Standard 1—Analysis, Inquiry, and Design

Intermediate

Mathematical Analysis

1. Abstraction and symbolic representation are used to communicate mathematically.

Students:

- **extend mathematical notation and symbolism to include variables and algebraic expressions in order to describe and compare quantities and express mathematical relationships.**

2. Deductive and inductive reasoning are used to reach mathematical conclusions.

Students:

- **use inductive reasoning to construct, evaluate, and validate conjectures and arguments, recognizing that patterns and relationships can assist in explaining and extending mathematical phenomena.**

This is evident, for example, when students:

▲ predict the next triangular number by examining the pattern 1, 3, 6, 10, ❒.

3. Critical thinking skills are used in the solution of mathematical problems.

Students:

- **apply mathematical knowledge to solve real-world problems and problems that arise from the investigation of mathematical ideas, using representations such as pictures, charts, and tables.**

Scientific Inquiry

1. The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

Students:

- **formulate questions independently with the aid of references appropriate for guiding the search for explanations of everyday observations.**
- **construct explanations independently for natural phenomena, especially by proposing preliminary visual models of phenomena.**
- **represent, present, and defend their proposed explanations of everyday observations so that they can be understood and assessed by others.**
- **seek to clarify, to assess critically, and to reconcile with their own thinking the ideas presented by others, including peers, teachers, authors, and scientists.**

This is evident, for example, when students:

▲ *After being shown the disparity between the amount of solid waste which is recycled and which could be recycled,** students working in small groups are asked to explain why this disparity exists. They develop a set of possible explanations and to select one for intensive study. After their explanation is critiqued by other groups, it is refined and submitted for assessment. The explanation is rated on clarity, plausibility, and appropriateness for intensive study using research methods.

2. Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

Students:

- **use conventional techniques and those of their own design to make further observations and refine their explanations, guided by a need for more information.**
- **develop, present, and defend formal research proposals for testing their own explanations of common phenomena, including ways of obtaining needed observations and ways of conducting simple controlled experiments.**
- **carry out their research proposals, recording observations and measurements (e.g., lab notes, audio tape, computer disk, video tape) to help assess the explanation.**

This is evident, for example, when students:

▲ develop a research plan for studying the accuracy of their explanation of the *disparity between the amount of solid waste that is recycled and that could be recycled.** After their tentative plan is critiqued, they refine it and submit it for assessment. The research proposal is rated on clarity, feasibility and soundness as a method of studying the explanations' accuracy. They carry out the plan, with teacher suggested modifications. This work is rated by the teacher while it is in progress.

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

Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

3. The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

Students:

- **design charts, tables, graphs and other representations of observations in conventional and creative ways to help them address their research question or hypothesis.**
- **interpret the organized data to answer the research question or hypothesis and to gain insight into the problem.**
- **modify their personal understanding of phenomena based on evaluation of their hypothesis.**

This is evident, for example, when students:

▲ carry out their plan making appropriate observations and measurements. They analyze the data, reach conclusions regarding their explanation of the *disparity between the amount of solid waste which is recycled and which could be recycled.**, and prepare a tentative report which is critiqued by other groups, refined, and submitted for assessment. The report is rated on clarity, quality of presentation of data and analyses, and soundness of conclusions.

Engineering Design

1. Engineering design is an iterative process involving modeling and optimization finding the best solution within given constraints which is used to develop technological solutions to problems within given constraints.

Students engage in the following steps in a design process:

- **identify needs and opportunities for technical solutions from an investigation of situations of general or social interest.**
- **locate and utilize a range of printed, electronic, and human information resources to obtain ideas.**
- **consider constraints and generate several ideas for alternative solutions, using group and individual ideation techniques (group discussion, brainstorming, forced connections, role play); defer judgment until a number of ideas have been generated; evaluate (critique) ideas; and explain why the chosen solution is optimal.**
- **develop plans, including drawings with measurements and details of construction, and construct a model of the solution, exhibiting a degree of craftsmanship.**
- **in a group setting, test their solution against design specifications, present and evaluate results, describe how the solution might have been modified for different or better results, and discuss tradeoffs that might have to be made.**

This is evident, for example, when students:

▲ reflect on the need for alternative growing systems in desert environments and design and model a hydroponic greenhouse for growing vegetables without soil.

▲ brainstorm and evaluate alternative ideas for an adaptive device that will make life easier for a person with a disability, such as a device to pick up objects from the floor.

▲ design a model vehicle (with a safety belt restraint system and crush zones to absorb impact) to carry a raw egg as a passenger down a ramp and into a barrier without damage to the egg.

▲ assess the performance of a solution against various design criteria, enter the scores on a spreadsheet, and see how varying the solution might have affected total score.

* A variety of content-specific items can be substituted for the italicized text

Standard 2—Information Systems

Intermediate

Information Systems

1. Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.

