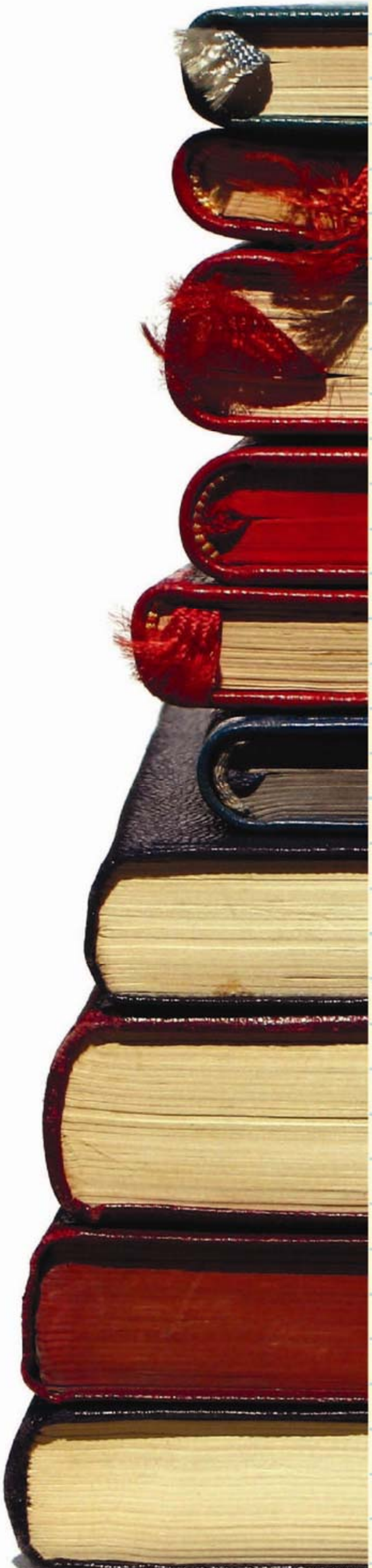


Comprehensive Curriculum

Revised 2008

Physical Science

Louisiana Department of
EDUCATION
Paul G. Pastorek, State Superintendent of Education

Physical Science

Table of Contents

***Louisiana Comprehensive Curriculum*, Revised 2008**
Course Introduction

The Louisiana Department of Education issued the *Comprehensive Curriculum* in 2005. The curriculum has been revised based on teacher feedback, an external review by a team of content experts from outside the state, and input from course writers. As in the first edition, the *Louisiana Comprehensive Curriculum*, revised 2008 is aligned with state content standards, as defined by Grade-Level Expectations (GLEs), and organized into coherent, time-bound units with sample activities and classroom assessments to guide teaching and learning. The order of the units ensures that all GLEs to be tested are addressed prior to the administration of *i*LEAP assessments.

District Implementation Guidelines
Local districts are responsible for implementation and monitoring of the *Louisiana Comprehensive Curriculum* and have been delegated the responsibility to decide if

- units are to be taught in the order presented
- substitutions of equivalent activities are allowed
- GLES can be adequately addressed using fewer activities than presented
- permitted changes are to be made at the district, school, or teacher level

Districts have been requested to inform teachers of decisions made.

Implementation of Activities in the Classroom
Incorporation of activities into lesson plans is critical to the successful implementation of the Louisiana Comprehensive Curriculum. Lesson plans should be designed to introduce students to one or more of the activities, to provide background information and follow-up, and to prepare students for success in mastering the Grade-Level Expectations associated with the activities. Lesson plans should address individual needs of students and should include processes for re-teaching concepts or skills for students who need additional instruction. Appropriate accommodations must be made for students with disabilities.

New Features
Content Area Literacy Strategies are an integral part of approximately one-third of the activities. Strategy names are italicized. The link (view literacy strategy descriptions) opens a document containing detailed descriptions and examples of the literacy strategies. This document can also be accessed directly at http://www.louisianaschools.net/lde/uploads/11056.doc.

A *Materials List* is provided for each activity and *Blackline Masters (BLMs)* are provided to assist in the delivery of activities or to assess student learning. A separate Blackline Master document is provided for each course.

The *Access Guide to the Comprehensive Curriculum* is an online database of suggested strategies, accommodations, assistive technology, and assessment options that may provide greater access to the curriculum activities**.** The *Access Guide* will be piloted during the 2008-2009 school year in Grades 4 and 8, with other grades to be added over time. Click on the *Access Guide* icon found on the first page of each unit or by going directly to the url http://mconn.doe.state.la.us/accessguide/default.aspx.

Physical Science
Unit 1: Introduction to Inquiry: Observation, Measurements, and Experimental Design

Time Frame: Approximately three weeks

Unit Description

Utilizing inquiry process skills, this unit will focus on making accurate, objective observations in addition to asking and developing testable questions as the foundation to scientific inquiry. Emphasis will also be placed on using the metric system to collect scientific data, along with organizing and reporting data and communicating results and conclusions.

Student Understandings

Students will gain skill in metric conversion, utilize inquiry process skills to design their own experiment, and determine density as one of many identifying properties of matter. They will also develop skills in the use of proper laboratory procedures with a strong emphasis on safety. Their knowledge of the metric system will be demonstrated through collection and analysis of scientific data.

Guiding Questions

1. Can students display proper laboratory safety procedures?
2. Can students make quality observations and ask testable questions?
3. Can students utilize accurate metric measurements in solving problems?
4. Can students demonstrate techniques used when solving problems?
5. Can students organize quantitative data into tables and graphs?
6. Can students correctly utilize inquiry processes in investigations?
7. Can students describe how to determine density of a substance?

Unit 1 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
1.	Write a testable question or hypothesis when given a topic (SI-H-A1)
2.	Describe how investigations can be observation, description, literature survey, classification, or experimentation (SI-H-A2)
3.	Plan and record step-by-step procedures for a valid investigation, select equipment

GLE #	GLE Text and Benchmarks
	and materials, and identify variables and controls (SI-H-A2)
4.	Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
10.	Given a description of an experiment, identify appropriate safety measures (SI-H-A7)
12.	Cite evidence that scientific investigations are conducted for many different reasons (SI-H-B2)
15.	Analyze the conclusion from an investigation by using data to determine its validity (SI-H-B4)
Physical Science	
1.	Measure the physical properties of different forms of matter in metric system units (e.g., length, mass, volume, temperature) (PS-H-A1)
2.	Gather and organize data in charts, tables, and graphs (PS-H-A1)

Sample Activities

Activity 1: Safety (SI GLE <u>10</u>)

Materials List: Student Safety Contract BLM, Safety Evaluation Lab BLM

Safety in the Science Classroom must be stressed from the beginning of the course. Make sure students understand proper procedures in handling equipment and chemicals. Always use Safety Glasses when working with chemicals or any material that may move toward the eyes, and when heat or flames are present. For teacher demonstrations, the teacher must always model proper safety procedures. Be sure that long hair is pulled back as well as securing loose fitting clothing that could potentially be a hazard. It is advisable to develop and utilize a safety contract with your students to clarify expectations in the laboratory setting prior to any lab work. An example is included in the black line masters for this unit. Obviously, individual classrooms and teaching situations will dictate additions or substitutions in the safety rules for a particular class. Make sure that all students know where the fire extinguishers, eye wash stations, showers, and emergency exits are located.

Using a simple experiment, or the Safety Evaluation Lab BLM, have students read the lab and identify the various safety concerns.
Always conduct a "dry run", utilizing safety procedures before the first laboratory activity, and again when any hazardous situations might arise. Additional information about safety in the secondary classroom can be found online at http://www.labsafety.org/ or at http://www.csss-science.org/safety.shtml.

Activity 2: Making Observations (SI GLEs: 2, 5, 12; PS GLE: 2)

Materials List: one birthday candle for each group, candle holder (rubber stoppers/ plastic lids/ piece of aluminum foil), matches or other type of lighter, science learning logs

Since observation is one on the most important activities in the science classroom and because it is the foundation of inquiry, students should practice making precise, detailed, and complete observations. Students should realize that investigations can be totally observational in nature, provided the observer records meaningful data. It is advisable that the teacher develop a system of compiling and organizing data along with daily reflections and notes for students to employ. Journals, learning logs, and/or three ring binders with divided sections all work very well and are an individual choice for the teacher. Scientists, explorers, and mathematicians have always kept records of their observations, new understandings, hypotheses, and reflections as a way to record their progress and document new ideas and learning. Science *learning logs* (view literacy strategy descriptions) are a great way for students to write out their thoughts and clarify their understandings. Writing about newly learned concepts or developing understandings forces connections to prior learning or creates more questions for students to explore to aid their understandings. Have students keep all relevant writing in their science *learning logs*.

Because this activity involves candles and fire, make sure all students are aware of and follow proper safety precautions. Make sure hair and loose clothing are secured. This activity is best completed individually with an observation candle set up provided for the group for close-up examination. Discuss with students the fact that, while many of them have obviously used a candle in the past, they may not have critically observed one until now. Give each group of 3-4 students one candle. Ask students to observe the unlit candle and record five observations. They should also record five questions about the candle.

Have students place the candle into a rubber stopper on a piece of foil or plastic square, or any other type of available candle holder. Instruct students to put on goggles and light the candle. Again, instruct students to record five observations and five questions.

Students should classify their observations as qualitative or quantitative. List student observations on the board or overhead, noting duplicates with a tally mark, and as a group (with teacher help as needed) determine if each is an observation or an inference based on the student's prior knowledge.

As a class, analyze how a good observation can lead to a testable question. Have students share their questions with other group members and have each group share the best question with the whole class. They should explain why it is a good question and what observation lead to that question.

Discuss effective techniques in organizing data. If no previous instruction has been given to constructing observation tables, the teacher must guide students in recording observations and data. Allowing students to determine a method to record their data as a class (with teacher guidance) will make student charts and tables more uniform and organized and also easier to share with other group members. Allow students to record their data into tables. Discuss why care should be taken to plan for data organization before any has been collected.

Activity 3: Inquiry and Experimental Design (SI GLEs: 1, 3, 4, 5, 9, 10; PS GLEs: 1, 2;)

Materials List: (per group) raisins, clear carbonated beverage, large beakers (or empty 2-liter bottles with the necks cut out), misc. material dependant on the designed experiment, Inquiry Presentation Rubric BLM, (per student) science learning logs

The purpose of this exploratory activity is to further develop student inquiry process skills. In cooperative groups of 3 to 4, students should design an experiment around a testable question that they themselves generate. The designed experiment should provide accurate and reasonable data to analyze, and it should clearly permit the collection of information that addresses the framing question of their investigation. Simple hands-on activities can be extended into full inquiry opportunities. Using a discrepant event like the dancing raisins activity can be an excellent start to an inquiry experiment. The dancing raisins activity is based upon the discrepant event resulting when a raisin is dropped into a glass of clear carbonated beverage. The raisin, being slightly denser than the liquid, initially sinks to the bottom of the glass. However, the raisin does not stay on the bottom of the glass. Carbon dioxide bubbles in the beverage will attach themselves to the submerged raisin, creating buoyancy, which causes the raisin to bob up to the surface. When a raisin reaches the surface, the bubbles on the top of the raisin break, the raisin rolls over, the remaining bubbles break, and the raisin sinks. Although raisins will dance in a variety of carbonated beverages, it is necessary to use a "clear" soda or carbonated water in order for the students to be able to observe how the bubbles stick to the raisins causing them to float.

To do this, begin the activity with an *opinionnaire* statement. (view literacy strategy descriptions). Write the following statement on the board: "Forensic Scientists are the only scientists who should be concerned with consistent techniques." (Define Forensic scientists if needed, but most of your students should be familiar with the popular crime scene shows from television). Rather than responding to a written *opinionnaire*, ask students to turn to a partner and either defend or dispute that statement stating why they have taken that stance. As students respond, write paraphrases of the statements on the board or overhead, marking any duplicate statements with a star. Add statements of your own as needed to show the need for various standard procedures in scientific experimentation. Students at this level should recognize the need for controlling variables, analyzing and graphing data, recording observations, making predictions and evaluating results. Tell students to look carefully at the following activity to see if their statements hold true for the scientific examinations to be conducted in this classroom.

Provide each group with the dancing raisins set-up—clear container filled with fresh clear carbonated beverage and about 20 raisins—and allow them to record their observations. Hopefully they will be able to determine that the "dancing" is caused by changes in density due to the attaching air bubbles The raisins are more dense than the soda and fall to the bottom, but when gas bubbles of CO2 attach themselves to the raisins, they become less dense and float to the top. When the bubbles pop at the surface, the raisins again fall, and the process repeats itself over and over. Allow time for group discussions and whole-class discussions about their observations.

Next pose this question to the students: Can you make the raisins dance faster, and if so, can you design an experiment to substantiate your claim? Allow cooperative groups to *brainstorm* (view literacy strategy descriptions) solutions to this challenge. During this *brainstorming*, the teacher should facilitate each group in choosing their experimental design, facilitate the planning of an investigation, and provide whole-group/whole-class instruction in various process skills (formulating a hypothesis to predict outcome, developing a step-by-step procedure, and recording and analyzing data) as needed to conduct the inquiry. Hopefully, the challenge itself—Can you make the raisins dance faster?—should generate the student question of faster than what? If not, the teacher should guide the students to that question. This should help focus on developing a hypothesis and generate much discussion about experimental design, controls, variables—both independent and dependent—as well as data recording and presentation (graphing, diagrams, etc.), along with appropriate safety precautions. This questioning may lead to (or the teacher might want to guide the students to) repeating the experiment but controlling and measuring the variables. These would include measuring the temperature and volume of the beverage, measuring the dancing of the raisins by counting bobs in a determined time interval, and recording the results. This controlled experiment should help students in determining their testable question. It is also helpful in helping students reflect on how the increased scientific examination affected their understanding and their learning. Using their science *learning logs* (view literacy strategy descriptions), have students reflect on the process they followed to develop their testable question. Suggestions to cover would be how they chose their variables and the resulting procedure, group collaboration, controls, etc. A short period of class time should be utilized to allow students to share their reflections with their group or other with other students in the class either one-on-one or as a whole class. Pairing students and allowing them to share (Pair and Share) often prevents students' stress of sharing with the entire class.

Upon approval of their experimental design, student groups will work through the activity a final time testing their generated question and then prepare a class presentation of their experiment and results. Using the final presentation as a guide, many unfocused or disorganized ideas can be clarified by asking students how they can explain that in their presentation. It may be necessary to provide additional whole group instruction (or review) on the oral presentation component of the lesson after the hands-on portion of the work has been completed. This activity could be conducted over a few class periods or extended to include research on density and buoyancy to be included in oral presentations or written reports. See the Inquiry Presentation Rubric BLM for a suggested evaluation rubric.

Activity 4: Making Measurements (SI GLEs: 4, 5, 15; PS GLEs: 1)

Materials List: Meter stick, thermometer, balance, 10 mL graduated cylinder, 250 mL graduated cylinder, 250 mL beaker, wood block, screw

Teacher Notes: It would be hard to overstate the importance of taking proper measurements in the science lab. The goal of most of the lab experiences is to compare the results of calculations to some known standard, and to determine possible errors or uncertainty. Students must be able to make measurements as accurately as possible depending on the instrument they use. Through direct instruction either whole class or group work, students should learn how to determine the accuracy of the various pieces of laboratory equipment they will be using though out the school year (rulers, balances, graduated cylinders, thermometers, etc). This process will probably take several class periods, with additional calculation practice with teacher-provided problems as extensions of the class activities. Direct instruction in using significant figures, scientific notation, unit conversions, and percent error should be provided as determined by assessing the level of your students. Additional information about significant figures, scientific notation, conversions, and accuracy and precision can be found at
http://www.ee.unb.ca/tervo/ee2791/intro.htm
http://www.chemtutor.com/numbr.htm#sci
http://chemlabs.uoregon.edu/Classes/Exton/Misc/determinate.html

I. Determining the limitations of common laboratory instruments
1. Have students observe the smallest place value represented by the lines on the meter stick (on the metric side). Record this value, with the appropriate unit (i.e. hundredth of a cm. or .01 cm), as the "smallest certain place value."
2. Instruct students to add one decimal place value (i.e., tenth becomes hundredth, or hundredth becomes thousandth) to the value from the previous step. This determines the estimation digit for this instrument. Students should record this value with appropriate units.
3. Students should repeat steps 1 and 2 for each of the following instruments and record these values: thermometer, balance, 10 mL graduated cylinder, 250 mL graduated cylinder, and 250 mL beaker.

4. Instruct students that when using these instruments throughout the school year, they must record their measurements to the value of the first estimated digit.

II. Measuring length

1. Have students measure the length, width and height of the wood block (book or any other larger rectangular object may be added or substituted for this object). Make sure they include an estimation digit for each measurement that matches the place value determined for the meter stick in Part I. Record these values with units.

III. Measuring mass

1. Make sure students understand how to zero the balance before each measurement.
2. Have students determine the mass of a clean, dry 10 mL graduated cylinder and record this value with the proper estimation digit and unit.
3. Add 10.0 mL of water to the graduated cylinder. Dry the outside of the cylinder to avoid massing extra water. Students will mass the graduated cylinder plus water and record this value with the proper estimation digit and unit.
4. Students will determine and record the mass of the wood block.
5. Students will determine and record the mass of the metal screw.

NOTE: Other appropriate items may be added to this list or substituted for the wood block and metal screw depending upon the availability.

IV. Measuring volumes of water

1. Students will measure out any appropriately-sized sample of water in the 10 mL graduated cylinder and record the volume with units to proper estimation digit.
2. Students will repeat step 1 with the 250 mL graduated cylinder and the 250 mL beaker.

V. Measuring the volume of an irregularly-shaped object

1. Students should place some water in the 10 mL graduated cylinder and record the value (4-6 mL would usually be best).
2. Have them carefully place the screw in the 10 mL graduated cylinder (make sure the screw used is smaller than the diameter of the cylinder). Tell students that it must be completely submerged and the volume must be no greater than 10 mL. Have them record the new water level.

VI. Measuring temperature

1. Have students take the temperature of the lab room and record with units to the proper estimation digit.

VII. Reviewing results

1. Review correct answers with students and re-teach if necessary for mastery. Have students compare the precision of the accuracy of the graduated cylinders and the beaker and discuss when an accurate measurement is required during experimentation and when very precise measurements are required.
2. Review how making as accurate and precise measurements as possible is required to receive valid data from experiments. Showing students how small errors are compounded through calculations into large errors is necessary to additional evidence to reduce experimental errors and to have proper, consistent, and reliable laboratory measurement skills.

Activity 5: Conversions (SI GLEs: 5, 6; PS GLEs: 1, 2)

Materials List: ruler, thermometer, graduated cylinder, balance, calipers, various items to measure (books, pencil, liquids, etc.), calculators

Prior to this activity, a combination of direct questioning and review of the metric units and prefixes used in measuring may be conducted. Provide students with ample opportunity to measure in metric units, and record various physical properties of matter such as the mass of a pencil, the height of a textbook, the temperature of a liquid, and the volume of a beverage glass. Allow students to work with triple beam balances, rulers, calipers, graduated cylinders, and thermometers. All data should be recorded in a data table. As students work, informally assess students' mastery of each measuring tool. Once mastery has been assessed and re-teaching has occurred as necessary, students are ready to convert the measured metric units into other metric units.

The teacher should demonstrate the use of dimensional analysis to convert one of the student measurements from one metric unit to another metric unit. For example, model converting pencil mass in grams to kilograms. The converted measurement may be recorded in the same data table. In order to accomplish this activity, students should work in groups of 2, 3, or 4 students. Provide students with additional practice conversion problems as needed to reach mastery. Additional metric activities, conversions, and information can be found online at http://www.nist.gov/public_affairs/kids/metric.htm and http://www.chemtutor.com/numbr.htm#sci

Activity 6: Density of Various Substances (SI GLEs: 4, 15; PS GLEs: 1, 2)

Materials List: two ice cubes the same size, water, isopropyl alcohol, clear containers

Because many students assume that a solid will always sink when placed in a liquid, correct student misconceptions with the following discrepant event. Prepare two ice cubes of equal size (you might want to make larger sizes for ease of student viewing) prior to the start of class. Place both ice cubes in clear containers such as beakers, one ice cube in water (it floats) and one ice cube in isopropyl alcohol (it sinks). Because the two colorless, clear liquids appear to be water, students initially might think that you have done something to the ice cube that sinks. This is why care must be taken in making the ice cubes the same size.

Accept all explanations of what the students are viewing. If time allows, you might want to let student groups layer water, colored salt water, glycerol, and colored isopropyl alcohol in a graduated cylinder and experiment with dropping various solid objects (cork, plastic, metal, wood, etc) into the density column to compare densities. Given the density of various objects, have students predict where the object will rest when placed in the density column. Have students test, record and report their results.

Activity 7: Density of Solids (SI GLEs: 4, 5, 7, 15; PS GLEs: 1, 2)

Materials List: various sizes of regularly shaped objects (square and rectangular blocks of wood, metal, plastic), graduated cylinder or overflow can, balance, metallic solids (aluminum, brass, copper, lead, steel, tin, zinc), graph paper, calculators

Students should be provided with ample opportunities to work with materials to calculate density. They are to demonstrate that the physical property of the density of a substance is a derived formula, calculated from mass divided by volume. Instruct students to determine, mass and volume of regularly shaped objects, such as rectangles and blocks of wood, metal, and/or plastic. They should calculate densities using proper units and record in student developed data tables. Have students measure the volume of some of the same objects through water displacements using graduated cylinders or overflow cans, and again calculate the densities of the objects. Students should compare the two calculations and determine any source of error between the two calculations.

Provide the students with several "unidentified" metallic solids such as aluminum, brass, copper, lead, steel, tin, and zinc. Using balances as well as graduated cylinders or overflow cans, have the students determine the mass and the volume of the metallic objects. Students should record this information in a data table. Once the information is recorded, students should calculate and record the density of the metallic objects.

Students should plot data in a mass vs. volume graph and analyze the slope for density. The ability to create and analyze graphs for trends and predictions is fundamental to the study of science. Some review of graphing and analyzing slope as a rate of change may be needed for students to accomplish this task. After consulting a chart or periodic table for known densities (or specific gravity) of the various substances, students are to identify correctly the metallic composition of their solids. Students should also calculate the density using the formula and compare their two calculated values (the slope and the formula calculation). Using the known density of their metal and their calculated densities students may calculate a percent error for their density/slope calculation.

Activity 8: RAFT Writing about Density (SI GLEs: 7, 15; PS GLEs: 1)

Materials List: science learning logs

Have students complete a *RAFT* (view literacy strategy descriptions) after their experimentation with the density of various objects This type of writing allows students to project themselves into unique roles and to look at the content from a unique perspective. In this case they will use their understanding of density to explain a situation that is different than water density as we know it on Earth. This type of writing should be creative and informative, and also show an understanding of the correct content. These writings may be done individually, in pairs, or in small groups as determined by the teacher.

Role: Astronaut Explorer to an "Earth-like" planet in another solar system
Audience: Mission Control
Form: Report of Observations
Topic: Observations that on this planet frozen, solid ice is not less dense than water, but more dense than liquid water

In their written report to Mission Control, students must record at least three observations of specific ice and water interactions on this planet and their resulting observation. These observations should be compared and contrasted with the same interaction on Earth. Recommendations should be given to Mission Control whether the continued exploration of this planet would lead to future habitation by Earthlings or the conditions are not optimal for human habitation. Students should be allowed to share their *RAFT*s in small groups or with the whole class. Students should listen for accurate information. *RAFT* writing should be kept in students' science *learning logs* (view literacy strategy descriptions).

Sample Assessments

General Guidelines

Assessment techniques should include use of drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

- Students should be monitored throughout the work on all activities via teacher observation and lab notebook entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will develop skills in measuring mass, length, and volume of known objects and liquids recording the measurement to the appropriate first digit of uncertainty. Stations for each type of measurement will be set up and students will rotate through each station.
- The student will analyze prefixes of the SI system for their numeric representation in relationship to the base unit (e.g., Centi (c)---- .01 and Kilo (k)---- 1000). Students will complete a chart of prefixes and their numeric representation.

- The student will complete various density problems, solving for mass, volume, or density.
- The student will create lab reports showing a complete analysis and understanding of the given concept. The student will complete graphs with correct scale, labels, and slope calculations when given sample data.

Activity-Specific Assessments

- Activity 1: The student will demonstrate understanding of proper lab behavior by accurately answering a teacher developed safety quiz.

- Activity 3: The oral presentation will be evaluated by a teacher-developed rubric given to students prior to the development of the experimental design. See Presentation Rubric BLM

- Activity 5: The student will determine the density of a group of 5-10 pennies, making sure that some are pre-1982, some 1982, and some post-1982. When students report various densities, they will be challenged to find an answer to the discrepancies in their results. Internet research should be conducted to determine the composition of pennies over the last fifty years and why it has changed.

Resources

- Marson, Ron. *TOPS Learning Systems: Metric Measure*. 1978.
- For additional information about the Dancing Raisins experiment: www.scifun.org/homeexpts/dancingraisins.htm http://www.theteacherscorner.net/lesson-plans/science/experiments/raisins.htm
- McKibban, Mike, Kathleen Landon, Walt Laidlaw, and David Lile. *Floaters and Sinkers: Solutions for Science and Math.* Fresno: AIMS Education Foundation, 1987.
- Texley, Julianna,Terry Kwan and John Summers. *Investigating Safely: A Guide for High School Teachers*: NSTA Press, 2004.
- For additional on-line density activities: http://www.edinformatics.com/math_science/mass_volume_density.htm
- For additional information on experimental design, inquiry, and error: http://www.curriculumtopicstudy.org/and http://www.isd77.k12.mn.us/resources/cf/SciProjInter.html

Physical Science
Unit 2: Nature of Matter

Time Frame: Approximately two to three weeks

Unit Description

The classification and properties of matter are explored by utilizing inquiry processes and modeling techniques, with an emphasis on differentiation among elements, compounds, and mixtures. The kinetic molecular theory is examined through the study of dissolving rates, modeling molecular behavior, and observing.

Student Understandings

Matter exists as pure substances or mixtures. Students should understand the various classifications of matter and how they are connected. Students will learn to differentiate among elements and compounds, which can only be separated or rearranged through chemical processes, as well as mixtures, which can be separated through various physical processes. Students develop and explain models of the Kinetic Theory of Matter and analyze phase changes among substances.

Guiding Questions

1. Can student classify matter based on observable and measurable properties?
2. Can student differentiate the types of mixtures?
3. Can student describe how stated factors affect rate of dissolving?
4. Can student utilize the kinetic molecular theory to describe the properties and structure of the different states of matter?
5. Can student describe the behavior of matter during phase changes?
6. Can student classify changes as chemical or physical?

Unit 2 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
1.	Write a testable question or hypothesis when given a topic (SI-H-A1)
2.	Describe how investigations can be observation, description, literature survey, classification, or experimentation (SI-H-A2)

GLE #	GLE Text and Benchmarks
3.	Plan and record step-by-step procedures for a valid investigation, select equipment and materials, and identify variables and controls (SI-H-A2)
4.	Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
10.	Given a description of an experiment, identify appropriate safety measures (SI-H-A7)
Physical Science	
11.	Investigate and classify common materials as *elements*, *compounds*, or *mixtures* (heterogeneous or homogeneous) based on their physical and chemical properties (PS-H-C1)
13.	Predict how factors such as particle size and temperature influence the rate of dissolving (PS-H-C3)
14.	Investigate and compare methods for separating mixtures by using the physical properties of the components (PS-H-C4) (PS-H-C1)
19.	Analyze and interpret a graph that relates temperature and heat energy absorbed during phase changes of water (PS-H-C7)
20.	Predict the particle motion as a substance changes phases (PS-H-C7) (PS-H-C3)
21.	Classify changes in matter as *physical* or *chemical* (PS-H-D1)
22.	Identify evidence of chemical changes (PS-H-D1)
27.	Distinguish between endothermic and exothermic reactions (PS-H-D6)

Sample Activities

Safety Note: Prior to any activity, all essential safety precautions should be identified by students.

