Physical Science Curriculum Support Document

Curriculum Support for the 2004 revision of the *North Carolina Standard Course of Study* for Physical Science

Acknowledgements

A group of dedicated and talented science teachers sent many hours developing these materials. The result is this resource that will facilitate the implementation of the North Carolina Science Curriculum.

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Every effort is made to keep these materials accurate and up to date. Check the Department of Public Instruction's website http://www.ncpublicschools.org/curriculum/science/scos/ for the most current version.

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Introduction

This support document includes the *North Carolina Standard Course of Study* goals and objectives along with detailed content description, a list of enrichment topics, and a collection of activities.

The Physical Science course is intended to be a laboratory course as are all of North Carolina's Standard Course of Study Science courses. Laboratory courses are designed to include laboratory experiences as an integral component. This means laboratory experiences where students ask questions, make observations, and collect, record and analyze data should be a regular part of the course. Students in Physical Science courses should have ample opportunities to experience using basic laboratory equipment such as balances, meter sticks, stopwatches, graduated cylinders, thermometers, and probe-ware. North Carolina does not require any one particular lab, but rather recommends a variety of laboratory experiences. It is up to the teacher and the local school district to determine which laboratory experiences will be most beneficial for their students given local facilities and opportunities; however, all students must be provided with laboratory experiences.

The particular laboratory investigations and classroom activities in this support document are not required, but serve as guides and resources for classroom teachers. Similar laboratory investigations may be substituted for the ones suggested.

The detailed content descriptions should serve as the minimum standard for physical science courses. Teachers are encouraged to extend these standards to provide students with a rich and rigorous learning experience. Vocabulary was intentionally minimized to provide teachers time to develop conceptual understanding of the topics.

Goal 1 is included to emphasize the importance of science as inquiry. Students should be provided many opportunities throughout the course to design and carry out investigations and to analyze and evaluate data. They should be required to present their data and explain their conclusions.

Goals

The Physical Science curriculum is designed to continue the investigation of the physical sciences begun in earlier grades. The Physical Science course will build a rich knowledge base to provide a foundation for the continued study of science. The investigations should be approached in both a qualitative and quantitative manner in keeping with the developing mathematical skills of the students. The unifying concepts and program strands provide a context for teaching content and process skill goals. The teacher should focus on integrating the unifying concepts and course strands with the course content.

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Unifying Concepts:

- Systems, Order and Organization
- Evidence, Models, and Explanation
- Constancy, Change, and Measurement
- Evolution and Equilibrium
- Form and Function.

Strands:

- Nature of Science
- Science as Inquiry
- Science and Technology
- Science in Personal and Social Perspectives.

Unifying Concepts

The following unifying concepts should unite the study of various physical science topics across grade levels. Focus on the unifying concepts of science will also help students to understand the constant nature of science across disciplines and time even as scientific knowledge, understanding and procedures change.

Unifying Concepts	Topics which demonstrate these concepts
Systems, Order and Organization	• Atomic structure • Periodic Table • Chemical reactions
Evidence, Models, and Explanation	• Nature of static electricity • Magnetism • Atomic theory
Constancy, Change, and Measurement	• Analyze motion-distance, velocity and acceleration • Physical and chemical change • Radioactivity
Evolution and Equilibrium	• Newton's Laws of Motion • Properties of solutions
Form and Function	• Energy storage-kinetic, potential, etc. • Electrical circuits

The Strands: Nature of Science

This strand includes the following sections: Science as a Human Endeavor, Historical Perspectives, and the Nature of Scientific Knowledge. These sections are designed to help students understand the human dimensions of science, the nature of scientific thought, and the role of science in society. Physical science is rich in examples of science as a human endeavor, historical perspectives on the development of scientific understanding, and the nature and role of science.

Strands	Ideas for integrating these strands
Science as a Human Endeavor Intellectual honesty and an ethical tradition are hallmarks of the practice of science. The practice is rooted in accurate data reporting, peer review, and making findings public. This aspect of the nature of science can be implemented by designing instruction that encourages students to work collaboratively in groups to design investigations, formulate hypotheses, collect data, reach conclusions, and present their findings to their classmates. The content studied in physical science is an opportunity to present science as a basis for engineering, electronics, computer science, astronomy and the technical trades. The diversity of physical science content allows for looking at science as a vocation. Scientist, artist, and technician are just a few of the many careers in which a physical science background is necessary. Perhaps the most important aspect of this strand is that science is an integral part of society and is therefore relevant to students' lives.	• Design inquiry activities which allow students to collect data and report their finding to their peers for review. • Encourage students to explore how physical science is an integral part of many diverse vocations. • Use current events to demonstrate the importance of understanding physical science.

Strands	Ideas for integrating these strands
Historical Perspectives Most scientific knowledge and technological advances develop incrementally from the labors of scientists and inventors. Although science history includes accounts of serendipitous scientific discoveries, most development of scientific concepts and technological innovation occurs in response to a specific problem or conflict. Both great advances and gradual knowledge building in science and technology have profound effects on society. Students should appreciate the scientific thought and effort of the individuals who contributed to these advances. Galileo's struggle to correct the misconceptions arising from Aristotle's explanation of the behavior of falling bodies led to Newton's deductive approach to motion in *The Principia*. Today, Newton's Law of Universal Gravitation and his laws of motion are used to predict the landing sites for NASA's space flights.	• Assign students to investigate the diverse group of scientists and cultures who have contributed to our understanding of physical science. • Create a timeline showing how an essential question such as "What explains the motions of celestial bodies?"

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The Strands: Nature of Science

Strands	Ideas for integrating these strands
Nature of Scientific Knowledge Much of what is understood about the nature of science must be addressed explicitly: • All scientific knowledge is tentative, although many ideas have stood the test of time and are reliable for our use. • Theories "explain" phenomena that we observe. They are never proved; rather, they represent the most logical explanation based on currently available evidence. Theories just become stronger as more supporting evidence is gathered. They provide a context for further research and give us a basis for prediction. For example, in physical science, atomic theory explains the behavior of matter based on the existence of tiny particles. And kinetic theory explains, among other things, the expansion and contraction of gases. • Laws are fundamentally different from theories. They are universal generalizations based on observations of the natural world, such as the nature of gravity, the relationship of forces and motion, and the nature of planetary movement. • Scientists, in their quest for the best explanations of natural phenomena, employ rigorous methods. Scientific explanations must adhere to the rules of evidence, make predictions, be logical, and be consistent with observations and conclusions. The *NSES* state "Explanations of how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific." (p. 201).	• Emphasize how the understanding of the atom and atomic structure has changed over time. • Discuss differences between scientific theories and laws. • Remind students how scientific explanations undergo rigorous scrutiny.
Science as Inquiry Inquiry should be the central theme in physical science. It is an integral part of the learning experience and may be used in both traditional class problems and laboratory work. The essence of the inquiry process is to ask questions that stimulate students to think critically and to	• Because of the importance of science as inquiry this aspect has been integrated into Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Strands	Ideas for integrating these strands
formulate their own questions. Observing, classifying, using numbers, plotting graphs, measuring, inferring, predicting, formulating models, interpreting data, hypothesizing, and experimenting all help students to build knowledge and communicate what they have learned. Inquiry is the application of creative thinking to new and unfamiliar situations. Students should learn to design solutions to problems that interest them. This may be accomplished in a variety of ways, but situations that present a discrepant event or ones that challenge students' intuitions have been successful. Classical experiments such as measuring inertia and the speed of falling bodies need not be excluded. Rather, they should be a prelude to open-ended investigations in which the students have the chance to pose questions, design experiments, record and analyze data, and communicate their findings. For example, after measuring the relationships among force, mass, and acceleration of falling bodies, students might investigate the phenomenon of "weightlessness", or, after measuring physical properties, they might investigate the connection (if any) between the density of certain liquids and their boiling point. Although original student research is often relegated to a yearly science fair project, continuing student involvement in research contributes immensely to their understanding of the process of science and to their problem-solving abilities. Physical science provides much potential for inquiries. "Does the aluminum baseball bat have an advantage over a wooden baseball bat?" "Why?" "Is one brand of golf ball better than another brand?" "Why?" The processes of inquiry, experimental design, investigation, and analysis are as important as finding the correct answer. Students will master much more than facts and acquisition of manipulative skills; they will learn to be critical thinkers. A solid conceptual base of scientific principles, as well as knowledge of science safety, is necessary for inquiry. Students should be given a supportive learning environment based on how scientists and engineers work. Adherence to all science safety criteria and guidelines for classroom, field, and laboratory experiences is imperative. Contact the Science Section at DPI for information and	• This idea should be integrated into the entire course and not just taught as a separate "lab introduction" unit.

Strands	Ideas for integrating these strands
professional development opportunities regarding North Carolina specific Science Safety laws, codes, and standards.	
Science and Technology It is impossible to learn science without developing some appreciation of technology. Therefore, this strand has a dual purpose: (a) developing students' knowledge and skills in technological design, and (b) enhancing their understanding of science and technology. The methods of scientific inquiry and technological design share many common elements including objectivity, clear definition of the problem, identification of goals, careful collection of observations and data, data analysis, replication of results, and peer review. Technological design differs from inquiry in that it must operate within the limitations of materials, scientific laws, economics, and the demands of society. Together, science and technology present many solutions to problems of survival and enhance the quality of life. Technological design is important to building knowledge in physical science. Telescopes, lasers, transistors, graphing calculators, personal computers, and photogates, for example, have changed our lives, increased our knowledge of physical science, and improved our understanding of the universe.	• Provide opportunities for students to utilize technology to collect and analyze data in laboratory settings. • Allow students to brainstorm ways that technology can be used to enhance scientific study in the future. • Discuss the limitation of technology in scientific study

Strands	Ideas for integrating these strands
Science in Personal and Social Perspectives This strand helps students in making rational decisions in the use of scientific and technological knowledge. "Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges. (NSES, p. 199). The NSES emphasizes that "students should understand the appropriateness and value of basic questions 'What can happen?' - 'What are the odds?' and 'How do scientists and engineers know what will happen?'" (NSES, p. 199). Students should understand the causes and extent of science-related challenges. They should become familiar with the advances that proper application of scientific principles and products have brought to environmental enhancement, better energy use, reduced vehicle emissions, and improved human health.	• Design scientific resolutions for local or global challenges. • Encourage debate about these resolutions and their consequences. • Research how science has help create new and improved products for public use, such as NASA developments.

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Detailed Description of Content

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.	
Goal 1 objectives are an *integral* part of *each of the other goals*. In order to measure and investigate scientific phenomena, students must be given the opportunity to design and conduct their own investigations in a safe laboratory. Investigations may also be conducted using simulations. See web resources for examples.	
Objective	***Content Description***
1.01 Identify questions and problems that can be answered through scientific investigations.	• Develop questions for investigation from a given topic or problem.
1.02 Design and conduct scientific investigations to answer questions about the physical world. • Create testable hypotheses. • Identify variables. • Use a control or comparison group when appropriate. • Select and use appropriate measurement tools. • Collect and record data. • Organize data into charts and graphs. • Analyze and interpret data. • Communicate findings.	• Distinguish and appropriately graph dependent and independent variables. • Report and share investigation results with others. • Discuss the best method of graphing/presenting particular data. • Use technology resources such as graphing calculators and computers to analyze data.
1.03 Formulate and revise scientific explanations and models using logic and evidence to: • Explain observations. • Make inferences and predictions. • Explain the relationship between evidence and explanation.	• Use questions and models to determine the relationships between variables in investigations.
1.04 Apply safety procedures in the laboratory and in field studies: • Recognize and avoid potential hazards. • Safely manipulate materials and equipment needed for scientific investigations.	• Read and interpret Material Safety Data Sheets (MSDS).

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Goal 1

1.05 Analyze reports of scientific investigations of physical phenomena from an informed scientifically literate viewpoint including considerations of: • Appropriate sample. • Adequacy of experimental controls. • Replication of findings. • Alternative interpretations of the data.	• Read and analyze newspaper, journal, and on-line articles.

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Goal 2

COMPETENCY GOAL 2: The learner will construct an understanding of forces and motion.			
Days	***Objective***	***Content Description***	***Suggested Activities***
13/180	**2.01** Measure and mathematically/graphically analyze motion: • Frame of reference (all motion is relative - there is no motionless frame). • Uniform motion. • Acceleration.	• Describe motion as a change of position. • Understand that all motion is relative. • Solve one dimensional frame of reference problems. • Differentiate between distance and displacement. *(Solve for displacement in simple situations --students are not expected to use trigonometry.)* • Differentiate between speed and velocity. • Apply concepts of average speed and average velocity to solve conceptual and quantitative problems. • Investigate how velocity is a relationship between displacement and time: $\bar{v} = \frac{\Delta d}{\Delta t}$ • Investigate how acceleration is a relationship between velocity and time: $\bar{a} = \frac{\Delta v}{\Delta t}$. • Using graphical analysis, solve for distance, time, and average velocity. Also analyze conceptual trends in the distance vs. time graphs such as constant velocity and acceleration. • Using graphical analysis, solve for velocity, time, and average acceleration. Also analyze conceptual trends in the velocity vs. time graphs such as constant velocity and acceleration. • Investigate acceleration due to gravity as an example of	• **Inquiry Support Lab:** Racing Marbles • **Inquiry Support Lab:** Rabbit • **Inquiry Support Lab:** Hot Wheel Acceleration • Enrichment: Investigate speed and time with motion detectors.

COMPETENCY GOAL 2: The learner will construct an understanding of forces and motion.			
Days	***Objective***	***Content Description***	***Suggested Activities***
		uniformly changing velocity: g = 9.8m/s/s.	
14/180	**2.02** Investigate and analyze forces as interactions that can change motion: • In the absence of a force, an object in motion will remain in motion or an object at rest will remain at rest until acted on by an unbalanced force. • Change in motion of an object (acceleration) is directly proportional to the unbalanced outside force and inversely proportional to the mass. • Whenever one object exerts a force on another, an equal and opposite force is exerted by the second on the first.	• Investigate the property of inertia as related to mass. • Mathematically and graphically analyze weight as the relationship between the acceleration due to gravity and mass of an object:. $F_g = mg$ • Investigate mathematically and graphically $F = ma$ with respect to acceleration as a change in motion. • Investigate balanced and unbalanced forces using the equation: $F = ma$. *(Solve for the unbalanced force in simple situations--students are not expected to use trigonometry.)* • Investigate friction as force that opposes the motion of an object. • Analyze Newton's Third Law as the relationship described by $\text{Force}_{\text{of Object A on Object B}} = -\text{Force}_{\text{of Object B on Object A}}$	• Investigate forces using spring balances and/or force probes. • **Enrichment Lab:** Egg drop soup-What affects terminal velocity?

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COMPETENCY GOAL 3: The learner will analyze energy and its conservation.			
Days	***Objective***	***Content Description***	***Suggested Activities***
11/180	**3.01** Investigate and analyze storage of energy: • Kinetic energy • Potential energies: gravitational, chemical, electrical, elastic, nuclear • Thermal energy.	• Calculate kinetic energy: $KE = \frac{1}{2}mv^2$ • Predict change in kinetic energy when mass or velocity change in $KE = \frac{1}{2}mv^2$. • Calculate gravitational potential energy: $PE = mgh = F_g h$ • Predict change in gravitational potential energy when mass or height change in $PE = mgh = F_g h$. • Analyze and investigate the relationship among kinetic, potential, and other forms of energy to see that total energy is conserved. (**Law of Conservation of Energy)** • Analyze and investigate different forms of potential energy: gravitational, chemical, electrical, elastic and nuclear. • Use conceptual analysis to investigate the characteristics of a substance-such as mass, specific heat capacity, and temperature-that affect its ability to absorb or release thermal energy. *(Students should only solve math problems with* $q = mC_p\Delta T$ *as an enrichment topic.)*	• **Inquiry Support Lab:** Domino Derby • **Inquiry Support Lab:** Conservation of Mechanical Energy • Pendulum in various positions • Ball in flight • Stretching a rubber band • Hand generator/turbine
7/180	**3.02** Investigate and analyze transfer of energy by work: • Force. • Distance.	• Calculate work: $W = F\Delta d$ • Investigate and analyze work and power. $P = \frac{W}{\Delta t} = \frac{F\Delta d}{\Delta t}$	• **Inquiry Support Lab:** Conservation of Mechanical Energy

COMPETENCY GOAL 3: The learner will analyze energy and its conservation.			
Days	***Objective***	***Content Description***	***Suggested Activities***
		(Students should be familiar with Joules and Newton-meters)	• Work and power lab with stairs.
9/180	**3.03** Investigate and analyze transfer of energy by heating: • Thermal energy flows from a higher to a lower temperature. • Energy will not spontaneously flow from a lower temperature to a higher temperature. • It is impossible to build a machine that does nothing but convert thermal energy into useful work.	• Differentiate among conduction, convection, and radiation energy transfers. • Investigate the interaction between substances of different temperatures. • Explain why no machine can be 100% efficient. • Differentiate between heat and temperature.	• Convection currents investigation: by adding drops of food coloring to warm and cold water. • Enrichment: Calorimetry lab showing energy transfer.

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COMPETENCY GOAL 3: The learner will analyze energy and its conservation.			
Days	***Objective***	***Content Description***	***Suggested Activities***
9	**3.04** Investigate and analyze the transfer of energy by waves: • General characteristics of waves: amplitude, frequency, period, wavelength, and velocity of propagation. • Mechanical waves. • Sound waves. • Electromagnetic waves (radiation).	• Identify the basic characteristics of a transverse wave: trough, crest, amplitude, and wavelength. • Identify the basic characteristics of a longitudinal (compressional) wave: amplitude, rarefaction, and compression. • Recognize the relationship between period and frequency. Conceptual understanding of inverse relationship. • Use the relationships among velocity, frequency, and wavelength to solve wave problems: $v_w = f\lambda$ • Explore the differences between compressional and transverse waves. • Understand that a wave's energy is related to its amplitude. • Investigate how the velocity of a sound wave varies through different mediums. • Interpret the electromagnetic spectrum (use reference tables) to determine relationships among energy, frequency, and wavelength. • Relate wave energies to possible health risks.	• Demonstrate wave characteristics with a slinky. • Enrichment: Calculate the speed of sound • Enrichment: Analyze the Doppler Shift • Enrichment: Investigate reflection and refraction of waves

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COMPETENCY GOAL 4: The learner will construct an understanding of electricity and magnetism.			
Days	***Objective***	***Content Description***	***Suggested Activities***
7/180	**4.01** Investigate and analyze the nature of static electricity and the conservation of electrical charge: • Positive and negative charges. • Opposite charges attract and like charges repel. • Analyze the electrical charging of objects due to the transfer of charge.	• Investigate and analyze the transfer of electrons to charge objects. • Demonstrate that opposite charges attract and like charges repel. • Compare and contrast the three methods of charging objects: o Conduction o Friction o Induction.	• **Inquiry Support Lab:** Electroscope • Electrostatic lab- investigating electrostatics using common household items. • Discuss how weather conditions affect static electricity (dry, cold days; humid days; storms). • Discuss build up of static electricity on vehicles and appliances (gas station pump safety).
14/180	**4.02** Investigate and analyze direct current electrical circuits: • Ohm's law. • Series circuits. • Parallel circuits.	• Interpret simple circuit diagrams using symbols. • Investigate open and closed circuits. • Apply Ohm's Law and the power equation to simple DC circuits: $V = IR$ and $P = VI$ • Distinguish between series and parallel circuits. • Conceptually explore the flow of electricity in series and parallel circuits. *(Calculations with series and parallel circuits are reserved as enrichment topics.)* • Explain how the flow of	• **Inquiry Support Activity:** Build Series and Parallel Circuits • **Inquiry Support Lab:** Bright Lights • Enrichment: Calculate cost to run appliances from electric bill.

		electricity through series and parallel circuits is affected by voltage and resistance.	
6	**4.03** Investigate and analyze magnetism and the practical applications of the characteristics of magnets. • Permanent magnets • Electromagnetism • Movement of electrical charges	• Describe the characteristics and behaviors of magnetic domains. • Investigate the attraction of unlike poles and the repulsion of like poles. • Investigate the strength of an electromagnet by varying the number of coils, varying current, or core material. • Develop an understanding of the relationship between electricity and magnetism in practical applications such as generators and motors.	• **Inquiry Support Lab:** Magnet Fields • Build simple electromagnet using wire, nail, and battery • **Inquiry Support Lab:** Motor • Enrichment: Build a light bulb

COMPETENCY GOAL 5: The learner will build an understanding of the structure and properties of matter.			
Days	***Objective***	***Content Description***	***Suggested Activities***
7/180	**5.01** Develop an understanding of how scientific processes have led to the current atomic theory. • Dalton's atomic theory. • J. J. Thomson's model of the atom. • Rutherford's gold foil experiment • Bohr's planetary model. • Electron cloud model.	• Illustrate how observations and conclusions from experimentation changed atomic theory over time. • Explain Dalton's atomic theory, which states the following: 1) Chemical elements are made up of atoms. 2) The atoms of an element are identical in their masses. (*Be sure students understand that this was shown to be false with the discovery of isotopes.)* 3) Atoms of different elements have different masses. 4) Atoms only combine in small, whole number ratios such as 1:1, 1:2, 2:3 and so on. • Explain and illustrate J. J. Thomson's plum pudding model. • Explain Rutherford's gold foil experimental conclusions. The atom is mainly empty space with a dense positively charged center. • Explain Bohr's model. Show how electrons are arranged in energy levels. Illustrate models with electrons in energy orbits. • Describe the electron cloud model and identify the number of electrons in each level ($2n^2$), focusing on the following levels: 2, 8, 18, and 32.	• Research scientists and their contributions to atomic theory. • Visually represent the progression of atomic theory • Build models of atoms • *(Bohr models are being used to give students a two-dimensional view of energy levels surrounding the nucleus. Bohr was only correct about the electron in the hydrogen atom orbiting the nucleus like a planet around the sun. The modern view explains electron orientation.)*
14/180	**5.02** Examine the nature of atomic structure: • Protons.	• Describe the charge, relative mass, and the location of protons, electrons, and	• **Inquiry Support Activity:**

COMPETENCY GOAL 5: The learner will build an understanding of the structure and properties of matter.			
Days	***Objective***	***Content Description***	***Suggested Activities***
	• Neutrons. • Electrons. • Atomic mass. • Atomic number. • Isotopes.	neutrons within an atom. • Calculate the number of protons, neutrons, electrons, and mass number in neutral atoms and ions. • Explain how the different mass numbers of isotopes contributes to the average atomic mass for a given element. (S*tudents are expected to understand this conceptually, not calculate.)* • Write the symbols for various isotopes (examples Carbon-12, $^{12}_{6}C$, C-12. • Draw Bohr models from hydrogen to argon including common isotopes.	M&M Isotopes
6/180	**5.03** Identify substances through the investigation of physical properties: • Density. • Melting point. • Boiling point.	• Define and explain physical properties. • Calculate the density of different substances (solids, liquids, and gases) $D = \frac{m}{V}$ • Recognize that phase changes are physical changes. • Investigate phase changes. • Graph, label and analyze heating/cooling curves for various substances. (*Students are not expected to do specific heat and phase change calculations unless as an enrichment topic*.) • Determine the identity of various substances by comparing properties with known substances.	• Graph the temperature change as ice changes to water and then to steam. • Determine relative density using a density column with household items