Students:

- **use a range of equipment and software to integrate several forms of information in order to create good quality audio, video, graphic, and text-based presentations.**
- **use spreadsheets and data-base software to collect, process, display, and analyze information. Students access needed information from electronic data bases and on-line telecommunication services.**
- **systematically obtain accurate and relevant information pertaining to a particular topic from a range of sources, including local and national media, libraries, museums, governmental agencies, industries, and individuals.**
- **collect data from probes to measure events and phenomena.**
- **use simple modeling programs to make predictions.**

This is evident, for example, when students:

▲ compose letters on a word processor and send them to representatives of industry, governmental agencies, museums, or laboratories seeking information pertaining to a student project.

▲ acquire data from weather stations.

▲ use a software package, such as Science Tool Kit, to monitor the acceleration of a model car traveling down a given distance on a ramp.

▲ use computer software to model how plants grow plants under different conditions.

2. Knowledge of the impacts and limitations of information systems is essential to its effective and ethical use.

Students:

- **understand the need to question the accuracy of information displayed on a computer because the results produced by a computer may be affected by incorrect data entry.**
- **identify advantages and limitations of data-handling programs and graphics programs.**
- **understand why electronically stored personal information has greater potential for misuse than records kept in conventional form.**

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

Students will access, generate, process, and transfer information using appropriate technologies.

3. Information technology can have positive and negative impacts on society, depending upon how it is used.

Students:

- **use graphical, statistical, and presentation software to presents project to fellow classmates.**
- **describe applications of information technology in mathematics, science, and other technologies that address needs and solve problems in the community.**
- **explain the impact of the use and abuse of electronically generated information on individuals and families.**

Standard 3—Mathematics
Intermediate

Mathematical Reasoning

1. Students use mathematical reasoning to analyze mathematical situations, make conjectures, gather evidence, and construct an argument.

Students:
- **apply a variety of reasoning strategies.**
- **make and evaluate conjectures and arguments using appropriate language.**
- **make conclusions based on inductive reasoning.**
- **justify conclusions involving simple and compound (i.e., and/or) statements.**

This is evident, for example, when students:

▲ use trial and error and work backwards to solve a problem.
▲ identify patterns in a number sequence.
▲ are asked to find numbers that satisfy two conditions, such as $n > -4$ and $n \le 6$.

Number and Numeration

2. Students use number sense and numeration to develop an understanding of the multiple uses of numbers in the real world, the use of numbers to communicate mathematically, and the use of numbers in the development of mathematical ideas.

Students:
- **understand, represent, and use numbers in a variety of equivalent forms (integer, fraction, decimal, percent, exponential, expanded and scientific notation).**
- **understand and apply ratios, proportions, and percents through a wide variety of hands-on explorations.**
- **develop an understanding of number theory (primes, factors, and multiples).**
- **recognize order relations for decimals, integers, and rational numbers.**

This is evident, for example, when students:

▲ use prime factors of a group of denominators to determine the least common denominator.
▲ select two pairs from a number of ratios and prove that they are in proportion.
▲ demonstrate the concept that a number can be symbolized by many different numerals as in:

$$\frac{1}{4} = \frac{3}{12} = \frac{25}{100} = 0.25 = 25\%$$

Sample Problems

The table below shows the height of a plant during a period of 3 weeks. Initially the plant was 5 inches tall. The table indicates the growth rate of the plant for week 1 through week 3.

Weeks (W)	0	1	2	3
Height (H) (in inches)	5	8	11	14

A) Write an equation that expresses the height (H) of the plant in terms of the number of weeks (W).

Answer: ____________________

B) Use the table or your equation to predict the height of the plant after 10 weeks.

2. An inspector found 5 defective cassettes out of a random sample of 200 cassette tapes. If 4,000 cassette tapes are produced each day, how many tapes would you expect to be defective? Write a proportion that can be used to solve this problem and then solve the problem.

Answer: ____________________

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

Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.

Operations

3. Students use mathematical operations and relationships among them to understand mathematics.

Students:

- **add, subtract, multiply, and divide fractions, decimals, and integers.**
- **explore and use the operations dealing with roots and powers.**
- **use grouping symbols (parentheses) to clarify the intended order of operations.**
- **apply the associative, commutative, distributive, inverse, and identity properties.**
- **demonstrate an understanding of operational algorithms (procedures for adding, subtracting, etc.).**
- **develop appropriate proficiency with facts and algorithms.**
- **apply concepts of ratio and proportion to solve problems.**

This is evident, for example, when students:

▲ create area models to help in understanding fractions, decimals, and percents.

▲ find the missing number in a proportion in which three of the numbers are known, and letters are used as place holders.

▲ arrange a set of fractions in order, from the smallest to the largest:

$$\frac{3}{4}, \frac{1}{5}, \frac{2}{3}, \frac{1}{2}, \frac{1}{4}$$

▲ illustrate the distributive property for multiplication over addition, such as

$2(a + 3) = 2a + 6$.

Modeling/Multiple Representation

4. Students use mathematical modeling/multiple representation to provide a means of presenting, interpreting, communicating, and connecting mathematical information and relationships.

