**Physical Science**

**Structure of Knowledge**

**Matter**

**Essential Understandings**

1. Matter has physical characteristics – density, malleability, etc. that can be described.
2. Matter can occur in solid, liquid and gas phases. Differences in phases due to the molecular motion of the atoms.
3. Classified as either heterogeneous or homogeneous.
4. Physical and chemical changes
5. Solutions are homogeneous mixtures of a solute dissolved in a solvent

**Key Concepts and Indicators**

1. Determine the density of materials and what density indicates.
2. Describe the difference in molecular energy for a solid, liquid and gas.
3. Use of heating curves to illustrate the phase of a material.
4. Illustrate the difference between a physical and a chemical change.
5. How a solvent is able to dissolve a solute, and the amount of solute that can dissolve in a solvent based upon temperature.

**Assessments**

**Density Lab** – students will measure the mass and volume for different shaped objects of the same material to show that the characteristic of density remains the same for the material regardless of its size or shape. Graphs of mass vs. volume will be made to determine the density of the material.

**Density Lab 2** – make simple hydrometers to show how the density of solutions changes based on the concentration of solute in solution. The hydrometer floats higher when the concentration of the solution increases. Data of height vs. concentration can be graphed. Different solutions (sugar, salt) could be produced to gauge the effect of different materials; also could use water, oil, alcohol as materials to float the hydrometer.

**Solution Lab** – students will make solutions of various materials (sugar, salt, etc.) and measure the concentration of the solution

* **Phase change of water lab** – students will observe ice converting to water converting to steam and measure the temperature at which these phase changes occur
* **Web Sites**
  + <http://phet.colorado.edu/> - virtual demos on concentration, solutions and solubility; density demostrations
* Homework
* Quizzes
* Tests

**Pacing –** 2 weeks

**Physical Science**

**Structure of Knowledge**

**Motion**

**Benchmark D:** Explain the movement of objects by applying Newton’s three laws of motion

**Essential Understandings**

1. Determine the displacement of an object by subtracting the initial position from the final position. Displacement can be positive or negative and may not be equal to the distance traveled.
2. Find the speed and velocity of a body and know what those values tell you about the motion of the body.
3. Be able to find constant velocity and instantaneous velocity of an object.
4. Find the acceleration of a body and know what this value tells you about the motion of the body.
5. A constant velocity means a body will gain an equal amount of distance each second.
6. A constant acceleration means the body will have an equal change in velocity each second.
7. Motion can be represented with position vs. time and velocity vs. time graphs, and those graphs can be interpreted to represent the motion of the body.
8. A body accelerates when it speeds up, slows down, or changes direction.
9. A body falling through the air accelerates due to gravity.

**Key Concepts and Indicators**

1. How to determine an objects displacement, speed, velocity and acceleration.
2. Identify constant speed motion and constant acceleration motion based on motion diagrams and graphs.
3. Interpret motion diagrams and motion graphs to describe the motion of the object.
4. Produce motion diagrams or motion graphs when given a description of the motion of an object.
5. Identify how distance is affected by speed and acceleration.
6. Relate displacement, velocity and acceleration to a body moving through the air under the influence of gravity.

