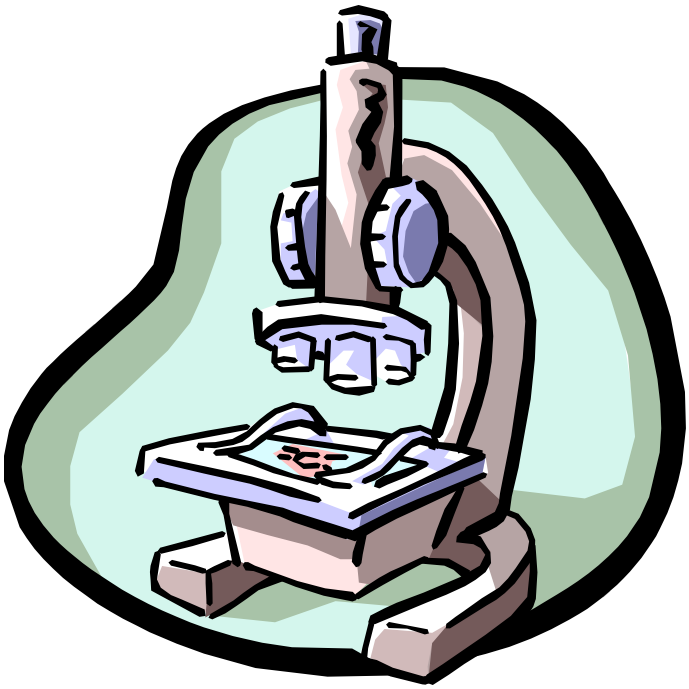
MELROSE PUBLIC SCHOOLS

SCIENCE AND TECHNOLOGY/ENGINEERING DOCUMENTS



INTRODUCTION

*Dates in this introduction were changed after the completion of the High School Science and Technology/Engineering benchmarks.

The following Science and Technology/Engineering documents were created through the efforts of Melrose staff and administrators. The work that resulted in these documents began in 2003 and culminated in 2005. 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 May 2001, was an integral part of our curriculum revision process.

"The result of all scientific investigation is a better understanding of natural processes."[1]
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 <u>every</u> 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, Spring of 2005

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
- Observe 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
- Recognize 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)
- Explore the use of tools 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, 2001)

- 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) 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

- Recognize the properties of water, solid and liquid as well as some of the qualities of water (e.g., the ability to take the shape of its container)
- Understand repeating patterns of seasons, days, weeks, months and years
- Understand concepts of weather changes and kinds of weather conditions
- Describe the importance of the sun to all living things

Life Science

- Observe how a seed grows and what it needs to survive
- Compare living and non-living objects
- Group living and non-living objects according to the characteristics they share
- Identify growth and changes in self and others
- Identify and explore the five senses in the world around us. Recognize that this is how we interact with our environment.
- Identify the basic needs of all people

Physical Science

- Describe and demonstrate knowledge of the different properties of matter (e.g., color, size, shape, weight and texture)
- Understand that under some conditions, objects can be balanced

Technology and Engineering

- Independently choose and use tools such as pencil, scissors, rulers, tape, thermometer, hand lenses, paper and stencils for a specific purpose

Skills of Inquiry/Scientific Process We Expect Students to Demonstrate

(from the MA Science and Technology/Engineering Framework, 2001)

- 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) to gather data and extend the senses
- Record observations and data with pictures, numbers, or written statements
- Discuss observations with others

Grade 1 Science and Technology/Engineering Benchmarks

Earth and Space

- Identify objects and materials as solid, liquid, or gas
- Explain evaporation and condensation in relation to weather
- Recognize that solids have a definite shape and that liquids and gas take the shape of their container

Life Science

- Explain how people and animals grow and change
- Describe the way in which, as growth and change occurs, many plants and animals closely resemble their parents in observed appearance
- Identify the parts of a plant and explain their purpose

Physical Science

- Explore and demonstrate the properties of sound and light

Technology and Engineering

- Identify and describe the characteristics of both natural materials (e.g., wood, wool) and human-made materials (e.g., plastic, styrofoam)
- Identify and explain some uses for natural and human-made materials
- Construct a piece of artwork or an invention using natural and human-made materials. Label the materials accurately.

