Ninth Grade Science

Curriculum Map

Red Clay Consolidated School District

August 2008

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NINTH GRADE SCOPE AND SEQUENCE DRAFT

Version 2 March 2008

September

Topic	Standards	GLEs	Assessment
Safety	Right-to-know Law		**1.** Safety Quiz/safety contract
Reading in Science/Nature of Science	1.1.1, 1.1.2, 1.1.4,1.1.5, 1.2.2	9.1.a, 9.1.d, 9.1.e	**2.** Aral Sea assessment (writing prompt) Current events, personal glossary, homework from text (ongoing).
motion, acceleration, forces	3.2.1, 3.2.2, 3.2.5	11.3.k, 11.3.n, 11.3.bb, 11.3.ee, 11.3.ff, 11.3.gg	**3.** Motion
Forces	3.1.2, 3.2.2	9.3.c, 9.3t, 9.3.v, 11.3.n, 11.3.v, 11.3.z, 11.3.aa,	**4.** Forces

October:

Topic	Standards	GLEs	Assessment
Friction	3.2.1, 3.2.2, 3.3.1, 3.3.2	9.3,ii, 9.3.jj, 11.3.g, 11.3.h, 11.3.i, 11.3.j, 11.3.k	**5.** Friction
Newton's laws	3.2.1, 3.2.2	11.3.i, 11.3.x, 11.3.y, 11.3.z, 11.3.cc, 11.3.hh, 11.3.ii,	**6.** Newton's Laws of Motion
Potential and kinetic energy	3.1.2, 3.2.2, 3.3.1	9.3.c, 9.3.d, 9.3.h, 9.3.t, 9.3.u, 9.3.aa	**7.** Potential and Kinetic Energy

November:

Topic	Standards	GLEs	Assessment
Gravitational potential energy, elastic potential energy	3.1.2, 3.1.4	9.3.f, 9.3.g, 9.3.o, 9.3.p, 9.3.q, 9.3.r, 9.3.s	**8.** Elastic Potential Energy
Power, thermal energy	3.1.4, 3.2.2, 3.3.1, 3.3.2	9.3.h, 9.3.w, 9.3.aa, 9.3.bb, 9.3.kk	**9.** Power and Thermal Energy
Energy Chains, sound waves	3.2.5, 3.3.1, 3.3.2, 3.3.3, 3.3.4	9.3.aa, 9.3.bb, 9.3.cc, 9.3.dd, 9.3.hh, 9.3.ii	**10.** Transfer of Energy Through Waves

December:

Topic	Standards	GLEs	Assessment
Mechanical waves	3.1.3, 3.3.3	9.3.l, 9.3.m, 9.3.n	**11.** Mechanical Waves and Sound Energy
Electromagnetic waves	3.1.1, 3.1.5, 3.3.3, 3.3.4, 3.3.5, 3.3.6	9.3.a, 9.3.b, 9.3.k, 9.3.ee, 9.3.ff, 9.3.gg	**12.** Electromagnetic Energy

January:

Topic	Standards	GLEs	Assessment
Physical/Chemical Changes in Matter	2.1.2, 2.1.7, 2.4.1, 3.2.7	9.2.c, 9.2.e, 9.2.m, 9.2.o, 9.5.a	**13.** Physical and Chemical Changes
Atomic theory	2.1.1, 2.1.2, 2.1.3, 3.2.9, 3.3.6	9.2.a, 9.2.b, 9.2.f, 9.2.g	**14.** Atomic Structure

Midterm

February:

Topic	Standards	GLEs	Assessment
Periodic Table	2.1.4, 2.1.5, 2.1.6	9.2.g, 9.2.h, 9.2.i, 9.2.m, 9.2.n, 9.5.b	**15.** Periodic Properties
Mixtures and Solutions	2.1.2, 2.2.1, 2.2.2	9.2.c, 9.2.d, 9.2.e, 9.2.t, 9.2.z	**16.** Mixtures and solutions
Properties of water, pH	2.1.7, 2.1.8, 2.2.1, 3.2.7	9.2.p, 9.2.r, 9.2.s, 9.2.w, 9.2.x, 9.2.y,	**17.** Properties of Water

March:

Topic	Standards	GLEs	Assessment
Electrons, bonding, energy levels	2.1.2, 2.1.5, 2.1.6, 3.1.6	9.2.j, 9.2.k, 9.2.l, 9.2.q, 9.3.i	**18.** Electrons and Bonding
Conservation of Matter	2.3.1	9.2.aa, 9.2.bb, 9.2.cc	**19.** Conservation of Matter
Chemical reactions	2.3.1, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.6	9.2.k, 9.2.aa, 9.2.bb, 9.2.cc, 9.3.i	**20.** Chemical Reactions

April:

Topic	Standards	GLEs	Assessment
Solar nebular theory	4.2.1, 4.2.2, 5.2.1, 5.2.5	9.4.a, 9.4.b	**21.** Solar nebula theory
Rocks and Minerals/ Rock cycle	5.1.1, 5.1.2	9.2.c, 9.2.d, 9.5.a, 9.5.b, 9.5.c, 9.5.d, 9.5.f	**22.** Rocks and Minerals

May:

Topic	Standards	GLEs	Assessment
Volcanoes and Earthquakes	5.1.4, 5.2.3, 5.2.4	9.5.e, 9.5.h, 9.5.i, 9.5.j, 9.5.k, 9.5.l, 9.5.r, 9.5.s	**23.** Earthquakes and Volcanoes
Plate Tectonics	5.1.3, 5.2.2, 5.2.5, 5.3.1	9.5.g, 9.5.m, 9.5.n, 9.5.o, 9.5.p, 9.5.q	**24.** Plate Tectonics

Final Exam

UNDERSTANDING THE SCIENCE CURRICULUM MAP
HIGH SCHOOL
Fall 2007

The Red Clay Consolidated School District is in the process of creating curriculum maps for each grade (K-12) in science. We have prepared a brief description of how the curriculum maps can be used in planning, delivering, and assessing science instruction.

Why use curriculum maps?

Beginning in August 2007, public schools in Delaware will be using the revised (2006) Delaware science standards (http://www.doe.k12.de.us/programs/pcs/science.shtml). The Science Coalition of Delaware has worked hard to create a rich science curriculum at all grades to meet these standards. The curriculum map will allow teachers to create a plan of instruction to meet these standards using curricula in which they have been trained. The map will allow teachers to adjust the pacing of their instruction to the needs of the students, the availability of resources, and the schedule of the school and district.

How are the curriculum maps organized?

I. Standards and GLEs:

The curriculum maps for each grade begin with a list of the standards for that grade cluster and the GLEs (Grade Level Expectations) for that grade. Red Clay has developed a coding system for both the standards and GLEs, and these coding systems are explained (see “Understanding the Revised Science Standards” and “Understanding the GLEs” enclosed). The standards represent the required instruction. In Delaware, the emphasis in science is on big ideas and concepts, not on memorizing facts, formulas, and other trivia. The GLEs represent the sorts of tasks, understandings, and skills we aim for our students to achieve in each grade.

II. Scope and Sequence:

Each map includes a Scope and Sequence. This is a timetable for the school year, organized by month. Listed for each month is a broad topic name, the standards (by number), the GLEs (by number) and the assessments for each topic. **The Scope and Sequence is driven by the assessments.** The purpose of the scope and sequence is to give an estimate of how long to spend on various topics and a rough sequence of topics. **This sequence may be adjusted as needed.** In every school, teachers should adjust topics of instruction to meet the needs of their students. Also, since resources are often shared among several teachers, some “juggling” of topics will always be necessary. The most important things about the Scope and Sequence are 1) the Standards must be taught, since the DSTP is a test of the Standards and 2) the Assessments (discussed below) must be administered and scored.

The order of topics on the Scope and Sequence is based on the training schedule at the Science Coalition of Delaware. Since teachers who take these trainings are expected to teach the units while in training, the Scope and Sequence reflects the Coalition’s sequence. If teachers must deviate from this sequence, this need should be discussed with the building principal and the Secondary Science Specialist. Because students sometimes change science classes during the year, it is important that they receive a consistent science program.

III. Assessments:

Each topic on the Scope and Sequence has an associated assessment. The assessments are referred to by number (24 in all). The assessments come in several formats:

a. **Short answer questions**. A topic may have 1-4 short answer questions for students to answer. They are in the same format as short answer questions on the DSTP, and like the DSTP questions, each has a scoring option of 2 points (complete response) 1 point (partial response) and 0 (incorrect response). The rubric which describes the criteria for each is a guideline. Teachers are encouraged to determine whether or not students have met the standards from answers on the assessments.

b. **Lab reports**: In high school, some of the big units (for ninth grade, Energy Across the Systems, Living by Chemistry, and Earth Systems) may include one laboratory report. Students may work in groups on the lab investigation, but each student should submit one report. A rubric for lab reports is included.

c. **Writing prompts:** Some of the assessments include a writing prompt, consisting of a letter or position statement that will require more extensive design on the part of the student. The rubric for writing prompts is included with each prompt.

These are formative assessments. They may be used in a variety of ways: as a warm-up question, as a quiz or test question, or as part of a larger activity. Their purpose is to determine if students have met the standards or not. Each big unit has a checklist for the assessments. Teachers will make a copy of each checklist for each of their classes in the content area. However the assessments are used, teachers will record student results on the checklist.

Some of these assessments are taken from the Science Coalition of Delaware's assessment website (www.scienceassessment.org). The Coalition website uses a two digit rubric to score student responses. While this is an acceptable way to score the Red Clay assessments, teachers are not required to use the two digit rubric, since it is extremely time consuming. However, if teachers require specific data about student misconceptions, they are encouraged to use the two digit rubric. Contact the Secondary Science Specialist for more information. As of August 2008, no ninth grade assessments are posted to the Coalition's assessment website.

IV. Text References/Vocabulary: Each topic includes a mini-glossary of terms and references from the textbooks adopted by Red Clay (for biology, this book is the following:

for Physical/Earth Science (9th grade course):

Dobson, K., Holman, J., and Roberts, M. *Science Spectrum Physical Science.* Austin, TX; Holt, Rinehart, and Winston; 2004

for Biology (10th grade course):

Campbell, N.A., Williamson, B., and Heyden, R.J. *Biology Exploring Life*. Upper Saddle River; NJ, Pearson Education, Inc; 2004.

Teachers are not required to use activities out of the textbook, but many find that the textbook is a useful resource for supplemental reading. The vocabulary list includes terms that students may have difficulty with, not just terms from the glossary in the textbook. The vocabulary list can be helpful for those teachers who use word walls and other vocabulary exercises.

Finally:

This curriculum map is designed to make the teacher's job easier so the teacher can concentrate on our students. If teachers finish a topic early in a given month, they are encouraged to move on. Likewise, if a topic takes longer than indicated by the map, they should use as much time as necessary to meet the students' needs. The Office of Curriculum and Instruction will need your feedback about how useful this map is. Any comments, questions, criticisms, or concerns (or praise) should be directed to any of the following:

Edward J. McGrath, Science Coordinator
Carolyn Zogby, Director of Instruction
Susan Rash, Director of Curriculum

UNDERSTANDING THE REVISED SCIENCE STANDARDS

There are eight standards in the Delaware Science Content Standards, each clustered for grades K-3, 4-5, 6-8, and 9-12. These clusters are the grade clusters assessed by the Delaware Student Testing Program (DSTP), are similar to the experiences and certification of teachers, and take into account the organization of schools and the frameworks of other content standards.

Standard 1, The Nature and Application of Science and Technology, is the ***foundational*** standard on which all others have been developed. This standard emphasizes learning content through inquiry, the interconnectedness of science, technology, and society, and the history and context of science.

The content standards for physical (standards 2 and 3), earth (standards 4 and 5), and life (standards 6, 7, and 8) science focus on big ideas and concepts that are important for all students to know. The eight standards are composed of broad standard statements which communicate the big ideas in the standards.

Each content standard is subdivided into **strands** with concepts that spiral up through the grade clusters and are written in developmentally appropriate ways guided by current educational research and experience. The big ideas and concepts in each standard are central to science education and focus on depth of concepts rather than breadth of facts or topics. All eight content standards comprise what is to be taught, learned, and assessed. For each strand, there is at least one **Enduring Understanding** and **Essential Question** identified. The Standards, Strands, Enduring Understandings, and Essential Questions are the same for all grade level clusters.

Within each grade level cluster, there are **substrands** which identify the content and/or skills that are addressed for that grade level cluster.

Understanding the coding system for the science standards:

Each of the substrands is identified by a three digit code. The first digit identifies the standard number. The second digit identifies the strand, and the third digit identifies the sub-strand. ***Please note: when identifying the standards by their three digit code, it is necessary to specify the grade level cluster.***

For example, for the 6-8 grade level cluster, standard 2.1.4 refers to

Standard 2: Materials and their Properties
Strand 1: Properties and Structure of Materials
Substrand 4: An important property of materials is their ability to conduct heat. Some materials, such as certain metals, are excellent conductors of heat while other materials, such as glass, are poor conductors (good thermal insulators).

UNDERSTANDING THE GRADE LEVEL EXPECTATIONS (GLE) IN SCIENCE

In revising the Delaware Science Content Standards, the Science Design Team has identified a series of Grade Level Expectations (GLEs) for each grade from Kindergarten through twelfth grade. These statements describe activities or performances that are designed to help students meet the standards at each grade level. Although students are tested (through the Delaware Student Testing Program in science) on the Content Standards, the Grade Level Expectations represent a mechanism by which students are expected to meet the standards.

Understanding the coding system for the GLEs:

Each of the GLEs is identified by two numerals (or K) followed by a letter. The first numeral represents the grade (K for Kindergarten). The second numeral represents the standard number as indicated below:

Standard 1: Nature and Application of Science and Technology
Standard 2: Materials and their Properties
Standard 3: Energy and its Effects
Standard 4: Earth in Space
Standard 5: Earth's Dynamic Systems
Standard 6: Life Processes
Standard 7: Diversity and Continuity of Living Things
Standard 8: Ecology

For example, GLE 9.3.u refers to

Grade 9
Standard 3
GLE u: Identify that 'work' is the process by which a force transfers energy to an object, and use measured quantities to make calculations of the work done by forces (W = energy transferred = F·D). (3.2.2) (3.3.2)

Each GLE is followed by the Content Standard(s) it supports (see "Understanding the Revised Science Standards).

At the end of the GLE document is a table which summarizes which GLEs support each standard.

RED CLAY NINTH GRADE ASSESSMENT LOG SY_______________

Unit 1: Energy Across the Systems

Student Name	#1 Safety Quiz	#2 Aral Sea	#3 Motion		#4 Forces			#5 Friction			#6 Newton Laws			#7 Potential Kinetic Energy		#8 Elastic Potential Energy			#9 Power and Thermal Energy		#10 Transfer of Energy Through Waves		#11 Mechanical Waves Sound Waves		#12 Electro-magnetic Energy	

Comments:

Teacher:______________________________

School:______________________________

Period:______________________________

RED CLAY NINTH GRADE ASSESSMENT LOG SY_______________

Unit 2: Living By Chemistry

Student Name	# 13 Physical Chemical Changes			#14 Atomic Structure			#15 Periodic Properties		#16 Mixtures and Solutions		#17 Properties of Water		#18 Electrons and Bonding			#19 Conservation of Matter		#20 Chemical Reactions	

Comments:

Teacher:_________________________________

School:_________________________________

Period:_________________________________

RED CLAY NINTH GRADE ASSESSMENT LOG SY_______________

Unit 3: Earth Systems

Student Name	#21 Solar Nebular Theory			#22 Rocks and Minerals		#23 Earthquakes and Volcanoes		#24 Plate Tectonics	

Comments:

Teacher:_________________________________

School:_________________________________

Period:_________________________________

SEPTEMBER

Topic 1: Safety

Activities: General safety training—Right-to-Know Law

Assessments: **1.** Safety Quiz
Safety Contract/Contrato de Seguiridad signed by each student

Text References/Vocabulary: none
Standards: none
GLEs: none

Topic 2: Reading in Science/Nature of Science

Standards:

1.1.1: Scientists conduct investigations for a variety of reasons including to explore new phenomena, to replicate other's results, to test how well a theory predicts, to develop new products, and to compare theories.

1.1.2: Science is distinguished from other ways of knowing by the use of empirical observations, experimental evidence, logical arguments and healthy skepticism.

1.1.3: Theories in science are well-established explanations of natural phenomena that are supported by many confirmed observations and verified hypotheses. The application of theories allows people to make reasonable predictions. Theories may be amended to become more complete with the introduction of new evidence.

1.1.4: Investigating most real-world problems requires building upon previous scientific findings and cooperation among individuals with knowledge and expertise from a variety of scientific fields. The results of scientific studies are considered valid when subjected to critical review where contradictions are resolved and the explanation is confirmed.

1.1.5: Understand that: In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge.

1.1.6: Knowledge and skills from sources other than science are essential to scientific inquiry. These include mathematics, reading, writing, and technology.

1.2.1: The pursuit of science can generate the need for advanced technology. Advanced technology, in turn, can provide the opportunity to pursue new scientific knowledge.

1.2.2: The social, economic, and political forces of a society have a significant influence on what science and technology programs are pursued, funded, and implemented.

GLEs

9.1.a: Identify and form questions that generate a specific testable hypothesis that guide the design and breadth of the scientific investigation.

9.1.b Design and conduct valid scientific investigations to control all but the testable variable in order to test a specific hypothesis. (1.1.2)

9.1.c Collect accurate and precise data through the selection and use of tools and technologies appropriate to the investigations. Display and organize data through the use of tables, diagrams, graphs, and other organizers that allow analysis and comparison with known information and allow for replication of results. (1.1.3)

9.1.d: Construct logical scientific explanations and present arguments which defend proposed explanations through the use of closely examined evidence.

9.1.e: Communicate and defend the results of scientific investigations using logical arguments and connections with the known body of scientific information.

9.1.f Use mathematics, reading, writing and technology when conducting scientific inquiries.

Assessments:

2. Aral Sea assessment (writing prompt)

Current events (see format and rubric)
Journaling
Personal glossary
Homework

Text references/vocabulary:

Chapter 1.1, pp. 4-10
Chapter 1.3, pp. 20-26

case study: a detailed description of a real-life situation in discovery science. Case studies may be used to illustrate unifying principles.

control: an experimental treatment which is used as a basis of comparison for other treatments in the same experiment.

data: recorded observations or measurements.

discovery science: a way of learning about the natural world by drawing inferences from observations of natural phenomena and experimentation. Also called inquiry science.

evidence: collected body of data, measurements, and concrete observations from experimentation.

law: a generalization which describes physical phenomena. A law (also called a principle) is sometimes expressed as a mathematical equation.

model: a physical, mental, or mathematical representation that allows an abstract concept to be perceived in a concrete way.

prove (v) proof (n): to use logical argument to show that a statement is true. (NOTE: it is not always necessary, appropriate, or possible to prove a statement in scientific reasoning. "Prove" should be distinguished from "support with evidence.")

hypothesis: a suggested answer to a testable question in science. A hypothesis always includes a rationale for the answer.

if-then reasoning: a type of logical argument in which one situation (the "if" statement) establishes a condition necessary for the second situation (the "then" statement) to occur.

inference: a logical interpretation of observations or other data.

observation: information about natural phenomena obtained by using the senses.

prediction: a statement describing a possible outcome of future events or experimentation.

qualitative: a description of data using characteristics, appearances, or properties.

quantitative: a description of data using numbers, proportions, or orders of magnitude.

system: A group of interdependent objects, processes, or other entities that interact to create a functioning whole.

theory: a well-tested explanation of a group of observations.

unit: In measurements, the label that identifies a measured or derived quantity (e.g. cm, kg, m/sec^2).

Topic 3: Motion, Acceleration, Forces

Standards:

3.2.1 Forces change the motion of objects. Newton's Laws can be used to predict these changes.

3.2.2 Forces are mechanisms that can transfer energy from one object to another. A force acting on an object and moving it through a distance does work on that object and changes its kinetic energy, potential energy, or both. Power indicates the rate at which forces transfer energy to an object or away from it.

3.2.5 Gravity is a universal force of attraction that each mass exerts on any other mass. The strength of the force depends on the masses of the objects and the distance between them. The force of gravity is generally not important unless at least one of the two masses involved is huge (a star, the Earth or another planet or a moon).

GLEs:

11.3.k Draw force diagrams to illustrate the action of friction when it acts to slow-down an object. Use an energy argument to describe how friction slows down a moving object.

11.3.n Describe how many of the forces acting between objects (friction and normal forces) and acting within objects (tensions, compressions and elastic forces) are manifestations of the electromagnetic forces that act between atoms and molecules in substances.

11.3.bb Observe how the direction of the acceleration relates to the direction of the total force.

11.3.ee Describe what the size of the acceleration of an object indicates about the object's motion (how quickly the object's velocity will change). Give examples of objects having large accelerations (motorcycles starting from rest, vehicles stopping abruptly, cars negotiating sharp curves) and objects having small accelerations (tractor trailers starting from rest, large ships slowing down, and vehicles traveling on long gradual curves on highways).

11.3.ff Conduct investigations to show that the acceleration due to gravity is the same for all objects near the surface of the earth. Use graphical analysis to determine the acceleration due to gravity from experimental data.

11.3.gg Use algebraic relationships that relate the acceleration of an object to its speed and position to make predictions about the motion of objects as they move along straight and circular paths.

Assessments:

3. Motion

Text references/vocabulary:

Chapter 10.1 and 10.2 pp. 318-330

acceleration: A change in the velocity of an object. Acceleration may be the result of a change in speed, a change in the direction of movement, or both.

average speed: The total distance an object moves divided by the total time over which it moved.

centripetal acceleration: The acceleration of an object moving in a circular path toward the circle's center. Centripetal acceleration occurs because the object's linear direction changes constantly in a circular path—therefore, the velocity changes constantly.

displacement: The total change in position of an object. Displacement refers to the distance and the direction, and does not account for the path an object travels.

distance: The total length an object moves. Distance does not include the direction moved, but it does account for the path taken. Therefore, if an object moves two meters to the left, then one meter to the right, its total distance is three meters, but its displacement is one meter to the left.

instantaneous speed: The speed of an object at any one instant.

motion: An object's change in position relative to a reference point.

rate: a general term describing change over time.

reference frame (reference point): a non-moving object or point that serves as a basis of comparison for describing the motion of another object.

speed: Change in distance over time.

uniform circular motion: The movement of an object in a circular path at constant speed.

velocity: Change in displacement over time. Like displacement and acceleration, velocity describes a direction. If two objects have opposite velocities, they are moving at the same speed in opposite directions.