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Goal 6

COMPETENCY GOAL 6: The learner will build an understanding of regularities in chemistry.			
Days	***Objective***	***Content Description***	***Suggested Activities***
7	**6.01** Analyze the periodic trends in the physical and chemical properties of elements. • Groups (families). • Periods.	• Define group (family) and period. • Locate the following on the periodic table: alkali metals, alkaline earth metals, transition metals, halogens, noble gases, metals, nonmetals, metalloids. • Compare and contrast the physical and chemical properties of metals, nonmetals, and metalloids. (Properties should include but not be limited to reactivity, physical state, melting and boiling point, ductility, malleability, conductivity, and luster.) • Analyze the periodic trend for atomic radius (left to right and top to bottom on periodic table).	• **Inquiry Support Lab:** Unknown substance
13	**6.02** Investigate and analyze the formation and nomenclature of simple inorganic compounds. • Ionic bonds (including oxidation numbers). • Covalent bonds. • Metallic bonds.	• Describe how ions form • Describe how ionic, covalent, and metallic bonds form and provide examples of substances that exhibit each type of bonding. • Represent elements, ions, and simple compounds with electron dot diagrams. • Predict an element's oxidation number based on its position in the periodic table and valence electrons, excluding the transition elements. • Name and write formulas for simple binary compounds. • Name and write formulas of compounds using polyatomic ions given in the reference	• **Inquiry Support Activity:** Carton compounds

<table>
<tr><th colspan="4">COMPETENCY GOAL 6: The learner will build an understanding of regularities in chemistry.</th></tr>
<tr><th>Days</th><th>Objective</th><th>Content Description</th><th>Suggested Activities</th></tr>
<tr><td></td><td></td><td>table.
<table>
<tr><th colspan="2">Polyatomic Ions</th></tr>
<tr><td>NH_4^+</td><td>Ammonium</td></tr>
<tr><td>$C_2H_3O_2^-$</td><td>Acetate</td></tr>
<tr><td>ClO_3^-</td><td>Chlorate</td></tr>
<tr><td>MnO_4^-</td><td>Permanganate</td></tr>
<tr><td>NO_3^-</td><td>Nitrate</td></tr>
<tr><td>OH^-</td><td>Hydroxide</td></tr>
<tr><td>CO_3^{2-}</td><td>Carbonate</td></tr>
<tr><td>CrO_4^{2-}</td><td>Chromate</td></tr>
<tr><td>SO_4^{2-}</td><td>Sulfate</td></tr>
<tr><td>PO_4^{3-}</td><td>Phosphate</td></tr>
</table></td><td></td></tr>
<tr><td>14</td><td>6.03 Identify the reactants and products of chemical reactions and balance simple equations of various types:
• Single replacement.
• Double replacement.
• Decomposition.
• Synthesis.</td><td>• Identify the reactants and products of a simple chemical equation.
• Use coefficients to balance simple chemical equations.
• Recognize that chemical equations must be balanced because of the law of conservation of matter.
• Classify chemical reactions as one of four types: single replacement, double replacement, decomposition, and synthesis. (Neutralization reaction is a type of double replacement reaction. See 6.05)</td><td>• Inquiry Support Lab: Types of reaction
• Inquiry Support Activity: Wipe away math
• (Students planning to take chemistry should know that another classification is combustion reactions. This may be included as an enrichment topic.)</td></tr>
</table>

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Goal 6

COMPETENCY GOAL 6: The learner will build an understanding of regularities in chemistry.			
Days	***Objective***	***Content Description***	***Suggested Activities***
7	**6.04** Measure and analyze the indicators of chemical change including: • Development of a gas. • Formation of a precipitate. • Release/absorption of energy (heat or light).	• Observe a process and describe the indicator(s) of chemical change it exhibits. • Differentiate between exothermic and endothermic reactions. (Color change is sometimes an indicator of chemical change-sometimes physical-discuss examples.)	• **Inquiry Support Lab:** Endothermic • **Inquiry Support Lab:** Exothermic
15	**6.05** Investigate and analyze the properties and composition of solutions: • Solubility curves. • Concentration. • Polarity. • pH scale. • Electrical conductivity.	• Give examples of solutions containing solutes and solvents of various phases such as alloys and carbonated drinks. • Explain the polar nature of water (The phrase "like dissolves like" is often used to explain why substance dissolves another which is an over simplification of the process). • Investigate the factors that affect the rate of solution of a solid including concentration, stirring, temperature, and surface area. • Compare and contrast electrical conductivity of solutions containing ionic and covalent solutes. • Interpret the solubility curves for solids (concentration vs temperature). Investigate various concentrations unsaturated through supersaturated. • Conduct an experiment to illustrate trends in solubility. • Identify the acid, base, and salt in a neutralization	• **Inquiry Support Lab:** Characterizing solutions • Marker/Crayon lab • Identify household items using indicators

COMPETENCY GOAL 6: The learner will build an understanding of regularities in chemistry.			
Days	***Objective***	***Content Description***	***Suggested Activities***
		reaction. (See 6.03) • Compare and contrast the physical and chemical characteristics of acids, bases, and neutral substances. • Develop an understanding of the concentration of ions in the organization of the pH scale. • Investigate the pH of various substances using various indicators: litmus paper, phenolphthalein, and pH paper.	
7	**6.06** Describe and explain radioactivity and its practical application as an alternative energy source: • Alpha, beta, and gamma decay. • Fission. • Fusion. • Nuclear waste.	• Compare and contrast the characteristics of alpha and beta particles and gamma rays. • Compare and contrast the alpha, beta, and gamma decay processes. • Compare and contrast the processes of fission and fusion. • Describe various means of dealing with nuclear waste over time.	• Research uses/problems of nuclear fission and fusion (medicine, energy, waste, defense, etc) • **Inquiry Support Activity:** Kabooom Chemistry Review • **Enrichment:** Study half life

Safety in the Science Classroom and Laboratory

Chemical Management:

In North Carolina, it is the responsibility of the Superintendent of a school system to appoint a qualified chemical hygiene officer to direct the development of and compliance with the chemical hygiene plan for the school system. This plan must include protocols and processes for chemical management for science laboratories and preparation rooms, as well as, professional development for science teachers and administrators. Because laws, codes and standards change, the plan must be reviewed and updated annually or more often as necessary.

Instruction, Supervision, and Maintenance of a Safe Learning Environment:

In North Carolina, it is the teacher's responsibility to address safety in planning instructional activities, laboratory investigations, and to supervise students so that all activities and investigations are carried out in a safe manner. The teacher is responsible for adhering to professional standards, NC laws and codes when assessing the learning environment. Ongoing professional development is an essential part of ensuring laboratory safety.

It is the principal's responsibility to provide personal protective equipment and resources to ensure science teachers can teach the North Carolina's science curriculum safely. All *North Carolina Standard Course of Study* Science classes are designed to be laboratory courses and must include a laboratory component.

The suggestions and resources for science safety and resources included here are in no way comprehensive but may serve as a quick reference for a few common safety issues.

1) Chemicals:
    a. Order only the amounts you will use for one year. Do as much microchemistry as possible to minimize hazards
    b. Be sure you have an appropriate storage system for chemicals.
    c. You must have the MSDS available for all chemicals in your classroom/prep room (including kitchen/grocery store chemicals). You should go over the MSDS information with students each time they will be using a chemical. Document this in your lesson plan book.
    d. Use the smallest amounts and weakest/most dilute concentrations of chemicals that you can and still have a viable investigation/demonstration.
    e. Be sure you have appropriate disposal arranged before using a chemical.
    f. Avoid the use of toxic chemicals.
    g. Sulfur is a common allergen. Reactions that use or produce sulfur compounds should be performed under a working hood.

h. Go over all hazards and safety precautions with students prior to each laboratory investigation/activity and document in your lesson plan book and with student work samples (i.e. quizzes or prelab assignments).
i. Be aware of latex allergies that some students have. Alternative types of gloves must be provided when students need gloves.

2) Be sure goggles are appropriate and meet standards for the planned investigation. Goggles designed for impact are different than those designed to protect against fluid splashing. Chemical splash goggles are required anytime students are using fluids. Be sure contact lens wearers have non-vented chemical splash goggles. Visor-type goggles are NOT appropriate or safe for activities using fluids.

DISCLAIMER: Mention of any company or product does not constitute endorsement by the NCDPI. In addition the inclusion of links to websites is not intended to reflect endorsement by DPI, nor is it intended to endorse any views expressed or products or services offered by the author of the reference or organization operating the server on which the reference is maintained. Also, suggestions for activities do not mean that these are the only way to conduct an experiment or activity.

Resources and References for Science Safety:

NCDPI Total Science Safety Program: Contact Benita Tipton, Science Consultant, btipton@dpi.state.nc.us. (919) 807-3933.

NCDPI School Insurance http://www.ncpublicschools.org/fbs/insurance/
This office will help you with risk control, safe facilities, and fire safety issues. Their website has several pages that address science safety issues and has links to websites with federal and state laws and codes.

NCDPI Publications

NCDPI has a variety of science safety posters – currently available: Science Safety Signs, Goggles: It's the Law, and a Science Chemicals Poster which provides a chart for the teacher to enter the title and date of a lab exercise along with information about specific chemicals, including the NFPA Hazards Rating, Personal Protective Equipment and the Waste Disposal Method.

The NCDPI **School Science Facilities Planner** is available to download as a PDF file http://www.schoolclearinghouse.org/pubs/SCIENCE.PDF

American Chemical Society
American Chemical Society Safety Guidelines
Chemical Safety for Teachers and Their Supervisors: Grades 7-12
Safety Audit/Inspection Manual
Teachers can order single copies by calling ACS at 1-800-227-5558.

29 CFR 1910 OSHA
General Industry Regulations
www.oshacfr.com

CRC Handbook of Laboratory Safety
5th edition
A. Keith Furr
www.crcpress.com

2000 Emergency Response Guidebook
U.S. Dept of Transportation
Research and special Programs Administration
http://hazmat.dot.gov/gydebook.htm

A Guide to Working With Corrosive Substances
Harry E. Payne, Jr
North Carolina Occupational Safety and Health Standards for General Industry
NC Department of Labor
Division of Occupational Safety and Health
4 West Edenton Street
Raleigh, NC 27601-1092

Handbook of Chemical Health and Safety
Robert J Alalmo editor
Learning by Accident
Edited: Fariba Mojtabai & James Kaufman
Volume # 2
The Laboratory safety Institute
192 Worchester Road
Natick, MA 01760

It's Elementary… and Beyond
www.chemed.org

MSDS Sheets for Chemicals (Material Safety Data Sheets)
Numerous sources – here are some links
www.flinnsci.com/homepage/cindex.html

www.uvm.edu/uvmsafety/labsafety/chemsafety/netmsds.html (grocery/kitchen chemicals)
www.msds.pdc.cornell.edu/msdssrch.asp
www.fishersci.com
www.osha.gov
www.cdc.gov/niosh

National Science Teachers Association www.nsta.org
Click on *Publications* and *Position Statements.*
Numerous NSTA position statements on Safety, Field Trips, Class Size, etc.
NSTA Safety Publications:
Exploring Safely: A Guide for Elementary Teachers- Terry Kwan & Juliana Texley
Inquiring Safely: A Guide for Middle School Teachers- Terry Kwan & Juliana Texley
Investigating Safely: A Guide for High School Teachers- Juliana Texley, Terry Kwan, & John Summers

The OSHA Answer Book (7th edition)
Mark Moran

Right-To Know Pocket Guide for school & University Employees
National Fire Rating System Reference Guide
Lab Safety Supply
PO Box 1368
Janesville, WI 53547-1368
1-800-356-0783

Safetycertified.com
1536 Kingsley Ave
Suite 126
Orange Park, FL 3207
1-800-597-2040

Safety in Academic Chemistry Laboratories
Volume 2
Accident Prevention for Faculty and Administrators 7th ed
(also have student version)
American Chemical Society
1155 16th St, NW
Washington, DC 20036

Safety in the Elementary (K-6) Science Classroom
Second Edition
Committee on Chemical Safety
1155 Sixteenth St, NW
Washington, DC 20036
Chemistry.org

Safety in High School and College Laboratories
Fisher Science Education
1 800 955 1177
1 800 955 0740 (f)
www.fisheredu.com

Science Classroom Safety and the Law
Flinn Scientific Inc.
P.O. Box 219
Batavia, IL60510
E-mail: flinn@flinnsci.com
Website: www.flinnsci.com

Science Laboratory Safety Manual
Linda M. Stroud, Ph.D.
www.sciencesafetyconsulting.com

Other safety resources are available from several science supply catalogs.

Suggested Chemicals and Equipment List for Basic Physical Science Activities and Labs

Common Household Chemicals
Baking soda
Corn starch
Distilled water
Food coloring
Isopropyl alcohol
Powdered sugar
Sugar
Sugar cubes
Table salt
Vegetable oil
Vinegar

Laboratory Chemicals
Hydrochloric acid
Hydrogen peroxide
Iron filings
Litmus paper
Magnesium
ph indicators
Phenolphthalein
Potassium iodide
Silver nitrate
Sodium hydroxide
Steel wool
Sulfuric acid
Zinc

Common Household Items	
Equipment	*Quantity*
Aluminum foil	1 roll
Balloons	100
Calculator	24
Candle	24
Coffee filter	1 box
Construction paper	1 pkg
Dominoes	12 bags
Holiday lights	1 strand
Individualized dry erase boards/markers	12
Irregular shaped objects	12
Marbles	2 bags
Matches	12 boxes
Nails	24
Paperclips	24 boxes
Pennies	4 rolls
Plastic cups	2 pkg
Plastic shoe box	6
Ruler	24
Scissors	24
Slinky (metal)	12
String	2 pkg
Stopwatch	12
Toy car	12
Wire- various gauges and materials	4 rolls

Laboratory Equipment	
Equipment	*Quantity*
Alligator clips	60
Aprons	24
Battery	24
Beaker-100mL	24
Beaker-250mL	24
Beaker-50mL	24
Beaker-600mL	12
Compass	24
Conductivity apparatus	1
Dish pans	6
Erlenmeyer flask-1000mL	2
Fume hood	1
Goggles	24
Graduated cylinder	12
Hot hands	12
Hot plates	12
Light bulb	20
Magnets	24
Meter sticks	12
Spring scale	12
Stirring rod	24
Stoppers	2
Test tube clamp	12
Test tube rack	12
Test tubes	100
Thermometer	12
Well plates	12

Activities and Labs

Racing Marbles: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.02 Design and conduct scientific investigations to answer questions about the physical world.

- Create testable hypotheses.
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Collect and record data.
- Analyze and interpret data.
- Communicate findings.

GOAL 2: The learner will construct an understanding of forces and motion.

2.01 Measure and mathematically/graphically analyze motion:

- Frame of reference (all motion is relative - there is no motionless frame).
- Uniform motion.
- Acceleration.

Introduction to the Teacher

Use the formula $\bar{\upsilon} = \frac{\Delta d}{\Delta t}$. Use groups of two for this activity.

Safety Considerations

Don't let students throw or play inappropriately with the marbles.

References

This activity was designed by Tom Skarr (Walter H. Page High School, Greensboro, NC) and adapted by Stephen Charles (Walter H. Page High School, Greensboro, NC).

Racing Marbles

Purpose
To determine how to calculate speed.

Materials
- One marble per group
- Metric ruler (30 cm)
- One book

Introduction to Student
Have you or a parental guardian ever been accused of speeding in a car? Ever wanted to prove the police officer wrong. We are going to figure that out today.

Procedure
1. On a level table top, place a 30 cm ruler at an incline of about 1.5 cm. Use a book at one end of the ruler to raise it.

2. Roll a marble down the incline

3. Record the distance the marble rolls at the bottom of the incline along the table top in two seconds. Repeat this procedure 2 more times.

Trial	***Distance***	***Time***	***Speed***
1			
2			
3			

****************************Math Alert*****************************

Use the formula: distance/time=speed

4. What is your average speed? Show ALL work.

Use the formula: Average speed= total distance/ total time

5. Record the distance the marbles rolls at the bottom of the incline along the table top in three seconds. Repeat this procedure 2 more times.

Trial	***Distance***	***Time***	***Speed***
1			
2			
3			

****************************Math Alert*****************************

Use the formula: distance/time=speed

6. What is your average speed? Show ALL work.

Use the formula: Average speed= total distance/ total time

Questions to Guide Analysis

1. Which trial has the higher average speed, two seconds or three seconds? Why?

2. What is the average distance the marble rolls in two seconds? Three seconds?

3. What information would you need to challenge a police officer who accused you of speeding?

Rabbit: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.02 Design and conduct scientific investigations to answer questions about the physical world.
- Create testable hypotheses.
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Collect and record data.
- Analyze and interpret data.
- Communicate findings.

GOAL 2: The learner will construct an understanding of forces and motion.

2.01 Measure and mathematically/graphically analyze motion:
- Frame of reference (all motion is relative - there is no motionless frame).
- Uniform motion.
- Acceleration.

Introduction to the Teacher

This is an easy way to reinforce the velocity/acceleration problems. The lab allows students to go outside in a supervised setting. It also lets students work off a bit of energy. If the weather is not cooperating, an indoor hallway is acceptable; it just needs to be long enough (may adjust the distances accordingly). Take any obstacles, *e.g.* trophy cases, doors, into account.

Groups of four are needed. One student is a rabbit, while the other three times. You may opt to rotate students, but it is less chaotic to only have one runner.

May also opt for extensions such as:
1. Calculate the distance rabbit would travel if they maintain their speed for 30s, for 60s etc.
2. Graph speeds for each trial.
3. Have groups post data for their rabbit. All students copy info and graph/compare all rabbits.
4. Graphs may be of just speeds or could be distance vs. time (can use to determine speed).
5. If graphs are used, have students predict distance rabbit would travel if graph continued.
6. If you have covered kinetic energy, you may have students calculate the KE as the rabbit runs.
7. Lab write up, cite areas where errors may have occurred

Safety Considerations
No high heels.

References
This activity was created by Dave Zwadyk (Southern Guilford High School, Greensboro, NC).

Rabbit: Laboratory

Purpose
To investigate the principles of velocity and acceleration

Materials
- Stopwatches (3 per group of 4 students)
- Track or long hallway measured
- Tape measure, possibly

Procedure
1. One student in the group is the designated rabbit. The other three are timers.
2. Timers station themselves at 10m, 25m, and 50m.
3. One trial per speed, the rabbit walks, walks fast and runs the 50m while timers record the time.
4. Back in the classroom, calculate the speed for the rabbit.
5. Also calculate the velocity for 0 – 10m and 0 -50m.
6. Explain during which segments/trials were the velocities and acceleration greatest.

Lab Data

	Time		
	10m	25m	50m
Walk			
Walk Fast			
Run			

	Velocity		
	0-10m	0-25m	0-50m
Walk			
Walk Fast			
Run			

Acceleration	Initial velocity	Final velocity
	0-10m	0-50m
Walk		
Walk Fast		
Run		

Hot Wheel Acceleration: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.02 Design and conduct scientific investigations to answer questions about the physical world.

- Create testable hypotheses.
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Collect and record data.
- Analyze and interpret data.
- Communicate findings.

GOAL 2: The learner will construct an understanding of forces and motion.

2.01 Measure and mathematically/graphically analyze motion:

- Frame of reference (all motion is relative - there is no motionless frame).
- Uniform motion.
- Acceleration

Introduction to the teacher:

In this lab, students will be studying acceleration due to gravity by observing Hot Wheels cars on inclined planes. The goal will be to determine the acceleration of the car with the inclined plane at different angles. The lab will show how graphs of displacement versus time and velocity versus time can be used to find acceleration. Use groups of four for this lab activity. Have students complete the pre-lab for this activity at home and check it the next day in class.

Safety Considerations:

Don't let students drop desk on their fingers or feet.

References:

This activity was designed by Demetris Smith (Walter H. Page High School, Greensboro, NC) and adapted by Stephen Charles (Walter H. Page High School, Greensboro, NC).

Hot Wheel Acceleration: Laboratory

Purpose

In this lab, you will be studying acceleration due to gravity by observing Hot Wheels cars on inclined planes. Your goal will be to determine the acceleration of the car with the inclined plane at different angles. The lab will show how graphs of displacement versus time and velocity versus time can be used to find acceleration.

Materials

- Hot Wheel Car
- Flat table top
- 2 books
- Meter stick
- Stopwatch

Procedure

Part A

1. Begin by designating one person to be the car holder, 2 people as distance markers, one person as a recorder, and one as a timer.

2. Raise one end of the inclined plane by placing the end on one book.

3. Trial run:

Have the car holder hold the car at the top of the ramp. When the car holder releases the car, have the timer begin timing. The timer should call out one-second intervals. Have the distance markers mark the position of the car with a finger for each interval. HINT: Each distance marker has two hands, so if they used a finger on the left hand to mark interval 1 and a finger on the right hand to mark off interval 2, the next distance marker can use their two hands to mark off intervals 2 and 3, Record the data below:

Time (s)	Position (cm)
1	
2	
3	
4	

Table 1

4. If you were not able to obtain the position for each time interval, try until you have a system that enables you to get all four positions.

5. Calculate the average speed for your trial. What formula must you use?

Part B
6. You will now repeat this procedure for two different heights of the desk. For each height, you will be doing three trials and averaging your data.

7. First raise one end of the desk up. Place one book underneath two legs on the same side. You just created your ramp.

8. Let the car run down the ramp 3 times. Record your data in table 2. Take the average position for each time and enter it into the table. Then for each time interval, calculate the distance traveled in 1 second. To calculate this, it will be the average position minus the previous average position. For the first time it is the average position minus zero. Be sure to measure the distance in centimeters.

9. Then calculate the velocity for each time interval by taking the displacement divided by the time interval (the interval is 1 second each time).

Time (s)	***Run 1 Position (cm)***	***Run 2 Position (cm)***	***Run 3 Position (cm)***	***Average Position (cm)***	***Distance traveled in 1 second***	***Velocity (cm/s)***
1						
2						
3						
4						

Table 2. Using one book.

10. Repeat this exact procedure, except this time raise the table up by using two books on the two legs.

Time (s)	***Run 1 Position (cm)***	***Run 2 Position (cm)***	***Run 3 Position (cm)***	***Average Position (cm)***	***Distance traveled in 1 second***	***Velocity (cm/s)***
1						
2						
3						
4						

Table 3. Using two books.

Questions to Guide Analysis

1. Create a velocity versus time graph for your two heights using the average positions you calculated and attach the graph to your report.

2. Calculate the acceleration of the car for each height. You can calculate acceleration two ways. One way is to find the slope of the graph. Show your work both ways. The second way is to use the formula:

$a = \frac{v_f - v_i}{t}$ v_f=velocity final v_i = velocity initial t= time a= acceleration

3. What is the main difference between the velocity graph for table 2 and 3?

4. How does the angle of the table affect the acceleration of your hot wheel?

5. What are some sources of error in this lab?

6. Using the above formula for acceleration answer the following word problems. Be sure to show ALL work.

A. A car on a freeway ramp accelerates from 12 meters/second to 24 meters/second in 9 seconds. What was the average acceleration of the car?

