

## INTRODUCTION

The following Science and Technology/Engineering documents were created through the collaborative efforts of The Curriculum Review Council, Melrose Public Schools staff, community members, and administrators. The work that resulted in these documents began originally in 2003. That information was published in a benchmark document during the 2005 school year. The 2005 document was revised as part of the 5-year Curriculum Review Cycle Process in 2010. A thorough review of current classroom practices and materials, prior curriculum documents, and the strands and standards contained in the Massachusetts Science and Technology/Engineering Curriculum Framework of 2006, was an integral part of our curriculum revision process. The document created by the Council was then utilized as the foundation to foster an investigative and inquiry-based approach to science, technology and engineering using Full Option Science System (FOSS) kits at the elementary level. We appreciate Mayor Rob Dolan's and the community's support of this endeavor. The benchmarks below reflect FOSS Kit alignment with the MA Science and Technology/Engineering Framework. Other benchmarks have been added to complete coverage and ensure that our students acquire a comprehensive understanding of concepts contained in the Massachusetts STE Frameworks.

"The result of all scientific investigation is a better understanding of natural processes."<sup>1</sup>  
This understanding not only expands our knowledge as a species, enabling us to protect, preserve and advance life, but also nourishes our natural sense of wonder and curiosity. With this in mind, our Science and Technology/Engineering programs are grounded in the belief that providing opportunities for students to: share their prior knowledge and possible misconceptions, investigate, experiment, collaborate, problem solve, and communicate their ideas, is central to instructional design.

We also know that in order to *carry out* their investigations, students must be competent in utilizing the scientific process. This process involves:

- a) Posing a question
- b) Predicting an outcome or formulating a hypothesis
- c) Designing and conducting an experiment specifying variables to be changed, controlled, or measured
- d) Observing and recording data
- e) Drawing conclusions based on evidence
- f) Presenting findings and communicating results.

This is a process we incorporate into our program at every grade level.

The fields of Science and Technology/Engineering are closely tied together. Advancements in one field often create advancements in the other. Both fields incorporate and utilize sound mathematical knowledge. It is our hope that as students move through our Science and Technology/Engineering programs, they become more confident thinkers, communicators, and problem solvers who enjoy the process of seeking answers and who have a deep respect for the complexity of life.

Patricia Muxie, Director of Curriculum, Winter 2011

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<sup>1</sup> *The Massachusetts Science and Technology/Engineering Curriculum Framework*, p.3

## **Pre-K Science and Technology/Engineering Benchmarks**

### **Earth and Space**

- Recognize that water, rocks, soil, and living organisms are found on and in the earth's surface.
- Describe weather changes from day to day and over the seasons.
- Identify some events around us that have repeating patterns, including seasons of the year, day and night.

### **Life Science**

- Recognize that animals (including humans) and plants are living things that grow, reproduce, and need food, air, water and shelter.
- Recognize that plants and animals have life cycles.
- Recognize that people and other animals explore the environment through their senses of sight, hearing, touch, smell and taste.
- Recognize changes that animals and plants go through as the seasons change (e.g., appearance, habitat).

### **Physical Science**

- Sort objects by observable properties such as size, shape, color, weight, and texture.
- Describe the various ways that objects can move (e.g., in a straight line, zigzag, back and forth, around, with varying rates of speed).

### **Technology/Engineering**

- Identify and describe the safe and proper use of tools and materials (e.g., glue, scissors, tape, ruler, paper, toothpicks, straws, spools, hand lens) to construct simple structures.
- Explore the use of tools and simple machines (e.g., ramp, wheel, pulley, lever) in a familiar setting for a specific purpose.

### **Skills of Inquiry/Scientific Process We Expect Students to Demonstrate**

(from the MA Science and Technology/Engineering Framework, 2006)

- Ask questions about objects, organisms, and events in the environment.
- Answer the question, "Why?" or "What would happen if...?"
- Make predictions based on observed patterns.
- Choose, name and use simple equipment and tools (e.g., rulers, thermometers, hand lenses, balance and meter sticks) to gather data and extend the senses.
- Record observations and data with pictures, numbers, or written statements.
- Discuss observations with others.

## **Kindergarten Science and Technology/Engineering Benchmarks**

### **Earth and Space**

- Understand repeating natural patterns of seasons, days, weeks, and months.

### **Life Science**

- Compare living and non-living things.
- Group living and non-living things according to the characteristics they share.
- Identify differences in appearances among individual humans, animals, and plants.
- Identify and explore the five senses in the world around us. Recognize that this is how we interact with our environment. Use appropriate sensory vocabulary to describe characteristics of a variety of objects and materials.
- Identify the similar needs of all people and all living things.

### **Physical Science**

- Describe and demonstrate knowledge of the different properties of matter (e.g., color, size, shape, weight and texture).

### **Technology and Engineering**

- Recognize the characteristics of and some uses for both natural (e.g., wood, fur, cotton, wool) and man-made (e.g., plastic, styrofoam) materials.
- Identify tools that are used by humans to extend their body's capacities (e.g., telescope).
- Independently choose and use tools such as pencil, scissors, rulers, tape, thermometer, hand lenses, paper and stencils for a specific purpose.
- Learn the name of one or more simple machines (e.g., pulley, lever, wheel, ramp). Draw, write, talk about and experiment with the actual object/s).

### **Skills of Inquiry/Scientific Process We Expect Students to Demonstrate**

- Ask questions about objects, organisms, and events in the environment.
- Conduct investigations based on the questions: *Why? What would happen if?*
- Make predictions based on observed patterns.
- Choose, name and use simple equipment and tools (e.g., rulers, thermometers, hand lenses, balance and meter sticks) to gather data and extend the senses.
- Record observations and data with pictures, numbers, or written statements.
- Discuss observations with others.
- Learn scientific vocabulary (e.g., height, weight, balance).

## **Grade 1 Science and Technology/Engineering Benchmarks**

### **Earth and Space**

- Understand repeating natural patterns of seasons, phases of the moon, cycle of the sun, days, weeks, months, and years.
- Describe weather changes from day to day and over the seasons.
- Understand the concept of weather conditions.
- Describe the importance of the sun to all living things.
- Understand that wind is moving air and can move things.
- Understand that air is a mixture of gases that is all around us
- Explain evaporation and condensation in relation to weather.
- Distinguish between various forms of precipitation (e.g., rain, snow, sleet, hail).

### **Life Science**

- Explain how people and animals grow, move and change.
- Describe the way in which, as growth and change occurs, many plants and animals closely resemble their parents in observed appearance
- Identify ways that people, animals, and plants change to adapt to the seasons.
- Observe how a seed grows and what it needs to survive.
- Group living and non-living things according to the characteristics they share.
- Identify an organism's habitat and explain how it provides for its basic needs.

### **Physical Science**

- Identify objects and materials as solid, liquid, or gas.
- Recognize that solids have a definite shape and that liquids and gas take the shape of their container.
- Understand that objects can be balanced. Explore how balance is achieved.
- Describe various ways objects can move.
- Demonstrate that the way to change the motion of an object is to apply a force (e.g., push or pull).
- Understand that force affects motion.

### **Technology and Engineering**

- Independently identify and describe the characteristics of and some uses for both natural (e.g., wood, fur, cotton, wool) and man-made (e.g., plastic, styrofoam) materials.
- Construct a piece of artwork or an invention using natural and human-made materials. Label the materials accurately.
- Identify tools and simple machines used for a purpose (e.g., ramp, wheel, pulley, lever).

### **Skills of Inquiry/Scientific Process We Expect Students to Demonstrate**

(from the MA Science and Technology/Engineering Framework, 2006)

- Ask questions about objects, organisms, and events in the environment.
- Answer the question, "Why?" or "What would happen if...?"
- Make predictions based on observed patterns.
- Choose, name and use simple equipment and tools (e.g., rulers, thermometers, hand lenses, balance and meter sticks) to gather data and extend the senses.
- Record observations and data with pictures, numbers, or written statements.
- Discuss observations with others.

## **Grade 2 Science and Technology/Engineering Benchmarks**

### **Earth and Space Science**

- Recognize that the sun supplies heat and light to the earth and is necessary for life.
- Understand the use of solar energy in the formation of coal, oil and direct heat.
- Independently identify examples of water, rocks, soil and living organisms that are found on the earth's surface.
- Explain how soil is formed by weathering, wind, and decomposition.
- Recognize the different properties of soil, including: color, texture, and the ability to retain water.

### **Life Science**

- Classify plants and animals as living things that grow, reproduce and need food/water/shelter.
- Recognize that living things have life cycles and can be classified according to similar characteristics.
- Recognize fossils and pictures of fossils. Understand that they provide us with information about living things that inhabited the earth years ago.
- Recognize and define a habitat as a place in which a plant/animal lives. Give examples.
- Identify the ways in which an organism's habitat provides for its basic needs (e.g., air, water, nutrients, light, and shelter).
- Recognize that changes in habitat can affect plants and animals.
- Recognize that people interact with their environment through their senses.

### **Technology/Engineering**

- Construct a habitat meeting criteria necessary to sustain life.
- Identify tools and simple machines used for a specific purpose.
- Identify and explain some characteristics and uses for natural and human-made materials.
- Identify and use tools properly and safely to construct simple structures.
- Describe how human beings use parts of the body as tools (e.g., teeth for cutting, hands for grasping) and compare their use with the ways in which animals use those parts of their own bodies.

