Hayti R-II School District
9th Grade Physical Science Curriculum

Our vision at Hayti High School is to prepare and motivate our students for a rapidly changing world by instilling in them critical thinking skills, academic excellence, leadership and respect for core values. Students will have success for today and be prepared for tomorrow.

Course Description: Physical Science is an introductory science course designed to familiarize the student with concepts of matter, forces, and energy in the universe. Emphasis is on scientific literacy and hands-on investigation.

Big Ideas:

- Asking Questions and Defining Problems
- Developing and using models (verbal, mathematical and graphical)
- Planning and carrying out investigations
- Analyzing and interpreting data tables and graphs
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in an argument from evidence
- Obtaining, evaluating, and communicating information.

Missouri Learning Standards (Priority)

- Analyze data to support and verify the concepts expressed by Newton's 2nd law of motion, as it describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of me for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] (9-12.PS2.A.1)
- Create a computational model to calculate the change in the energy of one component in a system when the changes in energy are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] (9-12.PS3.A.1)
- Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. (9-12.PS2.B.2)

- Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles. [Clarification Statement: Emphasis is on understanding the relative strength of forces between particles. Examples of parcels could include ions, atoms, molecules, and networked materials (such as graphite). (9-12.PS1.A.3)
- Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both qualitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] (9-12.PS3.B.1)
- Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media (9-12.PS4.A.1).
- Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] (9-12.PS4.A.2)

Unit 1: Experimental Design

Standards:

- **9-12.PS1.A.1**
- **9-12.PS1.A.3**
- **9-12.PS1.B.1**

***These standards will not be explicitly addressed in this unit, but the skills and processes necessary to master them (such as experimental design, data collection, data / graphical analysis, model building, etc.) will be taught to students.

Pacing: Year long. This unit will focus on the basics of designing, conducting and analyzing experiments. Students will be implementing these standards in every unit for the duration of the course.

Big Ideas:

- Scientists use experiments to investigate the universe.

Enduring Understanding:

- Scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation.
- Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations.
- Scientific inquiry includes evaluation of explanations (laws/principles, theories/models) in light of evidence (data) and scientific principles (understanding)
- The nature of science relies upon communication of results and justification of explanations.

Essential Questions:

1. How do scientists design experiments?
2. How do scientists determine if something is “true”?
3. How and why do scientists model what happens in the real world?
4. Can students use the scientific equipment effectively as well as make metric conversions?
5. Can the student set up a valid experiment including essential components?

Learning Targets:

- Students will conduct an experiment while following safety protocol.
- Students will be able to identify variables and constants.
- Students will associate units to quantities
- Students will construct a data table Create graphs to represent data (graphs should include title, labeled axis)
- Students will write a detailed procedure and conclusion
- Students will Use dimensional analysis to effectively convert units (metric and standard)

Unit 2: Mechanics (Newton's Laws of Motion)

Standards:

- **9-12.PS2.A.1** Analyze data to support and verify the concepts expressed by Newton's 2nd law of motion, as it describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of me for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.]
- **9-12.PS2.A.2** Use mathematical representations to support and verify the concepts that the total momentum of a system of objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.]
- **9-12.PS2.A.3** Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute]

Pacing: 12 blocks

Big Ideas:

- The motion of an object is determined by its change in position relative to another object or point.

Enduring Understanding:

- Students will understand the motion relative to a frame of reference.
- Students will be able to represent the moon of an object by looking at a position/acceleration vs. time graph.
- Students will be able to determine net force acting on an object and whether or not the object is accelerating according to Newton's 1st Law.

Essential Questions:

1. How can the moon of an object be described?
2. How does slope represent the state of motion of an object?
3. How is acceleration for an object represented graphically compared to constant velocity?
4. How can Newton's Laws be used to explain the current state of motion for an object?