Topic 4: Forces

Standards:

3.1.2 An object has kinetic energy because of its linear motion, rotational motion, or both. The kinetic energy of an object can be determined knowing its mass and speed. The object's geometry also needs to be known to determine its rotational kinetic energy. An object can have potential energy when under the influence of gravity, elastic forces or electric forces and its potential energy can be determined from its position.

3.1.3 Forces are mechanisms that can transfer energy from one object to another. A force acting on an object and moving it through a distance does work on that object and changes its kinetic energy, potential energy, or both. Power indicates the rate at which forces transfer energy to an object or away from it.

GLEs:

9.3.c Conduct investigations involving moving objects to examine the influence that the mass and the speed have on the kinetic energy of the object. Collect and graph data that supports that the kinetic energy depends linearly upon the mass, but nonlinearly upon the speed.

9.3.t Describe the role that forces play when energy is transferred between interacting objects and explain how the amount of energy transferred can be calculated from measurable quantities.

9.3.v Conduct investigations to determine what factors influence whether a force transfers energy to an object or away from the object, and how the direction of the force (relative to the direction of motion) influences the quantity of energy transferred by the force.

11.3.n Describe how many of the forces acting between objects (friction and normal forces) and acting within objects (tensions, compressions and elastic forces) are manifestations of the electromagnetic forces that act between atoms and molecules in substances.

11.3.v Use vector diagrams to illustrate how the total force is determined from a group of individual forces.

11.3.z Use examples to illustrate the differences between mass and force and explain why only forces can change the motion of objects.

11.3.aa Explain why an object with a large mass is usually more difficult to start moving than an object with a smaller mass.

11.3.bb Observe how the direction of the acceleration relates to the direction of the total force.

Assessments:

4. Forces

Text References/vocabulary:

Mechanical force: Chapter 11, pp. 346-375

air resistance: a force exerted by molecules of air on an object moving through the air. Unlike fluid friction, air resistance occurs because the air molecules form an obstacle to the moving object.

balanced forces: A pair of forces with equal magnitudes that act in opposite directions on the same object. When two forces are balanced, the object's motion doe not change. It will either remain at rest or continue to move with constant velocity.

force: An influence (push or pull) that changes the motion of an object.

net force: The total magnitude and direction of all forces acting on an object.

Newton (abbreviated "N"): A unit of force. One Newton is equal to one kg-m/sec^2.

unbalanced forces: Forces that act on an object in such a way that they are either not equal in magnitude or not opposite in direction or both. Unbalanced forces change the motion of an object.

Teachers are also welcome (but not required) to introduce other applications of force if desired as students become ready. These may be found in the following chapters:

Electric Force: Chapter 16.1, pp. 530-536

electric charge: A property of matter that affects the tendency of objects to be attracted to or repelled from one another. Electric charges are positive or negative. Like charges repel, unlike charges attract.

electric field: a region around a charged object where an electric force is exerted.

electric force: The force created by the mutual attraction or repulsion of electric charges. These charges are created by discrepancies in the amounts of electrons and protons in matter.

Magnetic Force: Chapter 17.1, pp. 564-567

magnet: a device usually made of iron, cobalt, or nickel that can be induced to create a magnetic force.

magnetic force: A force induced by moving electric fields. A magnetic force causes certain materials to be attractive or repulsive.

SCIENCE SAFETY QUIZ

Write your responses in the boxes provided.

1. When should we wear goggles in the lab?

2. What information is contained on a label?

3. What is an unauthorized experiment? Why is it not permitted?

4. When heating water on a hot plate, everyone in lab should wear goggles. List two other safety rules to follow when heating a beaker of water on a hot plate.

5. .When you heat a test tube over an open flame, you should always wear goggles. List two other safety rules to follow when heating a test tube over an open flame.

SCIENCE SAFETY QUIZ--RUBRIC

Write your responses in the boxes provided. (two points each.) NOTE: there are no criteria for a partial response (1). Each question is scored as a complete response (2) or an incorrect response (0)

1. When should we wear goggles in the lab?

Whenever we work with chemicals, with heat, with glassware, or with any danger from flying projectiles.

2. What information is always contained on a label?

The label contains the name of the chemical, date of preparation, and hazard information. Solutions also contain the concentration.

3. What is an unauthorized experiment? Why is it not permitted?

An unauthorized experiment is one that is not part of the assignment which student performs without first informing the teacher. Unauthorized experiments often produce hazardous conditions that students may not have anticipated. Because the teacher is not involved with their design, the teacher may have difficulty dealing with these hazards. Therefore, unauthorized experiments are forbidden.

4. When heating water on a hot plate, everyone in lab should wear goggles. List two other safety rules to follow when heating a beaker of water on a hot plate.

- Do not touch glass with bare hands. Use tongs or other protective devices.
- Keep area around hot plate free of clutter.
- Before heating, be sure beaker is free of cracks.
- No horseplay around hot plate.

(**any two are required for a complete response**)

5. .When you heat a test tube over an open flame, you should always wear goggles. List two other safety rules to follow when heating a test tube over an open flame.

- Shoulder length hair is tied back.
- Point opening of test tube away from other people.
- Test tube must be no more than ¼ full of any chemical.
- Use test tube holder (tongs) to hold test tube, not bare hands.

(**any two are required for a complete response**)

EARTH SYSTEMS—THE ARAL SEA

You have been called in to a town meeting of the town of Leninsk in the Republic of Uzbekistan. Leninsk is a small community on the southern bank of the Aral Sea. The residents of Leninsk have noticed for the past forty years that their beloved Aral Sea has become considerably smaller in area and volume. People seem to be developing unusual illnesses and the fishing industry has disappeared ("dried up.")

Prepare a five paragraph speech which addresses the following points:

- Why has the Aral Sea been disappearing?
- What can we do to keep the Aral Sea from getting any smaller? (If we can't keep this from happening, why not?)
- Based on the points you have made so far, what recommendation would you make to the people of Leninsk over the next five years? Should they evacuate? Should they redirect rivers that flow out of the Aral Sea? Justify your suggestions.

Information about the Aral Sea can be found at

http://edcwww.cr.usgs.gov/earthshots/slow/Aral/Aral

http://www.orexca.com/aral_sea.shtml

http://www.washingtonpost.com/wp-dyn/content/article/2007/07/09/AR2007070902072.html

RUBRIC FOR EARTH SYSTEMS—THE ARAL SEA

Characteristics of a level 3:

The respondent provides a specific explanation of factors which may have caused the volume of water in the Aral Sea to diminish over time. This explanation explains what factors maintained the Aral Sea system before 1960, and how changes made by the Soviet Union after 1960 caused changes. The respondent explores a variety of possible interventions to correct the problem, analyzing the consequences of each. The suggestions to the residents of Leninsk reflect the most logical course of action based on the state of the Aral Sea and the possible economic and health related ramifications of the situation. The response is free of errors in standard written English.

Characteristics of a level 2:

The respondent provides a specific explanation of factors which may have caused the volume of water in the Aral Sea to diminish over time. The respondent suggests one or more possible interventions to correct the problem, analyzing the consequences of each. The suggestions to the residents of Leninsk reflect a logical course of action based on the state of the Aral Sea and the possible economic and health related ramifications of the situation. The response contains few, if any, errors in standard written English, and these do not interfere with understanding.

Characteristics of a level 1:

The respondent provides an explanation of factors which may have caused the volume of water in the Aral Sea to diminish over time. The respondent suggests one or more possible interventions to correct the problem. The suggestions to the residents of Leninsk describe a course of action but are not supported by data. The response may contain some errors in standard written English that rarely interfere with understanding.

Characteristics of a level 0

The respondent provides a poor explanation of factors which may have caused the volume of water in the Aral Sea to diminish over time. The respondent either suggests no interventions to correct the problem, or the interventions suggested are inappropriate or irrelevant. No suggestions to describe a course of action are given, or the suggestions are inappropriate. The response may contain serious errors in standard written English that seriously interfere with understanding.

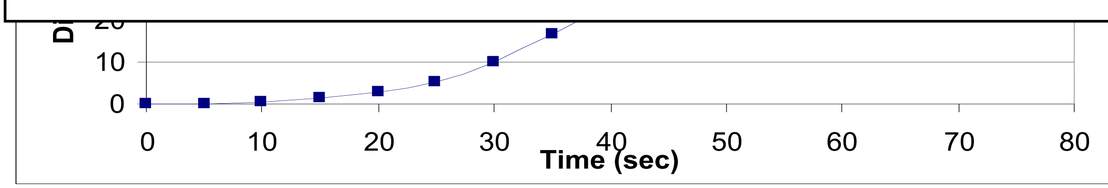
ASSESSMENT—MOTION

1. Poor Gustave! He was about to start his weekly shopping at the local supermarket, and the cart slipped out of his hands and rolled across the parking lot!

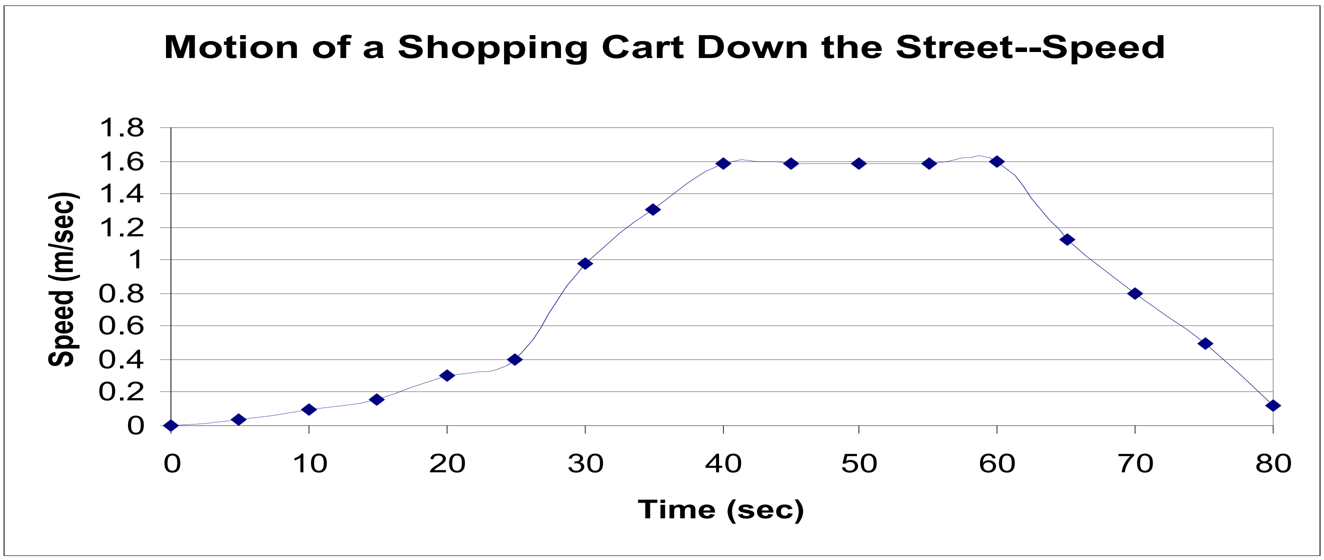
The graphs on the next page give information about the distance the cart rolled through the parking lot and the speed it was moving:

In the box below, write an explanation for the data shown in these two graphs. Use data from the graphs in your explanation.

The parking lot where Gustave lost his cart was paved blacktop. If the parking lot was grassy, how would the Distance Moved graph (the first one) look different? Explain your answer.



Go, Gustave, Go!!!!!



RUBRIC FOR ASSESSMENT—MOTION

1. In the box below, write an explanation for the data shown in these two graphs. Use data from the graphs in your explanation.

This item measures the student's ability to interpret graphical data and use it to explain a physical event.

Criteria for a complete response (2):

Student explains that because the cart increases in speed until 40 seconds, moves at constant speed for another 20 seconds, then decreases in speed, the cart must move down a hill then up a hill.

Criteria for a partial response (1):

Student correctly describes the trends in the graph **or** correctly explains the motion of the cart but not both.

Criteria for an incomplete response (0):

Student incorrectly interprets the data on the graphs (or does not mention the graphs) **and** gives an incorrect interpretation of the results.

The parking lot where Gustave lost his cart was paved blacktop. If the parking lot was grassy, how would the Distance Moved graph (the first one) look different? Explain your answer.

This item measures the student's ability to predict the effect of a different surface on the distance/time graph.

Criteria for a complete response (2):

Student explains that the curve on the distance/time graph will reach a lower peak because grass will interfere with the cart's forward motion.

Criteria for a partial response (1):

Student explains that the grass will interfere with the cart's forward motion but does not refer to the graph.

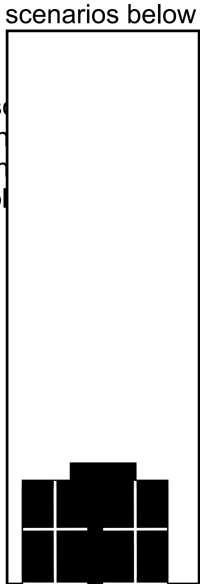
Criteria for an incorrect response (0):

Student gives an incorrect description of the graph or states that the shape of the graph cannot be predicted.

ASSESSMENT—FORCES

1. A <u>force</u> is an influence (push or pull) that changes the motion of an object.

Each of the scenarios below describes an object's motion (or lack of motion) and an outside force. For each scenario

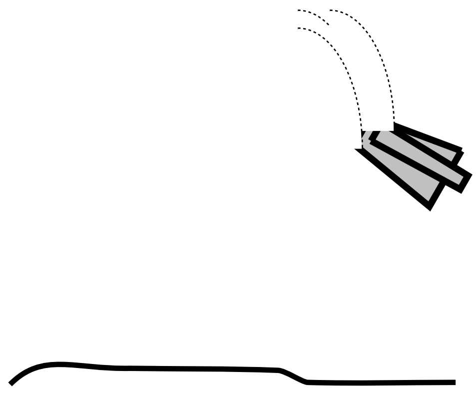


a) des[illegible] of the object at the beginning.
b) iden[illegible]ting on the object at the beginning (name of force and direction of action).
c) iden[illegible]rce that acts (name of force and direction of action).
d) expl[illegible]ide force changed the motion of the object.

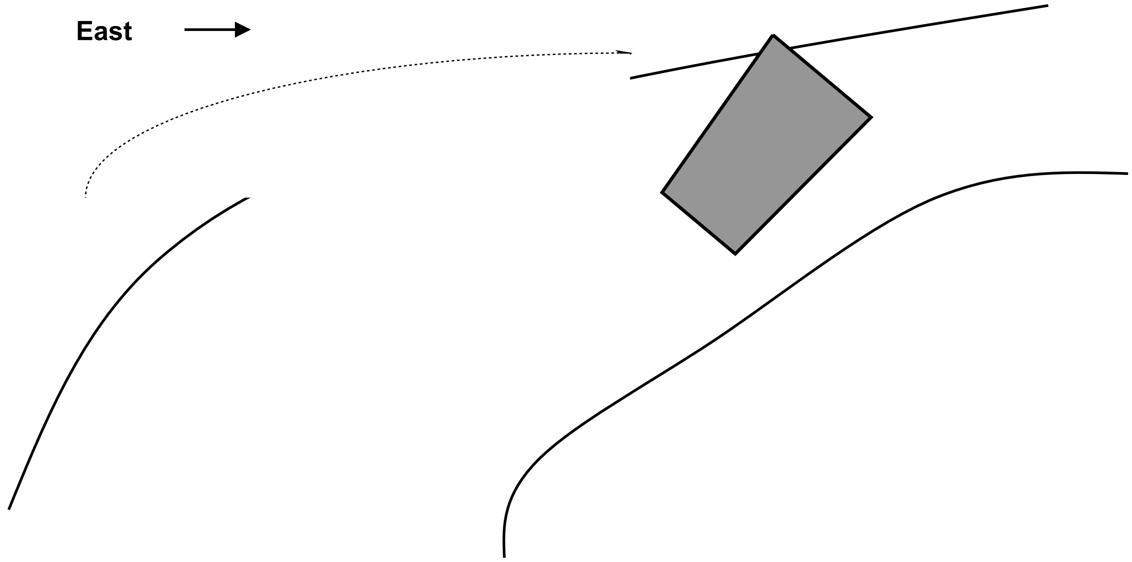
Scenario 1: [illegible]lling to the ground. When it reaches the ground, it stops. (note: the flowerpot does not break).

a.____

____



Scenario 2: an empty trash can is placed on a street corner. A wind moving toward the east blows the trash can down the street. (assume the wind is strong enough to cause the trash can to leave the ground temporarily).



a.____

____

b.____

____

c.____

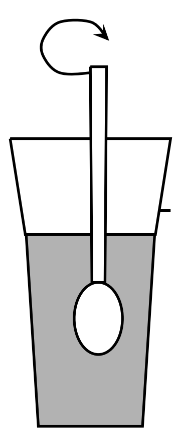
____

d.____

____

Scenario 3:

A spoon stirs a glass of chocolate milk in a circle at constant speed. (for this question, focus on the forces acting on the milk).



a.____________________________________

____

b.____________________________________

____

c.____________________________________

____

d.____________________________________

RUBRIC FOR ASSESSMENT—FORCES

Each of the scenarios below describes an object's motion (or lack of motion) and an outside force. For each scenario

a) describe the motion of the object at the beginning.
b) identify the forces acting on the object at the beginning (name of force and direction of action).
c) identify the outside force that acts (name of force and direction of action).
d) explain how the outside force changed the motion of the object.

These items measure a student's ability to describe forces in terms of source and direction. They also measure the student's understanding of how forces change motion: they may stop a moving object, start a stationary object moving, or change the direction of a moving object.

Scenario 1: a flowerpot is falling to the ground. When it reaches the ground, it stops. (note: the flowerpot does not break).

a. Flowerpot is falling to the ground.
b. Force of gravity is pulling object to the ground.
c. The ground exerts an upward supporting force ("ground" force, supporting force, or normal force are all appropriate)
d. The force exerted by the ground causes the flowerpot to stop moving (or come to rest).

Scenario 2: an empty trash can is placed on a street corner. A wind moving toward the east blows the trash can down the street (assume the wind is strong enough to cause the trash can to leave the ground temporarily).

a. Trash can is at rest.
b. Gravity is pulling trash can to the ground, the ground exerts an upward supporting force.
c. The wind exerts a force to the east.
d. The wind's force causes the trash can to begin moving from rest.

Scenario 3:

A spoon stirs a glass of chocolate milk in a circle at constant speed.

a. Milk is moving in a circular path.
b. Gravity holds milk in glass, glass exerts force supporting milk.
c. Spoon pushes milk in a sideways path that changes constantly. Net force on the milk is directed toward the center of the glass (centripetal force)
d. Direction of the moving path changes.

Each scenario is scored separately.

Criteria for a complete response (2)

Student correctly answers all four questions.

Criteria for a partial response (1):

Student answers no less than two questions correctly

Criteria for an incorrect response (0):

Student answers more than two questions incorrectly or incompletely.

OCTOBER

Topic 5: Friction

Standards:

3.2.1. Forces change the motion of objects. Newton's Laws can be used to predict these changes.

3.2.2. Forces are mechanisms that can transfer energy from one object to another. A force acting on an object and moving it through a distance does work on that object and changes its kinetic energy, potential energy, or both. Power indicates the rate at which forces transfer energy to an object or away from it.

3.3.1 Energy cannot be created nor destroyed. Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes. Recognizing that energy is conserved, the processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.

3.3.2 Most of the changes that occur in the universe involve the transformation of energy from one form to another. Almost all of these energy transformations lead to the production of some heat energy, whether or not heat energy is the desired output of the transformation process.

GLEs:

9.3.ii Use energy chains to trace the flow of energy through systems involving sliding friction and air resistance (for example, the braking action in vehicles or bicycles or a vehicle rolling to rest).

9.3.jj Explain that through the action of resistive forces (friction and air resistance) mechanical energy is transformed into heat energy, and because of the random nature of heat energy, transforming all of the heat energy back into mechanical energy (or any other organized form of energy) is impossible. Give examples where organized forms of energy (GPE, elastic PE, the KE of large objects) are transformed into heat energy but the reverse transformations are not possible.

11.3.g Conduct investigations to determine the relative sizes of static and kinetic frictional forces acting between two surfaces.

11.3.h Conduct investigations to determine what variables (mass, normal force, surface area, surface texture, etc.) influence the size of frictional forces that act between two objects.

11.3.i Give examples in which static friction is a force of propulsion, initiating the motion of an object. Use force diagrams to illustrate the forces acting on the object during this propulsion process.

11.3.j Use force diagrams to describe how static friction can prevent an object (that is subject to another force) from moving.

11.3.k Draw force diagrams to illustrate the action of friction when it acts to slow-down an object. Use an energy argument to describe how friction slows down a moving object.

Assessments:

4. Friction

Text References/vocabulary:

Chapter 10.3, pp. 331-336

fluid friction: A type of kinetic friction exerted by particles of a liquid or gas on an object moving through them. While fluid friction is always present when an object moves through a fluid, its tendency to affect the motion of the object is limited to situations where the fluid is extremely viscous or when the object is moving at high speeds.

friction: A force exerted by particles in direct contact with particles of another object. Friction is a force that interferes with the objects' slipping past one another.

kinetic friction: A frictional force that interferes with the movement of two surfaces that are in contact and are sliding over each other.

lubricant: A material that is applied to a surface to reduce friction (static and kinetic).

rolling friction: A type of kinetic friction that acts between a surface and a round object. Because rolling friction only affects a small portion of the surface of the round object, it is necessary for displacement of the round object.

sliding friction: A type of kinetic friction that occurs between a surface and an object that cannot roll.

static friction: A frictional force that acts on a stationary object. Static fricition Interferes with the motion of the object, and must be overcome this friction to begin moving.

traction: A synonym for static friction. Traction is generally used to refer to the friction that is necessary for motion to occur.