**Assessments**

* **Motion Diagram Labs** with tape – students prepare motion diagrams to represent different types of constant velocity motion and accelerated motion, and then walk the diagrams to feel that type of motion. They prepare simple distance vs. time and velocity vs. time graphs to relate the graphs and what they tell them about their motion that they walked.
* **Velocity Lab** – Students measure the velocity of an object and prepare graphs of distance and time and velocity and time. The motion is of constant velocity. They also collect photogate data to observe instantaneous speeds and how those speed values compare to their constant velocity motion.
* **Acceleration Lab** – students measure acceleration of an object on an incline by measuring the time it takes to change the velocity of the object. Various starting points on an incline are used to give a range of velocity and time data. The data can be graphed to show how velocity changes relative to time and the distance vs. time for an accelerated object.
* **Graph Matching Lab** motion detectors – Students are given motion detectors that provide graphs of distance vs. time and velocity vs. time that they have to interpret and match by moving a dynamics car. The aim is to be able to read the graph and determine what the motion is of the object, then reproduce it. They should also be able to realize the difference between what the distance graph tells you versus the velocity graph.
* **Acceleration Lab** – students observe and measure the acceleration of an object on an incline, and prepare graphs of accelerated motion, both distance vs. time and velocity vs. time.
* **Acceleration of Gravity** – students measure the acceleration of gravity by observing a ball falling toward a motion detector.
* **Web Sites**
  + <http://www.physicsclassroom.com/> - has explanations, questions and worksheets on various types of motion
  + <http://www.walter-fendt.de/ph14e/>
  + <http://phet.colorado.edu/> - on line lab files, The Moving Man in particular to produce graphs of different types of motion
* Homework
* Quizzes
* Tests

**Pacing –** 3 weeks

**Physical Science**

**Structure of Knowledge**

**Forces**

**Benchmark D:** Explain the movement of objects by applying Newton’s three laws of motion

**Essential Understandings**

1. Forces are interactions that act on a body.
2. Forces are vector quantities that give magnitude and direction.
3. Examine a variety of forces to observe their behavior, how they affect motion, which direction they point.
4. Newton’s Laws explain how objects interact and motion occurs.
5. When forces are balanced on an object, the object moves at a constant velocity.
6. When forces are not balanced, the object will move with an acceleration.
7. Forces that act on objects will occur in pairs. These forces are always equal in size but act in opposite directions on opposite bodies.

**Key Concepts and Indicators**

1. Identify the type of forces that act on a body.
2. Identify constant velocity motion occurs when forces acting on a body are balanced.
3. Identify accelerated motion occurs when the forces acting on a body are unbalanced, giving a net force.
4. Determine the value of the net force given one-dimensional forces acting on a body.
5. Find the size of a force when a net force is acting, when other one-dimensional forces are given.
6. Understand the types of forces that act on an object, when they act, and which direction they act.
7. Identify Newton’s third law as an interaction between two objects, and that the force that acts between the objects is equal in size, opposite in direction, and acts on each object.

**Assessments**

* **Parallel Force Lab** – as an illustration of Newton’s First Law, the sum of vertical forces acting on a meterstick at rest will be 0 N. Students will use force scales to measure supporting forces on a meterstick that has its weight and another weight acting on it. Weights will be calculated using the weight formula; these act down. The support forces of the force probes act up. The sum of these forces should equate to 0 N, or close.
* **Hooke’s Law Lab** – students will examine Newton’s first law by using Hooke’s Law. Forces will be identified and shown acting on the object. Students will use Newton’s first law to determine the amount of force in the spring (which will be the weight of the object from the spring).
* **Friction Lab** – students will examine friction by using Newton’s first law to pull a sled. The force of the pull is balanced by the friction force, which allows them to know the friction force. Different surfaces will be used to show how the amount of friction depends on the surface type, and also how the normal force changes the amount of friction force.
* **Newton Second Law Lab** – students will examine the relationship between force, mass and acceleration. Forces will be increased on a mass, which will increase the acceleration. A constant force will act on a mass, which will decrease the acceleration.
* **Centripetal Force Lab** – students will examine how gravity acts in a simulation using a string to spin a mass in a circular orbit. The gravitational pull on the planet is changed by changing the amount of mass that must be held up by the motion of the planet. The lab will also show that a force acting in a particular direction will cause the motion to change in that direction.
* **Web Sites**
  + <http://www.physicsclassroom.com/>
  + <http://www.walter-fendt.de/ph14e/>
  + <http://phet.colorado.edu/> Sims that illustrate force concepts: Force and Motion: basics; Masses and Springs; Fricton; Forces in 1 Directon; Force and Motion; The Ramp; Ramp: Forces and Motion; Buoyancy
* **Quizzes**
* **Tests**
* **Homework Assignments**