B. A car traveling 30 kilometers/hour hits a deer and stops in 3 seconds. What is the average acceleration of the car?

Hot Wheels Pre-Lab

1. What are my goals for the lab?

2. What are your goals for the lab?

3. Describe how your group will collect data for the acceleration of the car. Who has which responsibility?

4. Fill in the chart. HINT: Use the reference tables to calculate the missing information.

Time (s)	***Run 1 Position (cm)***	***Run 2 Position (cm)***	***Run 3 Position (cm)***	***Average Position (cm)***	***Distance traveled in 1 second***	***Velocity (cm/s)***
1	*10*	*9*	*11*			
2	*30*	*28*	*32*			
3	*60*	*55*	*63*			
4	*100*	*95*	*105*			

Egg Drop Soup: What Affects Terminal Velocity: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.02 Design and conduct scientific investigations to answer questions about the physical world.
• Create testable hypotheses.
• Identify variables.
• Use a control or comparison group when appropriate.
• Select and use appropriate measurement tools.
• Collect and record data.
• Analyze and interpret data.
• Communicate findings.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
• Explain observations.
• Make inferences and predictions.
• Explain the relationship between evidence and explanation.

GOAL 2: The learner will construct an understanding of forces and motion.

2.01 Measure and mathematically/graphically analyze motion:
• Frame of reference (all motion is relative - there is no motionless frame).
• Uniform motion.
• Acceleration.

2.02 Investigate and analyze forces as interactions that can change motion:
• In the absence of a force, an object in motion will remain in motion or an object at rest will remain at rest until acted on by an unbalanced force.
• Change in motion of an object (acceleration) is directly proportional to the unbalanced outside force and inversely proportional to the mass.
• Whenever one object exerts a force on another, an equal and opposite force is exerted by the second on the first.

GOAL 3: The learner will analyze energy and its conservation.

3.01 Investigate and analyze storage of energy:
• Kinetic energy
• Potential energies: gravitational, chemical, electrical, elastic, nuclear
• Thermal energy.

Introduction to the Teacher

Students will understand the following:

1. Gravity is the force of attraction that causes objects to fall toward the center of the earth.

2. Air resistance, or air friction, can slow down the acceleration of a falling object.
3. The area “fronting the wind” affects the amount of air resistance a falling object encounters.
4. Terminal speed is the speed at which the downward pull of gravity is balanced by the equal and upward opposing force of air resistance for a falling object.

Materials

- Lightweight plastic kitchen garbage-can liners
- Scissors
- Ruler
- 12 20-inch lengths of light string
- 3 plastic sandwich bags
- 3 raw eggs
- Graph paper for analysis

Procedure

1. Divide your class into several small groups, and distribute materials to each group.
2. Have students use the following directions to build three “parachutes” for an ordinary chicken egg:
    - From a lightweight plastic kitchen garbage-can liner, cut out three squares. Make one square 10”x 10”, a second square 20” x 20”, and a third square 30” by 30”.
    - Make a parachute out of each square by tying a piece of string to each corner of the square, then attaching the other ends of the strings to a plastic sandwich bag.
    - Place a raw egg in each of the sandwich bags.
3. Ask students to predict which egg has the best chance of surviving a drop from about ten feet from the floor. Students should explain the reasoning behind their predictions.
4. Have students drop each unfurled egg parachute from a height of ten feet, and then determine whether or not their predictions were confirmed. May be done at stadium or indoors in stairwell or in gym: If done indoors, place newspaper or plastic in drop zone to avoid sticky messes on the floor.
5. After each group has performed its experiment, ask students to describe the changing forces that acted on the parachutes as they fell and the resulting changes in the parachutes’ motion. How did the falls of the larger parachutes differ from the falls of the smaller ones?
6. Review with students that gravity pulled the parachutes downward; air resistance worked as an opposing force to gravity; the parachutes accelerated until the air resistance equaled the gravity, at which point the parachutes reached terminal speed; the bigger parachutes with a larger area fronting the wind created more air resistance than the smaller ones, so the bigger parachutes reached terminal speed earlier.

You can evaluate your students on their experiments using the following three-point rubric:
Three points: predictions based on sound reasoning, experiment carefully performed, results accurately and completely recorded, explanations clear and logical

Egg Drop Soup: What Affects Terminal Velocity: Background Information

Two points: predictions based on sound reasoning, experiment performed with sufficient care, results incompletely recorded, and explanations acceptable
One point: predictions based on guesswork, experiment performed with sufficient care, results incompletely or inaccurately recorded, explanations sketchy
You can ask your students to contribute to the assessment rubric by determining which scientific principles should be covered in the explanations

Special Considerations
Beware on windy days if lab is done outside, parachutes will float away from drop zone

References
This activity was adapted from
http://school.discovery.com/lessonplans/programs/forcesandmotion/ and modified by Dave Zwadyk (Southern Guilford High School, Greensboro, NC).

Egg Drop Soup: What Affects Terminal Velocity: Laboratory

Purpose

Students will understand the following:
1. Gravity is the force of attraction that causes objects to fall toward the center of the earth.
2. Air resistance, or air friction, can slow down the acceleration of a falling object.
3. The area "fronting the wind" affects the amount of air resistance a falling object encounters.
4. Terminal speed is the speed at which the downward pull of gravity is balanced by the equal and upward opposing force of air resistance for a falling object.

Materials

- Lightweight plastic kitchen garbage-can liners
- Scissors
- Ruler
- 12 20-inch lengths of light string
- 3 plastic sandwich bags
- 3 raw eggs
- Graph paper for analysis

Procedure

1. In small groups, build three "parachutes" for an ordinary chicken egg:
    - From a lightweight plastic kitchen garbage-can liner, cut out three squares. Make one square 10"x 10", a second square 20" x 20", and a third square 30" by 30".
    - Make a parachute out of each square by tying a piece of string to each corner of the square, then attaching the other ends of the strings to a plastic sandwich bag.
    - Place a raw egg in each of the sandwich bags.
2. Predict which egg has the best chance of surviving a drop from about ten feet from the floor. Explain the reasoning behind your predictions.
3. Drop each unfurled egg parachute from a height of ten feet, and then determine whether or not your predictions were confirmed. Be careful and don't make a mess.

Questions to Guide Analysis

1. Define the terms speed and acceleration. Explain how the two terms are related.

2. How can creating and analyzing graphs be useful for understanding forces and motion in objects?

3. Construct a position-versus-time graph for the following set of data: (D1 = 0 m, T1 = 0 sec), (D2 = 7 m, T2 = 3 sec), (D3 = 14 m, T3 = 6 sec), (D4 = 21 m, T4 = 9 sec), and (D5 = 28 m, T5 = 12 sec). Discuss how you would use this graph to determine the speed of the object being represented.

4. Is the object represented in question 3 moving with constant speed or constant acceleration? Explain how you arrived at your conclusion.

5. Debate what assumptions might be made about the unknown forces that are acting on the object represented by the graph in question 3. Explain the reasons for each of your assumptions.

6. If the object in question 3 continued to move, explain how you might use the graph, its gradient, and the data plotted on its x- and y-axes to determine how far the object would travel in 19.5 additional seconds.

7. From the graph constructed in question 3, calculate the object's speed at three-second intervals, then use this new information to construct a speed-versus-time graph for the object.

Domino Derby: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.02 Design and conduct scientific investigations to answer questions about the physical world.
- Create testable hypotheses.
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Collect and record data.
- Analyze and interpret data.
- Communicate findings.

GOAL 3: The learner will analyze energy and its conservation.

3.01 Investigate and analyze storage of energy:
- Kinetic energy
- Potential energies: gravitational, chemical, electrical, elastic, nuclear
- Thermal energy.

Introduction to the Teacher

As an opener, simply have each student or pair of students set the dominoes upright in a straight line no more than ¼ inch apart. As the dominoes are cheaply made, they are irregulars that give the students a challenge in setting them upright. Also, this is a good way to get the kids exposed to the transfer of energy as the dominoes usually fall more than once as they attempt to set them up. They also get exposed to factors such as the table or desk moving that transfers energy, etc., to the dominoes.

Once this exploratory session is completed, give the kids a task: using only their dominoes, the boxes in which the dominoes came, and optionally, their textbooks, they are to assemble a series of dominoes that will hit a toy car and cause it to move. Announce a "prize" (sometimes to motivate, again, it depends on your students) that will be presented to the student or pair of students that has their car move the longest distance.

The car must be on the desk top, only a small force is allowed to start the dominoes; the materials used are dictated by the size of the group. For example, two students can use 2 boxes of dominoes, 2 boxes and 2 textbooks.

This activity is challenging one for my students. It provides a challenging situation in which the conversion of PE to KE can be easily explored.

Reference

This activity was designed by Barbara Wallace (North Gaston High School, Dallas, NC).

Domino Derby: Laboratory

Purpose

- Analyze and investigate different forms of potential energy
- Analyze and investigate kinetic energy

Materials

- Boxes of dominoes (Dollar Tree $1/box)
- Toy cars
- Textbook (optional)

Questions to Guide Analysis

1. Why did the car move?

2. What factors affected the distance the car moved?

3. What is the connection between mass and height?

4. When will the car move the longest distance?

5. What did you do to prevent your dominoes from falling prematurely?

6. Did it matter how hard you hit the first domino to start the movement of the dominoes?

The Conservation of Mechanical Energy: Background Information

Targeted *Standard Course of Study* Goals and Objectives

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

GOAL 3: The learner will analyze energy and its conservation.

3.01 Investigate and analyze storage of energy:
- Kinetic energy
- Potential energies: gravitational, chemical, electrical, elastic, nuclear
- Thermal energy.

3.02 Investigate and analyze transfer of energy by work:
- Force.
- Distance.

Introduction to the Teacher

This lab was written for introductory physical science. It is utilized by the author in its present form following units on basic kinematics, basic dynamics (for both constant velocity and uniform acceleration), and introductory information on work, gravitational potential energy, and kinetic energy. The activity is the first exposure students have to the concept of energy conservation (and probably conservation laws). It also, through the questions, looks at the equivalency of work and energy in an attempt to see that work is a method of energy transfer. It also provides a physical experiment to serve as the starting point to look at other methods of energy transfer to account for differences in the change in PE of the hanging mass and the change in KE of the system.

Clarification of procedure:

1. Attach a light string between a mass and cart. Attach a pulley to one end of the table. Place the string over the pulley. Attach a paperclip to the string to act as a hanger for the mass. The string should be long enough that the mass can be next to the pulley and then fall completely to the floor without allowing the cart to collide with the pulley.

The string should be light and as inelastic as possible. Pulley string is available from Sargent-Welch and works well. To improve the quality of the experimental set-up, it would be acceptable to cut the string to the proper length and even to attach all parts for the student. At the very least, one setup should be shown and demonstrated to facilitate student progress.

2. Remove the hanging mass. Add small masses (paperclips of various sizes will do) to the end of the string so that when a gentle push is given to the cart, it will

move slowly across the table with constant velocity. (The hanging mass should not be attached to string during this time) The paperclips should remain on the string throughout the procedure.

Several boxes of paperclips of varying sizes need to be provided. They should be attached to the string until, with a gentle nudge, the cart moves slowly with constant velocity across the table. If it accelerates, too many paperclips have been added. If it stops, too few have been added. This step is carried out to simplify the system by accounting for friction. Once the paperclips have been attached they should remain attached. The hanging mass is then placed on the string. The net force on the system should be equivalent to the weight of the hanging mass.

3. Using a balance or spring scale, find the total mass of cart, hanging mass, paperclips and string. The mass should be recorded in kilograms in the data table. This combined mass is the mass of the ***system.***

Spring scales calibrated in kilograms or grams are useful here. Balances may be used if their capacity is great enough. The entire system mass is important in the calculation of KE since the mass of the entire system is accelerating.

4. Set up the system so that the hanging mass is at the pulley and ready to fall and pull the cart across the table.

5. Measure the distance through which the mass falls as it goes from the pulley to the floor.

Students should be cautioned that the starting point for the hanging mass should be the same in each trial.

6. Have one person hold the cart so that the hanging mass is suspended at the height measured in number 5. When the person holding the cart releases, start the stopwatch. Stop the watch when the mass hits the floor. Run several trials and average the time required for the mass to fall to the floor. Record the average time in your data table.

It is important that students are utilizing SI units. Mass: kg, Distance: m, Time: s, velocity: m/s, Force, N. If these units are utilized the energy/work equations will give Joules for energy. This is a common area of student problems.

References

This activity was designed by David English, Michelle Chadwick, and Jody Holloway from Northside High School Science Department Jacksonville, NC.

Answers to Questions:

The answers provided are intended for teacher use.

1.Calculate the average time required for the object to fall.

The average time (t) = Sum of times for each trial /5 trials

2. Calculate the average velocity for the falling object during the fall. (average velocity of the system)

Average velocity (v_{av}) = distance through which mass falls / average time

3. Calculate the Final Velocity of the falling object as it just reaches the floor.

Use equation: Average velocity (v_{av}) = ½(v_i + v_f): assume that the acceleration was uniform.
Therefore: $v_f = 2v_{av}$ where v_i = 0.0 m/s
This equation is no longer included in the NCSCOS but is useful here!

4. Calculate the potential energy of the hanging mass while suspended at its highest point.

Use equation: PE = mgh where m= mass of hanging object in kilograms
g = 9.8 m/s^2
h = height of hanging mass above floor in meters
Units are important. All masses should be in kilograms and distances in meters. The unit of PE is Joules

5. What is the potential energy of the mass while on the floor?

Use equation: PE = mgh where h = 0.0 meters (assuming floor is assigned the ground level)
Therefore: PE = 0.0 Joules

6. What was the change in potential energy as the object went from its highest position to its lowest position?

$\Delta PE = PE_f - PE_i$ (answer from number 5 – answer from number 4) This will give a negative value for potential energy. The interpretation is that PE decreases

7. Was the potential energy of the hanging mass lost? If not, what happened to it?

The potential energy wasn't lost; it was converted to kinetic energy. As potential energy decreased, the response of the system was to accelerate-increased KE.

8. What was the Kinetic energy of the SYSTEM when the hanging mass was suspended at the pulley?

Use equation: KE = 1/2 mv^2 Where m is the mass of the system in kilograms and v is the velocity while the system is at rest (0.0m/s)
This gives a KE of 0.0 m/s leading to a KE = 0.0 Joules

9. What was the kinetic energy of the SYSTEM when the hanging mass was just reaching the floor?

Use the equation: KE = 1/2mv^2, where m = mass of system (kg) and v = velocity of the system when the hanging mass hits the floor. This value should be equal to v_f found above. This value should be in m/s. The actual student answer depends on the specific experiment. It is important to use the mass of the system here since the entire system is accelerating, not just the hanging mass.

10. What was the change in kinetic energy experienced by the SYSTEM while the mass fell to the floor***?*** ***$\Delta KE = KE_f - KE_i$: KE_f is kinetic energy of the system as the hanging mass hits the floor and KE_i is the kinetic energy of the system as the mass is suspended at the pulley. This value should be a positive value, indicating that there has been a gain in KE.***

11. How does your answer in question 6 compare to your answer in question 10?
The answers to the two problems should be the same (in magnitude, opposite sign) if everything is ideal. Friction is an issue but should have been at least partially accounted for through the addition of the paperclips at the beginning of the procedure. This produces a "pulling force" that offsets the force of friction between the tabletop and the cart. We also do not consider the rotational KE of the wheels of the cart or pulley. This question provides a good source of discussion on accounting for energy and the Law of conservation of energy.

12. Was the system in a state of constant velocity or accelerated motion?
Accelerated

13. Was there a net (unbalanced) force acting on the system? If yes what was the source of the force? How do you know there was an unbalanced force?
Since the system was accelerating, there had to be an unbalanced force by Newton's second law. The source of the force is the earth acting on the hanging mass (gravity). The only opposing force is the force of the tabletop parallel to the direction of motion (friction). The system had to have an unbalanced force because it was accelerating. If all forces were balanced, constant velocity motion would be observed.

14. What portion of the system did the force act on?
It acted on the hanging mass. (The portion of the system sitting on the table is also acted on by the force but it is counteracted by the normal force of the table on the cart.)

15. Calculate the size of this force.
Since the force is due to the earth, the net force should be the "weight " of the hanging mass. $F_w = mg$. This is allowed because the paperclips should have offset friction if the setup was done properly. If no paperclips are used, $F_{net} = F_w - F_{friction}$

16. What is the scientific definition of work? Was work performed on this system?
Work = Force x distance   Yes work was performed on the system

17. If work was done, what object performed the work on the system?
The earth/earth's gravitational field performed the work.

18. Calculate the amount of work performed by this object.
Work = F x d where F = Weight of the hanging mass and d = distance the object falls

19. How does the amount of work performed compare to the change in potential energy experienced by the hanging mass and the change in kinetic energy experienced by the system?

It would be expected that the work done by the earth on the system would be equal to the change in gravitational potential energy of the hanging mass. This is because $\Delta PE = mg\Delta h$ and $mg = F_w$. Therefore $PE = F_w\Delta h$ where Δh = distance the hanging mass falls (d). Therefore, $\Delta PE = F_w d$ which is the definition of work. We also know that the change in potential energy = the change in kinetic energy. The work done by the earth on the hanging mass accelerated the system to velocity (v_f)

20. What was the point of adding paperclips to the string until constant velocity motion was exhibited? ***The addition of paperclips until CV motion was exhibited was to offset friction. This simplifies the math involved in this activity by making the net force equal to the weight of the hanging mass.***

The Conservation of Mechanical Energy: Laboratory

Purpose
The purpose of this lab is to investigate the relationship between the potential energy of a simple system and its conversion to kinetic energy.

Materials
- Dynamics cart
- Small mass (50 – 100 g)
- Balance
- String
- Table pulley
- Meter stick
- Stopwatch
- Masking tape
- Paperclips (various sizes)

Introduction to Students
A mass suspended above the floor will be attached by a string over a table pulley to a cart at rest on a table. When the mass is dropped, it will pull the cart horizontally across the table. In this activity you will be examining the energy conversions experienced by the system as it moves from rest to a higher velocity.

Procedure
1. Attach a light string between a mass and cart. Attach a pulley to one end of the table. Place the string over the pulley. Attach a paperclip to the string to act as a hanger for the mass. The string should be long enough that the mass can be next to the pulley and then fall completely to the floor without allowing the cart to collide with the pulley.
2. Remove the hanging mass. Add small masses (paperclips of various sizes will do) to the end of the string so that when a gentle push is given to the cart, it will move slowly across the table with constant velocity. (The hanging mass should not be attached to string during this time) The paperclips should remain on the string throughout the procedure.
3. Using a balance or spring scale, find the total mass of cart, hanging mass, paperclips and string. The mass should be recorded in kilograms in the data table. This combined mass is the mass of the ***system.***
4. Set up the system so that the hanging mass is at the pulley and ready to fall and pull the cart across the table.
5. Measure the distance through which the mass falls as it goes from the pulley to the floor.
6. Have one person hold the cart so that the hanging mass is suspended at the height measured in number 5. When the person holding the cart releases, start the

stopwatch. Stop the watch when the mass hits the floor. Run several trials and average the time required for the mass to fall to the floor. Record the average time in your data table.

Data Table I

Trial	Mass of SYSTEM (kg)	Mass of hanging object(kg)	Height of hanging object(m)	Time for object to fall (s)
1				
2				
3				
4				
5				
				Average time:

Questions to Guide Analysis
Part 1:

1. Calculate the average time required for the object to fall.

2. Calculate the average velocity for the falling object during the fall. (average velocity of the system)

3. Calculate the Final Velocity of the falling object as it just reaches the floor.

4. Calculate the potential energy of the hanging mass while suspended at its highest point.

5. What is the potential energy of the mass while on the floor?

6. What was the change in potential energy as the object went from its highest position to its lowest position?

7. Was the potential energy of the hanging mass lost? If not, what happened to it?

8. What was the kinetic energy of the SYSTEM when the hanging mass was suspended at the pulley?

9. What was the kinetic energy of the SYSTEM when the hanging mass was just reaching the floor?

10. What was the change in kinetic energy experienced by the SYSTEM while the mass fell to the floor?

11. How does your answer in question 6 compare to your answer in question 10?

12. Was the system in a state of constant velocity or accelerated motion?

13. Was there a net (unbalanced) force acting on the system? If yes what was the source of the force?

14. What portion of the system did the force act on?

15. Calculate the size of this force.

16. What is the scientific definition of work? Was work performed on this system?

17. If work was done, what object performed the work on the system?

18. Calculate the amount of work performed by this object.

19. How does the amount of work performed compare to the change in potential energy experienced by the hanging mass and the change in kinetic energy experienced by the system?

20. What was the point of adding paperclips to the string until constant velocity motion was exhibited?

Roller Coaster

Targeted *Standard Course of Study* Goals and Objectives

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

GOAL 3: The learner will analyze energy and its conservation.

3.01 Investigate and analyze storage of energy:
- Kinetic energy
- Potential energies: gravitational, chemical, electrical, elastic, nuclear
- Thermal energy.

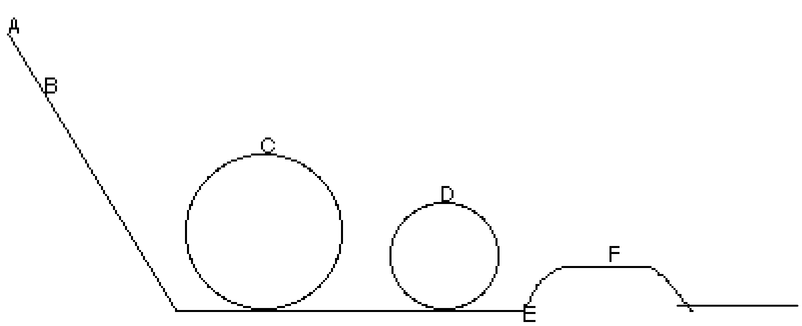
Materials:

- Hot Wheels © track, connectors and loop-the-loops
- Cars
- Tape
- Support stands (optional)

Introduction to the Teacher:

This activity is used as an inquiry lab. I simply instruct my students that they are to design a roller coaster on paper. It has to have one (gravity) drop hill, at least two loop-the-loops and one up and over hill. It has to end on the level floor, and it can have no outside forces. See the diagram below. The car has to complete the track several times in order for the design and completion to be successful. (scientific method)

You can set as many conditions as you like; I have found my limiting factors are usually time and materials. Once the design has been approved the kids are free to build their design. They will soon find out that they have to make several adjustments in order for the "ride" to work.



Extensions:

This lab is great for various levels of students. You can use it to wrap up a unit on energy conservation, forces, calculation of the KE and PE_{grav} when the kids measure the heights of the various hills and loops. Be sure to include the mass of the car as a measurement, as well. Students also can experience the effect of mass on KE and PE_{grav} in this lab. Honors kids have had the most success with this lab when including actual measurements. I give it to them as an activity in which they are on a design team for a new amusement park and have to design a new roller coaster.

I also use this to get them thinking about how gravity does work on the car and the role that movement (of the track) and friction play in the loss of energy.

References

This activity created by Barbara Wallace (North Gaston High School, Dallas, NC).

Electroscope: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

GOAL 4: The learner will construct an understanding of electricity and magnetism.

4.01 Investigate and analyze the nature of static electricity and the conservation of electrical charge:
- Positive and negative charges.
- Opposite charges attract and like charges repel.
- Analyze the electrical charging of objects due to the transfer of charge.

Introduction to the Teacher

Plastic tape can gain or lose negatively charged electrons in some situations. When tape is stuck to a table or other smooth surface then quickly removed, both the table and tape vie to steal negatively charged electrons from each other. Only negatively charged electrons are involved in the transfer because positively charged particles do not move in this situation. When two pieces of tape are ripped from the table, both will have the same charge. This charge can be positive or negative depending on whether the table or the tape wins the electron tug-of-war. These two pieces of tape will repel one another when brought in close contact because like charges repel.