Topic 6: Newton's Laws

Standards:

3.2.1 Forces change the motion of objects. Newton's Laws can be used to predict these changes.

3.2.2 Forces are mechanisms that can transfer energy from one object to another. A force acting on an object and moving it through a distance does work on that object and changes its kinetic energy, potential energy, or both. Power indicates the rate at which forces transfer energy to an object or away from it.

GLEs:

11.3.i Give examples in which static friction is a force of propulsion, initiating the motion of an object. Use force diagrams to illustrate the forces acting on the object during this propulsion process.

11.3.x Reflect on how forces can collectively act on the object and not change its motion (basis of Newton's 1st Law).

11.3.y Conduct investigations to reach qualitative and quantitative conclusions regarding the effects of the size of the total force and the object's mass on its resulting acceleration (Newton's 2nd Law, $a = F_{totat}/m$).

11.3.z Use examples to illustrate the differences between mass and force and explain why only forces can change the motion of objects.

11.3.cc Use Newton's Second Law to calculate the acceleration of objects that are subject to common forces (for example, gravity, constant pushing or pulling forces and/or friction).

11.3.hh Conduct investigations (or demonstrate) that under a variety of conditions when two objects collide they exert equal sized forces on each other. Use Newton's 2nd Law to explain why these two objects may react differently to equal sized forces.

11.3.ii Use vector diagrams and Newton's 3rd Law to explain how a bathroom scale indirectly indicates your weight.

Assessments:

6. Newton's Laws of Motion

Text references/vocabulary:

Newton's First Law, Newton's Second Law:	Chapter 11.1, pp. 346-351
Newton's Third Law:	Chapter 11.3, pp. 360-366

inertia: The tendency of an object to resist changes in motion. Inertia is the property by which a stationary object will not move unless acted on by an outside force, and a moving object will continue to move at constant velocity unless acted on by an outside force.

action: A description of an outside force acting on an object, changing the object's motion.

reaction: A description of the equal and opposite force that operates as a result of an action.

momentum: The measurable tendency of a moving object to resist being stopped. Momentum is the product of the mass times the velocity of an object (also, the force times the time). Momentum is a way of expressing the inertia of a moving object.

propulsion: Moving forward of an object as a result of a force.

Topic 7: Potential and Kinetic Energy

Standards:

3.1.2 An object has kinetic energy because of its linear motion, rotational motion, or both. The kinetic energy of an object can be determined knowing its mass and speed. The object's geometry also needs to be known to determine its rotational kinetic energy. An object can have potential energy when under the influence of gravity, elastic forces or electric forces and its potential energy can be determined from its position.

3.2.2 Forces are mechanisms that can transfer energy from one object to another. A force acting on an object and moving it through a distance does work on that object and changes its kinetic energy, potential energy, or both. Power indicates the rate at which forces transfer energy to an object or away from it.

3.3.1 Energy cannot be created nor destroyed. Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes. Recognizing that energy is conserved, the processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.

GLEs:

9.3.c Conduct investigations involving moving objects to examine the influence that the mass and the speed have on the kinetic energy of the object. Collect and graph data that supports that the kinetic energy depends linearly upon the mass, but nonlinearly upon the speed.

9.3.d Recognize that the kinetic energy of an object depends on the square of its speed, and that $KE = \frac{1}{2} mv^2$.

9.3.h Explain that heat energy represents the total random kinetic energy of molecules of a substance.

9.3.t Describe the role that forces play when energy is transferred between interacting objects and explain how the amount of energy transferred can be calculated from measurable quantities.

9.3.u Identify that 'work' is the process by which a force transfers energy to an object, and use measured quantities to make calculations of the work done by forces (W = energy transferred = $F \cdot D$).

9.3.aa Describe why it is significant that energy cannot be created (made) nor destroyed (consumed), and identify that that this property of energy is referred to as the Law of the Conservation of Energy.

Assessments:

7. Potential and Kinetic Energy

Text References/Vocabulary:

Mechanical Energy: Chapter 12.3 pp. 391-399
Chapter 12.4 pp. 400-408

Electromagnetic energy is addressed in December.
Chemical energy is addressed in January and March.
Thermal energy is addressed in November.

Vocabulary: Mechanical energy:

efficiency: The percentage of useful work output to work input of a machine. Because the machine involves an energy transfer that results in some randomness of energy, efficiency is always less than 100 %.

energy: The measurable quantity that describes changes in matter brought about by forces.

energy transfer: The flow of energy from one object to another when unbalanced forces act on the objects.

energy transformation: The conversion of energy from one form to another. Energy transformations often occur during energy transfer (but not always), and result in increased randomness. For this reason, energy transformation is not cyclic in nature.

gravitational potential energy: The potential energy of objects based on the distance between their centers of mass.

Joule: The SI unit of energy. One joule = 1 kg-m^2/sec^2.

kinetic energy: The energy associated with moving objects or particles.

kinetic: Referring to motion or movement.

mechanical energy: The sum of the kinetic and potential energies of objects in a system.

potential energy: A description of the energy of objects based on their relative positions.

work: The quantity of mechanical energy transferred by a force when it is applied to a body, causing the body to be moved over a distance.

ASSESSMENT 5—FRICTION

1. Friction is a resistive force that occurs between two surfaces moving past each other.

   Explain how friction can cause problems with the operation of a car engine in terms of energy transfer and transformation.

2. How does adding motor oil solve these problems?

3. Explain how friction is necessary for the car to move in the winter when the ground is icy.

RUBRIC FOR ASSESSMENT 5—FRICTION

1. Explain how friction can cause problems with the operation of a car engine in terms of energy transfer and transformation.

This item measures a student's understanding of how the force of friction transforms mechanical energy into heat energy, possibly to the detriment of moving parts.

Criteria for a complete response (2):

Student explains that as parts of the engine slide past one another, the force of friction resists this sliding. The mechanical energy is transformed into heat energy, and this heat energy can wear down the parts, melt various components, or ignite flammable substances. Other effects of excessive heat may be accepted for a complete response.

Criteria for a partial response (1):

Student states some of the harmful effects of heat but does not explain how friction causes heat **or** correctly explains how friction causes heat but does not explain why the heat is detrimental.

Criteria for an incomplete response (0):

Student explains how the engine can malfunction (e.g. “engine could seize up”) without referring to the influence of heat or how friction transforms mechanical energy.

2. How does adding motor oil solve these problems?

This item measures the student’s understanding of the connection between the structure of the contact surfaces and the force of friction.

Criteria for a complete response (2):

Student explains that oil provides a smoother connection (interface) between the two surfaces. This smoothness allows the surfaces to slide past one another more easily, reducing the force of friction, and reducing transformation of mechanical energy into heat energy.

Criteria for a partial response (1):

Student explains that oil enables the two surfaces to slide past one another, but does not address the problem of heat build-up.

Criteria for an incomplete response (0):

Student explains that motor oil cools the engine.

3. Explain how friction is necessary for the car to move in the winter when the ground is icy.

This item measures a student’s understanding that friction is necessary to allow movement along a surface or to stop forward motion.

Criteria for a correct response (2):

Student states that the force of friction (from sand or other gritty substance) opposes the force of the turning wheels, which allows the tire to grip the road as it turns, and as a result, move the car. Ice reduces this friction, and causes the tire to spin in place.

Alternatively, friction is necessary to reduce the forward motion of the car while braking by exerting a force that opposes the force of the wheels turning **or** friction prevents the tires from sliding back and forth (skidding). Students may use the word <u>traction</u> in place of friction in this question.

Criteria for a partial response (1):

Student states that friction may prevent skidding but doesn’t explain why. Alternatively, student states that friction causes the brakes to work but doesn’t explain this in terms of forces.

Criteria for an incomplete response (0):

Student response does not reflect an understanding that friction is a useful force in this circumstance.

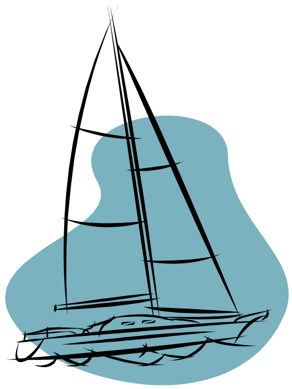
ASSESSMENT—NEWTON'S LAWS OF MOTION

Newton's First Law of Motion:
An object at rest tends to stay at rest until acted on by an outside force. An object in motion tends to remain in motion until acted on by an outside force.

Newton's Second Law of Motion (summarized):
net force = mass X acceleration

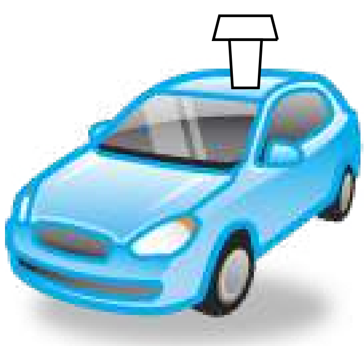
Newton's Third Law of Motion:
For every action there is an equal and opposite reaction.

1. You and five of your friends find yourself in a sailboat in the middle of the ocean. No wind is blowing.



You decide that together, the six of you will inhale and blow into the sails to get the boat to move. Assuming you are successful in filling the sails with air, will this strategy cause the boat to move in the direction you are blowing? Use Newton's Third Law of Motion to justify your answer.

2. As you look out your window, you notice that your neighbor has mistakenly set his cup of coffee on top of his car, and started to drive off.



As the neighbor drives down your street, he sees that he is about to hit another car. He slams on the brakes, missing the other car. However, his coffee flies off the roof, soaking the other car. Both drivers start yelling at each other.

Why did the neighbor's coffee fly off the roof of his car? Use Newton's First Law of Motion to justify your answer.

3. The Empire State Building in New York City stands at 380 meters (around 1250 feet). Some people have believed that if a person were to drop a dime off the giant building and it struck a person below, it would crack the second person's skull. Use Newton's Second Law of Motion to explain why this is not true.

RUBRIC FOR ASSESSMENT—NEWTON'S LAWS OF MOTION

1. You and five of your friends find yourself in a sailboat in the middle of the ocean. No wind is blowing.

   You decide that together, the six of you will inhale and blow into the sails to get the boat to move. Assuming you are successful in filling the sails with air, will this strategy cause the boat to move in the direction you are blowing? Use Newton's Third Law of Motion to justify your answer.

This item measures the student's understanding of Newton's third law of motion involves action/reaction pairs and how they differ from balanced forces.

Criteria for a correct response (2):

Student states that the boat won't move because the force exerted by the friends filling the sails is not an external force. The sails are also exerting a force on the air, so these forces are balanced forces within the boat.

Criteria for a partial response (1)

Student states the boat won't move but states it's because the friends can't blow hard enough to move the boat **or** gives a plausible explanation that does not address Newton's third law.

Criteria for an incorrect response (0):

Student states that the boat will not move but gives no explanation or an illogical explanation **or** student states that the boat will move, with or without an explanation.

2. Why did the neighbor's coffee fly off the roof of his car? Use Newton's First Law of Motion to justify your answer.

This item measures the student's understanding of inertia, and how the frame of reference of a moving object affects its behavior when movement stops.

Criteria for a complete response (2):

Student explains that while the car is moving, the coffee moves in the same frame of reference. When the car stops suddenly, the coffee continues moving forward because it is not anchored to the car. According to Newton's first law, since no outside force stops the coffee until it hits the other car, the coffee moves with the same forward motion it had while the car was in motion.

Criteria for a partial response (1):

Student explains that the coffee will fly off the roof because it's not anchored to the car, but does not explain the phenomenon in terms of Newton's first law.

Criteria for an incorect response (0):

Student states that when the car stops, it introduces a force on the coffee ("the car throws the coffee off" or something similar).

3. The Empire State Building in New York City stands at 380 meters (around 1250 feet). Some people have believed that if a person were to drop a dime off the giant building and it struck a person below, it would crack the second person's skull. Use Newton's Second Law of Motion to explain why this is not true.

This item measures a student's understanding of Newton's second law and its application to falling bodies.

Criteria for a complete response (2):

Student states that although a dime is falling from a great height, Newton's second law states that gravitational acceleration is a constant, and the mass (also a constant) will limit the force with which the dime will fall. According to the second law, the only factors that affect the force of the dime are the mass of the dime and gravitational acceleration. Height of the dime will not influence this force.

Criteria for a partial response (1):

Student states that the dime is too small to cause this kind of damage, but does not address Newton's second law as justification **or** states that the dime will be slowed by air resistance but does not address Newton's second law.

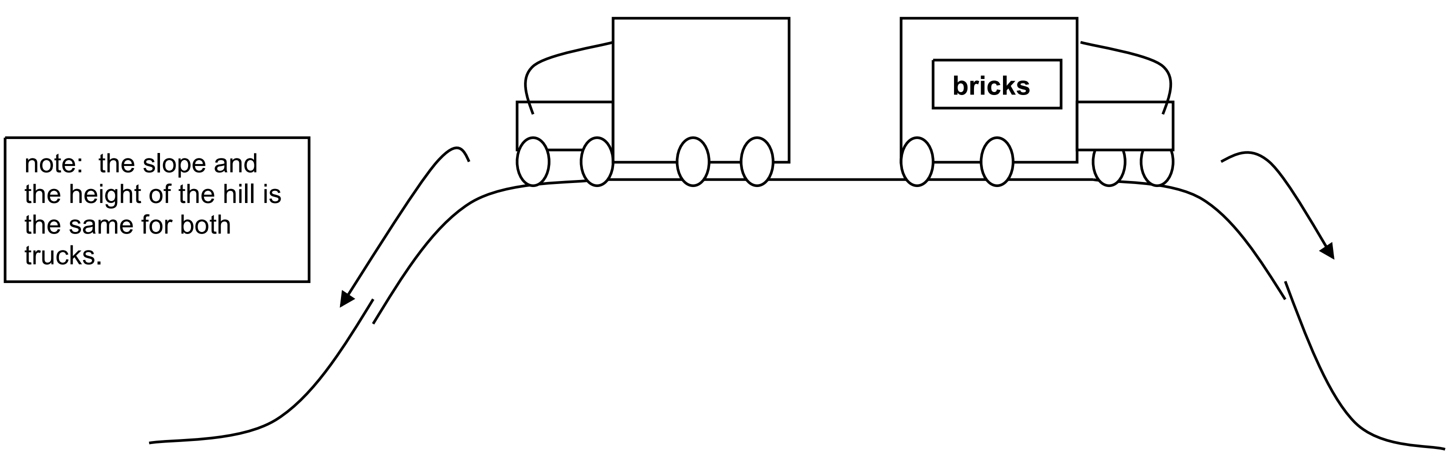
Criteria for an incorrect response (0):

Student justifies this claim based on fencing at the top of the observation tower to prevent dropping objects **or** justifies the claim based on the shape of the building **or** on some other justification unrelated to motion or Newton's laws.

ASSESSMENT—POTENTIAL AND KINETIC ENERGY

1. Two identical trucks are at the top of a hill. One truck is empty. The other truck is loaded completely with red bricks.

Both trucks coast down the hill with no brakes and the engines turned off. Assuming there is nothing to stop or slow either truck down, how will the trip to the bottom of the hill be different? Explain.



2. Your family has found an old safe in the attic, and it is locked. The key was lost years ago. You decide the best way to see what's inside is to drop it from a height and break it open.

The mass of the safe is 40 kg. If the safe hits the ground at a velocity of 25 m/sec, it will break open. What is the minimum height (in meters) should the safe be dropped from to ensure it breaks open? Show or explain how you got your answer.

Gravitational Potential Energy: GPE = mgh where m= mass (kg)
g = 9.8 m/sec^2
h = height (m)

Kinetic Energy: KE = ½ mv^2 where m = mass (kg)
v = velocity (m/sec)

RUBRIC FOR ASSESSMENT—POTENTIAL AND KINETIC ENERGY

1. Two identical trucks are parked at the top of a hill. One truck is empty. The other truck is loaded completely with red bricks.

Both trucks coast down the hill with no brakes and the engines turned off and continue moving along the road at the bottom of the hill until they come to rest. How will the total motion of the two trucks be different during this trip? Explain.

This item measures the student's understanding of how mass, velocity, and acceleration ultimately affect the object's total energy, both potential and kinetic.

Criteria for a complete response (2):

Student states that the truck with the bricks will travel further than the empty truck because its higher mass gives it more total energy. When the trucks reach the bottom of the hill, the truck with bricks will have more kinetic energy. It will therefore travel further than the other truck until the friction of the road stops it.

Criteria for a partial response (1):

Student explains that the truck with the bricks has more total energy, but interprets this difference incorrectly (e.g. states that the truck with bricks will reach the bottom first).

Criteria for an incorrect response (0):

Student gives an interpretation that does not address total energy, potential energy, or kinetic energy.

2. Your family has found an old safe in the attic, and it is locked. The key was lost years ago. You decide the best way to see what's inside is to drop it from a height and break it open.

   The mass of the safe is 40 kg. If the safe hits the ground at a velocity of 25 m/sec, it will break open. What is the minimum height (in meters) should the safe be dropped from to ensure it breaks open? Show or explain how you got your answer.

This item measures the student's ability to relate gravitational potential energy to kinetic energy. It also measures a student's ability to manipulate equations.

Criteria for a correct response (2):

Student equates the safe's gravitational potential energy at the top of the drop with the kinetic energy at the ground.

$mgh = 1/2mv^2$ since the mass of the safe is the same for both expressions, it cancels out.

$9.8 \times h = (25)^2$

$9.8 \times h = 625$

h = 63.7 meters

(NOTE: some students may choose to round gravitational acceleration to 10 m/sec^2. This will give a height of 62.5 meters. Students should be given credit for a correct answer in this situation.)

Criteria for a partial response (1):

Student establishes the equivalent relationship of gravitational potential energy to kinetic energy, but does not solve for the value of height.

Criteria for an incorrect response (0):

Student solves for height without giving an explanation.

NOVEMBER

Topic 8: Gravitational Potential Energy/Elastic Potential Energy

Standards:

3.1.2 An object has kinetic energy because of its linear motion, rotational motion, or both. The kinetic energy of an object can be determined knowing its mass and speed. The object's geometry also needs to be known to determine its rotational kinetic energy. An object can have potential energy when under the influence of gravity, elastic forces or electric forces and its potential energy can be determined from its position.

3.1.4 Thermal (heat) energy is associated with the random kinetic energy of the molecules of a substance.

GLEs:

9.3.f Conduct investigations and graph data that indicates that the energy stored in a stretched elastic material increases nonlinearly with the extent to which the material was stretched.

9.3.g Recognize that the energy stored in a stretched elastic material is proportional to the square of the stretch of the material, and a constant that reflects the elasticity of the material. (Elastic PE = $\frac{1}{2} kx^2$).

9.3.o Recognize that the gravitational force is a universal force of attraction that acts between masses, but this force is only significant when one (or both) of the objects is massive (for example, a star, planet or moon).

9.3.p Explain that as objects move away from the surface of a planet or moon, the gravitational pull on the object will decrease.

9.3.q Use examples to illustrate that near the surface of a planet or moon, the gravitational force acting on an object remains nearly constant. Recognize that on Earth, the object would have to be moved several hundred miles above the surface before the decrease in the force of gravity would become detectable.

9.3.r Explain the difference between the mass of an object and its weight. Identify that near the surface of the Earth, the gravitational force acting on the object (its weight) depends only on its mass, and that this force can be simply calculated from knowledge of the mass ($F_G = mg$).

9.3.s Conduct investigations to determine the behavior of elastic materials. Graph the data and identify the relationship between the extent of the stretch and the size of the elastic force (i.e., $F_{elastic} = kx$ where x = stretch).

Assessments:

8. Elastic Potential Energy

Text References/Vocabulary:

Chapter 12.3, 12.4; pp. 391-415 (NOTE: this section does not include information about elastic potential energy.)

elastic potential energy: The potential energy associated with a stretched or compressed elastic object that, when released, will regain its unstressed size and shape.

free fall: The motion of an object falling with a constant acceleration.

gravitational acceleration: The constant acceleration of an object to the center of Earth in a vacuum. Gravitational acceleration is 9.8 m/sec^2.

spring constant: A value (represented by k) that is a characteristic property of a compressible object. The spring constant relates force of compression to the distance compressed. This constant has the unit of Newton/meter.

terminal velocity: The constant velocity of a falling object when the force of air resistance is balanced with the force of gravity.

Topic 9: Power, Thermal Energy

Standards:

3.1.4 Thermal (heat) energy is associated with the random kinetic energy of the molecules of a substance.

3.2.2 Forces are mechanisms that can transfer energy from one object to another. A force acting on an object and moving it through a distance does work on that object and changes its kinetic energy, potential energy, or both. Power indicates the rate at which forces transfer energy to an object or away from it.

3.3.1 Energy cannot be created nor destroyed. Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes. Recognizing that energy is conserved, the processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.

3.3.2 Most of the changes that occur in the universe involve the transformation of energy from one form to another. Almost all of these energy transformations lead to the production of some heat energy, whether or not heat energy is the desired output of the transformation process.

GLEs:

9.3.h Explain that heat energy represents the total random kinetic energy of molecules of a substance.

9.3.w Recognize that power is a quantity that tells us how quickly energy is transferred to an object or transferred away from the object. Give examples that illustrate the differences between power, force and energy (for example, the energy needed to propel a vehicle is stored in the chemical energy of the fuel. Static friction is the force that propels the vehicle, and the power of the vehicle's engine helps to determine how quickly the vehicle can speed up …. and how quickly its engine uses fuel!).

9.3.aa Describe why it is significant that energy cannot be created (made) nor destroyed (consumed), and identify that that this property of energy is referred to as the Law of the Conservation of Energy.

9.3.bb Give examples that illustrate the transfer of energy from one object (or substance) to another, and examples of energy being transformed from one to another.