### **Skills of Inquiry/Scientific Process We Expect Students to Demonstrate**

(from the MA Science and Technology/Engineering Framework, 2006)

- Ask questions about objects, organisms, and events in the environment.
- Answer the question, "Why?" or "What would happen if...?"
- Make predictions based on observed patterns.
- Choose, name and use simple equipment and tools (e.g., rulers, thermometers, hand lenses, balance and meter sticks) to gather data and extend the senses.
- Record observations and data with pictures, numbers, or written statement.
- Discuss observations with others.

## **Grade 3 Science and Technology/Engineering Benchmarks**

### **Earth and Space Science**

- Explain the process of how soil is formed.
- Identify different types of soil, discussing color, texture and ability to support plant growth.
- Explain why different types of soil retain different amounts of water.
- Give examples of how the surface of the earth changes due to slow processes such as erosion/weathering and rapid processes such as volcanic eruptions and earthquakes.
- Describe the causes of earthquakes and volcanoes including tectonic plate motion.
- Describe how water on earth cycles in different forms and locations.
- Give examples of how the cycling of water has an effect on climates.

### **Life Science**

- Describe how energy derived from the sun is used by plants to produce sugars (photosynthesis) and is transferred from producers to consumers and decomposers.
- Give examples of behavior in response to stimuli (e.g., stems growing toward light, roots growing downward, hibernation, migration, flight in response to perceived danger).
- Identify animal behaviors that are instinctual (e.g., turtles burying their eggs) and others that are learned (e.g., humans building fires for warmth).
- Compare and contrast the physical characteristics of plants and animals from different habitats. Explain adaptations to specific habitats and environments.
- Identify the structures in plants that are responsible for food production, water transport, reproduction, growth, support, and protection.
- Recognize that plants and animals can survive harsh environments due to seasonal behaviors (e.g., hibernation, migration, shedding leaves etc.).
- Recognize the predictable life cycles of growth, development, reproduction, and death.
- Differentiate between inherited characteristics and those that are affected by climate or environment.

### **Physical Science**

- Compare and contrast solids, liquids, and gases based on the properties of each.
- Differentiate between the properties of objects (size, shape and weight) and the properties of materials (color, texture, hardness).
- Know and describe the three states of matter as they relate to the properties of water and the water cycle.
- Describe how water can be changed from one state to another by adding or taking away heat.
- Define sound as a form of energy produced by vibrations.
- Give examples of how energy can be transferred from one form to another.
- Demonstrate and explain the properties of sound (e.g., pitch determined by the speed of vibrations, volume).
- Recognize that light travels in a straight line until it strikes an object or travels from one medium to another.
- Demonstrate an understanding of the reflection, refraction, and absorption of light. (cont.)

### Grade 3 Science and Technology/Engineering continued

- Identify the basic forms of energy (e.g., light, sound, heat, electric, magnetic) and understand that they can cause motion or create change.
- Recognize that electricity in a circuit requires a complete loop through which the electrical current can pass.
- Give examples of how energy can be transferred from one form to another and can produce light, heat, and sound.

### **Technology/Engineering**

- Identify a problem that reflects the need for shelter, storage, or convenience. Propose/design a solution identifying and explaining the appropriate materials and tools needed for safe construction, and the reason why you chose your specific materials.
- Use vocabulary related to properties (e.g., weight, strength, flexibility, hardness).
- Identify and explain the difference between complex and simple machines (e.g., hand can opener that includes gears, wheel, wedge, and lever).
- Create/design a musical instrument. Describe its sound using appropriate vocabulary (e.g., pitch, vibration, volume). Relate its sound to any relevant design features (e.g., size, shape, weight).

### **Skills of Inquiry/Scientific Process We Expect Students to Demonstrate**

(from the MA Science and Technology/Engineering Framework, 2006)

- Ask questions and make predictions that can be tested.
- Select and use appropriate tools and technology (e.g., calculators, computers, scales, balances, meter sticks, and graduated cylinders) in order to extend observations.
- Keep accurate records while conducting simple investigations or experiments.
- Conduct multiple trials to test a prediction. Compare actual results with the prediction.
- Recognize simple patterns in data and use data to create a reasonable explanation for the results of an investigation or experiment.
- Record data and communicate findings to others using graphs, charts, maps, models, and oral/written reports.

## **Grade 4 Science and Technology/Engineering Benchmarks**

### **Earth and Space Science**

- Identify and describe the 3 types of rock (sedimentary, igneous, metamorphic). Explain their origins.
- Explain what a mineral is and how it is formed. Give examples.
- Identify and test physical properties of minerals (hardness, color, luster, cleavage, streak).
- Identify the structure of the earth. Name and locate its layers.
- Understand that earth is part of the part of the solar system that includes the sun, planets, and many moons.
- Identify the planets in our solar system and their order from the sun.
- Illustrate the difference between rotation and revolution.
- Explain the connection between rotation and day/night.
- Identify the differences between planets and stars.
- Depict the phases of the moon over the course of a month.

### **Life Science**

- Identify the major stages that characterize the life cycle: birth, growth, development, reproduction and death.
- Explain the term, “metamorphosis” in relation to a frog and butterfly.
- Give examples of how inherited characteristics may change over time as adaptations to changes in the environment that enable organisms to survive (e.g., shape of beak or feet, color, shape of neck, squid development).

### **Physical Science**

- Differentiate between properties of objects and properties of materials.
- Compare and contrast solids, liquids, and gases based on the basic properties of each of these states of matter.
- Identify the basic forms of energy (e.g., light, sound, heat, electrical, and magnetic) and recognize that energy is the ability to cause motion or create change.
- Recognize that sound is produced by vibrating objects and requires a medium in which to travel. Relate vibration to pitch.
- Recognize that light can be reflected, refracted or absorbed, and travels in a straight line until it strikes an object or travels from one medium to another.

### **Technology/Engineering**

- Given a problem that reflects the need for a design solution (e.g., the creation of an earthquake-safe building), create a structure or product using effective materials and specifications to resolve the problem.
  - Identify the relevant design features for building a prototype of a solution to a given problem.
  - Use different methods for representing solutions to problems (e.g., sketches, diagrams, graphic organizers, lists).
- (continued)

## **Skills of Inquiry/Scientific Process We Expect Students to Demonstrate**

(from the MA Science and Technology/Engineering Framework, 2006)

- Ask questions and make predictions that can be tested.
- Select and use appropriate tools and technology (e.g., calculators, computers, scales, balances, meter sticks, and graduated cylinders) in order to extend observations.
- Keep accurate records while conducting simple investigations or experiments.
- Conduct multiple trials to test a prediction. Compare actual results with the prediction.
- Recognize simple patterns in data and use data to create a reasonable explanation for the results of an investigation or experiment.
- Record data and communicate findings to others using graphs, charts, maps, models, and oral/written reports.

## **Grade 5 Science and Technology/Engineering Benchmarks**

### **Earth and Space Science**

- Differentiate between weather (e.g., air temperature, moisture, wind speed and direction, and precipitation) and climate.
- Distinguish between various forms of precipitation (e.g., rain, sleet, snow, hail).
- Describe the properties of water and the water cycle.
- Explain the impact of water currents and the jet stream on weather.

### **Life Science**

- Classify plants according to the physical characteristics they share.
- Identify the structures in plants (e.g., leaves, root, stem, flower, bark) that are responsible for food production, support, water transport, reproduction, growth, and protection.
- Recognize that plants and animals go through predictable life cycles that include birth, growth, development, reproduction, and death.
- Create a diagram of a complex food chain, describing how energy derived from the sun is used by plants and is transferred within the food chain. Include appropriate vocabulary labels such as photosynthesis, consumer, and decomposer.
- Explain the effects of changes in the environment or removal of a species from the food chain.
- Differentiate between observed characteristics of plants and animals that are fully inherited and characteristics that are affected by the climate or environment.
- Give examples of how inherited characteristics may change over time to ensure survival of the species (e.g., shape of beak, length of neck, color ).
- Give examples of how organisms can cause changes in their environment to ensure survival. Explain how some of these changes can affect the ecosystem.
- Recognize plant behaviors, such as the way seedlings stems grow toward the light, or the way roots grow downward due to gravity.

### **Physical Science**

- Recognize that energy is the ability to cause motion or create change.
- Identify the basic forms of energy as: light, sound, heat, electrical, magnetic.
- Give examples of energy being transferred from one form to another.
- Identify and understand complete and incomplete circuits.
- Recognize that electrical circuits require a complete loop through which an electrical current can pass.
- Differentiate between properties of objects ( e.g., size, shape, weight) and properties of materials (e.g., color, texture, hardness).
- Know that electricity can produce heat, light and sound.
- Identify and classify objects and materials as conductors or insulators.
- Explain the properties of magnetic poles.
- Identify magnetic objects from an array.
- Explain how electromagnets are made and used.
- Explain Newton's 3 laws of motion. Give examples.
- Describe the properties of and create a diagram that shows the forces of: friction, air resistance, inertia, and momentum. Explain how these forces work in the world.

## Grade 5 Science and Technology/Engineering continued

- Draw and label six simple machines.

