the audio wave. FM waves do not have a problem with interference because the noise background does not modify the radio wave frequency. In addition FM waves give better sound reproduction.

◆ Why do all FM radio stations end in an odd number in the United States?



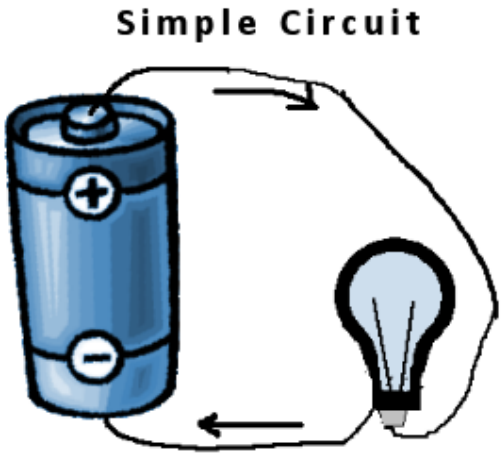
FM radio stations all transmit in a band between 88 megahertz (millions of cycles per second) and 108 megahertz. The band is divided into 100 channels, each 200 kHz (0.2 MHz) wide. The center frequency is located at 1/2 the bandwidth of the FM Channel, or 100 kHz (0.1 MHz) up from the lower end of the channel. For example, the center frequency for Channel 201 (the first FM channel) is 88.0 MHz + 0.1 MHz = 88.1 MHz. 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 center on odd numbers is 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.

Note: Some content on this page provided by the Federal Communications Commission Kids Zone (http://transition.fcc.gov/cgb/kidszone/)

Student Resource: Circuit Basics

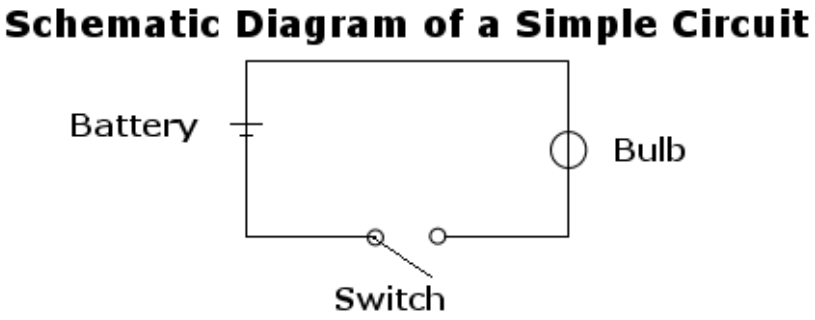
◆ Simple Circuit

A simple circuit consists of three minimum elements that are required to complete a functioning electric circuit: a source of electricity (battery), a path or conductor on which electricity flows (wire) and an electrical resistor (lamp) which is any device that requires electricity to operate. The illustration below shows a simple circuit containing, one battery, two wires, and a bulb. The flow of electricity is caused by excess electrons on the negative end of the battery being attracted to flow toward the positive end, or terminal, of the battery. When the simple circuit is complete, electrons flow from the negative terminal through the wire conductor, then through the bulb (lighting it up), and finally back to the positive terminal - in a continual flow.



◆ Schematic Diagram of a Simple Circuit

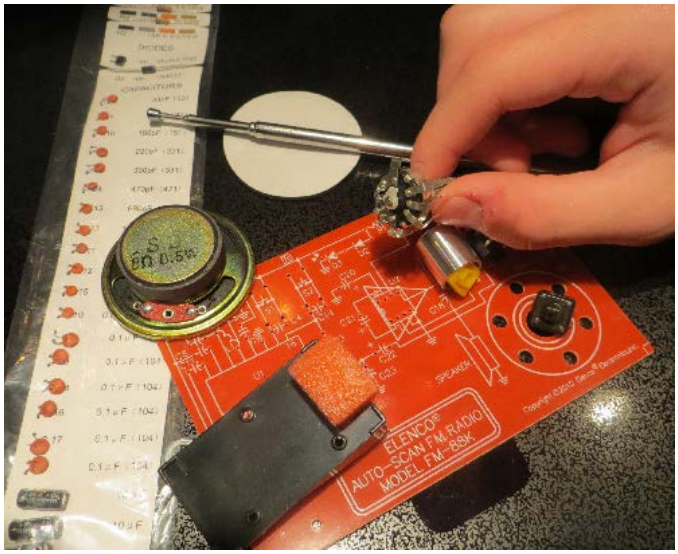
The following is a schematic diagram of the simple circuit showing the electronic symbols for the battery, switch, and bulb.