Students:

- **visualize, represent, and transform two- and three-dimensional shapes.**
- **use maps and scale drawings to represent real objects or places.**
- **use the coordinate plane to explore geometric ideas.**
- **represent numerical relationships in one- and two-dimensional graphs.**
- **use variables to represent relationships.**
- **use concrete materials and diagrams to describe the operation of real world processes and systems.**
- **develop and explore models that do and do not rely on chance.**
- **investigate both two- and three-dimensional transformations.**
- **use appropriate tools to construct and verify geometric relationships.**
- **develop procedures for basic geometric constructions.**

This is evident, for example, when students:

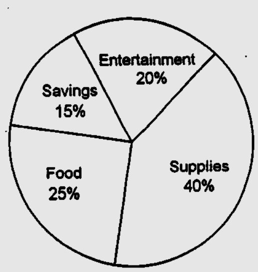
▲ build a city skyline to demonstrate skill in linear measurements, scale drawing, ratio, fractions, angles, and geometric shapes.

▲ bisect an angle using a straight edge and compass.

▲ draw a complex of geometric figures to illustrate that the intersection of a plane and a sphere is a circle or point.

Sample Problems

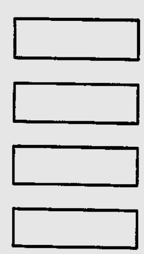
. The graph below shows how Sue spent her allowance last week.



If Sue's allowance is $6.00, how much of her allowance did she spend on entertainment last week?

TASK: SHARING

5. Six students were given four candy bars of equal size. Show how they could divide the candy bars so that each of them received the same amount of candy. Then use the numbers to express how much of a candy bar each student received.



Standard 3—Mathematics

Intermediate

Measurement

5. Students use measurement in both metric and English measure to provide a major link between the abstractions of mathematics and the real world in order to describe and compare objects and data.

Students:

- **estimate, make, and use measurements in real-world situations.**
- **select appropriate standard and nonstandard measurement units and tools to measure to a desired degree of accuracy.**
- **develop measurement skills and informally derive and apply formulas in direct measurement activities.**
- **use statistical methods and measures of central tendencies to display, describe, and compare data.**
- **explore and produce graphic representations of data using calculators/computers.**
- **develop critical judgment for the reasonableness of measurement.**

This is evident, for example, when students:

▲ use box plots or stem and leaf graphs to display a set of test scores.

▲ estimate and measure the surface areas of a set of gift boxes in order to determine how much wrapping paper will be required.

▲ explain when to use mean, median, or mode for a group of data.

Uncertainty

6. Students use ideas of uncertainty to illustrate that mathematics involves more than exactness when dealing with everyday situations.

Students:

- **use estimation to check the reasonableness of results obtained by computation, algorithms, or the use of technology.**
- **use estimation to solve problems for which exact answers are inappropriate.**
- **estimate the probability of events.**
- **use simulation techniques to estimate probabilities.**
- **determine probabilities of independent and mutually exclusive events.**

This is evident, for example, when students:

▲ construct spinners to represent random choice of four possible selections.

▲ perform probability experiments with independent events (e.g., the probability that the head of a coin will turn up, or that a 6 will appear on a die toss).

▲ estimate the number of students who might chose to eat hot dogs at a picnic.

Sample Problems

TASK: Donello's Pizzeria

1. Donello's is considering adding a 12" in diameter "large" pizza to its menu. One customer says that adding the large size pizza is unnecessary because it is the same amount of pizza as 2 of the 6" size pizzas. Use mathematics to determine if the customer is correct. Show your work and write a few sentences to explain your answer.

Answer ____________________

____

____

____

____

____

TASK: PAY PLANS

You have just gotten an after school job at City Outfitters. This company offers two different payment plans to its sales employees.

Plan A Earnings:	$110 per week plus 10% of sales
Plan B Earnings:	$80 per week plus 15% of sales

You need to decide which plan to choose and explain why you made this choice.

28. To help you decide, you ask the sales manager what the average weekly sales are. She tells you sales vary a lot, but average around $350 a week. How much would you expect to earn under each payment plan during an average week?

Answer: Plan A ____________________

Plan B ____________________

Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.

Patterns/Functions

7. Students use patterns and functions to develop mathematical power, appreciate the true beauty of mathematics, and construct generalizations that describe patterns simply and efficiently.

Students:

- **recognize, describe, and generalize a wide variety of patterns and functions.**
- **describe and represent patterns and functional relationships using tables, charts and graphs, algebraic expressions, rules, and verbal descriptions.**
- **develop methods to solve basic linear and quadratic equations.**
- **develop an understanding of functions and functional relationships: that a change in one quantity (variable) results in change in another.**
- **verify results of substituting variables.**
- **apply the concept of similarity in relevant situations.**
- **use properties of polygons to classify them.**
- **explore relationships involving points, lines, angles, and planes.**
- **develop and apply the Pythagorean principle in the solution of problems.**
- **explore and develop basic concepts of right triangle trigonometry.**
- **use patterns and functions to represent and solve problems.**

This is evident, for example, when students:

▲ find the height of a building when a 20-foot ladder reaches the top of the building when its base is 12 feet away from the structure.