Activity 1: Classifying Matter (SI GLEs: 5; PS GLEs: 11)

Materials List: safety goggles, penny, iron filings, salt, carbon (or graphite), carbonated beverage, sugar, glass beaker, baking soda, mossy zinc, and any other appropriate forms of matter

Have students work independently to complete a *word grid* (view literacy strategy descriptions) on the classification of matter using common substances easily obtainable for your classroom (example below). *Word grids* maximize student participation when they are student generated. This introductory activity will model this process for your students to use in the future. Additional blanks may be utilized for student additions. A large grid on poster paper may be posted on the wall or projected through an overhead or computer to aid in student recording.

Matter	Element	Compound	Mixture (heterogeneous or homogeneous)
Copper penny			
Distilled water			
Iron filings and salt			
Carbon			
Salt			
Sugar dissolved in water			
Carbonated beverage			
Mossy zinc			
Glass beaker			
Baking soda			

Display several types of matter (e.g., elements, compounds, and mixtures) such as copper, carbon, sodium chloride, copper sulfate, distilled water, ammonium nitrate, a saline solution, sucrose or sugar solution, iron filings mixed with sulfur, mossy zinc, and iron filings mixed with salt (or any other appropriate examples available). Have students work independently to predict and record in a *word grid* whether they view each type of matter as an element, compound, or mixture and to identify whether they are homogeneous or a heterogeneous mixture.

Question students by asking about the similarities and differences among the substances. Through discussion, disclose the correct answers to the classification. As critical terms and defining information is encountered, students should add to the chart in the correct area. Make sure the grid is large enough for students to add their own suggestions of matter to categorize.

For information about elements, compounds, and mixtures:

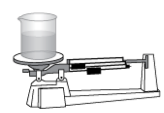
- http://library.thinkquest.org/19957/matter/compelemixbody.html?tqskip1=1
- Concept drawings of compounds, elements, and mixtures: http://www.darvill.clara.net/hotpots/emc.htm

Activity 2: Flowchart of Matter (SI GLEs: 5; PS GLEs: 11)

Materials List: index cards, reference material as needed, science learning logs

Have students make *vocabulary cards* (view literacy strategy descriptions) using the following terms: matter, compound, element, pure substance, mixture, heterogeneous, homogeneous. *Vocabulary cards* allow students to see connections between words, examples of the word, and the critical attributes associated with the term. Vocabulary cards allow students to improve their mastery over the terms and become an easily accessible reference for students to prepare for tests, quizzes, and other activities that utilize the term. To begin, distribute one 3 x 5 or 5 x 7 inch index card to each student and have them write the term "matter" in the center of the card. A definition (best if in their own words) should be written in the upper left corner. The characteristics or description of the term should be placed in the upper right corner. Ask students for examples of matter and include several of the best answers in the lower left corner. An illustration of the term should be placed in the lower right corner. Students should complete another six cards with the remaining terms. Allow them to review the cards and pair with a partner to share with and to quiz each other.

EXAMPLE OF
A VOCABULARY
CARD

substance that has mass and volume		can change state depending on the temperature
	matter	
solids, liquids, gases, and plasmas		

As a formative assessment, have students arrange their seven completed cards in a logical flowchart or concept map that shows the relationship among the terms. Again have students share their design with their group and defend the criteria they used to relate the terms. Allow students to rearrange their flowcharts if necessary to create the correct arrangement. The final chart should be written in their science *learning log* (view literacy strategy descriptions) along with questions that need to be asked to determine the type of matter, such as "Is it a pure substance?" or "Is it heterogeneous or homogeneous?"

Allow students to add to their *vocabulary cards* as new terms are added throughout the unit. Once students understand the basic process, this can be accomplished by early finishers or for homework as determined by the teacher. This allows students to make connections between new concepts and prior knowledge and also gives students an excellent tool to add to their study skills.

Activity 3: Separation of Mixtures (SI GLEs: 3; PS GLEs: 11, 14)

Materials List: salt, iron filings, beaker, water, hot plate, magnet, plastic storage bag or plastic wrap (to protect magnet), safety goggles

Since most materials in our world exist as mixtures, separation of mixtures to obtain pure substances is a very important process in industry and everyday life. *Brainstorm* (view literacy strategy descriptions) with students how they have seen mixtures separated in their own lives (coffee filters, air conditioning filters, fuel line filters with autos, etc.) Often everyday separation techniques are separating heterogeneous mixtures where the particles are different states. Filtration, evaporation, distillation, physical separation, and magnetism are often used for this type of separation. Chromatography is often used to separate homogenous mixtures as seen on forensic programs on television.

Working in small groups, have students design a separation technique based on physical properties for a mixture of salt and iron filings. (Other mixtures can be used with available materials: rice and beans, sugar and sand, bbs and sand, etc.) Re-emphasize that they should include appropriate safety measures for their investigations. Provide a review of various separation techniques, such as magnetism, filtration, evaporation, dissolving, distillation, and chromatography. On design approval, permit students to test their technique on at least one mixture and communicate their results through a lab report. Students should communicate their understanding of the physical separation techniques, including the following:

- What were the components that were mixed together?
- What were the physical characteristics of the mixture?
- Is there any way to separate the components so as to be able to recover one or more of them unchanged?
- When the components were separated, does each have the individual properties of the starting substances?

Activity 4: Kinetic Molecular Theory (SI GLE: 7; PS GLE: 20)

Materials List: Kinetic Molecular Theory BLM, beakers, hot and cold water, methylene blue powder (or other solid indicator—food coloring can be used if necessary), per group: 10 to 12 ping pong balls or other small soft rubber balls, plastic tub or clear container, safety goggles

As an introduction to the Kinetic Molecular Theory, fill one 600mL beaker with 500mL of cold water. Fill the other with 500mL of hot water. Set the beakers aside so that any motion in the water comes to rest. Now sprinkle equal quantities of methylene blue powder (or any other strongly colored chemical or solid indicator) on the water in both beakers. Twenty or thirty crystal grains are all that is needed. After observation, have students think, pair, and share with a partner to determine why the dye spreads faster in the hot water and why the dye eventually spreads evenly throughout both beakers. In this strategy, students think about the solution to the problem and then pair-up with a partner to share their ideas. After this discussion, students may change their original explanation. Review the Kinetic Theory of Matter along with changes of state among the four states of matter.

Using *split page notetaking* (view literacy strategy descriptions), have students record notes about the Kinetic Molecular Theory. See split page notes example for Kinetic Molecular Theory BLM. Students have great difficulty studying from poorly organized and/or poorly recorded notes. Taking some time to teach students methods in note taking is highly beneficial for student performance. Using overhead, print (either textbook, trade book, handout, or Internet site) or computer presentation for information, present a section of material to be covered. Students should draw a straight line from top to bottom on a page in their learning log approximately 2 inches from the left margin. In the left column, students record big ideas, names and key information with supporting information written in the right column. Urge students to paraphrase and abbreviate, but only what they can truly read and understand at a later date. The big ideas to include in this particular set of notes include matter, atoms, particles, molecules, temperature, solid, liquid, gas, average kinetic energy, and absolute zero. The teacher may determine other terms to add or delete according to the class needs. Also large amounts of material should be broken into smaller sections to be completed separately (this could be completed over a series of class periods). This technique can be used to help students organize important information and create a guide for future study.

After direct instruction on the behavior of the tiny, discrete particles of mater (atoms or molecules), have students demonstrate an understanding of the kinetic molecular theory via modeling the movement and the arrangement of the particles. As individual work and for assessment of understanding, ask students to diagram particles of matter in solid, liquid, and gaseous states. These conceptual diagrams should use circles to represent the particles of the substance showing increased distances along with the increased energy for each of the three states.

Following the completion of the concept diagrams, set up the following hypothetical situation:

> *One day the class is visited by an alien scientist that comes from the planet Mercury. The alien scientist wants to know what ice, water, and water vapor are like and how they act, because Mercury has no water.*

Tell the students they must come up with a way to describe what water is in its various forms (solid, liquid, and gas). Have each group design a way to demonstrate water in each of its states (solid, liquid, and gas) using 10-12 ping-pong or foam balls in a clear container (or plastic tub). Review their prior descriptions of the behavior of water in its various forms. Ask them if they could find someway to make all of the small balls act or behave like a single ice cube, a glass of water, or the water vapor in the air around them.

As each group is ready, have the students demonstrate their model for you (the Alien Scientist). Use the student’s explanations of the motion and behavior of the small balls, in describing the various forms of water, to show similarities between the motion and behavior of molecules and atoms in solids, liquids, and gases. Explain that all matter is made up of different kinds of atoms and different arrangements of atoms. Discuss the strengths and weaknesses of using the ping-pong ball analogy to describe matter in its various forms.

For information about the Kinetic Molecular Theory: www.psinvention.com/kinetic.htm

Activity 5: Rates of Dissolving (SI GLEs: 3, 4; PS GLEs: 13)

Materials List: beakers, graduated cylinder, hot plate or hot pots, sugar cubes, hot gloves, water, alcohol thermometer, wax paper, stop watch or clock with second hand, stirring rods, balance, index cards, safety goggles, science learning logs

Prior to this activity, identify safety concerns and review all safety rules.
Students should have prior knowledge of how one substance dissolves into another. In this simple activity, students will investigate the factors that affect the time it takes sugar to dissolve. Prior to the activity, discuss medicines used for stomach aches and have students record in their science *learning logs* (view literacy strategy descriptions), predictions of how to make various stomach ache remedies work faster or more efficiently.

Students should work in groups of three to four. Teacher note: Electric hot pots are a good alternative to hot plates for heating water in classrooms not equipped with separate lab stations. Review the lab procedures, have students create a data table to record the data to be collected during the lab. Have students crush one sugar cube in wax paper while leaving a second cube whole. Measure the mass of each to make sure they are equal masses (sugar crushed vs. sugar cube). Equal amounts of hot water should be placed into two beakers. Place the crushed sugar cube into one beaker at the same time as the whole sugar cube is place in the other beaker. Begin timing and record the time it takes for the sugar in each beaker to completely dissolve (no longer visible). Do not allow students to stir or shake the beaker.

If class time allows, have students *brainstorm* (view literacy strategy descriptions) (additional testing variables). Lead them to the following tests (or in a shortage of time assign the following tests). It is always advantageous for the student to determine testing criteria or to have the teacher lead them to the appropriate testing criteria.

Repeat the experiment using the following criteria:
1-hot water in each beaker, sugar cube in one, crushed sugar cube in the other, stir both at equal rates
2- hot water and room temperature water in each beaker, crushed sugar cube in both, no stirring
3—hot water and room temperature water in each beaker, crushed sugar cube in both, stirring at equal rates.

Using their experimental data, have students analyze the relationship between particle size (surface area) and rate of dissolving and the relationship between temperature and the rate of dissolving. Students should record their analysis in their journals or learning logs. Students should use their knowledge of the Kinetic Theory of Matter to explain their observations and results. Students should also indicate independent and dependent variables along with controlled variables utilized during the experiment. Review students' predictions about the types of stomach remedies that might work faster and discuss any revisions to their original ideas they may have after experimentation. Discuss the real world connections they see in everyday life to dissolving rates (drink mixes, cooking methods, types of medicines, manufacturing of chemicals, etc.)

Through direct instruction, define the terms *solute*, *solvent* and *solubility*. Have students make additional *vocabulary cards* (view literacy strategy descriptions) to add to their existing unit *vocabulary cards*.

Activity 6: It's All Just a Phase (SI GLE: 5; PS GLEs: 19, 20)

Materials List: ice, water, thermometer, hot plate, beaker, graph paper, safety goggles, science learning logs

Prior to this activity, all essential safety precautions should be identified and discussed by students and the teacher. Students should make a prediction of what a temperature vs. time graph of water would look like as solid ice is heated to water vapor. A rough sketch of the expected graph should be recorded in their journal or science *learning log* (view literacy strategy descriptions). As a demonstration or in small groups, heat a known amount of ice (in a water slurry) while recording the temperature at measured time intervals until the ice has melted, boiled, and a small amount has vaporized. Care should be taken to provide the same amount of energy throughout the observation. (Keep the Bunsen burner or hot plate at the same setting for the entire procedure.) Instruct students to record temperatures in a data table and use that data to create a temperature vs. time graph. Have the students analyze the graphical information. The teacher should use guiding questions to elicit the relationship between particle motion, energy changes, and the various states of matter. Have students analyze the graph to determine when there is a phase transition and why there is sometimes no temperature change even though additional energy is being absorbed. Ask students what they think is happening when energy is being absorbed and there is no accompanying temperature rise. Students may record observations in their journals in a student created data table and should complete the graph individually. Students should label freezing/melting point (which does not change due to the heat of fusion) and the condensation/boiling point (which does not change due to the heat of vaporization) on their graphs. After student data sheets have been collected or science *learning log* entries are completed, conduct a class discussion in which the accuracy of various responses is discussed and the class reaches a consensus on a correct analysis. In lieu of the actual demonstration, students could be provided with heating curve data for water and allowed to graph and analyze the resulting heating curve.

If temperature probes and graphing calculators or laptops are available, this lab can be performed to utilize current educational technology to collect this data and analyze results.

Activity 7: Changes of Matter: Physical or Chemical. (SI GLEs: 1, 2, 9, 10; PS GLEs: 21, 22)

Materials List: wooden craft stick, match, salt, evaporating dish or beaker, dry ice, aluminum foil, copper II nitrate solution, effervescent tablet, sealable plastic bag, rubber band, safety goggles

The purposes of this activity are to (1) observe both physical and chemical changes and (2) classify changes as physical or chemical. To assess prior knowledge, have the class compile a list of changes that indicate that a chemical reaction has taken place.

Provide student groups with an overview of the following laboratory investigation and be sure that they review and follow all safety procedures during this activity. Next, have them design a data table for recording observations, as well as identifying and recording the appropriate safety measures for this investigation. For the investigation, provide the students with a series of tasks to accomplish, such as breaking a wooden craft stick, striking and burning a match, putting sodium chloride in an evaporating dish and adding water, observing dry ice, putting a sliver of aluminum foil into a copper II nitrate solution, dropping an effervescent tablet into a sealable plastic bag containing water and then sealing the bag, and stretching a rubber band (or any other appropriate examples with available materials). Using their data table, students should first predict or hypothesize whether the substance will experience a physical or chemical change. Have groups conduct the investigations and record their observations in their data table. Have students conclude from their observed evidence whether or not a physical or chemical change occurred and cite evidence from their observations to justify their conclusions.

Through discussion, assist students in realizing that scientists gather data in different ways, not solely from experimentation, such as this experiment, but through other means such as observation, description, a literature survey and classification. Have students to suggest examples of major scientific discoveries that were made outside of the experimental lab (e.g., Newton's observation of the falling apple, observation through telescopes or microscopes, failed experiments such as Teflon, etc.).

Activity 8: Is it Physical or Chemical? (SI GLEs: 5, 7; PS GLEs, 11, 21, 22, 27)

Materials List: 4 pint size sealable plastic bags per group, sodium bicarbonate, water, calcium chloride, phenol red, plastic film canister or small test tube (to hold water/phenol red), tablespoon measuring spoons, splint or birthday candle, safety goggles, science learning logs, Physical or Chemical Change? BLM

As the sealable plastic bags expand, care should be used to prevent excessive pressure build-up. The bags may burst. Have students wear safety goggles at all times.

Prior to this activity, all essential safety precautions should be discussed taking note of containing loose hair, jewelry, clothing, etc. Students should work in groups of 3 to 4 students to complete this activity. Students are to conduct at least five observations of interactions between substances and label each as a chemical or physical change along with other observations. All observations should be recorded in their science *learning logs* (view literacy strategy descriptions). (Depending on time, other combinations of possible reactants can be observed and recorded as determined by teacher. See Physical or Chemical Change? BLM for a suggested data table, including answers.) To save on class time, students will use tablespoon measuring spoons (or plastic tablespoons) to measure solid materials rather than measuring out a specific amount in grams. This will save a tremendous amount of class time and allow students to have time to conduct all observations within one class period. Also the plastic bags can be rinsed out and reused if not damaged.

Bag 1: In a sealable plastic bag (pint size works well due to the production of gas in some of the bags), students should place 2 Tbsp, or 2 scoops of sodium bicarbonate (baking soda) and squeeze out excess air. Add 10 mL of water and quickly seal the bag. Students should shake the bag and record observations in a data table.

Bag 2: In a second sealable plastic bag, students should placed 1 Tbsp, or 1 scoop of calcium chloride and repeat the addition of 10 mL of water as in the first observation. Students should record observations.

Bag 3: In a third sealable plastic bag, place 2 Tbsp, or 2 scoops of sodium bicarbonate and 1 Tbsp, or 1 scoop of calcium chloride and mix thoroughly. Students should record observations.

10 mL of water should be added to bag 3, quickly remove excess air and close the baggie. Have students record observations.

In a sealable plastic bag, students should repeat experiment three, but replace the water with 10 mL of Phenol Red indicator and record their observations.

Instruct students to classify each of these changes as chemical or physical. They should utilize their observations from their data table to make their decisions. Ask students what the indicator in the fourth observation told them about the observed reaction? Ask students if they can identify the gas produced (CO_2)? Ask how they could test this prediction. Show students how to write a chemical equation for any chemical reaction that might have taken place. Depending on the level of your students and because this is an introductory activity to chemical reactions, the reaction can be written in words or chemical symbols. Lead students to define endothermic and exothermic reactions in their science *learning logs*. Ask if this is a physical change or a chemical change? and have students record their results.

Teacher Notes:

1) *a. There is a physical change in the first bag (dissolving)—see #5*
   b. A physical change occurs in the second bag (dissolving)
   c. In the third and fourth bags, a chemical change occurs—see #4 for equation
2) *The indicator should show that the reaction occurring in the third and fourth bag is acidic. Phenol Red will turn from red to yellow in the presence of an acid.*
3) *The gas that is produced is carbon dioxide, CO_2. It is formed from the carbonate ion, HCO_3^-. A burning splint or small birthday candle would show that the gas extinguishes the flame. Some fire extinguishers use carbon dioxide for this reason.*
4) *For teacher information, the chemical changes that occur in bags 3 and 4 can be represented by the following equation:*
   $2\ NaHCO_3\ (aq) + CaCl_2\ (aq) \text{->} CaCO_3\ (aq) + 2\ NaCl\ (aq) + H_2O\ (l) + CO_2\ (g)$
   For advanced students, the teacher could use the chemical reaction as an example of students' future learning. This activity serves as an introduction to chemical reactions. Students will learn how to name these chemicals by reading the formulas, predict products from the reactants, and write and balance equations such as this in the upcoming units of study.
5) *A physical or chemical change may be accompanied by a change of energy. If the change requires heat from the environment, it is said to be endothermic.*
   Solute + Solvent + HEAT ---> Solution (physical)
   Or Reactants + HEAT ---→ Product (chemical)
   If it releases energy to the environment, it is said to be exothermic.
   Solute + Solvent ----> Solution + HEAT (physical)
   Or Reactants ---→ Product + HEAT (chemical)
6) *Phenol Red can be used to show the presence of an acidic solution. It can be purchased at a swimming-pool supply store. Many common foods can also be used as pH indicators. One of these is red cabbage juice.*

Disposal:

Solid wastes may be placed in a solid-waste container. All solutions may be poured down the drain, followed by water. When calcium chloride is dissolved in water, heat is given off. Handle these solutions with care.

Sample Assessments

General Guidelines

Assessment techniques should include use of drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

- Students should be monitored throughout the work on all activities via teacher observation and lab notebook entries.

- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will demonstrate an ability to classify several types of matter (elements, compounds, mixtures) through a laboratory practical. Stations with examples of each type of matter should be included.
- The student will develop concept maps of matter, demonstrating an understanding of terms related to compounds, elements, and mixtures.
- The students will raise their hands as they smell the fragrance, after a small amount of room fragrance is sprayed in a far corner of the room. Have students explain the movement of the fragrance through the room using the Kinetic Molecular Theory.
- The student will predict the heating curve of various substances when given the melting/freezing point or vaporization/condensation points.
- The student will explain the difference between observable physical and chemical changes. Student responses with be evaluated with a teacher-made rubric.

Activity-Specific Assessments

- <u>Activity 4</u>: The student will draw\illustrate diagrams of all six phase changes: solid to liquid, liquid to solid, solid to gas, liquid to gas, gas to liquid, and gas to solid.

- <u>Activity 5</u>: Students will write a short analysis ranking the solubility of different substances dissolved in water such as, sugar, flour, powdered drink, cornstarch, instant coffee, talcum powder, soap powder, and gelatin. The same amount of each substance will be dissolved in water at the same temperature.

- <u>Activity 6</u>: The student will label freezing/melting points and condensation/boiling points when given a general phase diagram of any substance. Students will draw a small rectangle at each slope of the graph and illustrate the movement of the matter at that phase of the graph. Evaluate for accuracy.

Physical Science
Unit 3: Atomic Structure

Time Frame: Approximately four-five weeks

Unit Description

Utilizing inquiry processes and modeling techniques, students explore current atomic theory. Emphasis will be placed on utilizing the periodic table as a tool to understand periodic trends and chemical nomenclature. Through research and discussion, students will differentiate between fission and fusion and debate the issues relating to nuclear reactions and radiation.

Student Understandings

Knowledge of atomic structure includes identifying subatomic particles and comprehending various models of the structure of the atoms. Students will draw Bohr models, identify implications of the arrangement of the periodic table and explain periodic trends. Students will learn to name compounds and identify ionic and covalent compounds. Students should be able to differentiate between atomic fission and fusion and their end products.

Guiding Questions

1. Can students interpret models of atoms (Thomson's Plum Pudding Model, Rutherford's Model, Bohr Model, and Electron Cloud Model)?
2. Can students list the major components of an atom and provide the charge for each?
3. Can students recognize and explain patterns, simple periodic tendencies, and the relationship between placement on the periodic table and bonding?
4. Can students diagram a Bohr model for a given atom?
5. Can students use and interpret simple chemical symbols and formulas that scientists use to represent matter?
6. Can students model or interpret diagrams of simple organic compounds?
7. Can students describe radioactivity?
8. Can students differentiate between atomic fission and fusion?

Unit 3 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
2.	Describe how investigations can be observation, description, literature survey, classification, or experimentation (SI-H-A2)
4.	Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
8.	Give an example of how new scientific data can cause an existing scientific explanation to be supported, revised, or rejected (SI-H-A5)
11.	Evaluate selected theories based on supporting scientific evidence (SI-H-B1)
13.	Identify scientific evidence that has caused modifications in previously accepted theories (SI-H-B2)
Physical Science	
3.	Distinguish among symbols for atoms, ions, molecules, and equations for chemical reactions (PS-H-A2)
4.	Name and write chemical formulas using symbols and subscripts (PS-H-A2)
5.	Identify the three subatomic particles of an atom by location, charge, and relative mass (PS-H-B1)
6.	Determine the number of protons, neutrons, and electrons of elements by using the atomic number and atomic mass from the periodic table (PS-H-B1)
7.	Describe the results of loss/gain of electrons on charges of atoms (PS-H-B1) (PS-H-C5)
8.	Evaluate the uses and effects of radioactivity in people's daily lives (PS-H-B2)
9.	Compare nuclear fission to nuclear fusion (PS-H-B2)
10.	Identify the number of valence electrons of the first 20 elements based on their positions in the periodic table (PS-H-B3)
12.	Classify elements as *metals* or *nonmetals* based on their positions in the periodic table (PS-H-C2)
15.	Using selected elements from atomic numbers 1 to 20, draw Bohr models (PS-H-C5) (PS-H-B3)
16.	Name and write the formulas for simple ionic and covalent compounds (PS-H-C5)
17.	Name and predict the bond type formed between selected elements based on their locations in the periodic table (PS-H-C5)
18.	Diagram or construct models of simple hydrocarbons (four or fewer carbons) with single, double, or triple bonds (PS-H-C6)

Earth and Space Science	
5.	Explain how the process of fusion inside the Sun provides the external heat source for Earth (ESS-H-A3)
27.	Trace the movement and behavior of hydrogen atoms during the process of fusion as it occurs in stars like the Sun (ESS-H-D5)

Sample Activities

Activity 1: Rutherford's Simulation (SI GLEs: 2, <u>4</u>, <u>7</u>, 8, <u>11</u>, 13; PS GLE: <u>5</u>)

Materials List: Part 1: various research materials, Internet access, if possible
Part 2: copy of Atomic Simulation- 40 mm Circles BLM, Atomic Simulation- 25 mm Circles BLM, Top Page BLM, carbon paper, blank paper, 1.5 cm steel ball bearing or steel marble, ruler, calculator (one set per group), science learning log
Part 3: no additional materials

Part 1: To introduce modern atomic theory, review the evolving model of the atom including the ideas of Democritus, Aristotle, John Dalton, J.J. Thomson, Ernest Rutherford, Neils Bohr, and Erwin Schrodinger. Explain that scientific investigations can include descriptions, literature surveys, classifications, and research. Assign each group a scientist to research. Groups should prepare a poster presentation to model and explain each scientist's theory of the atom. Students should include some history of how the scientist's model was accepted by the scientific community of that time, and how the proposed model may have changed over time (and/or how it led to further explorations). Discuss how scientists have used indirect evidence to determine the modern theory of atomic structure and how our modern view of the atom has evolved. Through this process, students should come to understand that scientific investigations can be literature surveys, descriptions, or classification rather than simply experimentation.

Part 2: For this part of the activity, students will model Rutherford's gold foil experiment where he drew data from indirect measurements about the structure of the atom (the small nucleus containing the positively charged protons and the atom consisting mostly of empty space where the negatively charged electrons are found). Students will learn how to make an indirect measurement of a model "atom," a circle. Working in groups of 3 to 4, have students place one of the Atomic Simulation BLM face down on a piece of carbon paper. (Note: There are two different Atomic Simulation BLMs with different size circles, 40 cm diameter and 25 mm diameter. The teacher may choose for each group to use the same size circle or may choose for different groups to have different size circles.) Lay the Atomic Simulation BLM face up on the table and place the carbon paper face down on top of the Atomic Simulation BLM. The Top Page BLM should be placed on top of this stack with the rectangle facing outward. This stack of three should be taped securely as a group to the floor or the tabletop and the students should not be able to see the circles (atoms). The ball bearing will be dropped from a height of approximately 30 cm above the paper 100 times inside of the rectangle on the Top Page BLM. The ball bearing should be caught after one bounce on each drop so only one mark per drop will be recorded on the sheet of paper by the carbon paper and a false reading will not be recorded. The drops should be random and should cover the entire rectangle evenly when complete (don't count drops outside the rectangle). Have students take turns dropping the bearing 25 times each and only count the drop if it hits the paper. Note: It may help to have a dropper and a catcher to prevent double marks.