**Pacing** – 4 weeks

**Physical Science**

**Structure of Knowledge**

**Work and Energy**

**Essential Understandings**

1. Work is the process by which energy is transferred between objects and is found by the application of a force for a displacement.
2. Kinetic energy is energy due to the motion of an object.
3. Kinetic energy depends on the mass of the object and the speed of the object.
4. Gravitational potential energy is energy stored due to the height an object is above a surface.
5. Gravitational potential energy depends on the mass of the object, the height of the object, and the acceleration of gravity.
6. Energy can appear in many forms that can change from form to form.
7. As energy changes form, the amount of energy remains constant.

**Key Concepts and Indicators**

1. How to determine the amount of work done by a force.
2. How to determine the kinetic energy of an object.
3. How to determine the potential energy of an object.
4. Examine changes in energy that take place in a system and how the energy transforms from one type to another.
5. Represent the energy changes in a system (roller coaster car going downhill) using energy bar graphs.
6. Examine how energy changes occur in a system but the total amount of energy will remain constant.
7. Solve problems involving work, kinetic energy and potential energy.

**Assessments**

* **Work Lab –** students pull objects using a force scale for distances to measure the amount of work that is done.
* **Kinetic Energy Lab** – students will measure the kinetic energy of a cart. The will determine the mass and measure the speed to find the kinetic energy. The kinetic energy of the cart is given to the cart by a spring that does work on the cart.
* **Potential Energy and Work –** a ball is given potential energy on a ramp. That energy is used by the ball to push a wood block along a horizontal surface, doing work to the block to move it. Comparisons can be made between the amounts of potential energy the ball has to the amount of distance the block moves on the track.
* **Conservation of Energy Lab** – students will find the potential energy and kinetic energy of a car on a ramp at various locations to show that the total amount of mechanical energy remains the same.
* **Conservation of Mechanical Energy Ball Throw** – students can compare the potential and kinetic energies of a ball in flight using a motion detector. The detector will give them position and speed data that they can use to measure the energy at various points of the motion of the ball.
* **Pendulum Lab: Conservation of Energy** – students can measure the potential energy at the height of the swing, and measure the speed of the bob at the lowest part of the swing, to compare the energies of the ball at each location
* **Web Sites**
  + <http://www.physicsclassroom.com/>
  + <http://www.walter-fendt.de/ph14e/>
  + <http://phet.colorado.edu/> Energy Skate Park: Basics; Masses and Springs; Energy Skate Park; The Ramp
* **Homework**
* **Quizzes**
* **Tests**

**Pacing**  - 3 weeks

**Physical Science**

**Structure of Knowledge**

**Thermal Energy**

**Essential Understandings**

1. Atoms and molecules of materials are in constant motion.
2. Temperature measures the average motion of molecules of a substance.
3. The total molecular energy of the material is the thermal energy of the material.
4. Heat is the transfer of thermal energy from material to material.
5. As energy changes form, the amount of energy remains constant.
6. Conduction is heat transfer by direct contact.
7. Convection is heat transfer by moving material.
8. Radiation is heat transfer by electromagnetic waves.
9. Energy is transferred between objects of different temperatures until thermal equilibrium is established between the objects.
10. Objects undergo phase changes and differences in density as a result of heating.

**Key Concepts and Indicators**

1. How to measure the temperature of a body and what the temperature indicates about the molecular motion of the molecules of the body.
2. Heat flows between bodies based on temperature, and always flows from a high temperature to a lower temperature.
3. Objects can acquire heat energy differently and gain or lose temperature in different amounts based on their ability to absorb or release heat.
4. Realize that heat added to a body changes the molecular motion and energy.
5. Adding heat at a phase change changes the energy of the system but does not raise the temperature of the system.
6. Read and interpret phase change diagrams to determine the amount of energy needed to convert a substance in one state to another state.