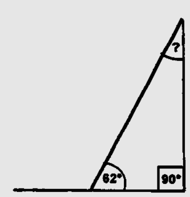
▲ investigate number patterns through palindromes (pick a 2-digit number, reverse it and add the two—repeat the process until a palindrome appears)

	42		86
	+24		+68
palindrome →	66		154
			+451
			605
			+506
		palindrome →	1111

▲ solve linear equations, such as 2(x + 3) = x + 5 by several methods.

Sample Problem

. A painter leaned a ladder up against the wall of my kitchen. The ladder forms an angle of 62° with the floor. What is the measure of the angle formed between the top of the ladder and the wall?



Answer: ____________________

Standard 4—Science

Intermediate

Physical Setting

1. The Earth and celestial phenomena can be described by principles of relative motion and perspective.

Students:
- **explain daily, monthly, and seasonal changes on earth.**

This is evident, for example, when students:

▲ create models, drawings, or demonstrations describing the arrangement, interaction, and movement of the Earth, moon, and sun.
▲ plan and conduct an investigation of the night sky to describe the arrangement, interaction, and movement of celestial bodies.

2. Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

Students:
- **explain how the atmosphere (air), hydrosphere (water), and lithosphere (land) interact, evolve, and change.**
- **describe volcano and earthquake patterns, the rock cycle, and weather and climate changes.**

This is evident, for example, when students:

▲ add heat to and subtract heat from water and graph the temperature changes, including the resulting phase changes.
▲ make a record of reported earthquakes and volcanoes and interpret the patterns formed worldwide.

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Students:
- **observe and describe properties of materials, such as density, conductivity, and solubility.**
- **distinguish between chemical and physical changes.**
- **develop their own mental models to explain common chemical reactions and changes in states of matter.**

This is evident, for example, when students:

▲ test and compare the properties (hardness, shape, color, etc.) of an array of materials.
▲ observe an ice cube as it begins to melt at temperature and construct an explanation for what happens, including sketches and written descriptions of their ideas.

4. Energy exists in many forms, and when these forms change energy is conserved.

Students:
- **describe the sources and identify the transformations of energy observed in everyday life.**
- **observe and describe heating and cooling events.**
- **observe and describe energy changes as related to chemical reactions.**
- **observe and describe the properties of sound, light, magnetism, and electricity.**
- **describe situations that support the principle of conservation of energy.**

This is evident, for example, when students:

▲ design and construct devices to transform/transfer energy.
▲ conduct supervised explorations of chemical reactions (not including ammonia and bleach products) for selected household products, such as hot and cold packs used to treat sport injuries.
▲ build an electromagnet and investigate the effects of using different types of core materials, varying thicknesses of wire, and different circuit types.

5. Energy and matter interact through forces that result in changes in motion.

Students:
- **describe different patterns of motion of objects.**
- **observe, describe, and compare effects of forces (gravity, electric current, and magnetism) on the motion of objects.**

This is evident, for example, when students:

▲ investigate physics in everyday life, such as at an amusement park or a playground.
▲ use simple machines made of pulleys and levers to lift objects and describe how each machine transforms the force applied to it.
▲ build "Rube Goldberg" type devices and describe the energy transformations evident in them.

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

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

The Living Environment

1. Living things are both similar to and different from each other and nonliving things.

Students:

- **compare and contrast the parts of plants, animals, and one-celled organisms.**
- **explain the functioning of the major human organ systems and their interactions.**

This is evident, for example, when students:

▲ conduct a survey of the school grounds and develop appropriate classification keys to group plants and animals by shared characteristics.

▲ use spring-type clothespins to investigate muscle fatigue or rulers to determine the effect of amount of sleep on hand-eye coordination.

2. Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

Students:

- **describe sexual and asexual mechanisms for passing genetic materials from generation to generation.**
- **describe simple mechanisms related to the inheritance of some physical traits in offspring.**

This is evident, for example, when students:

▲ contrast dominance and blending as models for explaining inheritance of traits.

▲ trace patterns of inheritance for selected human traits.

3. Individual organisms and species change over time.

Students:

- **describe sources of variation in organisms and their structures and relate the variations to survival.**
- **describe factors responsible for competition within species and the significance of that competition.**

This is evident, for example, when students:

▲ conduct a long-term investigation of plant or animal communities.

▲ investigate the acquired effects of industrialization on tree trunk color and those effects on different insect species.

4. The continuity of life is sustained through reproduction and development.

Students:

- **observe and describe the variations in reproductive patterns of organisms, including asexual and sexual reproduction.**
- **explain the role of sperm and egg cells in sexual reproduction.**
- **observe and describe developmental patterns in selected plants and animals (e.g., insects, frogs, humans, seed-bearing plants).**
- **observe and describe cell division at the microscopic level and its macroscopic effects.**

This is evident, for example, when students:

▲ apply a model of the genetic code as an analogue for the role of the genetic code in human populations.