9.3.kk Reflect on why organized forms of energy are more useful than disorganized forms (heat energy).

Assessments:

9. Power and Thermal Energy.

Text References/Vocabulary:

Power: Chapter 12.1, pp. 378-384.

machine: a device that redistributes force in such a way that a given amount of work becomes easier to do. Machines may change the direction of a force, increase the distance over which the force is applied, or do both.

mechanical advantage: The ratio of the output force of a machine and the input force of a machine. This ratio is often written as resistance force:effort force.

power: The amount of work done per unit time. The unit for power, the watt, is defined as 1 Joule/second.

Thermal Energy: Chapter 13.1 pp. 420-426
Chapter 13.2, pp. 427-434 (review of 8th grade concepts)
Chapter 13.3 pp. 435-444 (optional—use as enrichment)

cold: A sensation generated by the nervous system that heat energy is leaving a part of the body.

condensation: The phenomenon by which a gas turns to a liquid or solid through reduction of heat energy.

conduction (thermal): Transfer of heat through a solid. Conduction involves transfer of kinetic energy from one atom or molecule to another.

conservation of energy: When energy is transferred from one object to another, or transformed from one form to another, the total energy before the change is equal to the total energy after the change.

convection: Transfer of heat through a fluid. Convection occurs when heated molecules move faster and spread far apart, thus reducing the density of the substance. These molecules tend to rise above denser slower moving molecules. Convection involves transferring heat by transferring matter.

First Law of Thermodynamics: A generalization which describes conservation of energy.

heat engine: A machine that harnesses heat energy (generated from other forms) to mechanical energy. Heat engines are also called combustion engines.

heat: The total amount of kinetic energy of molecules in a substance.

hot: A sensation generated by the nervous system that heat energy is entering a part of the body.

insulation (thermal): The process by which heat energy transfer is slowed by using materials that either reflect heat or absorb it.

Kelvin: A centigrade temperature scale (freezing and boiling points of water are separated by 100 degrees) in which 0 º K is absolute zero.

radiation: Energy transfer in which electromagnetic radiation emanates from a source in every direction. When this radiation interacts with matter, the molecules and atoms in the matter increase kinetic energy, resulting in heat.

specific heat: A characteristic property of matter. Specific heat is the amount of heat necessary to raise the temperature of one gram of the substance by one degree Kelvin (Celsius).

temperature: The average kinetic energy of the molecules in a substance

Topic 10: Energy Chains, sound waves

Standards:

3.2.5 Gravity is a universal force of attraction that each mass exerts on any other mass. The strength of the force depends on the masses of the objects and the distance between them. The force of gravity is generally not important unless at least one of the two masses involved is huge (a star, the Earth or another planet or a moon).

3.3.1 Energy cannot be created nor destroyed. Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes. Recognizing that energy is conserved, the processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.

3.3.2 Most of the changes that occur in the universe involve the transformation of energy from one form to another. Almost all of these energy transformations lead to the production of some heat energy, whether or not heat energy is the desired output of the transformation process.

3.3.3 Waves (e.g., sound and seismic waves, waves in water, and electromagnetic waves) carry energy that can have important consequences when transferred to objects or substances.

3.3.4 When waves interact with materials, the energy they transfer often leads to the formation of other forms of energy. These interactions, which depend upon the nature of the material and the wavelength of the waves, can be used to create practical devices (e.g., sonar and ultra sound imaging, solar cells, remote control units, and communication devices).

GLEs:

9.3.aa Describe why it is significant that energy cannot be created (made) nor destroyed (consumed), and identify that that this property of energy is referred to as the Law of the Conservation of Energy.

9.3.bb Give examples that illustrate the transfer of energy from one object (or substance) to another, and examples of energy being transformed from one to another.

9.3.cc Use energy chains to trace the flow of energy through physical systems. Indicate the source of the energy in each example and trace the energy until it leaves the system or adopts a form in the system that neither changes nor is transferred. Make qualitative estimates all the forms of the energy involved and reflect on the consequences of the energy transfers and transformations that take place. For example, trace the flow of the radiant energy carried by sunlight that strikes the roof of a home. Reflect on how the color of the roof (light vs. dark) will have an impact on the ability to heat and cool the house and possibly the functional lifetime of the roofing materials themselves.

9.3.dd Use diagrams and energy chains to illustrate examples of the selective absorption of mechanical waves in natural phenomena and examples of how the selective absorption of mechanical waves is used to conduct investigations in medicine, industry and science (for example ultrasound imagery, detecting the epicenter of earthquakes, testing structures for defects, and conducting explorations of the earth's crust and mantle).

9.3.hh Use energy chains to trace the flow of energy in a selective absorption process (for example sunburn, Greenhouse Effect, microwave cooking).

9.3.ii Use energy chains to trace the flow of energy through systems involving sliding friction and air resistance (for example, the braking action in vehicles or bicycles or a vehicle rolling to rest).

Assessments;

10. Energy Chains and Mechanical Energy

Text References/vocabulary:

Chapter 14, pp. 452-481.
Chapter 15.4, pp. 512-518.

<u>amplitude:</u> The greatest distance from resting position that particles are displaced by a transverse wave. Amplitude represents the height above or below the baseline.

<u>antinode:</u> The location where two crests or two troughs of standing waves coincide. Antinodes result in constructive interference.

<u>compression:</u> The part of a longitudinal wave where particles are packed closest together.

<u>constructive interference:</u> The superimposition of two waves in which crests combine and troughs combine to create a resultant wave with larger amplitudes than either component wave.

<u>crest:</u> The highest point of a wave above the baseline.

destructive interference: The superimposition of two waves in which the crests combine with troughs to create a resultant wave with a diminished amplitude.

diffraction: A change in wave direction when the wave passes an obstacle or an opening.

electromagnetic wave: A wave generated by a disturbance in electric and magnetic fields. Electromagnetic waves travel in a vacuum at the speed light (3×10^8 m/sec).

energy chain: A description of the energy transfers and transformations that occur during a flow of energy through various events.

frequency: number of crests that pass a given point in a given time interval. The unit of frequency is waves/sec (or sec^{-1}).

longitudinal wave: A wave in which particles in the medium vibrate in the same direction as wave movement. Longitudinal waves are always mechanical waves.

mechanical wave: A wave generated by a disturbance in matter.

medium: The matter through which a mechanical wave passes.

node: A location in standing waves where a crest coincides with a trough of equal magnitude. A node results in a location with an amplitude of zero.

period: The time during which one wavelength of a wave passes a point.

pulse: A single crest and trough of a wave.

rarefaction: The part of a longitudinal wave where particles are furthest apart.

reflection: The bouncing back of a wave when that wave is unable to pass through an obstacle. Waves are reflected at an angle equal in magnitude to the angle at which it contacts the obstacle.

refraction: The bending of a wave as it passes from one medium to another. Refraction occurs when the wave changes speed.

resonance: An additive phenomenon that occurs when two objects naturally vibrate at the same frequency. Constructive interference occurs, and greater energy is transmitted through the resultant wave.

resonating frequency: The common frequency at which two waves experience resonance.

sine curve: The shape of a transverse wave. A sine wave is characterized by a repeating pattern of crests and troughs of equal magnitude.

standing wave: A pattern of vibration that occurs when a series of waves are reflected continuously, simulating a wave that is standing still.

surface wave: A wave that occurs on Earth's crust as a surface expression of a transverse wave under the crust.

transverse wave: A wave in which particles in the medium or electromagnetic fields vibrate in a perpendicular direction to wave movement. Since transverse waves can be either electromagnetic waves or mechanical waves, they do not always require a medium.

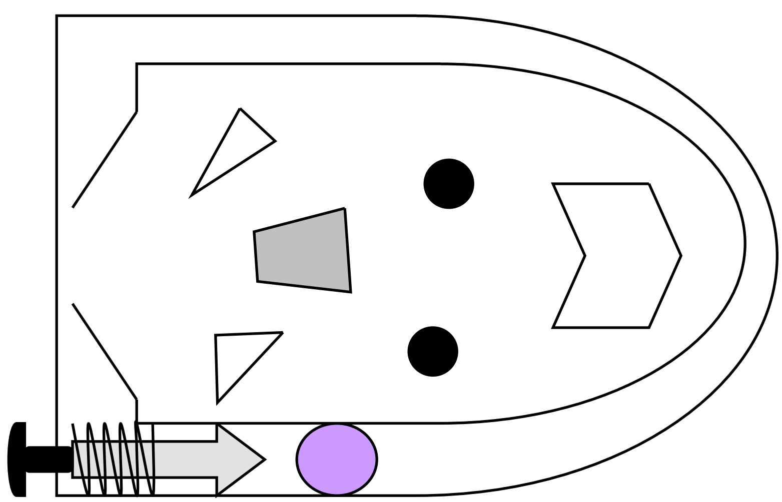
trough: The lowest point of a transverse wave.

wave: A regular disturbance in matter or through electromagnetic fields. Waves transmit energy through matter or through empty space. Although they may represent a disturbance in matter, waves do not specifically transport matter.

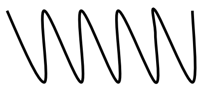
wavelength: The linear distance from the crest (or compression) of one pulse of a wave to another crest or compression.

Assessment: Elastic Potential Energy

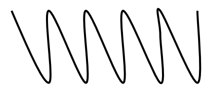
An arcade owner designed a pinball game in which a plunger is pulled backward, compressing a tight spring. When the plunger is released by the player, the spring pushes the plunger into a steel ball. The energy of the plunger pushes the ball forward and begins the pinball game.



The arcade owner examined two springs for the plunger. Both springs were 20 cm long when the machine was not used.

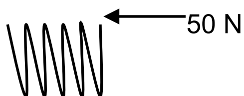


spring A

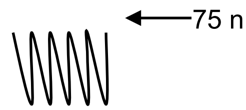


Spring B

When both plungers are pulled, both springs are compressed to a length of 10 cm. Spring A requires 50 N of force to do this. Spring B requires 75 N of force to do this.

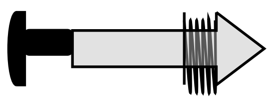


spring A



spring B

1. Assume the plunger compresses each spring to the maximum compression.



Which spring will cause the ball to move faster when used with the plunger? Explain your reasoning in terms of potential energy.

will the

3. Why would the ball finally come to rest? Assume the ball could roll forward with nothing to block its path. Refer to the energy of the ball in your response.

Rubric for Assessment: Elastic Potential Energy

1. Which spring will cause the ball to move faster when used with the plunger? Explain your reasoning in terms of potential energy.

This item measures the student's understanding that an object's potential energy of motion is related to the object's position.

Criteria for a complete response (**2**)

Student states that spring B will cause the ball to move faster because more force is required to compress it completely. This means, spring B has more potential energy, and will make the ball move faster. (NOTE: students may use the formula EPE = ½ kx^2, but this is not necessary for a complete response).

Criteria for a partial response (**1**):

Student chooses spring B, but does not relate the choice to the force required to compress (NOTE: stating that "spring B is stiffer than spring A" does not convey this idea) **or** does not relate the choice to the potential energy of the spring **or** student chooses spring A with an explanation consistent with a complete response.

Criteria for an incorrect response (**0**):

Student chooses spring A without an explanation consistent for a complete response **or** student chooses spring B with no explanation or with an explanation that does not relate the choice to the force required to compress or to potential energy of the spring.

2. When the plunger is released, it strikes the ball, and the ball gains kinetic energy. At what point will the ball have its maximum kinetic energy? Explain. Assume the ball rolls on a horizontal surface.

This item measures a student's understanding that energy in a closed system is conserved and that potential energy can be converted to kinetic energy.

Criteria for a correct response (**2**)

Student states that maximum kinetic energy will occur when the spring has returned to its pre-compressed length because it has potential energy as long as it is compressed. When the plunger is released, the potential energy converts to kinetic energy, which is transferred to the ball.

Criteria for a partial response (**1**):

Student states that maximum kinetic energy will occur after the ball has left the plunger, with the explanation that the ball is moving, but does not relate kinetic energy to the potential energy of the spring.

Criteria for an incorrect response (**0**):

Student states that maximum kinetic energy will occur as soon as the ball is put into motion, with or without an explanation **or** student response shows no understanding of the nature of kinetic energy.

3. Why would the ball finally come to rest? Assume the ball could roll forward with nothing to block its path. Refer to the energy of the ball in your response.

This item measures a student's understanding of the forms energy can take and that energy is conserved through its transformations.

Criteria for a correct response (**2**):

Student states that the kinetic energy of the ball is transferred as heat energy to the surface on which it is rolling. Student may also indicate that the kinetic energy is released as sound or transferred to the air particles.

Criteria for a partial response (**1**):

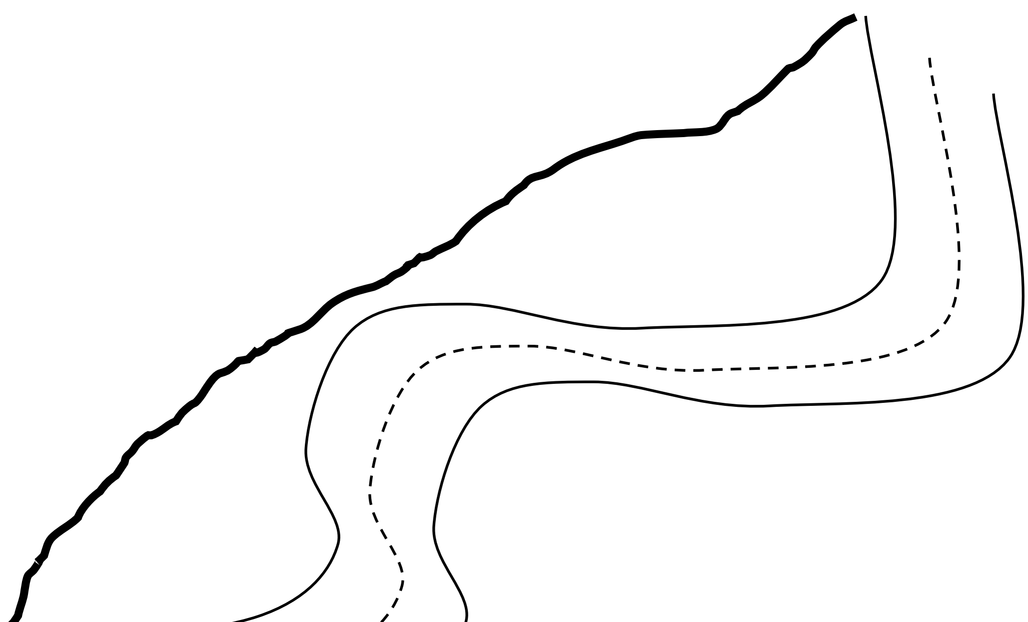
Student states that the surface on which the ball is rolling stops the ball, but does not relate this to a transfer of energy.

Criteria for an incorrect response (**0**):

Student relates the ball coming to rest to the effects of gravity **or** student states that the ball will not ever come to rest.

ASSESSMENT—POWER AND THERMAL ENERGY

1. In science, we define **power** as the rate at which energy is expended or work is done. Power is calculated by dividing energy (in Joules) by time (seconds). The unit of power is the Watt.



Most mountain roads are built so that they curve up the side of the mountain rather than following a straight path to the peak. Explain why curving the road provides an advantage for a car climbing the mountain **or** why curving the road provides a safety feature for a car driving down. In your explanation, use the concept or definition of **power** as defined above to support your answer.

2. A refrigerator is a device that moves heat from food into the room. As long as the door stays closed, as the refrigerator runs, heat is transferred from the room into a special cooling liquid in the coils, then out to the room.

The Wilson family went to the beach for the weekend in the middle of July. When they returned on Monday afternoon, Mrs. Wilson found that one of her two children had left a whistle on top of the refrigerator. The whistle wedged itself in the door of the freezer, leaving it propped open.

When Mrs. Wilson opened the freezer door, there was a huge block of ice over all the food in the main compartment of the freezer. All of the food in the door of the freezer had melted (thawed).

Each of the Wilson children accused the other sibling of leaving the whistle in this spot.

Explain why the whistle resulted in a large block of ice forming in the freezer. In your answer, state where the ice came from and why it froze.

RUBRIC FOR ASSESSMENT—POWER AND THERMAL ENERGY

1. Most mountain roads are built so that they curve up the side of the mountain rather than following a straight path to the peak. Explain why curving the road provides an advantage for a car climbing the mountain **or** why curving the road provides a safety feature for a car driving down. In your explanation, use the concept or definition of **power** as defined above to support your answer.

This item measures the student's understanding of power as the rate of work done over time.

Criteria for a complete response (2):

Student states that curving the road increases the amount of time required to climb to the top. The same work is done, but less power is exerted to do this work **or** student uses the same logical reasoning to explain that it will take more time to descend the mountain, and less power will be used. By using less power, the car will have more control during the descent.

Criteria for a partial response (1):

Student states that climbing the hill (or descending the hill) will require less force because the winding path increases the distance traveled. Although this is correct, it does not address the concept of power directly.

Criteria for an incorrect response (0):

Student states that the curved path makes it easier to climb the hill or slows the descent but does not explain why this occurs.

2. Explain why the whistle resulted in a large block of ice forming in the freezer. In your answer, state where the ice came from and why it froze.

This item measures the student's understanding of how heat energy is transferred and how this transfer affects the phases of matter.

Criteria for a complete response (2):

Student states that when the whistle held the door open, water in the air entered the freezer. Since the freezer was moving heat from the inside to the outside, it moved heat from the water entering through the open door. This loss of heat resulted in the entering water turning to a large ice block.

Criteria for a partial response (1):

Student states that water from the air froze inside the freezer but does not address why it froze.

Criteria for an incorrect response (0):

Student states that the water came from the food.

ASSESSMENT—TRANSFER OF ENERGY THROUGH WAVES

Below are six different situations in which energy is transferred through mechanical waves. **Choose one from list A and one from list B.** You will create an energy chain which explains how energy is transferred from one object to another.

In your energy chains you will need to include the following:

- The source of energy at the start.
- Each object that transfers (or absorbs) energy.
- A description of how the wave transfers energy, including the medium through which it travels.

NOTE: sound waves are a form of mechanical wave.

List A:

- A machine generates high frequency sound waves (ultrasound) to create an image of a developing fetus (baby) in a pregnant mother-to-be.

- A child blows across the opening of a soda bottle, producing a musical tone.

- You enter an empty auditorium and say “hello.” The sound of “hello” echoes for about two seconds.

List B:

- You’re at the neighborhood pool, and an adult jumps in. Two seconds later, you are splashed with water.

- Two children are playing basketball in the living room. The ball hits the bottom of a wall. A picture hanging on the wall a few feet away falls off.

- You are putting sheets on your bed. You unfold the top sheet, and “whip” it away from you. The sheet now covers the whole bed.

RUBRIC FOR ASSESSMENT—TRANSFER OF ENERGY THROUGH WAVES

For each energy chain:

Criteria for a complete response (2):

- Logical sequential flow of energy. Each item transferring energy is identified.
- The wave is described in terms of the medium through which it travels.

Criteria for a partial response (1):

Logical sequential flow of energy; however, not all items are identified **or t**he wave is described in terms of the medium through which it travels but not both.

Criteria for an incorrect response (0):

Incorrect identification of objects transferring energy **or i**ncorrect identification of medium of wave travel.

DECEMBER

Topic 11: Mechanical Waves

Standards:

3.1.3 Mechanical waves result from the organized vibrations of molecules in substances. Kinetic energy can be transferred very quickly over large distances by mechanical waves.

3.3.3 Waves (e.g., sound and seismic waves, waves in water, and electromagnetic waves) carry energy that can have important consequences when transferred to objects or substances.

GLEs:

9.3.l Use diagrams to illustrate how the motion of molecules when a mechanical wave passes through the substance is different from the motion associated with their random kinetic energies.

9.3.m Use diagrams or models to explain how mechanical waves can transport energy without transporting matter.

9.3.k Reflect on why mechanical waves will pass through some states of matter better than others.

Assessments:

11. Mechanical Waves and Sound Energy

Text references/vocabulary:

Chapter 15.1, pp. 490-498.

decibel: A measure of relative intensity of sound (loudness). By definition, zero decibels is the lowest tone that an average ear can discern in a noiseless environment. Normal human speech heard at 1 meter registers approximately 40-60 decibels.

echolocation: The process by which certain animals are able to determine the location of barriers or prey. Whales, certain bats, and other animals emit a sound which bounces off a barrier and returns to the sender. The shorter the period between transmission and reception of the sound, the closer the barrier.

harmonics: Whole number multiples of the standing waves of a musical instrument. Harmonics make different notes possible.

hertz: A unit of wave frequency defined as one cycle per second (sec^{-1})

infrasound: Sound waves with a frequency below the detectable limit of the human ear. Infrasonic sound waves have been reported to induce feelings of uneasiness and dread in humans.

intensity: Describing a sound wave, a general description of the loudness of a sound wave (related to power of the sound wave). Describing a light wave, a general description of the brightness of the light wave.

natural frequencies: Frequencies of sound waves at which an object is likely to vibrate when stimulated.

pitch: The "highness" or "lowness" of a sound, as determined by frequency.

sonar: A technological application of sending sound waves (usually ultrasound) out and receiving the reflected sound wave as a means of detecting objects (see "echolocation.")

sound; The perception by an animal of organized longitudinal waves in a medium (often air or water).

threshold: The minimum frequency of a wave that can be detected by an animal's senses.

ultrasound: Sound waves whose frequency is above the detectable limit of a human ear. Ultrasound technology is used to study organs and tissues inside the body without harming human cells (a hazard of X-rays).

Topic 12: Electromagnetic Waves

Standards:

3.1.1 Electromagnetic waves carry a single form of energy called electromagnetic (radiant) energy.

3.1.5 Magnetic energy and electrical energy are different aspects of a single electromagnetic energy, which results from the motion of electrical charges.

3.3.3 Waves (e.g., sound and seismic waves, waves in water, and electromagnetic waves) carry energy that can have important consequences when transferred to objects or substances.