**Assessments**

* **Heat transfer lab/demonstration** with cans and light – use the demonstration to show the three types of heat transfer occurring as heat moves from a light, through a can and into the air inside the can. The cans are also different colors (silver and black) which allow students to see how each can allows for the transfer of heat differently.
* **Specific heat lab** – students will measure the specific heat of a known substance by measuring the change in temperature that the object has on water when the object is placed into water. The temperature change can be used to calculate the specific heat. Using different samples will also show how different materials have different abilities to transfer heat energy.
* **Phase change lab with ice** – student will melt ice in a known amount of warm water. The cool water produced will warm to a final equilibrium temperature with the warmer water. By finding the amount of heat gained by the cool water, students will see that the amount of energy gained to warm the water is not equal to the amount of energy lost by the warm water – some of that energy had to go into melting the ice, without a change in temperature of the ice. Relating what they see with a heating curve will be made.
* **Phase change of water lab** – students will observe ice converting to water converting to steam and measure the temperature at which these phase changes occur
* **Web Sites**
  + <http://www.physicsclassroom.com/>
  + <http://www.walter-fendt.de/ph14e/>
  + <http://phet.colorado.edu/> Energy Forms and Changes; States of Matter: Basics; Friction; Gas Properties; States of Matter
* **Homework**
* **Quizzes**
* **Tests**

**Pacing** – 3 weeks

**Physical Science**

**Structure of Knowledge**

**Electricity**

**Essential Understandings**

1. Electricity is the movement of electrons, known as a current
2. Power source supplies existing electrons with energy by separating opposite electric charges.
3. Resistors oppose the rate of charge in the circuit.
4. Electric charges use energy to pass through a resistor
5. Electric potential and resistance affect the amount of current in a circuit.

**Key Concepts and Indicators**

1. Illustrate the origin and motion of electrons in a circuit.
2. Understand the role of a battery as the energy source and resistors as the energy dissipaters in an electric circuit.
3. Show how electric potential affects the current in a circuit.
4. Show how resistance affects the current in a circuit.

**Assessments**

* **Circuits** – students will build a simple circuit with a battery and light bulb and measure the current and voltage in the circuit.
* **Web Sites**
  + <http://phet.colorado.edu/> demonstration files for electric circuits, including Ohm’s Law and the resistance of w wire
* **Quizzes**
* **Homework Assignments**
* **Tests**

**Pacing** – 2 weeks

**Physical Science**

**Structure of Knowledge**

**Waves**

**Benchmark G:** Demonstrate that waves (e.g. sound, seismic, water, light) have energy and waves can transfer energy when they interact with matter.

**Essential Understandings**

1. Waves carry energy.
2. Light is one form of electromagnetic energy.
3. Electromagnetic waves do not require a medium for travel, while mechanical waves do require a medium. The medium characteristics will change the speed of the wave motion.
4. Waves reflect from surfaces.
5. Waves can pass through and into a material and change speed and direction as they do so.
6. Waves can interact with each other and superimpose on each other.
7. Waves have the ability to bend around corners or through openings in barriers.
8. Relate observations of mechanical waves (springs, water) to electromagnetic waves.
9. The Doppler Effect occurs when waves are produced from a source that has a relative motion towards or away from an observer.

**Key Concepts and Indicators**

1. Understand that the medium affects the speed of a wave and that observing waves in various media can illustrate how the medium is affecting the wave motion.
2. Understand that waves are energy moving between two places.
3. Understand the law of reflection.
4. Observe and explain how refraction takes place as a wave enters a new material.
5. Observe and show how waves interfere with each other; how they add or subtract amplitudes when they meet; and how they continue their motion after the interaction.
6. Examine diffraction of waves as the wave passes around a barrier.