The same principle applies to two pieces of tape that are stuck together and quickly ripped apart. In this situation, one piece of tape gains negatively charged electrons while the other piece of tape loses them. As a result, the tape with the sticky side in the center of the tape "sandwich" becomes positively charged while the tape with the smooth side in the center of the tape sandwich becomes negatively charged. Opposites attract, so these tapes will be drawn to one or another when brought in close contact.

When a comb is run through hair or across a wool fabric, it becomes negatively charged. Thus, positively charged tapes will be attracted to the comb and negatively charged tapes will be repelled. Uncharged items attract both positively and negatively charged items. Your body is normally uncharged and should attract both positive and negative tapes.

You may have noticed that when trying to use plastic wrap to cover your food, the plastic tends to cling to itself. In unrolling the wrap and pulling it apart, the plastic becomes charged, just as the two pieces of tape did in the tape sandwich in this experiment.

Electroscope: Background Information

Because one part of the plastic wrap steals electrons from the other, different parts of the wrap have different charges. This causes the plastic to stick to itself.

On humid days, the water vapor in the air may interfere with the charges in this experiment. If it is moist outside, you may get better results by waiting until a drier day to attempt this experiment.

TIPS:

- A Styrofoam plate may be substituted in place of the comb. If this situation occurs, the plate must be rubbed against one's hair for a full minute.
- Some tables may not charge tape, so test your tables before trying this activity in class. If your table will not charge the tape, try other smooth surfaces before giving up.

Safety Considerations

Don't get cut by pulling off a piece of tape.

References

This activity was adapted from http://www.exploratorium.edu/snacks/electroscope.html and modified by Stephen Charles (Walter H. Page High School, Greensboro, NC).

Electroscope: Laboratory

Purpose
To describe and demonstrate transfer of electrons, how this transfer affects charges of the cellophane tape, and how charges interact with each other.

Materials (per group)
- 4 plastic straws with flexible ends
- 2 plastic film canisters
- 1 roll of cellophane tape
- Modeling clay (play dough)
- Plastic comb
- Electron Slide Assessment Sheet

Introduction to the Student
Plastic tape can gain or lose negatively charged electrons in some situations. When tape is stuck to a table or other smooth surface then quickly removed, both the table and tape try to steal negatively charged electrons from each other. Only negatively charged electrons are involved in the transfer because positively charged particles do not move in this situation. When two pieces of tape are ripped from the table, both will have the same charge. This charge can be positive or negative depending on whether the table or the tape wins the electron tug-of-war. Who will win the electron tug-o-war?

Procedure
1. Fill two film canisters half full of modeling clay and insert the inflexible ends of the two straws into each canister. Bend the straws so that they will form horizontal arms in opposite directions. All straws should be of equal height.

2. Tear off two 10 cm of cellophane tape. Label them A and B and press firmly to a flat surface such as a table. Leave one end of each tape sticking up as a handle.

3. QUICKLY pull the tapes from the surface. Stick one piece of the tape to an arm of a straw in one canister and the other piece to an arm of the second canister. The charge will slowly leak off the tape, so you may need to recharge your tapes by repeating this step after a few minutes of use.

4. Move the canister so that the tapes face each other at about 15 cm apart. Slowly move the canisters closer together. Record what happens.

5. Tear off two more 10 cm strips of cellophane tape and label them C and D. Stick the sticky side of piece D to the smooth side of C, leaving a handle on each.

6. Quickly pull the pieces apart and place them on the two remaining electroscope arms. Bring these two arms close together. Record what happens.

7. Rub a comb through your hair. The comb will become negatively charged. Place the comb near each of the dangling tapes. Record what happens.

Lab Data

Tape	Attracted/Repelled by comb	Charge of Tape
A		
B		
C		
D		

Questions to Guide Analysis

1. How do the tapes react when brought near one another?

Tape from the table (A and B):	Attract	Repel
Tape pulled apart from each other (C and D)	Attract	Repel

2. The tapes that were stuck to one another and then pulled apart have different charges. Why?

Build Series and Parallel Circuits: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.02 Design and conduct scientific investigations to answer questions about the physical world.
- Create testable hypotheses.
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Collect and record data.
- Analyze and interpret data.
- Communicate findings.

GOAL 4: The learner will construct an understanding of electricity and magnetism.

4.02 Investigate and analyze direct current electrical circuits:
- Series circuits.
- Parallel circuits.

Introduction to the Teacher

The students will build circuits and measure current and voltage. I have the students draw the circuits so they will learn the circuit symbols. The students could use wire but the use of aluminum foil reinforces the concept that metal conduct electricity. The ornamental lights are usually donated.

Safety Consideration

Batteries can become hot if left connected for long periods of time. Students should hook up battery only long enough to observe the lights.

References

This activity was designed by Carolyn Elliott (South Iredell High School, Statesville, NC).

Build Series and Parallel Circuits: Activity

Purpose
To design, build, and test series and parallel circuits.

Materials
- Large sheet of heavy paper
- Aluminum foil or wire
- Tape
- Ornamental lights (3) with sockets or (Cut individual light from ornamental set of lights)
- Battery (6V=4C or 9V with connectors)
- Pencil
- Ammeter
- Voltmeter

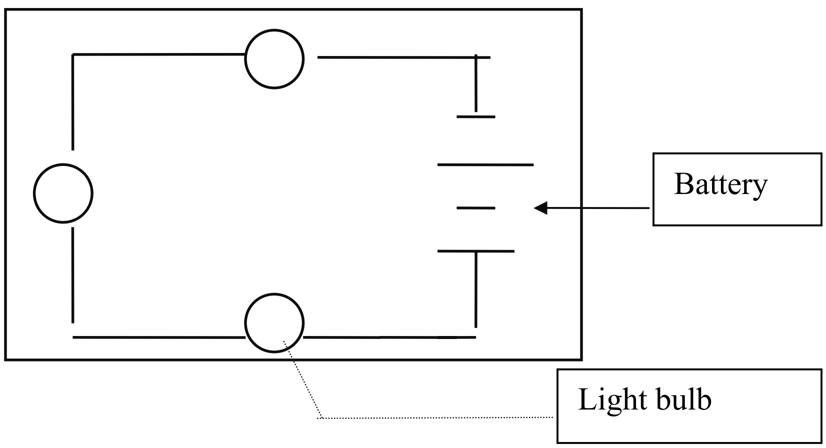
Introduction to Students
There are two types of electrical circuits. Series circuits have only one path for electrons to take. Parallel Circuits have two paths for the electrons to take.

Procedure
1. On the large sheet of paper, draw a series circuit that contains three lights and one battery source. USE THE CORRECT SYMBOLS.
2. Construct the series circuit using the light, foil or wire, switch and battery. Test the setup.
3. Test for the amount of current and voltage. An Ammeter measures electric current and should be connected in series with the circuit. A voltmeter measures potential difference across part of a circuit and should be connected in parallel across a part of the circuit.
4. Draw and construct a parallel circuit. Test the setup. Note the brightness of the lights. What happens with one bulb is removed?
5. Test for the amount of current and voltage.

Build Series and Parallel Circuits: Activity

Lab Data

Circuit	Current	Brightness	Bulb Removed	Voltage
Series				
Parallel				



Questions to Guide Analysis

1. Is there a difference in the brightness of the bulbs in the parallel and series circuits?

2. What happens when a bulb is removed in the series circuit?

3. What happens when a bulb is removed in the parallel circuit?

4. How does the voltage change?

Bright Lights: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

GOAL 4: The learner will construct an understanding of electricity and magnetism.

4.02 Investigate and analyze direct current electrical circuits:
- Series circuits.
- Parallel circuits.

Introduction to the Teacher

Make sure the lights used are able to withstand 9 Volts! I test them before the lab and make sure of this. Some lights will blow, so check them! And make sure all batteries are equally charged. A nearly dead battery will ruin the effects of this activity! Each student or pair of students is given 3-stripped ornamental lights, a 9 Volt battery and a 9-V connector. Twisting the ends of the bare wire together in series, one at a time, makes a simple series circuit. This is done so that students can observe the brightness of the lights as each one is added in series. Students note the dimming of the bulbs as each is added. A discussion is then initiated as students' reason through the possible causes for the dimming.

Once the reason for the dimming has been identified, move on and have the students make a parallel circuit with the same 3 lights by twisting three light ends together and then twisting the other 3 ends together so that the lights are "parallel". It is important to note that students should hypothesize as to the dimming effects in this parallel arrangement before they connect the wires to the battery. As they connect the battery, they are surprised to see all three lights equally as bright!

Approach this lab in as much of an inquiry manner as possible. Guide them through it but do not tell them what is happening. Let them figure out why the brightness changes. Have them look at the formulas for the potential difference, current and resistance for series and parallel circuits. This also allows them to get used to the math involved in circuits.

Safety Considerations

Make sure students don't keep the circuits connected (wires to batteries) as the batteries will overheat and may be a safety issue.

References

This activity was designed by Barbara Wallace (North Gaston High School, Dallas, NC).

Bright Lights: Laboratory

Purpose
- Interpret simple circuit diagrams.
- Investigate open and closed circuits.
- Distinguish between series and parallel circuits.
- Conceptually explore the flow of electricity in a series and parallel circuits.

Materials
- 3 Ornamental lights with the ends stripped (bare copper wire)
- 9 Volt batteries
- 9 V connectors (optional)

Introduction to Student
Have you ever been trying to decorate with ornamental lights and part of the string worked while the rest did not? This lab will allow you to explore the science behind this experience along with learning the practical applications of circuit electricity.

Procedure A
1. Obtain 3-stripped ornamental lights, a 9 Volt battery and a 9-V connector.
2. Twist the ends of the bare wire together in series, one at a time.
3. Note the apparent brightness of each light after it is connected in the circuit.

Questions to Guide Analysis
1. What happens to the brightness of each light as you add one more light to the circuit?
2. Why or why not do you think the brightness changed?
3. Draw a complete circuit diagram of the finished circuit.

Procedure B
1. Obtain 3-stripped ornamental lights, a 9 Volt battery and a 9-V connector.
2. Twist the ends of the bare wire of all three lights so as to make a parallel circuit.
3. Note the apparent brightness of all three lights as they are connected in parallel.
4. Remove each light, one at a time, noting any change in the apparent brightness of each light.

Questions to Guide Analysis
1. What happens to the brightness of each light as you add one more lights to the circuit?
2. Why or why not do you think the brightness changed?
3. Draw a complete circuit diagram of the finished circuit.

Magnetic Fields: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:

- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

GOAL 4: The learner will construct an understanding of electricity and magnetism.

4.03 Investigate and analyze magnetism and the practical application of the characteristics of magnets.

Introduction to the Teacher

This is a good introduction to magnet fields. This activity shows that the magnetic field can be mapped. I use this activity to explain magnetic domains. As I am passing out magnets, I explain that they should not be dropped. If the magnets are dropped the domains can become unaligned. I stop and draw domains on the board. Also, this is a good time to explain how heating will affect the domains.

Safety Consideration

Students should not place magnets near TV, computer disk, computer screen, or near watches. Use this time to explain how magnets will affect these items.

Reference:

This activity was designed by Carolyn Elliott (South Iredell High School, Statesville, NC).

Magnetic Fields: Laboratory

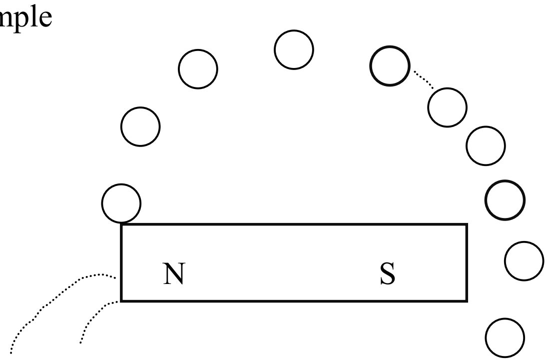
Purpose
Investigate and analyze magnetism and the practical application of the characteristics of magnets.

Materials (each group)
- 2 bar magnets
- Small compass
- Pencil
- Horseshoe magnet
- Large sheet of paper

Introduction to students
A magnet exerts forces. In this activity the students will map the magnetic field around a magnet, two magnets, and a horseshoe magnet.

Procedure
1. Center one bar magnet in the center of the large sheet of paper. Draw around the magnet. Place the compass near the ends of the bar magnet. Place a dot to show the direction of the needle on the compass. Move the compass and line the compass needle with the dot. Continue until the line returns to the magnet or goes off the page. Connect the dots to show the magnetic field around the magnet. Draw at least 10 lines of magnetic forces from each end of the magnet.

Example



2. Repeat the procedure with two bar magnets, place the north and south poles about 3 centimeters apart.

3. Repeat the procedure with two bar magnets; place the south (north) and south (north) poles about 3 centimeters apart.

4. Repeat the procedure with horseshoe magnet.

Questions to Guide Analysis

1. Describe the lines of the magnetic field around a bar magnet, horseshoe magnet.

2. How does the magnetic field change when like poles were together? Opposite poles?

3. Where is the magnetic field the strongest? Explain the reasons based on your evidence.

Motor: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

GOAL 4: The learner will construct an understanding of electricity and magnetism.

4.02 Investigate and analyze direct current electrical circuits:
- Series circuits.
- Parallel circuits.

4.03 Investigate and analyze magnetism and the practical application of the characteristics of magnets.

Introduction to the Teacher

A coil of wire becomes an electromagnet when current passes through it. The electromagnet interacts with a permanent magnet, causing the coil to spin. Voila! You have created an electric motor.

We have successfully run motors on one 1.5 volt D battery; additional batteries seem to make it easier to get the motor to run. You may want to try 6-volt lantern batteries. We have also had excellent results using a power supply (battery eliminator) set to about 4 volts. The advantage of the power supply is that it will supply a substantial current over a period of time. Unlike batteries, it doesn't have to be replaced. Experiment with what you have, and use whatever works! A current flow through the wire coil and creates an *electromagnet*. One face of the coil becomes a north pole, the other a south pole. The permanent magnet attracts its opposite pole on the coil and repels its like pole, causing the coil to spin.

Another way to describe the operation of the motor is to say that the permanent magnets exert forces on the electrical currents flowing through the loop of wire. When the loop of wire is in a vertical plane, the forces on the top and bottom wires of the loop will be in opposite directions. These oppositely directed forces produce a twisting force, or *torque*, on the loop of wire that will make it turn.

Why is it so important to paint half of one projecting wire black? Suppose that the permanent magnets are mounted with their north poles facing upward. The north pole of the permanent magnet will repel the north pole of the loop electromagnet and attract the south pole. But once the south pole of the loop electromagnet was next to the north pole of the permanent magnet, it would stay there. Any push on the loop would merely set it rocking about this equilibrium position.

By painting half of one end black, you prevent current from flowing for half of each spin. The magnetic field of the loop electromagnet is turned off for that half-spin. As the south pole of the loop electromagnet comes closest to the permanent magnet, the paint turns off the electric current. The inertia of the rotating coil carries it through half of a turn, past the insulating paint. When the electric current starts to flow again, the twisting force is in the same direction as it was before. The coil continues to rotate in the same direction.

In this motor, the sliding electrical contact between the ends of the coil of wire and the paper clips turns off the current for half of each cycle. Such sliding contacts are known as *commutators*. Most direct current electric motors use more complicated commutators that reverse the direction of current flow through the loop every half cycle. The more complicated motors are twice as powerful as the motor described here.

This motor can also be used to demonstrate how a generator works. Try hooking up the ends of the paper clips to a sensitive galvanometer instead of the battery. Spin the coil and see if any current registers on the meter.

References
This activity was adapted from Exploratorium and modified by Barbara Wallace (North Gaston High School, Dallas, NC).

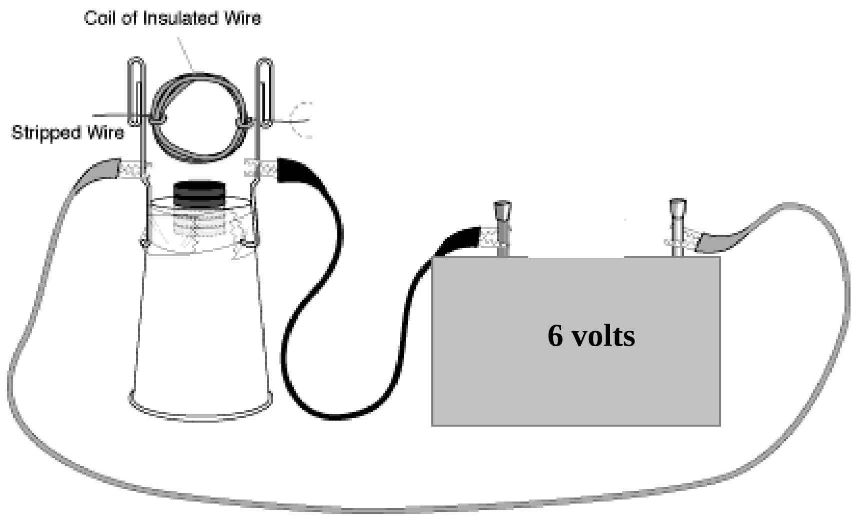
Motor: Laboratory

Purpose
To investigate and analyze magnetism and the practical applications of the characteristics of magnets.

Materials
- 5 small disk or rectangular ceramic magnets (available at Radio Shack)
- 2 large paper clips
- A plastic or Styrofoam cup
- A solid (not stranded) enameled or insulated 20-gauge copper wire, about 2 feet (60 cm) long (available at Radio Shack)
- Masking tape
- A battery or power supply (a 6 Volt works very well)
- 2 electrical lead wires with alligator clips at both ends (available at Radio Shack)
- Wire strippers (if you are using insulated wire)
- Sandpaper (if you are using enameled wire)
- A battery holder (if you are using batteries other than a 6 Volt)

Introduction to Student
A coil of wire becomes an electromagnet when current passes through it. The electromagnet interacts with a permanent magnet, causing the coil to spin. You have created an electric motor. Follow the directions of your teacher carefully in order to successfully make an electric motor.

Procedure
Obtain the materials listed above from your teacher. Wind the copper wire into a coil about 1 inch (2.5 cm) in diameter. Make four or five loops. Wrap the ends of the wire around the coil a couple of times on opposite sides to hold the coil together. Leave about 2 inches (5 cm) projecting from each side of the coil, and cut off any extra. (See diagram below)



If you are using insulated wire, strip the insulation off the ends of the wire projecting from the coil. If you are using enameled wire, use the sandpaper to remove the enamel.

Turn the cup upside down and place two magnets on top in the center. Attach three more magnets inside the cup, directly beneath the original two magnets. This will create a stronger magnetic field as well as hold the top magnets in place.

Unfold one end of each paper clip and tape them to opposite sides of the cup, with their unfolded ends down. (See diagram above.) Sandpaper the entire paper clip to make sure good connections are made when completing the circuit. Rest the ends of the coil in the cradles formed by the paper clips. Adjust the height of the paper clips so that when the coil spins, it clears the magnets by about l/l6 inch (1.5 mm). Adjust the coil and the clips until the coil stays balanced and centered while spinning freely on the clips.

Once you have determined how long the projecting ends of the coil must be to rest in the paper-clip cradles, you may trim off any excess wire. (The length of the projecting ends depends on the separation of the paper-clip cradles, which in turn depends on the width of the base of the cup you are using. See diagram above.). Use the clip leads to connect the battery or power supply to the paper clips, connecting one terminal of the battery to one paper clip and the other terminal to the other paper clip.

Give the coil a spin to start it turning. If it doesn't keep spinning on its own, check to make sure that the coil assembly is well balanced when spinning, that the enamel has been thoroughly scraped off if enameled wire has been used, that the projecting end has been painted with black pen as noted, and that the coil and the magnet are close to each other but do not hit each other. You might also try adjusting the distance separating the paper clip cradles: This may affect the quality of the contact between the coil and the cradles.

Keep making adjustments until the motor works. Have patience! The success rate with this design has been quite good.

Questions to Guide Analysis

1. How do the magnets affect the flow of the electrical current?

2. Why is it important to sand off the paint and plastic form the enameled wore and paper clips?

3. What forces are present in this motor?

4. Does it make the coil turn faster by placing more voltage into the circuit? Why or why not?

5. Can you increase the spin by using more magnets? Why or why not?

M and M Isotopes: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:

- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

GOAL 5: The learner will build an understanding of the structure and properties of matter.

5.02 Examine the nature of atomic structure:

- Protons.
- Neutrons.
- Electrons.
- Atomic mass.
- Atomic number.
- Isotopes.

Introduction to the Teacher

The extremely small size of atoms makes it impossible to count them or determine their individual atomic masses using direct means. An instrument called a mass spectrometer allows for such determinations. Average atomic masses depend on the number and masses of the isotopes of the element.

In this activity, you are given one element, Mm. There are two isotopes of this element. Both are naturally occurring. The two isotopes are plain and peanut. Substitutes for candies are beans, marbles, or poker chips.

Safety Considerations

Be sure students know how to use a balance and be able to tare mass.
If students want to eat their elements, be sure all hands are clean and precautions are used when massing the M and M's to protect from contamination. Be sure they only eat their element after every student is finished and the lab time is over.

References:

This activity was designed by Stephen Charles (Walter H. Page High School, Greensboro, NC).

M and M Isotopes: Activity

Purpose

To determine how isotopes are different and how to calculate average atomic mass of an element.

Materials (per group)

- Digital balance
- One fun size bag of plain M and M's
- One fun size bag of peanut M and M's

Introduction to Student

The extremely small size of atoms makes it impossible to count them or determine their individual atomic masses using direct means. An instrument called a mass spectrometer allows for such determinations. Average atomic masses depend on the number and masses of the isotopes of the element.

In this activity, you are given one element, Mm. There are two isotopes of this element. Both are naturally occurring. The two isotopes are plain and peanut.

Procedure

1. Obtain a bag of plain and peanut M and M's.

2. Count the number of plain M and M's. Record your data in the chart provided.

3. Count the number of peanut M and M's. Record you data in the chart provided.

4. Find the total numbers of M and M's, both plain and peanut added together. Record your data here.

5. Mass the plain M and M's. Record your data.

6. Mass the peanut M and M's. Record your data.

Lab Data

Type of Mm	Number of Mm	<u># of Mm</u> total both Mm	Percentage	Mass	Isotope weighted mass (% x mass)
plain					**(a)**
peanut					**(b)**

Average element Mm mass = mass (a) + mass (b)
Average element Mm mass = ________ + __________ = _____________

Questions to Guide Analysis

1. Compare you results to your classmates. Are they the same? Why or Why not?

2. Calculate the average weighted grade on the last quiz of my class last year on this chapter. Show all work.

5 students made a 100%

20 students made a 80%

Unknown Substance: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
• Explain observations.
• Make inferences and predictions.
• Explain the relationship between evidence and explanation.

1.04 Apply safety procedures in the laboratory and in field studies:
• Recognize and avoid potential hazards.
• Safely manipulate materials and equipment needed for scientific investigations.

GOAL 5: The learner will build an understanding of the structure and properties of matter.

5.03 Identify substance through the investigation of physical properties.

GOAL 6: The learner will build an understanding of regularities in chemistry.