3.3.4 When waves interact with materials, the energy they transfer often leads to the formation of other forms of energy. These interactions, which depend upon the nature of the material and the wavelength of the waves, can be used to create practical devices (e.g., sonar and ultra sound imaging, solar cells, remote control units, and communication devices).

3.3.5 Through reflection and refraction, electromagnetic waves can be redirected to produce concentrated beams or images of their source.

3.3.6 When radiant energy is absorbed or emitted by individual atoms or molecules, the changes in energy involve the jump of an electron from one distinct energy level to another. These energy changes, which are characteristic of the atom or molecule, can be used to identify the material.

GLEs:

9.3.a Recognize that electromagnetic energy (radiant energy) is carried by electromagnetic waves.

9.3.b Use diagrams to illustrate the similarities shared by all electromagnetic waves and differences between them. Show how wavelength is used to distinguish the different groups of EM waves (radio waves, microwaves, IR, visible and UV waves, X-rays and gamma waves).

9.3.k Recognize that electromagnetic waves transfer energy from one charged particle to another. Use graphics or computer animations to illustrate this transfer process. Give everyday examples of how society uses these transfer processes (for example, communication devices such as radios and cell phones).

9.3.ee Explain that what happens to electromagnetic waves that strike a substance (reflection, transmission, absorption) depends on the wavelength of the waves and the physical properties of the substance.

9.3.ff Investigate how radio waves, microwaves, infrared waves, visible waves and ultraviolet waves behave when they strike different substances. Record how effectively different materials reflect, absorb and transmit different kinds of EM waves. Draw conclusions based on this data and the physical properties of the substances (for example some substances absorb visible waves, but not radio waves). Other materials absorb UV waves, but not visible waves).

9.3.gg Give examples that illustrate how the selective absorption of EM waves explains physical phenomena. For example; how X-rays can be used to detect broken bones beneath the skin and how coating on eyeglasses and sunglasses protect the eyes by permitting visible waves to pass but absorb UV waves.

Assessments:

12. Electromagnetic energy.

Text references/vocabulary:

Chapter 15.2-15.4, pp. 499-518

angle of incidence: The angle above which a wave (usually of light) strikes a surface.

angle of reflection: The angle above which a wave (usually of light) bounces from a surface. The angle of incidence is equal to the angle of reflection.

color: The perception of wavelength by the human eye. Visible light produces colors with wavelengths between 400 nanometers (violet) to 700 nanometers (red).

electromagnetic spectrum: A ranking of electromagnetic waves by increasing wavelength. The shortest waves have a wavelength of approximately 10^{-14} meters (gamma rays), and the longest have a wavelength of up to 10^{6} meters (radio waves).

gamma ray: A high energy electromagnetic wave with an extremely short wavelength. Gamma rays are produced as a result of nuclear disintegrations (radioactivity) and nuclear fusion. Gamma rays have such a high energy that they are considered hazardous to human tissue.

infrared radiation: Electromagnetic radiation with a wavelength ranging from 10^{-5} meters to 10^{-3} meters (approximately). Infrared radiation is often absorbed by matter, increasing the temperature. As heat energy is applied to matter, it emits infrared radiation as well.

lens: A curved piece of glass that concentrates light rays to a point or disperses them from an imaginary point.

light ray: a representation in space of a wave of electromagnetic radiation.

microwave: Electromagnetic radiation with a wavelength ranging from 10^{-3} meters to 10^{-1} meters (approximately). Lower frequency microwave radiation is used to heat food because water and tissue tend to absorb these wavelengths and raise the temperature of the material.

mirage: A distortion of visible light rays by density differences in the atmosphere such that virtual images of distant objects that may be beyond the horizon or of “water on the road.”

nanometer: A unit of length equal to 10^{-6} meters. Visible light has a wavelength of between 400 and 700 nanometers.

photon: A discrete “packet” of visible light. Although the word “particle” is sometimes applied to a photon, a photon is not a form of matter; it is a form of electromagnetic energy.

prism: A piece of glass cut in such a way as to split visible light into its component frequencies.

radio wave: Electromagnetic radiation with a wavelength greater than 1 centimeter. Radio waves are used in many communication technologies. Since distant galaxies and other celestial phenomena emit electromagnetic radiation, naturally occurring radio waves are used to study such phenomena.

real image: An image of an object formed by light rays coming from the object and converging to a point.

ultraviolet radiation: Electromagnetic radiation with a wavelength between 10 nanometers and 400 nanometers (approximately). Ultraviolet waves pass through air and water vapor, but are absorbed by human skin. Some materials (fluorescent) absorb ultraviolet radiation and emit the radiation as visible light.

virtual image: An image of an object created by the eye from diverging light rays. A virtual image appears to emanate from a given location, but in fact, a virtual image does not have an actual point of origin.

X-ray: Electromagnetic radiation with a wavelength less than 10^{-8} meters. X-rays penetrate human tissue but not bone, and are used to study internal anatomy. X-rays can lead to cell and tissue damage in large doses or over long periods of repeated exposure.

ASSESSMENT—MECHANICAL WAVES AND SOUND WAVES

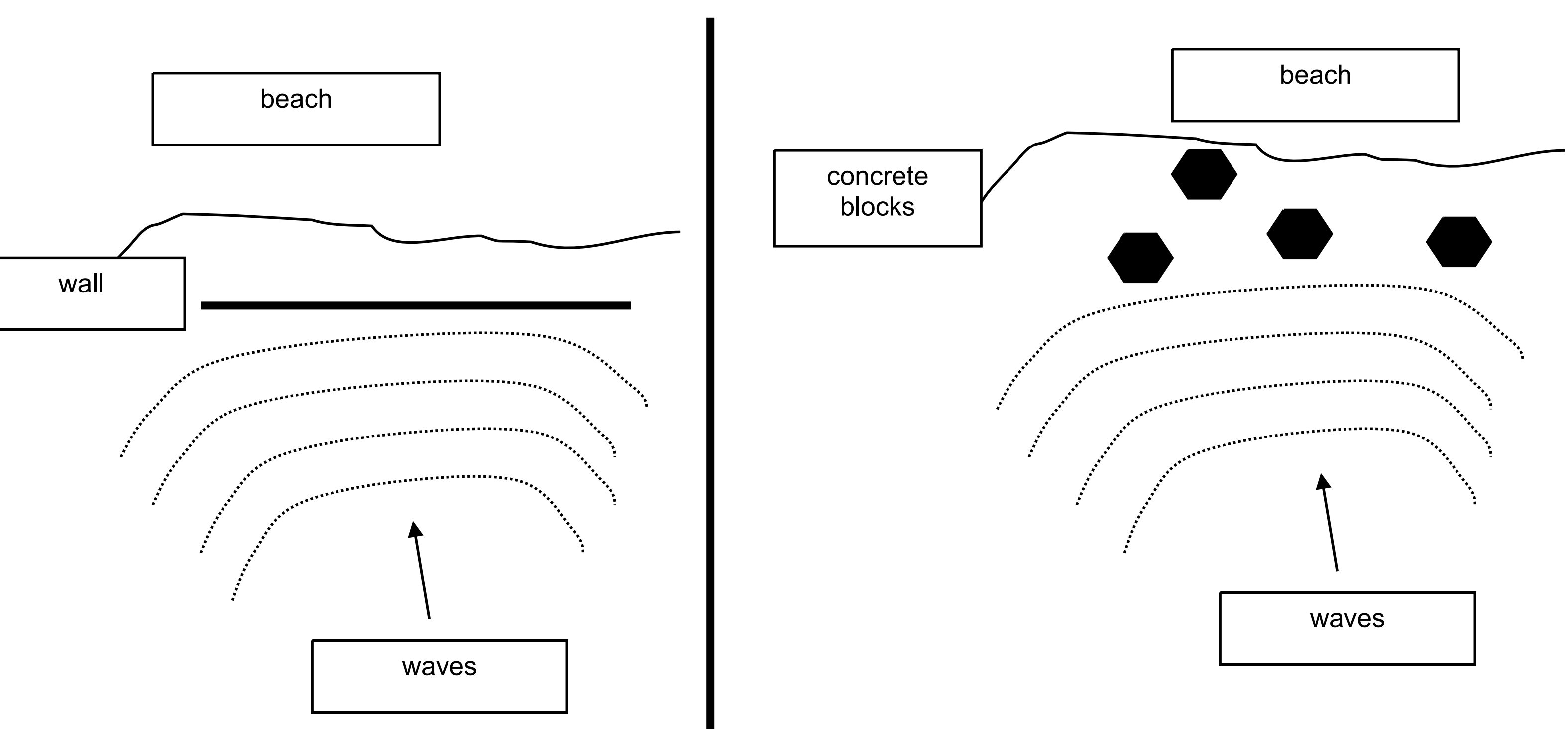
1. The ocean floor is the least understood location on the Earth. Scientists cannot use simple observation to learn how the ocean floor looks because light does not penetrate to the bottom (4-7 miles below the surface of the water).

   Scientists use sound waves to chart the ocean floor. They send out a high frequency sound wave, and measure the time it takes to bounce off a structure, then return. Structures that are far away will cause the sound wave to take more time to return.

   One reason this method is effective is that sound waves travel through water faster than they travel through air. Why do they travel faster in water?

2. At the beach, ocean waves strike the beach continuously. These waves transmit large amounts of energy, and can damage homes and other structures built along the beach.

Although an obvious solution to the problem of wave erosion might be to build a wall to stop the waves, it turns out that concrete blocks are more effective in protecting beach property from the destructive power of ocean waves.



Unlike walls, which block wave energy from reaching the shore, concrete blocks allow the waves to pass through. Walls are more likely to be destroyed by crashing waves than are the concrete blocks. Explain why this is true in terms of what happens when waves make contact with a barrier or a change in medium.

RUBRIC FOR ASSESSMENT—MECHANICAL WAVES AND SOUND WAVES

1. Scientists use sound waves to chart the ocean floor. They send out a high frequency sound wave, and measure the time it takes to bounce off a structure, then return. Structures that are far away will cause the sound wave to take more time to return.

   One reason this method is effective is that sound waves travel through water faster than they travel through air. Why do they travel faster in water?

This item measures the student's understanding of how the state of matter affects the transmission of a mechanical wave.

Criteria for a complete response (2):

Student states that since water molecules are more closely packed than molecules in air. Waves are transmitted by energy being passed through collisions of molecules. These collisions are more frequent in a liquid than in a gas. Therefore, sound waves travel through water faster than through sound.

Criteria for a partial response (1):

Student states that sound travels faster in water because the molecules are closer together but does not explain about the role of collisions of molecules.

Criteria for an incorrect response (0):

Student identifies the role of ocean waves with transmission of sound.

2. Unlike walls, which block wave energy from reaching the shore, concrete blocks allow the waves to pass through. Walls are more likely to be destroyed by crashing waves than are the concrete blocks. Explain why this is true in terms of what happens when waves make contact with a barrier or a change in medium.

This item measures the student's understanding of how mechanical waves interact with barriers.

Criteria for a complete response (2):

Student states that walls will reflect most of the energy of the wave or will be damaged by the force of the wave (since it receives the full energy). The concrete blocks will create openings for the wave to be transmitted. They also cause diffraction (that is, they change direction slightly) which disperses some of their energy, resulting in a smaller force striking the beach.

Criteria for a partial response (1):

Student states that the blocks receive less energy from the wave, but doesn't explain why.

Criteria for an incorrect response (0):

Student states that the blocks receive less water from the wave.

ASSESSMENT—ELECTROMAGNETIC ENERGY

1. One of the effects of electromagnetic radiation is that under certain circumstances, electromagnetic rays from the sun can cause a painful reaction in humans called sunburn.

   If a person sits in the sun on a cloudy day in the summer, exposed areas of the body can become sunburned. If the areas of the body are covered by white clothes, these areas will not be sunburned, even if the sun is very hot and bright.

   Explain why sunburn can occur in the first circumstance (when clouds are blocking the sun) but not in the second (when the sun is much hotter and brighter than on the cloudy day). In your answer, refer to how electromagnetic waves interact in both situations.

2. Explain how using a magnifying glass in the sun can cause paper to burn. In your response, describe the energy transfers and transformations that occur, and describe the role of electromagnetic (light) waves in this process.

RU[illegible]GY

1. Explain why sunburn can occur in the first circumstance (when clouds are blocking the sun) but not in the second (when the sun is much hotter and brighter than on the cloudy day). In your answer, refer to how electromagnetic waves interact in both situations.

This item measures the student's understanding of how different materials vary in their ability to absorb, reflect, or transmit electromagnetic energy.

Criteria for a complete response (2):

Student states that clothing will absorb or reflect electromagnetic waves more effectively than clouds. For this reason, the sun's energy passes through the clouds, and sunburn occurs on a cloudy day. However, clothing does absorb or reflect this energy, and the skin is protected even in direct sunlight.

Criteria for a partial response (1):

Student states that the clouds do not block the suns rays but does not refer to transmission, absorption, or reflection of electromagnetic energy.

Criteria for an incorrect response (0):

Student states that clouds magnify the sun's rays **or** that clouds are gas but clothing is solid and this difference prevents sunburn.

2. Explain how using a magnifying glass in the sun can cause paper to burn. In your response, describe the energy transfers and transformations that occur, and describe the role of electromagnetic (light) waves in this process.

This item measures the student's understanding of how electromagnetic energy can be transformed into other forms of energy.

Criteria for a complete response (2):

Student explains that electromagnetic rays from the sun are refracted into a single point by the magnifying glass. As they are concentrated, they transfer their energy to the molecules of paper and in the air. This transfer of energy results in random heat energy, which raises the temperature to the point where the paper burns.

Criteria for a partial response (1):

Student explains that electromagnetic rays from the sun are refracted into a single point by the magnifying glass, and that this causes the paper to burn, but does not discuss transfer of heat energy to the molecules of paper.

Criteria for an incorrect response (0):

Student explains that heat energy from the sun is concentrated by the magnifying glass.

JANUARY

Topic 13: Physical and Chemical Changes

Standards:

2.1.2 Elements and compounds are pure substances. Elements cannot be decomposed into simpler materials by chemical reactions. Elements can react to form compounds. Elements and/or compounds may also be physically combined to form mixtures.

2.1.7 A change in physical properties does not change the chemical composition of the substance. The physical properties of elements and compounds (such as melting and boiling points) reflect the nature of the interactions among their atoms, ions, or molecules and the electrical forces that exist between.

2.4.1 Chemical reactions result in new substances with properties that are different from those of the component parts (reactants).

3.2.7. Electromagnetic forces are responsible for the physical properties of materials (e.g., the boiling point of a liquid) and the mechanical properties of materials (e.g., surface tension).

GLEs

9.2.c Classify matter as mixtures (which are either homogeneous or heterogeneous) or pure substances (which are either compounds or elements.)

9.2.e Classify various common materials as an element, compound or mixture.

9.2.m Recognize that metals have the physical properties of conductivity, malleability, luster, and ductility.

9.2.o Recognize that physical changes alter some physical properties of a substance but do not alter the chemical composition of the substance.

9.5.a Identify mineral specimens according to their chemical and physical properties. Mineral specimens include calcite, quartz, mica, feldspar, and hornblende. Properties include hardness (Moh's scale), streak, specific gravity, luster, cleavage, crystal shape, and color, and other properties that are useful for identification of specific minerals such as reaction with hydrochloric acid.

Assessments:

5. Physical and Chemical Changes in Matter

Text References/Vocabulary:

Chapter 2.2 pp. 45-52
Chapter 2.3 pp. 53-58
Chapter 3.1 pp. 69-79

amorphous solid: a solid in which the particles (atoms or molecules) are not in any organized arrangement. Examples include rubber, wax, and glass.

atmospheric pressure: The force exerted by air in the atmosphere at a given location. Also called air pressure.

atom: the smallest particle of an element that retains all the chemical properties of the element.

boiling point: the temperature at which a substance gains enough kinetic energy from its surroundings to change from a liquid to a gas at atmospheric pressure.

chemical change: a change in matter in which the physical and chemical properties of the ending materials differ from those of the starting materials. Chemical changes do not involve introduction or removal of elements; rather, they result in creation of new pure substances made from the same elements in the starting materials.

chemical property: A characteristic property of matter that relates to its tendency to change (or not change) its physical properties when exposed to energy changes or other forms of matter.

chemistry: the scientific study of the composition, structure, properties, and changes that occur in matter.

compound: a pure substance with identifiable chemical properties that is composed of two or more elements that are combined chemically. A compound cannot be broken into simpler substances by physical means; it can, however, be broken into simpler substances (elements) by chemical means.

conservation of energy: a property of physical and chemical changes in which the total energy of the system is the same before and after the change. Although it may be transferred and transformed (e.g. potential energy to kinetic energy, mechanical energy to heat energy), energy is neither created nor destroyed in a physical or chemical change.

conservation of mass: a property of physical and chemical changes in which the total mass of the starting materials is equal to the total mass of the ending materials. These changes may involve a change in physical state, but in chemical and physical changes, every atom before the change is present after the change.

density: The mass of a known volume of a substance.

element: a pure substance with identifiable chemical properties that cannot be broken down into simpler substances by chemical means.

energy: the ability of particles or objects to do work or exhibit motion, or change matter.

evaporation: a process by which a liquid gains energy at a temperature below the boiling point and becomes a gas.

flammability: a type of reactivity which relates to the tendency of a substance to chemically combine spontaneously and relatively quickly with oxygen. The tendency of a substance to burn.

freezing point: the temperature at which a substance transfers enough kinetic energy to its surroundings to change from a liquid to a solid at atmospheric pressure.

gas: A phase of matter in which a substance has no definite shape or volume. Gases fill the container they occupy.

kinetic energy: The energy of motion of an object or the particles (atoms, molecules, ions) of a substance.

liquid: A phase of matter in which a substance has a definite volume but no definite shape. Liquids take the shape of that part of the container they occupy.

matter: Anything in the universe that has mass and takes up space

melting point: the temperature at which a substance gains enough kinetic energy from its surroundings to change from a solid to a liquid at atmospheric pressure.

miscible (immiscible): a property of two or more liquids. Miscible liquids can dissolve one another. Immiscible liquids cannot dissolve one another--they form distinct layers.

mixture: a physical combination of two or more substances such that the chemical properties of each substance are retained. A mixture can be separated by physical means.

molecule: the basic unit of covalently bonded atoms. A molecule may consist of atoms of the same element or of atoms of different elements.

physical change: a change in matter in which the physical properties of the starting materials are changed, but the chemical properties are not changed. Physical changes include changes in state and creation of solutions.

physical property: a characteristic property of matter that relate to its appearance (e.g. color, density, luster) or its behavior in response to energy changes (e.g. malleability, melting point, conductivity).

pure substance: a sample of matter with unique chemical properties. A pure substance may be either a compound or an element.

reactivity: the tendency of a substance to be chemically changed.

solid: A phase of matter in which a substance has a definite shape (which is not dependent on its container) and volume.

sublimation: : a process by which a solid gains kinetic energy from its surroundings and becomes a gas without becoming a liquid. Whether a substance undergoes sublimation (sublimes) depends on the substance’s physical properties and the ambient pressure.

substance: a physical description of a type of matter.

temperature: the average kinetic energy of all particles in an object or substance; how "hot" something is. Temperature is measured in degrees Celsius or degrees Kelvin.

thermal energy: the total kinetic energy of all the atoms in an object or substance.

Topic 14: Atomic Theory

Standards:

2.1.1 All matter is composed of minute particles called atoms. Most of the mass of an atom is concentrated in the nucleus. In the nucleus, there are neutrons with no electrical charge and positively charged protons. Negatively charged electrons surround the nucleus and overall, the atom is electrically neutral.

2.1.2 Elements and compounds are pure substances. Elements cannot be decomposed into simpler materials by chemical reactions. Elements can react to form compounds. Elements and/or compounds may also be physically combined to form mixtures.

2.1.3 Isotopes of a given element differ in the number of neutrons in the nucleus. Their chemical properties remain essentially the same.

3.2.9 The nuclear forces that hold the nucleus of an atom together are much stronger than the repulsive electric forces acting between the protons that would make the nucleus fly apart, therefore, most atoms have stable nuclei.

3.3.6 When radiant energy is absorbed or emitted by individual atoms or molecules, the changes in energy involve the jump of an electron from one distinct energy level to another. These energy changes, which are characteristic of the atom or molecule, can be used to identify the material.

GLEs:

9.2.a Explain that matter is composed of tiny particles called atoms that are unique to each element, and that atoms are composed of subatomic particles called protons, neutrons, and electrons.

9.2.b Describe the relative charge, approximate mass, and location of protons, neutrons, and electrons in an atom.

9.2.f Describe isotopes of elements in terms of protons, neutrons, electrons, and average atomic masses. Recognize that isotopes of the same element have essentially the same chemical properties that are determined by the proton and electron number.

9.2.g Use the Periodic Table to identify an element's atomic number, valence electron number, atomic mass, group/family and be able to classify the element as a metal, non-metal or metalloid.

Assessments:

14. Atomic Structure

Text References/Vocabulary:

Chapter 4.1, pp. 104-108

electron: A subatomic particle with a negative charge of -1. The mass of an electron is approximately 0.001 times the mass of a proton.

energy level: A defined region where electrons move around the nucleus of an atom. An atom's energy level corresponds to a distance from the nucleus.

isotope: Any of two or more atoms of an element with different atomic masses. Because they have the same atomic number, isotopes will have the same (or similar) chemical properties.

neutron: A subatomic particle with a net charge of zero. Neutrons are located in the nucleus of the atom, and the mass of a neutron is almost exactly the same as the mass of a proton.

nucleus (atomic): The central part of an atom containing the protons and neutrons. The nucleus represents more than 99% of the mass of the atom, but very little of the volume of an atom.

proton: A subatomic particle with a net positive charge of +1. Protons are located in the nucleus of the atom, and the mass of a proton is almost the same as that of a neutron, and over 1000 times greater than that of an electron.

subatomic particle: A particle contained within an atom.