Learning Targets:

- Students will calculate acceleration, speed and velocity
- Students will associate units with quantities

- Students will determine motion for an object graphically
- Students will identify the state of equilibrium for an object Determine direction of an object (positive and negative)
- Students will be able to graph the motion of an object

Unit 3:Forces

Standards:

- **9-12.PS2.A.1** Analyze data to support and verify the concepts expressed by Newton's 2nd law of motion, as it describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of me for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.]
- **9-12.PS2.A.2** Use mathematical representations to support and verify the concepts that the total momentum of a system of objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.]
- **9-12.PS2.A.3** Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute]

Pacing: 18-20 blocks

Big Ideas:

- Forces affect motion

Enduring Understanding:

- Forces are classified as either contact forces (pushes, pulls, friction, buoyancy) or non-contact forces (gravity, magnetism), that can be described in terms of direction and magnitude.
- Every object exerts a gravitational force on every other object
- Newton’s Laws of Moon explain the interaction of mass and forces, and are used to predict changes in moon
- Perpendicular forces act independently of each other

Essential Questions:

1. What is the difference between mass and weight?
2. How does mass and force affect the acceleration of an object?
3. What factors affect gravitational forces?
4. What are the forces acting on an object? Does this cause the object to speed up, slow down, change directions, or remain at rest.
5. How does the net force acting on an object result in its change in moon?
6. What are action/reaction pairs in any example of an object?

Learning Targets:

- Students will conduct an experiment while following safety protocol.
- Students will associate units to quantities.
- Students will be able to calculate weight from mass.
- Students will be able to use Newton's 2nd law equation.
- Students will predict the state of motion for an object.
- Students will be able to diagram forces acting on an object.
- Students will be able to identify action/reaction pairs.

Unit 4:Momentum

Standards:

- **9-12.PS2.A.2** Use mathematical representations to support and verify the concepts that the total momentum of a system of objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.]
- **9-12.PS2.A.3** Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.]

Pacing: 12 blocks

Big Idea:

- The motion of an object is described by its change in position relative to another object or point.

Enduring Understanding:

- Momentum depends on the mass of the object and the velocity with which it is traveling.

Essential Questions:

1. What are the factors that affect momentum?
2. How can the momentum of an object be changed?
3. How is momentum conserved?
4. What are the different types of collisions?
5. What steps are necessary to calculate momentum or the unknown variable using the momentum equation?

Learning Targets:

- Students will calculate momentum for an object.
- Students will describe how the factors of impulse result in momentum change.
- Students will identify a collision as elastic or inelastic.
- Students will solve for unknown variables using conservation of momentum equations.
- Students will explain the change in velocity as a result of a collision based on the law of conservation principle.

Unit 5:Work, Power, and Energy

Standards:

- **9-12.PS3.A.1** Create a computational model to calculate the change in the energy of one component in a system when the changes in energy are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.]
- **9-12.PS3.A.2** Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.
- **9-12.PS3.A.3** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.]

Pacing: 12 blocks

Big Ideas:

- Energy has a source, can be stored, and can be transferred but is conserved within a system.
- Forces affect motion

Enduring Understanding:

- Forms of energy have a source, a means of transfer (work and heat), and a receiver.
- Mechanical energy comes from the moon (kinetic energy) and/or relative position (potential energy) of an object.
- Energy can be transferred within a system as the total amount of energy remains constant (i.e., Law of Conservation of Energy).
- Work transfers energy into and out of a mechanical system.

Essential Questions:

1. How can we identify when work has been done?
2. What is the relationship between work and power?
3. How do simple machines make work easier?
4. What are the various forms of energy?
5. How does energy take on various forms based on the Law of Conservation of Energy?

Learning Targets:

- Students will design or implement a lab experiment using simple machines to calculate work done, efficiency, mechanical advantage and other ways of measuring a machine's effectiveness.
- Students will apply the definition of work to everyday scenarios.
- Students will determine the power output for a simple machine.
- Students will identify the energy transformations that take place in a system.
- Students will calculate the amount and types of energy that exist at various stages.

Unit 6: Electricity and Magnetism

Standard:

- **PS2.B.2** Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

Pacing:12 blocks

Big Ideas:

- Changes in properties and states of matter provide evidence of the atomic theory of matter
- Forces affect motion

Enduring Understanding:

- The atomic model describes the electrically neutral atom
- Magnetic forces are related to electrical forces as different aspects of a single electromagnetic force

Essential Questions:

1. What is the structure of an atom?
2. What gives an element its properties?
3. Why are electrons, rather than protons, the principal charge carriers in metal wires?
4. What factors contribute to static electricity?
5. What effect does applying resistance do to the electric current?
6. If the voltage impressed across a circuit is held constant while the resistance doubles, what change occurs in the current?
7. How do the different circuits cause different amounts of current?
8. Why are some pieces of iron magnets and others are not?
9. What factors increase the strength of an electromagnet?
10. What is the relationship between current and magnetism?