6.02 Investigate and analyze the formation and nomenclature of simple inorganic compounds –ionic bonds and covalent bonds

6.04 Measure and analyze the indicators of chemical change including –development of a gas, formation of a precipitate, release/absorption of energy (hear or light)

6.05 Investigate and analyze the properties and composition of solutions: pH scale, electrical conductivity, polarity, concentration

Introduction to the Teacher

At the North Carolina Science Leadership Conference on Inquiry, Michael P. Clough of Iowa State University gave me an idea for an inquiry lab that I felt was safe for chemistry unit in physical science. He had used the lab for chemistry so I modified and extended the lab to meet the needs of my students and the *North Carolina Standard Course of Study* and National Standards. I developed an inquiry lab that would extend over the entire unit on chemistry. This meets the changing emphases of the National Standards of investigation over an extended period of time.
When we begin our discussion of physical properties, the students are given five small, labeled tubes of unknown labeled 1-5. The substances are salt, sugar, baking soda, cornstarch, and powdery dish detergent. The first day the students spend at least fifteen minutes observing the unknowns. I walk around asking questions concerning physical properties-crystal, powdery, texture, color, and odor. When students ask for magnifying glasses I supply them. The students are reminded to keep neat, organized information in their notebooks.

Safety Consideration:

- Students should wear goggles, aprons, and plastic gloves for this activity.
- The substances are household items but they are tested with chemicals.
- Do not taste any of the unknowns.
- Treat all the unknowns with caution and respect.
- Avoid spillage.
- Use only the amount needed.

- Never return excess unknowns back to the bottle, as this will contaminate the stock material.
- **ALL SAFETY RULES WILL BE ENFORCED.**

References

This activity was designed by Carolyn Elliott (South Iredell High School, Statesville, NC).

Unknown Substance: Laboratory

Purpose

Investigate the chemical and physical properties of unknown substances and use these properties to identify the unknown substances.

Introduction to the Student

When I entered the classroom this morning I found some substances on the lab floor. I collected the substances in tubes. I also found five jars without lids. I need to identify which substance came from which jar. You will investigate the substance from the five jars during this nine weeks. At the end of this chemistry section, I will give each group a sample of the substances found on the floor. The substances were found in different areas so all the samples may not be the same. Your tube may contain one, two, three, four or all five substances. You will determine which substances are in your tube. The goal is not to identify the substances. You will do some investigations with the substances. You are to determine properties of the materials that are in your tubes. You must collect all the information you can about these materials as we study about different properties of matter.

Today, working in groups, I will give you fifteen minutes to make observations of the substances. Keep accurate records so you can use them later. You must organize your data and you must keep a record of your step-by-step procedure so you can use it to determine what the unknown substances are in your sample from the floor. We will perform more tests as we continue to study about matter. (All the unknowns are household items.)

Safety: Do not *taste any of the unknowns. Treat all the unknowns with caution and respect. Avoid spillage. Use only the amount needed. Never return excess unknowns back to the bottle, as this will contaminate the stock material.* ***ALL SAFETY RULES WILL BE ENFORCED.***

Later you will be given samples from the floor as a team you will try to determine what makes up these samples. You will do this by running the same test on your unknowns and comparing the results to your previous results.

Procedure

The students will design their own experiments and procedures. Some hints are included. The rubrics will be helpful as a guide.

Hints:
Color-before and during the test
Texture-What does it fell like? Is it lumpy, smooth, or rough?
Size-Is it small grains or fine powder? What happens to the particles during the test? Does it dissolve, go into solution, or liquids run off?
Smell- Waft the air above the samples. Is there a smell? Is there a smell during the test?

Sound- Do you hear anything during the test?
Liquid- Do they soak in, run off, change color or cause any bubbling? Does a chemical or physical change take place during the test?
Time- How long do the reactions take? Do things happen immediately or do they take awhile?

Lab Data

1. Description color, odor, crystal- power-fine or chunk,
2. Water dissolved or not
3. Vinegar-reaction/chemical reaction
4. Iodine-reaction (indicator)
5. Universal indicator-pH number, acid, base, neutral
6. Heating-melts
7. Conduct electricity-dissociation, bonding?

Questions to Guide Analysis

1. Describe each reaction is it a chemical or physical reaction-Describe how you know.
2. What procedure did you use to identify the samples?
3. Procedure must be clear and precise-Remember if I wanted to follow the procedure so I would get the same results.
4. Compare your results with the results of the other test you have run. You may want to test your results several times to be sure your results are accurate. What evidence do you have to support your idea? You must refer to specific test results in your explanation.

<u>You must include the Unknown powder letter</u> and the numbers of the samples that the results match.

UNKNOWN RUBRIC

5 substances	**Complete** Neat, precise	6	**Complete**	4	**Not complete**	2	**Missing**	0	**Total**
Description Color, odor, Crystal Powder-fine clumps									
Density									
Vinegar Physical/chemical									
Iodine test									
Solution Dissolve/not dissolve									
Universal indicator									
Conductivity									
Heat Test									

TEST OF UNKNOWN

Description	2	
Hypothesis	2	
Procedure	8	
Vinegar	2	
Iodine	2	
Solution	2	
Universal indicator	2	
Conductivity	2	
Heat	2	
Identified the two unknown	20	
Explanation (Why it is the number –and ---?)	8	

Total

Carton Compounds: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
• Explain observations.
• Make inferences and predictions.
• Explain the relationship between evidence and explanation.

GOAL 6: The learner will build an understanding of regularities in chemistry.

6.01 Analyze the periodic trends in the physical and chemical properties of elements.
• Groups (families).
• Periods.

6.02 Investigate and analyze the formation and nomenclature of simple inorganic compounds.
• Ionic bonds (including oxidation numbers).
• Covalent bonds.
• Metallic bonds.

Materials (per group of 2 students)

- 1 egg carton
- 10 marbles
- One small piece of construction paper
- Scissors

Introduction to the Teacher

Elements need to be happy. In order for them to be happy, they have to have 2 electrons in the first energy level. If they are in the second energy level they have to have 8 electrons to be happy. If they are not happy, they find a way to get happy. They get happy by combining with another element. When they combine, they combine in two ways:

1) Ionic bonding-when one metal transfers valence electrons to a nonmetal so each element achieves an octet.
2) Covalent bonding-when two nonmetals share valence electrons.

When two elements combine and have full energy levels, then they are happy. If the element is happy then the chemist calls it a stable compound. We will make some of these stable compounds.

Physical Science Support Document

Carton Compounds: Background Information

Procedure

1. Get an egg carton.
2. In the first two holes put one marble in each one
3. In the second two holes cut a piece of paper the size of the holes and put the paper in the holes. This shows the difference between each energy level.
4. Assign each group an element—either Hydrogen or Oxygen. Make sure you have them in the proportion of H_20.
5. Ask the students to fill the cartons with marbles representing electrons. Each marble will represent one electron.
6. Ask the students if either of their elements is happy? No should be the answer.
7. Ask them using the groups around them, How can they make that element happy?
8. Steer the discussion so that they lead to the words "sharing electrons."
9. Water is a covalent molecule. Therefore, place the hydrogen element electron in one of the slots that needs an electron. Do the same for the other hydrogen element.
10. Ask the students if each of the elements is happy? Yes should be the answer.
11. Ask them what type of bond this is? Covalent should be the answer.
12. Assign each group an element—either Lithium or Fluorine. Make sure you have them in the proportion of Li^+ F^-.
13. Ask the students to fill the cartons with appropriate number of marbles. Each marble will represent one electron.
14. Ask the students if either of their elements is happy? No should be the answer.
15. Ask them using the groups around them, How can they make that element happy?
16. Steer the discussion so that the discussion leads to the words "loosing and gaining electrons."
17. Lithium Fluoride is an ionic molecule. Therefore, place the one electron (just the marble) from Lithium into the open slot on Fluorine.
18. Ask is each element happy? Yes, why is each element happy? They have a full outer energy shell
19. What type of bond is this? Ionic because the elements lost/gained electron.

Questions to Guide Analysis

1. What is the minimum number of elements that must combine to make a compound?

2. What is the difference between ionic and covalent bonds?

3. What does stable mean?

4. How many electrons does the first energy level need to be stable?

5. How many electrons does the second energy level need to be stable?

Extensions
Have students come up with other combinations of elements.

Safety Considerations
Be careful so that no one misuses the scissors.

References
This activity was adapted from *Glencoe Physical Science* and was modified by Stephen Charles (Walter H. Page High School, Greensboro, NC).

Types of Reactions: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.02 Design and conduct scientific investigations to answer questions about the physical world.
- Create testable hypotheses.
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Collect and record data.
- Analyze and interpret data.
- Communicate findings.

1.05 Analyze reports of scientific investigations of physical phenomena from an informed scientifically literate viewpoint including considerations of:
- Appropriate sample.
- Adequacy of experimental controls.
- Replication of findings.
- Alternative interpretations of the data.

GOAL 6: The learner will build an understanding of regularities in chemistry.

6.03 Identify the reactants and products of chemical reactions and balance simple equations of various types:
- Single replacement.
- Double replacement.
- Decomposition.
- Synthesis.

Introduction to the Teacher

Clear well plates work best. It is helpful to place plates over black paper to better see bubbles. You will need to give students either the formulas for the compounds or the charges of the transition metals in order for them to write the balanced chemical reactions. Fe +3, Cu +2, Zn +2, Ag +1

Safety Considerations

Students should wear goggles because students will be working with HCl, Make sure disposal of materials is done correctly.

References

This activity was adapted from *Exploring Physical Science- Prentice Hall* and was modified by Tammy Schooley (East Carteret High School, Beaufort, NC).

Types of Reactions: Laboratory

Purpose
To study and explore single replacement and double replacement reactions.

Materials
- Safety goggles
- Well plate
- Iron
- Zinc
- Copper
- Magnesium
- Aluminum
- HCl
- Silver (I) nitrate
- Potassium iodide
- Distilled water
- Graduated cylinder
- 2 cups or beakers

Introduction to Student

Part A- Single Replacement Reactions
In nature, elements can occur either free or in a compound. The tendency of as particular element to combine with other substances is a measure of the ACTVITY of the element. In a single replacement reaction, an uncombined element replaces a less active element that is combined in a chemical compound. The less active element is then freed.

For example, in the reaction Zinc + Copper Sulfate ---→ Zinc Sulfate + Copper,
Zinc replaces the less active copper. In part A of this investigation you will observe how various metals undergo single replacement reactions when placed in an acid. If the metal is more active than the hydrogen in the acid, it will replace the hydrogen and hydrogen gas will be released.

Part B- Double Replacement Reactions
In a double replacement reaction, a clear solution of an ionic compound is added to a clear solution of another ionic compound. The positive ions of one compounds reacts with the negative ions of the other compound to form a Precipitate, a gas, or water. A precipitate is an insoluble solid.

Procedure

Part A Part 1

1. Label 5 wells on the well plate. Place 1 piece of magnesium in well 1, aluminum in 2, iron in 3, copper in 4 and zinc in 5.
2. Using the pipette, add 2 drops of HCl to each well. Observe the color of the liquid at time zero. Observe what happens for 3 minutes. Look for bubbles. Record observations
3. Carefully pour the HCl into the waste beaker and then place the metals in the metal container. Rinse the well plate.

Part A Part 2

1. Place a piece of copper in well 1.
2. Place 3 drops of Silver (I) nitrate on the copper. Observe for 3 minutes.

Part B

1. Pour 50 ml of distilled water into cup A and into cup B.
2. Add substance A to cup A. Stir until dissolved.
3. Add substance B to cup B. Stir until dissolved.
4. Pour A into B. Observe. Stir it and observe.

Lab Data

Part A Part 1

	Magnesium	**Aluminum**	**Iron**	**Copper**	**Zinc**
Reaction					

Questions to Guide Analysis

Part A Part 1

1. Write the single replacement reaction for each reaction
   a. Magnesium

   b. Aluminum

   c. Iron

   d. Copper

   e. Zinc

2. Which of the metals are more active than hydrogen? Less active?

3. The rate of hydrogen gas production is an indication of the relative reactivity of metals. List the metals in order of their activity from most active to least active.

4. Nonmetals can also be involved in single-replacement reactions. If chlorine is more active than bromine, write the equation for the reaction between chlorine and potassium bromide.

Part A Part 2

1. Identify the color of the copper at the beginning of the experiment. What color is the liquid?

2. Identify the color of the solid after several minutes. Identify the color of the solid after several minutes.

3. Describe what happened to cause the color changes.

4. Are the substances in the well the same as the starting substances? Explain

5. Write the equation for the reaction that took place.

Part B

1. What happened when you mixed A with water?

2. What happened when you mixed B with water?

3. What happened when you mixed A and B together?

4. What ions were present in the potassium iodide solution?

5. Write the equation for the reactions that took place.

Wipe Away Math Lab : Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

GOAL 6: The learner will build an understanding of regularities in chemistry.

6.03 Identify the reactants and products of chemical reactions and balance simple equations of various types:
- Single replacement.
- Double replacement.
- Decomposition.
- Synthesis.

Purpose
To demonstrate and communicate balancing of chemical equations.

Materials
- Expo Markers- one for each student
- Dry wash cloths or old rags
- White erase board- puzzle pieces work the best (Wal-Mart)
- List of chemical equations

Procedure
1. The teacher will balance one or two problems by themselves.
2. Get into pairs groups of two.
3. Each student gets one piece of the white erase board and one marker.
4. One student in the pair is responsible for the products and the other is responsible for the reactants.
5. Then give the students a chemical equation to copy down. The student responsible for the products copies the products and the person responsible for the reactants copies the reactants on their own boards. Then the students and teacher will balance each equation (be sure to a make sure that each elements have the same number of each atom on both sides).
6. After the students have one equation balanced connect the pieces of puzzles together and draw the arrow. Be sure that the reactants are on the left side and products are on the right side.
7. Hold up the puzzle pieces when the equations are balanced.

Questions to Guide Analysis

1. Write each chemical equation that you balanced in chemical symbols.

2. Write each chemical equation that you balanced in words.

3. What type of reaction is each chemical.

References

This activity was created by Stephen Charles (Walter H. Page High School, Greensboro, NC).

Endothermic Exercise: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

GOAL 3: The learner will analyze energy and its conservation.

3.01 Investigate and analyze storage of energy:
- Kinetic energy
- Potential energies: gravitational, chemical, electrical, elastic, nuclear
- Thermal energy.

3.03 Investigate and analyze transfer of energy by heating:
- Thermal energy flows from a higher to a lower temperature.
- Energy will not spontaneously flow from a lower temperature to a higher temperature
- It is impossible to build a machine that does nothing but convert thermal energy into useful work.3.03)

GOAL 6: The learner will build an understanding of regularities in chemistry.

6.04 Measure and analyze the indicators of chemical change including:
- Development of a gas.
- Formation of a precipitate.
- Release/absorption of energy (heat or light).

Introduction to the Teacher

This is an easy and inexpensive lab that uses a common household chemical, Epson Salts (Magnesium Sulfate). When Epson salts are added to water, it uses the water's natural heat energy to split apart ions of sulfate and magnesium. More heat energy is being used up than is being produced during this chemical reaction. This is why the water gets colder, and why Epsom salts are used to soak a sprained ankle and draw the heat out of the injury.

Extension: You can introduce the laws of thermal dynamics with the relationship between the transfer of energy from a high to low. (Example: energy flowing from the *hot* sprained ankle to the *cool* water.)

Safety Considerations

Chemicals can be body tissue irritant. Avoid contact with eyes. Wear goggles.

References

This activity was adapted from **http://chemistry.about.com** and modified by Pam Griffiths (Havelock High School, Havelock, NC).

Endothermic Exercise: Activity

Purpose
To demonstrate that some chemical reactions causes the product to become cold.

Materials
- Thermometer
- 20 ml of Epson Salts (Magnesium Sulfate)
- 40 ml of tap water (room temperature)
- Disposable stir stick
- 50 ml Pyrex beaker

Procedure
1. Fill the beaker with 40 ml of tap water.
2. Take an initial temperature reading and record the temperature as 'initial Temperature' or 'T_i'.
3. Pour the Epson Salts into the beaker and use the stir stick to dissolve the salts.
4. Record all observations.
5. Take a final temperature reading and record the temperature as 'final Temperature' or 'T_f'.

Exothermic Exercise: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

GOAL 3: The learner will analyze energy and its conservation.

3.01 Investigate and analyze storage of energy:
- Kinetic energy
- Potential energies: gravitational, chemical, electrical, elastic, nuclear
- Thermal energy.

3.03 Investigate and analyze transfer of energy by heating:
- Thermal energy flows from a higher to a lower temperature.
- Energy will not spontaneously flow from a lower temperature to a higher temperature
- It is impossible to build a machine that does nothing but convert thermal energy into useful work.3.03)

GOAL 6: The learner will build an understanding of regularities in chemistry.

6.03 Identify the reactants and products of chemical reactions and balance simple equations of various types:
- Single replacement.
- Double replacement.
- Decomposition.
- Synthesis.

6.04 Measure and analyze the indicators of chemical change including:
- Development of a gas.
- Formation of a precipitate.
- Release/absorption of energy (heat or light).

Introduction to the Teacher

This is an easy and inexpensive lab that uses common household supplies: Hydrogen Peroxide and yeast. When yeast and hydrogen peroxide mix chemically, the hydrogen peroxide changes into oxygen and water molecules. The bubbles are produced by the oxygen gas escaping during the chemical change. This change also produces heat. A thermometer is not necessary for this experiment since the change in temperature is very noticeable and the solution can make a mess on the thermometer.

Exothermic Exercise: Background Information

Students should be encouraged to use all of their observation skills, including the sense of touch. The students can feel a tremendous increase in temperature while holding the cup and making other observation. These observations should include: bubbles forming, steam, increase in temperature, and smell.

Extension: You can use this experiment to discuss decomposition reactions and the use of enzymes in the yeast as a catalyst. You can also write out the chemical equation for the decomposition of Hydrogen Peroxide and have your students balance the equation.

$$H_2O_2 \rightarrow H_2O + O_2$$

Balanced $2H_2O_2 \rightarrow 2H_2O + 2O_2$

Safety Considerations

Chemicals are slightly toxic if inhaled or ingested and are severe irritant to skin, eyes and respiratory tract. Wear goggles.

References

This activity was adapted from **http://chemistry.about.com** and modified by Pam Griffiths (Havelock High School, Havelock, NC).

Exothermic Exercise: Activity

Purpose
To demonstrate that an exothermic reaction produces heat.

Materials
- Small plastic cup
- Small scoop of dry yeast
- 20 ml of 3% Hydrogen Peroxide (OTC)
- Disposable stir stick
- Thermometer (optional)

Procedure
1. Scoop the dry yeast into the plastic cup.
2. Pour the hydrogen peroxide in and gently stir with the stir stick.
3. Record all observations and note for the indicators of a chemical change.

Questions to Guide Analysis
1. What is an exothermic reaction?

2. What indicates that this activity was exothermic?

Characterizing Solutions: Background Information

Targeted *Standard Course of Study* Goals and Objectives

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.01 Identify questions and problems that can be answered through scientific investigations.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

COMPETENCY GOAL 6: The learner will build an understanding of regularities in chemistry.

6.05 Investigate and analyze the properties and composition of solutions:
- Solubility curves.
- Concentration.
- Polarity.
- pH scale.
- Electrical conductivity.

Introduction to the Teacher

This activity is utilized after a discussion of chemical bonding, chemical nomenclature, and an introduction to solutions (solute, solvent, solubility, concentration…..). It is best used as an introduction to various properties of solutions of interest to a chemist. The substances listed in data table one are chosen to provide clear divisions between acids and bases as well as electrolytes and non-electrolytes. Ionic and covalent substances are chosen so that there is little confusion of properties that should be left out of physical science and covered later in a chemistry class. For instance, ionic salts are chosen which have no pH effect. The only pH effect will be from the ionic hydroxides and from traditional, Arrhenius acids. Substitutions can be made in this list but care should be taken to make sure that unwanted pH effects aren't included. Do not use salts containing the anion of a weak acid (conjugate base of the weak acid) or conjugate acid of a weak base (most common would be ammonium salts). The final classification should be similar to the following:

a. pH < 7, electrolyte, blue litmus turns red, compound likely contains covalent bonds, formula contains a Hydrogen, Hydrogen at the beginning of the formula (HCl, $HC_2H_3O_2$, H_2SO_4)
b. pH > 7, electrolyte, red litmus turns blue, formula contains a hydroxide, formula likely represents an ionic compound ($NaOH$, KOH, $Ca(OH)_2$

c. pH approximately 7, no change in litmus color, electrolyte, formula likely ionic ($NaCl$, KCl)

d. pH approximately 7, no change in litmus color, nonelectrolyte, formula likely covalent. (Water, $C_{12}H_{22}O_{11}$, C_2H_5OH)

Each solution should be mixed to the same concentration (approximately 0.10 M is appropriate. The same results will result if other concentrations are used.

Equipment utilized in the activity depends on the school. For pH, pHydrion paper may be used or a pH probe could be used if available. For conductivity, I use a Labpro with a conductivity sensor. In the past, I have used a battery or battery replacement power supply with an ammeter to detect current. Other commercially available conductivity equipment is available. Refer to Fisher Science Education or Sargent-Welch for available equipment. Vernier Software and Technology is another very useful source. Part IV **requires** a method to quantify conductivity. Litmus paper could be replaced with any available indicator including red cabbage juice. In addition, other indicators could be added to the procedure to increase student exposure to a set of indicators.

Part II allows students to apply their classification system to common substances.

Parts III and IV require students to make quantitative measurements of pH and electrical conductivity. The Vernier LabPro system works well here.

Pedagogy: As written, the activity is intended to be open ended to some degree. All reasonable classification systems developed by students should be accepted during the discussion of the activity. Some sort of student presentation should be included at the end of part one. This could include a brief presentation of results on transparency/overhead or on a small whiteboard or a lab report. Following student presentation of results to part I, it is the teacher's job to bring the student designed classification systems and the terminology that they have developed into mainstream, accepted science. Terms such as acid, base, salt, electrolyte, and nonelectrolyte should be introduced after students have gained experience with the required chemical tests and before Part II. Definitions included should be appropriate to the course and level of students. For instance, a formal definition of pH must consider the math level of the students and their exposure to logarithms. This level of definition is likely beyond the current physical science NCSCOS.

Safety Considerations

Recipes for Solutions: The following recipes are for 1.00 L of **0.10 M solutions** of each solute. Use of correct, safe technique is required when mixing these solutions and handling the chemicals is expected.

Solute
HCl: Add 8.3 mL concentrated HCl to 1000 mL H_2O
NaOH: Dissolve 4.0 g Solid sodium hydroxide in 1000 mL water
$HC_2H_3O_2$: Dissolve 5.7 mL glacial acetic acid in 1000 mL water
NaCl: Dissolve 5.85 g solid NaCl in 1000 mL water
KOH: Dissolve 5.6 g solid KOH in 1000 mL water
$Ca(OH)_2$: Dissolve 7.41 g solid calcium hydroxide in 1000 mL water

H_2SO_4: Dissolve 5.6 mL concentrated sulfuric acid in 1000 mL water	
KCl: Dissolve 7.5 g solid potassium chloride in 1000 mL water	
$C_{12}H_{22}O_{11}$: Dissolve 34.2 g solid sucrose in 1000 mL water	
C_2H_5OH: Dissolve 4.6 mL absolute, denatured ethanol to 1000 mL water (approximation)	
Distilled H_2O (pure solvent): Use fresh, distilled water	

References
This activity was designed by David English, Michelle Chadwick, and Jody Holloway from Northside High School Science Department Jacksonville, NC.

Answers to Questions
Part I

1. Examine the colors of Litmus in the solution. Place the solutions into groups of substances that have similar effects on litmus. State the reason that you have grouped the substances as you have.