5. Organisms maintain a dynamic equilibrium that sustains life.

Students:

- **compare the way a variety of living specimens carry out basic life functions and maintain dynamic equilibrium.**
- **describe the importance of major nutrients, vitamins, and minerals in maintaining health and promoting growth and explain the need for a constant input of energy for living organisms.**

This is evident, for example, when students:

▲ record and compare the behaviors of animals in their natural habitats and relate how these behaviors are important to the animals.

▲ design and conduct a survey of personal nutrition and exercise habits, and analyze and critique the results of that survey.

6. Plants and animals depend on each other and their physical environment.

Students:

- **describe the flow of energy and matter through food chains and food webs.**
- **provide evidence that green plants make food and explain the significance of this process to other organisms.**

This is evident, for example, when students:

▲ construct a food web for a community of organisms and explore how elimination of a particular part of a chain affects the rest of the chain and web.

7. Human decisions and activities have had a profound impact on the physical and living environment.

Students:

- **describe how living things, including humans, depend upon the living and nonliving environment for their survival.**
- **describe the effects of environmental changes on humans and other populations.**

This is evident, for example, when students:

▲ conduct an extended investigation of a local environment affected by human actions, (e.g., a pond, stream, forest, empty lot).

Standard 5—Technology

Intermediate

Engineering Design

1. Engineering design is an iterative process involving *modeling* and *optimization* used to develop technological solutions to problems within given constraints.

Students engage in the following steps in a design process:

- **identify needs and opportunities for technical solutions from an investigation of situations of general or social interest.**
- **locate and utilize a range of printed, electronic, and human information resources to obtain ideas.**
- **consider constraints and generate several ideas for alternative solutions, using group and individual ideation techniques (group discussion, brainstorming, forced connections, role play); defer judgment until a number of ideas have been generated; evaluate (critique) ideas; and explain why the chosen solution is optimal.**
- **develop plans, including drawings with measurements and details of construction, and construct a model of the solution, exhibiting a degree of craftsmanship.**
- **in a group setting, test their solution against design specifications, present and evaluate results, describe how the solution might have been modified for different or better results, and discuss tradeoffs that might have to be made.**

This is evident, for example, when students:

▲ reflect on the need for alternative growing systems in desert environments and design and model a hydroponic greenhouse for growing vegetables without soil.
▲ brainstorm and evaluate alternative ideas for an adaptive device that will make life easier for a person with a disability, such as a device to pick up objects from the floor.
▲ design a model vehicle (with a safety belt restraint system and crush zones to absorb impact) to carry a raw egg as a passenger down a ramp and into a barrier without damage to the egg.
▲ assess the performance of a solution against various design criteria, enter the scores on a spreadsheet, and see how varying the solution might have affected total score.

Tools, Resources, and Technological Processes

2. Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.

Students:

- **choose and use resources for a particular purpose based upon an analysis and understanding of their properties, costs, availability, and environmental impact.**
- **use a variety of hand tools and machines to change materials into new forms through forming, separating, and combining processes, and processes which cause internal change to occur.**
- **combine manufacturing processes with other technological processes to produce, market, and distribute a product.**
- **process energy into other forms and information into more meaningful information.**

This is evident, for example, when students:

▲ choose and use resources to make a model of a building and explain their choice of materials based upon physical properties such as tensile and compressive strength, hardness, and brittleness.
▲ choose materials based upon their acoustic properties to make a set of wind chimes.
▲ use a torch to heat a steel rod to a cherry red color and cool it slowly to demonstrate how the process of annealing changes the internal structure of the steel and removes its brittleness.
▲ change materials into new forms using separate processes such as drilling and sawing.
▲ process energy into other forms such as assembling a solar cooker using a parabolic reflector to convert light energy to heat energy.
▲ process information into more meaningful information such as adding a music track or sound effects to an audio tape.

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

Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

Computer Technology

3. Computers, as tools for design, modeling, information processing, communication, and system control, have greatly increased human productivity and knowledge.

Students:

- **assemble a computer system including keyboard, central processing unit and disc drives, mouse, modem, printer, and monitor.**
- **use a computer system to connect to and access needed information from various Internet sites.**
- **use computer hardware and software to draw and dimension prototypical designs.**
- **use a computer as a modeling tool.**
- **use a computer system to monitor and control external events and/or systems.**

This is evident, for example, when students:

▲ use computer hardware and a basic computer-aided design package to draw and dimension plans for a simple project.

▲ use a computer program, such as Car Builder, to model a vehicle to desired specifications.

▲ use temperature sensors to monitor and control the temperature of a model greenhouse.

▲ model a computer-controlled system, such as traffic lights, a merry-go-round, or a vehicle using Lego or other modeling hardware interfaced to a computer.