Learning Targets:

- Identify subatomic particles and their charges in an atom
- Explain how static electricity occurs in detail
- Predict if attraction or repulsion will occur between two charges
- Be able to explain how an electrically charged object can be attracted to a neutral object
- Understand that in order to have an electrical current an electrical potential (voltage) must be present
- Use ohm's law to calculate for unknown variables in a circuit
- Be able to identify characteristics of a series and parallel circuit
- Be able to draw schematic diagrams of the two types of simple circuits
- Find the current, voltage and resistance in a circuit
- Explain why some pieces of iron can become magnetic

Unit 7:Heat and Thermal Energy

Standards:

- **PS1.A.3** Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles. [Clarification Statement: Emphasis is on understanding the relative strengths of forces between particles. Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite)**.**
- **PS3.B.1** Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.]

Pacing: 12 blocks

Big Ideas:

- Changes in properties and states of matter provide evidence of the atomic theory of matter.
- Energy has a source, can be stored, and can be transferred but is conserved within a system.

Enduring Understanding:

- Physical changes in states of matter due to thermal changes in materials can be explained by the Kinetic Theory of Matter.
- Forms of energy have a source, a means of transfer (work and heat) and a receiver.

Essential Questions:

1. What is the difference between heat, temperature and thermal energy?
2. How is temperature measured? (3 scales)
3. Why do some objects heat up or cool down faster than others?
4. Why doesn't temperature change when undergoing a phase change?
5. Why is evaporation a cooling process and condensation a warming process?
6. What are the different types of heat transfer?
7. What is thermal equilibrium?
8. How does thermal expansion affect certain objects? How is water different from other objects?

Learning Targets:

- Students will explain the difference between thermal energy, heat and temperature .
- Students will distinguish between a heat conductor and insulator.
- Students will use a graph to explain that when the energy of the particles making up a substance changes, either the temperature must change or the phase, but not both at the same time.
- Students will convert between Celsius, Fahrenheit and Kelvin scales.
- Students will calculate energy using the specific heat equation.
- Students will determine the change in temperature using the principle that heat is neither gained nor lost.
- Students will explain water's role in climate.

Unit 8:Waves

Standards:

- **PS4.A.1** Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.
- **PS4.A.2** Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.]

Pacing: 12 blocks

Big Ideas:

- Energy has a source, can be stored, and can be transferred but is conserved within a system.

Enduring Understanding:

- Forms of energy have a source, a means of transfer (work and heat) and a receiver.
- Electromagnetic energy from the sun (solar radiation) is a major source of energy on Earth.

Essential Questions:

1. What are the main types of waves?
2. How does a mechanical wave compare/contrast to an electromagnetic wave?
3. What causes waves?
4. What determines the frequency of a wave?
5. How does changing the medium of a wave affect the speed?
6. How is the amplitude of a wave related to the energy in a wave?
7. What is a standing wave? Are standing waves a property of transverse waves, of longitudinal waves, or of both?
8. Distinguish between constructive interference and destructive interference.
9. How is frequency related to pitch in a sound wave?
10. What are overtones?

Learning Targets:

- Students will Identify characteristics of a transverse wave (wavelength, amplitude, crest and trough).
- Students will identify characteristics of a longitudinal wave (compressions and rarefactions).

- Students will find the frequency and period in a wave.
- Students will know wavelength and frequency to solve for the speed of a wave.

Standards Based Assessment
Student Proficiency

Conversion Grading Rubric

	4	3.5	3	2.5	2	1.5	1
	100%	95%	90%	89-80%	79%-70	69%-60	59% and below
Criteria	Correctly answers all questions correctly **including stretch**	Correctly answers all essential component questions **and partial knowledge of stretch**	Answers all essential component questions.	Misses 1-2 essential components	Misses 3 essential components	Misses 4 or more essential components	Even with assistance demonstrates no knowledge of the concepts