Student Worksheet:

◆ Engineering Teamwork and Planning

You are part of a team of engineers given the challenge of creating a working FM radio receiver and transmitter and then sending and receiving your own broadcast! You'll work as a team and divide up the work and have a system for keeping track of parts.



◆ Research Phase

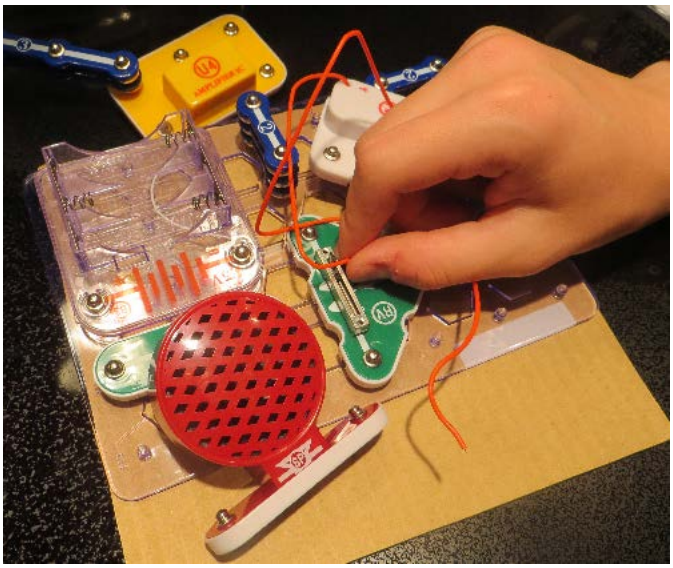
Read the materials provided to you by your teacher. If you have access to the internet ahead of the activity, visit some of the suggested websites to get a feel for the history of radio and its impact on global society.

◆ Building Phase

Follow the detailed instructions within your kit to create your team's radio. If you are building the advanced kit that requires soldering, be sure to do this only under the supervision of your teacher.

◆ Reflection

Complete the reflection questions below:



1. What challenges did you have, if any, in constructing your radio? How did you resolve any challenges you encountered?

2. Was your radio transmitter able to send FM transmissions? If not, what troubleshooting steps did you take to resolve the problem?

3. Was your radio receiver able to receive FM transmissions? If not, what troubleshooting steps did you take to resolve the problem?

4. Do you think that this activity was more rewarding to do as a team, or would you have preferred to work alone on it? Why?

5. Were you surprised to see how complex the inner workings of a radio could be? Why or why not?

6. What do you think engineers might do to improve how a radio works in the future? What would you recommend?

For Teachers: Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades K-4 (ages 4-9)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- Properties of objects and materials
- Light, heat, electricity, and magnetism

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understanding about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in local challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor

◆National Science Education Standards Grades 5-8 (ages 10-14)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- Transfer of energy

CONTENT STANDARD E: Science and Technology

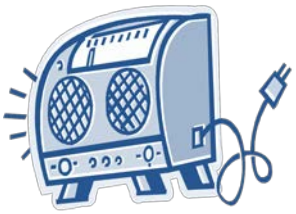
As a result of activities in grades 5-8, all students should develop

- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in society



For Teachers:
Alignment to Curriculum Frameworks (cont.)

◆National Science Education Standards Grades 5-8 (ages 10-14)

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor
- Nature of science
- History of science

◆National Science Education Standards Grades 9-12 (ages 14-18)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in local, national, and global challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

◆Next Generation Science Standards Grades 3-5 (Ages 8-11)

Energy

Students who demonstrate understanding can:

- 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Engineering Design

Students who demonstrate understanding can:

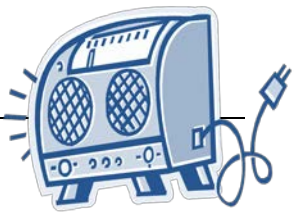
- 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

◆Next Generation Science Standards Grades 6-8 (Ages 11-14)

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.



For Teachers:
Alignment to Curriculum Frameworks (cont.)

◆Next Generation Science Standards Grades 9-12 (Ages 14-18)

Waves and their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

- HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interact ions with matter to transmit and capture information and energy.

◆Standards for Technological Literacy - All Ages

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- Standard 2: Students will develop an understanding of the core concepts of technology.

Technology and Society

- Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- Standard 7: Students will develop an understanding of the influence of technology on history.

Design

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 12: Students will develop abilities to use and maintain technological products and systems.

The Designed World

- Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.