### **Technology/Engineering**

- Identify and explain the appropriate materials and tools needed to safely construct a given prototype of a solution to a given problem.
- Demonstrate different ways in which a problem can be represented (e.g., sketches, diagrams, graphic organizers, lists).
- Make a working model of a machine.
- Compare natural systems with mechanical systems that are designed to serve similar purposes (e.g., a bird's wing as compared to an airplane's wing).
- Explain the difference between simple and complex machines.
- Create a diagram of a complex machine and label the simple machines within it.
- Identify materials used to accomplish a design task based on a specific property (e.g., hardness, flexibility, strength).

### **Skills of Inquiry/Scientific Process We Expect Students to Demonstrate**

(from the MA Science and Technology/Engineering Framework, 2006)

- Ask questions and make predictions that can be tested.
- Select and use appropriate tools and technology (e.g., calculators, computers, scales, balances, meter sticks, and graduated cylinders) in order to extend observations.
- Keep accurate records while conducting simple investigations or experiments.
- Conduct multiple trials to test a prediction. Compare actual results with the prediction.
- Recognize simple patterns in data and use data to create a reasonable explanation for the results of an investigation or experiment.
- Record data and communicate findings to others using graphs, charts, maps, models, and oral/written reports.

**SCIENCE AND TECHNOLOGY/ENGINEERING BENCHMARKS**  
**GRADE 6**

**Note: Numbers to the left of the benchmarks refer to the Massachusetts Science and Technology/Engineering framework standard the benchmarks reflect.**

**Earth and Space Science**

2. Describe the layers of the earth, including the lithosphere, the hot convecting mantle, and the dense metallic core.
  - a. Describe the composition of earth's inner and outer core, mantle, and crust.
  - b. Describe changes of pressure and temperature at increasing depths of the earth's interior.
3. Differentiate among radiation, convection, and conduction, the three mechanisms by which heat is transferred through the earth's system.
4. Explain the relationship among the energy provided by the sun, the global patterns of atmospheric movement, and the temperature differences among the water, land and atmosphere.
5. Describe how the movement of the earth's crustal plates causes both slow changes in the earth's surface (e.g., formation of mountains and ocean basins) and rapid ones (e.g., volcanic eruptions and earthquakes).
  - a. Describe the forces that move the earth's plates.
  - b. Compare the 3 types of plate boundaries.
  - c. Describe theories of continental drift and ocean floor spreading.
  - d. Explain how fossil and rock evidence supports the theory of continental drift.
  - e. Compare the 3 types of seismic waves.
  - f. Explain the cause of most earthquakes.
  - g. Describe the types of volcanoes and their ejecta.
  - h. Explain why there is so much seismic activity around the Pacific Rim and in the middle of the Atlantic Ocean.
  - i. Explain how the movements of plates affect the occurrences of earthquakes and volcanoes around the globe.
6. Describe and give examples of ways in which the earth's surface is built up and torn down by natural processes, including deposition of sediments, rock formation, erosion, and weathering.
  - a. Explain how minerals form.
  - b. Identify minerals by their physical properties.
  - c. Classify the three types of rocks – igneous, metamorphic and sedimentary.
  - d. Relate the type of rock to the way it was formed.
  - e. Describe the rock cycle.
7. Explain and give examples of how physical evidence, such as fossils and surface features of glaciation, supports theories that the earth has evolved over geologic time.
8. Recognize that gravity is a force that pulls all things on or near the earth toward the center of the earth. It plays a major role in the formation of the solar system and in determining the motion of the stars and planets. (continued)

**Life Sciences**

1. Classify organisms into the currently recognized kingdoms according to characteristics that they share. Be familiar with organisms from each kingdom.
  - a. Explain how binomial nomenclature is used to classify living things.
  - b. Describe characteristics of and give examples of members of the 5 Kingdoms.
  - c. Identify the major structure in viruses and monerans and describe how they obtain energy and reproduce.
  - d. Distinguish among the major forms of fungi.
  - e. Describe ways in which viruses, bacteria, protists and fungi could be harmful or beneficial.
  - f. Compare ferns, mosses and multicellular algae.
  - g. Describe the structures of seed plants.
  - h. Describe major characteristics of invertebrates.
  - i. Compare differences between warm-blooded and cold-blooded vertebrates.
  - j. Distinguish among amphibians, fish, reptiles and birds.
  - k. Distinguish between internal and external fertilization.
  - l. Describe the main characteristics of the three basic groups of mammals.
2. Understand that all organisms are composed of cells and that many organisms are single-celled. Differentiate between prokaryotic and eukaryotic cells.
9. Understand the difference between sexual reproduction (two parents) and asexual reproduction (one parent).
10. Give examples of ways in which genetic variation and environmental factors are causes of evolution and the diversity of organisms.
11. Recognize that evidence drawn from geology, fossils, and comparative anatomy provides the basis of the theory of evolution.
12. Relate the extinction of species to a mismatch of adaptation and the environment.
17. Identify ways in which ecosystems have changed throughout geologic time in response to physical conditions, interactions among organisms, and the actions of humans. Describe how changes may be catastrophes such as volcanic eruptions or ice storms.
18. Recognize that biological evolution accounts for the diversity of species development through gradual processes over many generations.
  - a. Define evolution.
  - b. Explain how an adaptation can increase an organisms chance for survival.
  - c. Explain how natural selection leads to new and varied species.
  - d. Describe the effects of migration and isolation on evolution.
  - e. Explain how fossils provide information about the earth's past.
  - f. Describe how events in earth's history can be put in correct order.
  - g. Discuss the law of superposition.
  - h. Explain how false intrusions and extrusions provide clues to earth's past.
  - i. Explain how radioactive dating is used to determine ages of rocks and fossils.
  - j. Identify major divisions of geologic time.
  - k. Discuss surface features and life forms that characterize the four eras of geological time.

(continued)

Grade 6 Science and Technology/Engineering benchmarks continued

**Physical Science**

- 14, 16 Understand, explain, and demonstrate concepts of convection, conduction, and radiation, as part of heat transfer in the Earth's system.

**Technology/Engineering**

4. Identify and explain the steps of the engineering design process:
- a. identify the need or problem
  - b. research the problem
  - c. develop possible solutions
  - d. select the best solution
  - e. construct a prototype
  - f. test and evaluate
  - g. communicate the solution
  - h. redesign if necessary.
1. Given a design task, identify appropriate materials (e.g., wood, paper, plastic, aggregates, ceramics, solvents, adhesives) and tools one could use based on specific properties and characteristics (e.g., weight, strength, hardness, and flexibility).
- 1.2 Identify appropriate measuring, hand, and power tools used to hold, lift, carry, fasten, and separate, and explain their safe and proper use.
- 1.3 Identify the safe and proper use of measuring tools, hand tools, and machines (e.g., band saw, drill, screw driver, tape measure) needed to construct a prototype of an engineering design.
5. Demonstrate methods of representing solutions to a design problem using sketches, orthographic projections, and multiview drawings.
8. Explain how design features such as size, shape, weight, function and cost limitations would affect the construction of a given prototype.
13. Identify and explain icons and symbols used to communicate in a global economy.
20. Identify and explain different forces affecting bridge and tower construction (e.g., compression, tension, bending, and shear).
19. Identify and describe major types of bridges (e.g., arch, beam, suspension) and their appropriate uses.
21. Describe and explain the effects of loads and structural shapes on bridges.
18. Describe and explain the parts of a structure (e.g., foundation, flooring, decking, wall, roofing).

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Grade 6 Science and Technology/Engineering continued

16. Describe the manufacturing organization (e.g., corporate structure, research and development, production, marketing, quality control, and distribution).
23. Given a transportation problem, explain a possible solution using the universal systems model.

Students will also be able to:

- Understand the benefits of computer aided design.
- Identify vocations and occupations which utilize background knowledge in technology education.

**Skills of Inquiry/Scientific Process We Expect Students to Demonstrate**

(from the MA Science and Technology/Engineering Framework, 2006)

- Formulate a testable hypothesis.
- Design and conduct an experiment specifying variables to be changed, controlled, and measured.
- Select appropriate tools and technology (e.g., microscopes, thermometers, computers, balances, graduated cylinders) and make quantitative observations.
- Present and explain data and findings using multiple representations including: tables, graphs, mathematical and physical models, and demonstrations.
- Draw conclusions based on data or evidence presented in tables or graphs, and make inferences based on patterns or trends in the data.
- Communicate procedures and results using appropriate science and technology terminology.
- Offer explanations of procedures, and critique/ revise them.

**SCIENCE AND TECHNOLOGY/ENGINEERING BENCHMARKS**  
**GRADE 7**

**Note:** Numbers to the left of the benchmarks refer to the Massachusetts Science and Technology/Engineering framework standard the benchmarks reflect.

**Earth and Space Science**

3. Describe heat as being a transfer of thermal energy. Define and explain the difference between radiation, convection, and conduction.