Students will now use indirect measurements to calculate the diameter of the circle in millimeter. After 100 drops, have students

1. Remove the stack of paper from the floor or tabletop and discard the carbon paper and the Top Page BLM.
2. Using the page with circles and carbon marks, count and record the total number of marks that hit the paper. This number should be 100, but due to miscounting it may be a few more or few less. If the mark is not completely on the paper do not count it.
3. Count and record the total number of marks that are completely inside the circles. Do not include those that might touch the edge of the circle.
4. Measure the dimensions of the rectangle in millimeters and calculate its area

Since the circles are all the same size and the marks are random then the following proportion can be assumed:

$$\frac{\text{total \# circle marks}}{\text{total \# marks on paper}} = \frac{\text{total area of all the circles}}{\text{total area of rectangle}}$$

Solving for the total area of all the circles yields the following equation:

$$\text{total area of all the circles} = \frac{(\text{total \# of circle marks})(\text{total area of rectangle})}{\text{total \# marks on paper}}$$

To determine the area of one circle, divide the total area of all the circles by the total number of circles. This will tell you the area of the circle from indirect measurement.

$$\text{area of one circle} = \frac{\text{total area of all circles}}{\text{number of circles}}$$

Calculate the radius for one indirectly measured circle.
Remember: Area of circle = pi (radius)^2
Therefore: radius = square root [(area of circle) / pi]

Next, calculate the radius of the circle through direct measurement. Measure the diameter of a circle in millimeters using a ruler and solve for the radius
Remember: radius of circle = ½ diameter of circle

Compare the indirect calculation of the radius of your circle with the direct measurement of the radius of your circle. Calculate a percent error.

$$\frac{(\text{indirect radius} - \text{direct radius})}{\text{direct radius}} \times 100 = \text{percent error}$$

The radius of the circle determined by indirect methods compared to the radius of the circle calculated through direct measurement should be close. Students should have between a 5% and 15% error.

Using their science *learning logs* (view literacy strategy descriptions), have students compare and contrast their experiment with Rutherford's gold foil experiment and how he discovered that the small nucleus is made of protons (the positive charges) and that the majority of the atom is empty space where the electrons are located. They should indicate each piece of equipment used by Rutherford and how it was represented and simulated in their experiment. (alpha particle/steel ball bearing; gold foil/carbon paper; and circle/atom) They should also determine if Rutherford and his staff had a chance to calculate their percent error and the accuracy of their discoveries. Also have students identify two potential sources of error in their experiment and how they could minimize these errors if they had a chance to complete the activity again. Their analysis should also contain the most important information that Rutherford learned, i.e., that the atom contains a tiny core (the nucleus with most of the atom's mass) and is composed of mostly empty space (the electron cloud with the atom's volume).

Part 3: As a closure for this activity, have students complete RAFT writing (view literacy strategy descriptions) about Rutherford's gold foil experiment. RAFT writing offers students the opportunity to apply and extend their newly acquired knowledge from a unique perspective. The writing should be creative and informative. Allow time for students to share their writing with a classmate or with the whole class.

R—their role is an alpha particle, a particle made up of two protons and two neutrons

A—the audience is their friends (other alpha particles) back in the original radium sample, the radioactive element that emits the alpha particles

F—the form of writing is an email, letter, or postcard

T—the topic is their journey through the gold foil to their position on the zinc sulfide fluorescent detecting screen

If technology is available, a webquest, *Evidence of Atoms*, can be used for research or reinforcement and can be found online at
http://www.chemheritage.org/EducationalServices/webquest/dalton.htm
An online Indirect Observation Simulator and more information about Rutherford's experiment can be found at
http://www.chemeng.uiuc.edu/~alkgrp/mo/gk12/dreamweaver/rutherford/ and at
http://micro.magnet.fsu.edu/electromag/java/rutherford/

Activity 2: Atoms and the Periodic Table (SI GLE: 7; PS GLEs: 3, 5, 6)

Materials List: deck of playing cards (one per group)

Each group of 3-4 students will receive a deck of playing cards (or a copy of the 52 cards). The group must determine an orderly arrangement for their cards. After completing their ordering students should choose one card from the arrangement and write a procedure on locating its position in the arrangement. Different groups might have different arrangements, but their procedures must reflect this difference. Students will compare this arrangement to the arrangement of the Periodic Table. Utilizing scientific readings and direct instruction, students will learn how to "read" a square from the periodic table. Students should compare the arrangement that Mendeleev used (based on atomic mass and the elements that were discovered because of this arrangement) with the modern arrangement created by Moseley (based on atomic number).

As a formative assessment for the teacher and a study aid for students, have students begin a *vocabulary self-awareness chart* (view literacy strategy descriptions) for the Periodic Table of Elements. Students will have a range of understanding about the Periodic Table and a word grid helps the teacher and student assess their understanding of the terms before addition information and learning activities are provided. The target vocabulary should included atom, element, atomic symbol, proton, neutron, electron, nucleus, atomic number, mass number, average atomic mass, valence electrons, atomic energy levels, electron cloud, and additional blank rows for additional words to be added as the unit progresses. This *vocabulary self-awareness chart* will be maintained throughout the study of atomic structure. The teacher may want to have an ongoing *vocabulary self-awareness chart* posted in the classroom to refer to during the course of the unit. An example is provided below.

Word	+	√	-	Example	Definition
atom					
element					
atomic symbol					
proton					
electron					
neutron					
nucleus					
atomic number					
mass number					
average atomic mass					
isotope					
ions					
valence electrons					
atomic energy levels					
electron cloud					

Upon the introduction of the *vocabulary self-awareness chart*, do not provide students with definitions or examples. Allow them to rate their understanding of each word with either a "+" (understand well), a "√" (limited understanding or unsure), or a "-" (don't know at all). After direct instruction, assigned text readings, practice with the Periodic Table, completion of activity 3, activity 4, activity 5, etc., students should return to their chart often and add new information to it, with the goal being to replace all check marks and minus signs with plus signs. By continually revisiting the chart and revising their understandings, students will have multiple opportunities to practice and extend their knowledge. Make sure that students include the charge of the particles, the location where the particles are found, and their mass in relation to each other".

Activity 3: Average Atomic Mass (SI GLEs: 5, 7; PS GLEs: 5, 6)

Materials List: copy of periodic table

Students often understand weighted averages when you compare it to the calculation of grades or sports percentages, such as slugging average for baseball. As an anticipation activity, have students calculate the grade of a student that has grades of 94.0, 95.5, 91.0, 82.5, 93.5, 91.5, 92.0, 89.5, 90.0, and 93.0 with all grades counting equally. Ask students which grade affected the average the most. Did the lower grade bring the entire average down as much, why or why not? Next have students calculate a weighted average if the student will have their grade determined with 70% of their grade for tests and class work and 30% of their grade for homework. The scores are 95.0, 92.0, 91.5, 92.5, 91.0, 95.0, 90.0 for tests and class work and 89.0, 90.0, and 89.0 for homework. Ask which grade affected the average the most for the weighted average. This comparison should lead into the concept of relative abundance.

Through direct instruction and using the Periodic Table, make sure students understand that the atomic mass is actually an average atomic mass of all of the isotopes of that element. The abundance of each isotope is used in the calculation of this weighted atomic average mass. From the periodic table select various elements and have students determine the mass number for that element. (Average atomic mass rounded to the nearest whole number yields the mass number of the most abundant isotope for that element.) Students should calculate the number of protons, number of electrons, and number of neutrons for this selected element. Repeat as necessary until mastery is determined.

Have students complete calculations of the average atomic mass for various elements. This is done by first multiplying the atomic mass of each isotope by its individual relative abundance. These are added together to get the average atomic mass for the element. Students should complete this calculation for several elements and then compare their calculations with the atomic mass of the element from the periodic table.

Some examples might include the following:

1. chlorine-35 34.969 amu 75.77% abundance
   chlorine-37 36.966 amu 24.23% abundance
   ANSWER:
   (34.969 amu X .7577) + (36.966 amu X .2423) = 35.45 amu

2. silicon-27 27.977 amu 92.23% abundance
   silicon-28 28.976 amu 4.67% abundance
   silicon-29 29.974 amu 3.10 % abundance
   ANSWER :
   (27.977 amu X .9223) + (28.976 amu X .0467) + (29.974 amu X .0310) = 28.08 amu

Activity 4: Atomic Modeling and Families of the Periodic Table (SI GLE: 7; PS GLEs: 3, 5, 6, <u>10</u>, <u>15</u>)

Materials List: copy of the Periodic Table

Prior to this activity, discussion of the structure of the atom should have included Bohr's contributions to atomic theory. Make sure that students understand how the Bohr Model differs from the current theories of what the atom is thought to look like. However, it is an easily understood model for students to master and chemists often refer to this early atomic model to illustrate many concepts of what happens at the nanoscale level of atoms. Following a teacher demonstration, have students draw Bohr diagrams (the most abundant isotope) for selected elements from the first 20 on the periodic table. (Students can work in groups, pairs or individually). Have students use information from the periodic table in developing their Bohr model diagrams and instruct them to identify the valence electrons in their Bohr model diagrams. Students should use the average atomic mass rounded to the nearest whole number to determine the mass number (protons plus neutrons).

Incorporating their prior knowledge of atoms and subatomic particles, students should create a three-dimensional model of an atom of an assigned element following guidelines provided by the teacher. Models should be constructed of non-perishable materials and should not exceed a predetermined size.

Activity 5: Chemical Families and Their Properties (SI GLEs: 5, 7; PS GLEs: <u>10</u>, <u>12</u>)

Materials List: (per student) copy of the Periodic Table; resources with information about groups or families of the Periodic Table, such as text, trade books, Internet, etc.; science learning logs; (for teacher only, Families of the Periodic Table BLM)

After direct instruction or completion of assigned text reading, students should identify the main group or representative elements on the periodic table (groups

1,2,13,14,15,16,17,18) and complete a modified *word grid* (view literacy strategy descriptions) of families of the Periodic Table. A completed example for the teacher is available as Families of the Periodic Table BLM. *Word grids* typically have related terms in the first column and defining information or characteristics across the top row. They are most effective as a learning tool when students determine the defining information or characteristics. Have students draw a word grid in their science *learning logs* (view literacy strategy descriptions), only writing in the families in the first column. Ask students some of the characteristics of element families that they learned from their assigned text reading or direct instruction. As a group, students should come up with critical information pertaining to the families (see the Families of the Periodic Table BLM) such as metal, non-metal, or metalloid; number of valence electrons; group; oxidation number, solid, liquid or gas; physical or chemical properties; bonds easily with; etc. These characteristics identified will be determined by the class and guided by the teacher.

Allow students to complete their grid. They may work individually or in pairs as determined by the teacher. Some cells on the grid will simply have check marks or stars to indicate that characteristic and others will have numbers or short phrases to record that characteristic. Note that this *word grid* must be used with a Periodic Table. Students should not be expected to memorize the Periodic Table, but should be expected to utilize the Periodic Table to gather information and understand how it is constructed. After completion, allow students time to quiz each other over the content in the grid. Also, ask students to compare similarities and differences of the families. For example: How are the oxygen family and the nitrogen family alike in chemical properties? or How do alkali metals differ from the noble gases?

Activity 6: The Nuts and Bolts of Chemical Formulas (SI GLEs: 5, 7; PS GLEs: 3, 4)

Materials List: (per group) container of nuts, container of bolts, balance, science learning logs, calculator

Prior to this activity, review the law of definite proportions (a chemical compound always contains exactly the same proportion of elements by mass) and the law of constant composition, (all samples of a given chemical compound have the same elemental composition) if this has not been introduced. Through direct instruction, ensure that students comprehend atoms combine in whole-number ratios to form chemical compounds and chemical formulas are used as a shorthand way to show the ratios of elements in that compound. Review and show examples of the use of subscript and parenthesis in writing chemical formulas. In this activity, nuts and bolts will be used to show chemical formulas in a concrete model.

Before the activity, have student work in groups of three to four to complete the following *story chain* (view literacy strategy descriptions). Story chains allow students to use writing, and communication skills to work as a group to answer a question or complete a story. The first student initiates the story, the next, adds a second line. The next, a third line, etc. This continues until the last student is expected to solve the problem. All group members should be prepared to clarify and revise their addition to the story to help with the overall understanding of the problem.

This story is about Felix's test score (choose a name that is not represented in your classroom). He or she writes a statement of how many problems Felix missed on his recent science quiz.

> Example: Felix missed 4 problems on the Element Science Quiz.

The second student writes a statement about how many problems were on the science quiz.

> Example: Mrs. C. Wizard developed 12 problems for the Element Science Quiz.

The third student writes a statement about the score written on top of the page of science quiz.

> Example: A large red 8 out of 12 was written on Felix's paper.

The fourth student must calculate the percentage the teacher should assign to the science quiz.

> Example: Mrs. C. Wizard wrote a 67% next to the sad face on Felix's Element Science Quiz.

Students should check each other for accuracy and clarity. After the first story chain, have students write a short statement or equation in their science *learning logs* (view literacy strategy descriptions) as to how a percentage is calculated (e.g., part/whole x 100). When students understand the process, have them create other short stories about baseball batting percentages, percentage of time spent in class each day vs. time spent talking on the phone, etc. After each student has had an opportunity to answer the problem in the *story chain*, students may begin the chemical formula activity.

Announce to students that they will use the same mathematical process in calculating the percent composition of the elements Boltium (Bo--the bolts) and Nutter (Nu--the nuts) in various compounds they will form.

Each group will receive a container of Boltium, with each bolt representing an atom of Boltium, and a container of Nutter, with each nut representing an atom of Nutter. Make sure that students recognize there are no safety issues with handling our model elements!

1. Students should determine and record the mass of one Boltium atom and one Nutter atom, using a balance.

2. Using the atoms of Boltium and Nutter, they should build three different compounds listed in the table below.
3. Write the chemical formula for these compounds.
4. Using the balance, determine the mass of the compound.
5. Calculate the percent composition of each element in the chemical compound using the following formula: mass of the atoms/mass of the compound.
6. Finally, calculate the ratio of Boltium atoms in the compound and the ratio of the Nutter atoms in the compound.
7. Complete steps 2-6 for two additional compounds determined by their group.
8. Students should complete Table A.

Table A

Chemical Formula Bo_xNu_y	**mass of compound (grams)**	**% Bo** **mass of bolts / mass of compound X 100**	**% Nu** **mass of nuts / mass of compound X 100**	**ratio of Bo** **% of bolts / mass of 1 bolt**	**ratio of Nu** **% of nuts / mass of 1 nut**
Bo_2Nu_1					
Bo_6Nu_3					
Bo_2Nu_2					

Define the terms empirical formula and molecular formula through direct instruction. The simplest whole number ratio by which elements combine is written in the form of an empirical formula. The actual number of atoms of each element in the compound is called the molecular formula. Ionic compounds, which form ionically bonded lattices are written as empirical formulas and covalent compounds, which form molecules, are usually written with molecular formulas. Activity 8 concerns types of bonding, but some direct instruction concerning bonding may be appropriate at this point in Activity 6.

Have students determine the empirical formula and the molecular formula for each compound. Divide the larger of the two ratios of Bo and Nu by the smaller ratio, and then divide the smaller of the two ratios by itself to equal one. The goal is to have a ratio of Nu to Bo in the form of X: 1. If the students' ratios are not whole numbers, they should convert them to whole numbers. For example, $Bo_{0.5}Nu_1$ would become Bo_1Nu_2 or simply $BoNu_2$ since the 1 subscript is implied.

Students should complete Table B.

Compounds	**ratio of Nu**	**ratio of Bo**	**largest ratio / smallest ratio** **Is it Nu or Bo?**	**smallest ratio / smallest ratio** **Is it Nu or Bo?**	**Empirical Formula Bo_xNu_y**	**Molecular Formula Bo_xNu_y**
Bo_2Nu_1						
Bo_6Nu_3						
Bo_2Nu_2						

Activity 7: Names and Formula (SI GLE: 5; PS GLEs: 3, 4)

Material List: Periodic Table, Writing Chemical Formulas BLM

After completing Activity 6, students should understand that a chemical formula is a combination symbols and numerical subscripts that represents the composition of a compound. The symbols indicate which elements are present and the numerical subscripts indicate the relative proportion of each element in the compound. These proportions can be predicted using the oxidation numbers (charges) of the elements. When atoms acquire a charge they are called ions.

To guarantee a clear and reliable exchange of information, all scientists (not just chemists!) use the same system for writing chemical formulas. It is important for students to understand reading and writing chemical formulas. The following rules should be used for writing chemical formulas:

1. For a neutral compound, the sum of the oxidation numbers of the elements (ions) must equal zero. One positive (+) charge will neutralize one negative (-) charge.
2. Elements (ions) with a positive oxidation numbers (charges) are written first
3. When the relative proportion of the polyatomic ion in a ternary compound (one containing three or more elements) is greater than one, the symbol for that ion must be enclosed in parenthesis and followed by a numerical subscript indicating its relative proportion, as in the ternary compound Aluminum Sulfate whose formula would be $Al_2(SO_4)_3$.

Review the common polyatomic ions found on the Chemical Formulas BLM with students prior to the activity. Note: Teachers my use this BLM and/or additional similar versions with additional or substituted ions. Using the first cation and ion, follow through the process of writing the cation first followed by the anion, criss-cross the superscripts, and then write the final formula leaving off 1 as implied. Students should then write the name of the compound.

As closure to this activity have students answer the following questions and/or questions provided by the teacher through discussion or written work. Student understanding can be assessed through this process.

What is a chemical formula? What information does a subscript in a chemical formula provide? When do you need to use a parenthesis in writing a chemical formula? When do you need to use a roman numeral in the name of a compound?

Activity 8: Bonding (SI GLEs: 5, 7; PS GLEs: 4, 7, 15, 16, 17)

Materials List: science learning logs

Begin this activity by allowing students to add the terms covalent bonds, molecule, polar covalent bond, non-polar covalent bond, ionic bonds, cation, anion, crystal lattice to the *vocabulary self-awareness chart* (view literacy strategy descriptions) begun in Activity 2. If needed, review, re-teach, and practice the concepts of valence electrons, ion formation and the methods by which ionic and covalent bonding occurs between elements. As a rule of thumb, typically metals and non-metals form ionic compounds, non-metals and non-metals form covalent bonds, and transition metals and non-metals can form ionic bonds and sometimes covalent bonds.

Have students utilize the periodic table and Bohr diagrams to predict ion formation. Next, incorporating their knowledge of valence electrons, the octet rule, and the periodic table, have students predict and record the bonding tendencies (i.e., ionic bond or covalent bond) between two stated elements. Once the predictions have been made, have the students, working in pairs, draw the formation of the bond between the elements via manipulating the electrons associated with each in atomic models. Lewis Dot diagrams work well for visualization in this activity. Students should identify each diagram as a covalent, ionic, or metallic compound.

Depending on the level of the students, teachers may want to include the more common covalently bonded, polyatomic ions as possible cation (ammonium) and ions in this activity. They may be included initially or as an extension to the original discussion.

Return to the *vocabulary self-awareness chart* (view literacy strategy descriptions) to update and identify new connections and additional comprehension.

After forming the chemical bond, students should then identify and record the compound's formula and name, using correct chemical nomenclature.

Activity 9: Nomenclature of Chemical Compounds---Its all in a Name (SI GLEs: 2; PS GLEs: 4, 16, 17)

Materials List: several stock chemical bottles, various chemical formulas written on the board or overhead

In this activity, students will investigate how to name simple chemical compounds through classification and description. Begin the activity by displaying several stock chemical bottles (5--10) from the chemical inventory. Leave the chemical formula exposed while covering up the name and record the formulas on the board. Some common examples might be sodium chloride, ammonium chloride, sucrose, glucose, potassium nitrate, potassium chloride, water, hydrochloric acid, nitrogen dioxide, hydrogen gas, etc. The teacher won't obviously have all of these particular compounds in the classroom, but some can be found and additional examples can be provided on the board. Instruct the students to convert the chemical formulas into names. First, students must identify the compound as ionically bonded or covalent bonded (or diatomic in the case of hydrogen gas). Instruction should follow as needed on chemical nomenclature of binary compounds and polyatomic ions. Care should be taken to ensure that students understand the use of subscripts in formulas (review activity 6 and 7 if needed). Provide students with additional opportunities to practice writing compound formulas and names.

Activity 10: Hydrocarbons (SI GLE: 7; PS GLE: 18)

Materials List: Hydrocarbons BLM (one per group), gumdrops, toothpicks

Provide direct instruction, with visuals, on structural formulas of carbon compounds**.** Prior to constructing 3-D models of molecules, students should identify structures (isomers) and functional groups (-OH, -COOH, benzene rings, etc.) identifiable with hydrocarbons and other carbon based molecules. Students should work in groups of four, using gumdrops and toothpicks to build simple carbon molecules (NOTE: gumdrops are used because they are inexpensive and easy to attach to the toothpick. Students are NOT allowed to eat the gumdrops because they are reused by each class and are touched by multiple people. Remind students of the possible hazards of eating in the chemical lab setting.) Provide each group with a copy of the Hydrocarbons BLM containing the molecular formulas of various hydrocarbons. Remind and review with students that the empirical formula for many covalent compounds is not the correct structural molecular formula for the actual formula. When supplying students with gumdrops and tooth picks, make sure you designate carbon with a dark color and hydrogen with a light color. (Predetermine colors for other elements such as oxygen and nitrogen if used. See examples on the Hydrocarbons BLM). Set down the following rules:

1. Carbon has 4 bonds.
2. Hydrogen has 1 bond.
3. The hydrogen atoms must be as far apart as possible from the other hydrogen atoms.

Let students work on building models, making sure they represent the different molecular formulas assigned to them. Instruct them to make sure they incorporate the tetrahedral bond angle on the model to be correct. The teacher should circulate throughout the room to determine correctness of the molecule, re-teach if necessary to correct misconceptions, and provide assistance where necessary.

Activity 11: Nuclear Reactions (SI GLE: 2, 5; PS GLE: 8, 9; ESS: 5, 27)

Materials List: research materials that might include science text, trade books, downloaded and printed Internet articles, newspaper articles, appropriate video or video segments; Nuclear Reactions Venn Diagram BLM

Using a *graphic organizer* (view literacy strategy descriptions) such as a Venn diagram (example is the Nuclear Reactions Venn Diagram BLM), ask students to compare and contrast nuclear fission, nuclear fusion, and radioactive decay by conducting a literature survey. They should place information that is shared by all three in the center common circle, information shared by any two types of nuclear reactions in their common overlapping area, and information individual to the nuclear reaction in its individual circle. Students should gather information through text readings and Internet or library research. To ensure student understanding, students should work individually on the initial research, and then share information with a partner to check for similarities and/or discrepancies. The use of diagrams or video segments to explain radioactivity and the difference between the processes of nuclear fission and fusion and radioactive decay are good review techniques. Ask students if they know what generates Earth's internal heat. Explain that decay of radioactive isotopes and gravitational energy generates Earth's internal heat.

Radiation exposure is measured in millirems (mrems). Common yearly exposure in an individual's daily life is around 360 mrems per year. For people working with nuclear materials, levels under 5,000 mrems per year are considered safe. Most students have the misconception that any radiation exposure is harmful and are not aware that they are exposed to small amounts of radiation at all times during their routine daily activities. If access to the Internet is available, an interesting activity is calculating students' personal yearly radiation exposure from American Nuclear Society's Radiation Dose Chart found at http://www.ans.org/pi/resources/dosechart/. There is also a printable version of the Radiation Dose Chart found at the above site that the teacher can download and copy for students to complete if access to the Internet is not available to the classroom.

To include a real-life application of radiation, ask students if they know what generates Earth's internal heat. Explain that decay of radioactive isotopes and gravitational energy generates Earth's internal heat. As a practical application activity, have students use colored disks of paper or plastic to construct a diagram illustrating the steps of hydrogen fusion in the Sun and stars. An illustration and movies of this four-step process of Hydrogen Fusion is available online at http://www.windows.ucar.edu/tour/link=/sun/Solar_interior/Nuclear_Reactions/Fusion/Fusion_in_stars/H_fusion.html. A diagram of this process can also be found at http://hyperphysics.phy-astr.gsu.edu/hbase/astro/procyc.html. Use different colored disks for the following particles: hydrogen protons, a positron (energy released), and a neutron. To introduce fusion modeling, use the colored disks to demonstrate that when a proton emits a positron, it is converted to a neutron. Instruct students that the steps to include in their diagram are

1. Two hydrogen protons fusing
2. The release of a positron (energy)
3. Deuterium (1 proton and 1 neutron)
4. Fusing one more hydrogen proton with the deuterium to form He^3
5. Fusing two He^3 nuclei and releasing two hydrogen protons to form a helium nucleus composed of two protons and two neutrons.

Explain to students that the fusion process that they have illustrated is responsible for the production of the vast amounts of energy that radiates from the Sun and stars. Conclude with a class discussion on the use of fission in nuclear reactors to produce energy and why fusion has not been used for energy production.

Activity 12: Opposing Viewpoints: Advantages and Disadvantages of Nuclear Energy (SI GLEs: 5; PS GLE: 8, 9)

Materials List: Is Nuclear Energy Safe? Opinionnaire BLM, various types of research materials, science texts, Internet, trade books, journal or newspaper articles, history texts, etc.

Have students complete an *opinionnaire* (view literacy strategy descriptions) about nuclear energy. An example is the Is Nuclear Energy Safe? Opinionnaire BLM. Opinionnaires are highly beneficial in promoting deep and meaningful understandings by activating and building relevant prior knowledge and igniting interest in and motivation to learn more about certain content areas. They also allow students to self-examine their own ideas, attitudes, and points of view. They also provide a vehicle for influencing others with their own ideas.

After completing the pre-debate section of each statement, indicate if they agree or disagree with each statement. It is advisable to have students complete this in ink so they are committed to a particular stand. Through discussion, evoke from the students ways that nuclear energy has not only been helpful to man (in the treatment of cancer) but also ways that nuclear energy has been harmful to man (e.g., aftermath of the atomic bomb) as well.

With this discussion in mind, establish teams in order to debate the issue, How safe is nuclear energy? (If students have not had experience with debates, model and/or discuss expected behaviors for debating.) There are two ways to set up a classroom debate. You can simply divide the class into two teams and have them represent viewpoint of the two sides (safe vs. not safe). Another way to set up a classroom debate is to assign the debate to two groups of students, perhaps 4-5 students on each side. The remaining students must still conduct research as they will prepare questions for one or both sides of the debate after the opposing sides have presented their arguments supporting their stance.

Give students the opportunity to prepare their arguments and/or questions by allowing them time to conduct research as well as compose their strategy with their teammates. Students should logically defend their position using direct historical evidence for this analysis.

After the debate, have students complete their *opinionnaire* indicating if they agree or disagree with each statement after hearing the presentation of both sides and also after their own personal research. Have students share with the class any changes they may have had and why.

Sample Assessments

General Guidelines

- Students should be monitored throughout the work on all activities via teacher observation and journal entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- When possible, students should assist in developing any rubrics that will be used.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will compare valence electrons for elements in various families, alkali metals, alkali earth metals, boron, carbon, nitrogen, oxygen, halide, and noble gases and analyze for the compounds they form.
- The student will calculate average atomic mass for various elements, using mass number of the isotope and its percent abundance.
- The student will demonstrate their understanding of terms, compounds, ions, bonding, etc. with a chemistry bingo game. The teacher should design cards with various terms using standard bingo format. Play the bingo game to determine student understanding of concepts. A template for a version of *Chemistry Bingo* can be found online at http://www2.ncsu.edu/ncsu/pams/science_house/learn/CountertopChem/exp30.html

Activity-Specific Assessments

- Activity 4 and 5: The student will state families, periods, metals, nonmetals, and number of valence electrons or electron energy levels of an element based on its position on the periodic table when provided with a blank periodic table.

- Activity 11: The student will label diagrams illustrating fusion and fission reactions correctly, indicating the correct names of the subatomic particles involved in the reactions.

- Activity 12: The student will be given points for accurate statements or well-defined questions during the debate. The teacher might assign team points or designate a student or team of students to assign points during the debate.

Resources

- Information of Rutherford's gold foil experiment: Online at http://science.howstuffworks.com/atom6.htm

- Information on radioactive decay: Online at
- http://ithacasciencezone.com/chemzone/lessons/11nuclear/nuclear.htm

- Additional activities, resources, demonstrations from University of Wisconsin-Madison Chemistry Professor Bassam Z. Shakhashiri: Online at http://scifun.chem.wisc.edu/

- American Chemical Society resources: Online at http://www.chemistry.org/acs/

- Printable Periodic Table and other interactive activities: Online at http://education.jlab.org/itselemental/index.html

Physical Science
Unit 4: Chemical Reactions

Time Frame: Approximately three weeks

Unit Description

Chemical reactions will be classified and related to the law of conservation of matter and the balancing chemical equations. The pH of substances will be investigated using a variety of indicators. Chemical concepts will be applied to students' personal environments.