ASSESSMENT—PHYSICAL AND CHEMICAL CHANGES IN MATTER

1. A popular recipe for noodles is listed below:

4 cups of flour

1/3 teaspoon salt

water

butter

Make a dough of 1 quart flour, 1/4 tsp. salt and water, so they can be molded into the shape of noodles. Then put in boiling salt water and cook about 10 minutes. Drain noodles.

When this recipe is followed correctly, the ingredients become a thick, sticky mass with a consistency of clay.

Explain how you can tell that the ingredients experienced a physical change but not a chemical change.

2. When a stick of yellow butter is melted in a pan, the following events happen in this sequence:

a) the stick becomes a liquid from the bottom up.
b) the pool of yellow liquid starts to form bubbles
c) the smell of the butter has not changed but becomes more noticeable.
d) the color of the liquid becomes brown
e) the smell of the butter changes to become bitter.
f) the liquid disappears, and the material in the pan becomes black
g) smoke rises from the pan.

a) Which of these events is evidence of a physical change without a chemical change? Explain.

b) Which of these events is evidence of a chemical change? Explain.

RUBRIC FOR ASSESSMENT—PHYSICAL AND CHEMICAL CHANGES IN MATTER

1. Explain how you can tell that the ingredients experienced a physical change but not a chemical change.

This item measures a student's ability to distinguish the characteristics of a physical change from the characteristics of a chemical change.

Criteria for a complete response (2):

Student states that the materials have changed their appearance (e.g. flour is powdery, dough is moist and sticky) but they have not changed into another substance **or** student states that the properties of the ingredients have not changed **or** that the flour, water, butter, and salt can all be separated from one another. This separation would not be possible if a chemical change had occurred.

Criteria for a partial response (1):

Student states that the change did not result in various pieces of evidence (e.g. bubbles, color change, odor change, etc). While these pieces of evidence often indicate a chemical change, the response must show an understanding of how a chemical change differs from a physical change.

Criteria for an incorrect response (0):

Student states that creation of dough in this manner is a chemical change **or** student states that because no chemicals were added (or used), a chemical change did not occur.

2. a) Which of these events is evidence of a physical change without a chemical change? Explain.

This item measures the student's ability to distinguish a chemical change from a physical change.

Criteria for a correct response (2):

Student identifies events a-c as evidence of a physical change but not a chemical change because in each, a phase change has occurred (or progressed) but the substances have not changed identity. (NOTE: the student may identify the disappearance of water from event f as a physical change. If this is the only reference to events d-g, this response is consistent with a correct response)

Criteria for a partial response (1):

Student identifies one or two of these three events, providing the correct explanation.

Criteria for an incorrect response (0):

Student identifies events from d-g with or without an explanation **or** student identifies events from a-c but does not provide a correct explanation.

b) Which of these events is evidence of a chemical change? Explain.

Criteria for a correct response (2):

Student identifies events d-g as evidence of a chemical change. In each, the substance (butter) has taken on new properties, and therefore, has changed into a new substance.

Criteria for a partial response (1):

Student identifies some of the events listed in d-g as evidence of a chemical change, but not all of them. Student provides a correct explanation.

Criteria for an incorrect response (0):

Student identifies events from a-c as evidence of a chemical change. Explanation is missing, incorrect, or consistent with a physical change.

ASSESSMENT—ATOMIC STRUCTURE

You may use a Periodic Table of the Elements for this assessment item.

1. A scientist is studying pure samples of three elements. The scientist analyzes the make-up of the atoms of each sample and obtains the following results.

Element 1: Atoms contain 32 protons, 32 electrons, 38 neutrons

Element 2: Atoms contain 31 protons, 31 electrons, 39 neutrons

Element 3: Atoms contain 31 protons, 31 electrons, 38 neutrons

For each sample, identify the name of the element which elements (if any) are isotopes. Explain your reasoning.

2. Both hydrogen gas (H_2) and helium gas (He) are lighter than air. If a balloon is filled with either gas, the balloon will float in the air.

Using the position of both elements (hydrogen and helium) on the Periodic Table of Elements, explain why children's balloons may be safely filled with helium but not with hydrogen.

3. Electric force causes positively charged particles (like protons) to attract negatively charged particles (like electrons). However, particles with the same electric charge (like two positive charges) are repelled from each other.

   A different force, nuclear force, causes the protons and neutrons in the nucleus to stay together. Which of these forces is stronger? Explain.

RUBRIC FOR ASSESSMENT—ATOMIC STRUCTURE

1. A scientist is studying pure samples of three elements. The scientist analyzes the make-up of the atoms of each sample and obtains the following results.

Element 1: Atoms contain 32 protons, 32 electrons, 38 neutrons

Element 2: Atoms contain 31 protons, 31 electrons, 39 neutrons

Element 3: Atoms contain 31 protons, 31 electrons, 38 neutrons

For each sample, identify the name of the element and which elements (if any) are isotopes. Explain your reasoning.

This item measures the student's understanding of how the make-up of an atom's nucleus affects an element's identity and atomic mass. The item also measures a student's understanding that different isotopes of an element have the same chemical properties.

Criteria for a complete response (2):

1) Student states that Element 1 is Germanium (Mo).
Element 2 is Gallium (Ga).
Element 3 is Gallium (Ga)

Elements 2 and 3 are isotopes of each other (but not of element 1) because their atomic numbers are the same (31) but they have different atomic masses (element 2 has an atomic mass of 60, element 3 has an atomic mass of 59).

Criteria for a partial response (1):

Student meets all the criteria for part 1 but not part 2 **or** meets all the criteria for part 2 but not part 1 .

Criteria for an incorrect response (0):

Student does not meet the criteria for a correct response for part 1 or for part 2.

2. Both hydrogen gas (H_2) and helium gas (He) are lighter than air. If a balloon is filled with either gas, the balloon will float in the air.

   Using the position of both elements (hydrogen and helium) on the Periodic Table of Elements, explain why children's balloons may be safely filled with helium but not with hydrogen.

This item measures the student's understanding of periodic trends and the ability to use the Periodic Table to predict chemical properties of elements.

Criteria for a complete response (2):

Student states that hydrogen is likely to react explosively with oxygen because by its position on the Periodic Table, its outermost energy level is incomplete. Helium does not react with oxygen because its outermost energy level is full. Helium is in the group of elements called the "noble gases." Since helium is non-reactive, it is safe to use in children's toys.

Criteria for a partial response (1):

Student states that hydrogen gas explodes and helium does not explode, but does not relate this tendency to location of the elements on the Periodic Table.

Criteria for an incorrect response (0):

Student states that hydrogen is poisonous but helium is not.

3. Electric force causes positively charged particles (like protons) to attract negatively charged particles (like electrons). However, particles with the same electric charge (like two positive charges) are repelled from each other.

A different force, nuclear force, causes the protons and neutrons in the nucleus to stay together. Which of these forces is stronger? Explain.

This item measures a student's understanding of the difference between nuclear force and electric force.

Criteria for a correct response (2):

Student states that the nuclear force is stronger. If the electric force were stronger, the nucleus of atoms would fly apart because of all the protons repelling one another.

Criteria for a partial response (1):

Student states that the nuclear force is stronger, but gives no explanation or an incorrect explanation.

Criteria for an incorrect response (0):

Student states that electric force is stronger, with or without an explanation.

FEBRUARY

Topic 15: Periodic Properties

Standards:

2.1.4 The periodic table arranges the elements in order of atomic number (the number of protons). The elements are grouped according to similar chemical and physical properties. Properties vary in a regular pattern across the rows (periods) and down the columns (families or groups). As a result, an element's chemical and physical properties can be predicted knowing only its position on the periodic table.

2.1.5 An atom's electron structure determines its physical and chemical properties. Metals have valence electrons that can be modeled as a sea of electrons where the valence electrons move freely and are not associated with individual atoms. These freely moving electrons explain the metallic properties such as conductivity, malleability, and ductility.

2.1.6 Ionic compounds form when atoms transfer electrons. Covalent compounds form when atoms share electrons. Both types of interactions generally involve valence electrons and produce chemical bonds that determine the chemical property of the compound.

GLEs:

9.2.g Use the Periodic Table to identify an element's atomic number, valence electron number, atomic mass, group/family and be able to classify the element as a metal, non-metal or metalloid.

9.2.h Determine the physical and chemical properties of an element based on its location on the Periodic Table.

9.2.i Investigate differences between the properties of various elements in order to predict the element's location on the Periodic Table.

9.2.m Recognize that metals have the physical properties of conductivity, malleability, luster, and ductility.

9.2.n Explore the extent to which a variety of solid materials conduct electricity in order to rank the materials from good conductors to poor conductors. Based on the conductivity data, determine patterns of location on the Periodic Table for the good conductors versus the poor conductors.

9.5.b Identify a few of the most common elements in the Earth's crust, oceans, and atmosphere and confirm their location on the periodic table (example: Si, O, C, N, H, Al). Compare the relative abundance of elements found in the Earth's crust, oceans, and atmosphere. Trace carbon as it cycles through the crust, ocean, and atmosphere.

Assessments:

15. Periodic Properties

Text references/vocabulary:

Chapter 4.2 (note: the discussion of orbitals on page 114 may be omitted)
Chapter 4.3 pp. 111-128 (the description of semi-conductors on pp. 127-128 may be omitted)

alkali metal: An element in Group 1 of the periodic table. Alkali metals are generally soft metals that react vigorously with water and oxygen. Atoms of alkali metals have one electron in their highest energy level, and form cations with a charge of +1.

alkaline earth: An element in Group 2 of the periodic table. Alkaline earths are generally soft metals that react with water (or steam) and oxygen. Atoms of alkaline earths have two electrons in their highest energy level, and form cations with a charge of +2.

energy level: A defined region where electrons move around the nucleus of an atom. An atom's energy level corresponds to a distance from the nucleus.

group (family): On the Periodic Table, a vertical column of elements whose ground state atoms all have the same number of electrons in the highest energy level. Elements in the same group often have similar chemical properties.

halogen: An element in Group 17 of the periodic table. Halogens are generally non-metals that react vigorously with alkali metals. Halogens also generally are found as diatomic molecules in nature. Atoms of halogens have seven electrons in their highest energy level, and form anions with a charge of -1.

ion: An atom with a net electrical charge. Ions occur when the number of electrons is unequal to the number of protons.

metal: An element characterized by high luster, malleability (as a solid), and good electrical conduction. .

metalloid: An element which has characteristics of both metals and nonmetals

noble gas: An element in Group 18 of the periodic table. Noble gases are generally non-reactive at standard temperature and pressure. Atoms of noble gases have eight electrons in their highest energy level, and occur as stable atoms.

nonmetal: An element characterized by low luster, brittleness (as a solid), and poor electrical conduction. Some nonmetals are gases at room temperature and atmospheric pressure. Nonmetals may lose, gain, or share electrons in chemical reactions.

period: A horizontal row on the Periodic Table. Elements in the same period have electrons in the same highest energy level (for neutral atoms).

Periodic Law: The chemical and physical properties of elements recur at regular intervals as atomic number of the elements increases.

Periodic Table: A graphic organizer of the known elements in which elements are ranked by atomic number and arranged so that vertical columns represent elements with the same number of valence electrons and horizontal rows represent elements with electrons in the same highest energy level.

periodic: Tending to repeat properties at regular intervals.

valence electrons: An electron in an atom that participates in bonding.

Topic 16: Mixtures and Solutions

Standards:

2.1.2 Elements and compounds are pure substances. Elements cannot be decomposed into simpler materials by chemical reactions. Elements can react to form compounds. Elements and/or compounds may also be physically combined to form mixtures.

2.2.1 Properties of solutions, such as pH, solubility, and electrical conductivity depend upon the concentration and interactions of the solute and solvents.

2.2.2 A variety of methods can be used to separate mixtures into their component parts based upon the chemical and physical properties of the individual components.

GLEs:

9.2.c Classify matter as mixtures (which are either homogeneous or heterogeneous) or pure substances (which are either compounds or elements.)

9.2.d Explain that elements are pure substances that cannot be separated by chemical or physical means. Recognize that compounds are pure substances that can be separated by chemical means into elements.

9.2.e Classify various common materials as an element, compound or mixture.

9.2.t Recognize that mixtures can be separated by physical means into pure substances.

9.2.z Investigate factors that affect the materials' solubility in water and construct solubility curves to compare the extent to which the materials dissolve.

Assessments:

16. Mixtures and Solutions

Text References/vocabulary:

Chapter 7.1
Chapter 7.2 pp. 224-238

alloy: A mixture of solids or solids and liquids involving at least one metal. An alloy tends to produce a mixture with the most desirable aspects of all components (e.g. the color of gold with the strength of copper).

aqueous: Referring to a solution in which the solvent is water.

chromatography: A method of separating miscible liquids by adsorbing them onto a medium. The mixed components separate according to solubility in the solvent (called an elluent).

colloid: A suspension in which the particles are tiny enough that they don't settle.

distillation: A method of separating miscible liquids by boiling the mixture and collecting the different components. Distillation requires that the liquids being separated have different boiling points that can be distinguished in the laboratory.

emulsion: A liquid colloid, usually prepared by vigorous mixing.

filter (filtration): A method of separating a suspension of solid particles from a liquid by trapping the solids in a barrier (the filter) while allowing the liquids to pass through he barrier, either by gravity or with a vacuum.

heterogeneous mixture: A mixture in which the particles can be easily distinguished from one another.

homogeneous mixture: A mixture in which the particles are evenly distributed and cannot be easily distinguished. Homogeneous mixtures include colloids and solutions.

hydrogen bond: A relatively weak chemical interaction (as compared to ionic bonds or covalent bonds) where an atom of oxygen, nitrogen, or flourine from one molecule is attracted to a hydrogen atom that is covalently bonded to another atom of oxygen, nitrogen, or flourine from another molecule. This phenomenon is generally associated with interactions between water molecules and most biological molecules (e.g. proteins, carbohydrates, nucleic acid).

---C--O---H < hydrogen bond> O===C----

miscible: Referring to liquids that can form a solution with one another.

mixture: A physical combination of substances in which each substance retains its unique properties.

nonpolar: Referring to a bond or a covalent compound where the negative charge of the electrons is the same throughout.

polar: Referring to a bond or a covalent compound where the negative charge of the electrons is concentrated in one location.

solute: In a solution, one or more dissolved components that is in low concentration.

solution: A mixture in which components are combined at the molecular level. A solution is a homogeneous mixture.

solvent: In a solution, the dissolved component in the highest concentration. In many solutions, the designation of solute and solvent is arbitrary.

Topic 17: Properties of Water/pH

Standards:

2.1.7 A change in physical properties does not change the chemical composition of the substance. The physical properties of elements and compounds (such as melting and boiling points) reflect the nature of the interactions among their atoms, ions, or molecules and the electrical forces that exist between.

2.1.8 A change of phase may occur when there is a change in the potential energy of the atoms or molecules of a substance.

2.2.1 Properties of solutions, such as pH, solubility, and electrical conductivity depend upon the concentration and interactions of the solute and solvents.

3.2.7 Electromagnetic forces are responsible for the physical properties of materials (e.g., the boiling point of a liquid) and the mechanical properties of materials (e.g., surface tension).

GLEs:

9.2.p Conduct investigations to determine the effect of heat energy on the change of state (change of phase) of water. Sketch and interpret graphs representing the melting, freezing, evaporation and condensation of water.

9.2.r Apply the kinetic molecular theory to explain that a change in the energy of the particles may result in a temperature change or a change of phase (change in state).

9.2.s Use a model or a diagram to explain water's properties (e.g., density, polarity, hydrogen bonding, boiling point, cohesion, and adhesion) in the three states of matter. Cite specific examples of how water's properties are important (i.e., water as the "universal").

9.2.w Describe how the process of diffusion or the movement of molecules from an area of high concentration to an area of low concentration (down the concentration gradient) occurs because of molecular collisions.

9.2.x Explore how various solutions conduct electricity and rank the liquids from good conductors to poor conductors. Explain the characteristics that allow some solutions to have better electrical conductivity than others.

9.2.y Measure the pH of a solution using chemical indicators to determine the relative acidity or alkalinity of the solution. Identify the physical properties of acids and bases.

Assessments:

17. Properties of Water

Text References/Vocabulary:

Water:

Chapter 3.1 pp 70-78
Chapter 7.2 pp. 232-238

pH:

Chapter 8, pp. 256-281 (omit the sections that discuss calculation of pH from molarity)

acid: An ionic compound that tends to donate H^{+1} ions in solution; or, an aqueous solution with a higher concentration of H^{+1} ions than OH^{-1} ions.

adhesion: A property of water molecules such that the molecules tend to be attracted to surfaces. Adhesion is one of the phenomena that allows capillary action of water in plants.

base: A material that tends to decrease the concentration of H^{+1} ions in an aqueous solution; an aqueous solution with a higher concentration of OH^{-1} ions than H^{+1} ions.

cohesion: A property of water molecules such that the molecules tend to be attracted to one another through electrostatic attractive forces between polar molecules. Cohesion is responsible for surface tension.

conductivity (electrical): The tendency of a material to conduct an electric charge. The electrical conductivity of an aqueous solution is a measure of the concentration of dissolved ions.

detergent: A water-soluble cleaner that can emulsify dirt and oil. Detergents differ from soaps in that the former contain petroleum products. For this reason, detergents can emulsify more nonpolar substances than soaps can.

electrolyte: A dissolved ionic substance in an aqueous solution that conducts an electric charge.

indicator: Referring to pH, a colored substance that changes color in response to changes in the concentration of H^{+1} in solution.

neutralization: A chemical reaction in which an acid and a base produce a salt and molecules of H_2O.

pH: A measure of the acid content or base content of an aqueous solution. The pH scale ranges from 0 to 14. A pH of 0 represents 1 M HCl. A pH of 14 represents 1 M NaOH. A solution with a pH of 7 has an equal concentration (in molarity) of H^{+1} and OH^{-1} ions.

phase change: A change in physical state of matter (solid, liquid, or gas) caused by increase or decrease in total kinetic energy of the matter.

salt: An ionic compound that occurs when a positive ion replaces the H^{+1} ion of an acid.

soap: A cleaner produced as the salt of a fatty acid which creates an emulsion of dirt and oils with water.

surface tension: A force created by cohesion of water molecules in which a “skin” forms on the surface of water. If the surface tension is greater than the gravitational force of a body on the water, the body can stay on the surface even if the body is denser than water.

weak (strong) acid or base: A weak acid or base is one which does not ionize completely in aqueous solution. A strong acid or base ionizes completely. Strong or weak is not an indication of the concentration of the acid or base nor of the relative safety to humans of either.

ASSESSMENT—PERIODIC PROPERTIES

You will need a Periodic Table of the Elements to complete this assessment.

1. The chemical formula for table salt (sodium chloride) is NaCl. Some people are not able to tolerate sodium chloride, so they use a salt substitute to flavor their food.

   Although KCl (potassium chloride) makes a good salt substitute, $CaCl_2$ (calcium chloride) does not. Explain why KCl can substitute for NaCl as a seasoning but $CaCl_2$ cannot, using the positions of elements on the Periodic Table.

2. The chemical properties of neon gas (Ne) are very different from the properties of oxygen gas (O_2); however, the properties of neon gas are very similar to those of argon gas (Ar). Explain these findings in terms of the elements' electrons and positions on the periodic table.

RUBRIC FOR ASSESSMENT—PERIODIC PROPERTIES

1. The chemical formula for table salt (sodium chloride) is NaCl. Some people are not able to tolerate sodium chloride, so they use a salt substitute to flavor their food.

   Although KCl (potassium chloride) makes a good salt substitute, $CaCl_2$ (calcium chloride) does not. Explain why KCl can substitute for NaCl as a seasoning but $CaCl_2$ cannot, <u>using the positions of elements on the Periodic Table.</u>

This item measures the student's ability to apply the principles of periodicity to actual phenomena.

Criteria for a complete response (2):

Student explains that because potassium and sodium are in the same family, they will tend to have similar chemical properties (such as flavor). Since calcium is in a different family, it will tend to have different properties from those of sodium.

Criteria for a partial response (1):

Student explains why KCl can substitute for NaCl according to the criteria above **or** explain why $CaCl_2$ cannot substitute for NaCl but not both.

Criteria for an incorrect response (0):

Student gives an explanation that is unrelated to the positions of elements on the Periodic Table.

2. the chemical properties of neon gas (Ne) are very different from the properties of oxygen gas (O_2); however, the properties of neon gas are very similar to those of argon gas (Ar). Explain these findings in terms of the elements' electrons and positions on the periodic table.

This item measures a student's understanding of how location of an element on the Periodic Table can predict some of its chemical properties.

Criteria for a complete response (2):

Student explains that since neon and argon are in the same family, they will tend to have similar properties (NOTE: listing these properties is not necessary for a complete response). Oxygen is in a different family (although the same energy level). Therefore, oxygen will have different properties from the other two.

Criteria for a partial response (1):

Student explains the similarity of properties between neon and argon according to the criteria shown above **or** the difference in chemical properties of neon and oxygen, but not both.

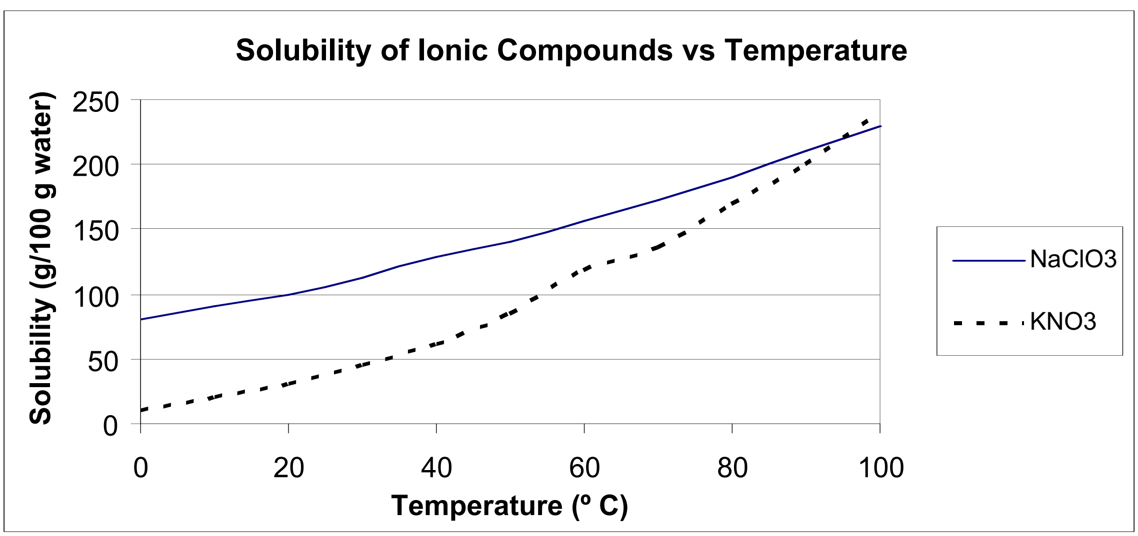
Criteria for an incorrect response (0):

Student describes the chemical properties of the listed gases without explaining the findings.