**From Robert J. Marzano's Formative Assessment and Standards Based Grading

Strand : PS1.A.1			
Topic: Experimental Design			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Use the organization of the periodic table to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** ● Will be able to identify mass number and net charge of various elements. **The student exhibits no major errors or omissions.**		● Students are given diagrams to identify the position of the subatomic particle within an atom. ● Students are given varying amounts of protons, neutrons, and electrons to determine the mass number or other unknown values.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Will be able to identify charges and position of subatomic particles and how it relates to different elements. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Same as above.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: PS1.A.3			
Topic: Experimental Design			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles.** ○ The students will be able to use scientific equipment to measure quantities using metric units. ○ Students will include correct units on all answers / measurements. ○ Students will be able to construct a useful data table and generate a graph from the data. **The student exhibits no major errors or omissions.**		● Given objects, students will be able to find mass, volume, length and density ● Conduct a lab to acquire data and graph said data.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Recognizes or recalls specific terminology, such as: ○ graduated cylinder, metric ruler, triple beam balance ● Performs basic processes, such as: ○ identify the lab equipment associated with the quantities ● Recognizes or recalls specific terminology, such as: o axes, best fit line ● Performs basic processes, such as:		● Identifying the equipment associated with the measurement ● Given a blank data table or graph, students can apply labels

	o Labeling and titling a graph and data table **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: PS2.A.3			
Topic: Motion and Newton's 1st Law			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.** ○ Students will be able to understand motion relative to a frame of reference and can differentiate velocity from acceleration. Students can use this understanding to perform basic calculations to find speed, distance, and acceleration. ○ Students will be able to represent the motion of an object graphically or describe the motion of an object by looking at a position/velocity vs. time graph. **The student exhibits no major errors or omissions.**		● Given an object in motion, identify the frame of reference ● Determine if an object is accelerating through calculations. ● Given data students can construct appropriate graphs and find their slope. ● Given graphs, students can describe the motion of an object.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Recognizes or recalls specific terminology, such as: o velocity, acceleration, frame of reference, ● Performs basic processes, such as: o connects values to quantities o recognizes which equation to apply		● Identify values in relation to the quantities they represent ● Can recall basic equations.

	● Can differentiate between graphs of constant and non-constant velocity. ● Know which direction an object is moving based on a graph of its motion. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: PS2.A.1			
Topic: Newton's 1st and 2nd Laws			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Analyze data to support and verify the concepts expressed by Newton's 2nd law of motion, as it describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.** ○ Students will be able to determine net force acting on an object and whether or not an object is accelerating according to Newton's First Law. ○ Students will understand the relationship between mass, net force and acceleration and can use this understanding to predict the behavior of an object under the influence of one or several forces. **The student exhibits no major errors or omissions.**		● Draw / interpret force diagrams of different scenarios. ● Find the net force given a force diagram. ● Observe and describe the motion of a HoverPuck. ● Solve for net force, mass, and/or acceleration using Newton's 2nd Law.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Can state Newton's 1st Law. ● Can apply Newton's 1st Law for a stationary or moving object. ● Can define equilibrium ● Can recall Newton's 2nd Law. ● General understanding of relationship between net force / mass and acceleration. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Give examples of relationship (e.g. a loaded car doesn't accelerate as much as an empty car)
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		

Strand : PS2.A.2			
Topic: Newton's 2nd & 3rd Law			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Use mathematical representations to support and verify the concepts that the total momentum of a system of objects is conserved when there is no net force on the system.** ● Students will identify the different types of forces that act on an object and know factors that affect those forces (e.g. coefficient of friction). Students can represent these forces in a free body diagram. ● Will be able to analyze action/reaction pairs. ● Can use Newton's 2nd Law to explain why equal forces do not produce equal responses. **The student exhibits no major errors or omissions.**		● Given a scenario, students can draw F.B.D. ● Can determine the net force from a force diagram and solve for any acceleration. ● Given a scenario, students can identify action-reaction pairs. ● Students can explain examples of Newton's 3rd Law in action (e.g. walking, gun recoil, etc.)
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Know definitions of different types of forces and the directions that they act. ● Can recognize examples of these forces. ● Can state Newton's 3rd Law and recognize simple examples.		● Same as above.