Student Understandings

Students will observe a number of chemical changes and predict the results of planned laboratory activities and investigations.. Students will identify the signs of a chemical reaction, name chemical compounds from the formula, determine the correct formulas for compounds using information on elements in the periodic table, classify chemical reactions, balance chemical equations, identify endothermic and exothermic reactions, and measure temperature and pH changes

Guiding Questions

1. Can student identify evidence of chemical reactions?
2. Can student differentiate among types of simple chemical reactions?
3. Can student explain the purpose for balancing equations?
4. Can student recognize the relationship between the mass of the products and the mass of the reactants in a chemical reaction?
5. Can student describe the effects of various factors on the rate of a chemical reaction?
6. Can student differentiate among acid, base, and neutral substances?
7. Can student determine the pH of substances using indicators and classify the substances as acid, base, or neutral?
8. Can student relate chemistry to everyday life?

Unit 4 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
2.	Describe how investigations can be observation, description, literature survey, classification, or experimentation (SI-H-A2)

GLE #	GLE Text and Benchmarks
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
10.	Given a description of an experiment, identify appropriate safety measures (SI-H-A7)
14.	Cite examples of scientific advances and emerging technologies and how they affect society (e.g., MRI, DNA in forensics) (SI-H-B3)
Physical Science	
1.	Measure the physical properties of different forms of matter in metric system units (e.g., length, mass, volume, temperature) (PS-H-A1)
21.	Classify changes in matter as *physical* or *chemical* (PS-H-D1)
22.	Identify evidence of chemical changes (PS-H-D1)
23.	Classify unknowns as *acidic*, *basic*, or *neutral* using indicators (PS-H-D2)
24.	Identify balanced equations as neutralization, combination, and decomposition reactions (PS-H-D3)
25.	Determine the effect of various factors on reaction rate (e.g., temperature, surface area, concentration, agitation) (PS-H-D4)
26.	Illustrate the laws of conservation of matter and energy through balancing simple chemical reactions (PS-H-D5) (PS-H-D3) (PS-H-D7)
28.	Identify chemical reactions that commonly occur in the home and nature (PS-H-D7)

Sample Activities

Activity 1: Evidence of Chemical Reactions (SI GLE: 5, 9, PS GLEs: 1, 21, 22)

Materials List: 24 well reaction plate, plastic beral pipettes, 1M hydrochloric acid, 1M sodium hydroxide, sodium bicarbonate, 0.1 M silver nitrate, forceps or spatula, blue litmus paper, aluminum foil, mossy zinc, magnesium ribbon, alcohol thermometer or temperature probe, science learning log, safety goggles, gloves, aprons

Part 1: Students will complete a modified *word grid* (view literacy strategy descriptions) to label chemical and physical changes. A word grid provides students with an organized framework for learning related terms through analysis of their similarities and differences. In this case, students will be learning to differentiate two types of reactions. A sample (with answers) is provided below.

	chemical change	physical change
nail rusting	Y	N
sugar dissolving in tea	N	Y
powdered drink mix dissolved in water	N	Y
ice melting	N	Y
bread toasting	Y	N
paper tearing	N	Y
. . . similar types of examples		

Make sure students understand that physical changes do not change the chemical make up of a substance. A major student misconception is that dissolving of a substance is a chemical change rather than simply a physical change. Provide time for students to quiz each other over the content of the grid in preparation for class activities and tests.

Part 2: PRIOR TO THIS ACTIVITY REVIEW ALL SAFETY PROCEDURES. Students will use a 24 well reaction plate (or individual test tubes if well plates are unavailable) to observe several chemical reactions. (TEACHER NOTE: this can be done as a whole class demonstration using the overhead and one reaction plate.) Have students prepare a data table to record observations in their science *learning logs* (view literacy strategy descriptions). Students should measure and record the temperature of each solution before and after the reaction. Make sure that the thermometer or temperature probe is rinsed thoroughly and dried between readings. They will record all observations of reactants and products immediately after the reaction and again 5-10 minutes after the reaction. Use beral pipettes to deliver all solutions into the reaction plate.

1. Add 1 mL of 1 M hydrochloric acid, HCl to each of the six wells in row 1. Record the temperature and appearance of the HCl.
2. Test well 1 with blue litmus paper and record results.
3. Add 1 mL of 1 M sodium hydroxide, NaOH to well 1. Record temperature and test with a new piece of blue litmus paper.
4. Add small pinch (spatula tip) of sodium bicarbonate, $NaHCO_3$ to well number 2, record observations.
5. Add 1 mL 0.1 M silver nitrate, $AgNO_3$ and record all observations.
6. Using forceps add a small piece of mossy zinc to well 4 and record all observations.
7. Use forceps or spatula tip to add one small piece of aluminum foil rolled into a small ball into well 5 and record all observations.
8. Add one small piece of magnesium ribbon to well 6 and record all observations.

Have students review their reactions and compile a list of observations that indicate a chemical reaction took place. Make sure that students understand that some of these observations will be present during a physical change as well, but often two or more are present with a chemical change. Have students defend their conclusions that they draw from their observations. Observations should include formation of a solid precipitate, formation of a gas, color change, pH change, and temperature change. Two reactants showed no change, indicating no reactions. During the discussion of results, make sure students understand that other indications of a chemical reaction include the formation of light or fire and that pH change, temperature change, and color change can also be observed in physical changes such as dissolving, as was seen in Unit 3 activities. Often we know that a chemical reaction has occurred because more than one of these indicators is present.

Activity 2: Classifying Reaction Types (SI GLE: 5; PS GLEs: 21, 22, 24)

Materials List: science learning logs

Begin this introductory activity with a *Directed Reading-Thinking Activity, DR-TA* (view literacy strategy descriptions). To help students comprehend text that describes and provides examples of the types of chemical reactions, use the appropriate section of text (information can also be found at http://dbhs.wvusd.k12.ca.us/webdocs/Equations/Equations.html at Reaction Types Tutorial Section) and take students through the following steps:

- Ask students to categorize the types of chemical reactions with which they may be familiar and record. Record student responses on board or overhead.
- Ask questions that invite predictions, such as the following: Why do scientists classify information? Based on what we've already discussed, what do you expect to learn about chemical reactions in this reading? Have students write their predictions in their science *learning logs* (view literacy strategy descriptions).
- Allow students to read the appropriate section of text concerning types of chemical reactions, stopping after reading about single replacement reactions to revise their predictions. Ask students to reread their predictions. They should revise or add to their predictions if necessary and record the appropriate information about single replacement reactions. Repeat this cycle several times as you and your students read through each of the reaction types. When finished, have students summarize what they have just read in their science *learning logs*. Have them share their summaries with another student and allow peer review to determine if their summaries are complete and can be supported with information from the text.
- Once the reading is completed, use student predictions as a discussion tool. Ask students to reflect on their original predictions and track changes in their thinking and understanding about the types of chemical reactions as they confirmed or revised their predictions. Students should write statements of overall understanding in their science *learning logs*.

Emphasize to students that they should use this same process when they read their science textbook on their own to aid in their understanding of various topics. By reading small portions of text and recording notes, they can develop a better understanding of the required content material.

Activity 3: Observing Reaction Types (SI GLE: 5; PS GLEs: 21, 22, 24)

Materials List: 50 g mossy zinc, 50 mL 1.0 M copper II sulfate solution or aluminum foil, 50 mL 1.0 M copper II chloride solution, 50 mL 0.1 M copper II chloride solution and 50 mL1.0 M sodium phosphate solution, 50 mL 1 M sodium hydroxide, 50 mL 1M hydrochloric acid, aluminum foil, steel wool or magnesium ribbon, crucible tongs, Bunsen burner, 50 mL 3% hydrogen peroxide and 50 g manganese oxide or solid manganese, test tubes or 24 well reaction plate, Petri dish, 250 mL beaker, universal indicator, science learning logs, Types of Chemical Reactions BLM, Chemical Reaction Types Demonstration BLM, safety goggles, gloves, and aprons

Teacher Note: Students should not look directly at the burning magnesium as it burns extremely bright and can damage eyesight. Review all safety procedures prior to the activity.

Review the criteria for and process of classifying chemical reactions as combination (or synthesis), combustion, decomposition, single replacement, double replacement or neutralization (which is a special type of a double replacement reaction) learned in Activity 2a. Students will work in groups to observe an example of each type of chemical reaction. The observation can take place using small beakers, test tubes, or plastic well trays. This can also alternatively be conducted as a whole class demonstration. If completed as a whole class demonstration, the quantities may need to be increased to allow for a larger sample for viewing. Students should record all observations of reactants, evidence that a chemical reaction has occurred and the properties of the products, in their science *learning logs* (view literacy strategy descriptions).

Some example reactions might include the following:

- Place a piece of mossy zinc and 1 mL of 1.0 M copper II sulfate, $CuSO_4$ solution in a test tube or in a 24 well reaction plate OR 15 cm x 15 cm piece of aluminum foil placed in a 250 mL beaker with 150 mL of 1.0 M copper II chloride, $CuCl_2$ (single replacement).
- Place 50 mL of 0.1 M copper II chloride, $CuCl_2$ solution in a 250 mL beaker and add 50 mL of a 1.0 M sodium phosphate, Na_3PO_4 (double replacement).
- Place a small amount of steel wool in the bottom of a small beaker or jar (tape in place if necessary) and invert over a dish containing 1-2 mL of water. Observe after a few days (Teacher note: you may want to prepare one a few days in advance for comparison to speed up observation time) or hold a 10 cm strip of magnesium ribbon with crucible tongs and ignite the other end in a Bunsen burner flame. After ignition, hold the burning magnesium over a ceramic fiber square until the reaction is complete. **DO NOT LOOK DIRECTLY AT THE BURNING MAGNESIUM AS IT BURNS EXTREMELY BRIGHT**(combination or synthesis).
- Light a Bunsen burner and observe flame (combustion of methane gas CH_4).
- Place 2 mL 3% H_2O_2 and add a pinch of MnO_2 or a few pieces of solid Mn in a test tube or 24 well reaction plate (decomposition).

- Place 1mL of 1M HCl along with a few drops of universal indicator in a test tube. The color will be red in the presence of an acid. Measure and record pH. Add 1mL of 1M NaOH along with a few drops of universal indicator observe change in color. Color should be purple. Add 1mL of NaOH (without indicator) to the original test tube of 1M HCl with indicator. The color will change to green when the reaction is neutralized (neutralization).

Students should record all observations. Help them to write a balanced equation for each reaction through direct instruction, and allow them to identify the type of reaction. See Chemical Reaction Types Demonstration BLM for answers for the example reactions. Depending on chemicals available, other suitable reactions can be used for the demonstration as determined by the teacher.

Additionally, provide students with the Types of Chemical Reactions BLM that has numerous balanced chemical reactions listed. Have the students identify and record the reaction type occurring in each example.

Activity 4: Law of Conservation of Mass and Energy (SI GLEs: 9; PS GLEs: 1, 22, 26)

Materials List: (per group) 10 mL graduated cylinder, 125 mL Erlenmeyer flask, small test tube, small forceps, rubber stopper, 10 mL 0.5 M copper II chloride, $CuCl_2$ solution, 0.1 M silver nitrate, $AgNO_3$ solution, balance, science learning logs, safety goggles, gloves, aprons

This activity can be completed in groups of 3-4 students or as a whole class activity. Place 10 mL of the copper II chloride solution in the 125 mL Erlenmeyer flask. Place 3 mL of the silver nitrate solution into the test tube and lower into the Erlenmeyer flask with forceps without allowing the two solutions to come into contact with each other. Place the rubber stopper into the flask and measure the initial mass of the entire system—flask, test tube, two un-mixed solutions and stopper—and record. While making sure the stopper is in place, swirl or turn the flask so the two solutions mix together. After the two solutions have mixed, measure the mass of the entire system again and record the final mass. Compare the initial and final mass and discuss with students why this mass did not change. Allow students to offer evidence that a chemical reaction did take place inside the flask (color change, formation of precipitate) and allow them to defend their conclusion in their science *learning logs* (view literacy strategy descriptions). If there is any difference in the two masses, it may be due to the precision of the balance used. Reinforce with students that the mass remains the same due to the law of conservation of mass; the mass of the reactants must equal the mass of the products.

Activity 5: In Balance (SI GLEs: 5, 7, 9; PS GLE: 24, 26)

Materials List: various colored game chips, Reactant and Product BLM, science learning logs, Balancing Chemical Equations BLM
Before learning to balance equations, students must understand how to accurately count the number of atoms of each element in a reaction along with understanding how a chemical formula is accurately written. Review Activity 7 of Unit 3 if necessary.

Balance and complete the information for reaction 1 on the Balancing Chemical Reactions BLM as a whole class.

1. Students should work in groups of 3 to 4 students and select a color chip to represent each element in reaction 1. TEACHER NOTE: other things may be substituted for the colored game chips such as colored paper clips, colored circles of construction paper, etc. For example 1, choose two red chips for Cl_2, one blue chip for K and one green chip for Br on the reactant side of the equation. Utilizing the Reactant and Product BLM, students should place the chips side by side to represent each compound with each compound separated by the + symbol (i.e. two red chips touching for Cl_2 on the left side of the plus sign and one blue chip touching one green chip for KBr on the right side of the plus sign). Continuing with the pattern chosen for their elements in their reactants, have students now create similar representations of the products and place them on the right side of the yield sign.
2. Have students count all of the atoms of each element on the reactant side of the paper and count all of the atoms of each element on the product side. If the number of each atom is the same for reactant and product then the reaction is balanced. If the number is not equal, add additional units of the compound to the appropriate side or sides until the total number of the atoms on the reactant side equals to the total number of like atoms on the product side.
3. Once the numbers on each side are equal, then the reaction is balanced. Students should count up the units of each compound and place that number in the blank in front of that compound. If the coefficient is a one, it is not written, but implied.
4. Reaction 1 is completed for them on the Balancing Chemical Reactions BLM for demonstration purposes, but it is still important to work through the example so students know exactly how to use the chips. For more student practice, the teacher may add additional reactions to supplement the five reactions included on the BLM.
5. Chemical reactions can be balanced by trial and error and updating as you change coefficients. But some general tips can help students with this task:
   a. Make sure that the chemical formula is written correctly and then do not change the subscripts.
   b. Begin balancing the most complicated or largest compound first
   c. Polyatomic ions are balanced as units and not as individual atoms, therefore your students must understand about polyatomic ions before beginning to balance equations.

After student groups have completed balancing the equations (this may be at the beginning of the next class period), ask students to respond to the following prompt in their science *learning logs* (view literacy strategy descriptions). Recording reflective thinking about what was learned in the previous class allow students to make connections and to identify gaps in their understanding.
Why do we balance chemical equations?

After students have written for five to seven minutes, have various students share their conclusions they have drawn with the class and have them explain and defend their answers. Through teacher-student dialogue, direct the students to understand that balanced equations follow the law of conservation of mass as well as the law of conservation of energy. Continue to evoke responses from the students by asking them to identify various forms of energy that can be converted from chemical energy during a chemical reaction, such as heat, light, and sound. Remind students of prior activities conducted where they identified indicators of a chemical reaction taking place and where they measured and compared masses of reactants and products. Allow students to record any additional information in their science *learning logs* to add to their original answer to the prompt.

If technology is available, an online tutorial on balancing equations can be found at http://science.widener.edu/svb/tutorial/rxnbalancingcsn7.html

Activity 6: Reaction Rates (SI GLEs: 9, 10; PS GLE: 25)

Materials List: three 600 mL beakers (or other large beakers of same size on hand), 50 mL 1 M hydrochloric acid, 50 mL 0.5 M hydrochloric acid, 50 mL 0.25 M hydrochloric acid, 10 g sodium bicarbonate, Stopwatch or clock with second hand, water, effervescent tablets, safety goggles, gloves, aprons

Students should identify and review all safety procedures to be followed during this activity. Engage students in a laboratory investigation to determine the effects of (1) concentration, (2) temperature, and (3) amount of surface area on reaction rate. For each of the following demonstrations, have students identify the dependent and independent variables.

For concentration, fill three large beakers (of the same size) with 50 mL of 1 M HCl, 0.5 M HCl, and 0.25 M HCl and place on an overhead projector. Simultaneously add 10 g of baking soda, $NaHCO_3$ to each beaker. Record the time needed for each reaction to go to completion. Students should compare results and discuss the outcome.

For temperature, place a large beaker of cold water and a large beaker of room temperature water on an overhead projector. Simultaneously drop ½ of an effervescent tablet in each beaker. Observe the rate of gas formation, noting that gas forms much slower at lower temperatures.

For amount of surface area, prepare two large beakers of room temperature water and place on an overhead projector. Simultaneously place a whole effervescent tablet in one beaker and a completely crushed effervescent tablet in the other. Hold a concluding discussion to determine the class consensus as to the effect of these three variables on the reaction rate. Students should demonstrate their understanding with a written analysis and conclusion of the effects of temperature, concentration of reactants, and surface area on reaction rates.

Activity 7: Acid, Base, or Neutral? (SI GLE: 10; PS GLE: 23, 28)

Materials List: various household chemicals (such as vinegar, carbonated beverages, bleach, lemon juice, milk, baking soda, diluted drain cleaner, water, orange juice, cranberry juice), litmus paper, universal indicator, beet juice or purple cabbage juice, 0.5 M hydrochloric acid, 0.5 M sodium hydroxide, 0.5 calcium hydroxide, diluted ammonia, 1.0 M sodium chloride solution, 24 well reaction plates or test tubes, safety goggles, gloves, aprons

Students should identify and follow all safety procedures during this activity. The purpose of this activity is to classify substances as acid, base, or neutral, based on evidence of pH determined by the use of indicators. Prior to this investigation, the class should have explored the characteristics of acids, bases, and neutral solutions, including an explanation or demonstration of neutralization and analysis of the pH scale. Allow the students to try various indicators such as litmus paper, universal indicator, beet juice, or purple cabbage juice while testing the pH of common household chemicals such as vinegar, carbonated beverage, bleach, lemon juice, milk, baking soda, diluted drain cleaner, and water. Discuss the advantages and disadvantages of the various indicators while also referring to the sensitivity of each. To further reinforce this topic cognitively, provide students with some “unidentified” low-concentration solutions such as hydrochloric acid, sodium hydroxide, sulfuric acid, calcium hydroxide, ammonia, and sodium chloride solution, and have them analyze pH levels to classify each as an acid, base, or neutral substance. Include a culminating discussion in which students are asked to provide examples of acids and bases in everyday life. Some examples include pH measurements in everyday life, such as soil ph for gardeners, water pH for water quality, aquariums, swimming pools, shampoo pH in advertisements, food pH in various types of foods, and why you need antacid medication if you consume too much acidic food. This activity can be extended using samples that students bring to class to provide various test substances, such as various types of water (local municipal water, well water, bottled waters, well water, lake, pond, or river water, aquarium water, swimming pool water, etc.).

Activity 8: Chemistry in the News (SI GLE: 2, 14; PS GLE: 28)

Materials List: various print resources, magazines, newspapers, Internet

Establish the setting by reminding students that chemistry is involved in their everyday lives from the digestion of their breakfast to fueling their vehicles. With this in mind, tell students that over the next week they are each to research, collect, and summarize articles from magazines, newspapers, or the Internet illustrating how chemical reactions touch their everyday lives. The teacher should stress that science investigations can be literature research as well as observation and experimentation. They should seek to find local examples for their community, such as water quality, food safety, hazardous wastes, etc., as well as examples that pertain to Louisiana and its large chemical and petrochemical industries. Encourage students to also utilize examples that might appeal to teenagers such as the chemistry behind fireworks, perfume, hair coloring, cooking, manufacturing of various sports equipment, the emerging ethanol industry, etc. Students should cite examples where scientific advances in chemistry have affected society. To culminate this activity into a meaningful experience, students should be provided with a reporting format as determined by the teacher. This may be a traditional report, a poster presentation, a multimedia presentation, a brochure, or some other applicable student product. To achieve maximum personal experience, students should complete this activity individually. This activity could be conducted for a longer period of time if assigned at the beginning of the unit rather than the end. Students could collect information over the duration of the unit as they learned more about chemical reactions.

Sample Assessments

General Guidelines

Assessment techniques should include use of drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

- Students should be monitored throughout on all activities via teacher observation of work and lab notebook entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will predict products and balance equations when given reactants.
- The student will describe signs that a chemical reaction has occurred and evaluate with a teacher-made rubric.
- The student will design and conduct a simple experiment that will provide accurate and reasonable data to answer the following questions: Does agitation (stirring) affect reaction rate? If so, how? The experimental design should permit the collection of information that addresses the guiding question of the investigation. The experimental design and lab performance will be evaluated with a teacher-made rubric.

Activity-Specific Assessments

- Activity 3: The student will observe a reaction demonstrated by the teacher. After given a list of the reactants, students will write a chemical equation to identify reactants, products, and the type of reaction that took place. Evaluate student work for accuracy.

- Activity 4: The student will identify equations that are balanced and ones that are not balanced using a card sort.

- Activity 8: The student will research specific careers in the chemical field. Students may work in groups or individually to present a poster to illustrate their job descriptions to the class.

Resources

- Kessler, James H. *The Best of Wonder Science.* Albany: Delmar Publishers, 1997.
- Sarquis, Jerry L., Mickey Sarquis, and John P. Williams. *Teaching Chemistry with Toys.* Middleton: Terrific Science Press, 1995.
- Balancing Equations Using Algebraic Methods: Online at http://dwb.unl.edu/calculators/activities/BalEqn.html
- Types of Equations: Online at http://dbhs.wvusd.k12.ca.us/webdocs/Equations/Equations.html

Physical Science
Unit 5: Matter, Forces, and Motion

Time Frame: Approximately four to five weeks

Unit Description

The understanding of how matter, motion, and forces are related, along with a comprehension of Newton's laws of motion and the effects of forces on objects will be developed. Two activities in this unit provide an earth-science-based application of physical science principles. The Earth Sciences provide many real world opportunities to integrate the different science disciplines. These two activities could also be done as part of unit eight, which is dedicated to Earth Science applications.

Student Understandings

Beginning with the determination of mass and weight and continuing investigations of forces, students will design experiments to accurately test hypotheses about motion, speed, and direction. Newton's laws of motion will be thoroughly explored. Students will develop the ability to construct and interpret graphs of motion. Building on Newton's second law, the conservation of momentum in collisions is introduced at this level.

Guiding Questions

1. Can students describe forces?
2. Can students differentiate between mass and weight?
3. Can students describe motion as constant, and determine speed, acceleration, and velocity?
4. Can students use Newton's laws of motion to analyze and describe how things move?
5. Can students describe or model how the net force affects the motion of an object?
6. Can students relate the application of some of Newton's laws of motion to the order of the solar system?
7. Can students distinguish the four main forces in nature: gravity, electromagnetic, and strong and weak nuclear forces?

Unit 5 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
4.	Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
10.	Given a description of an experiment, identify appropriate safety measures (SI-H-A7)
11.	Evaluate selected theories based on supporting scientific evidence (SI-H-B1)
15.	Analyze the conclusion from an investigation by using data to determine its validity (SI-H-B4)
16.	Use the following rules of evidence to examine experimental results: (a) Can an expert's technique or theory be tested, has it been tested, or is it simply a subjective, conclusive approach that cannot be reasonably assessed for reliability? (b) Has the technique or theory been subjected to peer review and publication? (c) What is the known or potential rate of error of the technique or theory when applied? (d) Were standards and controls applied and maintained? (e) Has the technique or theory been generally accepted in the scientific community? (SI-H-B5) (SI-H-B1) (SI-H-B4)
Physical Science	
1.	Measure the physical properties of different forms of matter in metric system units (e.g., length, mass, volume, temperature) (PS-H-A1)
2.	Gather and organize data in charts, tables, and graphs (PS-H-A1)
29.	Differentiate between *mass* and *weight* (PS-H-E1)
30.	Compare the characteristics and strengths of forces in nature (e.g., gravitational, electrical, magnetic, nuclear) (PS-H-E1)
31.	Differentiate between speed and velocity (PS-H-E2)
32.	Plot and compare line graphs of acceleration and velocity (PS-H-E2)
33.	Calculate velocity and acceleration using equations (PS-H-E2)
34.	Demonstrate Newton's three laws of motion (e.g., inertia, net force using $F = ma$, equal and opposite forces) (PS-H-E3)
35.	Describe and demonstrate the motion of common objects in terms of the position of the observer (PS-H-E4)
37.	Model and explain how momentum is conserved during collisions (PS-H-F2)
Earth and Space Science	
16.	Use the nebular hypothesis to explain the formation of a solar system

GLE #	GLE Text and Benchmarks
28.	Identify the relationship between orbital velocity and orbital diameter (ESS-H-D6) (PS-H-E2)
29.	Demonstrate the elliptical shape of Earth's orbit and describe how the point of orbital focus changes during the year (ESS-H-D6)

Sample Activities

Activity 1: Forces (SI GLEs: 5, 7; PS GLEs: 2, 30)

Materials List: (one per student for this activity) 5 x 7 inch index card, (per group) various objects of different masses (examples: text book, large washers, blocks of wood or metal), spring scales, meter stick, sand paper, aluminum foil

Teacher Note: Activity 1, which investigates forces, and Activity 6, which investigates Newton's three laws of motion are related in concepts and continuous in student understanding. They may be presented together.

As an introduction to forces and as a formative assessment, students should *brainstorm* (view literacy strategy descriptions) what they know about forces. Brainstorming can be used as an effective method to activate prior knowledge and it also helps set a purpose for reading and/or performing an activity. Write the word "force" on the center of the board or overhead transparency. Allow students to work in small groups or as a whole class to offer ideas about force. Make sure that students understand that all ideas are accepted during a *brainstorming* activity. Record student responses as a list or a web. Have students read an appropriate selection of text from the textbook or other source determined by the teacher. After reading the selection, return to the list created during brainstorming to determine if the recorded responses should be accepted as written, corrected, or deleted as not relevant.

Have students create a *vocabulary card* (view literacy strategy descriptions) for the term *force*. Vocabulary cards help students see the connections between terms, examples of the term, and the critical attributes associated with the term. Using 5 x 7 inch index cards the term *force* should be written in the center of the card.

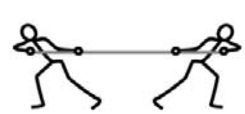
EXAMPLE OF A VOCABULARY CARD

an action that causes a body to accelerate

can be a push, a pull, or a lift

force

gravity, electromagnetic, nuclear



Students should write the definition in the upper left-hand corner of the card. The characteristics of force should be written on the upper right-hand side; these might come from the brainstorming list created earlier. One or two of the best examples of force from the brainstorming session should be written on the lower left side of the card. Finally, an illustration should be included on the lower right-hand side of the card.

More vocabulary cards will be added to this first card during the unit. Students should be aware of the necessity to keep up with their cards and to add to their cards, as this is a valuable tool for review for future activities, quizzes, and tests.

As a discovery activity on force and motion, have students observe factors that affect the force applied on an object. Use objects of different masses (any object will work, books, mass weights, large washers, etc.) and spring scales.

After dividing the class into two groups, assign Procedure A to one group and Procedure B to the other.

Procedure A. Students will measure the mass of the three objects with different masses. The spring scale should be attached and the object should be pulled a distance of 100 cm. The force required should be recorded in newtons (N). This process should be repeated for the remaining two objects, and data should be recorded.

Procedure B. Students will attach the spring scale to one object and pull it along a distance of 20 cm. The force in newtons (N) should be recorded. Students will place a piece of sandpaper to the tabletop and the same object should be pulled along the same distance (20 cm) on the sand paper to record the force. Students should repeat the force measurement using the same object, replacing the sandpaper with aluminum foil.