**Assessments**

* **Wave Labs and Demonstrations** – students will use springs to examine basic wave characteristics and behaviors – reflecting from ends, traveling through the medium, interfering with each other, transferring into a new medium.
* **Ripple tank computer** applet for demonstrations of wave phenomena in 2D space – reflection, refraction, diffraction and interference <http://www.falstad.com/ripple/index.html>
* **Light Labs** - Reflection, Refraction, Diffraction and Interference – all labs will allow students to observe that light has the same characteristics as mechanical waves. These labs include: mirrors; refraction of light; lenses; diffraction and interference
* Wave handouts/photographs of wave behavior
* **Web Sites**
  + <http://www.physicsclassroom.com/>
  + <http://www.walter-fendt.de/ph14e/>
  + <http://phet.colorado.edu/> Wave Interference; Radio Waves and Electromagnetic Fields; Waves on a String; Bending Light; Geometric Optics;
* **Quizzes**
* **Homework Assignments**
* **Tests**

**Pacing** – 3 weeks

**Physical Science**

**Structure of Knowledge**

**Atoms and Periodic Table**

**Benchmark A:** Describe that matter is made of multiple particles called atoms and atoms are compromised of even smaller components. Explain the structure and properties of atoms.

**Benchmark C:** Describe the identifiable physical properties of substances (e.g. color, hardness, conductivity, density, concentration, ductility). Explain how changes in these properties can occur without changing the chemical nature of the substances.

**Essential Understandings**

1. The periodic table is organized according to common properties.
2. All atoms contain protons, neutrons and electrons.
3. The atom has a structure, which is illustrated in the periodic table.
4. Discovery of structure – Thomson, Rutherford and Bohr
5. The structure of an atom helps to give an atom its physical and chemical properties.
6. Ions are charged atoms, containing different number of electrons than protons.
7. Isotopes are elements with different masses, based on different numbers of neutrons in the nucleus.

**Key Concepts and Indicators**

1. Understand how to read and interpret the periodic table.
2. Understand how to read different atomic nomenclature and symbols, which tell you atomic mass, atomic weight and numbers of electrons.
3. Know the parts of an atom, how many particles belong in the atom, and where in the atom these particles must be.
4. Understand the role that the atomic parts and structure play on the properties of elements and materials.
5. Build ions of atoms based on the placement of the atom on the periodic table.
6. Build isotopes of atoms based on given mass information.
7. Determine the number of electron shells for an atom, and determine the number of valence electrons in that atom based on placement on the periodic table.

**Assessments**

* **Element Research Project**
* **Atomic Models** – making the atom based on its structure – number of protons, neutrons and electrons, in proper place and with the proper amount of each item
* **Periodic Table work** – identifying properties and structure based on the periodic table; identify how ions are formed based on location on the periodic table
* **Quizzes**
* **Homework Assignments**
* **Tests**
  + <http://www.physicsclassroom.com/>
  + <http://phet.colorado.edu/> Check the chemistry section of PhET for atomic building sims, Rutherford scattering, isotope models

**Pacing –** 3 weeks

**Physical Science**

**Structure of Knowledge**

**Reactions/Chemistry**

**Essential Understandings**

1. Atoms form ions by gaining or losing electrons, becoming negatively or positively charged in the process.
2. Atoms connect using their electrons to form molecules and compounds.
3. Atoms bond together by sharing electrons (covalent bonding) or by electrical forces due to opposite charge (ionic bonding)
4. The structure of an atom helps to give an atom its physical and chemical properties.
5. Chemical equations are ways for compounds to interact and form new substances.
6. In Chemical reactions, the total mass and charge will always be the same.

**Key Concepts and Indicators**

1. Understand how to read and interpret the periodic table.
2. Know the parts of an atom, how many particles belong in the atom, and where in the atom these particles must be.
3. Be able to identify a bond as ionic or covalent based on the elements that are being bonded together.
4. Be able to write chemical formulas for bonds, based on how many of each element is required to make the compound when bonding
5. Identify chemical equations by type, and realize that the total mass and type of atoms must be the same on both sides of the equation.
6. Balance chemical equations using conservation of charge and mass.