**Life Sciences**

2. Recognize that all organisms are composed of cells, and that many organisms are single-celled (unicellular), e.g., bacteria, yeast. In these single-celled organisms, one cell must carry out all of the basic functions of life.
  - a. State the three basic concepts included in the cell theory.
  - b. Distinguish between unicellular and multicellular organisms.
  - c. State the cell theory and describe the invention of the microscope.
3. Compare and contrast plant and animal cells, including major organelles (e.g., cell membrane, cell wall, nucleus, cytoplasm, chloroplasts, mitochondria, vacuoles).
  - a. Compare and contrast the structure of plant and animal cells.
  - b. Describe the function of cell organelles.
  - c. Describe the composition of the cell nucleus.
4. Recognize that within cells, many of the basic functions of organisms (e.g., extracting energy from food and getting rid of wastes) are carried out. The way in which cells function is similar in all living organisms.
  - a. Discuss diffusion and osmosis.
  - b. Distinguish between active and passive transport through cell membranes.
  - c. Explain why cells cannot grow by increasing in size.
  - d. Describe the phases of mitosis (cell division).
5. Describe the hierarchical organization of multicellular organisms from cells to tissues to organs to systems to organisms.
  - a. Identify the characteristics of living things.
  - b. Identify the basic needs of living things.
  - c. Describe the life processes common to living things.
  - d. Explain why cells specialize.
  - e. Describe how the structure of a certain type of cell enables it to carry out its particular function.
  - f. Describe the five levels of organization found in all living things.
  - g. Identify the structures and functions of the body's major organ systems.
6. Identify the general functions of the major systems of the human body (digestion, respiration, reproduction, circulation, excretion, protection from disease, and movement, control, and coordination) and describe ways that these systems interact with each other.
9. Compare sexual reproduction (half of the genes from each parent) with asexual reproduction (each offspring an identical copy of the parent's cell). (continued)

## Grade 7 Science and Technology/Engineering continued

- 10, 12 Review and better understand adaptations in relation to ecology.
13. Give examples of ways in which organisms interact and have different functions within an ecosystem that enable the ecosystem to survive.
14. Explain the roles and relationships among producers, consumers and decomposers in the process of energy transfer in a food web.
  - a. Distinguish among producers, consumers and decomposers.
  - b. Trace the path of solar energy through a food chain.
15. Explain how dead plants and animals are broken down by other living organisms and how this process contributes to the system as a whole.
16. Recognize that producers (i.e., plants that contain chlorophyll) use the energy from sunlight to make sugars from carbon dioxide and water through a process called photosynthesis. This food can be used immediately, stored for later use, or used by other organisms.
  - a. Explain how a change to organisms affects other organisms in the food webs.
  - b. Describe food chains and food webs.

### **Physical Science**

1. Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.
  - a. Identify characteristic properties of matter and explain their uses.
2. Differentiate between volume and mass. Define density.
3. Recognize that the measurement of volume and mass requires understanding of the sensitivity of measurement tools (e.g., rulers, graduated cylinders, balances) and knowledge and appropriate use of significant digits.
5. Recognize that there are more than 100 elements that combine in a multitude of ways to produce compounds that make up all of the living and nonliving things that we encounter.
  - a. Calculate the density of a substance.
  - b. Distinguish between mixtures and pure substances (i.e., elements and compounds).
  - c. List information in a periodic table and describe how it is organized.
  - d. Compare chemical and physical properties of metals, non-metals and metalloids.
  - e. Identify and describe different groups of metals and how reactivity changes across the periodic table.
  - f. Locate non-metals and metalloids in the periodic table. (continued)

## Grade 7 Science and Technology/Engineering continued

6. Differentiate between an atom (i.e., the smallest unit of an element that maintains the characteristics of that element) and a molecule (i.e., the smallest unit of a compound that maintains the characteristics of that compound).
  - a. Explain how atoms are the particles that make up all matter.
  - b. Explain the structure of an atom.
  - c. Compare the movement of particles in solids, liquids and gases.
  - d. Explain how energy is involved in changes of state.
7. Give basic examples of elements and compounds.
8. Differentiate between mixtures and pure substances.
11. Explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed.
12. Graph and interpret distance vs. time graphs for constant speed.
13. Differentiate between potential and kinetic energy. Identify situations where kinetic energy is transformed into potential energy and vice versa.
  - a. Calculate acceleration.
  - b. Explain how force and mass are related to motion.
  - c. Identify factors that determine friction force below two surfaces.
14. Recognize that heat is a form of energy and that temperature change results from adding or taking away heat from a system.
15. Explain the effect of heat on particle motion through a description of what happens to particles during a change in phase.
16. Give examples of how heat moves in predictable ways, moving from warmer objects to cooler ones until they reach equilibrium.

### **Technology/Engineering**

Note: Technology and Engineering benchmarks for Grades 6-8 are the same, however, the projects used to master the benchmarks are more complex at each grade level.

4. Identify and explain the steps of the engineering design process:
  - a. identify the need or problem
  - b. research the problem
  - c. develop possible solutions
  - d. select the best solution
  - e. construct a prototype
  - f. test and evaluate
  - g. communicate the solution
  - h. redesign if necessary.
23. Given a transportation problem, explain a possible solution using the universal systems model. (continued)

## Grade 7 Science and Technology/Engineering continued

1. Given a design task, identify appropriate materials and tools one could use based on specific properties and characteristics (e.g., weight, strength, hardness, and flexibility).
- 2,3 Identify the safe and proper use of hand tools and power tools used to hold, lift, carry, fasten, and separate.
5. Demonstrate methods of representing solutions to a design problem using sketches, orthographic projections, and multiview drawings.
8. Explain how design features such as size, shape, weight, function and cost limitations would affect the construction of a given prototype.
13. Identify and explain icons and symbols used to communicate in a global economy.
20. Identify and explain different forces affecting bridge and tower construction (e.g., compression, tension, bending, and shear).
19. Identify and describe major types of bridges (e.g., arch, beam, suspension) and their appropriate uses.
21. Describe and explain the effects of loads and structural shapes on bridges.
18. Describe and explain the parts of a structure (e.g., foundation, flooring, decking, wall, roofing).
16. Describe the manufacturing organization (e.g., corporate structure, research and development, production, marketing, quality control, and distribution).

Students will also be able to:

- Understand the benefits of computer aided design.
- Identify vocations and occupations which utilize background knowledge in technology education.

### **Skills of Inquiry/Scientific Process We Expect Students to Demonstrate**

(from the MA Science and Technology/Engineering Framework, 2006)

- Formulate a testable hypothesis.
- Design and conduct an experiment specifying variables to be changed, controlled, and measured.
- Select appropriate tools and technology (e.g., microscopes, thermometers, computers, balances, graduated cylinders) and make quantitative observations.
- Present and explain data and findings using multiple representations including: tables, graphs, mathematical and physical models, and demonstrations.
- Draw conclusions based on data or evidence presented in tables or graphs, and make inferences based on patterns or trends in the data.
- Communicate procedures and results using appropriate science and technology terminology.
- Offer explanations of procedures, and critique and revise them.

## **SCIENCE AND TECHNOLOGY/ENGINEERING BENCHMARKS**

### **GRADE 8**

**Note:** Numbers to the left of the benchmarks refer to the Massachusetts Science and Technology/Engineering framework standard the benchmarks reflect.

#### **Earth and Space Science**

1. Recognize, interpret and be able to create models of the earth's common physical features in different mapping representations, including contour maps.
  - a. Describe the use of topographic maps to show relief of land surface.
  - b. Interpret symbols and colors used on topographical maps.
  - c. Identify features of maps.
  - d. Compare different map projections.
  - e.
- 2, 5 Review the layers of the earth and the movement of the crustal plates.
8. Recognize that gravity is a force that pulls all things on and near the earth toward the center of the earth. Gravity plays a major role in the formation of the planets, stars, and solar system and in determining their motions.
9. Describe lunar and solar eclipses, the observed moon phases, and tides. Relate them to the relative positions of the earth, moon, and sun.
10. Compare and contrast properties and conditions of objects in the solar system (i.e., sun, planets, and moons) to those on Earth (i.e., gravitational force, distance from the sun, speed, movement, temperature, and atmospheric conditions).
11. Explain how the tilt of the earth and its revolution around the sun result in an uneven heating of the earth, which in turn causes the seasons.
  - a. Describe factors that interact to cause weather.
  - b. Identify the three layers of the sun's atmosphere.
  - c. Discuss nuclear reactions that occur in the core of the sun.
  - d. Describe the "storms" that occur on the sun's surface.
  - e. Explain how unequal heating by the sun affects the origination of local and global wind systems.
  - f.
12. Recognize that the universe contains many billions of galaxies, and that each galaxy contains many billions of stars.
  - a. Describe the three types of galaxies.
  - b. Describe the Milky Way Galaxies.
  - c. Describe the characteristics of novas, nebulae, and star clusters.
  - d. Describe the Milky Way Galaxy position in relation to the Local Group and Virgo Super Cluster.
  - e. Describe the size, brightness, and composition of stars.
  - f. Identify the main sequence stars using a Hertzsprung-Russell diagram.
  - g. Identify the sun's major constellations.
  - h. Explain motion of circumpolar constellations.
  - i. Contrast the position of a constellation at different times of the year.