Through class discussion, allow groups to determine the relationship between force and the motion of the objects for each procedure. They should recognize that the force needed to move an object along a surface depends on the mass of the object and the type or nature of the surface.

Activity 2: Mass vs. Weight (SI GLEs: 5, 15; PS GLEs: 1, 2, 29)

Materials List: (per student) 5--5 x 7 inch index cards;(per group) spring scale, balance, plastic baggie, various objects such as small book, rubber band, size c or d battery, large rubber stopper, glue stick, and known mass (note: other appropriate objects can be substituted according to availability in the individual classroom), Mass vs. Weight BLM (one per student), graph paper (one per student), Mass vs. Weight BLM

As students often have misconceptions about the nature of gravity and difficulty understanding the difference between mass and weight, begin this activity with a review/discussion of the role of gravity in determining weight and the difference between mass and weight. Discuss the instruments used to determine weight (scales) and mass (balance), including everyday places where students might have encountered scales such as the post office, grocery store, or doctor's office and balances such as see-saws, measuring devices, etc. Make sure that students understand that mass is a fixed property of an object, but weight fluctuates due to the force of gravity on the object. Through direct instruction, review with students the metric unit of force, the newton, as this is often confusing to students. Students should create *vocabulary cards* (view literacy strategy descriptions) for the words *mass*, *weight*, *balance*, *spring scale*, *newton*, and *gram*.

Working in groups of 3-4 students, have students measure the mass of several objects using a balance and the weight of the same objects using a spring scale. Knowing that the Moon has 1/6th the gravity of the Earth, have students calculate the mass and weight of the same objects on the Moon. See Mass vs. Weight BLM for an example of this student activity. Students should create a weight vs. mass graph for their data and answer the related questions. NOTE: See Mass vs. Weight BLM with answers for expected student answers.

Activity 3: Frame of Reference (SI GLE: 7; PS GLE: 35)

Materials List: science learning logs, (for demo) flat-bed cart or wagon, ball

Using their science *learning logs* (view literacy strategy descriptions), have students answer the following question: Does the Sun set or the Earth rise? After students have written their answers, have them share their ideas with another student. Conduct a class discussion to develop the definition of a frame of reference to be the object or point from which movement is determined. Continue the science *learning log*/class discussion process by asking the students to identify the frame of reference in the following scenarios:

1. You are watching a bus move past you at a moderate speed. A car, moving at a greater speed passes the bus. (Earth is the frame of reference for both)
2. Now suppose you are riding in the bus. (The bus is the frame of reference.)
3. The car's speed relative to the bus is greater. So the car appears to be moving past you as you look out the window of the bus. (If the car is the frame of reference, the speed of the bus relative to the car is less. So the bus appears to be moving backward.)

As a class, operationally define *motion* as a change in position relative to a frame of reference. To check students' understanding, have them answer the following questions:

1. Suppose you are standing at your window and see a mail truck at your mailbox delivering mail. You walk away for several moments and return to the window. The mail truck is in front of your neighbor's house now. How do you know the truck moved?
2. A satellite is in orbit 210 km above Earth. Another satellite orbiting at 200 km above Earth passes it. Describe the motion of the two satellites using the following frames of reference: (a) Earth (b) the higher satellite (c) the lower

satellite.

3. Suppose that you are sitting in a parked car. Another car passes you at a speed of 50 km/hr. Describe what a passenger in the other car sees.

Students can observe a demonstration of frame of reference if it is possible to do the following activity: Using a flat bed cart or wagon (the athletic department may be a source), have one student, seated in the wagon, throw a ball up in the air and catch it while a second student pulls the wagon past a stationary student. Compare their views of the tossed ball while in the air.

Activity 4: Motion (SI GLEs: 4, 5, 7; PS GLEs: 1, 31, 33)

Materials List: (per group) small wind-up toy, meter stick, timer, (per student) 3-5 x 7 index cards, various applicable word problems for *speed*, *velocity*, and *acceleration* (if available, digital timers and photogates, graphing calculators and motion detectors, and/or marble, car, or air tracks)

As an introduction to "motion," students will operationally define *speed*. Have the students time small wind up toys as they roll or walk across the table. It is preferable that different groups have different toys. Ask them to compare the speed of the toys. They should determine that to calculate and then compare the speed, they must measure the distance the wind-up toy traveled and the time it took to travel that distance. Provide students with meter sticks or tapes and timers to determine the speed of their toy. Have them conduct three trials and calculate an average speed to compare with other toys.

After this introductory activity, students should complete additional *vocabulary cards* (view literacy strategy descriptions) for the terms *speed*, *velocity*, and *acceleration* using 5 x 7 index cards.

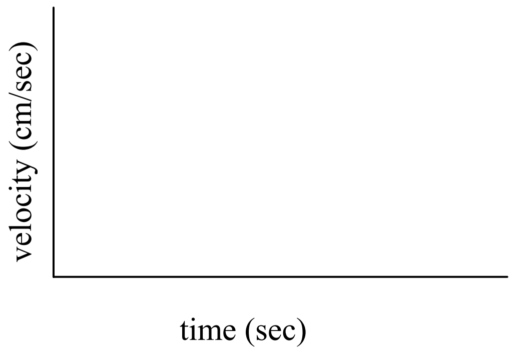
Following this introductory activity, the teacher should have students conduct additional experiments using inclined planes to further investigate speed, velocity, and acceleration. Teacher note: if available, technological equipment such as photogates and digital timers, marble, car, or air tracks, and/or graphing calculators and motion detectors can be used to teach these concepts. This type of equipment provides the student the opportunity to record more accurate data and thus have better derived data for conclusion purposes.

In addition, demonstrate and explain the difference between positive and negative acceleration. Provide students with word problems concerning speed, velocity, and acceleration. Through direct instruction, the teacher should model problem solving techniques for each type of problem. To complete the problems, have students not only solve for the unknown variable but also differentiate between speed and velocity by providing a direction when necessary. Use formative assessment to determine the amount of guided practice in problem solving needed.

Activity 5: Graphing Motion (SI GLEs: 4, 5, 6, 10; PS GLEs: 2, 31, 32)

Materials List: (per group) ramp or straight track, car or rolling vehicle (preferably larger than 4 inches), timer or stopwatch (if available, use digital timers, photogates, and/or motion detectors), various line graphs of motion (see Motion Graphs Example BLM)

As a modified *anticipation guide* (view literacy strategy descriptions), show students a graph of velocity vs. time (see example below)



Anticipation guides are used before reading, or modified to use before conducting an experiment, to interest students and set a stage for the upcoming learning. The information gathered through anticipation guides can also serve as formative assessment for the teacher to determine the current student understandings of the new topic. In this anticipation guide, the students are predicting what the graphs will look like for acceleration of a car down a ramp and for a car moving at the same speed on a flat surface. This prediction will be used for closure to the activity, for students to replace incorrect prior concepts with newly learned and corrected ones, or reinforce correct concepts if students' predictions are correct.

In their science *learning logs* (view literacy strategy descriptions), have students draw the graph axis (shown above) with labels and then draw their prediction of the graph line for car rolling down an inclined plane or ramp. Have students draw the graph axis again and draw what they predict the graph would look like for a car going the same speed on a flat surface. Make sure that students understand that this is a prediction prior to conducting the experiment and that they will return to this information after collecting data and creating a graph using the data from their experiment to determine if their original prediction in the graph was correct.

With groups of 3 to 4 students, have students collect data of a car rolling down an inclined plane or ramp. Small toy cars may be used, but make sure they are large enough to roll freely down the track in as straight a line as possible. If available, this activity works much better with digital timers, photogates, and/or motion detectors. With this type of equipment, student data is generally more precise and accurate and yields better graphs. If unavailable in the science department, science teachers might check with the mathematics department to see if any equipment is available to borrow.

Set up the ramp and instruct students to not raise or lower the track during the activity. Students should time the car for three separate distances (A, B, C) on the track (they may have to catch the car at predetermined points along the track or table/floor if the track transitions smoothly to the table/floor). At each distance, students should time the car for three trials and average the time for that distance (A, B, or C). Students should calculate an overall acceleration of their car down the ramp from start to the last point C.

Students should calculate the velocity of their car at each distance (A, B, C) and create a velocity vs. time graph of their three velocities. (If time allows, have students calculate the velocities of more points, or if ramps are uniform throughout the groups, have different groups use different distances and combine data form more points on the graph). Students should draw in the best-fit line or curve. Note: if students are using stopwatches, the data may not show the slight curve due to the acceleration, but a general trend of increased velocity or acceleration should be noted.

Students should choose two points that fall closest to their best-fit line and calculate the slope of the line between those two points. Some review of the calculation of slope may be necessary prior to this analysis. Since slope = Δ y/ Δ x = Δ velocity/ Δ time, then it follows that the slope of a velocity vs. time graph must show the acceleration between those two points since acceleration = velocity/time. Students should analyze their calculated acceleration for their car and compare it to their derived acceleration from their graph.

Students should return to their anticipation guide, the original prediction of the graph of the motion of a car accelerating. In their science *learning logs*, have students record the correct graph (the graph utilizing their collected date) and compare the predicted graph with the experimental graph. Have students write a brief explanation if their prediction was correct or incorrect and why.

As an extension, have students interpret various line graphs of motion to identify the slopes for positive acceleration, negative acceleration, and constant motion. See Motion Graph Examples BLM for two examples of completed graphs with explanations. Students should be supplied with additional examples or allowed to construct graphs and interpretations of their own.

If graphing calculators and motion detectors are available, an excellent activity for graphing motion can be found at the Texas Instruments educational site, Forensics Case 12: Hit and Run: Using information from an event data recorder to reconstruct an accident This activity can be found online at
http://education.ti.com/educationportal/activityexchange/Activity.do?cid=US&aId=6379

Activity 6: Newton's Three Laws of Motion (SI GLEs: 5, 7; PS GLE: 34)

Materials List: (whole class demo) aluminum pie plate, unbreakable, plastic cup, thick sponge, golf ball, broom, (per group) clear plastic cup, index card, wooden clothespin, ramp, various books to support ramp, toy vehicle, 10 washers, masking tape, meter stick or metric measuring tape, stopwatch or timer, 2 pencils or straws, small plastic soda bottle (clean and empty), vinegar, 5 g baking soda, 200 mL vinegar, cork or stopper, paper towel, (per student) safety goggles, various word problems to calculate force, mass, and acceleration

Students should experience Newton's three laws through inquiry explorations, observations, discussion, and problem solving.

Give each group of students a clear plastic cup, an index card, and a wooden clothespin. Instruct the students to place the card on top of the cup and stand the clothespin on its two handles, straight up and down. Students should take turn flicking the card to see if they can remove the index card while dropping the clothespin into the cup. After everyone in the group has had a chance to experience Newton's first law of motion, have students record their observations in their science *learning logs* (view literacy strategy descriptions) with an explanation of the first law of motion. Make sure that students understand that the outside force that stops an object in motion on the Earth includes gravity and friction.

For a student investigation of the second law of motion, have student groups set up a ramp using meter sticks and several books. One end of the ramp should be on the books and the other end lined up with a piece of masking tape on the floor. Students should place a toy vehicle at the top of the meter stick and allow it to roll down the ramp, making sure they only release it and don't push the vehicle. Use an additional meter stick to measure how far the vehicle rolls. Repeat this step for two additional trials and calculate an average distance traveled. Students should add five washers of equal size to the vehicle (tape them on the roof) and repeat the three trials and calculate a second average distance. Have students add five more washers for a total of ten and complete the three trial runs to calculate an average distance traveled. Ask students how increasing mass (adding more washers) affects the force of objects in motion (the distance the vehicle rolls)? Have students write an explanation for their observations in their science *learning logs* using Newton's second law, $F = m \times a$.

For a demonstration of the third law of motion, place two pencils on a smooth surface on the ground outside about 8 cm apart. The student with the assigned role of vinegar cannon preparer will place 200 mL of vinegar into the dry and empty soda bottle.

Teacher Note: It is imperative that the baking soda and vinegar used in this experiment are fresh and properly stored before the lab. Weakened vinegar will ruin the effectiveness of the vinegar cannon. If the reaction runs too fast, adding less vinegar can slow the reaction. Also make sure that students have safety goggles for eye protection.

The vinegar cannon preparer will place the 5g of baking soda into a paper towel. When the experiment is ready to be run, the student will proceed to insert the baking soda wrapped in paper towel into the soda bottle. Immediately, the student will cork the mouth of the soda bottle firmly and lay the soda bottle on its side on top of the pencils. The teacher should ensure that the mouth of the vinegar cannon is facing away from the students. Shortly thereafter, a large amount of pressure should be generated in the bottle. As a result, the pressure within the soda bottle will eject the cork forward sending the bottle backwards. Ask students what chemical reaction was taking place in the bottle? Ask students why the cannon was placed on the two pencils? Make sure that students understand that forces come in pairs, and that in the example of the bottle, the gas pushed on the bottle/cork and the bottle/cork pushed back. The forces were unbalanced and the bottle moves back when the cork flies off. A common student misconception is that the action-reaction pair is that the action of the gas production created the reaction of the bottle moving backwards. The pair of forces must be in contact directly with each of the other forces.

Students should identify, label, and calculate balanced and unbalanced forces, net forces, and action-reaction pairs through whole class discussion and individual problem solving. Provide opportunities for students to solve word problems in calculating forces, mass, and acceleration.

After ascertaining student understanding of Newton's laws of motion, have students create a *SPAWN* writing (view literacy strategy descriptions). This may be conducted as a starting activity following completion of the examination of Newton's Three Laws. Give students a reasonable amount of time to write. In this example, the *SPAWN* is used as a unique way for students to reflect on their learning and also as a way for the teacher to determine if they fully understand the concept. The letters in *SPAWN* stand for ***S*** *- Special Powers;* ***P*** *- Problem Solving*; ***A*** *- Alternative Viewpoints.* ***W*** *- What If?;* ***N*** *– Next.* One or more of the conditions may be given as a prompt, as the teacher determines which one accommodates the type of thinking about the content the students should exhibit. SPAWN writing can be used to anticipate on content to be presented, or as in this case, as a reflection on what has just been learned. *SPAWN* writings should not be graded as formal writings and students should be given a specific time frame to create them. Most can be adequately constructed in 10 minutes.

.

Students will write in response to the following Alternative Viewpoints prompt:

Imagine that Newton's three laws of motion suddenly change and objects no longer follow the "rules" when they move on Earth. Write a letter to a friend explaining how the motion of objects in your everyday life is now different because of this change. Allow students to share their responses with a partner or the class while others listen for accuracy and logic.

Activity 7: Conservation of Momentum (SI GLEs: 7; PS GLE: 37)

Materials List: (per group) five pennies, (whole class) Newton's Cradle, if available, video clips, a series of illustrations, or a computer simulation of a crash dummy involved in a car accident

When given five pennies, students should experiment to determine why when four pennies are lined up and the fifth is slid toward the end of the line, only one penny moves from the line. They should repeat this discovery using two pennies slid toward the line of the remaining three pennies. Have students record and describe how the total momentum of the objects before the collision was the same as the total momentum of the objects after the collision. Students should also use diagrams or sketches (models) in their descriptions. Students should show how the pennies follow the Law of Conservation of Momentum; the momentum of a system is constant if there are no external forces acting on the system. In this case, the system is the line of five pennies and they are motionless until a force from the student is applied. After the collision of the one penny with the group, the penny on the other side slides off with a force equal to the one placed from the other side. Therefore, momentum is conserved and is the same for the input as for the output.

If available, a Newton's Cradle (sometimes referred to as impact balls or collision balls) is an excellent device to demonstrate conservation of momentum. It is a popular toy with metal spheres just touching at rest. The device can be used to demonstrate highly elastic collisions in which both momentum and kinetic energy are very nearly conserved. Pull one pendulum back and release it. When it strikes the remaining pendula, the last in the row flies off almost as fast as the first one hits the row, while all of the others, including the first, remain nearly at rest. Release two, and two fly off the other end. Release three, and when they strike the remaining two, three fly off, and two remain at rest, etc.

Additional examples could include video clips, a series of illustrations, or a computer simulation of a crash dummy involved in a car accident. The teacher may provide a demonstration of toy cars or carts colliding. Again have students record and describe how the total momentum of the objects before the collision compared with the momentum after the collision. Require students to use diagrams or sketches (models) in their descriptions. Allow students to suggest how the scenario of conservation of momentum could be demonstrated using other models in the lab.

Activity 8: Orbital Travel (SI GLEs: 4, 5, 7, 15; PS GLE: 2; ESS GLEs: 28, 29)

Materials List: (per group) straw, string, weight, such as a large washer, (per student) safety goggles, two push pins, 6-8 inch length of string, paper, cardboard, planetary orbital charts

Teacher Note: Safety goggles should be worn as eye protection for this activity.

Satellite technology affects many areas of our lives today. A satellite's minimum speed depends upon its distance from Earth. To remain in a stable orbit and not fall back to Earth, the satellite has to move at a specific speed determined by its distance from Earth. The *period* of a satellite is how long it takes to complete one circuit (called a revolution) around Earth. Students should complete an orbital velocity investigation using a piece of string with a weight tied to one end and the other running through a plastic tube or straw and tied with a large knot (to prevent the string from separating from the straw).

Standing a safe distance from the other students, the individual should hold on to one end of the string and swing the weight in a circle. The pull of the swinging weight must be countered by the student exerting a force while holding on to the end of the string. Students should measure the radius of the orbital circle created and use this number to determine the diameter and circumference of the circles being outlined by the string and weight. This information should be used to compute the velocity. It may be difficult to do for one orbit, so suggest timing a number of orbits; for example, ten and dividing by ten. Following this, pull the end of the string down shortening the radius of the swing. Again calculate the velocity of the weight as it completes an orbit. Repeat once more making the radius even shorter and graph the results. Students should identify that with the satellites in Earth orbit, the force holding them in place is gravity.

A similar activity about orbital velocity can be found in the Focused Learning Lessons (#22) at http://www.louisianaschools.net/lde/uploads/5613.pdf. This lesson also includes information in construction of a similar orbital velocity model.

Provide the students with a chart of the planets that includes mean orbital velocity and distance from the Sun in astronomical units. This information can be found at http://solarsystem.nasa.gov/planets/charchart.cfm. (also see the Focused Learning Lesson #22 referenced above). The difference can be demonstrated by having one student stand in a position to represent the Sun while a second student representing Mercury must complete four revolutions around the Sun before a third student modeling Earth's motion will complete one revolution in the same amount of time. Have students compare the numbers to find the inverse relationship between velocity and the square root of the orbital radius. Provide the students with the accepted distance to the Moon (384,400 km) and have them determine the length of time it takes the Moon to complete one orbit. Instruct students to calculate the orbital velocity of the Moon.

Two of the forces at work in the orbit of the planets around the Sun are gravity and inertia. Every planet not only feels the gravitational pull of the Sun but each planet actually tugs at all the other planets. Students should construct an ellipse using a simple string and pencil apparatus. An ellipse can be drawn by placing a string, tied in a circle around two tacks (the two foci of the ellipse) pushed through a piece of paper placed on top of a piece of cardboard. Holding the string taut, trace out the ellipse by moving the pencil just inside the string. A simple explanation of drawing an ellipse can be found at http://astrosun2.astro.cornell.edu/academics/courses/astro201/ellipse.htm.

Allow students time to explore the measurements seen when a planet is positioned on the ellipse. Discuss how that position changes over the course of one revolution and compare length of years for various planets. Direct students to use the planetary charts to compare the orbital paths of the planets to each other and note their observations and comparisons. Which are most nearly circular, which are most elongated, and which planets could be paired based on orbital shape?

Activity 9: From Dust to System (SI GLEs: 7, 11; PS GLE: 30; ESS GLE: 16)

Materials List: science learning logs, 5 x 7 index cards (4 per students)

Through direct instruction, a comparison of the strengths of the forces in nature (e.g., gravitational, electrical, magnetic, nuclear) should be used to develop an understanding of the nebular theory of the formation of the solar system.

Have students add the terms *gravitational forces*, *electrical forces*, *magnetic forces*, and *nuclear forces* to their *vocabulary cards* (view literacy strategy descriptions).

As gas and dust collected, forming an interstellar cloud, a collapse may have been triggered by increasing density or shockwave. While material was being gravitationally pulled toward the center, the cloud fragmented. Discuss with students why was this fragmentation partially responsible for the difference in size between the inner terrestrial planets and the outer gas giants?

Spinning objects have a tendency to flatten as reflected in the shape of the planets. The faster a body rotates, the more flattening occurs at the poles. Ask students for examples of objects that move well because of their shape. Students should offer ideas like Frisbees ™ or flat stones that skip on the surface of water.

According to the nebular hypothesis, several stages took place in the evolution of the solar system. Students should prepare a flow chart in their science *learning logs* (view literacy strategy descriptions) showing the nebular hypothesis of solar system formation. The graphic should list major processes such as angular momentum, gravitational energy, and kinetic energy while also identifying major characteristics such as spinning, heating, and flattening as they occur in the process.

Teacher Note: See resource list for additional information on nebular hypothesis.

An addition activity about basic forces can be found at http://www.louisianaschools.net/lde/uploads/5601.pdf as a review of the four fundamental forces in nature.
Additional information about the four basic forces in nature can be found at http://hyperphysics.phy-astr.gsu.edu/hbase/forces/funfor.html or http://csep10.phys.utk.edu/astr162/lect/cosmology/forces.html

Activity 10: History of the Scientific Understanding of Motion (SI GLEs: 6, 11, 16; PS GLE: 30)

Materials List: various research materials, written text and reference books, trade books, Internet, and appropriate CD ROM's, DVDs, or videos

The study of motion remains central to scientific inquiry and continues to have an important impact on such diverse fields as astronomy, architecture, engineering, rocketry, automobile design, and many other areas. To increase and strengthen students basic understanding of the current knowledge and comprehension of the forces in nature (gravity, electromagnetism, and the strong and weak nuclear forces), separate them into research groups of three to four students and assign the task of researching the theories of motion of Galileo, Newton, and Einstein. Give each group the outline of Benchmark SI-H-B5, GLE 16 to use as guiding questions in their research of each scientist's theory.

16. Use the following rules of evidence to examine experimental results:
    (a) Can an expert's technique or theory be tested, has it been tested, or is it simply a subjective, conclusive approach that cannot be reasonably assessed for reliability?
    (b) Has the technique or theory been subjected to peer review and publication?
    (c) What is the known or potential rate of error of the technique or theory when applied?
    (d) Were standards and controls applied and maintained?
    (e) Has the technique or theory been generally accepted in the scientific community? (SI-H-B5) (SI-H-B1) (SI-H-B4)

Encourage student groups to include other scientists who contributed to the theories and also to examine the important role that mathematics plays in explaining motion.

If the teacher has access, the Discovery Streaming video *Elements of Physics: motion, force, and gravity* (found at http://www.lpb.org/education/cyberchannel.cfm) is an excellent source of information that may be shown to the class and discussed. The Galileo Project (found at http://galileo.rice.edu/) is another excellent resource. Additionally, student groups may conduct their own search from the Internet or written text, CD ROMs, and videos available in their school library. Findings may be presented orally to the class or through a student-created multimedia presentation as determined by the teacher.

Sample Assessments

General Guidelines

Assessment techniques should include use of drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

- Students should be monitored throughout the work on all activities via teacher observation of the students' work and lab notebook entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will use the principles of Newtonian mechanics to describe accurately and predict motion. They will provide examples to demonstrate their understanding of the types of forces, the ways that forces interact, and the expected motion that results from specified forces.
- The student will use qualitative, quantitative, and graphical methods to communicate accurately their understanding of motion and the factors that affect it.
- The student will analyze the slope of velocity vs. time motion graphs to determine acceleration. They will compare with acceleration calculated with the formula and calculate a percent error.

Activity-Specific Assessments

- Activity 4: The student will analyze, interpret, and describe the type of motion represented with each graph when presented with various graphs of motion (position, velocity, and acceleration).

- Activity 5: The student will analyze various motion graphs and provide a written description of the specific motion of the object over time.

- Activity 7: The student will explain why rockets can accelerate in space where there is little or no matter using the Law of Conservation of Momentum.

Resources

- Hixon, B. K., Bernoulli's *Book.* Salt Lake City: The Wild Goose Company, 1991.
- Robertson, William. *Force & Motion: Stop Faking It! Finally Understanding Science So You Can Teach It.* Arlington: NSTA Press, 2002.
- For an on-line mass-weight converter, see http://www.exploratorium.edu/ronh/weight/index.html

- For a discussion of Newton's Three laws of Motion, see
  http://www.sciencemaster.com/jump/physical/newton_law.php
  http://www.lerc.nasa.gov/WWW/K-12/airplane/newton.html
  http://www.physicsclassroom.com/Class/newtlaws/newtltoc.html
- For extensive activities utilizing Newton's Three Laws and Rocketry, see
  http://exploration.grc.nasa.gov/education/rocket/bgmr.html
- For a on-line activity for Newton's Three Laws and Roller Coasters, see
  http://www.funderstanding.com/k12/coaster/
- For information about orbit speed of planets, see
  http://solarsystem.nasa.gov/planets/index.cfm
  http://liftoff.msfc.nasa.gov/academy/rocket_sci/orbmech/vel_calc.html
- For Discovery Streaming Videos (must have log in and password), see
  http://streaming.discoveryeducation.com/index.cfm or
  http://www.lpb.org/education/cyberchannel.cfm
- For information and illustrations to explore the nebular hypothesis of the solar system, see
  http://csep10.phys.utk.edu/astr161/lect/solarsys/nebular.html
  http://www.nineplanets.org/origin.html

Physical Science
Unit 6: Energy, Work, and Power

Time Frame: Approximately four weeks

Unit Description

Investigations or activities involving simple and compound machines are used to test hypotheses. The relationship between energy, work, and power will be developed along with the concepts associated with energy, types of energy, and energy transformations.

Student Understandings

Using inquiry processes, students will demonstrate their understanding of simple and compound machines and will describe the relationships among energy, work, and power. Students will identify and examine differences between potential and kinetic energy, and also analyze various energy transformations.

Guiding Questions

1. Can students differentiate between potential and kinetic energy?
2. Can students relate energy, work, and power?
3. Can students contrast simple and compound machines?
4. Can students determine the efficiency of a machine?
5. Can students describe the various forms of energy?
6. Can students identify how thermal energy is transferred?

Unit 6 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
2.	Describe how investigations can be observation, description, literature survey, classification, or experimentation (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)

GLE #	GLE Text and Benchmarks
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
10.	Given a description of an experiment, identify appropriate safety measures (SI-H-A7)
12.	Cite evidence that scientific investigations are conducted for many different reasons (SI-H-B2)
Physical Science	
36.	Measure and calculate the relationships among energy, work, and power (PS-H-F1)
38.	Analyze diagrams to identify changes in kinetic and potential energy (PS-H-F2)
39.	Distinguish among thermal, chemical, electromagnetic, mechanical, and nuclear energy (PS-H-F2)
40.	Demonstrate energy transformation and conservation in everyday actions (PS-H-F2)
Earth and Space Science	
7.	Analyze how radiant heat from the Sun is absorbed and transmitted by several different earth materials (ESS-H-A5)

Sample Activities

Activity 1: Kinetic Energy & Potential Energy (SI GLE: 5, 7; PS GLE: 38)

Materials List: rubber band, (per group) two rulers, small paper cup, glass marble, steel marble, several books of different heights, stopwatch, balance, illustrations of kinetic and potential energy from magazines, books, Internet, or other print sources, additional energy word problems

As an introduction to kinetic and potential energy, show students a rubber band that you stretch between your two index fingers. Ask them to predict what will happen when you release the rubber band (it flies across the room). Stretch the rubber band more and ask them to predict if anything different will occur (it flies farther across the room). SAFETY NOTE: Aim rubber band to empty space across the room. Define energy as the ability to do work; energy waiting to do work is potential and energy of motion is kinetic.