Technological Systems

4. Technological systems are designed to achieve specific results and produce outputs, such as products, structures, services, energy, or other systems.

Students:

- **select appropriate technological systems on the basis of safety, function, cost, ease of operation, and quality of post-purchase support.**
- **assemble, operate, and explain the operation of simple open- and closed-loop electrical, electronic, mechanical, and pneumatic systems.**
- **describe how subsystems and system elements (inputs, processes, outputs) interact within systems.**
- **describe how system control requires sensing information, processing it, and making changes.**

This is evident, for example, when students:

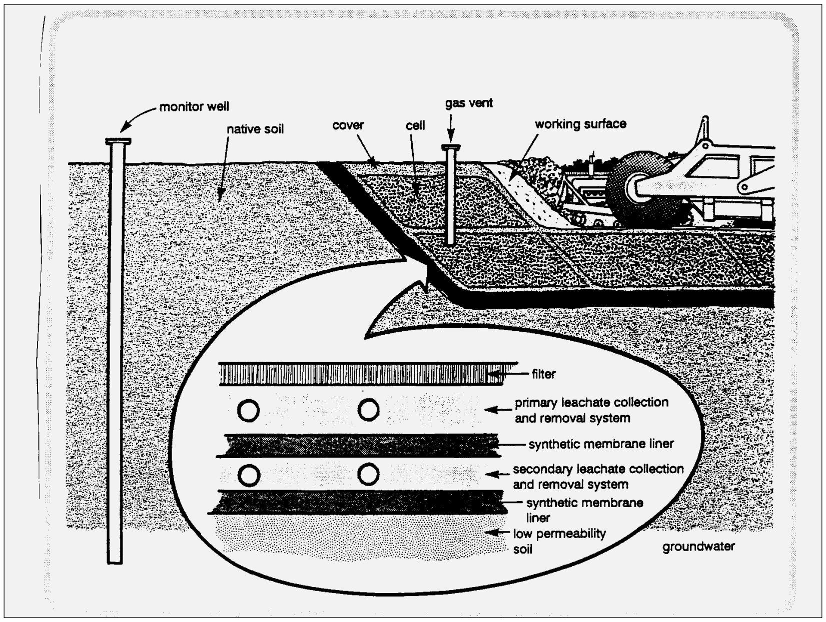
▲ assemble an electronic kit that includes sensors and signaling devices and functions as an alarm system.

▲ use several open loop systems (without feedback control) such as a spray can, bubble gum machine, or wind-up toys, and compare them to closed-loop systems (with feedback control) such as an electric oven with a thermostat, or a line tracker robot.

▲ use a systems diagram to model a technological system, such as a model rocket, with the command inputs, resource inputs, processes, monitoring and control mechanisms, and system outputs labeled.

▲ provide examples of modern machines where microprocessors receive information from sensors and serve as controllers.

Sample Problem/Activity



Systems diagram for a filter system

Standard 5—Technology
Intermediate

History and Evolution of Technology

5. Technology has been the driving force in the evolution of society from an agricultural to an industrial to an information base.

Students:
- **describe how the evolution of technology led to the shift in society from an agricultural base to an industrial base to an information base.**
- **understand the contributions of people of different genders, races, and ethnic groups to technological development.**
- **describe how new technologies have evolved as a result of combining existing technologies (e.g., photography combined optics and chemistry; the airplane combined kite and glider technology with a lightweight gasoline engine).**

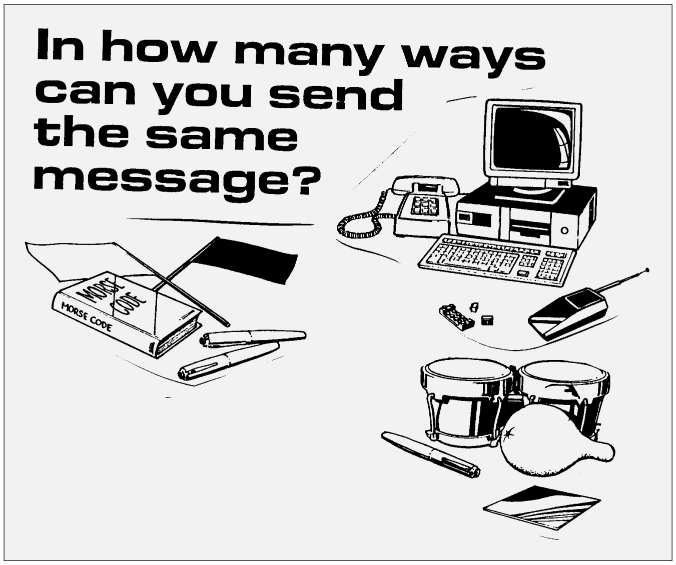
This is evident, for example, when students:

▲ construct models of technological devices (e.g., the plow, the printing press, the digital computer) that have significantly affected human progress and that illustrate how the evolution of technology has shifted the economic base of the country.