**Life Sciences**

1. Strengthen understanding of the classification of organisms into kingdoms according to shared characteristics.
7. Recognize that every organism requires a set of instructions that specifies its traits. These instructions are stored in the organism's chromosomes. Heredity is the passage of these instructions from one generation to another.
  - a. Describe the main function of chromosome theory in heredity.
  - b. Describe the main functions of chromosomes.
8. Recognize that hereditary information is contained in genes located in the chromosomes of each cell. A human cell contains about 30,000 different genes on 23 different chromosomes.
  - a. Distinguish between mitosis and meiosis.
  - b. Explain what occurs in each step of meiosis.
  - c. Distinguish between phenotypes and genotypes.
  - d. Explain how a Punnett Square can be used to predict the results of genetic crosses.
  - e. Explain that genes are the unit of heredity and are carried on chromosomes.
  - f. Distinguish between dominant and recessive traits.
  - g. Explain the law of Segregation.
  - h. Explain the Law of Independent Assortment.
  - i. Distinguish between homozygous organisms and heterozygous (hybrid) organisms.
9. Compare sexual reproduction (offspring inherit half of their genes from each parent) with asexual reproduction (offspring is an identical copy of the parent's cell) in greater depth.
10. Discuss mutations and genetic disorders.
14. Strengthen understanding of the roles and relationships of producers, consumers, and decomposers in the process of energy transfer in a food web. (continued)

**Physical Science**

1. Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.
2. Differentiate between volume and mass. Define density.
3. Recognize that the measurement of volume and mass requires understanding of the sensitivity of measurement tools (e.g., rulers, graduated cylinders, balances) and knowledge and appropriate use of significant digits.
4. Explain and give examples of how mass is conserved in a closed system.
  - a. Explain how a chemical equation illustrates the law of conservation of mass.
  - b. Write and balance chemical equations to show conservation of mass in chemical reactions.
5. Recognize that there are more than 100 elements that combine in a multitude of ways to produce compounds that make up all of the living and nonliving things that we encounter.
  - a. Discuss how chemical equations are used to describe chemical reactions.
  - b. Distinguish between elements and compounds.
  - c. Predict oxidation numbers of atoms according to their position on the Periodic Table of Elements.
6. Differentiate between an atom (the smallest unit of an element that maintains the characteristics of that element) and a molecule (the smallest unit of a compound that maintains the characteristics of that compound).
  - a. Explain that all matter is composed of atoms.
  - b. Describe the subatomic structure of a particular element.
  - c. Describe chemical bonding in terms of an atom's electron arrangement.
7. Give examples of elements and compounds.
  - a. Predict the formation of compounds between elements.
8. Differentiate between mixtures and pure substances.
  - a. Use indicators to distinguish among acids, bases and neutral substances.
  - b. State properties of acids and bases.
9. Recognize that a substance (element or compound) has a melting point and a boiling point, both of which are independent of the amount of the sample.
10. Differentiate between physical changes and chemical changes.  
(e.g., Explain that chemical reaction is accompanied by a change in properties (exothermic vs. endothermic reaction) and a change in energy of substances involved.) Describe characteristics of chemical reactions.

## Grade 8 Science and Technology/Engineering continued

12. Graph and interpret distance vs. time graphs for constant speed.
15. Explain the effect of heat on particle motion through a description of what happens to particles during a change in phase.

### **Technology/Engineering**

Note: Technology and Engineering benchmarks for Grades 6-8 are the same, however, the projects used to master the benchmarks are more complex at each grade level.

4. Identify and explain the steps of the engineering design process:
  - a) identify the need or problem
  - b) research the problem
  - c) develop possible solutions
  - d) select the best solution
  - e) construct a prototype
  - f) test and evaluate
  - g) communicate the solution
  - h) redesign if necessary.
9. Identify the five elements of a universal systems model: goal, inputs, processes, outputs, and feedback.
6. Describe and explain the purpose of a given prototype.
11. Identify and explain the appropriate tools, machines, and electronic devices used to produce and/or reproduce design solutions.
10. Identify and explain the components of a communication system (e.g., source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination).
12. Identify and compare communication technologies and systems.

### **Manufacturing**

17. Explain the basic processes in manufacturing systems (e.g., cutting, shaping, assembling, joining, quality control and safety).
15. Explain and give examples of the impact of interchangeable parts, the use of automation, and components of mass-produced products.
26. Give examples of adaptive or assistive devices and explain their purpose.
14. Describe, compare and explain the manufacturing systems of custom and mass production.
27. Identify examples of bio-engineered products and explain their purpose and benefits.

(continued)

## Grade 8 Science and Technology/Engineering continued

### **Transportation**

22. Identify and compare examples of transportation systems and devices that operate on land, in the air, on water and in space.
24. Describe propulsion, guidance, suspension, control, and support in relation to transportation subsystems.
25. Identify and explain lift, drag, friction, thrust, and gravity in a vehicle or device used for transportation.
23. Given a transportation problem, explain a possible solution using the universal systems model.

### **Skills of Inquiry/Scientific Process We Expect Students to Demonstrate**

(from the MA Science and Technology/Engineering Framework, 2006)

- Formulate a testable hypothesis.
- Design and conduct an experiment specifying variables to be changed, controlled, and measured.
- Select appropriate tools and technology (e.g., microscopes, thermometers, computers, balances, graduated cylinders) and make quantitative observations.
- Present and explain data and findings using multiple representations including: tables, graphs, mathematical and physical models, and demonstrations.
- Draw conclusions based on data or evidence presented in tables or graphs, and make inferences based on patterns or trends in the data.
- Communicate procedures and results using appropriate science and technology terminology.
- Offer explanations of procedures, and critique and revise them.

**\*The Pre-K-8 document above incorporates the revisions completed by the Curriculum Review Council in June of 2010.**

## **INTRODUCTION TO MELROSE HIGH SCHOOL SCIENCE AND TECHNOLOGY/ENGINEERING BENCHMARKS**

The Melrose High School Science Department has built its Science and Technology/Engineering program on the foundation of the following Massachusetts Frameworks beliefs:

- Students learn best in an environment that conveys high academic expectations for all
- An effective program gives students opportunities to collaborate in scientific and technological endeavors and communicate their ideas and findings
- Investigation, experimentation, and problem solving are central to learning
- Science and Technology/Engineering are integrally related to the discipline of Mathematics but can also be connected to all other disciplines
- When planning instruction, we must address students' prior knowledge and misconceptions
- Assessment serves to inform instruction and assists in the evaluation of student progress
- Support from parents and the community is essential to the success of our program
- A coherent program requires district-wide planning.

As recommended in the Massachusetts State Frameworks, we also believe it is important to incorporate skills of inquiry into our instruction. With this in mind, we encourage students to:

- Pose questions and state hypotheses based on prior scientific observations, experiments, and knowledge
- Distinguish between hypothesis and theory as scientific terms
- Either individually or as part of a team, design and complete an experiment that extends over several days or weeks
- Use mathematics to analyze and support findings and to formulate conclusions
- Simulate physical processes or phenomena using different kinds of representations
- Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions
- Revise scientific models
- Communicate and defend a scientific argument.

*\*The following document represents a revision of the original 2005 document created through the efforts of the Melrose High School Science and Technology/Engineering Department.*

**SCIENCE AND TECHNOLOGY/ENGINEERING BENCHMARKS  
BIOLOGY  
MELROSE HIGH SCHOOL**

**Structure and Function of Cells**

- Relate cell parts/organelles to their functions.
- Differentiate between prokaryotic cells and eukaryotic cells, in terms of their general structures and degrees of complexity.
- Distinguish between plant and animal cells.
- Describe how cells function in a narrow range of physical conditions, such as temperature and pH, to perform life functions that help to maintain homeostasis.
- Explain the role of cell membranes (diffusion, osmosis, and active transport).
- Identify the reactants and products in the general reaction of photosynthesis.
- Provide evidence that the organic compounds produced by plants are the primary source of energy and nutrients for most living things.
- Identify that cellular respiration produces ATP. Explain the interrelated nature of photosynthesis and cellular respiration.
- Describe and compare the processes of mitosis, meiosis, and the cell cycle and their significance.
- Explain the interrelated nature of photosynthesis and cellular respiration.
- Distinguish between aerobic and anaerobic respiration.

**Genetics**

- Describe the structure and function of DNA and distinguish between replication, transcription, and translation.
- Describe the general pathway by which ribosomes produce proteins by using tRNAs to translate genetic information encoded in mRNAs.
- Explain how mutations in the DNA sequence of a gene may result in phenotypic change in an organism and in its offspring.
- Differentiate between dominant, recessive, co-dominant, polygenic, and sex-linked traits.
- State Mendel's laws of segregation and independent assortment.
- Use a Punnett Square to determine the genotype and phenotype of monohybrid crosses.
- Explain how zygotes are produced in the fertilization process.
- Recognize that while viruses lack cellular structure, they have the genetic material to invade living cells.
- Describe the processes of replication, transcription, and translation and how they relate to each other in molecular biology.

(continued)

## High School Biology continued

### **Evolution and Diversity**

- Explain how the fossil record and other evidence support the theory of evolution.
- Illustrate how genetic variation is preserved or eliminated from a population through Darwinian natural selection (organic evolution) resulting in biodiversity.
- Describe how the taxonomic system classifies living things into domains and kingdoms.
- Explain how biotic and abiotic factors can lead to speciation.
- Relate characteristics of kingdoms to evolutionary history.