As a follow-up activity, have students set up a ruler with one end on a book and the other end on the desk. Place a paper cup (with a rectangular notch cut into the top of one edge) upside down on the table at the end of the ruler. (The notch now looks like a mouse hole at the end of the ruler.) Students should place a marble at the top of the ruler and release it. It will roll down the ruler, into the cup and force the cup backwards along the table. (Have students investigate what happens when more books are used to place the end of the ruler on. The top of the ruler is now higher when the marble is released. Students should experiment with and compare a steel marble to the glass marble.) Through direct instruction and class discussion, have students operationally define potential and kinetic energy from their experimentation. Introduce the formulas to calculate kinetic energy

(KE = 1/2 mv^2) and gravitational potential energy (PE = mgh). Provide student groups with a stopwatch, an additional ruler, and a balance and allow them to calculate potential and kinetic energy for their experiment.

Following this combination of direct instruction and discovery investigation on potential energy as stored energy and kinetic energy as energy in motion, provide students with diagrams that illustrate these types of energy and changes in kinetic and potential energy. Some examples might include gasoline as chemical potential energy and its conversion into kinetic energy in an engine after it has burned, thermal potential energy in water as it turns to steam and opens the whistle of a kettle, gravitational potential energy of water in a dam that is converted into the kinetic energy of the turning electrical generators, or elastic potential energy of a bouncing ball and the height it returns to after its bounce. Have the students analyze the information in the illustrations utilizing teacher-generated questions. Questions should be developed to have students classify the type of energy illustrated, describe changes when illustrated, and determine which will elicit the relationship between the potential and kinetic energy. As an extension, provide students with word problems utilizing energy and have them calculate kinetic and potential energy.

Activity 2: Modeling Kinetic and Potential Energy with Roller Coasters (SI GLE: 7; PS GLE: 38)

Materials List: toy car track (foam pipe insulation can be substituted), marbles, meter stick, balance, science learning log, (optional: photogates, motion detectors)

Using a modified *DR-TA* (view literacy strategy descriptions), students will make predictions about the amount of kinetic energy and potential energy along a roller coaster of their design. DR-TA is an instructional approach that invites students to make predictions, and then check their predictions during and after the reading or experimentation. The *directed reading-thinking aloud (DR-TA)* strategy utilized with experimentation allows students to utilize inductive and deductive reasoning as they predict and text their predictions with actual experimentation.

Begin the DR-TA with reviewing information learned in Activity 1 of this unit. This will serve as the background component of the strategy to engage students. Tell students that they will be working in their groups to create a roller coaster with two hills that will allow a marble, utilizing its potential and kinetic energy to travel the entire length of the track. In their science *learning logs* (view literacy strategy descriptions) have students design their track indicating where potential energy will be the highest and lowest and where kinetic energy will be the highest and lowest. They should also indicate how they will be able to measure this difference. (Note: Potential energy (PE = mhg) can be measured using a meter stick to measure height and a balance to measure mass, but kinetic energy (KE = ½ mv2) may be more difficult to measure (i.e., the velocity) if the optional equipment (photogates or motion detectors) is not available. This KE measurement may only consist of a visual observation of relative speed if the optional equipment is not available.

Utilizing student groups of 3-4, provide each group with toys car tracks, marbles, and a meter stick. Challenge the student groups to design a roller coaster with two hills. The goal is to have the largest measurement combined in the height of the two hills (total height of hills) and still have the marble travel to the end of the track. As the groups work together, they should begin to recognize that by manipulating height of the hills, they can increase the speed of the marble so that it can travel over the top of both hills to the end of the track. As the height of the hills of the roller coaster are changed, students should record the effects each design change has on the speed of the marble and its travel length. Using their science *learning logs*, students should record all data from each trial and draw a labeled diagram of their final track design, including height measurements. They should explain the relationship of height to potential energy and the resulting kinetic energy. They should also explain the effects of speed on the momentum of the marble as it travels over their designed coaster. With successful trials, they should revisit their original *DR-TA* to check and revise their original predictions, if needed. As closure to this activity, ask students to compare what they expected to learn from this experiment with their prediction and what they actually learned from the activity. When students have a chance to predict and revise their predictions, they often have much to say about the process of their learning. These reflections can be written in their science *learning logs* and then shared with their group or with the whole class.

If access to the Internet is available, this investigation can be conducted as an on-line roller coaster simulation. Two are available on-line
http://www.funderstanding.com/k12/coaster/ or
http://www.learner.org/interactives/parkphysics/coaster/

Activity 3: Energy, Work, and Power—the Basics (SI GLEs: 5, 7; PS GLE: 36)

Materials List: science learning log, stairwell, timer, meter stick, additional word problems concerning work, power, and energy

Part 1: Work
As a demonstration to develop the definition of work (work can be defined as the product of the force used to move an object times the distance the object is moved), pick up a stack of books from the desktop. Tell students you just did work on the stack of books and ask them to write a short explanation of two to three sentences in their science *learning logs* (view literacy strategy descriptions) as to why this was work. Students should recognize that a force was exerted in the direction of the motion of the books. After students have recorded their analysis, walk with the books (held in the same position) across the room. Tell students that you did not do any work on the books according to the scientific definition of work. Again allow them to write a short explanation as to why this demonstration was not work (since the force holding the books

up was not in the same direction as the motion across the floor; moving the books across the room is NOT work, but lifting them up is work).

Demonstrate the calculation of work and explain the meaning of a joule (J). Use guided questioning and direct instruction to assist students in constructing their understandings of the relationship of work and energy (energy being the ability to do work) and the relationship of work and power (power being the rate at which work is done).

Part 2: Power
Divide students into groups of 3 to 4 students. Each group should choose one student who doesn't mind sharing his/her weight with the group. This student will also walk up a flight of stairs as well as run up the stairs. (NOTE: if no staircase is available, stadium or gymnasium stairs can be substituted) Calculate the student's weight in newtons by multiplying the weight in pounds by the conversion factor of 4.45 (NOTE: lbs x 4.45 = newtons). The group should time the student walking up a flight of stairs in seconds, and then time the student running up the same set of stairs. Care should be taken not to trip and student groups should take turns allowing for the size of the stairwell. Measure the vertical height of the flight of stairs to the nearest 0.01 meter. (Measure each step and multiply by the number of steps). Using the formula w = F x d, calculate the work of walking up the stairs and running up the stairs for the student. (Note: F = weight in newtons of the student and d = height of the stairs). Using the formula P = w/t, calculate the power required to walk verses run up the stairs. Have students determine if there is a difference in the work in joules done in walking compared to running up the stairs. Also have students determine if there is a difference in the power in watts of walking up the stairs to running up the stairs. Compare the student's power to the power of a 150-watt bulb.

Provide students with word problems concerning energy, work, and power in which they must solve for the unknown variable. They should utilize the following formulas:
Work (joules) = F(N) x d(m)
Power (watt) = w (J) / t (sec)
Power (watt) = { F (N) x d (m) } / t (sec)

Activity 4: Machines (SI GLEs: 5, 10; PS GLE: 36)

Materials List: various simple machines around classroom or school, science learning logs, large sheet of paper or poster

Because students have studied simple machines in previous grade levels, it is important to assess their understanding of the types of simple machines prior to working with them. Students will create a *vocabulary self-awareness chart* (view literacy strategy descriptions) prior to this activity. Students may add additional terms to the list as they proceed through the activity. Each vocabulary word is rated according to the student's understanding, including an example and a definition, on a rating scale from being very comfortable with the word to unsure (+, √, or –) of the word if it is new to the student.

Over the course of conducting the activity, students should add new information to the chart. The goal is to bring all students to a comfortable level with the content vocabulary. Because students continually revisit their vocabulary charts to revise their entries, they have multiple opportunities to practice and extend their growing understanding of important content terms. An example of the *vocabulary self-awareness chart* is shown below.

Simple Machines Vocabulary Self-Awareness Chart

word	+	√	–	example	definition
pulley					
lever					
screw					
wheel and axle					
wedge					
inclined plane					
load					
fulcrum					
effort					

After students have a chance to complete their initial *vocabulary self-awareness chart,* as a whole class identify simple machines that might be found in the classroom and/or at school. Some examples might include the overhead projector screen (pulley), doorstop (wedge), door knob (wheel and axle), paper cutter (wedge/lever), scissors (wedge/lever), screwdriver (lever), tape dispenser (pulley), door push bar (lever), flagpole (pulley), bolt (screw), ceiling fan (wheel and axle), etc. For each machine, students should identify how force is transferred and locate and label load, fulcrum, and effort point on student-drawn diagrams of the various identified simple machines. Have students use their science *learning logs* (view literacy strategy descriptions) to update their *vocabulary self-awareness chart* along with recording these diagrams and explanations.

Once students have identified examples of all six types of simple machines—pulley, wheel and axle, lever, wedge, screw, and inclined plane—facilitate a class discussion with calculations of work output compared to work input in determining the efficiency of each machine. A compound machine should then be demonstrated, such as a pair of scissors or a rotary pencil sharpener (not an electric one). Students should differentiate between simple and compound machines.

Incorporating their knowledge of simple and compound machines, student groups of three to four should select a task, such as pouring a can of soda, activating an alarm clock, or brushing a dog's hair, in which they must utilize at least five simple machines to create a compound machine that will perform the desired task. Have students identify appropriate safety procedures for this task. A poster or large diagram of their "Rube Goldberg" completed compound machine should be shared with the class as well as displayed throughout the room. Remind students to return to their *vocabulary self-awareness charts* for any necessary updates and additions.

If the Internet is available, wonderful videos of Rube Goldberg machines can be found at http://www.youtube.com/watch?v=DtVkzgKObv0 or http://www.youtube.com/watch?v=UScbWzhieNc

This site is often blocked by school districts, but sometimes individual pages can be unblocked for classroom use. If your district allows this, these two individual sites are worth the trouble taken to show these to classes of students. They may be used as an introduction or as a concluding activity for simple machines.

Activity 5: Types of Energy (SI GLEs: 5, 6; PS GLE: 39)

Materials List: text or other material for assigned reading about energy forms or video on similar subject

Begin this activity with a lecture, video, or assigned reading about the various forms of energy, making sure the information covers thermal, chemical, electromagnetic, electrical, mechanical, and nuclear energy. Place students into six groups, with each group assigned to become "expert" in one form of energy. In this *professor know-it-all* activity (view literacy strategy descriptions), the students are given time to review and take notes on their assigned form of energy. The teacher tells them they will be called on randomly to come to the front of the room and provide "expert" answers to questions from their peers about their assigned content. Also the groups are asked to generate 3-5 questions about all of the energy forms they might anticipate being asked and that they can ask other experts.

As each form of energy is reviewed, that expert group comes to the front of the class. A student is allowed to ask a question. The group huddles and determines the best answer for that question and one "professor know-it-all" answers for the group. The teacher should remind students asking the questions to think carefully about the answers received and challenge or correct the "professor know-it-alls" if answers were not correct or need elaboration and amending. After 5 minutes or so, a new group of "professor know-it-alls" can take their place in front of the class, and continue the process of students questioning students.

Initially, it may be necessary and helpful for the teacher to model the various types of questions expected from students about the content. For example, students should ask the know-it-alls both factual and higher-level questions. If critical questions are not asked, the teacher should pose those questions to the group. Continue this process until each form of energy is questioned and reviewed.

Utilizing their newly acquired information, students should construct a concept map, chart, or some other type of *graphic organizer* (view literacy strategy descriptions) comparing and contrasting the six different forms of energy. For personal comprehension, students should work individually on this activity.

Activity 6: Transformations (SI GLE: 6, 7; PS GLE: 40)

Materials List: large paper or poster board, markers, various research materials, (optional: digital presentation software)

Incorporating their knowledge of the various forms of energy, have students select a task, such as cooking food, using an electric can opener, activating an alarm clock, or pouring a glass of milk, in which they must utilize the concept of energy transformations to perform the desired task. Working in pairs, instruct students to describe the task in steps, illustrate the steps, identify the forms of energy used in each step of the task, and label the energy transformations occurring at each step. Require students to incorporate at least five transformations in their illustrated explanations. Students' work may be shared in small group settings or as class presentations as well as displayed throughout the room. An alternative presentation would be the creation of an instructional pamphlet or brochure for their chosen task, or if time allows, student groups may create a multimedia presentation.

Activity 7: Thermal Energy and How It Moves (SI GLE: 2, 9, 12; PS GLE: 40; ESS GLE: 7)

Materials List: aluminum foil, throw rug or thick towel, science learning logs

Begin this activity by reviewing with students the Kinetic Molecular Theory (Unit 2, Activity 4), which explains the relationship between molecules and the energy they possess. Specifically review the concept that as heat energy is increased for a substance, the particles of the substance move faster. The molecules of a substance above absolute zero are always in motion and therefore possess kinetic energy. Obviously the motion of the molecules is random and chaotic, but the total of this kinetic energy is the substance's thermal energy, commonly referred to as heat energy.

Through direct instruction with students, reinforce the difference between heat and temperature (students commonly have the misconception that heat and temperature are the same thing). Heat is a form of energy caused by the internal kinetic energy or motion of the molecules of a substance. Temperature is the measure of the average kinetic energy of the molecules of a substance. Review with students that heat is energy that is transferred between two things because of a temperature difference, and heat always flows on its own from a hotter to a cooler substance (regardless of the amount of each substance).

Ask students to describe what happens when they hold an ice cube tightly in their hand. (The ice melts; their hand feels cold, etc). Students often mistakenly think that the coldness of the ice is transferred to their hand; however, the opposite is actually true. The heat of their hand causes the ice cube to melt due to transfer of heat from hotter (their hand) to colder (the ice cube).

Ask students to describe what happens when they accidentally touch the metal handle of a hot saucepan cooking food on the stove. (It burns their finger). This is an everyday example of heat transfer from hotter to cooler. Additionally, have students explain why they might feel heat on their toes at the bottom of their refrigerator. (The refrigerator's job is to cool substances (remove heat energy) and that heat energy must be transferred somewhere. It is often exhausted through the grill at the bottom of the refrigerator and they feel the heat on their bare toes.)

Place a piece of aluminum foil flat on the table and a thick towel flat next to it. Allow students to put one hand on the aluminum foil and the other hand on the towel. They should observe and assess the different temperatures. The metal feels colder than the towel because the aluminum foil allows the heat from their hand to move through it whereas the towel does not. Substances or things feel cold to the touch when heat energy is drawn away from your skin, and alternatively, substances or things feel warm when heat energy is transferred to your skin. (This is also an example of conductors and insulators).

Ask students to identify the original source of thermal energy for Earth (the Sun). Review with students how that heat transfer occurs through radiation, conduction and convection and instruct them to record examples of each in their science *learning logs* (view literacy strategy descriptions). Conduction allows heat transfer through direct contact between molecules. Faster moving molecules transfer some of their thermal energy to slower moving molecules. (Ironing clothes, spoon in a cup of hot soup). Convection occurs mostly in fluids (gases and liquids) by means of up and down flows of convection currents, warmer rises and cooler sinks (wind, various forms of weather, rice rising and falling in boiling water, ocean currents). Radiation is the transfer of thermal energy through empty space (or air once it reaches Earth) in the form of infrared radiation (feeling hot from the sun's rays, cooking marshmallows without the campfire touching them).

As a conclusion to this activity, instruct students to make a list of places in their homes or at school where thermal energy may be escaping to the outside. Students can work individually or in groups of 3 to 4 as determined by the teacher. They must determine if this thermal loss is due to conduction, convection, or radiation. Impress on students that scientific investigations can be conducted for many different reasons: to gather new information, help cure diseases, save money or make a profit, change existing ideas, etc. In this instance the information found in their investigation could be used to make repairs and save money on energy costs of heating and cooling. Students should try to find at least one example of each of the three transfers of energy. Each student or student group should complete an energy report that includes the following:

1) instance and location of the thermal energy loss found
2) identification of the type of heat transfer occurring at the site of the energy loss
3) explanation that supports their identification (why is this an example of conduction, convection, or radiation specifically)
4) ways the thermal loss could be reduced in this particular example.

The teacher should set the parameters of time needed for identification of thermal loses, completion of the report, and the number of thermal energy losses to be identified by the students in the report. If technology is available, students could create multimedia presentations to present to the class and/or school administration for help in reducing school costs.

Sample Assessments

General Guidelines

Assessment techniques should include use of drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

- Students should be monitored throughout the work on all activities via teacher observation of their work and journal entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- When possible, students should assist in developing any rubrics that will be used.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will analyze the relationship between potential and kinetic energy of a falling object.
- The student will construct a compound machine to perform a simple task. They may not use an existing compound machine but must build one from two or more simple machines.
- The student will design an investigation that will provide accurate and reasonable data to answer the following question: Utilizing energy transformation, how can I construct a device that will use at least three energy transformations? The device design and testing will clearly permit the collection of information that addresses the framing questions of the investigation.

Activity-Specific Assessments

- Activity 1 and Activity 2: The student will differentiate between kinetic and potential energy for various points (as determined by the teacher) along a roller coaster or other amusement park ride.

- Activity 3: The student will determine and compare the work output of various machines given the force and distance.

- Activity 6: The student will make a chart that shows the transformation of energy from one form to another in the following scenario. (Students must use terms learned during the unit correctly and incorporate key concepts.) Sam wakes up at 5:45 am, showers, dresses, and eats a bowl of oatmeal. It is a nice day, so he rides his bike to school, which is up the hill from his house. Sam has a light attached to his bike that is powered when he pedals. Sam now rides to school.

Resources

- Taylor, Beverly A. P., James Poth, and Dwight J. Portman. *Teaching Physics with Toys.* Middleton: Terrific Science Press, 1995.
- Robertson, William C. *Energy: Stop Faking It! Finally Understanding Science So You Can Teach It.* Arlington: NSTA Press, 2002.
- Yeany, Bill. *If You Build It, They Will Learn: 17 Devices for Demonstrating Physical Science.* Arlington: NSTA Press, 2006.
- Tymony, Cy. *Sneaky Uses for Everyday Things*. Kansas City: Andrews McMeel Publishing, 2003.

Physical Science
Unit 7: Light and Sound

Time Frame: Approximately two to three weeks

Unit Description

This unit thoroughly examines the properties of waves, including visible light and the electromagnetic spectrum and sound. Two activities in this unit provide earth science-based applications of physical science principles. These activities could also be completed along with activities of Unit 9, which is dedicated to earth science applications.

Student Understandings

Incorporating inquiry processes, students will examine and identify properties of waves as they relate to light and sound. The electromagnetic spectrum will be analyzed, and connections will be made among the phenomena of light, electricity, and magnetism. Students will be able to identify and explain the Doppler Effect.

Guiding Questions

1. Can students define waves and describe the properties of waves?
2. Can students relate waves to aspects of everyday life?
3. Can students describe the relationship between the wavelength and frequency of waves?
4. Can students describe the composition of white light?
5. Can students differentiate among the waves in the electromagnetic spectrum?
6. Can students interpret and explain diagrams illustrating the laws of refraction and reflection?
7. Can students identify and describe the Doppler Effect?
8. Can students explain at least one application of the Doppler Effect?

Unit 7 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)

GLE #	GLE Text and Benchmarks
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6)
14.	Cite examples of scientific advances and emerging technologies and how they affect society (e.g., MRI, DNA in forensics) (SI-H-B3)
Physical Science	
41.	Identify the parts and investigate the properties of transverse and compression waves (PS-H-G1)
42.	Describe the relationship between wavelength and frequency (PS-H-G1)
43.	Investigate and construct diagrams to illustrate the laws of reflection and refraction (PS-H-G1)
48.	Compare properties of waves in the electromagnetic spectrum (PS-H-G3)
49.	Describe the Doppler effect on sound (PS-H-G3)
50.	Identify positive and negative effects of electromagnetic/mechanical waves on humans and human activities (e.g., sound, ultraviolet rays, X-rays, MRIs, fiber optics) (PS-H-G4) (PS-H-G3)
Earth and Space Science	
23.	Identify the evidence that supports the big bang theory (ESS-H-D1)
26.	Identify the elements present in selected stars, given spectrograms of known elements and those of the selected stars (ESS-H-D4)
30.	Summarize how current technology has directly affected our knowledge of the universe (ESS-H-D7)

Sample Activities

Activity 1: Waves—Energy in Motion (SI GLEs: 5, 7; PS GLEs: 41)

Materials List: science learning logs, stopwatch, meter stick or longer measuring tape (if available), student chairs, large area

Often high school students bring a range of word understandings to the classroom; therefore, it is important to assess students' word knowledge prior to a discovery activity. This process is valuable for students because it highlights their understanding of what they know, as well as what they still need to learn in order to fully comprehend the content material. To begin this activity, have students fill out a *vocabulary self-awareness chart* (view literacy strategy descriptions) in their science *learning logs* (view literacy strategy descriptions).

With *vocabulary self-awareness charts*, target vocabulary for the upcoming activity is identified and presented to the student in chart form. See the example below. Students should add terms to the list as they read. Each vocabulary word is rated by the student on a scale of being very comfortable with the term (+), somewhat sure/unsure with the term (√), or totally new term (–), along with including an example and a definition. Over the course of the activity and the unit, students should add new information to the chart. The goal is to bring all students to a comfortable level with the unit's content vocabulary. Because students continually revisit their vocabulary charts to revise their entries, they have multiple opportunities to practice and extend their growing understanding of important content terms. Students should also be encouraged to add terms to their chart at anytime during the unit.

Waves Vocabulary Self-Awareness Chart

word	+	√	–	example	definition
wave					
wavelength					
crest					
trough					
frequency					
amplitude					
period					

By physically doing the "wave" made popular at sporting events, students will investigate waves in terms of their properties, frequency, amplitude, wave velocity, and wavelength. Students will then describe the behavior of waves as they interact and hit one another.

Place a chair for each student close together in a circle. If there is a space limitation, this activity can be conducted outside or in a gym. Two students will serve as timer and counter/recorder; they will stand outside the circle. Have other seated students practice a few waves. Students should identify all parts of a wave, including the crest, the trough, and the normal rest position. They should identify these points in their human wave, observing that they have no trough position in their wave.

To incorporate a trough, have students stand with raised hands for the crest and then kneel with hands lowered for the trough. The second student in the human wave will raise their hands when the first one begins to kneel. The rest position will be halfway between hands up/standing and hands lowered/kneeling. This may take some practice trials.

After this wave has gone around the circle with success (a few continuous rounds), have students identify the wavelength (distance from crest to crest, i.e., distance from student with hands up to next student with hands up), crest (highest point of wave, i.e., student with hands up), and amplitude (distance from rest to crest, i.e., distance from student with hands at rest to student with hands up). An average of the amplitude will be taken with this "human wave" because heights will vary between students.

Students should identify the wave medium as being themselves and should recognize that the wave they have demonstrated is an example of a transverse wave. Note: the medium for a wave is the substance or material which carries the wave; make sure students add this term to their *vocabulary self awareness charts*. It is difficult to do the wave by standing and kneeling, so to simplify from this point in the activity have students go back to the original sitting and standing wave for the remainder of the activity.

Ask the students to define the period of their wave, the time it takes for one student to stand and sit back down. The timekeeper, who is outside the circle, should calculate the period of the wave as the students do their wave.

Challenge students to demonstrate how they would double the period (they should go one half the original speed) and how to cut their original period in half (they should go twice as fast).

Students should define their frequency by having the timekeeper time the students doing the wave for a set time (30-60 seconds), while another student outside the circle counts the number of waves that go by.

Challenge the students to double their frequency (they should double their speed). Then ask them to cut the frequency in half (they should half their original speed). Because this requires the cooperation of everyone in the circle, many attempts may be necessary to achieve the desired results.

To conclude this activity, discuss what would happen when two waves interact. Allow students to simulate this interference.

For final closure, have students revisit their wave *vocabulary chart* to revise or add definitions and examples. They should also update their rating of their understanding of the term.

This activity is based on materials developed by ROBIE project participants Erin Babin, Greg Sollie, Celeste Carmouche, Lucy Dunaway, Michele Macloud, Shelly Simmons and Mary Gail Yeates under the direction of Dr. Greg Guzik. The project was funded by the Louisiana Technology Innovation Fund and further supported by Louisiana State University. Permission to use was granted by Dr. Guzik. More information can be found at http://www.bro.lsu.edu/radio/Classroom/classroom.html.

Activity 2: Understanding Transverse and Compression Waves (SI GLEs: 5, 7, 9; PS GLEs: 41, 42)

Materials List: (per group) double length slinky ™, rope, or other type of long spring, length of plastic tubing, science learning logs, Wave Venn Diagram BLM, safety goggles

To investigate compression or longitudinal waves, students should lay the spring out on a smooth floor to a length of about 6 to 10 meters. One student (the holder) holds one end that does not move during the observation. Another student (the shaker) holds the opposite end of the spring in one hand. With their free hand, the shaker should grasp the stretched spring about a meter from their end. Have the shaker pull the meter of spring together toward their hand on the end of the spring and then release it. Make sure the shaker does not let go of the fixed end in their other hand. Instruct students to observe the single wave, or pulse, that travels along the spring. In a compression (or longitudinal) wave, the pulse of energy moves back and forth along the same direction as the wave travels (the length of the spring). Point out to students that the wave carries energy, but the spring remains stationary after the pulse has passed through it and reflected from the other end. Note: The compression wave can be seen more easily if the students tie small pieces of string to several tops of the loops of the spring and watch their motion when the spring is pulsed. Using their science *learning logs* (view literacy strategy descriptions), students should record their observations and sketch/label the compression wave. Have them answer the following questions along with any others determined by the teacher and/or students:

- What did you observe about the progress of the compression wave? (*The wave traveled down the length of the spring and back from the end until it slowed and stopped.*)
- What happens to the energy of the wave? (*It dissipates as the friction between the floor and the spring are overcome.*)
- Where do we find compression waves on Earth? (*Sound waves and seismic waves (the P waves) are compression waves. Seismic waves called S waves are shear waves and do not pass through liquids, such as the molten core.)*

To investigate and compare transverse waves, students should hold the spring along the floor in a similar manner as before. The holder holds his/her end stationary at all times, and the shaker moves his/her hand back and forth at right angles to the stretched spring until a pulse is produced that travels down only one side of the spring (the "bump" on the spring due to the pulse is only on the right or left side of the spring). In a transverse wave the wave or pulse of energy moves at right angles (transverses to) the length of the spring. Students should also recognize this wave as similar to the one studied in Activity 1.

Again using their science *learning logs*, have students record their observations and sketch/label their transverse wave. Using their spring wave model, have students answer the following questions along with any others as determined by the teacher and/or students:

- Does the size of the pulse change as it travels along the spring? (*Yes.*)
- If yes, how does it change? *(It becomes smaller.*)
- Does the pulse reflected from the far stationary end return to you on the same side of the spring as the original wave, or does it return on the opposite side? (*It returns on the opposite side.*)

- Why? (*Since the holder is holding the spring stationary, the wave has to invert [or reflect] to continue to move back down the spring.*)
- Does a change in the tension of the spring have any effect on the speed of the pulses? Note that when you stretch the spring farther, you are changing the nature of the medium through which the pulses move. (*As the tension in the spring increases, the speed of the pulses increases. If the tension is decreased, then the speed of the pulses will decrease. This is a direct relationship*.)