**Assessments**

* **Chemical equation problems**
* **Chemical labs –** simple experiments that show the different types of reactions and how the two chemicals mix to make new materials
* **Quizzes**
* **Homework Assignments**
* **Tests**
  + <http://www.physicsclassroom.com/>
  + <http://phet.colorado.edu/> Check the chemistry section for balancing chemical equation sim and others

**Pacing – 2** weeks

**Physical Science**

**Structure of Knowledge**

**Nuclear Activity**

**Benchmark A:** Describe that matter is made of multiple particles called atoms and atoms are compromised of even smaller components. Explain the structure and properties of atoms.

**Benchmark F:** Explain how energy may change from or be redistributed but the total quantity of energy is conserved

**Essential Understandings**

1. Radioactivity is a naturally occurring process that releases particles and energy from the atomic nucleus.
2. There are three types of radioactivity, called alpha, beta and gamma.
3. Each radioactivity has different properties and characteristics.
4. Half life is the time for half of a radioactive substance to decay into a new substance.
5. Radioactivity led to the discovery of fission and fusion.
6. Fission is the splitting of heavy nuclei to release energy.
7. Fusion is the joining of light molecules to release energy.

**Key Concepts and Indicators**

1. Identify the types of radioactivity by property.
2. Write radioactivity equations, showing the transmutation of the mother element into the daughter element.
3. Determine the amount of time or the amount of material left during a radioactive decay process using half life.
4. Identify a fission reaction and understand why fission is used as a fuel, as well as identify pitfalls and advantages with fission over other types of fuels.
5. Identify a fusion reaction and know that it presently takes place in stars.

**Assessments**

* **Radioactivity and Half-life** dice lab – students will observe how nuclei go through the process of decay, and use the process to determine the half life of a substance.
* **Radioactive dating lab** – students will age rocks by counting radioactive and daughter nuclei in a sample. By knowing what the mother element is and its half life, the amount of material left gives an age of the rock sample.
* **Rock strata sequencing lab** – (optional lab) students are given a rock layer sample, from different regions, in various states of incompleteness, to give the relative ages of the rock layers.
* On line rock strata sequencing
* Fission and fusion applets online
* **Web Sites**
  + <http://www.physicsclassroom.com/>
  + <http://www.walter-fendt.de/ph14e/>
  + <http://phet.colorado.edu/> Beta Decay, Alpha Decay, Fission; other appropriate ones that fit this section
* **Quizzes**
* **Homework Assignments**
* **Tests**

**Pacing –** 2 weeks

**Physical Science**

**Structure of Knowledge**

**The Universe**

**Essential Understandings**

1. History of the universe starting with the Bing Bang and the use of Hubble’s law to show expansion of the universe.
2. Galaxies are a vast collection of stars, with various shapes.
3. Stars are the result of fusion and gravitational collapse.
4. Stars are classified by size, color, luminosity and mass.

**Key Concepts and Indicators**

1. Explain the motion of a galaxy as viewed from Earth, based on the blue shift or red shift of light from the galaxy.
2. Understand the process of star formation from clouds of hydrogen and helium.
3. Illustrate fusion in a star to the production of heavier elements.
4. Use a Hertzspring-Russell diagram to relate a star’s characteristics to its place on the main sequence.

**Assessments**

* **Interpretation of Hertzsprung-Russell diagram** – students will use a HR diagram and start characteristics to locate a star on the diagram and predict the future stellar evolution of this star
* **Galaxy project** – students will illustrate the different types of galaxies (whirlpool, elliptical, globular) and explain how their formation took place
* **Quizzes**
* **Homework Assignments**
* **Tests**

**Pacing** – 3 weeks