Skills of Inquiry/Scientific Process We Expect Students to Demonstrate

(from the MA Science and Technology/Engineering Framework, 2001)

- 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) 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
- Understand the use of solar energy in the formation of coal, oil and direct heat
- Understand that air is a mixture of gases that is all around us and that wind is moving air
- Describe weather changes from day to day and over the seasons
- Independently identify examples of water, rocks, soil and living organisms that are found on the earth's surface

Life Science

- Classify plants and animals as living things that grow, reproduce and need food/water/shelter
- Recognize that fossils 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 the basic need for air, water, nutrients, light, and shelter
- Recognize that living things can be classified according to similar characteristics
- Recognize that changes in habitat can affect plants and animals
- Describe how changes in habitat affected dinosaurs

Physical Science

- Demonstrate that the way to change the motion of an object is to apply a force (i.e. push or pull)
- Understand that force affects motion

Technology/Engineering

- Construct a habitat meeting criteria necessary to sustain life
- Identify tools and machines used for a specific purpose
- 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 parts of their own bodies

Skills of Inquiry/Scientific Process We Expect Students to Demonstrate

(from the MA Science and Technology/Engineering Framework, 2001)

- 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) 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
- Describe how water on earth cycles in different forms and locations
- Give examples of how the cycling of water has an effect on climates
- Explain how pollution and a lack of recycling can contribute to the endangerment/extinction of a species
- Give examples of recycling
- Identify sources of water pollution

Life Science

- Create a simple food chain that begins with the sun
- Recognize that some animal behaviors are learned and some are instinctive
- Give examples of behavior in response to stimuli (e.g., 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

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
- Demonstrate and explain the properties of sound (e.g., pitch determined by the speed of vibrations, volume)

continued

Grade 3 Science and Technology/Engineering benchmarks continued…

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 construction, and the reason why you chose your specific materials.
- 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, 2001)

- Ask questions and make predictions that can be tested
- Select and use appropriate tools and technology (e.g., calculators, computers, scales, 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

- 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 and describe the 3 types of rock (sedimentary, igneous, metamorphic). Explain their origins.
- Identify the structure of the earth. Name and locate its layers.
- 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
- 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
- Describe the causes of earthquakes and volcanoes including tectonic plate motion
- Identify and locate examples of famous volcanoes around the globe
- 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
- Identify the North Star and various constellations (e.g., Big Dipper, Little Dipper, Orion)
- Explain solar and lunar eclipses
- 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
- Identify the body parts of insects
- Explain the difference between insects and arachnids
- Sketch and name an insect which meets all identifying criteria

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 using effective specifications to resolve the problem
- Use different methods for representing solutions to problems (e.g., sketches, diagrams, graphic organizers, lists)

continued

Grade 4 Science and Technology /Engineering benchmarks continued…

Skills of Inquiry/Scientific Process We Expect Students to Demonstrate
(from the MA Science and Technology/Engineering Framework, 2001)

- Ask questions and make predictions that can be tested
- Select and use appropriate tools and technology (e.g., calculators, computers, scales, 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

Life Science

- 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 removing 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 etc.)
- Give examples of how organisms can cause changes in their environment to ensure survival. Explain how some of these changes can effect the ecosystem.

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
- Know that electricity can produce heat, light and sound
- Identify and classify objects and materials as conductors or insulators
- 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
- 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.
- Draw and label six simple machines
- Explain the difference between simple and complex machines
- Create a diagram of a complex machine and label the simple machines WITHIN it

Technology/Engineering

- Identify and explain the appropriate materials and tools needed to construct a given prototype
- 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)

continued

Grade 5 Science and Technology/Engineering benchmarks continued…

Skills of Inquiry/Scientific Process We Expect Students to Demonstrate
(from the MA Science and Technology/Engineering Framework, 2001)

- Ask questions and make predictions that can be tested
- Select and use appropriate tools and technology (e.g., calculators, computers, scales, 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 solid 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

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.

continued

Grade 6 Science and Technology/Engineering benchmarks 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.
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 provide 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

1. Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.
    a. Describe matter in terms of specific properties.
    b. Identify the general properties of matter, weight, density, texture and color.
    c. Explain that all matter is composed of particles in constant motion.
    d. Demonstrate how particles kept in solids are closely packed and barely moving, liquid particles are less closely packed and moving freely, gas particles are widely spaced and moving freely.
2. Differentiate between volume and mass and be able to define density.
    a. Demonstrate that the volume of a fixed amount of gas varies inversely with pressure exerted on it provided temperature is constant.
    b. Demonstrate that the volume of gas increases as temperature increases and decreases as temperature decreases.
    c. State and explain the gas laws.
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.
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).

Technology/Engineering (Grades 6 & 7)

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 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

continued

Grade 6 Science and Technology/Engineering Benchmarks continued…

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)

23. Given a transportation problem, explain a possible solution using the universal systems model

The following two bullets are optional:

- 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, 2001)

- 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 7

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

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 (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 or 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 (offspring inherit half of their genes from each parent) with asexual reproduction (offspring is an identical copy of the parent's cell).

continued

Grade 7 Science and Technology/Engineering benchmarks continued….

