

Standard 6—Interconnectedness: Common Themes Intermediate

Systems Thinking

1. Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Students:

- describe the differences between dynamic systems and organizational systems.
- describe the differences and similarities between engineering systems, natural systems, and social systems.
- describe the differences between open- and closed-loop systems.
- describe how the output from one part of a system (which can include material, energy, or information) can become the input to other parts.

This is evident, for example, when students:

- ▲ compare systems with internal control (e.g., homeostasis in organisms or an ecological system) to systems of related components without internal control (e.g., the Dewey decimal, solar system).

Models

2. Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Students:

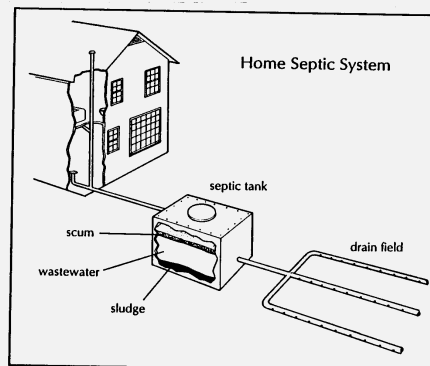
- select an appropriate model to begin the search for answers or solutions to a question or problem.
- use models to study processes that cannot be studied directly (e.g., when the real process is too slow, too fast, or too dangerous for direct observation).
- demonstrate the effectiveness of different models to represent the same thing and the same model to represent different things.

This is evident, for example, when students:

- ▲ choose a mathematical model to predict the distance a car will travel at a given speed in a given time.
- ▲ use a computer simulation to observe the process of growing vegetables or to test the performance of cars.
- ▲ compare the relative merits of using a flat map or a globe to model where places are situated on Earth.
- ▲ use blueprints or scale models to represent room plans.

Sample Problem/Activity

What happens after water goes down the drain?



Key ideas are identified by numbers (1).
Performance indicators are identified by bullets (•).
Sample tasks are identified by triangles (▲).

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Magnitude and Scale

3. The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Students:

- cite examples of how different aspects of natural and designed systems change at different rates with changes in scale.
- use powers of ten notation to represent very small and very large numbers.

This is evident, for example, when students:

- ▲ demonstrate that a large container of hot water (more volume) cools off more slowly than a small container (less volume).
- ▲ compare the very low frequencies (60 Hertz AC or 6×10 Hertz) to the mid-range frequencies (10 Hertz-FM radio) to the higher frequencies (10^{15} Hertz) of the electromagnetic spectrum.

Equilibrium and Stability

4. Equilibrium is a state of stability due either to a lack of changes (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

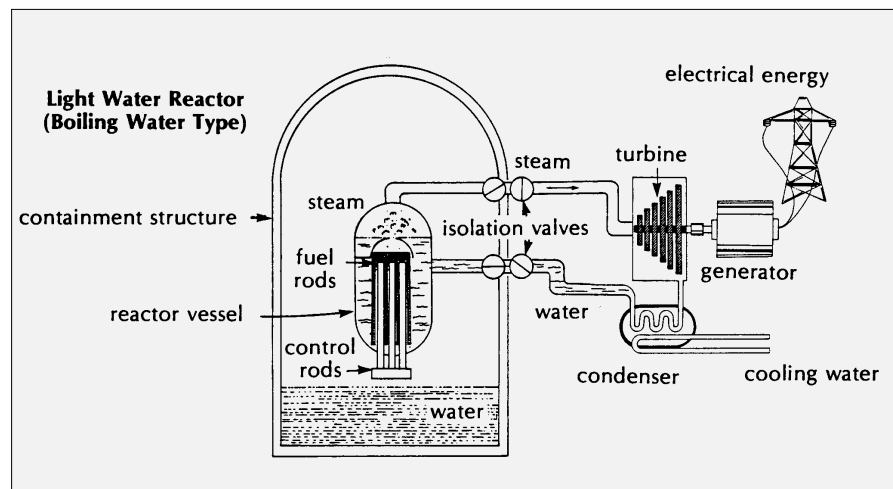
Students:

- describe how feedback mechanisms are used in both designed and natural systems to keep changes within desired limits.
- describe changes within equilibrium cycles in terms of frequency or cycle length and determine the highest and lowest values and when they occur.