Substance
HCl: Blue litmus turns red
NaOH: Red litmus turns blue
$HC_2H_3O_2$: Blue litmus turns red
NaCl: No color change
KOH: Red litmus turns blue
$Ca(OH)_2$: Red litmus turns blue
H_2SO_4: Blue litmus turns red
KCl: No color change
$C_{12}H_{22}O_{11}$: No color change
C_2H_5OH: No color change
Distilled H_2O (pure solvent): no color change

2. Examine the electrical conductivity seen with each solution. Place the solutions into groups based on their ability to conduct electricity. In words, state the reason that you have grouped the substances as you have.

Electrolytes	***Nonelectrolytes***
HCl, NaOH, $HC_2H_3O_2$, NaCl, KOH, $Ca(OH)_2$, H_2SO_4, KCl	***$C_{12}H_{22}O_{11}$, C_2H_5OH***

3. Examine the pH of the solutions. Place the solutions in groups based on your pH measurements. In words, state the reason that you have grouped the substances as you have.

pH <7	***pH> 7***	***pH approximately equal to distilled water***
HCl, $HC_2H_3O_2$, H_2SO_4	***NaOH, KOH, $Ca(OH)_2$***	***NaCl, KCl, $C_{12}H_{22}O_{11}$,***

		C_2H_5OH

4. Place the solutions in as few groups as possible while considering all the tests at once. Provide a NAME for each group. Provide a written explanation for the groupings you have produced.

pH<7, electrolyte, litmus turns blue to red (Group A)	***pH >7, electrolyte, turns red litmus to blue (Group B)***	***pH approximately equal to distilled water, electrolyte, no litmus color change (Group C)***	***pH approximately equal to distilled water, NONelectrolyte, no litmus color change (Group D)***
HCl, $HC_2H_3O_2$, H_2SO_4	***NaOH, KOH, $Ca(OH)_2$***	***NaCl, KCl***	***$C_{12}H_{22}O_{11}$, C_2H_5OH***

Accept any name for the group, groups labeled by letter as above is appropriate.

5. Examine the formulas for the solutes in the aqueous solutions you have tested and classified. From the formulas, suggest similarities of the group members that could possibly account for the differences in how the substances react to the tests.

Group A: All formulas contain a leading hydrogen (H^{1+})
Group B: All formulas contain hydroxide bonded to a metal atom
Group C: All formulas contain a metal and nonmetal (students may point out that there is a chloride in each-no real effect from this fact)
Group D: Each formula contains carbon, hydrogen and oxygen. All are covalent molecular

6. What is the function of water (not a solution) being included in the tests?
Water is present to see the test results of the solvent with no effect from a solvent. Experimental control.

7. Prepare a brief presentation of your classification system on a Whiteboard. Include all information you feel is necessary to describe your system to the class. Be prepared to present!
Accept all presentations. If misconceptions are noted, draw the student's attention to them through questioning.

Part II:

1. Based on part I, what inferences can you draw regarding the chemical nature of the solutes in the solutions above? (Electrolyte, nonelectrolyte, acid, base, salt, covalent, ionic?)

Vinegar	***Electrolyte, acid, covalent***
Ammonia	***Electrolyte, base, covalent***
Rubbing	***Nonelectrolyte,***

Alcohol	***covalent***
Baking soda	***Base, electrolyte, ionic***
Finger nail polish remover	***Nonelectrolyte, covalent***
Lemon Juice	***Electrolyte, acid, covalent***
Peroxide	***Nonelectrolyte, covalent***
7-Up	***Electrolyte, acid, covalent***

Part III:

1. What happens to pH as an acid is added to water?
The pH of the water/solution drops quickly to below 7 and continues to drop as acid is added.

2. The HCl and $HC_2H_3O_2$ solutions had the same concentration. What is meant by the term concentration?
Concentration is a measure of the quantity of solute dissolved in a specific quantity of solvent.

3. How did the final pH value compare for the two solutions (50 mL water + 50 drops acid).
The pH of the hydrochloric acid solution should be lower than the pH of the acetic acid solution

4. Based on the definition of pH, what can you conclude regarding the difference between the two acids when in water?
If pH measures the concentration of hydrogen ion in a solution (or hydronium ion), the acetic acid solution has a lower concentration of hydrogen ion even though the solutions are the same concentration in terms of the original solvents. Not as much hydrogen ion is generated from the acetic acid.

Part IV:

1. We have determined that acids are electrolytes. What is an electrolyte?
An electrolyte is a solute that, when dissolved in water, produces a solution that can conduct electricity.

2. How did the solutions compare regarding their ability to conduct electricity?
The acetic acid has lower conductivity than the hydrochloric acid solution.

3. Which acid is a more effective electrolyte?

Hydrochloric acid is a more effective electrolyte.

4. Using your text or other sources, what is meant by the terms, strong acid and weak acid?

A strong acid is an acid that ionizes 100% when in dilute, aqueous solution. There is no aqueous molecular acid. A weak acid ionizes much less than 100%. The vast majority of the dissolved acid is in aqueous molecular form.

5. Which of the two acids appears to be a strong acid? Weak?

Based on conductivity measurements, the hydrochloric acid appears to have produced more ions; it is likely a strong acid. The conductivity of equal amounts of acetic acid is less. It is likely a weak acid.

6. Is it possible to produce a low pH with a weak acid?

It is possible to produce very low pH values with a weak acid. It requires a higher concentration than required by a strong acid.

7. Is it possible to measure pH of a solution of unknown concentration/identity and identify the acid as strong or weak?

Without knowing the concentration of the acid, pH says nothing about "strength". pH measures concentration of hydrogen ion, not the percentage ionization of the acid in aqueous solution.

Characterizing Solutions: Laboratory

Purpose
The purpose of this activity is to develop and use a classification system for solutions based on several properties that can be examined in the laboratory.

Materials
- Containers of solutions to be tested
- Blue and Red Litmus Paper
- Conductivity apparatus
- pH probe or pHydrion paper
- Small bathroom cups or 50 mL beakers
- Several common, household chemicals
- 25 or 50 mL graduated cylinder
- Droppers

Introduction to Students
In this activity you will examine several properties of aqueous solutions. An aqueous solution is prepared by dissolving a solute in water. The properties that you will examine include whether or not the solution will conduct electric current, the "pH" of the solution, and the color of the pigment, litmus, when placed in the solution. The observations you make will be recorded and you will sort the solutions into groups with similar characteristics. You will then use your classification system to classify several common household chemicals.

Procedure
Part I:
1. Using a graduated cylinder, measure out 20 mL of one of your solutions. Pour the solution into a clean cup or small beaker.
2. Based on the chemical formula and the elements that make up the solute, do you suspect the compound is ionic or covalent? Record your answer in the data table.
3. Dip a piece of red litmus paper into the cup. Find the substance in your data table and record the color of the paper after exposing the paper to the solution. Repeat with blue litmus paper.
4. Test the electrical conductivity of the solution with the conductivity equipment. Record your results in the data table.
5. Test the pH of the solution using the supplied equipment. Record your results in data table I.
6. Repeat the procedure with each solution. ***Be sure to thoroughly wash any glassware that is used to contain different solutions. Contamination could significantly affect your results!***

Data Table I

Substance	Ionic or Covalent	Color of Red Litmus in solution	Color of Blue litmus in solution	Conductivity of solution (yes or no)	pH of solution
HCl					
NaOH					
$HC_2H_3O_2$					
NaCl					
KOH					
$Ca(OH)_2$					
H_2SO_4					
KCl					
$C_{12}H_{22}O_{11}$					
C_2H_5OH					
Distilled H_2O (pure solvent)					

Questions to Guide Analysis

Part I:

1. Examine the colors of Litmus in the solution. Place the solutions into groups of substances that have similar effects on litmus. State the reason that you have grouped the substances as you have.
2. Examine the electrical conductivity seen with each solution. Place the solutions into groups based on their ability to conduct electricity. In words, state the reason that you have grouped the substances as you have.
3. Examine the pH of the solutions. Place the solutions in groups based on your pH measurements. In words, state the reason that you have grouped the substances as you have.
4. Place the solutions in as few groups as possible while considering all the tests at once. Provide a NAME for each group. Provide a written explanation for the groupings you have produced.
5. Examine the formulas for the solutes in the aqueous solutions you have tested and classified. From the formulas, suggest similarities of the group members that could possibly account for the differences in how the substances react to the tests.
6. What is the function of water (not a solution) being included in the tests?
7. Prepare a brief presentation of your classification system on a Whiteboard.

Include all information you feel is necessary to describe your system to the class. Be prepared to present!

Procedure
Part II:
Carry out the procedure in part one using the household chemicals in the place of the solutions. Complete Data Table II. Assign each solution to the named category you produced in question 4 above.

Data Table II

Solution	Litmus Test (blue →red or red →blue?)	pH Test	Conductivity Test
Vinegar			
Ammonia			
Rubbing Alcohol			
Baking soda			
Finger nail polish remover			
Lemon Juice			
Peroxide			
7-Up			

Questions to Guide Analysis
Part II:
1. Based on part I, what inferences can you draw regarding the chemical nature of the solutes in the solutions above? (Electrolyte, nonelectrolyte, acid, base, salt, covalent, ionic??)

Procedure

Part III:

1. Obtain 50 mL of distilled water. Measure and record the pH.
2. Using a dropper, add 5 drops HCl to the water. Stir the solution thoroughly. Measure and record the pH.
3. Continue step 2 until 50 drops of HCl have been added. Record the pH after every 5 drops.
4. Repeat the procedure with $HC_2H_3O_2$.

Data Table III

Drops of HCl	pH	Drops of $HC_2H_3O_2$	pH
0		0	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
35		35	
40		40	
45		45	
50		50	

Questions to Guide Analysis

Part III:

1. What happens to pH as an acid is added to water?
2. The HCl and $HC_2H_3O_2$ solutions had the same concentration. What is meant by the term concentration?
3. How did the final pH value compare for the two solutions (50 mL water + 50 drops acid).
4. Based on the definition of pH, what can you conclude regarding the difference between the two acids when in water?

Procedure

Part IV: (Optional)

1. Repeat the procedure for part III but measure the conductivity of the solution rather than pH.

Data Table IV

Drops of HCl	Conductivity	Drops of $HC_2H_3O_2$	Conductivity
0		0	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
35		35	
40		40	
45		45	
50		50	

Questions to Guide Analysis

Part IV:

1. We have determined that acids are electrolytes. What is an electrolyte?
2. How did the solutions compare regarding their ability to conduct electricity?
3. Which acid is a more effective electrolyte?
4. Using your text or other sources, what is meant by the terms, strong acid and weak acid?
5. Which of the two acids appears to be a strong acid? Weak?
6. Is it possible to produce a low pH with a weak acid?
7. Is it possible to measure pH of a solution of unknown concentration/identity and identify the acid as strong or weak?

KABOOM CHEMISTRY REVIEW: Background Information

Targeted *Standard Course of Study* Goals and Objectives

GOAL 5: The learner will build an understanding of the structure and properties of matter.
GOAL 6: The learner will build an understanding of regularities in chemistry.

Introduction to the Teacher:

Kaboom is a review game used to review large amounts of material in short amounts of time. You will need the following to play:

1. Kaboom Firecracker Can: oatmeal or coffee can. Wrap in red paper and write the word “Kaboom.” Poke a hole in the top of the lid and place a pipe cleaner in it. The pipe cleaner is the fuse.

2. The attached sheet of questions

3. Someone to keep score.

4. Rewards for the winning team. For example: candy or homework pass.

Have the class divided into two teams of students. Assign a name for each group. Carry the Firecracker Can from one person to another. One person from the first team draws a slip of paper from the Kaboom Can. If that person can answer the question without using notes or another group member, the team receives 2 points. If the person cannot answer the question then they can ask the team to help. If the team helps they receive 1 point. If the team does not know, then the other team can steal 2 points by answering the question correctly. However, if a student draws a Kaboom slip then all the points on their team goes to the other team.

This activity asks questions from all of the chemistry goals. This game was a great motivational tool in my classroom. The students actually wanted to draw a question. Beware some students may try to peek to see which slip they pull. Don’t let them do that.

Reference

This activity was designed by Stephen Charles (Walter H. Page High School, Greensboro, NC).

KABOOOOOOOOOOOOOOOOOOOOM Review

What is physical science?

List six steps to the scientific method.

What is the difference between a theory and law?

What is a control?

What is a constant?

What does SI stand for?

What is the SI unit for length?

What is the SI unit for mass?

What is the SI unit for temperature?

What is the SI unit for light intensity?

What is mass?

What is density?

Where is the independent variable placed at on a graph?

Where is the dependent variable placed at on a graph?

What are the four states of matter?

What does the Kinetic Theory Law state?

What is the most common form of matter?

What happens to a gas as it is heated?

What is heat of fusion?

What is heat of vaporization?

What is a homogenous mixture?

KABOOM CHEMISTRY REVIEW: Activity

What is a heterogeneous mixture?

Name three physical properties of matter.

What does the law of conservation of mass state?

What does the chemical symbol Mg mean?

What is the atomic mass of Hydrogen?

How many neutrons does the isotope C^{14} have?

Who organized the periodic table?

What is the oxidation state of halogens?

What is the oxidation state of Alkaline Earth metals?

List three elements in Alkali metals?

What does chemically stable mean?

How many valence electrons does oxygen have?

What did Lewis invent?

What is the difference between covalent and ionic bonds?

What is a polar molecule?

What is a binary compound?

How would I name the compound NaCl?

What is the difference between a solute and solvent?

Name three things that will increase dissolving rate.

What is solubility?

Describe the difference between saturated, unsaturated, and supersaturated solutions.

What is on the left side of a chemical equation?

KABOOM CHEMISTRY REVIEW: Activity

What is on the right side of a chemical equation?

What is the difference between coefficient, subscript, and superscript?

What happens in a synthesis and decomposition reaction?

What is the difference between a single and double displacement reaction?

What is the difference between an endothermic and exothermic reaction?

What is an indicator?

What type of ions does an acid form?

What type of acid is Sulfuric Acid with a pH of 1?

What type of base is Ammonia with a pH of 13?

What is the pH of your blood?

Is acid rain a strong acid or weak acid?

What is a neutralization reaction?

How is a salt produced?

What are the three types of radiation?

Who was the first to discover radiation?

What type of radiation is the most penetrating? Least penetrating?

What is the difference between fusion and fission?

What is a chain reaction?

How do they dispose of nuclear radioactive waste currently?

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KABOOM CHEMISTRY REVIEW: Activity

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Physical Science Reference Tables (2006)

Introduction

The *North Carolina Physical Science Reference Tables* (2006) are included in this support document on the following four pages. The purpose is to allow students and teachers to focus on understanding and applying concepts rather than memorizing equations. These reference tables are intended for students to use throughout the Physical Science course. Another copy of the *North Carolina Physical Science Reference Tables* will be provided to students when they take the End-of-Course Physical Science Test. Students should be given their own copy of these reference tables at the beginning of the Physical Science course and asked to use it frequently so that they become familiar with all of the information provided.

Careful consideration was given to the question of which variables to use to represent various quantities. Different resources such as state-adopted textbooks and the CRC Handbook of Chemistry and Physics each use different variables for some quantities. Therefore, the variables used on the *North Carolina Physical Science Reference Tables* may not be the same as those used by a particular textbook. For example, gravitational potential energy is sometimes symbolized by U_g, however the *North Carolina Physical Science Reference Tables* use PE_g because this symbol is likely to be clearer to students.

Students should become comfortable with the variables used on the *North Carolina Physical Science Reference Tables* (2006) well before the End-of-Course Physical Science Test. Teachers can ensure this by teaching students to use the tables and making them available for a variety of classroom assessments.

Notice that the Electromagnetic Spectrum information is now presented from longest wavelength to shortest wavelength. (This reverses the presentation in the previous edition.)

Students should also become proficient with the algebra skills needed to solve the equations provided for any of the variables and to use substitution to combine equations when needed.

The *North Carolina Physical Science Reference Tables* are available on the DPI website linked to the 2004 curriculum. Please check the web to be sure you are using the most up-to-date version.

Physical Science Reference Tables

MOTION AND ENERGY	
$\bar{v} = \frac{\Delta d}{\Delta t}$	v = velocity
	d = position
	t = time
$a = \frac{v_f - v_i}{\Delta t}$	a = uniform acceleration
$F = ma$	F = force
$F_g = mg$	m = mass
$W = F\Delta d$	F_g = weight
	g = acceleration due gravity on Earth = 9.8 m/s/s
$P = \frac{W}{\Delta t}$	W = work
	P = power
$PE_g = mgh = F_g h$	PE_g = gravitational potential energy
	h = height
$KE = \frac{1}{2}mv^2$	KE = kinetic energy
$v_w = f\lambda$	v_w = wave velocity
	f = frequency
	λ = wavelength
ELECTRICITY	
$V = IR$	V = electrical potential difference
$P = VI$	I = current
	R = resistance
	P = power
DENSITY	
$D = \frac{m}{V}$	D = density
	m = mass
	V = volume

PERIODIC TABLE

1 IA								
1 **H** Hydrogen 1.008	2 IIA							
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012							
11 **Na** Sodium 22.99	12 **Mg** Magnesium 24.31	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB
19 **K** Potassium 39.10	20 **Ca** Calcium 40.08	21 **Sc** Scandium 44.96	22 **Ti** Titanium 47.88	23 **V** Vanadium 50.94	24 **Cr** Chromium 51.99	25 **Mn** Manganese 54.94	26 **Fe** Iron 55.85	27 **Co** Cobalt 58.93
37 **Rb** Rubidium 85.47	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.91	40 **Zr** Zirconium 91.22	41 **Nb** Niobium 92.91	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.91
55 **Cs** Cesium 132.91	56 **Ba** Barium 137.38	57 **La** Lanthanum 138.91	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.95	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.21	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.22
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (264)	108 **Hs** Hassium (269)	109 **Mt** Meitnerium (268)

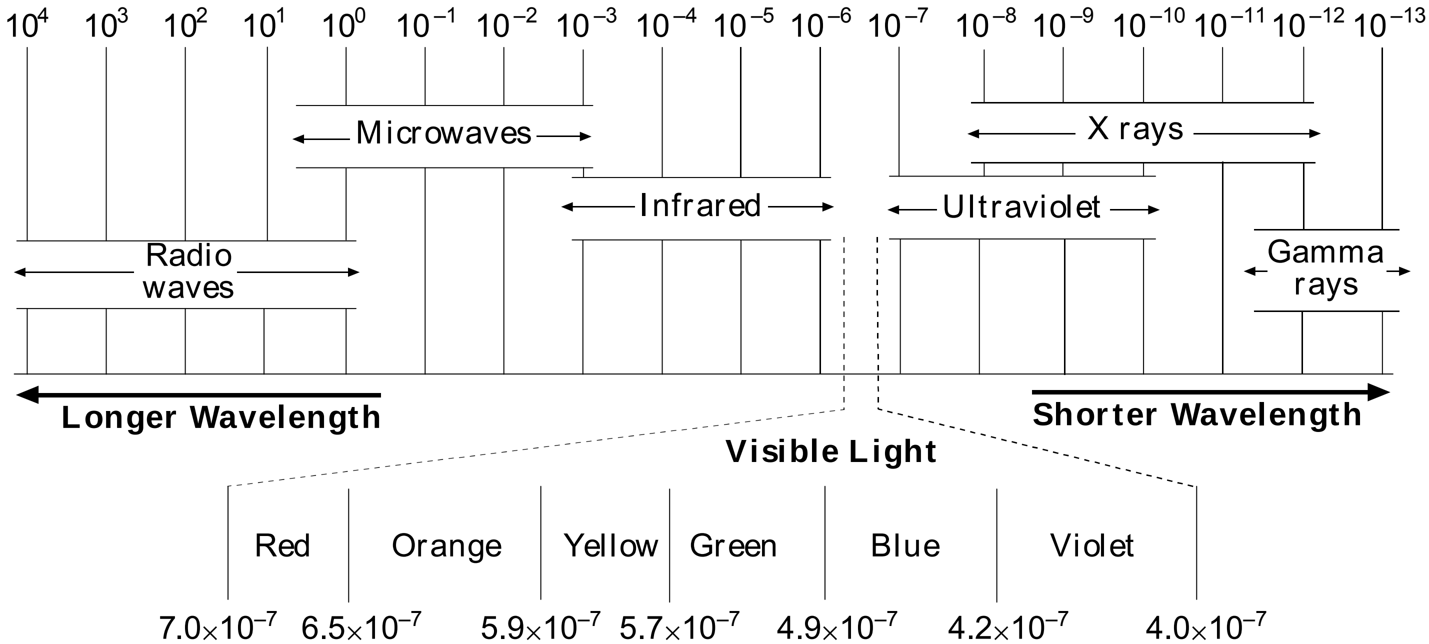
58 **Ce** Cerium 140.12	59 **Pr** Praseodymium 140.91	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.96	64 **Gd** Gadolinium 157.25
90 **Th** Thorium 232.04	91 **Pa** Protactinium 231.04	92 **U** Uranium 238.04	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)

OF THE ELEMENTS

								18 VIIIA
			13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	2 **He** Helium 4.003
			5 **B** Boron 10.81	6 **C** Carbon 12.01	7 **N** Nitrogen 14.01	8 **O** Oxygen 16.00	9 **F** Fluorine 19.00	10 **Ne** Neon 20.18
10 VIIIB	11 IB	12 IIB	13 **Al** Aluminum 26.98	14 **Si** Silicon 28.09	15 **P** Phosphorus 30.97	16 **S** Sulfur 32.07	17 **Cl** Chlorine 35.45	18 **Ar** Argon 39.95
28 **Ni** Nickel 58.69	29 **Cu** Copper 63.55	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.72	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92	34 **Se** Selenium 78.96	35 **Br** Bromine 79.90	36 **Kr** Krypton 83.80
46 **Pd** Palladium 106.42	47 **Ag** Silver 107.87	48 **Cd** Cadmium 112.41	49 **In** Indium 114.82	50 **Sn** Tin 118.71	51 **Sb** Antimony 121.76	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90	54 **Xe** Xenon 131.29
78 **Pt** Platinum 195.08	79 **Au** Gold 196.97	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.38	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
110 **Ds** Darmstadtium (271)	111 **Rg** Roentgenium (272)	112 **Uub** Ununbium (277)						

65 **Tb** Terbium 158.93	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.97
97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (254)	103 **Lr** Lawrencium (262)

Electromagnetic Spectrum
(measurement in meters)



Polyatomic Ions	
NH_4^+	Ammonium
$C_2H_3O_2^-$	Acetate
ClO_3^-	Chlorate
MnO_4^-	Permanganate
NO_3^-	Nitrate
OH^-	Hydroxide
CO_3^{2-}	Carbonate
CrO_4^{2-}	Chromate
SO_4^{2-}	Sulfate
PO_4^{3-}	Phosphate

Alternative sequencing schemes for Physical Science

Alternative sequencing schemes are provided to show several possible ways of organizing the course and approximate recommended amounts of time to spend on the different topics. Other sequences are certainly possible. Pacing guides are **not** provided because the detail that makes a useful pacing guide depends on local factors such as what materials and resources you have available for laboratories and activities, available textbooks, how you choose to integrate topics and themes, whether materials are shared across classrooms, your local calendar, etc. etc.