For the next investigation, have students attach a length of plastic tubing (or rope) to the end of their spring, and again create a transverse wave. This demonstrates what occurs when a wave travels from one medium to another, an event called refraction. After recording their observations in their science *learning logs* and sketching the wave model, students should be able to answer the following question:

- What happens to the pulse, or wave when it reaches the place where the spring is attached to the tubing (the boundary between the two media)? *(When a wave hits the boundary between the two types of material, part of the wave is reflected and part is transmitted.)*
- Describe its size, its shape, its speed, and the direction in BOTH media after the pulse reaches the boundary. Notice that at the far end of your spring, where it is attached to the different media, the tubing should now be free to move back and forth at the joint, which it was unable to do before because the holder was holding it. If you notice that the far end of the spring is not moving freely, be sure to make a note of it in your observations as you record the answer to this question. (*If the boundary is free to move, the reflected pulse should be on the same side as the incident [original] pulse, smaller than the incident pulse, the same shape as the incident pulse, and should travel with the same speed. The wave or pulse, that travels into the other medium [the tubing], will be on the same side of the new medium as the incident wave, but it will be smaller than the original pulse, and travel with a different speed.*)

To investigate interference, have students detach the tubing they added for the prior investigation. Instruct students to return to their original transverse wave generation model, and have the shaker send a pulse down the spring at the exact same time that the holder sends a pulse down the spring. They must be sent on the same side and students may need to practice this before making a final observation. The waves meet and interact; this is called interference. Instruct students to record their observations and sketch/label their interference model. They should describe the size, the shape, the speed, and the direction of each wave or pulse during and after the interaction. Teacher note: it will be easier to see what happens in the interaction if one pulse is larger than the other. They should then answer the following questions along with any others as determined by the teacher:

- What happens when the two pulses reach the center of the spring? (*When the* *two pulses meet in the center, they will add together to make a pulse that is as large as the sum of the two pulses. The shape should be the same, just larger. The speed of the pulses remains the same as they travel through each other.* Teacher note: students will often say that the pulses bounce off of each other or reflect. If they do this, suggest that the students make the pulses different sizes and that they lower the tension in the spring.)

- What happens when two pulses on opposite sides of the spring meet? To investigate this, students must send one wave down the right side and have their partner must send another down the left side at the same time.
- Students should describe the size, the shape, the speed, and the direction as they did in previous questions. (*When waves or pulses on opposite sides of the spring meet, they cancel out if the pulses are the same size. If they are not the same size the addition [or subtraction] of the pulses when they meet should result in a smaller pulse being formed, but only momentarily. The shape will flatten out if the pulses are the same size or become smaller if they are not the same size. The speed of the two pulses should stay the same*.)
- As the two pulses pass each other when they start on opposite sides of the spring, can you observe a point on the spring that does not move at all? Explain. (*There is a point where the spring does not move if the pulses start from opposite sides of the spring. This is called a node. It is formed when the opposite motions of the spring cancel out and there is no movement*.)
- From the observations you have just made make a general statement about the displacement caused by the addition of two waves or pulses at the same point. (*Waves or pulses traveling in the same medium either add together or subtract from each other when they meet.*)

To investigate the relationship between wavelength and frequency, have the shaker vibrate his/her hand steadily back and forth while the holder holds the opposite end of the spring stationary. They should produce a train of waves or pulses, called a periodic wave. Remind students that the distance between any two adjacent crests on such a periodic wave is the wavelength. The rate at which you vibrate the spring will determine the frequency of the periodic wave. Instruct students to produce various short bursts of periodic waves having different frequencies. After their experimentation, have students record their observations in the science *learning logs*, and determine the relationship between wavelength and frequency. They should record specific observations from their experiment to defend their position on this relationship. (*Wavelength and frequency are inversely proportional. As the wavelength gets smaller, the frequency increases. As the student moves his/her hand faster, the waves are closer together. Any of these three sentences is an acceptable answer.*)

As closure to this activity, allow students to add some or all of the following terms to their *vocabulary self-awareness chart* (view literacy strategy descriptions) in their science *learning logs* (in addition to any the teacher indicates): *transverse wave*, *compression wave*, *reflected wave*, *pulse*, *refraction*, *incident wave*, *node*, *interference*, *direct relationship*, *indirect relationship*. Additionally, they can complete a *graphic organizer* (view literacy strategy descriptions) in the form of a Venn diagram to compare and contrast transverse and compression waves. See Wave Venn Diagram BLM for handout.

This activity was adapted from *Waves Light Up the Universe*, produced as part of the Education and Public Outreach program of NASA's Swift Mission. More information can be found at http://swift.sonoma.edu/education/slinky_booklet/index.html

Activity 3: Opposing Viewpoints (SI GLEs: 9, 14; PS GLE: 50)

Materials List: Radiation Opinionnaire BLM, appropriate text reading about radiation

This activity is meant to be a springboard to engage students in the topic of the electromagnetic spectrum for the activities that follow. Have students complete the Radiation *Opinionnaire* (view literacy strategy descriptions) BLM prior to reading a short appropriate selection of text about the various forms of radiation in the electromagnetic spectrum. Depending on the text, the teacher may need to adjust the supplied *opinionnaire*. Using an opinionnaire requires students to generate statements about the topic of radiation and forces them to take positions and defend them. The emphasis is on students' points of view and not the "correctness" of their opinions. At this point in the unit, students have had not investigated the electromagnetic spectrum in depth, but prior knowledge should offer some basis for their opinions.

Have students work in pairs to read and discuss each statement, then write down reasons for their opinions. Encourage students to write clear, concise, thoughtful answers for their justification of their opinion. At this point in the activity, after opinions have been written, allow students to read the appropriate text with content about the electromagnetic spectrum. After reading, offer students the opportunity to discuss and revise their opinions with their partner. Afterward, invite students to share their opinions for each statement and separate supporters from non-supporters. Force each student to take a stand. Then, ask the two groups to briefly debate the statement and allow for any students who have changed their minds to move to the other group. By taking a stand on issues related to radiation and the electromagnetic spectrum and engaging in critical discussion about those issues, students will heightened their expectation of the content about radiation to follow and make many new connections from their opinions and ideas to those of their classmates. Specific topics related to the questions may arise as a result of this discussion. The teacher should use his/her discretion in selecting topics to debate. The discussion should evoke from the students that electromagnetic waves have not only been helpful to man (e.g., in allowing us to see and communicate) but also harmful to man (e.g., in causing cancer from overexposure to the Sun). The discussion of the statements should show students how strongly these types of energies are integrated into their daily lives.

Activity 4: Electromagnetic Spectrum: It's Not Just What You See! (SI GLEs: 5, 7; PS GLEs: 48)

Materials List: spectrometer (or spectroscopes), fluorescent light, calculator, Measuring Visible Light BLM, science learning log

To predict and physically verify the relationship of frequency and wavelength of visible light have students investigate the fluorescent light found in the classroom (hallway or nearest room with fluorescent lighting, if classroom doesn't have fluorescent lighting) using a spectrometer. A spectrometer is an optical instrument used to study and measure properties of light over a specific area of the electromagnetic spectrum. Inexpensive spectrometers for use in the classroom can be obtained and are often found in physics labs. Spectrometers allow students to actually determine the wavelength of the light component they are viewing, and it is the preferred instrument for this activity. However, if none are available, simple spectroscopes can be easily made. Spectroscopes will break down the light into its components, but students must use additional charts (like the ones found below) for specific wavelengths. Instructions on how to make and use spectroscopes can be found at
http://asd-www.larc.nasa.gov/edu_act/simple_spec.html
http://sci-toys.com/scitoys/scitoys/light/cd_spectroscope/spectroscope.html

Divide students into groups of three to four, and taking turns using the spectrometer, instruct them to look at the spectrum of fluorescent light. They should determine the wavelength at the center of the bright band of each color, reading the scale to the nearest tenth. Exact wavelengths for various colors of light can be found at http://eosweb.larc.nasa.gov/EDDOCS/Wavelengths_for_Colors.html and a summary is found below:

Accepted Average Wavelength of Visible Light (400-700 nm)

violet	400 nm
indigo	445 nm
blue	475 nm
green	510 nm
yellow	570 nm
orange	590 nm
red	650 nm

The following percent error calculation of this activity may be considered as optional or enrichment by some teachers. Students will calculate the percent error for wavelength of each color by comparing their calculated values to the original values as shown above. From prior activities, students have learned about the fundamental concepts of frequency (f) and wavelength (λ) of light. They will need the constant value of the speed of light in vacuum:

C (speed of light) = 3.00×10^8 m/s (meters per second)

And the formula relating speed of light, frequency, and wavelength:

C (m/s) = *f* (frequency in Hertz (HZ)) X λ (wavelength in meters (m))

Students may not be familiar with these formulas. They must be introduced to students along with the symbols used specifically for each variable. For example, C is to designate the speed of light, *f* is the commonly accepted symbol for frequency, and λ is the symbol used for wavelength.

For the calculation of percent error, use the following formula (note nanometers (nm) must be converted to meters (m) for the frequency calculations):

$$\text{Percent Error} = \frac{\text{accepted value (m) - calculated value (m)}}{\text{accepted value (m)}} \times 100$$

Students will record their observations and calculations in a table similar to the one below (found on the Measuring Visible Light BLM):

Color of fluorescent light	**Spectrometer reading to nearest nm**	**Wavelength (λ) in nanometers**	**Wavelength (λ) in meters**	**Frequency (Hz) *f* = c / λ**	**Percent Error**
red					
orange					
yellow					
blue					
green					
violet					

For closure to this part of the activity, ask students why their observed wavelength might be different from the accepted values of the wavelengths of the various colors of the visible spectrum (*user error, sensitivity of the spectrometer, etc.).* What did you notice about the frequency of the colors of the spectrum as the wavelength changed? (*As the wavelength decreased, the frequency increased.*) Why did you see different colors through the spectrometer (or spectroscope) when the fluorescent light is white? (*White light is a mixture of light colors and therefore a mixture of light frequencies. The spectrometer [or spectroscope] separated the mixture of light into separate wavelengths that allowed us to see the individual colors and measure the wavelength.*)

Knowing that decreasing the wavelength of the visible part of the electromagnetic spectrum increases the frequency of the light, have students apply that concept to the entire electromagnetic spectrum. A chart of the Electromagnetic Spectrum can be found at http://eosweb.larc.nasa.gov/EDDOCS/Wavelengths_for_Colors.html. Using that chart or a similar chart, have students provide examples of uses of each component of the electromagnetic spectrum and also to explore how their lives are affected by electromagnetic radiation by keeping an electromagnetic journal for one week. This may be kept in their science *learning log* (view literacy strategy descriptions). Ask them to record each time they observe or come in contact with electromagnetic radiation each day--such as listening to the radio, talking on their cordless phone, watching cable TV, going through security at the airport, getting a sunburn, etc. Students should record the date, time, and a one-sentence explanation of the incident, including what type of electromagnetic radiation they encountered. Instruct students to share these encounters with electromagnetic radiation and create a class tally, which can then be graphed and analyzed to find out the most popular daily activity involving exposure to electromagnetic radiation.

At the close of this journal activity, review with students the "wave-particle" dual nature of light. It is important for them to understand that this is not a difference in what radiation is across the spectrum, but only in how it behaves. Low energy photons (such as radio) behave more like waves, while higher energy photons (such as X-rays) behave more like particles. Also discuss that the term radiation does not always mean harmful energy.

Activity 5: Properties of Light: It's the Law (SI GLEs: 5; PS GLE: 43)

Materials List: (per group) three small, flat mirrors; pen light or laser pointer; index card; sheet of white paper; small ball of clay; highly polished spoon; magnifying hand lens; safety goggles; prism; plastic sheet; glass beaker; water; unsharpened pencil or skewer; cooking oil; small glass eyedropper; science learning logs

Working in groups of three to four, have students place the flat mirror perpendicular and on top of the paper. Shine the penlight (or laser) on the mirror from the side at an angle (caution students about viewing lasers directly, and monitor their use closely). Students should trace a pencil line along the edge of the mirror and then from the mirror/paper interface along the two light paths. Ask students what they notice about the angle at which the light is reflected from the mirror? (*It is the same as the angle of the incident light ray*.) Have students investigate a few more angles to see if this is always the case for the flat mirror. Students should record their observations in their science *learning logs* (view literacy strategy descriptions) along with a definition of the law of reflection in their own words. To test their new understanding of reflection, place an index card with a one-inch black circle somewhere in the room. Challenge students to use their light source and three mirrors to shine their light on the circle (lasers work best in this activity). The clay will help in positioning the mirrors in a stationary position. Remind students to keep their mirrors perpendicular to the table. (Students must reflect their light from one mirror to the next mirror to the third mirror to the index card.)

Have students look at one side of the spoon and determine if their reflection is upside-down or right-side-up. Students should observe if the image is smaller or larger than their actual face. Once everyone in the group has observed and recorded their observations, the students should turn the spoon over and make the same observations and recordings.

Have students compare and contrast the side of the spoon that caves inward (the concave side) to the side that bends outward (the convex side).

Supply student groups with a magnifying hand lens and ask students to determine how it works. They should notice that the lens is convex on both sides. Convex lenses magnify objects larger and concave lenses magnify objects smaller (magnification is defined as causing an image to appear larger or smaller than the corresponding object although we often only use it in conjunction with making images larger). Mirrors can also magnify images if the surface is convex rather than flat. Discuss with students that the law of reflection still applies, but the shape of the surface can cause the angle of reflection to be different from the angle of incidence (the original image or beam of light).

Using their prisms, the penlight or laser pointer, and various mediums such as water, plastic, and glass, allow students to investigate the angle that the light travels through the various mediums, the plastic, and the glass, and record their observations.

Instruct students to fill the beaker 2/3 full of water and place the pencil or skewer inside the beaker in the water. Students must view from above the glass to notice any changes to the pencil's appearance. They should also look at the pencil from the side of the glass and up towards the water surface. The apparent "bending" of the pencil is the difference of the light refraction in different mediums, air, water, and glass. Tell students to determine exactly where the light is bending. They should draw a diagram showing the pencil and how light from the pencil travels to their eyes.

Direct students to pour the water out of the glass and replace it with some cooking oil, deep enough to submerge the glass part of the eyedropper. The air should be squeezed out of the eyedropper and then placed in the oil. Make sure that students are watching the eyedropper as the bulb is released and the oil flows into the dropper. Using their knowledge of the law of refraction students should explain what they are seeing. When light travels from one medium to another, the place where the medium changes is called the interface. Depending on the medium, some of the incident light is reflected and part of the incident light is refracted or its path is "bent" in relation to the path of the incident light. Both the reflection and the refraction occur at the interface.

Activity 6: Stellar Spectra (SI GLEs: <u>6</u>, 7, <u>14</u>; PS GLEs: <u>48</u>, 50; ESS GLE: <u>26</u>, 30)

Materials List: spectrometers or spectroscopes; gas spectrum tubes (if available); incandescent light; fluorescent light; and natural sunlight; various pictures taken with IR, UV, or visible spectrum; element spectra; combined element spectra

Safety note: Do not view the Sun directly with any spectroscope as this can permanently damage eyesight; rather view light in a direction away from the Sun itself.

Review the components of the electromagnetic spectrum as to wavelength and frequency, and the order of the colors and wavelengths of visible light. Also review the uses of the various energies found in the electromagnetic spectrum identifying positive and negative effects on humans and human activities (e.g., UV rays, X-rays, microwaves, etc). Discuss how uses of these technologies have affected society and everyday life.

In this activity students will explore a technological use of the properties of light combined with the properties of elements. Using spectrometers or spectroscopes (and gas spectrum tubes, if available) have students view the spectrum of incandescent, fluorescent, and natural sunlight. (Viewing light through the classroom window is acceptable, as long as the Sun is not viewed directly. An alternative to sunlight would be natural sunlight light bulbs that are now commonly available). Instructions on how to make and use spectroscopes can be found at
http://asd-www.larc.nasa.gov/edu_act/simple_spec.html
http://sci-toys.com/scitoys/scitoys/light/cd_spectroscope/spectroscope.html

Determine students understanding of modern astronomical telescopes by viewing various pictures taken of stars and other objects (visible, UV, IR, etc.; these can be downloaded from http://science.hq.nasa.gov/kids/imagers/ems/index.html; go to the bottom of the page and scroll through the various areas of the electromagnetic spectrum). Explain that rather than taking pictures, some of the new instruments actually capture spectrograms of stars to determine their composition and movement.

For this activity, students will utilize an interactive website to examine spectra of elements, compare those to spectra from stars, and identify the elements detected in the star's spectra. If Internet access is available, have students go to http://www.learner.org/teacherslab/science/light/color/spectra, read the background information on spectrographs, and complete the online activity. If computers are not available, the teacher can print out the spectral analysis sheets from this activity on a color printer and use those to complete the activity with students. Guide students in analyzing each spectrogram for its component elements. (These spectrograms were taken of a star's atmospheres.) Students must complete the analysis of the unknown spectrogram by comparing it with the known spectra of various elements (calcium, magnesium, iron, and hydrogen). The investigation is essentially the same if conducted online or as a paper and pencil activity. As a result of this analysis, students will recognize that analysis of the electromagnetic spectrum of distant stars can yield much information about the star's composition.

Activity 7: Sound Waves and The Doppler Effect (SI GLEs: 5, 6, 7; PS GLEs: 48, 49; ESS GLEs: 23, 30)

Materials List: Sound KWL BLM, science learning logs

As an anticipatory activity, have students fill in a *graphic organizer* (view literacy strategy descriptions) in the form of a KWL chart about sound and the Doppler Effect. See Sound KWL BLM for an example of the chart. Once the chart is completed, have students discuss what they already know about this phenomenon, provide examples, and share what they are interested in learning about it. After analyzing the KWL charts, the teacher should address misconceptions or gaps in understanding with direct instruction, specific text readings, and guiding questions to improve student understanding of the relationship between pitch, frequency, and wavelengths.

If computer instruction is available, a good applet that shows sound waves and the Doppler Effect can be found at http://www.walter-fendt.de/ph11e/dopplereff.htm. Another good source online is http://www.glenbrook.k12.il.us/gbssci/phys/Class/waves/u10l3d.html. This Doppler Effect diagram can be printed out as an example for students. Most students can explain what they hear as an ambulance approaches and passes them, but they cannot explain why. Instruct students to record illustrations in their science *learning logs* (view literacy strategy descriptions) to explain the Doppler Effect. Provide students with the opportunity to complete their Sound KWL chart individually to indicate what they have learned from the lesson.

Apply the Doppler Effect to light by showing that electromagnetic waves from an object moving away will demonstrate a red shift as the waves are stretched and the compression of waves results in a blue shift when an object is approaching. A teacher lead discussion should investigate areas of science where the Doppler Effect is applied. An immediate response may be with Doppler based weather reports. After direct instruction, students should be able to indicate what part of the weather system will demonstrate a red shift and which area of activity will show a blue shift. In addition, students should be asked to explain how Doppler readings are made with the instruments. They should also be able to explain the technology available to scientists and researchers today, and how that technology provides evidence that supports the Big Bang theory. Several spectral images showing shifted patterns should be given to the students for interpretation. Information about this spectral shift can be found online at http://en.wikipedia.org/wiki/Spectral_class, http://en.wikipedia.org/wiki/Red_shift, http://imagine.gsfc.nasa.gov/YBA/M31-velocity/spectral-info.html

Sample Assessments

General Guidelines

Assessment techniques should include use of drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

- Students should be monitored throughout the work on all activities via teacher observation of their work and journal entries.
- All student-developed products should be evaluated as the unit continues.

- Student investigations should be evaluated with a rubric.
- When possible, students should assist in developing any rubrics that will be used.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student's overall progress will be evaluated through checklists as they conduct inquiry investigations.
- Students will identify the spectra of various elements as their spectral fingerprint.
- Students should pair and share with a partner when discussing differences between the laws of reflection and refraction.
- The students will reexamine their KWL charts to analyze what they thought they knew prior to this activity. Research indicates that students will retain their previous misconceptions about a topic, in preference to new information, until they actively recognize and correct their own errors. Therefore, it is important to have students re-examine the facts/beliefs they put on their KWL list. It will also be helpful to review the list by marking each entry as correct or incorrect. Previously held incorrect ideas will be replaced with correct information.

Activity-Specific Assessments

- Activity 3: Students will analyze their changes in opinions as a result of the specific assigned readings.

- Activity 4 and 6: Using spectrometers or spectroscopes, students will analyze various spectrums of specific elements for their fingerprint spectra. Given specific spectrums, students should identify the elements present.
- Activity 5: The student will work in groups to design an experiment to illustrate the laws of reflection or refraction. They should test their experimental design and create a final report.

Resources

- Project Robie can be found online: http://www.bro.lsu.edu/radio/Classroom/classroom.html
- Astronomical images available online: http://hubblesite.org/gallery/
- Spectrograms of stars available online: http://www.learner.org/teacherslab/science/light/color/spectra/

- Information about Doppler Effect online:
  http://www.exploratorium.edu/origins/hubble/tools/doppler.html
  http://www.kettering.edu/~drussell/Demos/doppler/doppler.html
- Information about the electromagnetic spectrum online:
  http://imagine.gsfc.nasa.gov/docs/science/know_l1/emspectrum.html
- Tour of properties of light online:
  http://cse.ssl.berkeley.edu/light/light_tour.html
- Information on red shift and blue shift that supports the Big Bang Theory online: http://www.arachnoid.com/sky/redshift.html
  http://library.thinkquest.org/26220/stars/spect.html
  http://archive.ncsa.uiuc.edu/Cyberia/Bima/doppler.html
- Various resources about color, light, and sound can be found at
  http://www.iit.edu/~smile/physinde.html

Physical Science
Unit 8: Electricity and Magnetism

Time Frame: Approximately three weeks

Unit Description

This unit thoroughly examines the properties of static electricity, electric circuits, magnetic fields, and the relationship between electricity and magnetism.

Student Understandings

Incorporating inquiry processes, students will examine and identify properties and connections between the phenomena of electricity and magnetism. Students will, investigate the production of static electricity, construct electrical circuits, map magnetic fields, and build an electromagnet.

Guiding Questions

9. Can students create and define static electricity?
10. Can students construct a complete circuit?
11. Can students differentiate between parallel and series circuits?
12. Can students trace the flow of electrical energy in a diagram of a complete circuit?
13. Can students describe a magnetic field?
14. Can students describe a relationship between electricity and magnetism?

Unit 8 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6)
14.	Cite examples of scientific advances and emerging technologies and how they affect society (e.g., MRI, DNA in forensics) (SI-H-B3)

GLE #	GLE Text and Benchmarks
Physical Science	
44.	Illustrate the production of static electricity (PS-H-G2)
45.	Evaluate diagrams of series and parallel circuits to determine the flow of electricity (PS-H-G2)
46.	Diagram a magnetic field (PS-H-G2)
47.	Explain how electricity and magnetism are related (PS-H-G2)

Sample Activities

Activity 1: Electric Words (SI GLE: 7)

Material List: text or appropriate reading selection, science learning logs, 5 x 7 index cards, GIST Example for Teacher BLM

The ability to summarize is perhaps the most important subskill involved in a student's comprehension. It is difficult to master as students tend to say too much or too little, thus, the value of summarizing is lost. *GISTing* (view literacy strategy descriptions) is an excellent strategy for helping students paraphrase and summarize essential information. The concept of electricity is often discussed at length in textbooks with much of the material repeated for emphasis. Helping students sort through this large amount of information and determining what is most important is a valuable skill worthy of the time is often takes to teach. In GISTing, students read sections of text and are then required to limit the *GIST* (or summary) of a paragraph to a set number of words. The GIST should be recorded in their science *learning logs* (view literacy strategy descriptions).

The teacher should select an appropriate section of text about current electricity on which to write *GISTs*. It's best to start with relatively short paragraphs of no more than three to five sentences, if possible. However, science texts often have paragraphs much longer. (This is a way to help students conquer using the text as a reference and how to get important information out of a large amount of text.) If only longer paragraphs are available, conduct the *GIST* on fewer selected and appropriate paragraphs.

Next, the teacher should establish a limited number of spaces to represent the total number of words of the *GIST*, say 15 or so. Have students read the first sentence of the paragraph and, using only the 15 spaces allowed, write a statement in those 15 spaces capturing the essential information of the sentence (students don't have to use all spaces, but can not use more). This is the beginning of their *GIST*. Now the students read the second sentence of the paragraph and using the information from the first and second sentences of the paragraph they rewrite their GIST statement by combining information from the first sentence with information from the second (fitting in the 15 allotted spaces).

This process continues with the remaining sentences of the paragraph. As students read each succeeding sentence they should rework their *GIST* statement by accommodating any new information from the sentence into the existing *GIST* statement, while not using any more than the allotted number of spaces. Finally, students should share their *GISTs* with a partner for comment and critique.
NOTE: See the GIST Example for Teacher BLM with an example of a *GIST* of a paragraph of text.

As a follow up to the *GIST* activity, have students create a *vocabulary card* (view literacy strategy descriptions) for the terms they will encounter in their study of electricity. *Vocabulary cards* help students see the connections between terms, examples of the term, and the critical attributes associated with the term. See the example below. Using 5 x 7 inch index cards the term *electricity* should be written in the center of the card.

EXAMPLE OF
A VOCABULARY
CARD

Flow of electric current

Carries energy to make devices work

electricity

Lighted bulbs, hairdryer on

Students should write the definition in the upper left-hand corner of the card and the characteristics of electricity on the upper right-hand side. One or two examples of electricity are written on the lower left side of the card. Finally, an illustration should be included on the lower right-hand side of the card.

Initially, have students prepare cards from terms already covered. These are determined by the teacher, but in the course of the unit, the terms may include *static electricity*, *conduction*, *induction*, *electric discharge*, *electric current*, *electric charge*, *circuit*, *battery*, *potential difference*, *voltage*, *resistance*, *superconductor*, *Ohm's Law*, *direct current*, *alternating current*, *power*, *series circuit*, *parallel circuit*, *fuse*, *circuit breaker*. More vocabulary cards will be added to this first card during the unit as students use that term. Students should be aware of the necessity to keep up with their cards and to add to their cards, as this is a valuable tool for review for future activities, quizzes, and tests.

Activity 2: Static Electricity (SI GLEs: 7, 9; PS GLE: 44)

Materials List: (per two students) two balloons, wool cloth, bits of tissue paper (confetti), hard rubber or plastic comb, science learning logs

Utilizing balloons and students' hair, have students compare and contrast, through trial and error, the interactions between (a) a balloon that has been rubbed against hair and one that has not been rubbed against hair, and (b) two balloons that have both been rubbed against hair. To accomplish this task, students should work in pairs, record their observations, and hypothesize about the cause and effects of static electricity. They should be able to defend their conclusions based on their experimentation. Conduct a debriefing or culminating discussion in which students report their recorded results, explain what they infer is the cause and effect(s) of static electricity, and defend their position to the rest of the class. Included in this whole-class discussion, the teacher should review the structure of atoms and the ability of electrons in outer energy levels to freely move. Even though the size of protons and electrons are quite different, the magnitudes of their individual charges are equal (and opposite) to each other. Often student misconceptions arise due to their conception of moving charges. If an electron moves from one atom to another, the one gaining the electron becomes negatively charged and the one loosing the electron becomes positively charged. Included in this discussion should also be a comparison of conductors and insulators. Conductors have charge particles that freely move and insulators do not. However, the molecules of seemingly neutral insulators can be realigned to have the positive ends positioned differently from the negative ends.

A discussion of the various ways that static charging, friction, induction, and conduction occur is appropriate. Make sure that students understand that static electricity is the build-up of electrical charges on an object (whether it is positive or negative). Once the charge is built up, the charges do not flow; they are now at rest. Therefore the term static, meaning stationary or not moving, is appropriate.