ASSESSMENT—MIXTURES AND SOLUTIONS

1. Sugar dissolves more easily in hot water than cold water. However, oxygen gas dissolves more easily in cold water than hot water. Explain both of these observations.

2. Below is a solubility graph of two solids in water: KNO_3 and $NaClO_3$.



Assume you have two beakers, each containing 100 ml of water at 30 ºC. You add 70 grams of KNO_3 to beaker 1, and 70 grams of $NaClO_3$ to beaker 2.

Which beaker would have undissolved precipitate in the 30 º C water? Use data from the graph to explain.

RUBRIC FOR ASSESSMENT—MIXTURES AND SOLUTIONS

1. Sugar dissolves more easily in hot water than cold water. However, oxygen gas dissolves more easily in cold water than hot water. Explain both of these observations.

This item measures the student's understanding of how the kinetic theory of matter affects solubility of materials.

Criteria for a complete response (2):

1. Student states that sugar dissolves more easily in hot water because the increased kinetic energy of the molecules increases the likelihood that water molecules will interact with undissolved sugar molecules.

2. Student states that oxygen dissolves more easily in cold water because as the kinetic energy of the water/oxygen solution increases, the oxygen molecules are more likely to escape into the air, decreasing the concentration of oxygen in the water.

Criteria for a partial response (1):

Student meets one of the two criteria for a complete response but not both.

Criteria for an incomplete response (0):

Student explains both phenomena incorrectly or incompletely.

2. Assume you have two beakers, each containing 100 ml of water at 30 ºC. You add 70 grams of KNO_3 to beaker 1, and 70 grams of $NaClO_3$ to beaker 2.

Which beaker would have undissolved precipitate in the 30 º C water? Use data from the graph to explain.

This question measures the student's ability to read and interpret graphs.

Criteria for a complete response (**2**):

1. States that the beaker with KNO_3 will have undissolved precipitate **or** that $NaClO_3$ will have no undissolved precipitate.

2. States that for $KNO_{3,}$, the point representing 70 g/100 g water and 30 º C is above the solubility curve, the solid will not dissolve completely in water at this temperature **or** that for $NaClO_{3,}$ the point representing 70 g/100 g water and 30 º C is below the solubility curves, and the solid will dissolve completely in water at this temperature.

Criteria for a partial response (**1**):

Explains how the graph can be used to decide if a solid is dissolved at a certain temperature, but does not identify which solids are dissolved **or**

Gives a correct explanation for which solids are dissolved but identifies $NaClO_3$ as the solid which will have undissolved precipitate.

Criteria for an incorrect response (**0**):

Gives no explanation (or an incorrect explanation) for why the solids are dissolved (regardless of which solids are identified).

NOTE: the phrase "use data from the graph" implies that a correct explanation (criterion 2 for a complete response) is necessary to receive credit for this question.

ASSESSMENT—PROPERTIES OF WATER

1. Certain insects called water striders are able to walk across the surface of water without falling in. Use the unique properties of water (in liquid form) to explain how the water strider is able to do this.

2. If a person who is working with oil-based paint gets these materials on her hands, she will not be able to remove the paint from her hands by washing with soap and water. However, if she rubs her

hands with cooking oil first, the paint will come off, and then she can wash her hands with soap and water to get them clean.

Explain why soap and water will not remove the paint, but cooking oil will remove it in terms of the properties of water.

RUBRIC FOR ASSESSMENT—PROPERTIES OF WATER

1. Certain insects called water striders are able to walk across the surface of water without falling in. Use the unique properties of water (in liquid form) to explain how the water strider is able to do this.

This item measures a student's understanding of how molecular interaction of water molecules accounts for surface tension.

Criteria for a complete response (2):

Student states that water molecules are polar, and have strong attractive forces to one another. These attractive forces create a "skin" on the surface of the water (surface tension) which creates a support for the water strider to walk across.

Criteria for a partial response (1):

Student explains that the water creates surface tension for the water strider to walk across, but does not explain what surface tension is.

Criteria for an incorrect response (0):

Student explains the phenomenon in terms of pollution in the water.

2. If a person who is working with oil-based paint gets these materials on her hands, she will not be able to remove the paint from her hands by washing with soap and water. However, if she rubs her hands with

cooking oil first, the paint will come off, and then she can wash her hands with soap and water to get them clean.

Explain why soap and water will not remove the paint, but cooking oil will remove it in terms of the properties of water.

This item measures a student's understanding of how polarity (or lack thereof) affect solubility.

Criteria for a complete response (2):

Student explains that since water is a polar substance and oil based paint is a non-polar substance, water will not dissolve the paint. Cooking oil is also a non-polar substance, and may be used to remove the paint.

Criteria for a partial response (1):

Student explains that water will not dissolve oil based paint because water is polar and the paint is non-polar **or** explains that cooking oil is non-polar and will dissolve the non-polar paint, but not both.

Criteria for an incorrect response (0):

Student explains that water and oil don't mix, but does not explain this in terms of polarity.

MARCH

Topic 18: Electrons, Bonding, Energy Levels

Standards:

2.1.2 Elements and compounds are pure substances. Elements cannot be decomposed into simpler materials by chemical reactions. Elements can react to form compounds. Elements and/or compounds may also be physically combined to form mixtures.

2.1.5 An atom's electron structure determines its physical and chemical properties. Metals have valence electrons that can be modeled as a sea of electrons where the valence electrons move freely and are not associated with individual atoms. These freely moving electrons explain the metallic properties such as conductivity, malleability, and ductility.

2.1.6 Ionic compounds form when atoms transfer electrons. Covalent compounds form when atoms share electrons. Both types of interactions generally involve valence electrons and produce chemical bonds that determine the chemical property of the compound.

3.1.6 Chemical energy is derived from the making and breaking of chemical bonds.

GLEs:

9.2.j Use the Periodic table to predict the types of chemical bonds (e.g., ionic or covalent) in a variety of compounds.

9.2.k Use models or drawings to illustrate how molecules are formed when two or more atoms are held together in covalent bonds by "sharing" electrons. Use models or drawings to illustrate how ionic compounds are formed when two or more atoms "transfer" electrons and are held together in ionic bonds.

9.2.l Explain how an atom's electron arrangement influences its ability to transfer or share electrons and is related its position on the periodic table. Recognize that an atom in which the positive and negative charges do not balance is an ion.

9.3.i Recognize that chemical energy is the energy stored in the bonding of atoms and molecules.

Assessments:

18. Electrons and Bonding

Text References/Vocabulary:

Chapter 5.1, 5.2 pp. 144-158
(optional) Chapter 5.3 pp. 159-164

bond: A close association between two atoms that affects the chemical and physical properties. A bond forms when electrons are exchanged from one atom to another, shared by the nuclei of two atoms, or generally attracted by high electronegativity of an atom.

chemical formula: A representation of a compound which lists the atomic symbols of the elements (usually written in order of increasing electronegativity), with the number of atoms of each written as a subscript.

covalent bond: A chemical bond created when electrons of two atoms are associated with both nuclei (shared). In a nonpolar covalent bond, the sharing of electrons is equal between the atoms. In a polar covalent bond, the electrons are attracted to one nucleus more than the other.

covalent compound: A compound made up exclusively of covalent bonds. The smallest components of covalent compounds are molecules.

crystal: A regular repeating pattern of atoms, ions, or molecules of a substance in the solid state.

ionic bond: A chemical bond created by electrostatic attraction that occurs when a cation (or polyatomic cation) loses valence electrons to an anion (or polyatomic anion).

ionic compound: A compound that contains one ionic bond.

molecular formula: The chemical formula of a covalent compound.

multiple bond: A covalent bond formed between two atoms that share two or three pairs of electrons. A single bond is a covalent bond between atoms that share one pair of electrons.

octet: An arrangement of electrons in an atom or ion such that the highest energy level possesses six electrons in the **s** orbital and six electrons in the **p** orbital. A stable octet may occur three ways: an atom of a noble gas, when an anion gains enough electrons to fill the highest energy level, and when a cation loses enough electrons to empty the highest energy level.

polyatomic ion: An ion composed of more than one atom. The atoms of a polyatomic ion are covalently bonded to one another. An older term for polyatomic ion is radical.

Topic 19: Conservation of Matter (note: Topics 19 and 20 can be combined if desired)

Standards:

2.3.1. The total mass of the system remains the same regardless of how atoms and molecules in a closed system interact with one another, or how they combine or break apart.

GLEs:

9.2.aa Conduct and explain the results of simple investigations to demonstrate that the total mass of a substance is conserved during both physical and chemical changes.

9.2.bb Recognize that chemical changes alter the chemical composition of a substance forming one or more new substances. The new substance may be a solid, liquid, or gas.

9.2.cc Balance simple chemical equations and explain how these balanced chemical equations represent the conservation of matter.

Assessments:

19. Conservation of Matter

Text References/Vocabulary:

Chapter 6.3 pp. 198-201 (omit the section on mole ratios)

chemical equation: A representation of elements or compounds that participate in a chemical reaction. The chemical formula of each substance is written. Reactants are written to the left of a horizontal arrow and products are written to the right of the arrow. The arrow always points from reactants to products.

chemical reaction: A change in matter where chemical bonds are broken and others are re-formed, creating new compounds and transforming energy.

Law of Conservation of Mass: When matter undergoes a chemical reaction, the mass of the starting materials (reactants) is equal to the mass of the ending materials (products).

product: A substance that is produced in a chemical reaction.

reactant: A substance that is consumed in a chemical reaction.

Topic 20: Chemical Reactions

Standards:

2.3.1. The total mass of the system remains the same regardless of how atoms and molecules in a closed system interact with one another, or how they combine or break apart.

2.4.1. Chemical reactions result in new substances with properties that are different from those of the component parts (reactants).

2.4.2. There are different types of chemical reactions. Precipitation reactions produce insoluble substances (e.g., double replacement). The transfer of electrons between atoms is a reduction-oxidation (redox) reaction (e.g., single-replacement combustion, synthesis, decomposition). Some acid/base reactions involve the transfer of hydrogen ions.

2.4.3. The rate of a chemical reaction depends on the properties and concentration of the reactants, temperature, and the presence or absence of a catalyst.

2.4.4. Energy is transformed in chemical reactions. Energy diagrams can illustrate this transformation. Exothermic reactions release energy. Endothermic reactions absorb energy.

3.1.6 Chemical energy is derived from the making and breaking of chemical bonds.

GLEs:

9.2.k Use models or drawings to illustrate how molecules are formed when two or more atoms are held together in covalent bonds by "sharing" electrons. Use models or drawings to illustrate how ionic compounds are formed when two or more atoms "transfer" electrons and are held together in ionic bonds.

9.2.aa Conduct and explain the results of simple investigations to demonstrate that the total mass of a substance is conserved during both physical and chemical changes.

9.2.bb Recognize that chemical changes alter the chemical composition of a substance forming one or more new substances. The new substance may be a solid, liquid, or gas. (2.4.1)

9.2.cc Balance simple chemical equations and explain how these balanced chemical equations represent the conservation of matter.

9.3.i Recognize that chemical energy is the energy stored in the bonding of atoms and molecules.

Assessments:

20. Chemical Reactions

Text References/Vocabulary:

Chapter 6.1 pp. 184-189
Chapter 6.3 pp. 198-201

activation energy: The amount of energy that must be added to a chemical reaction to break the bonds of the reactants. All chemical reactions are associated with an activation energy.

balanced chemical reaction: A chemical equation that is written to reflect that the total number of atoms of each element are the same in the reactants and the products. This is done by writing coefficients in front of chemical formulas of compounds.

chemical energy: The net energy associated with a chemical reaction.

combustion: The oxidation reaction of an element or compound (usually with O_2) in which energy is released as heat.

electrolysis: A chemical reaction that occurs with an input of electrical energy.

endothermic: Referring to a chemical reaction that absorbs energy.

exothermic: Referring to a chemical reaction that releases energy.

precipitate: A solid residue that forms when the product of a chemical reaction is insoluble in the solvent used.

ASSESSMENT—ELECTRONS AND BONDING

1. In general, two atoms calcium (Ca, atomic number = 20) cannot form a stable ionic or covalent bond with one another. On the other hand, two atoms of oxygen (O, atomic number of 8) can form a covalent bond with one another. Explain this difference in bonding. You may use diagrams in your answer, but they are not required.

2. Magnesium (Mg) is a metal that bends easily and conducts electricity well. Sulfur (S) is a nonmetal that does not bend (it actually crumbles when stressed) and does not conduct electricity well. Explain why aluminum has the properties listed in terms of valence electrons.

3. r.
sugar break when sugar dissolves. Explain both of these observations.

RUBRIC FOR ASSESSMENT—ELECTRONS AND BONDING

1. In general, two atoms calcium (Ca, atomic number = 20) cannot form a stable ionic or covalent bond with one another. On the other hand, two atoms of oxygen (O, atomic number of 8) can form a covalent bond with one another. Explain this difference in bonding. You may use diagrams in your answer, but they are not required.

This item measures a student's understanding of the importance of the octet rule on forming stable covalent or ionic bonds.

Criteria for a complete response (2):

Student explains that since calcium must lose two outer electrons, there is no way that two calcium atoms can share outer electrons in any way to achieve a stable octet. However, if two oxygen atoms were to share four electrons (creating a double bond), each atom would have eight outer electrons in the highest energy level. Lewis dot structures may be part of this response, but they are not required for a complete response.

Criteria for a partial response (1):

Student explains that the oxygen atoms share electrons, but does not explain how, **or** student states that metals cannot form stable bonds with one another but does not explain why.

Criteria for an incorrect response (0):

Student explains that the oxygen atoms share electrons, but does not explain how, **and** student states that metals cannot form stable bonds with one another but does not explain why.

2. Magnesium (Mg) is a metal that bends easily and conducts electricity well. Sulfur (S) is a nonmetal that does not bend (it actually crumbles when stressed) and does not conduct electricity well. Explain why aluminum has the properties listed in terms of valence electrons.

This item measures the student's understanding that the nature of metallic bonds (a "sea" of valence electrons mutually shared among many atoms) accounts for the properties of metals.

Criteria for a complete response (2):

Magnesium atoms have only two valence electrons. In magnesium metal, the valence electrons tend to move freely from atom to atom, allowing electric charges (carried by electrons) to flow easily and allowing the metal to bend easily. Sulfur atoms have six valence electrons. These electrons do not flow easily, so sulfur conducts electricity poorly and tend to break rather than bend.

Criteria for a partial response (1):

Student gives a correct explanation for the behavior of magnesium **or** the behavior of sulfur, but not both.

Criteria for an incorrect response (0):

Student gives no response or an incorrect response for the behavior of both elements.

ASSESSMENT—CONSERVATION OF MATTER

1. One day, you dissolve two tablespoons of sugar (approximately 30 ml) into 250 ml of water (approximately 1 cup). After you have dissolved the water, the volume of the sugar solution is still 250 ml. How could you experimentally demonstrate that all of the matter in this situation has been conserved?

2. When a stack of papers with a mass of 5 grams is burned, it turns to ash. The ash has a total mass of 0.01 grams. Discuss why the amounts are different in terms of conservation of matter.

RUB

1. One day, you dissolve two tablespoons of sugar (approximately 30 ml) into 250 ml of water (approximately 1 cup). After you have dissolved the water, the volume of the sugar solution is still 250 ml. How could you experimentally demonstrate that all of the matter in this situation has been conserved?

This item measures the student's understanding that when substances are combined physically, mass is conserved, even if volume is not.

Criteria for a complete response (2):

Student suggests determining the mass of the sugar and the water before mixing and after mixing. The two should be the same. The student does not have to write a detailed experimental procedure for a complete response.

Criteria for a partial response (1):

Student suggests covering the container of water, suggesting that if nothing can enter or leave the system, matter must be conserved. This is an example of a proof but not an experimental demonstration.

Criteria for an incorrect response (0):

Student suggests tasting the water, and if it is sweet, matter has been conserved (both water and sugar are present).

2. When a stack of papers with a mass of 5 grams is burned, it turns to ash. The ash has a total mass of 0.01 grams. Discuss why the amounts are different in terms of conservation of matter.

   This item measures a student's understanding that if matter is conserved, it may have changed phase (i.e. a gas may be given off).

   Criteria for a complete response (2):

   Student states that in burning the paper, gases are given off, and the difference in mass is accounted for by the gas.

   Criteria for a partial response (1):

   Student states that the ash is what's left after burning, but does not refer to gases being given off.

   Criteria for an incorrect response (0):

   Student explains that the process of burning caused some of the paper or ash to be blown away.

3. Both NaCl (salt, an ionic compound) and sugar ($C_6H_{12}O_6$, a covalent compound) dissolve in water. However, the ionic bond in NaCl breaks when salt dissolves, but none of the covalent bonds in sugar break when sugar dissolves. Explain both of these observations.

This item measures the student's understanding of the difference between ionic bonds and covalent bonds.

Criteria for a complete response (2):

Student explains that the ionic bond of NaCl formed when one atom lost electrons and the other gained the same number of electrons. Since both Na and Cl are now electrically charged, they are attracted to the positive and negative electric charges of water molecules more than to each other. In the case of sugar molecules, the covalent bonds are formed by electrons being shared by atoms. The bonds do not break in water because the bonded atoms are not electrically charged.

Criteria for a partial response (1):

Student explains the behavior of the ionic bond of NaCl or the covalent bonds of sugar, but not both.

Criteria for an incorrect response (0):

Student explains the findings in terms of the number of atoms in each compound.

ASSESSMENT—CHEMICAL REACTIONS

1. Matches give off large amounts of heat and light because the chemicals in the match heads combine with oxygen gas and give off carbon dioxide and water in a chemical reaction. Why don't the matches light by themselves in the matchbook?

2. One way of disinfecting a cut is to pour hydrogen peroxide (H_2O_2) on it. Harmful bacteria are killed by hydrogen peroxide. Our cells are not, because our cells are able to cause the following chemical reaction to occur:

$$\underset{\text{Hydrogen peroxide}}{H_2O_2} \rightarrow \underset{\text{water}}{H_2O} + \underset{\text{oxygen}}{O_2}$$

When this reaction occurs, bubbles are formed.

In the space below, balance the reaction with hydrogen peroxide, and explain (using the equation) why bubbles form.

RUBRIC FOR ASSESSMENT—CHEMICAL REACTIONS

1. Matches give off large amounts of heat and light because the chemicals in the match heads combine with oxygen gas and give off carbon dioxide and water in a chemical reaction. Why don't the matches light by themselves in the matchbook?

This item measures a student's understanding that chemical reactions involve energy changes, and that activation energy is required to get all chemical reactions going.

Criteria for a complete response (2):

Student explains that the matches require an input of energy to get the reaction started. This input is rubbing the match head on the match cover.

Criteria for a partial response (1):

Student explains that striking the match provides heat but does not address the chemical reaction.

Criteria for an incorrect response (0):

Student states that the matches are not exposed to oxygen until they are struck.

2. In the space below, balance the reaction with hydrogen peroxide, and explain (using the equation) why bubbles form.

This item measures the student's ability to balance a simple chemical equation and to identify how the chemical reaction causes measurable changes in matter.

Criteria for a complete response (2):

Student balances the equation as follows:

$2H_2O_2 \rightarrow 2H_2O + O_2$

The bubbles come from the O_2 gas being given off.

Criteria for a partial response (1):

Student balances the equation correctly **or** identifies the bubbles correctly but not both.

Criteria for an incorrect response (0):

Student is unable to balance the equation correctly and identifies the bubbles as something other than O_2 gas.

APRIL

Topic 21: Solar Nebular Theory

Standards:

4.2.1. The motion and the basic elements (periodic table) that comprise our Solar System are consistent with the theory that the Solar System emerged from a large disk of gas and dust.

4.2.2. The Earth's atmosphere, crust, and interior have changed since the formation of the planets. Driven by internal heat (radioactive decay and heat from accretion), the Earth's layers have separated by density into a solid core, molten mantle, and crust of solid rock composed of plates.

GLEs:

9.4.a Explain the formation of solar systems using the Solar Nebular Theory including the origin of the planets and Sun from the nebula, the evolution of planets, and the dispersal of left over gas and dust.

9.4.b Describe how the Earth formed (using the Solar Nebular Theory) into a solid core, molten mantle, crust of solid rock composed of plates, and early atmosphere as a result of the densities of the elements.