Sequencing Scheme I (based on a 90 day class)

Days	Unit	Topics
14	The Atom and Periodic Table	Atomic theory, structure of atom, atomic mass, atomic number, isotopes, and periodic table
10	Compounds	Ionic bond, covalent bond, metallic bond, density, boiling and melting points, heating curve, naming and writing compounds
12	Reactions	Chemical equation, reactant, product, coefficient, law of conversation of matter, types of reactions, chemical/physical change, and precipitate
8	Solutions	Solution, colloids, suspensions, like dissolves like, solubility, concentration, polarity, pH, and conductivity
12	Motion	Frame of reference, distance, position, velocity, speed, and acceleration
10	Forces	Inertia, force, mass, weight, Newton's laws of motion, and friction
12	Work and Energy	Kinetic energy, potential energy, gravitational potential energy, chemical energy, elastic energy, nuclear energy, radioactivity, fusion, fission, thermal energy, force, distance, work, thermal energy, temperature, waves, sound waves, mechanical waves, and electromagnetic waves
12	Electricity	Static electricity, Ohm's law, current electricity, series circuits, parallel circuits, and magnetism

Physical Science Support Document

Alternative Sequencing schemes

Sequencing Scheme II (based on a 180 day class)

Days	Unit	Topics
30	Motion and forces	Frame of reference, distance, position, velocity, speed, acceleration, inertia, force, mass, weight, Newton's laws of motion, and friction
30	Work and Energy	Kinetic energy, potential energy, gravitational potential energy, chemical energy, elastic energy, nuclear energy, radioactivity, fusion, fission, thermal energy, force, distance, work, thermal energy, temperature, waves, sound waves, mechanical waves, and electromagnetic waves
30	Electricity	Static electricity, Ohm's law, current electricity, series circuits, parallel circuits, and magnetism
25	The Atom and Periodic Table	Atomic theory, structure of atom, atomic mass, atomic number, isotopes, and periodic table
20	Compounds	Ionic bond, covalent bond, metallic bond, density, boiling and melting points, heating curve, naming and writing compounds
25	Reactions	Chemical equation, reactant, product, coefficient, law of conversation of matter, types of reactions, chemical/physical change, and precipitate
20	Solutions	Solution, colloids, suspensions, like dissolves like, solubility, concentration, polarity, pH, and conductivity

Physical Science Curriculum Comparison

Big Idea	Adopted 1999	Adopted 2004
Inquiry Skills	Introduction and Strands	Goal 1
	Note for inquiry skills: *The inquiry skills will be integrated into each of the other goals.*	
Motion	Goal 1 Objective 1.01	**Goal 2 Objective 2.01**
Forces	**Goal 1 Objective 1.02**	Goal 2 Objective 2.02
	Note for Newton's Laws: *The focus will be on the concepts and applications of the laws.*	
Energy	Goal 1 Objective 1.03 –includes work, power, kinetic energy, potential energy, and conservation of energy Goal 2 –includes thermal energy, expansion, contraction, phase change, heat of fusion, heat of vaporization, temperature, specific heat, first law of thermodynamics, and second law of thermodynamics Goal 4–includes characteristics of waves, properties of waves, and Doppler Effect	Goal 3 –includes kinetic energy, potential energy, thermal energy, work, heat flow, and waves
	Note for thermal energy: *The focus will be shifted to a qualitative/conceptual approach. There will be no emphasis on quantitative problem solving. (In the new curriculum thermal energy may be found in 2004 objective 3.03 and a bullet under 2004 objective 3.01 instead of a separate goal.)* **Note for waves:** *The focus will be shifted to the characteristics and types of waves. (In the new curriculum waves may be found in 2004 objective 3.04 instead of a separate goal.)*	
Electricity and Magnetism	Goal 3 –includes static electricity, conservation of energy, charging objects, Ohm's law, circuits, and magnetism	Goal 4 –includes static electricity, conservation of energy, Ohm's law, circuits, and magnetism
	Note for charging objects: *This topic is a bullet in 2004 objective 4.01 instead of a separate objective.*	

Physical Science Support Document

Physics Curriculum Comparison

<table>
<tr><th>Big Idea</th><th>Adopted 1999</th><th>Adopted 2004</th></tr>
<tr><td rowspan="2">Structure and Properties of Matter</td><td>Goal 5 –includes atomic theory, atomic structure, radioactivity, formation of simple inorganic compounds, physical properties, and periodic trends</td><td>Goal 5 –includes atomic theory, atomic structure, and physical properties</td></tr>
<tr><td colspan="2">Note for atomic theory: The focus will be on the models and the electron cloud model has also been added to 2004 objective 5.01.
Note for physical properties: Specific heat has been removed as a bullet.
Note for radioactivity, formation of simple inorganic compounds, and periodic trends: These topics have been moved to 2004 Goal 6.</td></tr>
<tr><td rowspan="2">Regularities in Chemistry</td><td>Goal 6 –includes identification of chemical reactions, balance chemical reactions, gas laws, solubility, indicators of chemical change, acids and bases</td><td>Goal 6 –includes periodic trends, formation of simple inorganic compounds, chemical reactions, indicators of chemical change, properties of solution, and radioactivity</td></tr>
<tr><td colspan="2">Note for periodic trends: Symbols have been removed as a bullet. The concept should be covered, but the names and symbols may be found on the periodic table.
Note for formation of simple inorganic compounds: Metallic bonds have been added as a bullet and the phrase "including oxidation numbers" has been added to the ionic bonds bullet. Polyatomic ions have been added and are included on the reference table.
Note for chemical reactions: Combustion has been removed as a bullet.
Note for indicators of chemical change: Chemical change has been adjusted by adding a bullet for the release/absorption of energy (heat or light) and omitting the bullet for change in color.
Note for acids and bases: This topic has been changed from an objective to a part of the discussion of solutions in the bullets of 6.05.
Note for solution: Strength and degree of dissociation and ionization have removed as bullets. Solubility curve and polarity have been added as bullets.
Note for radioactivity: Nuclear waste has been added as a bullet.
Note for gas laws: Gas laws have been removed.</td></tr>
</table>

Bibliography

National Research Council. (1996). *National Science Education Standards.* Washington, D.C.: National Academy Press.

Honors Physical Science Curriculum Support

Curriculum Support
for the 2004 revision of the
North Carolina Standard Course of Study for
Honors Physical Science

Acknowledgements

These materials are intended to provide examples for translating the goals and objectives of the honors physics curriculum into good instructional design.

A group of dedicated and talented science teachers spent many hours developing these materials. The result is this resource that will facilitate the implementation of the North Carolina Science Curriculum.

A special thanks to the authors of these materials:

Kristin Campbell, Greene Central High School
Carolyn Elliott, South Iredell High School
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Honors Physical Science Curriculum Support

Honors Science Courses

All of the honors science courses share the following characteristics and assumptions:

- Students enrolled in honors courses will learn the material in the standard course of study for the course at greater depth than in the standard level version of the course. The support documents for the course include appropriate honors extensions by objective.
- Students enrolled in the honors version of the course will take the same EOC as students enrolled in the standard level version of the course.
- Students who choose an honors science course are expected to work more independently than students in standard level courses.
- Because students can be expected to cover the standard level material more independently there will be time for more enrichment topics as specified in the course descriptions for specific honors courses.
- Students who choose an honors science course will be expected to complete more independent in-depth scientific investigations and to report on them using a more formal scientific laboratory report format.
- Students who choose an honors science course will be expected to read about recent scientific research and present their findings orally and in writing.

Many of the materials and activities suggested for honors courses will also be appropriate for some students enrolled in standard level versions of the course. The difference may be in the level of independence expected of students and the amount of time activities may take. All students, not just those in honors courses, should experience challenging work and some level of independent inquiry in their science courses. Teachers should include some of the enrichment topics for all students.

Honors Physical Science Phase-out

Honors Physical Science will be available for implementation from the 2005-2006 school year through the 2007-2008 school year. The honors committee had serious concerns about this course. Physical Science is an introductory level course similar to Algebra I. Many students are successful in the *North Carolina Standard Course of Study* Chemistry and Physics without the Physical Science course. Students who are interested in scientific and technical careers need to take more advanced courses including Chemistry, Physics, and second level courses. After the implementation of the more rigorous 2004 science standards in the middle school and implementation of 5th and 8th grade science testing it is expected that students interested in an honors science program will be well prepared to take Honors Chemistry and Honors Physics without an introductory Physical Science course. Therefore, the Physical Science course will no longer be available as an Honors course after the 2007-2008 school year. The materials in this guide are provided in hopes that they will continue to be used to enrich standard level courses after the Honors Physical Science phase out.

Honors Physical Science Curriculum Support

Definition of Honors Science Courses

Honors science courses are designed to demand more challenging involvement than standard science courses. They must be demonstrably more challenging than standard courses and provide multiple opportunities for students to take greater responsibility for their learning. Honors science courses should be distinguished by a difference in the quality of the work expected rather than merely by the quantity of the work required.

Purposes of Honors Science Courses

Honors science courses should be designed for students who have demonstrated an advanced level of interest and achievement in a given subject area. The rationale for honors courses is not to provide a means to attract students to enroll in classes for additional credit, but rather to offer challenging, higher level courses for students who aspire to an advanced level of learning. Furthermore, students and parents should be informed that honors science courses are more demanding and have requirements beyond those of standard science courses.

Honors courses should be developed as an integral component of a differentiated program of study that provides an array of opportunities for all students based on their aptitudes, affinities, and interests.

Scheduling Honors Science Courses and Standard Level Courses Together

Honors and standard levels may be offered in the same classroom simultaneously when necessary. For example, a small school with limited physics enrollment may find it necessary to combine these two groups of students for instruction. Teachers in this position will need to put special emphasis on appropriate differentiation in their planning. Professional development with a focus on differentiation is recommended in this case.

Characteristics of Honors Science Courses

Honors science courses will address the same goals and objectives as the corresponding *NC Standard Course of Study*; however, they should address the content with greater complexity, novelty, acceleration, and/or pacing. Honors science courses should reflect a differentiation of curriculum, both in breadth and depth of study. Honors science courses should exemplify the following characteristics:

- Require a higher level of cognition and quality of work than the standard course
- Enable students to become actively involved in classroom and laboratory learning experiences
- Involve students in exploratory, experimental, and open-ended learning experiences

Honors science courses should provide opportunities for the following:

- Problem-seeking and problem-solving
- Participation in scholarly and creative processes
- Use of imagination
- Critical analysis and application
- Personalized learning experiences

- Learning to express/defend ideas
- Learning to accept constructive criticism
- Becoming a reflective thinker
- Becoming an initiator of learning

Essential Questions

Essential questions are designed to focus attention on main ideas. They are used in honors courses to prompt thinking and spark discussion of key elements within a larger context. Essential questions are helpful in working through the steps in problem-solving, planning, and decision making processes.
Essential questions reflect the most historically important issues, problems and debates in a field of study. In the sciences, essential questions should be used to help students make connections across particular disciplines such as biology and chemistry to the larger unifying concepts of science as well as to focus on essential questions within disciplines. For example, "What factors affect the motion of objects?", "How can we represent these factors?" and "How can we combine the various factors to predict motion?" are essential questions within Physics. "What other explanations could account for this data?" and "How can we measure that?" are essential questions in all of the sciences. By examining such questions, students engage in higher order thinking. Essential questions are open-ended with no single, correct answer.

Essential questions are meant to stimulate inquiry, debate and further questions, and can be reexamined over time. They are designed to be thought provoking to students, engaging them in sustained, focused inquiries, culminating in meaningful performances (McTighe & Wiggins, 2004).

Instructors of honors science courses are expected not only to pose essential questions to the students, but also to guide students in generating their own essential questions. The Honors Science Portfolio should include a list of essential questions with specific indications of how these essential questions are to be used in the honors class.

Honors Physical Science Curriculum Support

Introduction to Honors Physical Science

These materials were developed to assist in the development and implementation of Honors Physical Science courses. It should be noted, however, that **this document is not an honors teaching portfolio**. Each individual LEA and/or honors physical science teacher needs to create a portfolio to document their own honors Physical Science course. The materials included in this document are sample activities and suggestions provided to help in the portfolio development process. Honors courses may be developed at the LEA, school or teacher level. A local review and monitoring process should be put in place. As teachers develop their honors portfolios, they should use this opportunity to document what they are already doing well, while further developing the rigor in their courses. This should be seen as an on-going process. Courses should be revised and reviewed each year.

Essential Questions: Essential questions may be organized by teaching units rather than by the *Standard Course of Study*. Their purpose is to help focus teachers and students on the most important or essential concepts. Often an essential question bridges between objectives or serves as an organizing question for a unit that brings in concepts from several goals and objectives. Some essential questions will recur throughout the course. Sometimes after writing the overarching question, teachers will need to consider "entry point" questions to help students do the research and understand the background to access the topic at a higher level. Below are some internet resources related to essential questions.

http://www.myprojectpages.com/support/ess_questpopup.htm

http://www.essentialschools.org/cs/resources/view/ces_res/137

http://members.tripod.com/~ozpk/0000000EQ - this page starts with an assortment of links to other essential question sites and then has some examples - the ones in this site will help teachers make interdisciplinary connections beyond the sciences.

Precautions:

- **All students**, not just those in honors courses, should experience challenging work and some level of independent inquiry in their courses.
- Many of the materials and activities suggested for honors courses will also be appropriate for some students enrolled in standard level versions of the course.
- Teachers should include some of the enrichment topics for all students.
- **Independent does not mean unsupervised!**
    - Teachers must still provide appropriate supervision at all stages.
    - For independent projects teachers should give choices of topics or have a process in place for topic review and approval.
    - Teachers should always review project design carefully for safety reasons and to be sure the project will provide an appropriate learning experience.

  - Actual laboratory work must be supervised. Younger and less experienced students will need more scaffolding to make this a productive learning experience.
  - Independent **DOES** mean that the teacher will **NOT** provide all of the structure and step by step instructions.
- **Independent does not mean alone or unsupported!**
  - Just as adults in all sorts of industries usually work in teams, students may also work in teams.
  - Teachers may need to provide some assistance to students in finding appropriate sources and models of appropriate performances.

A more extensive introduction to the development of honors courses is in the *Honors Course Implementation Guide* available for download at: http://www.ncpublicschools.org/curriculum/honorsguide

Honors Physical Science Curriculum Support Document

Honors Physical Science

Course Code 3010

Honors Physical Science is an introductory course designed for highly motivated students who have demonstrated an advanced level of interest, learning, and achievement in the area of science and mathematics. The course will follow the *North Carolina Standard Course of Study* for Physical Science but will include more exploratory, experimental, open-ended work, and in depth study of all *NCSCOS* goals. The course will require higher order thinking skills such as analysis, generating, integrating, and synthesis. The class will include inquiry lab investigations that will provide problem seeking and solving opportunities for students that relate to real life scenarios. The class will include at least four of the six honors objectives listed below and may also include two or three enrichment topics in addition to those required by the *Standard Course of Study* for Physical Science and will require students to complete an in-depth independent study. Students will be required to make a presentation of the independent, in-depth study. Honors Physical Science is intended to be offered as a ninth grade course. The *North Carolina End-of-Course Test for Physical Science* is required to receive credit for this class. This course cannot be taken for credit after passing Chemistry or Physics. Students may not take Honors Physical Science in addition to standard level *Standard Course of Study* Physical Science.

Honors Objectives

The following objectives are extensions of or in some cases in addition to those in the 2004 revision of the *Standard Course of Study* for Physical Science. The numbers are to show placement in the *Standard Course of Study* for Physical Science.

1.06H Design, conduct and evaluate scientific investigations to study physical science phenomena:

- Evaluate student-generated hypotheses by designing and carrying out independent physical science inquiry activities.
- Assess the relevance of physical science phenomena to real world scenarios and recent research.
- Document scientific processes and analysis in formal writing on a continuing basis.
- Assess qualitatively possible sources of error and suggest ways to improve investigations.
- Summarize the results of scientific investigations and/or research to the larger community, including but not restricted to students, parents, and community groups.

Teachers should also include at least four of the following six honors objectives:

2.03H Use the Law of Conservation of Momentum to predict the results of collisions.

3.05H Examine the behavior of light in different media and applications in optics:

- Refraction
- Reflection

- Diffraction
- Interference

5.04H Assess the behaviors of gases and liquids:

- Boyle's Law
- Charles's Law
- Archimedes' Principle
- Bernoulli's Law

5.05 H Investigate changes in thermal energy.

6.07 H Analyze movement of electrons in chemical reactions.

- Oxidation
- Reduction

6.08H Assess the formation of polymers.

Honors Physical Science Curriculum Support Document

Honors Physical Science

Activities and Labs for Honors Physical Science

While this guidebook presents the following activities and laboratory investigations as honors activities, each is recommended for use in the standard level physical science classroom with suitable structure and scaffolding so that all students may benefit from participation in inquiry science.

Inquiring Minds Want to Know: Background Information

Inquiring Minds Want to Know

Targeted *Standard Course of Study* Goals and Objectives:

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.
Other objectives as targeted by teacher or chosen by student.

Essential Question(s):

How do inquiring minds investigate scientific processes?
How does the scientific method really work?

Introduction to Teacher:

This describes the steps to help students begin ongoing science projects in which students develop ways to work through the scientific process piece by piece in order to understand the overall problem. Students will choose a topic related to chemistry or physics which they will then investigate. The project can be limited to 9 weeks or take the entire semester. The project can be performed in groups or given as an individual project.

Explanation of Explaining the Processes and How Students Should Use What They Learn

- **Introduction to Scientific Method** (Puzzle Activity)

I used a puzzle to open up the topic of the scientific method. The puzzle was broken into 60 pieces. Students had to take what they knew about puzzles in order to figure out what they did not know. What the students did not know was what the puzzle said. So I asked them questions like: What is this? How do you know it is a puzzle? How to do you start to put the puzzle together? How do you tell the outside pieces from to inside pieces? What other elements help you put a puzzle together? After the question the students worked together to put the puzzle together on the board. After finishing, I had one student read it out loud. The puzzle states: Science is piecing together the things that you know in order to understand the things you do not yet know. I expanded upon that statement from there.

- **Choosing a topic**: Have students select 5 topics/ areas of interest (say or write why are they interested in the topic and what would they investigate?), and then narrow it down to three topics, and from three topics to one problem.
- **Form a testable hypothesis**. Work with students on whether their hypothesis is testable.
- **Develop a procedure**: (Peanut butter and Jelly activity)

Students should write a procedure in which they tell someone else how to make a Peanut Butter and Jelly sandwich. They must use details in order to accurately describe the sequence of steps to make a sandwich. After they feel they have written their procedure the way they want it ask a student volunteer to read it out loud. You as the teacher may follow their steps or have a student follow them. Remember, if they don't tell you things that would make sense, don't do them. Example: Step 1: Place peanut butter on the bread. (Teacher can pick up the jar of peanut butter and place it on the loaf of bread.)

After discussing how to write procedures, the students should break up into their groups and follow through with writing a procedure that will correlate with their hypothesis. This should include a description of materials needed (including set-up and equipment) and then follow with the procedure of their experiment. This is then turned in to the teacher, so that the teacher can make sure the students are on the right path and can be guided back on track.

Data and Observation: Students from here should schedule a time to set-up their experiment (if needed to do at school) or they can perform it at home. Any experiment with safety concerns should be performed at school under teacher supervision. Their experiments should be carried out based on their procedures. Students should document all observations that are made through out the whole process. Data that can be put into graphs and charts should be encouraged and expected. Students should also come up with a way in which they will show their findings as a presentation. This can include taking pictures as they go, or even videoing parts of their experiment. (Pictures would be great for a lab that requires things taking place over time.)

Analysis and Conclusion: Students will interpret data and observations using the activity started above. They should discuss any patterns they see in the data. They should discuss various explanations for these patterns and evidence in favor and against each explanation. Students will then use what they learned about interpreting data and observations to make conclusions about their data. Their conclusion should state whether or not their data agrees with their hypothesis. They should also discuss and, if possible, carry out any needed changes in their procedures. Everyone should be able to suggest at least one change (no experiment is perfect the first time!!!).

Differentiation from Standard-level:

Honors students should be expected to write a more formal report. Standard-level students may need more scaffolding and support especially in forming a testable hypothesis and in writing their results.

Safety/Special Considerations:

All Lab Safety Rules Apply!!
Every project needs teacher approval before experiments are performed.

References:

This activity was designed by Kristin Campbell from Greene Central High School and Andrea Stewart from Andrews High School.

Inquiring Minds Want to Know

Targeted *Standard Course of Study* Goals and Objectives:
COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.
Other objectives as targeted by teacher or chosen by student.

Essential Question(s):
How do inquiring minds investigate scientific processes?
How does the scientific method really work?

Introduction (purpose with background information):
You will be performing an ongoing research experiment in which you will gather information on a topic of your choice and follow through with that topic going through the processes of the scientific method.

Materials:
Will depend on the topic chosen.

Procedure:
1. Choose a topic:
   Select 5 topic/areas of interest (why are you interested in this topic and what would you investigate), and then narrow it down to three topics, and from three topics to one problem.
2. Form a hypothesis.
3. Develop a procedure:
   After discussing how to do procedures, break up into your groups and follow through with writing a procedure that will correlate with your hypothesis. Design an experiment that will test your hypothesis. Write the procedure for your experiment. This should include a description of materials needed (including set-ups and equipments) and the procedure of your experiment.
4. Approval: This is turned in to your teacher so that the teacher can make sure you are on the right path.
5. Experiment: Conduct approved experiment.
6. Data and Observation:
   Document all observations that are made throughout the whole process. You should collect data that can be organized into graphs and charts. You should also come up with a way in which you will show your findings as a presentation. This can include taking pictures as you go, or even videoing parts of your experiment. (Pictures would be great for a lab that requires things taking place over time.)
7. Analysis and Conclusion:

Use what you learned about interpreting data and observations to make conclusions about your own data. You should look for relationships between elements in your experiment that relate and those that do not. Inside your conclusion you should state whether or not their data agrees with your hypothesis. If it does why do you think it worked? If it does not agree, what do you think made it change what you thought it would do? And how can you redesign your lab. You should also include whether your findings agreed or not, what could be changed in order to make your experiment that much better. Everyone should have at least one thing (no experiment is perfect the first time!!!).

8. Formal Report and Presentation:
   A formal lab report will be submitted and a presentation on material is required.

Safety:

Safety Contract Signed
Teacher approval is necessary to begin project.

Questions to Guide Analysis:

- What is the problem?
- What is the independent variable? Dependent variable?
- What is your control?
- What type of information do you plan to obtain from your experiment?
- What are problems that you for see coming up?
- How can you use this experiment in everyday life?