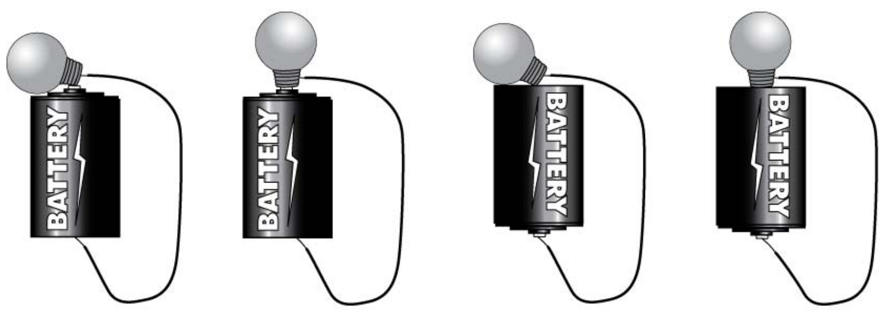
Allow students to investigate interactions between a hard rubber or plastic comb, small bits of tissue paper, and wool cloth. Instruct students to hold the comb close to the bits of tissue paper on their desk and observe. Have then rub the comb with a piece of wool cloth, again hold the comb near the bits of tissue paper, and once more observe. In this demonstration, the comb does not have to touch the paper bits for the paper to move. This is an example of induction of charges within a neutral material. In this case, the molecules of the paper realign themselves with all the negative ends the same way and all the positive ends the opposite way. Rubbing the comb with the wool cloth (friction) allows electrons to move from the cloth to the comb. The comb is now negatively charged and causes movement of charges within the paper and thus the comb and the side of the paper more negatively charged attract. After a few seconds, through conduction, some bits of paper repel from the comb because they have acquired a similar charge of the comb. Have students identify and illustrate this process through drawing/recording in their science *learning logs* (view literacy strategy descriptions).

In closing the lesson, provide a clear explanation that includes the cause and effects of static electricity. Including a discussion of the real-world phenomenon of lightening as the discharge of static electricity build up between clouds and Earth (and also between clouds) is a great way to apply newly acquired understandings of static electricity.

Activity 3: Electricity (SI GLE: 5, 6, 7; PS GLE: 45)

Materials List: (for whole class) Christmas tree lights (one parallel and one series), (per group) various lengths of covered wire with ends striped, D batteries, flashlight bulbs, bulb holders, switches, (if available circuit boards and/or multimeters), science learning logs

Provide students with one wire, one D battery, and one bulb, and have them work in pairs or small groups to create a complete circuit as an engagement activity. Have them record diagrams of successful circuits in their science *learning logs* (view literacy strategy descriptions). There are four correct answers, two with changing the bulb to positive and negative and two with the wire connecting to the ridges of bulb and the end of the bulb on the battery and the wire connecting to the end of the bulb and the ridges of the bulb on the battery.



Display two strings of Christmas tree lights: one wired in a parallel circuit and one wired in a series circuit. Remove a light bulb from each light string and have the students observe and record what happens. Allow students to briefly discuss in groups of 3-4 why one string remained lit and the other went out. Allow students to offer their best explanations. Through whole class direct instruction, explain and illustrate the difference between series and parallel circuits.

Using wires, batteries, bulbs, and switches have students create series and parallel circuits. Have students demonstrate and record the effects of removing a bulb from each type of circuit, adding bulbs to each type of circuit, and adding an additional battery to each type of circuit. If circuit boards and/or multimeters are available have student utilize those in their investigations. Multimeters can be used to measure the current, voltage, and resistance within circuits.

Furnish students with diagrams that illustrate series and parallel circuits. Instruct students on the meaning of symbols used in circuit diagrams. Trace the path of electrical energy through two of the circuits, one of each type, together as a class for guided practice. Have the students analyze these two diagrams to determine if the circuit is complete and if light bulbs will remain lit when one light bulb is removed from the circuit. Have students analyze the additional diagrams, trace the flow of electricity, and label the circuit diagrams as parallel, series, or incomplete. These diagrams can be completed individually or in groups of 2-4 students, as determined by the teacher.

For closure to the activity, ask student if they can suggest a reason for the price difference in the series wired Christmas tree lights and the parallel wired Christmas tree lights (*additional wire for parallel, more labor for parallel, etc*.).

Activity 4: Magnetism (SI GLEs: 9; PS GLE: 46)

Materials List: (per group) bar magnet, horseshoe magnet, paper, compass, iron filings, transparency film, safety goggles, gloves, science learning logs

Safety Note: Eye irritation can occur from the iron filings. Instruct students to wear safety goggles and avoid rubbing their eyes during this activity. Students should wear gloves or wash hands after the activity to remove all traces of the small iron filings.

In this activity, students will work in groups of two to three to make a magnetic map (a map of the magnetic field). Have student place the bar magnet in the middle of the piece of paper and carefully trace around it to mark its position under the paper. Note: the paper must not be moved from this position during the remainder of the exercise. Have one student place the compass on or close to the paper near the magnet. Determine the farthest point between the compass and the magnet where the compass needle is affected by the magnetic field. Have students carefully draw a few arrows along this distance to indicate the way the compass needle is pointing. Repeat this process several times around the magnet, making sure that students record at least 6-8 areas (both short sides, both long sides, and between these along the bar magnet). Have students connect these lines of arrows to determine where the magnetic field exists. Students should identify areas where it is the strongest (at the poles), and where it is the weakest (along the long length of the bar).

Provide the student groups with bar magnets and iron filings. Have the students place transparency film under and over the magnet. Next, have students sprinkle filings on the top transparency to view the magnetic field around the magnet and to observe the interaction between two magnetic fields when a second magnet is added. Instruct students to diagram the magnetic field observed, including arrows to indicate the direction of the lines of force as learned in their prior activity. When students have completed this part, ask them to predict what the magnetic field of a horseshoe magnet would look like. Then let the groups repeat the above procedure with a horseshoe magnet. Alternatively, teachers can use the overhead to show the magnetic fields to the whole class at one time and this part of the activity can be conducted as a whole group.

For real-life connection, illustrate the magnetic field surrounding Earth and its poles. Allow students to investigate and interpret the interactions between the Earth and a compass. Require students to write a paragraph comparing their bar magnet model with the Earth's magnetic field.

To allow students to reflect on what they have just learned, have them create a *SPAWN* (view literacy strategy descriptions) writing. In this strategy, the teacher presents the

SPAWN prompt to students by writing it on the board or projecting it from the overhead or computer. The students should write their responses within a reasonable period of time, in most cases 10 minutes should be adequate. Have students copy the prompt into their science *learning logs* (view literacy strategy descriptions) before writing responses and record the date. Since this is not formal writing, *SPAWN* writing should not be graded as such and only completion point awarded if a grade is given. *SPAWN* writing should be viewed as a tool that students can use to reflect their developing knowledge and critical thinking.

The *SPAWN* acronym stands for:

S-special powers

Your body has suddenly acquired the ability to turn on and off a magnetic field. Explain what walking around the school is like

P-problem solving

You used a compass in one of your investigations. Explain how a compass works.

A-alternative viewpoints

Why do we call the end of the compass needle that points north, the north end if opposite poles attract and like poles repel?

W-what if?

What would happen if the Earth's magnetic poles suddenly shifted places overnight?

N-next

If you wrap wire around a piece of iron and then run an electric current through it, it becomes a magnet (an electromagnet). Why do you think this happens?

Choose one of the above prompts (or similar prompts) for student's *SPAWN* writings, or allow students to choose their own prompt. With the Special Powers and What if? prompts, students must apply their knowledge to unique situations. The Problem solving prompt allows further thought about a common everyday object. The Alternative viewpoint prompt allows students to investigate a common misconception (the geographical north pole is really the geographical south pole if the north end of the compass needle [and north ends of a magnet] is attracted to it.). The next prompt allows students to predict about the next activity.

The teacher should choose the best prompt for the students and what he or she wishes to emphasize and/or review. When complete, allow students to share their *SPAWN* writings in groups or with the whole class.

Activity 5: Electromagnetic Connection (SI GLEs: 7, 9, 14; PS GLE: 47)

Materials List:

Part 1: magnetic transparent compass to be used on the overhead projector, D cell battery, 9’ insulated wire (stripped on each end)

Part 2 (per group): large nail, long lengths of coated copper wire (stripped on each end), D-cell battery, electrical tape, paper clips

Part 3 (per group): D cell battery, round ceramic magnet, two paper clips, sandpaper, electrical tape, approximately 30 “ length of thinly coated copper wire (stripped on the ends)

SAFETY NOTE: Holding wires to the poles of batteries in a closed circuit may cause a large production of heat, and could burn students’ fingers if they hold the wire in contact with the batteries. Caution students to be careful when making circuits.

Part 1: The Dutch physicist, Hans Christian Oersted is credited with experimentation that led to the discovery of electromagnetism. A similar experiment is easy to perform using an overhead projector, a transparent compass, a D-cell, and 9” thick, flexible insulated wire (stripped on the ends). Use a fresh D-cell battery because the experiment draws a large current from the battery (really a short circuit), but only for a very short time.

Place the compass on the glass, and let everyone see that it points north. (Note: if a transparent compass is not available or easy to locate, an alternative would be to have students perform this activity in groups of 3 to 4. There are safety precautions in doing that because the short circuit of the battery generates a lot of heat quickly and students might get a slight burn if not careful.)

Then with your thumb, press one end of the wire against the bottom of the D-cell (or tape in place with a small length of electrical tape). The wire should form a short loop, coming back close to the other terminal of the battery, but not touching it.

Position the wire so that the middle of the wire passes over the compass needle and is parallel to it. Then touch the other end of the wire to the other end of the battery--just a short touch (1-2 seconds). The needle will immediately pivot to stand at 90 degrees to the wire.

Explain to the students that you will not hold the connection for very long because it is an example of a short circuit, not good for the battery, and it also it generates a lot of heat at the contact ends of the battery.

Next, reverse the electrical contacts by turning the D-cell battery around. The needle will swing to stand at 90 degrees in the opposite direction. Have students record their observations in the science *learning logs* (view literacy strategy descriptions). Make sure students include a diagram of both positions of the battery and the results on the compass. Since the compass pointed in the opposite direction when the battery direction was changed, students should see the connection between the flow of the current and the direction of the magnetic field as recorded by the compass. Students should operationally define electromagnetism as the relationship between electricity and magnetism. A magnetic field is created when an electric current flows through a wire, with a direction of the magnetic field the same as the direction of current.

Part 2: Provide student groups with nails, copper wire, magnets, and a battery and challenge them to build a simple electromagnet that will pick up the most paper clips. Through trial and error, allow students to discover that increased wraps of wire (in the same direction) will increase the induced magnetism. Discuss the relationship between electricity and magnetism. Show students what happens when loops overlap to the overall induced magnetism (often a group will inadvertently do this and not understand why their magnetic strength has decreased).

Part 3: Provide directions, discuss safety measures, and have students construct a simple electromagnetic motor using a D-cell battery; a round, ceramic magnet; paper clips; electrical tape; sand paper; and a coil of thinly coated copper wire, stripped on the ends. Tape the magnet to the round side of the battery. Unwind one end of two paper clips and lightly sand these ends of the paper clips to remove the coating and assure a good connection. Tape the unwound end of each paperclip to each terminal of the battery so that the paperclip extends up and the magnet is also on top of the battery. The coil of copper wire should be about 2-3 cm in diameter with wire extensions on either side. Place the wire coil extensions into the hooks created by the unwound ends of the paperclips. It should spin freely if everything is set up correctly. Instructions for a similar simple electric motor can be found at http://www.exploratorium.edu/snacks/stripped_down_motor.html and commercial versions of this simple device are available from many science supply companies.

Instruct students to analyze each device constructed, the electromagnet, and the electric motor, in order to describe the relationship between electricity and magnetism for each device. The electricity from the battery induces magnetism in the nail, and the magnetic field creates the spin in the electric motor. To accomplish these tasks, students should work in pairs or small groups.

For closure, have students write explanations in the science *learning logs* to communicate their analysis of the electricity/magnetism relationship. They should also analyze how Oersted's discovery of relationship between electricity and magnetism affects their lives today. Make additional *vocabulary cards* (view literacy strategy descriptions) for the new terms from this activity.

Sample Assessments

General Guidelines

Assessment techniques should include use of drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

- Students should be monitored throughout the work on all activities via teacher observation of the students' work and journal entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- When possible, students should assist in developing any rubrics that will be used.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will construct series and parallel circuits and trace the flow of electrical energy through each circuit; this will be evaluated through teacher assessment.
- The student's overall progress will be evaluated through checklists as they conduct inquiry investigations.
- The student will create diagrams of magnetic fields.
- The student will work in groups to create multimedia presentations or videos to introduce the concept of electricity to lower elementary students.
- The student will compare and contrast series and parallel circuits.

Activity-Specific Assessments

- Activity 2: The students will demonstrate their understanding of static electricity utilizing a classroom demonstration assessment. Tie a piece of "O" shaped cereal to one end of a 30 cm length of thread. Find a place to attach the other end so that the cereal does not hang close to anything else. Charge a clean rubber or plastic comb by vigorously rubbing it with a piece of wool. Slowly bring the comb near the cereal. It will swing to touch the comb. Hold it still until the cereal jumps away by itself. Now try to touch the comb to the cereal again. It will move away as the comb approaches. Have students write a short explanation of what happened in the demonstration. (Expected explanation: Rubbing the comb with the wool removed electrons from the comb and it now has a negative charge. The neutral cereal was attracted to it.

When they touched, electrons slowly moved from the comb to the cereal. Now both objects had the same negative charge, and the cereal was repelled.)

- Activity 3: The student will construct electrical circuits, consisting of batteries, wires, switches, and bulbs given an electrical diagram.

- Activity 5: The student will design an alarm system for his or her school locker when given magnets, wires, batteries, buzzers, switches, light bulbs and bulb holders. He or she should provide a detailed circuit drawing and a working model.

Resources

- Allen, Maureen, et al. *Electrical Connections.* Fresno: AIMS Education Foundation, 1991.
- http://www.iit.edu/~smile/physinde.html
- Robertson, William C. *Electricity and Magnetism: Stop Faking It! Finally Understanding Science So You Can Teach It.* Arlington: NSTA Press, 2005.

Physical Science
Unit 9: Integration of Physical Science and Earth Science Principles

Time Frame: Approximately two and one half weeks

Unit Description

Applications of physical science concepts to additional science content areas aids students in making connections and transferring and retaining knowledge and comprehension. In this unit applications that integrate Earth and space science concepts are featured.

Student Understandings

Students will develop the ability to illustrate and explain the reason for Earth's seasons and to apply physical science concepts in describing the relationship between the angle of radiation, seasonal changes, and the consequences for Earth's temperature. By investigating the characteristics of the different layers of Earth's atmosphere, students will understand the processes by which heat is transferred across the boundaries between layers. Students will investigate the physical processes driving lithospheric plates as they move.

Guiding Questions

1. Can students describe or illustrate the changes in angle and intensity of solar radiation that causes seasons as Earth orbits the Sun?
2. Can students describe the consequences of overexposure to ultraviolet radiation from the Sun?
3. Can students relate density, force, and pressure to processes in Earth's core, mantle, and crust?
4. Can students differentiate among forms of heat transfer, conduction, convection, and radiation?
5. Can students identify how nuclear energy, from Earth's core, is involved with lithospheric plate movements?

Unit 9 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
2.	Describe how investigations can be observation, description, literature survey, classification, or experimentation (SI-H-A2)
4.	Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
8.	Give an example of how new scientific data can cause an existing scientific explanation to be supported, revised, or rejected (SI-H-A5)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
12.	Cite evidence that scientific investigations are conducted for many different reasons (SI-H-B2)
Physical Science	
8.	Evaluate the uses and effects of radioactivity in people's daily lives (PS-H-B2)
30.	Compare the characteristics and strengths of forces in nature (e.g., gravitational, electrical, magnetic, nuclear) (PS-H-E1)
39.	Distinguish among thermal, chemical, electromagnetic, mechanical, and nuclear energy (PS-H-F2)
50	Identify positive and negative effects of electromagnetic/mechanical waves on humans and human activities (e.g., sound, ultraviolet rays, X-rays, MRIs, fiber optics) (PS-H-G4) (PS-H-G3)
Earth and Space Science	
4.	Describe the relationship between seasonal changes in the angle of incoming solar radiation and its consequences to Earth's temperature (e.g., direct vs. slanted rays) (ESS-H-A2)
6.	Discuss how heat energy is generated at the inner core-outer core boundary (ESS-H-A4)
11.	Describe the processes that drive lithospheric plate movements (i.e., radioactive decay, friction, convection) (ESS-H-A7) (ESS-H-A3) (ESS-H-A4)
12.	Relate lithospheric plate movements to the occurrences of Earthquakes, volcanoes, mid-ocean ridge systems, and off-shore trenches found on Earth (ESS-H-A7)

Sample Activities

Activity 1: Solar Radiation and the Seasons (SI GLEs: 2, 4, 7, 9, 12; PS GLEs: 8, 50; ESS GLE: 4)

Materials List: light source (light bulb in a socket), wooden kabob skewer, 4” (or larger) foam ball, black marker, science learning log

Teacher Note: If the instructor prefers to incorporate the Earth Science activities in the earlier units to illustrate the relationship of the principles with real world studies, this activity could be used in Units 1, 6, or 7.

Following a brief review of the visible light spectrum and ultraviolet radiation, explain to students that they are to explore the angle of solar radiation on Earth and how it is related to seasons and the variation of temperatures in seasons. Divide the class into cooperative groups of 3 to 4 students and provide each group with a light source (naked light bulb in a socket; review safety precautions and warn students of touching the hot light bulb), a wooden kabob skewer, a foam ball (representing Earth), and a marker. Prepare the foam ball prior to class by pushing the skewer through the center of the foam ball to represent its axis, marking around the center of the ball to represent the equator, marking the North and South poles. With students, demonstrate tilting the ball at approximately 23.5°, rotating the ball counter clockwise, and moving the ball (Earth) around the light source with the axis (skewer) tilted at approximately 23.5° from left to right at all times.

Have students practice with their models, and orbit the ball (Earth) counterclockwise around the light source (Sun) with its axis tilted in order to observe where the light strikes Earth. Students should sketch the portions of Earth receiving the strongest light at four different positions: the Northern Hemisphere tilted toward the Sun (June), the Southern Hemisphere tilted toward the Sun (December), and at points midway between these two points. Students may need to perform multiple trials of the revolution of their model to make complete observations. Using their observations and diagrams, have students answer the following questions in their science *learning log* (view literacy strategy descriptions):

1. As Earth moves through its orbit, the focus of the light shifts in what direction? (*from northern hemisphere to southern hemisphere*)
2. How does the tilt of Earth's axis affect the hemisphere receiving the most solar radiation? (*the sun’s rays are more direct and concentrated; therefore, the climate is warmer*)
3. What two characteristics of Earth in its orbit cause the seasons? (*the tilt and the position during its orbit*)
4. At which point does the Northern Hemisphere receive the most intense solar radiation? (*during the summer months*)
5. At which point would the average temperature be less in the Northern Hemisphere and why? (*during the winter months, because the sun’s rays are not hitting directly, are not as concentrated, and are spread over a larger area*)

6. What is the danger from exposure to intense solar radiation? (*sunburn, skin cancer, cataracts*)
7. What forms of insulation (natural and man-made) protect humans from solar radiation? (*sunscreen, sunglasses, ozone layer, atmosphere*)
8. Name three advantages of receiving solar radiation. (*vitamin D production, healthy bones for humans, alternative source of energy*)
9. What was the purpose of this investigation? (*to model the Earth's orbit around the sun and determine how the amount of sunlight affects our seasons*)
10. Do all investigations have to be experimental? (*no, they can be research based, analysis of models, etc*)
11. What are three reasons to conduct investigations? (*to answer questions, to understand natural processes, to learn new information*)

Students should write and defend the answers to their questions and their overall conclusions based on the results of their experimentation. This may be done in small-group discussions or as whole-class discussions.

Activity 2: It's Hot Inside (SI GLE: 5, 7, 8; PS GLE: 39; ESS GLE: 6)

Materials List: (per group) small nougat filled candy bar or chocolate chip granola bar (not to be eaten), napkin or paper towel, science learning logs

Teacher Note: If the instructor prefers to incorporate the Earth Science activities in the earlier units to illustrate the relationship of the principles with real world studies, this activity could be used in Units 5 or 7.

Provide each student with small, nougat filled candy bar or chocolate chip granola bar and napkins. Students should not consume the candy in a laboratory setting. Have students determine the density of the bar by measuring mass and volume and record all data in their science *learning log* (view literacy strategy descriptions). Students should carefully apply pressure to the candy using their napkins and again determine density by measuring mass and volume (after applying pressure). Allow students to write a comparison of the two physical states of the candy bar (before and after the application of pressure). The teacher should extend the discussion to ask about the layers of Earth and what might happen to both pressure and temperature in approaching the core. Remind students of the earlier lesson on the radioactive decay taking place in Earth's interior layers (Unit 3, Activity 11).

Have students research the comparison of composition, temperatures, and densities for the layers of Earth's internal structure and develop a chart to show the information. They should determine how the information has been gathered and create a timeline to show how theories of Earth's internal structure have changed over time. Students should analyze how this information relates to Earth's magnetic field and its change over time, as recorded in the rock record.

Scientists are still not sure about what provides the heat in the Earth's core but one theory is that it might come from some of the iron becoming solid and joining the inner core, or perhaps it is generated by radioactivity, like the heat of the Earth's crust.

The molten metal is believed to be circulating**.** By moving through the existing magnetic field, it creates a system of electric currents, spread out through the core, somewhat like Faraday's disk dynamo**,** discussed in Unit 8. The currents possibly create a magnetic field, which leads to a distribution of magnetic forces. Scientists have problems with this explanation because the resulting magnetic field is necessary to generate the current in the first place**.** This is a typical "which-came-first" type of scientific puzzle.

The inner core, which acts as a giant dynamo, rotates at a rate different from the rest of the planet. Each year the inner core rotates, an additional three degrees more than the rest of the planet. This occurs because the solid, inner core (which is about the size of the Moon) is surrounded by a much larger liquid outer core. Together the two form a giant electrical motor. It is from this area that Earth's magnetic field is thought to be generated. While the inner core rotates, a current of heat rises and flows into the outer core. A discussion of convection as the means of energy transmission through the liquid iron of the outer core to the upper layers of Earth should be used to further an understanding of the factors at work. The students should distinguish and analyze the various forms of energy (thermal, chemical, electromagnetic, mechanical, and nuclear) through discussion. Students should calculate how many years it takes for the inner core to complete an additional rotation. Information about the dynamo theory and thermal convection can be found online at http://understandearth.com/Geomagnetic Field Generation.htm or http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/magearth.html.

After analyzing the theorized structure of the Earth's core, have students create a *SPAWN* writing (view literacy strategy descriptions). This may be conducted as a culminating activity following completion of the examination of Earth's internal structure. Give students a reasonable amount of time to write. In this example, *SPAWN* is used as a unique way for students to reflect on their learning and also a way for the teacher to determine if they fully understand the concept. The letters in *SPAWN* stand for five categories of writing prompts: ***S** - Special Powers; **P** - Problem Solving*; ***A** - Alternative Viewpoints. **W** - What If?; **N** – Next.* One or more of the categories may be used to generate a prompt, as the teacher determines which one accommodates the type of thinking about the content the students should exhibit. SPAWN writing can be used to anticipate content to be presented, or as in this case, as a reflection on what has just been learned. *SPAWN* writings should not be graded as formal writings, and students should be given a specific time frame to create them. Most can be adequately constructed in 10 minutes.

.

Students will write in response to the following *Special Powers* prompt:

Imagine that you have been given the special assignment to work in a glass domed viewing room at the top of the inner core. Visualize how the Earth's structures up to the surface would appear when seen from your frame of reference.

Have students write a report to their boss on Earth's surface of what they observe from their position at the top of the inner core. Remind them to include the movement of materials and heat that they observe. Allow students to share their responses with a partner or the class while others listen for accuracy and logic.

Activity 3: Plate Tectonics (SI GLEs: 8, 9; PS GLEs: 30, 39; ESS GLEs: 11, 12)

Materials List: various types of research materials (print, video, DVD, Internet), Earth plate boundary map

Teacher Note: If the instructor prefers to incorporate the Earth Science activities in the earlier units to illustrate the relationship of the principles with real world studies this activity could be used in Units 5 or 6.

Explain to students that they will examine how force, friction, and stress affect Earth's surface. Prior to this activity, pre-assess student understanding of the forms of energy transfer by having the students create a *vocabulary self-awareness chart* (view literacy strategy descriptions). Since students bring a wide range of understanding to the classroom, allowing them to determine the level of their comprehension of a term prior to reading or using that term in context of an activity leads to increased understanding and the higher comprehension of the overall topic as they learn. Energy transfer is a topic that ninth grade students have studied before, but one that is often necessary for review. Students should create a chart similar to the one below. It should contain the terms: *conduction*, *radiation*, and *convection*.

Word	+	√	-	Example	Definition
conduction					
radiation					
convection					

If student understanding is low, then have them read a selected section of text from their text or another appropriate source to review the terms. Allow them time to return to their *vocabulary self-awareness chart* to update and add any required information. The goal is to have all minuses and checks converted to pluses, along with the inclusion of accurate definitions and appropriate examples for these three key terms.

Have students work in small groups to research the topics of continental drift and plate tectonics. Their assignment is to describe the theories, tell how they have changed, summarize the evidence that caused a change in the theories relating to plate movements over time, and to identify the forces and mechanisms that cause plate movements. Provide reference materials related to the science of Earth or conduct a library and Internet search. If computers connected to the Internet are available, animations of plate movements over time, the history behind the plate tectonics theories, and the mechanisms that drive plate movement can be found on the Internet at http://www.ucmp.berkeley.edu/geology/tectonics.html. This activity could be in the form of a webquest if technology is available for student use.

Assign different mechanisms for plate movements to student groups. Each mechanism can be assigned to more than one group. The mechanisms include divergent boundaries (which contain the geological features of mid-ocean ridges, sea floor spreading, and rift valleys), convergent boundaries (which contain the geologic features of deep sea trenches, island arcs, volcanic chains [underwater and continental], and mountains), and transform boundaries (which include the occurrence of earthquakes). Instruct student groups to produce a model, identify the forces and energy at work in their mechanism, and describe the results of such forces (e.g., volcanoes, earthquakes, tsunamis, etc.). Have each group demonstrate and explain their model to the class.

Sample Assessments

General Guidelines

Assessment techniques should include use of drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

- Students should be monitored throughout the work on all activities via teacher observation of their work and lab notebook entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will compare and contrast conduction, convection, and radiation.
- The student will shine a flashlight at an angle and then directly above a piece of graph paper, making sure that the height above the paper is the same both times. The student will compare the areas of light distribution and apply it to seasonal changes on Earth.
- The student will determine and compare densities of the layers of the Earth.

Activity-Specific Assessments

- Activity 1: The student will work in groups and will be assigned a particular location on Earth. The student will determine the position of the Sun in the sky for their location at noon for four days during the year: winter solstice, vernal equinox, summer solstice, and autumnal equinox. The student will demonstrate the position of the Sun for those four times through drawings or models.

- Activity 2: The student will research the size, density, temperatures, and composition of each of Earth's four layers. Using research, the student will design and construct a scale model of the interior of the Earth. The student will include a written report detailing the attributes of each layer.

- Activity 3: The student will identify the tectonic forces occurring or ones that have occurred when given a location on a plate boundary map and a geophysical relief map. The student will write a short analysis of his or her location as if he or she were a geologist preparing a report to the USGS. Plate boundary maps can be found online at http://www.ig.utexas.edu/research/projects/plates/images/topo.pb.htm or http://zephyr.rice.edu/plateboundary/plate.11.17.pdf

Resources

- *Plate Tectonics.* Available on the Internet at http://www.ucmp.berkeley.edu/geology/tectonics.html
- *Plate Tectonics.* Available on the Internet at http://volcano.und.nodak.edu/vwdocs/vwlessons/plate_tectonics/introduction.html
- *Understanding plate motions.* Available on the Internet at http://pubs.usgs.gov/publications/text/understanding.html http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/magEarth.html
- *Earth's magnetic field:* Available on the Internet at http://solidearth.jpl.nasa.gov/PAGES/mag01.html