### **Ecosystems**

- Explain how biotic and abiotic factors cycle in an ecosystem (water, carbon, oxygen, and nitrogen).
- Use a food web to identify and distinguish producers, consumers, and decomposers and explain the transfer of energy through trophic levels.
- Analyze changes in an ecosystem resulting from natural causes, changes in climate, human activity or introduction of non native species.

### **Ecosystem Relationships**

- Identify the factors in an ecosystem that influence fluctuations in population size.
- Explain how symbiotic behavior produces interactions within ecosystems.

### **The Chemistry of Life**

- Explain the significance of carbon in organic molecules.
- Recognize the six most common elements in organic molecules (C, H, N, O, P, S).
- Describe the composition and functions of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids).
- Describe how dehydration synthesis and hydrolysis relate to organic molecules.
- Explain the role of enzymes in biochemical reactions.

### **Human Anatomy and Physiology**

- Explain how the major organ systems have functional units with specific anatomy that perform the function of that organ system.
- Describe how the function of individual systems within the human are integrated to maintain a homeostatic balance in the body.

Note: In the course entitled, “Bioethical Issues,” students demonstrate knowledge of various biological concepts (e.g., DNA, ecology) and discuss them in the context of the impact they have on society. Students also discuss the ethics of scientific progress and research in biology-related areas.

**SCIENCE AND TECHNOLOGY/ENGINEERING BENCHMARKS**  
**CHEMISTRY**  
**MELROSE HIGH SCHOOL**

**Properties of Matter**

- Identify and explain some of the physical properties that are used to classify matter (e.g., density, melting point, and boiling point).
- Explain the difference between mixtures and pure substances.
- Describe the three states of matter in terms of energy, particle motion, and phase transitions.
- Distinguish between chemical and physical changes.

**Atomic Structure**

- Trace the development of the atomic theory and the structure of the atom from the ancient Greeks to the present (e.g., Dalton, Thompson, Rutherford, Bohr, and modern theory).
- Interpret Dalton's atomic theory in terms of the Laws of Conservation of Mass, Constant Composition, and Multiple Proportions.
- Identify the major components of the nuclear atom (protons, neutrons, and electrons) and explain how they interact.
- Understand that matter has properties of both particles and waves.
- Using Bohr's model of the atom, interpret changes (emission/absorption) in electron energies in the hydrogen atom corresponding to emission transitions between quantum levels.
- Describe the properties of alpha, beta, and gamma radiation.
- Write balanced nuclear reactions.
- Describe the electromagnetic spectrum in terms of wavelength and energy; identify regions of the electromagnetic spectrum.
- Write the electron configurations for elements.
- Compare nuclear fission and fusion as well as mass defect.
- Recognize that some elements spontaneously break down into new elements through the process of radioactive decay. Explain this process demonstrating knowledge of stable and unstable isotopes.
- Explain the concept of half-life.

**Periodicity**

- Explain the relationship of an element's position on the periodic table to its atomic number and mass.
- Use the periodic table to identify metals, nonmetals, metalloids, families (groups), periods, valence electrons, and reactivity with other elements in the table.
- Relate the position of an element on the periodic table to its electron configuration.
- Identify trends on the periodic table (e.g., ionization energy, electro negativity, electron affinity, and relative size of atoms and ions).

**Chemical Bonding**

- Explain how atoms combine to form compounds through both ionic and covalent bonding.
- Draw Lewis dot structures for simple molecules. (continued)

## High School Chemistry continued

- Relate electro negativity and ionization energy to the type of bonding an element is likely to undergo.
- Predict the shape of simple molecules and their polarity.
- Identify the types of intermolecular forces present based on molecular geometry and polarity.
- Predict chemical formulas based on the number of valence electrons.
- Name and write the chemical formulas for simple ionic and molecular compounds, including those that contain common polyatomic ions.

### **Chemical Reactions**

- Balance chemical equations by applying the law of conservation of mass.
- Recognize synthesis, decomposition, single displacement, double displacement, and neutralization reactions.
- Understand the mole concept in terms of number of particles, mass and gaseous volume.
- Determine molar mass, percent compositions, empirical formulas, and molecular formulas.
- Calculate mass-mass, mass-volume, volume-volume, and limiting reactant problems for chemical reactions.
- Calculate percent yield in a chemical reaction.

### **Gases and Kinetic Molecular Theory**

- Using the Kinetic Molecular Theory explain the relationship between pressure, volume, temperature, and number of particles in a gas sample.
- Explain the relationship between temperature and average kinetic theory.
- Perform calculations using the ideal gas law.
- Describe the conditions under which a real gas deviates from ideal behavior.
- Interpret Dalton's Law of Partial Pressures and use it to calculate partial pressures and total pressures.
- Use the combined gas law to determine changes in pressure, volume, or temperature.

### **Solutions**

- Describe the process by which solutes dissolve in solvents.
- Identify and explain the factors that affect the rate of dissolving.
- Describe the dynamic equilibrium that occurs in saturated solutions.
- Calculate concentration in terms of molarity, molality and percent by mass.
- Use a solubility curve to determine saturation values at different temperatures.
- Calculate the freezing point depression and boiling point elevation of a solution.
- Write net ionic equations for precipitation reactions in aqueous solutions.

### **Acids and Bases**

- Recognize acids and bases in terms of the presence of hydronium and hydroxide ions and relate their concentrations to the pH scale. Explain the contributions of Arrhenius and Bronsted in relation to this information.
- Compare and contrast the nature, behavior, concentration and strength of acids and bases: (continued)

## High School Chemistry continued

- a. Acid-base neutralization
  - b. Degree of dissociation or ionization
  - c. Electrical conductivity.
- Explain how indicators are used in titrations and how they are selected.
  - Describe an acid-base titration. Identify when the equivalence point is reached and its significance.
  - Calculate the pH or pOH of aqueous solutions using the hydronium or hydroxide ion concentration.
  - Identify and explain a buffer and how it works.

### **Equilibrium and Kinetics**

- Identify the factors that affect the rate of a chemical reaction (e.g., temperature), and the factors that can cause a shift in equilibrium (e.g., concentration, pressure).
- Write the equilibrium expression and calculate its constant for a reaction.
- Predict the shift in equilibrium when the system is subjected to a stress (LeChatelier's Principle).
- Explain rates of reaction in terms of collision frequency, energy of collisions, and the orientation of colliding molecules.
- Define the role of activation energy in a chemical reaction.

### **Thermochemistry**

- Interpret the Law of Conservation of Energy.
- Explain the relationship between energy transfer and disorder in the universe.
- Analyze the energy changes involved in physical and chemical processes using calorimetry.
- Apply Hess' Law to determine the heat of a reaction.

### **Oxidation-Reduction and Electrochemistry**

- Describe oxidation and reduction.
- Assign oxidation numbers.
- Balance oxidation-reduction equations by using half-reactions.
- Identify the components of, and describe the processes that occur in an electrochemical cell.
- Explain how a battery works.
- Compare and contrast voltaic and electrolytic cells and their uses.
- Calculate the net voltage of a cell given a table of standard reduction potentials.

**SCIENCE AND TECHNOLOGY/ENGINEERING BENCHMARKS**  
**PHYSICS**  
**MELROSE HIGH SCHOOL**

**Motion and Forces**

- Distinguish between vector quantities (velocity, acceleration, and force) and scalar quantities (speed and mass).
- Illustrate how to represent vectors graphically and be able to add them graphically.
- Distinguish between, and solve problems involving, velocity, speed, and constant acceleration.
- Create and interpret graphs of motion (e.g., position vs. time, speed vs. time, velocity vs. time, constant acceleration vs. time).
- Explain the relationship between mass and inertia.
- Interpret and apply Newton's first law of motion.
- Interpret and apply Newton's second law of motion to show how an object's motion will change only when a net force is applied.
- Use a free body force diagram with only co-linear forces to show forces acting on an object, and determine the net force on it.
- Qualitatively distinguish between static and kinetic friction, what they depend on and their effects on the motion of objects.
- Interpret and apply Newton's third law of motion.
- Understand conceptually Newton's law of universal gravitation.
- Identify appropriate standard international units of measurement for force, mass, distance, speed, acceleration, and time, and explain how they are measured.
- Identify and explain rotational motion.

**Conservation of Energy and Momentum**

- Interpret and provide examples that illustrate the law of conservation of energy.
- Provide examples of how energy can be transformed from kinetic to potential and vice versa.
- Apply quantitatively the law of conservation of mechanical energy to simple systems.
- Describe the relationship among energy, work, and power both conceptually and quantitatively.
- Interpret the law of conservation of momentum and provide examples that illustrate it. Calculate the momentum of an object.
- Identify appropriate standard international units of measurement for energy, work, power, and momentum.

**Waves**

- Recognize the measurable properties of waves (e.g., velocity, frequency, wavelength) and explain the relationships among them.
- Interpret and be able to apply the laws of reflection and refraction (qualitatively) to all waves.
- Explain the relationship between the speed of a wave (e.g., sound) and the medium it travels through.
- Distinguish between transverse and longitudinal waves.  
*Note: Advanced Placement and Honors students will also be able to:*
- Differentiate between wave motion (simple harmonic nonlinear motion) and the motion of objects (nonharmonic) (continued)

## High School Physics continued

- Distinguish between mechanical and electromagnetic waves.
- Recognize the effects of polarization, wave interaction, and the Doppler effect.
- Explain, graph, and interpret graphs of constructive and destructive interference of waves.
- Recognize the characteristics of a standing wave, and explain the conditions under which two waves on a string or in a pipe can interfere to produce a standing wave.