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 (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 (elements and compounds).
    c. List information in 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 Benchmarks continued….

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 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.

<u>Technology/Engineering</u> (Grades 6 & 7)

4. Identify and explain the steps of the engineering design process:
    i. identify the need or problem
    j. research the problem
    k. develop possible solutions
    l. select the best solution
    m. construct a prototype
    n. test and evaluate
    o. communicate the solution
    p. redesign if necessary

23. Given a transportation problem, explain a possible solution using the universal systems model

<u>continued</u>

Grade 7 Science and Technology/Engineering benchmarks 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)

The following two bullets are optional:

- 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, 2001)

- 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.
3. Differentiate among radiation, conduction, and convection, 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 water, land and atmosphere.
    a. Explain how earth's atmosphere becomes heated by energy from the sun (conduction, convection, radiation).
    b. Describe instruments used to measure weather factors.
    c. Explain relationships between air density and pressure.
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.

continued

Grade 8 Science and Technology/Engineering Benchmarks continued….

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

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).

continued

Grade 8 Science and Technology/Engineering Benchmarks 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 and chemical changes.
    a. Explain that chemical reaction is accompanied by a change in properties (exothermic vs. endothermic reaction) and a change in energy of substances involved.
    b. Describe characteristics of chemical reactions.
15. Explain the effect of heat on particle motion through a description of what happens to particles during a change in phase.

c**ontinued**

Grade 8 Science and Technology/Engineering benchmarks continued…

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

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 devises 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 benchmarks 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, 2001)

- 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

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 of May 2001, 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 was created through the hard work and collaborative efforts of the Melrose High School Science and Technology/Engineering Department from 2004-2005.*

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, codominant, 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

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 (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

Continued

- Relate the position of an element on the periodic table to its electron configuration
- Identify trends on the periodic table (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
- 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

Continued

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:
    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

Continued

- 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 (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

Continued

- 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 harrmonic nonlinear motion) and the motion of objects (nonharmonic)
- 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 (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

Continued

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 exits in four phases, and explain what happens during a phase change

SCIENCE & TECHNOLOGY/ENGINEERING BENCHMARKS
INTEGRATED SCIENCE
MELROSE HIGH SCHOOL

Earth and Space Science

- Explain how the transfer of energy through radiation, conduction, and convection contributes to global atmospheric processes (e.g., storms, winds)
- Explain how the revolution of the earth and the inclination of the axis of the earth cause the earth's seasonal variations (equinoxes and solstices)
- Trace the development of a lithospheric plate from its growing margin at a divergent boundary (mid-ocean ridge) to its destructive margin at a convergent boundary (subduction zone). Explain the relationship between convection currents and the motion of the lithospheric plates.
- Explain how the sun, earth, and solar system formed from a nebula of dust and gas in a spiral arm of the Milky Way Galaxy about 4.6 billion years ago

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
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 (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 (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 (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 (solid, liquid, gas, plasma) in terms of energy, particle motion, and phase transitions

Continued

- 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
- 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

Physics

- Relate thermal energy to molecular motion
- Recognize that matter exists in four phases, an 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 the wavelength

SCIENCE AND TECHNOLOGY/ENGINEERING BENCHMARKS
MARINE ECOLOGY
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, and 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
- 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 HCO_3 and $CaCO_3$ 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

Continued

- Trace the development of a lithospheric plate from its growing margin at a divergent boundary (mid-ocean ridge) to its destructive margin at a convergent boundary (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 AT
- Explain the interrelated nature of photosynthesis and cellular respiration
- Describe how the taxonomic system classifies living things into domains (eubacteria, archaebacteria, and eukaryotes) and kingdoms (animals, plants, fungi, etc.)
- 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
- Identify the factors in an ecosystem that influence fluctuations in population size
- Analyze changes in an ecosystem resulting from natural causes, changes in climate, human activity, or introduction of non-native species
- Explain how symbiotic behavior produces interactions within ecosystems

Continued

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 (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

Continued

- Compare and contrast the nature, behavior, concentration and strength of acids and bases
    a. Acid-base neutralization
    b. Degree of dissociation or ionization
    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 (temperature, concentration) and the factors that can cause a shift in equilibrium (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., ¼" = 1'0")
- 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)
- 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

Continued

Energy and Power Technologies-Electrical Systems

- Identify and explain the components of a circuit including a source, conductor, load, and controllers (i.e. 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 (i..e., 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
- 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 what a relational database is
- 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

Continued

- 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
MELROSE HIGH SCHOOL

- 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