▲ develop a display of pictures or models of technological devices invented by people from various cultural backgrounds, along with photographs and short biographies of the inventors.

▲ make a poster with drawings and photographs showing how an existing technology is the result of combining various technologies.

Sample Problem/Activity



Impacts of Technology

6. Technology can have positive and negative impacts on individuals, society, and the environment and humans have the capability and responsibility to constrain or promote technological development.

Students:
- **describe how outputs of a technological system can be desired, undesired, expected, or unexpected.**
- **describe through examples how modern technology reduces manufacturing and construction costs and produces more uniform products.**

This is evident, for example, when students:

▲ use the automobile, for example, to explain desired (easier travel), undesired (pollution), expected (new jobs created), unexpected (crowded highways and the growth of suburbs) impacts.

▲ provide an example of an assembly line that produces products with interchangeable parts.

▲ compare the costs involved in producing a prototype of a product to the per product cost of a batch of 100.

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

Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

Management of Technology

7. Project management is essential to ensuring that technological endeavors are profitable and that products and systems are of high quality and built safely, on schedule, and within budget.

Students:

- **manage time and financial resources in a technological project.**
- **provide examples of products that are well (and poorly) designed and made, describe their positive and negative attributes, and suggest measures that can be implemented to monitor quality during production.**
- **assume leadership responsibilities within a structured group activity.**

This is evident, for example, when students:

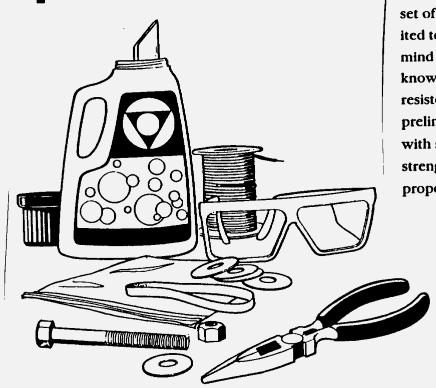
▲ make up and follow a project work plan, time schedule, budget, and a bill of materials.

▲ analyze a child's toy and describe how it might have been better made at a lower cost.

▲ assume leadership on a team to play an audio or video communication system, and use it for an intended purpose (e.g., to inform, educate, persuade, entertain).

Sample Problem/Activity

Can we build a working speaker?



Classroom Activity

1. Divide the class into groups consisting of four students each. Challenge each group to design a plan for the construction of a homemade radio speaker for the eight-ohm speaker jack on an inexpensive transistor radio or cassette recorder. Provide each group with a set of materials, and inform students that they are limited to the use of these materials in their designs. Remind students to draw upon the information and knowledge they possess about electromagnets, current, resistors, and circuits. After each group has generated a preliminary plan, hold a class discussion. Work out with students a class consensus plan that combines the strengths and minimizes the weaknesses of their group-proposed plans (see Procedural Notes section).

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.

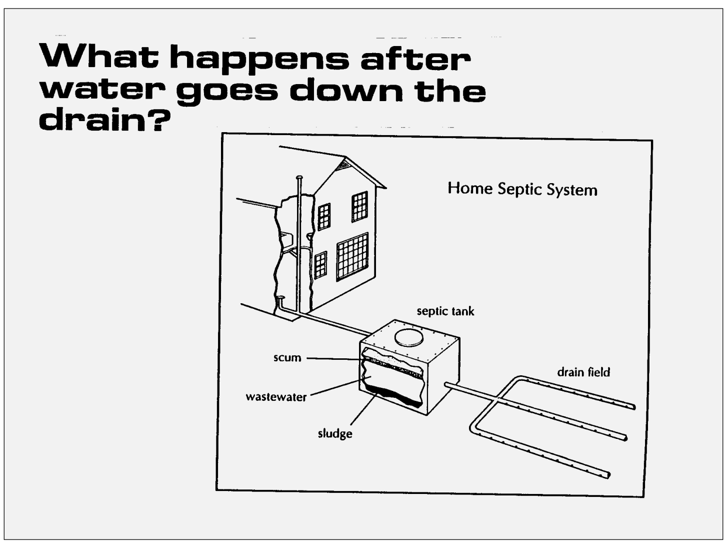
Students:

- **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



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 x 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

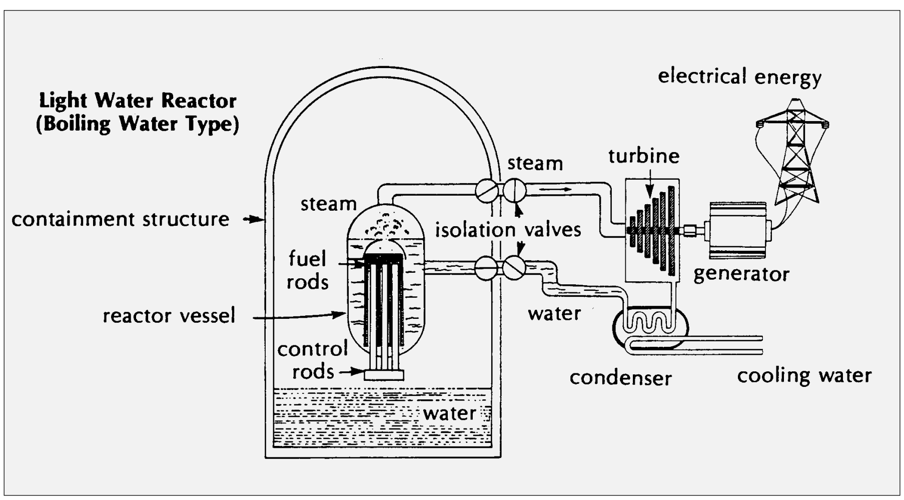
4. Equilibrium is a state of stability due either to a lack of changes (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