This is evident, for example, when students:

- ▲ compare the feedback mechanisms used to keep a house at a constant temperature to those used by the human body to maintain a constant temperature.
- ▲ analyze the data for the number of hours of sunlight from the shortest day to the longest day of the year.

Sample Problem/Activity



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Patterns of Change

5. Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Students:

- use simple linear equations to represent how a parameter changes with time.
- observe patterns of change in trends or cycles and make predictions on what might happen in the future.

This is evident, for example, when students:

- ▲ study how distance changes with time for a car traveling at a constant speed.
- ▲ use a graph of a population over time to predict future population levels.

Optimization

6. In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Students:

- determine the criteria and constraints and make trade-offs to determine the best decision.
- use graphs of information for a decision making problem to determine the optimum solution.

This is evident, for example, when students:

- ▲ choose components for a home stereo system.
- ▲ determine the best dimensions for fencing in the maximum area.

Sample Problem/Activity

HOW MANY IS ENOUGH?

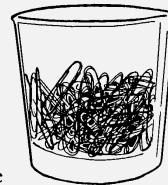
■ *Students will be able to use a simple model to illustrate resource depletion and will be able to suggest variations to the model which would allow management of population size for a wildlife species.*

Evaluation

Students are able to identify factors that influence population size, and they suggest reasons why unlimited killing of wild creatures by humans has more of a long-term effect on some species than on others.

Classroom Activity

1. Form student groups of four or five. Display a container more than half full of paper clips. Tell students that each clip represents an individual of one kind of bird and that all the clips in this container represent a wild bird population (i.e., all are of the same species).



The container represents the habitat for the population. Also display a similar container less than half full of the same size, but a different color, of paper clip. Explain that each of the clips in this container represents one individual of another population (i.e., a different species) of wild birds. Finish introducing the bird game (see Procedural Notes section) and have students play the game.

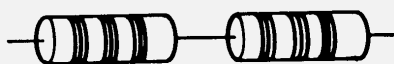
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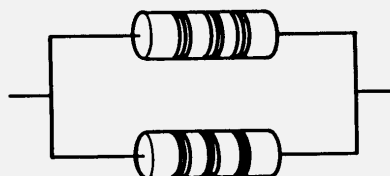
Sample Problem/Activity

What is a resistor and how can it be used?

In Series



In Parallel



These activities focus on resistors:

► **Technology:** Carefully open one or more unplugged electronic devices around your house, and list the various types of resistors employed in the different devices. (You may use schematics to describe the types of resistors instead of naming the types.) Calculate an average value of a typical resistor in a domestic appliance.

► **Social Studies:** Research the invention of the resistor and ways in which its use has expanded over time. / Explore patent law as it would relate to the discovery of a new type of resistor.

► **Language Arts:** Write a play which chronicles the life history of a resistor from the creation of its original constituent materials to the end of its useful life.

► **Mathematics:** Create a computer program that will calculate the overall resistance for a particular circuit when different types of resistors are employed. / Calculate the resistance of one of the circuits used in this activity if several different values of resistors are utilized within the circuit.

► **Health:** Write to Underwriters Laboratories to find out about their work testing electrical devices in the interest of consumer safety.

► **Home and Career Skills:** Conduct a mini-family workshop in which you explain to members of your household the use of resistors. / Investigate careers in electronics.

► **Arts:** Produce a small flip-chart presentation of the movement of electrons within a circuit in which two resistors reside, so that when the booklet is flipped with the fingers, the electrons appear to move through the circuit. Alternatively, create a set of overhead transparencies that your teacher can use to demonstrate this phenomenon.

► **Foreign Languages and Cultures:** Research periodical literature to find out which nations are the leading producers of resistors.