### **Electromagnetism**

- Recognize the characteristics of static charge, and explain how a static charge is generated.
- Interpret and apply Coulomb's law.
- Explain the difference in concept between electric forces and electric fields.
- Develop a qualitative and quantitative understanding of current, voltage, resistance, and the connection between them.
- Identify appropriate units of measurement for current, voltage, and resistance, and explain how they are measured.
- Analyze circuits (e.g., find the current at any point and the potential difference between any two points in the circuit) using Kirchoff's and Ohm's laws.

### **Electromagnetic Radiation**

- Describe the electromagnetic spectrum in terms of wavelength and energy, and be able to identify specific regions such as visible light.
- Explain how the various wavelengths in the electromagnetic spectrum have many useful applications such as radio, television, microwave appliances, and cellular telephones.
- Calculate the frequency and energy of an electromagnetic wave from the wavelength.
- Recognize and explain the ways in which the direction of visible light can be changed.
- Recognize, describe and explain the optics of lenses, mirrors, and shadows.

### **Heat and Heat Transfer**

- Explain the relationship among temperature change in a substance for a given amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance.

*Advanced Placement students will also be able to:*

- Relate thermal energy to molecular motion.
- Differentiate between specific heat and heat capacity.
- Recognize that matter exists in four phases, and explain what happens during a phase change.

**SCIENCE & TECHNOLOGY/ENGINEERING BENCHMARKS**  
**PHYSICAL SCIENCE**  
**MELROSE HIGH SCHOOL**

**Chemistry**

- Identify and explain some of the physical properties that are used to classify matter (e.g., density, melting point, and boiling point).
- Explain the difference between mixtures and pure substances.
- Describe the four states of matter (solid, liquid, gas, plasma) in terms of energy, particle motion, and phase transitions.
- Identify the major components of the nuclear atom (protons, neutrons, and electrons) and explain how they interact.
- Explain the relationship of an element's position on the periodic table to its atomic number and mass.
- Explain how atoms combine to form compounds through both ionic and covalent bonding.
- Balance chemical equations by applying the law of conservation of mass.

**Physics**

- Explain the relationship between mass and inertia.
- Interpret and apply Newton's first law of motion.
- Interpret and apply Newton's second law of motion to show how an object's motion will change only when a net force is applied.
- Understand conceptually Newton's law of universal gravitation.
- Interpret and provide examples that illustrate the law of conservation of energy.
- Differentiate between wave motion (simple harmonic nonlinear motion) and the motion of objects (nonharmonic).
- Recognize the measurable properties of waves (e.g., velocity, frequency, wavelength) and explain the relationships among them.
- Describe the electromagnetic spectrum in terms of wavelength and energy, and be able to identify specific regions such as visible light.

**SCIENCE AND TECHNOLOGY/ENGINEERING BENCHMARKS  
ASTRONOMY (WHEN OFFERED)  
MELROSE HIGH SCHOOL**

**Earth and Space Science**

- Describe the components of the electromagnetic spectrum and give examples of its impact on our lives.
- Describe the characteristics of waves (e.g., wavelength, frequency, velocity, amplitude).
- Describe the nature of the continuous emission and absorption spectrum that indicates the composition of stars.
- Explain how the transfer of energy through radiation, conduction, and convection contributes to global atmospheric processes(e.g., storms, winds).
- Explain how the layers of the atmosphere affect the dispersal of incoming radiation through reflection, absorption, and reradiation.
- Explain how the revolution of the earth and the inclination of the axis of the earth cause the earth's seasonal variations (e.g., equinoxes and solstices).
- Describe how the inclination of the incoming solar radiation can impact the amount of energy received by a given surface area.
- Explain what causes the tides and describe how they affect the coastal environment.
- Explain how scientists study the earth's system through the use of a combination of ground-based observations, satellite observations, and computer models of the earth system, and why it is necessary to use all of these tools together.
- Explain that weather is the most significant source of erosion and how both physical and chemical weathering: lead to the formation of sediments and soils, affect the shape of rocks, and create specific landscapes depending on what weathering process is dominant under a specific climate.
- Explain how seismic data is used to reveal the interior structure of the layered earth.
- Explain the *Big Bang Theory* and discuss the evidence that supports it (e.g., background radiation, and the Relativistic Doppler effect ~ red shift).
- Define the unit of distance called a light year.
- Use the Hertzsprung-Russell Diagram to explain the life histories of stars.
- Compare and contrast the final three outcomes of stellar evolution (e.g., black hole, neutron star, white dwarf) based on mass.

**Chemistry**

- Identify and explain some of the physical properties that are used to classify matter (e.g., density, melting point, and boiling point).
- Describe the four states of matter (e.g., solid, liquid, gas, plasma) in terms of energy, particle motion, and phase transitions.
- Identify the major components of the nuclear atom (e.g., protons, neutrons, and electrons) and explain how they interact.
- Understand that matter has properties of both particles and waves.
- Describe the electromagnetic spectrum in terms of wavelength/energy and identify regions of the electromagnetic spectrum.
- Compare nuclear fission and nuclear fusion and mass defect.

(continued)

## High School Astronomy continued

### Physics

- Relate thermal energy to molecular motion.
- Recognize that matter exists in four phases, and explain what happens during a phase change.
- Describe the electromagnetic spectrum in terms of wavelength and energy, and be able to identify specific regions such as visible light.
- Explain how the various wavelengths in the electromagnetic spectrum have many useful applications such as radio, television, microwave appliances, and cellular telephones.
- Calculate the frequency and energy of an electromagnetic wave from its wavelength.

## SCIENCE AND TECHNOLOGY/ENGINEERING BENCHMARKS MARINE ECOLOGY (WHEN OFFERED) MELROSE HIGH SCHOOL

### Earth and Space Science

- Provide examples of how the unequal heating of the earth and the Coriolis Effect influence global circulation patterns, and show their impact on Massachusetts weather and climate (e.g., convection cells, trade winds, westerlies, polar easterlies, land/sea breezes, mountain/valley breezes).
- Explain the dynamics of oceanic currents, including upwelling, density, deep water currents, the local Labrador Current, the Gulf Stream, and their relationship to global circulation within the marine environment and climate.
- Describe the effects of longshore currents, storms, and artificial structures (e.g., jetties, sea walls) on coastal erosion in Massachusetts.
- Explain what causes the tides and describe how they affect the coastal environment.
- Explain how scientists study the earth system through the use of a combination of ground-based observations, satellite observations, and computer models of the earth system, and why it is necessary to use all of these tools together.
- Recognize, describe, and differentiate between renewable (e.g., solar, wind, water, biomass) and nonrenewable (e.g., fossil fuels, nuclear{Ura-235}) sources of energy.
- Explain the advantage and limitations of renewable sources of energy.
- Explain the advantage and limitations of nonrenewable sources of energy.
- Describe ways in which people have tried to control the use of renewable and nonrenewable sources of energy (e.g., scientific advances, prices).
- Describe the effects on the environment of using both renewable and nonrenewable sources of energy.
- Describe ways in which scientists are addressing effects on the environment of using both renewable and nonrenewable sources of energy (e.g., creation of new technologies).
- Explain that weather is the most significant source of erosion and how both physical and chemical weathering lead to the formation of sediments and soils, affect the shape of rocks, and create specific landscapes depending on what weathering process is dominant under a specific climate. (continued)

## High School Marine Ecology continued

- Explain the nitrogen and carbon cycles and their roles in the improvement of soils for agriculture.
- Describe how the oceans store carbon dioxide as dissolved  $\text{HCO}_3^-$  and  $\text{CaCO}_3$  precipitate.
- Explain how water flows into and through a watershed (e.g., aquifers, wells, porosity, permeability, water table, capillary water, runoff).
- Compare and contrast the processes of the hydrologic cycle including evaporation, condensation, precipitation, surface runoff and groundwater percolation, infiltration, and transpiration.
- Trace the development of a lithospheric plate from its growing margin at a divergent boundary (e.g., mid-ocean ridge) to its destructive margin at a convergent boundary (e.g., subduction zone). Explain the relationship between convection currents and the motion of the lithospheric plates.
- Relate earthquakes, volcanic activity, mountain building, and tectonic uplift to plate movements.
- Relate the effects of sudden seafloor movements to the generation of tsunamis.
- Provide examples of how societies have been affected by tectonic activity (e.g., hazards from eruptions and earthquakes, bedrock type and soil conditions, building designs).