Assessements:

21. Solar Nebula Theory

Text references/vocabulary:

Chapter 19.3, pp. 646-654.; Chapter 21.1, pp. 700-701 only atmosphere: A covering of gases that surrounds a body in the universe like a planet or star. These gases are attracted to this body by gravity.

closed system: A system that does not exchange matter with its surroundings. Closed systems generally require an outside input of energy from the surroundings to be sustained.

crust: A solid layer of rock forming the outermost layer of the Earth's lithosphere. The thickness of the crust ranges from approximately 8 km (oceanic crust) to approximately 36 km (continental crust).

gas cloud: A large cloud of interstellar gas in the universe that usually results from a prior cataclysmic event in space. According to the Solar Nebular Theory, the material in a gas cloud forms the building materials for stars and planets.

geosphere: The parts of the Earth that extend from the inner core outward to the crust.

hydrosphere: The portion of the Earth's surface that is covered in water (approximately 71 % of the Earth's surface).

inner core: The innermost layer of the geosphere. The inner core forms a sphere approximately 2400 km in diameter. The inner core consists of iron, cobalt, and nickel kept solid (from extreme pressure) and is the source of Earth's magnetic field.

interstellar: Referring to vast expanses of space between stars or solar systems.

mantle: A layer of the geosphere that lies directly beneath the crust. The mantle is approximately 2900 km thick, and ranges from a solid state in its outermost part to a semisolid state close to the Earth's core. This difference in state is a result of increasing temperatures toward the Earth's center. Convection currents in the mantle are believed to provide the mechanism for plate tectonics.

nebula: a large (billions of kilometers in any direction) of interstellar gas and dust. Nebulae (pl) are the result of massive explosions (novas or supernovas) occurring with pre-existing stars.

open system: A system that exchanges matter and energy with its surroundings. An open system must continually receive matter from the environment in order to continue.

outer core: The liquid layer of the geosphere located between the inner core and the mantle. The outer core is 2200 km thick and composed of iron and nickel.

planet: A body that orbits a star, massive enough to maintain a gravity field which creates a roughly spherical shape, and which clears its orbital neighborhood.

protoplanet: large bodies (larger than planets) of gas and interstellar dust that come together through gravitational attraction to eventually form planets.

solar nebular theory: An explanation for the formation of the sun and its planets. The solar nebula theory states that the sun and planets formed by gradual condensation from a spinning cloud (nebula) of gas and dust.

star: A large body of matter in the universe that converts matter to energy through nuclear fusion reactions.

Topic 22: Rocks and Minerals/Rock Cycle

Standards:

5.1.1. Minerals are the building blocks of rocks. Common rock-forming minerals found in Delaware (calcite, quartz, mica, feldspar, and hornblende) can be identified by their chemical and physical properties.

5.1.2. Rocks can be classified as igneous, metamorphic and sedimentary based on the method of formation. The natural cycling of rocks includes the formation of new sediment though erosion and weathering and of new rock through heat and compaction of the sediment.

GLEs:

9.2.c Classify matter as mixtures (which are either homogeneous or heterogeneous) or pure substances (which are either compounds or elements.)

9.2.d Explain that elements are pure substances that cannot be separated by chemical or physical means. Recognize that compounds are pure substances that can be separated by chemical means into elements.

9.5.a Identify mineral specimens according to their chemical and physical properties. Mineral specimens include calcite, quartz, mica, feldspar, and hornblende. Properties include hardness (Moh's scale), streak, specific gravity, luster, cleavage, crystal shape, and color, and other properties that are useful for identification of specific minerals such as reaction with hydrochloric acid.

9.5.b Identify a few of the most common elements in the Earth's crust, oceans, and atmosphere and confirm their location on the periodic table (example: Si, O, C, N, H, Al). Compare the relative abundance of elements found in the Earth's crust, oceans, and atmosphere. Trace carbon as it cycles through the crust, ocean, and atmosphere.

9.5.c Classify and describe features that are used to distinguish between igneous, sedimentary, and metamorphic rocks.

9.5.d Describe energy sources, processes, and transformations of Earth materials as they progress through the rock cycle to form new sedimentary, metamorphic, and igneous rocks. Discuss how the cycling of rock is continuous.

9.5.f Identify sandstone, shale and limestone by their composition and texture. Explain how sandstone, shale, and limestone can be changed into the metamorphic rocks quartzite, slate, and marble.

Assessments:

22. Rocks and Minerals

Text References/Vocabulary:

Chapter 21.3 pp. 722-724
Chapter 21.4 pp. 725-730 (for review only)

chemical weathering: Weathering that occurs when dissolved chemicals in rain water (usually acidic) dissolve rocks.

deposition: The transport and dropping off of sediment by flowing water, wind, or glaciers.

erosion: The wearing away of rock by moving water, wind, or glaciers.

extrusive rock: Igneous rock that forms when lava cools on Earth's surface or under water.

igneous: Rock that forms from solidification of magma or lava.

intrusive rock: Igneous rock that forms when magma cools beneath Earth's surface.
metamorphic: Rock that forms when igneous or sedimentary rock is exposed to extreme heat and/or pressure over long periods of time. While the heat does not melt the rock, the crystal structure of the rock changes.

mineral: A rock forming material characterized by a definite chemical composition, solid state, and naturally occurring.

molten: Referring to rock, heated to the liquid state.

physical weathering: Weathering that occurs when water seeps into cracks in rocks, freezes, and makes the crack wider as the ice expands.

rock cycle: A description of how igneous, sedimentary, and metamorphic rock are interconverted through melting and re-solidifying (igneous), deposition (sedimentary), and the combination of heat and pressure (metamorphic).

rock: A mixture of minerals that create predictable substances out of Earth's materials. The types of rocks that occur in a region give an idea of the natural history of the region over geologic time.

sedimentary: Rock that forms from deposition and cementation of other rocks or from evaporation of bodies of water which creates crystals of dissolved substances. Unlike igneous and metamorphic rock, sedimentary rock can contain intact fossils under certain circumstances.

weathering: The process of breaking rock into smaller pieces as a result of weather phenomena.

ASSESSMENT—SOLAR NEBULAR THEORY

1. According to the nebular theory, the sun and planets of the solar system was formed from a massive cloud of gas and dust.

   Describe the forces that caused the sun and planets to form from this gas cloud.

2. What caused the temperature of particles in this cloud to increase to the temperature of the sun?

3. Explain how the temperature of the primitive Earth (from about 4 billion years ago) and the materials which make up the planet caused the Earth's interior to be layered into layers.

RUBRIC FOR ASSESSMENT—SOLAR NEBULAR THEORY

1. According to the nebular theory, the sun and planets of the solar system was formed from a massive cloud of gas and dust.

   Describe the forces that caused the sun and planets to form from this gas cloud.

This item measures the student's understanding of the role of gravity and external forces on formation of stars and planets.

Criteria for a complete response (2):

Student states that 1) some external force disturbed the cloud of gas and dust, and that

2) the gravitational forces of the gas and dust particles caused areas in the cloud to come together, forming dense areas in the cloud. These areas continued to increase in mass, attracting more matter through gravity, and eventually became the sun and solar system.

NOTE: the response may describe the external force that originally disturbed the cloud, but this is not necessary for a complete response.

Criteria for a partial response (1):

Student states that material in the cloud was disturbed by an external force and condensed into the sun and solar system, but does not list gravity as the force that causes this condensation **or** student identifies gravity as the force that caused condensation of gas and dust but does not identify an external force which initiated formation of the solar system.

Criteria for an incorrect response (0)

Student gives an incorrect description of formation of the sun **or**

student gives a correct description of formation of the sun but states that the planets formed from material ejected from the sun.

2. What caused the temperature of particles in this cloud to increase to the temperature of the sun?

This item measures the student's understanding that heat is generated as particles are continually compressed.

Criteria for a complete response (2):

Student states that as more particles continued to be attracted by gravity in the cloud, the increased number of collisions produced heat energy, which raised the temperature of the bodies that eventually became the sun. Student may indicate that through this process, the temperature of the planets increased as well, but this statement is not necessary for a complete response.

Criteria for a partial response (1):

Student states that the temperature increased as the particles moved faster as the bodies increased in size, but does not explain why an increase in size resulted in more heat.

Criteria for an incorrect response (0):

Student states that as energy of the bodies increased they eventually caught fire, forming a star.

3. Explain how the temperature of the primitive Earth (from about 4 billion years ago) and the materials which make up the planet caused the Earth's interior to be layered.

This item measures the student's understanding that primitive Earth consisted of molten rock, and how density differences among Earth materials resulted in the layers of the Earth.

Criteria for a complete response (2):

Student states that the primitive Earth was hot enough that all rock was liquid. Denser materials sank to the middle and became the core. Less dense materials floated to the outside and became the crust. Materials of intermediate densities became the mantle.

NOTE: student does not need to name the layers (crust, mantle, core) for a complete response. Student may state that the core is made of mostly iron and the crust is made of mostly silicon and aluminum compounds, but this information is not necessary for a complete response.

Criteria for a partial response (1):

Student states that the primitive Earth was molten, but does not state the role of density difference on layer formation **or** student states that denser materials formed the core and less dense materials formed the crust but does not mention that the rock was molten when these layers formed.

Criteria for an incorrect response (0):

Student states that primitive Earth was hot but does not state that it was molten **and** student states that different rocks formed in different places but does not identify density as the reason.

ASSESSMENT—ROCKS AND MINERALS

1. In science class, you are working with various mineral samples. You have three white mineral samples in front of you. They are all about the same size (about the size of a large strawberry).

   One mineral sample is <u>calcite</u>, one is <u>quartz</u>, and one is <u>mica</u>.

   All of the samples are white.

   None of the samples are labeled.

Describe the steps you would take to determine which mineral is which. Be sure to state what results (if you perform a test) each mineral would give that would reveal its identity.

2. Sedimentary rock can become metamorphic rock over millions of years through the effects of intense heat and pressure. Explain how metamorphic rock can become sedimentary rock (over millions of years).

RUBRIC FOR ASSESSMENT—ROCKS AND MINERALS

1. Describe the steps you would take to determine which mineral is which. Be sure to state what results (if you perform a test) each mineral would give that would reveal its identity.

This item measures the student's ability to classify mineral samples on the basis of distinguishing characteristics

(NOTE: students should be permitted to consult references on this assessment. The purpose is to develop a classification scheme, not to memorize characteristics of minerals).

Criteria for a complete response (2):

Student describes a series of characteristics that distinguish each mineral sample definitively. For example:

Bubbles in the presence of acid: calcite
Appears in sheets: mica
Not as above: quartz

Or, distinguish minerals by hardness.

Criteria for a partial response (1):

Student describes distinguishing tests or characteristics, but does not state the results of the three mineral samples.

Criteria for an incorrect response (0):

Student lists tests or characteristics that do not distinguish the three mineral samples **or** lists characteristics that cannot be determined (e.g. mineral came from an ocean—there's no way to tell).

2. Sedimentary rock can become metamorphic rock over millions of years through the effects of intense heat and pressure. Explain how metamorphic rock can become sedimentary rock (over millions of years).

This item measures the student's understanding that the rock cycle describes a sequence of events by which all three rock types can be transformed into one another.

Criteria for a complete response (2):

Student explains that metamorphic rock can be broken apart through weathering or erosion, deposited, and cemented to become sedimentary rock.

Criteria for a partial response (1):

Student explains that metamorphic rock is cemented but does not explain that the rock is broken first.

Criteria for an incorrect response (0):

Student suggests that metamorphic rock is melted before becoming sedimentary rock (this may occur, but it does not explain how metamorphic rock can be transformed directly into sedimentary rock).

MAY

Topic 23: Volcanoes and Earthquakes

Standards:

5.1.4 Continental and oceanic rock differ in overall composition, density and age. These differences help explain the distribution and configuration of land masses and ocean basins.

5.2.3 Earthquakes result when rocks rupture and slide by one another releasing stored energy which travels through the geosphere in the form of waves. Local earthquake risks can be assessed and preparations made to minimize the hazards.

5.2.4 The type and eruptive style of volcanoes is determined by the viscosity and gas pressure of the magma. The effects of these eruptions can have both local and global consequences.

GLES:

9.5.e Describe how igneous rocks are formed. Classify igneous rocks according to crystal size and mineral assemblage.

9.5.h Explain how exposivity, type (shield, strato, etc.) and shape of a volcano is related to the properties of its magma and its location along different plate margins.

9.5.i Identify volcanic products (lava, mudflow, pyroclastic projectiles, ash, gases) associated with various types of volcanoes and their eruptions. Describe the effect of these products on life and property. Explain how the products of volcanic activity influence both long-term and short-term changes in the Earth system.

9.5.j Describe how energy within the Earth's interior is released in the form of earthquake waves, and explain how these waves affect Earth's surface. ((5.2.3)

9.5.k Describe how earthquake energy is represented on seismograms and describe how these waves can be used to determine the origin and intensity of earthquakes. (5.3.1)

9.5.l Describe the effects on life and property from consequences of earthquake such as landslides, liquification, surface faulting and tsunamis. Cite ways these hazards can be minimized.

9.5.r Explain how technology such as GPS, tilt meters, etc., can be used to predict earthquake and volcanic activity.

9.5.s Describe ways in which people use historical data, geologic maps, and technologies to minimize earthquake damage.

Assessments:

23. Earthquakes and Volcanoes

Text References/Vocabulary:

Chapter 21.2 pp. 709-717

cinder cone volcano: A volcano composed mostly of lava and cinders containing high amounts of silicon (felsic lava). Cinder cone volcanoes tend to be relatively small, triangular, and erupt violently.

earthquake: A disturbance in Earth's crust caused by moving tectonic plates or other phenomena. An earthquake releases energy within the crust in the form of mechanical (seismic) waves.

epicenter: The location on Earth's surface above the focus of an earthquake.

focus: The location within Earth's crust where plates shifted and an earthquake originated.

hot spot: A location on Earth's surface below which mantle plumes shoot up forming volcanoes. Hot spots occur in the middle of tectonic plates rather than at plate boundaries. The Hawaiian islands are located above a hot spot.

lava: Molten rock that seeps onto Earth's surface.

magma: Molten rock that remains below Earth's surface.

Mercali scale: A rating system for earthquakes based on the amount of damage they cause.

P wave: A longitudinal wave generated from the focus of an earthquake. P waves are the first waves generated (P stands for "primary"), and they move through solid rock and molten rock.

plate boundary: A geographic location that corresponds to the leading edge of a tectonic plate. Earthquakes and volcanoes frequently occur at plate boundaries.

Richter scale: A rating system for earthquakes based on the energy released.

S wave: A transverse wave generated from the focus of an earthquake. S waves are generated after P waves because they move more slowly than P waves. They only move through solid rock. The amount of time between when a P wave is recorded and an S wave can determine the distance from the focus of the quake.

seismic: Referring to earthquakes.

seismograph: An instrument that measures wave movement in the crust.

shield volcano: A volcano composed mostly of lava containing high amounts of iron (mafic lava). Shield volcanoes tend to be dome shaped. They erupt frequently but more gently than cinder cones.

surface wave: Rolling waves generated along Earth's surface during an earthquake. Surface waves generally do most of the damage to objects on the surface.

volcano: A mountain created by accumulation of molten rock and debris from Earth's interior.

Topic 24: Plate Tectonics

Standards:

5.1.3 Earth's geosphere is composed of layers of rocks which have separated due to density and temperature differences and classified chemically into a crust (which includes continental and oceanic rock), a hot, convecting mantle, and a dense metallic core.

5.2.2 Tectonic plates press against one another in some places (convergence), pull apart in other places (divergence), or slide past each other. These plate movements may result in the formation of mountain ranges, and can lead to earthquakes, volcanic eruptions, and tsunamis. The consequences of these events impact the surrounding atmosphere, geosphere, hydrosphere, and the life existing within them.

5.2.5 The atmosphere can be described as being in a state of dynamic equilibrium which is maintained in part by plate tectonic processes which recycle atmospheric gases trapped in the ground back into the atmosphere.

5.3.1. Advances in science and technology (such as satellite imaging, Global Positioning Satellite (GPS), and Geographic Information Systems (GIS)) have improved our understanding of global and local changes that result from Earth system interactions, and our capacity to anticipate and mitigate natural hazards such as volcanoes and earthquakes.

GLEs:

9.5.g Investigate the densities, composition, and relative age of continental (felsic) and oceanic (mafic) rocks. Explain why the continental crust, although thicker in most places, overlies oceanic crust. Use this information to explain why oceanic crust subducts below continental crust in convergent plate boundaries and explain the configuration of land masses and ocean basins.

9.5.m Use models or computer simulations to demonstrate the processes and origin of landforms at diverging, converging and transform plate boundaries. Show on a map how plate tectonics, earthquakes, and volcanoes are spatially related.

9.5.n Investigate how thermal convection relates to movement of materials. Apply this knowledge in explaining the cause of movement of the Earth's plates.

9.5.o Research and describe evidence that supports the Theory of Plate Tectonics to include rock magnetism and the age of the sea floor.

9.5.p Explain how the Theory of Plate Tectonics demonstrates that scientific knowledge changes by evolving over time. Recognize that although some theories are initially rejected, they may be re-examined and eventually accepted in the face of new evidence.

9.5.q Explain how data from Global Positioning Systems can be used to predict and determine the direction and rate of movement of Earth's plates and sea floor spreading.

Assessments:

24. Plate Tectonics

Text References/Vocabulary:

Chapter 21.1 pp. 700-708

convergent plate boundary: A plate boundary where two tectonic plates move into one another. If both plates are continental plates, mountains (like the Himalayas or the Alps) form. If at least one plate is an oceanic plate, a trench forms.

divergent plate boundary: A plate boundary where two tectonic plates move away from one another. These boundaries are also called "spreading centers."

fault: A discontinuity in the crust caused by a seismic disturbance.

lithosphere: The layer of the crust and upper mantle that is solid. The tectonic plates make up the lithosphere.

mid-ocean ridge: A spreading center in the middle of the ocean where lava is deposited on the ocean floor, creating new crust. The Atlantic Ocean and the Red Sea are both the site of mid-ocean ridges.

Pangaea: A description of a supercontinent that existed approximately 200 million years ago. Pangaea represented a single land mass on Earth which was fragmented over the course of time by plate tectonics.

plate tectonics: The theory proposed by Alfred Wegener that Earth's crust is made of several continental and oceanic plates that move about on the mantle. As a result, the positions of the continents (and therefore, the oceans) changes over the course of millions of years.

strike-slip fault: A plate boundary where two plates slide past one another. Strike-slip faults do not create volcanoes but the plate movements generate earthquakes. The San Andreas Fault in California is an example of a strike-slip fault.

subduction: The sinking of one tectonic plate (always oceanic) under another (either continental or oceanic) due to density differences in the rocks. Subduction occurs at converging plate boundaries and causes oceanic crust to return to a molten state. Subduction zones and spreading centers cause a dynamic equilibrium to occur in the formation and destruction of crust on Earth.

trench: A massive (up to 11.5 km deep) depression in Earth's crust that occurs at subduction zones. Trenches occur at converging plate boundaries involving oceanic plates.

ASSESSMENT—EARTHQUAKES AND VOLCANOES

1. Explain how an earthquake that occurs in San Francisco, California can be detected in Denver, Colorado, which is over 1200 miles away.

2. The volcano Mauna Loa in Hawaii produces a relatively hot, thin lava. Mt. Vesuvius, a volcano near Naples, Italy, produces a cooler thick lava. Explain how the differences in the lavas produced by these volcanoes affects the types of eruptions each volcano experiences.

RUBRIC FOR ASSESSMENT—EARTHQUAKES AND VOLCANOES

1. Explain how an earthquake that occurs in San Francisco, California can be detected in Denver, Colorado, which is over 1200 miles away.

This item measures the student's understanding that earthquakes transmit energy through Earth by means of waves.

Criteria for a complete response (2):

Student explains that the earthquake is caused by plates in Earth's crust relieving pressure by sliding past one another. This release of energy generates waves in the crust which travel far distances.

Criteria for a partial response (1):

Student explains what an earthquake is and that they travel great distances but does not discuss waves.

Criteria for an incorrect response (0):

Student explains an earthquake incorrectly and does not discuss waves.

2. The volcano Mauna Loa in Hawaii produces a relatively hot, thin lava. Mt. Vesuvius, a volcano near Naples, Italy, produces a cooler thick lava. Explain how the differences in the lavas produced by these volcanoes affects the types of eruptions each volcano experiences.

This item measures the student's ability to make predictions about different volcanoes on the basis of the type of lava they produce.

Criteria for a complete response (2):

Student explains that the Mauna Loa volcano will tend to erupt frequently but not violently. Student also explains that Mt. Vesuvius will tend to erupt occasionally but violently. The cooler lave will tend to have more trapped gas. This will tend to cause more pressure to build up so that eruptions are violent.

Criteria for a partial response (1):

Student explains that Mauna Loa will erupt less violently than Mt. Vesuvius but does not explain why.

Criteria for an incorrect response (0):

Student explains that Mauna Loa will erupt more violently than Mt. Vesuvius, with or without an explanation.

ASSESSMENT—PLATE TECTONICS

1. According to plate tectonic theory, Earth's crust is made of large plates that move around a few centimeters each year, changing the positions of the continents over geologic time. According to the theory, what processes under the crust cause the plates to move?

2. When an oceanic plate converges with a continental plate, the oceanic plate always subducts (that is, moves under) the continental plate. How does the composition of oceanic crust and continental crust cause this pattern to occur?

RUBRIC FOR ASSESSMENT—PLATE TECTONICS

1. According to plate tectonic theory, Earth's crust is made of large plates that move around a few centimeters each year, changing the positions of the continents over geologic time. According to the theory, what processes under the crust cause the plates to move?

This item measures the student's understanding of the role of convection currents in the mantle on movement of crustal plates.

Criteria for a complete response (2):

Student explains that the solid inner core of Earth heats the molten mantle under the crust. As mantle heats, convection currents occur. In some locations, the hot mantle pushes up on the crust and generates new crust as well as uplift. Elsewhere, the cooler mantle sinks, pulling down on the crust, and causing the crust to be pulled to the mantle and melt.

Criteria for a partial response (1):

Student states that mantle pushes up in some areas and pulls down in others, but does not explain about convection currents.

Criteria for an incorrect response (0):

Student suggests that ocean currents move the plates around.

2. When an oceanic plate converges with a continental plate, the oceanic plate always subducts (that is, moves under) the continental plate. How does the composition of oceanic crust and continental crust cause this pattern to occur?

This item measures the student's understanding that oceanic crust is made of denser materials than continental crust.

Criteria for a complete response (2):

Student explains that oceanic crust is denser than continental cruse because of the rocks which make it up. As a result, the oceanic crust always subducts under the continental crust.

Criteria for a partial response (1):

Student explains that oceanic crust is denser than continental crust but does not explain why.

Criteria for an incorrect response (0):

Student explains that oceanic crust is wet so it is heavier.