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



Standard 6—Interconnectedness: Common Themes Intermediate

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.

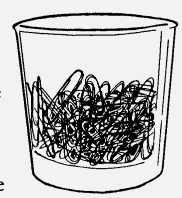
Sample Problem/Activity

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.*

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.

Evaluation

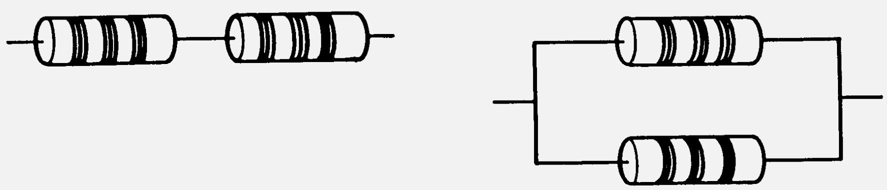
Students are able to identify factors that influence population size, and they suggest reasons why unlimited killing of wild creatures by humans has more of a long-term effect on some species than on others.

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.

Sample Problem/Activity

What is a resistor and how can it be used?



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.

Standard 7—Interdisciplinary Problem Solving Intermediate

Connections

1. The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

Students:

- **analyze science/technology/society problems and issues at the local level and plan and carry out a remedial course of action.**
- **make informed consumer decisions by seeking answers to appropriate questions about products, services, and systems; determining the cost/benefit and risk/benefit tradeoffs; and applying this knowledge to a potential purchase.**
- **design solutions to real-world problems of general social interest related to home, school, or community using scientific experimentation to inform the solution and applying mathematical concepts and reasoning to assist in developing a solution.**
- **describe and explain phenomena by designing and conducting investigations involving systematic observations, accurate measurements, and the identification and control of variables; by inquiring into relevant mathematical ideas; and by using mathematical and technological tools and procedures to assist in the investigation.**

This is evident, for example, when students:

▲ improve a habitat for birds at a park or on school property.

▲ choose a telescope for home use based on diameter of the telescope, magnification, quality of optics and equatorial mount, cost, and ease of use.

▲ design and construct a working model of an air filtration device that filters out particles above a particular size.

▲ simulate population change using a simple model (e.g., different colors of paper clips to represent different species of birds). Timed removals of clips from plastic cups represents the action of predators and varying the percentage of the return of clips to cups represent differences in reproductive rates. Students apply mathematical modeling techniques to graph population growth changes and make interpretations related to resource depletion.

Strategies

2. Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

Students participate in an extended, culminating mathematics, science, and technology project. The project would require students to:

- **work effectively**
- **gather and process information**
- **generate and analyze ideas**
- **observe common themes**
- **realize ideas**
- **present results**

This is evident, for example, when students, addressing the issue of auto safety in an interdisciplinary science/technology/society project:

▲ use an electronic data base to obtain information on the causes of auto accidents and use e-mail to collect information from government agencies and auto safety organizations. Students gather, analyze, and chart information on the number and causes of auto accidents in their county and look for trends.

▲ design and construct a model vehicle with a restraint system to hold a raw egg as the passenger and evaluate the effectiveness of the restraint system by rolling the vehicle down a ramp and into a barrier; the vehicle is designed with crush zones to absorb the impact. Students analyze forces and compute acceleration using F=ma calculations. They present their results, including a videotaped segment, to a driver education class.

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

Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Skills and Strategies for Interdisciplinary Problem Solving

Working Effectively: Contributing to the work of a brainstorming group, laboratory partnership, cooperative learning group, or project team; planning procedures; identify and managing responsibilities of team members; and staying on task, whether working alone or as part of a group.

Gathering and Processing Information: Accessing information from printed media, electronic data bases, and community resources and using the information to develop a definition of the problem and to research possible solutions.

Generating and Analyzing Ideas: Developing ideas for proposed solutions, investigating ideas, collecting data, and showing relationships and patterns in the data.

Common Themes: Observing examples of common unifying themes, applying them to the problem, and using them to better understand the dimensions of the problem.

Realizing Ideas: Constructing components or models, arriving at a solution, and evaluating the result.

Presenting Results: Using a variety of media to present the solution and to communicate the results.

Sample Problem/Activity