Rubric:

Oral Presentation (45 pts)	**A**	**B**	**C**	**D**	**Total**
Display (10 pts)	Clear visual, easy to follow, well organized	Well organized but hard to follow	Lack of organization	No clarity	
Eye Contact/ Speech (10 pts)	Makes eye contact w/ audience. Speaks clearly	Some eye contact, speaks reasonably clearly	Limited eye contact, not coherent in speech	No eye contact, speech inappropriate	
Knowledge (15 pts)	Very knowledgeable display used as reference	Some what knowledgeable, display read	Read entire display	Did not understand project	
Audience (10 pts)	Handled all questions accurately	Answered most questions accurately	Lacked accuracy	Could not answer questions	

Formal Report (45 pts)	**A**	**B**	**C**	**D**	**Total**
Background Info (5 pts)	Complete with references and documentation	Complete with limited references or documentation	Limited with only a couple references.	Questionable information and no references.	
Hypothesis (5 pts)	Solid, testable with clear variables that can be varied one at a time	Testable with poorly differentiated or described variables	Too broad to be tested, variables unclear	Weak	
Procedure (10 pts)	Detailed step by step experiment with detailed testing of each variable	Step by step experiment with variables	Lacking order with some variables	No order cannot identify variables	

Data: Graphs/ Charts (10 pts)	Clear and Organized observations with correctly labeled graphs and charts	Clear and Organized observations with incomplete graphs and charts	Organized observations with no graphs and charts	Unorganized observations with no graphs and charts	
Analysis (5 pts)	Detailed, interpretation of collected data and variables	General, interpretation of data and variables	Some interpretation of data	Misinterpretation of data	
Conclusion (10 pts)	Clear, concise, uses evidence to support conclusion; refers back to hypothesis	Concise, uses some evidence to support conclusion, refers back to the hypothesis	States conclusion related to hypothesis but does not use evidence as support.	Ambiguous	

Mousetrap Car Lab

Targeted *Standard Course of Study* Goals and Objectives:
COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.
COMPETENCY GOAL 2: The learner will construct an understanding of forces and motion.
COMPETENCY GOAL 3: The learner will analyze energy and its conservation.

Essential Question(s):
How is friction related to acceleration, and velocity of a vehicle's motion?
How is energy transferred in starting and stopping motions?

Introduction to Teacher:
***This is an inquiry based lab experiment. Students should research and critically think and analyze throughout the project**.

- Show examples of previously made vehicles for reference
- Put examples in motion (one good, average, poor example). Do not allow students to handle in seats (demo only)
- Set up bins with mousetraps and other spare parts.
- Handout rubric on day 1
- Handout project information sheet and have parent signature checked off before student begins project
- If student has problems with mechanics of vehicle, look at it and share helpful hints as to what they may want to repair or improve.
- You may point out general source of problems but allow student to make repair decisions.

Differentiation from Standard-level:
Standard level students may need more assistance designing vehicles.
Honors students: All work is to be done on their own, using own materials and presenting findings to class at a given date.

Safety/Special Considerations:
Caution in use of springs on mousetraps
Allergies to adhesives
Sharp objects

References:
This activity was designed by Crystal Houser from South Point High School, Belmont, NC.

Mousetrap Car Lab

Targeted *Standard Course of Study* Goals and Objectives:

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.
COMPETENCY GOAL 2: The learner will construct an understanding of forces and motion.
COMPETENCY GOAL 3: The learner will analyze energy and its conservation.

Essential Question(s):

How is friction related to acceleration, and velocity of a vehicle's motion?
How is energy transferred in starting and stopping motions?

Introduction (purpose with background information):

Define and explain velocity and acceleration in your own words.
Define and explain friction in your own words.
Describe a real life example of friction, velocity and acceleration that you are familiar with.

Materials: to build vehicle

Mouse trap
String
Wheels and axles
Glue
Scissors
Materials to enhance friction

Materials: to use at school to collect data

Stop watch
Meter stick

Procedure:

1. Construct a car (vehicle) using materials you have assembled.
2. Work with your group to test each car. You will measure velocity and acceleration in 3 separate trials.
3. Graph your data as follows:
   Graph # 1 (a distance vs. time graph)
   Each student will graph their groups average velocity (3 – 4 in group), each person having 3 trials of data to plot on their graph.
4. Use a best-fit line to illustrate the trend of the average velocity. Graph # 2
5. Choose one car from each group that best matches your average velocity as shown by your best-fit line in graph # 1
6. Calculate the velocity of this car at one second intervals of the trial. This is called a time split.
7. Plot this data as a distance vs. time graph.
8. Write a formal Lab report using the rubric provided.

Safety:
Caution in use of springs on mousetraps
Allergies to adhesives
Beware of sharp objects.

Questions to Guide Analysis:
1. Explain what happens to the acceleration if your velocity increases/ decreases during its run.
2. What happens to your velocity and acceleration when friction between the surfaces of the wheels and track increases/decreases?
3. At what time was your vehicle moving the fastest? (The beginning, the middle or end of its run?)
4. Explain the exchange of energy taking place in your vehicle.

References (for further research):
http://users.bigpond.net.au/mechtoys/mouse.html
http://www.geocities.com/CapeCanaveral/5080/ Best Mouse trap car
http://www.docfizzix.com/how_work.htm This is a commercial site with useful pictures and tips.

Mouse Trap Vehicle Project Rubric Parent Signature ______________________				
Background	0 - 2	3-4	5	
Velocity, acceleration and friction are completely and accurately described; suitable scenario for illustrating real life example is accurately described and explained.	May have failed to state or failed to give explanation of 2 terms and real life example; demonstrated a questionable level of understanding by more than two major errors and/or omissions	Made a statement of each term and discussed a real life example including all three terms; understanding level is suitable but not perfect as evidenced by one or two major errors and/or omissions	Made clear and accurate statement of each term and real life example; discussed and correctly identified each term with relation to the other; demonstrated an excellent understanding by accurate and explicit explanations	
Hypothesis, Procedure, Data Completely described and recorded the hypothesis, procedure and data in formal lab report.	0-10 On two or more instances, failed to provide a complete description of a part of the required elements	11-20 Failed to provide one complete description of a part of the required elements	21-25 Provided complete descriptions of required elements	
Analysis and Conclusion Completely and correctly answers analysis questions. Application of concepts reveals high level of understanding	0-8 Concept understanding limited as demonstrated by lack of depth in answers to questions. Several errors are evident.	9-15 Good understanding of application of concepts. Understanding level still developing as evidenced by few errors in analysis and conclusion.	16-20 Understanding of concepts evident by an abundance of correct application of concepts in analysis and conclusion. Deep understanding is well developed as evidenced by no errors.	
Applications to Real World **C**ompletely and correctly identifies real world example. Describes velocity, acceleration and friction.	0-8 Fails to explain real world example and application of velocity, acceleration.	9-15 Real world example is relevant. Example lacks thorough explanation of required concepts.	16-20 Real world example is relevant; example includes thorough and correct discussion of required concepts.	
Graphs Complete and accurately labeled. Titles and axes labeled with physical quantities and units. Axes accurately scaled.	0-3 Fails to include both graphs. Two or more required elements missing or incorrect.	4-6 Both graphs are included. Failed to provide one required element.	7-10 Both graphs complete and accurate. Included all required elements.	
Trials and data Data listed with formulas and all math work included	0-8 Fails to include all data and work.	9-15 Data and work mostly complete but lacking some data and work.	16-20 Data and math work complete with documented results. No more than one error.	

Honors Physical Science Curriculum Support
"A Picture Is Worth A Thousand Words"

Targeted *Standard Course of Study* Goals and Objectives:
COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.
COMPETENCY GOAL 2: The learner will construct an understanding of forces and motion.
COMPETENCY GOAL 3: The learner will analyze energy and its conservation.
COMPETENCY GOAL 4: The learner will construct an understanding of electricity and magnetism.
COMPETENCY GOAL 5: The learner will build an understanding of the structure and properties of matter.
COMPETENCY GOAL 6: The learner will build an understanding of regularities in chemistry.
(Including all honors objectives in the honors curriculum)

Essential Question(s):
How is physical science concepts related to real life situations?

Introduction to Teacher:
How did I come up with this project? Do you know any student that does not like to take photographs? While watching an old filmstrip that was good but had outdated photos, I decided that my students could take photos of their surroundings and match these to the goals and objectives. That is how this project began in my classes a few years ago. The project shows the students that physical science is related to real life. I know longer hear "Why do I have to take physical science?" This is a good way for students to review the goals and objectives.
I do have two digital cameras in my room and computers that the students can use to make the PowerPoint presentation. This was important in the beginning but now more students have their own computers and digital cameras.

- The project will begin with topics relating to the nature of science. Students will take twenty-four photos, four from each of the goals two-six and four from any goals.
- These photos must be creative and must be related to a specific scientific concept.
- The photographs must be original and can not be taken from the internet. Some of the topics include static electricity, Boyle's Law, Charles' Law, Newton's Three Laws of Motion, kinetic energy, potential energy, chemical and physical changes, and others related to the *North Carolina Standard Course of Study*. For example, for chemical and physical changes the student may select a rusty nail. The students then have to explain why this picture is a chemical change.

Procedure:

1. Take 24 photographs during the course of physical science.
   A. Take four photographs from each Goal (Goals 2-6). This will give you 20 photographs. The remaining photographs may be taken from any goal. Use different objectives under each goal.
   B. Photographs must be related to real life (events that occur in real life and are not set-ups).
   C. Photographs must match the goal.

D. Description with each photo must include the complete goal and objective. A complete explanation of why the photo represents the goal must be included.

2. Presentation to the class:
   Presentations to the class may be in the form of PowerPoint, website or journal. All captions a must be typed or word processed.

Differentiation from Standard-level:
In standard-level this may be done in **groups** and/or you may assign fewer photographs.

Safety/Special Considerations:
Special consideration: Be sure project is equitable for students that do not own cameras and computers. For example you may provide digital cameras that can be checked out and arrange class time in the computer lab.

References:
This activity was designed by Carolyn Elliott, South Iredell High School.

Honors Physical Science Curriculum Support
"A Picture is Worth a Thousand Words"

Targeted *Standard Course of Study* Goals and Objectives:
COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.
COMPETENCY GOAL 2: The learner will construct an understanding of forces and motion.
COMPETENCY GOAL 3: The learner will analyze energy and its conservation.
COMPETENCY GOAL 4: The learner will construct an understanding of electricity and magnetism.
COMPETENCY GOAL 5: The learner will build an understanding of the structure and properties of matter.
COMPETENCY GOAL 6: The learner will build an understanding of regularities in chemistry.
(Including all honors objectives in the honors curriculum)

Essential Question(s):
Why do I need to know physical science or how does physical science relate to the real world?

Introduction (purpose with background information):
The project will begin with topics relating to the nature of science. Students will take twenty-four photos, four from each of the goals two-six and four from any goals. These photos must be demonstrate creativity and must be related to a specific scientific concept. They must be original photographs. The photos can not be taken from the internet. Some of the topics include static electricity, Boyle's Law, Charles' Law, Newton's Three Laws of Motion, kinetic energy, potential energy, chemical and physical changes, and others related to the *North Carolina Standards Course of Study*. For example, for chemical and physical changes you may select a rusty nail.
Students are asked to purchase a camera as part of the supplies needed for the class. Students are to take photographs as each goal is covered in class. Students are asked to complete the project at least two week before the end of the semester or end of the course.

Materials:
Computer
Camera or digital camera
PowerPoint software

Procedure:

1. Take 24 photographs during the course of physical science.
   A. Take four photographs from each Goal (Goals 2-6). This would give you 20 photographs. The remaining photographs may be taken from any goals. Use different objectives under each goal.

   B. Photographs must be related to real life (events that occur in real life and are not set-ups).
   C. Photographs must match the goal.
   D. Description with each photo must include the complete goal and objective. A complete explanation of why the photo represents the goal must be included.
2. Presentation to the class: Presentation to the class may be a PowerPoint, webpage or journal. All captions a must be typed or word processed.

Safety:
Pay attention to safety when photographing moving objects!

Questions to Guide Analysis:
1. Is your photo a real life situation?
2. Does the photograph match the goal and objective?
3. Have you given a complete explanation of why the real life situation represents the goal and objective?
4. Are the photos clear, creativity, and in focus?
5. Are the photos arranged by goals and objectives? Begin with goal 1 and all slides for goal 1 then goal 2, etc.

Honors Physical Science Curriculum Support

"A Picture Is Worth a Thousand Words"

Project **(100 points)**	**Exemplary** **20-15 points**	**Proficient** **15-10 points**	**Progressing** **10-5 points**	**Not Meeting Expectations 5-0 points**	**Total points**
Photo **(20 points)**	Creativity, clear photos, all in focus, neat format, all 24 photo included	All photo, some unclear, neat format, complete	Fewer than 12 photos, not complete	Incomplete, unclear,	
Goals and Objective **(20 points)**	Complete goal and objective for all photos, all goals and objectives match the photos	Complete goal and objective for all photos, most goals and objectives match the photos	Fewer than 12 goal and objective match the photos	Incomplete, few goals and objective are included and few match the photos	
Explanation **(20 points)**	Clear, precise, detailed, all explanation of goals and objectives match the photos	All explanation of goals and objectives match the photos	Fewer than 12 explanation of goals and objectives match the photos	Lack of enough explanation, incomplete, unsatisfactory	
Related to real life **(20 points)**	All photos are related to real life, clear, show creativity	All photos are related to real life, clear	Fewer than 12 are related to real life	Unclear, inadequate number are related to real life	
Presentation **(20 points)**	PowerPoint, same sequence as goals, Clear, complete, understandable	Unclear understandable, same sequence as goals	Less than complete, sometimes unclear, less than adequate	Random photos and objectives, unclear, incomplete	

Unknown Substances-Background Information

Targeted *Standard Course of Study* Goals and Objectives:
COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.
COMPETENCY GOAL 5: The learner will build an understanding of the structure and properties of matter.
COMPETENCY GOAL 6: The learner will build an understanding of regularities in chemistry.

Essential Question(s):
How can one use chemical and physical properties to identify household white powders?

Introduction to Teacher:

At the North Carolina Science Leadership Conference on Inquiry, Michael P. Clough of Iowa State University gave me an idea for an inquiry lab that I felt was safe for the chemistry unit in physical science. He had used the lab for chemistry so I modified and extended the lab to meet the needs of my students and the North Carolina Standard Course of Study and National Standards. I developed an inquiry lab that would extend over the entire unit on chemistry. This meets the changing emphases of the National Standards of investigation over an extended period of time. This activity covers much of the new goal one in the NCSCOS as well as content goals in related to Physical Science goals 5 and 6.

Begin this activity at the beginning of the discussion of physical properties. Start by giving the students five small labeled containers numbered 1-5. These containers should contain salt, sugar, baking soda, corn starch, and powered dish detergent. Present this as a mystery.

> *When I entered the classroom this morning I found some substances on the lab floor. I collected the substances in tubes. I also found five jars without lids. I need to identify which substance came from which jar. You will investigate the substances from the five jars during the next quarter.*
>
> *Today, working alone, I will give you fifteen minutes to make observations of the substances. Keep accurate records so you can use them later. You must organize your data and you must keep a record of your step-by-step procedures. This information will be used later to determine what the unknown substances are in your sample from the floor. We will perform more tests as we continue to study about matter.*

The first day the students spend at least fifteen minutes observing the unknowns. I walk around asking questions concerning physical properties-crystal, powdery, texture, color, and odor. When students ask for magnifying glasses I supply them. The students are reminded to keep

neat, organized information in their notebooks. This activity is continued as the students study chemistry. The students will test the five substances with universal indicator (color-Ph), vinegar (chemical properties), water (solution-dissolve), conductivity (bonds-ions) and heat test. These tests can be done in order of the study in chemistry. You may want to use other tests on the samples. I let the students determine, with guidance, what tests to use. I have done density but since I do not measure the amount in the final "unknowns" this did not prove to be helpful in identification. It can still be used and then you can discuss with the students why this can not be used in the final identification. Another test includes taking the temperature of the reactions then determining if they are exothermic or endothermic. The heat test is done with a hot plate. I have the students place small labeled amounts of each sample on aluminum foil or aluminum pie plates and place on the hot plate with a wire shield. The students can observe the results. If safety is a concern, demo this with the five substances. This is where I "man" the hot plate for each test for the final test for safety reasons. I only use one hot plate which I control. When the study of chemistry is completed give each student a mixture of three substances in their unknown sample. The three substances in the final sample should contain different three substances; ex. sample "*A*" may have salt, sugar, and starch, sample "*B*" salt, corn starch, baking soda, etc
At the end of the chemistry section, I will give each individual a sample of the substances found on the floor. The substances were found in different areas so all the samples may not be the same. Your sample may contain one, two, three, four or all five substances. You will determine which substances are in your sample. You will do some investigations with the substances. You are to determine properties of the materials that are in your sample. You must collect all the information you can about your sample, compare it to your study of the five known substances and identify if your sample matches substances from Jar 1, 2, 3, 4, or 5.

Honors Physical Science Curriculum Support

Unknown Substances

Teacher's Key

	Heat	Vinegar	Physical property	Conductivity	Iodine
Sugar	Melts				
Baking soda		Bubbles reaction			
Salt				Light will flash red	
Corn starch					Dark blue-positive reaction
Dish Detergent	Pops when heated		Odor not crystal nor fine power,	red light blinks but not as strong as salt	

Key to identify each substance:

- Baking soda-vinegar-chemical change
- Sugar- crystals -melts when heated-brown, sweat smell-only one that melts-low melting point
- Salt -crystals –conducts electricity.
- Corn starch-iodine-turns dark blue
- Dish detergent-odor, conduct electricity but not as well as salt, pops when heated basic

Observation should include:

Color-before and during the test

Texture-What does it fell like? Is it lumpy, smooth, or rough?

Size-Is it small grains or fine powder? What happens to the particles during the test? Does it dissolve, go into solution, or liquids run off?

Smell- Waft the air above the samples. Is there a smell? Is there a smell during the test?

Sound- Do you hear anything during the test? (popping)

Liquid- Do they soak in, run off, change color or cause any bubbling? Does a chemical or physical change take place during the test?

Time- How long do the reactions take? Do things happen immediately or do they take awhile?

Tests should include observations of physical properties, chemical and physical changes, use of indicators, determination of pH, ability to of substances to conduct electricity, and melting point

Honors Physical Science Curriculum Support

Unknown Substances

Differentiation from Standard-level:

Honors students will work on this individually, will have three substances in the unknown substances. Honors students will be required to have an in-depth explanation of their analysis. Standard-level classes will work in groups and will be given two substances in their unknown. A different rubric is used to grade this activity.

Safety/Special Considerations:

At the end of the lab teachers should dispose of or properly label "unknowns" Do not leave unknowns for future teachers as they would then have to perform extensive testing to determine that these are safe household substances.

Students should wear goggles, aprons, and plastic gloves for this activity.

- The substances are household items but they are tested with chemicals.
- Do not taste any of the unknowns.
- Treat all the unknowns with caution and respect.
- Avoid spillage.
- Use only the amount needed.
- Never return excess unknowns back to the bottle, as this will contaminate the stock material.

ALL SAFETY RULES WILL BE ENFORCED

References:

This activity was designed by Carolyn Elliott, South Iredell High School.

Unknown Substances

Targeted *Standard Course of Study* Goals and Objectives:

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.
COMPETENCY GOAL 5: The learner will build an understanding of the structure and properties of matter.
COMPETENCY GOAL 6: The learner will build an understanding of regularities in chemistry.

Essential Question:

How can one use chemical and physical properties to identify household white powders?

Introduction:

When I entered the classroom this morning I found some substances on the lab floor. I collected the substances in tubes. I also found five jars without lids. I need to identify which substance came from which jar. You will investigate the substance from the five jars during the next quarter. At the end of the chemistry section, I will give each individual a sample of the substances found on the floor. The substances were found in different areas so all the samples may not be the same. Your sample may contain one, two, three, four or all five substances. You will determine which substances are in your sample. The goal is not to identify the substances but rather to determine the properties of the materials that are in your sample and compare these properties to those of the known substances. You will do a variety of investigations with the substances. You must collect all the information you can about your sample, compare it to your study of the five known substances and identify if your sample matches substances from Jar 1, 2, 3, 4, and/or 5.

Later you will be given samples from the floor to determine what makes up these samples. You will do this by running the same test on your unknowns and comparing the results to your previous results.

Materials:

Well plates
Stirring rods
Powders from the teacher
Vinegar-dropper bottles
Iodine-dropper bottles
Water-dropper bottles
Universal indicator-dropper bottles
Conductivity device
Hot plate
Magnifying glass

Aluminum foil
Balance-density
Thermometers

Final test
Unknown with three substances

Procedure:

Design the experiments to determine the chemical and physical properties of the five substances. The results from these tests will be used to identify the Unknown substances from the floor.

Safety:

Students should wear goggles, aprons, and plastic gloves for this activity.

- The substances are household items but they are tested with chemicals.
- Do not taste any of the unknowns.
- Treat all the unknowns with caution and respect.
- Avoid spillage.
- Use only the amount needed.
- Never return excess unknowns back to the bottle, as this will contaminate the stock material.
- Teacher will help with the heat test.

ALL SAFETY RULES WILL BE ENFORCED.

Questions to Guide Analysis:

1. Are all observation included in a neat, understandable table?
2. What procedure did you use to identify the samples? List the procedures; these are needed to get the same results in the final test.
3. What is the relationship between conductivity and the types of bonds?
4. What is the purpose of indicators? What do indicators tell us?
5. Describe each reaction, identify as a chemical or physical reaction. Describe how you know if it is a chemical or physical reaction?
6. Determine the solubility of the substance. Does it dissolve?
7. Compare your results with the results of the other test you have run. (You may want to test your results several times to be sure your results are accurate.).
8. What evidence do you have to support your identification of the unknown? You must refer to specific test results in your explanation.

Rubric: Test of the 5 Known Substances

	Exemplary	Proficient	Not meeting expectations	Score
Physical Properties **(15 points)**	Observations, exemplary description of all physical properties: color, odor, crystalline shape, powdery substance, fine power, clumps, solubility of all substances, explanation of what happened, neat, precise, results and conclusion shown in table.	Complete results and description, includes most needed information	Incomplete, failed to include all physical properties, sometime unclear, less than adequate	
Indicators **(15 points)**	Observations, includes pH level, color of substance with universal indicator, positive or negative for starch test, results and conclusion shown in table, complete, neat and precise.	Complete results and description, includes most needed information, table is unclear, some pH values	Incomplete, not in neat table, sometime unclear, less than adequate, missing pH values	
Conductivity **(10 points)**	Observations, positive or negative for conductivity, indication of the types of bonds, results and conclusion shown in table, complete, neat and precise.	Complete results and description, includes most needed information, table is unclear	Incomplete, not in neat table sometime unclear, less than adequate, failed to list type of bonds	
Heat Test **(10 points)**	Observations, melting point high or low, results and conclusion shown in table, complete, neat and precise.	Complete results and description, includes most needed information, table is unclear.	Incomplete, not in neat table sometime unclear, less than adequate,	
Physical/Chemical Changes (vinegar) **(10 points)**	Observations, indicator of chemical and physical changes, what indicated the chemical change, results and conclusion shown in table, complete, neat and precise.	Complete results and description, includes most needed information, table is unclear, missing indicators of change.	Incomplete, not in neat table sometimes unclear, less than adequate, did not state type of change	

Rubric: Part II –Test of the Unknown-Report

	Exemplary	**Proficient**	**Not meeting expectations**
Scientific Method (10 points)	Includes hypothesis, list all procedures-numbered in correct order, complete easy to understand, followed all safety precautions, results are presented clear, neat and precise.	Somewhat complete, includes most steps in procedure, vague hypothesis	Incomplete, unclear, not easy to follow, not specific
Data (10 points)	Results presented in a table, neat, all test results were included, all tests were preformed, and results were clear, easy to read.	Not all tests were preformed on the unknown, not easy to follow	Incomplete, results were not clear, hard to follow, few test were preformed
Analysis (20 points)	Articulate, complete explanation of why it was substance __, __, and ___. All three substances were correctly identified, and results were compared to test of the five substances.	Complete explanation, missed one of the three substances.	Incomplete, did not correctly identify unknown substances, explanation was not complete.