## Biology

- Explain the significance of carbon in organic molecules.
- Recognize the six most common elements in organic molecules (C, H, N, O, P, S).
- Describe the composition and functions of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids).
- Describe how dehydration synthesis and hydrolysis relate to organic molecules.
- Explain the role of enzymes in biochemical reactions.
- Differentiate between prokaryotic cells and eukaryotic cells, in terms of their general structures and degrees of complexity.
- Distinguish between plant and animal cells.
- Describe how cells function in a narrow range of physical conditions, such as temperature and pH, to perform life functions that help to maintain homeostasis.
- Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, and active transport).
- Identify the reactants and products in the general reaction of photosynthesis. Describe the use of isotopes in this identification.
- Provide evidence that the organic compounds produced by plants are the primary source of energy and nutrients for most living things.
- Identify how cellular respiration is important for the production of ATP.
- Explain the interrelated nature of photosynthesis and cellular respiration.
- Describe how the taxonomic system classifies living things into domains (e.g., eubacteria, archaeobacteria, and eukaryotes) and kingdoms (e.g., animals, plants, fungi).
- Explain how biotic and abiotic factors cycle in an ecosystem (e.g., water, carbon, oxygen, and nitrogen).
- Use a food web to identify and distinguish producers, consumers, and decomposers, and explain the transfer of energy through trophic levels.
- Identify the factors in an ecosystem that influence fluctuations in population size.
- Analyze changes in an ecosystem resulting from natural causes, changes in (continued)

## High School Marine Ecology continued

- climate, human activity, or introduction of non-native species.
- Explain how symbiotic behavior produces interactions within ecosystems.

### Physics

- Differentiate between wave motion (simple harmonic nonlinear motion) and the motion of objects (nonharmonic).
- Recognize the measurable properties of waves (e.g., velocity, frequency, wavelength) and explain the relationships among them.
- Distinguish between transverse and longitudinal waves.
- Distinguish between mechanical and electromagnetic waves.
- Interpret and be able to apply the laws of reflection and refraction qualitatively to all waves.
- Recognize the effects of polarization, wave interaction, and the Doppler effect.
- Explain, graph, and interpret graphs of constructive and destructive interference of waves.
- Explain the relationship between the speed of a wave (e.g., sound) and the medium it travels through.
- Recognize the characteristics of a standing wave and explain the conditions under which two waves on a string or in a pipe can interfere to produce a standing wave.

### Chemistry

- Identify and explain some of the physical properties that are used to classify matter (e.g., density, melting point, and boiling point).
- Understand that matter has properties of both particles and waves.
- Describe the electromagnetic spectrum in terms of wavelength and energy (e.g., identify regions of the electromagnetic spectrum).
- Explain how atoms combine to form compounds through both ionic and covalent bonding.
- Name and write the chemical formulas for simple ionic and molecular compounds, including those that contain common polyatomic ions.
- Balance chemical equations by applying the law of conservation of mass.
- Using the kinetic molecular theory, explain the relationship between pressure and volume (Boyle's law), volume and temperature (Charles' law), and the number of particles in a gas sample (Avogadro's hypothesis).
- Explain the relationship between temperature and average kinetic energy.
- Use the combined gas law to determine changes in pressure, volume, or temperature.
- Describe the process by which solutes dissolve in solvents.
- Identify and explain the factors that affect the rate of dissolving (e.g., temperature, concentration, and mixing).
- Use a solubility curve to determine saturation values at different temperatures.
- Define Arrhenius' theory of acids and bases in terms of the presence of hydronium and hydroxide ions, and Bronsted's theory of acids and bases in terms of proton donor and acceptor, and relate their concentrations to the pH scale.
- Compare and contrast the nature, behavior, concentration and strength of acids and bases:
  - a. Acid-base neutralization
  - b. Degree of dissociation or ionization (continued)

## High School Marine Ecology continued

- c. Electrical conductivity.
- Identify a buffer and explain how it works.
- Explain how indicators are used in titrations and how they are selected.
- Describe an acid-base titration. Identify when the equivalence point is reached and its significance.
- Calculate the pH or pOH of aqueous solutions using the hydronium or hydroxide ion concentration.
- Identify the factors that affect the rate of a chemical reaction (e.g., temperature, concentration) and the factors that can cause a shift in equilibrium (e.g., concentration, pressure, volume, temperature).

### **SCIENCE AND TECHNOLOGY/ENGINEERING BENCHMARKS TECH ED AND CAD GRADES 6-12**

**Note: At the high school level, through CAD courses, after initial exposure to broad design concepts, students may choose one of three paths on which to focus their studies: architectural design, mechanical drawing, or electrical design.**

#### **Engineering Design**

- Identify and explain the steps of the engineering design process (e.g., identify the problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign).
- Demonstrate knowledge of pictorial and multi-view drawings (e.g., orthographic projection, isometric, oblique, perspective) using proper techniques.
- Demonstrate the use of drafting techniques with paper and pencil or computer-aided design (CAD) systems when available.
- Apply scale and proportion to drawings (e.g.,  $\frac{1}{4}$  inch = 1foot).
- Interpret plans, diagrams, and working drawings in the construction of a prototype.

#### **Construction Technologies**

- Distinguish among tension, compression, shear, and torsion, and explain how they relate to the selection of materials in structures.
- Identify and explain the engineering properties of materials used in structures (e.g., elasticity, plasticity, thermal conductivity, density).

#### **Energy and Power Technologies-Fluid Systems**

- Explain Bernoulli's Principle and its effect on practical applications (i.e., airfoil design, spoiler design, a carburetor).
- Differentiate between hydraulic and pneumatic systems and provide examples of appropriate applications of each as they relate to manufacturing and transportation systems.

#### **Energy and Power Technologies-Thermal Systems**

- Differentiate among conduction, convection, and radiation in a thermal system (e.g., heating and cooling a house, cooking). (continued)

## High School Tech Ed and CAD continued

- Give examples of how conduction, convection, and radiation are used in the selection of materials, (e.g., home and vehicle thermostat designs, circuit breakers).
- Explain how environmental conditions influence heating and cooling of buildings and automobiles.

### **Energy and Power Technologies-Electrical Systems**

- Identify and explain the components of a circuit including a source, conductor, load, and controllers ( e.g., switches, relays, diodes, transistors, integrated circuits).
- Explain the relationship between resistance, voltage, and current (Ohm's Law).
- Determine the voltages and currents in a series circuit and a parallel circuit.
- Explain how to measure voltage, resistance, and current in electrical systems.

### **Communication Technologies**

- Identify and explain the applications of light in communications (e.g., reflection, refraction, additive, and subtractive color theory).
- Explain the components of a communication system (e.g., source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination).
- Identify and explain the applications of laser and fiber optic technologies (e.g., telephone systems, cable television, medical technology, and photography).

### **Manufacturing Technologies**

- Explain the manufacturing processes of casting and molding, forming, separating, conditioning, assembling, and finishing.

## **SCIENCE AND TECHNOLOGY/ENGINEERING MICROSOFT OFFICE BENCHMARKS MELROSE HIGH SCHOOL**

### **Microsoft Word**

- Format, copy, write protect, and save to a diskette.
- Create, save and retrieve a word processing document.
- Use spell check and the thesaurus functions.
- Change margins and the orientation of a word document before printing.
- Format a document, set up columns, use a code to number pages in a document, create a header and footer, set tabs in a document, and use a code to insert the current date into a document.
- Use the find and replace commands.
- Insert and format footnotes properly.
- Use all menu item and tool bar items.
- Create return address labels as well as mailing labels.
- Program the computer to create simple macros.

### **Microsoft Excel**

- Know the components of a spreadsheet and the benefits of using Excel as a spreadsheet program.
- Use formulas and functions to perform calculations.
- Use the sum, average, and round functions.
- Understand relative copying. (continued)

- Change the width of columns and rows.
- Format a spreadsheet.
- Understand and use more advanced features such as *Max*, *Min* and *If* functions.
- Use absolute and relative copying.
- Create charts of spreadsheet data.
- Sort information in a spreadsheet.
- Freeze selected rows and cells so they do not move up and down.
- Copy spreadsheet data into a word processor document.

### **Access – Relational Database**

- Know the function of a relational database.
- Know all parts of a relational database and learn how to plan and design a database.
- Create a database. Create and save forms.
- Enter records and query a table.
- Rename, add and delete fields.
- Update a form and add/update/delete a record.
- Create a select query, define relationships between tables, and sort query results.
- Create a report from a database.
- Demonstrate how to integrate the word processor, spreadsheet and database.

### **PowerPoint**

- Demonstrate how to create a presentation using PowerPoint.
- Demonstrate how to display a presentation in five different ways.
- Edit, add, and delete slides.
- Add pictures and clipart to a slide.
- Add footnotes to slides.
- Use slide transitions and build effects.
- Demonstrate how to add a chart from a spreadsheet to a slide.

## **SCIENCE AND TECHNOLOGY/ENGINEERING BENCHMARKS**

### **WEB PAGE DESIGN**

- Know Internet terms, browsers, and the history of the Internet.
- Design a web page.
- Use HTML tags to create a web page.
- Create internal and external links on a web page.
- Understand and apply knowledge about page layout.
- Organize pages using tables and frames.
- Insert graphics into a web page to include: graphics taken from the Internet, scanned images and digital images.
- Understand the difference between jpg, gif, and bitmap images.
- Create links from graphics on a web page.
- Understand the basic principles of design, including: color, spacing, lines, and background textures.
- Apply knowledge of the set up of style sheets.
- Perform the following computer operating functions: saving, opening, uploading, downloading, and file organization.
- Critique their work and the work of others in a non-threatening manner.
- Gain a working knowledge and experience of cooperative learning in small groups.