	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand : PS2.A.2			
Topic: Momentum			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Use mathematical representations to support and verify the concepts that the total momentum of a system of objects is conserved when there is no net force on the system.** ○ Students can identify the factors that affect momentum and can use those factors to calculate the amount of momentum. ○ Understand the relationship between momentum, force and time in order to predict how a given force changes momentum. **The student exhibits no major errors or omissions.**		● Students will calculate momentum of objects in a variety of situations. ● Students can describe real-world examples of how to safely change momentum using a small force over a longer time. (e.g. air bags)
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Can state the definition of momentum and perform simple calculations using p = mv. ● Recognize that forces can change momentum. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Same as above.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	

Strand: PS2.A.3			
Topic: Momentum			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.** ○ Students can use the Law of Conservation of Momentum to predict the outcome of collisions and explosions. **The student exhibits no major errors or omissions.**		● Students will explore the difference between elastic and inelastic collisions. ● Explore collisions with class demonstrations and online collision simulations.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students recognize that momentum will not change if no net force is exerted. (Momentum is conserved). ● Students can perform simple collision/explosion calculations. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Same as above.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: PS3.A.2			
Topic: Work and Energy			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).** ○ Students will understand the law of conservation of energy and can apply it to predict the speed, height, stretch. Mass, etc of objects as energy is converted from one form to another. ○ Students will be able to give real-world examples of energy stored in various ways. **The student exhibits no major errors or omissions.**		● Students will show transfer of energy with pie charts or other diagrams. ● Students will practice solving problems using conservation of energy. ● Students can give scenarios of energy stored in one or more ways.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students can recognize the transfer of energy from one form to another.		● Same as above

	● Students can use the definition of each type of energy to calculate the amount of energy stored. ● Can state the Law of Conservation of Energy. ● Students can define the characteristics of systems with energy stored as, gravitational, elastic, chemical, kinetic and thermal. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand : PS3.A.1			
Topic 5: Work and Energy			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Create a computational model to calculate the change in the energy of one component in a system when the changes in energy are known.** ○ Students will understand how work changes the energy in a system and can determine the amount of work done on an object. ○ Given the amount of work, students can predict the final velocity, height, etc of the system. ○ Students can recognize when a force does no work. ○ Students understand the difference between work and power and can calculate the rate at which work is done. ○ Students can describe how power affects the time needed to do work. **The student exhibits no major errors or omissions.**		● Students will give real-world examples of work done. ● Students will diagram work/energy with bar charts or other diagrams. ● Students will practice calculations. ● Students will compare real-world devices of differing power. ● Students will calculate their own power while running up stairs.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**		● Same as above.

		• Students can recognize when work has been done. • Students can state the definition of work and use it to calculate the work done to an object. • Students can define power and calculate how much power is used to do work in simple situations. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**	
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: PS3.A.3			
Topic: Work and Energy			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	

Score 3.0	**The student:**
	• **Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.**
	  ○ Students will understand that simple machines do not decrease the amount of work, and can describe why/how they make work easier.
	  ○ Students can calculate efficiency and mechanical advantage.
	The student exhibits no major errors or omissions.
			• Students will do lab activities measuring the force needed to accomplish tasks with and without various simple machines
			• Students will give examples of real-life simple machines in action.

	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** • Students can identify different types of simple machines. • Students know that S.M.'s decrease force needed by increasing distance. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		• Same as above.

	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**	
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.
Score 0.0	**Even with help, no understanding or skill demonstrated.**	

Strand: PS2.B.2		
Topic: Electricity and Magnetism		
Grade: 9		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**	
	3.5 In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.** ○ Students will be able to describe electrical forces between objects. ○ Should be able to calculate the various quantities of a circuit such as resistance, current, voltage and power. ○ Will be able to use Ohm's Law to determine the current, voltage or resistance in a circuit. ○ Students will be able to explain the correlation between electricity and magnetism. **The student exhibits no major errors or omissions.**	● Be able to explain real life examples of static electricity (i.e. lightning, van der graaf generator, balloons) ● Given a schematic diagram, determine the voltage, current, resistance , and power in a parallel and series circuit. ● Calculate the voltage, resistance and current using Ohm's Law. ● Students will construct an electromagnet.
	2.5 No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**	● Identity whether a circuit is parallel or series.

	● Students will be able to illustrate and describe the current in circuits. ● Students will be able to identify properties of the wire that will affect its ability to conduct electricity. ● Students will be able to explain the effects of magnetism. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**	● Be able to illustrate a schematic diagram of a circuit. ● Compare the properties of the wire that make it an effective conductor. ● Know the difference between conductors and insulators. ● Students should know that like charges attract and unlike charges repel. ● Basic understanding of the structure of the atom. ● Identify magnetic material ● Understand the Earth's magnetic properties and its sources.
	1.5 Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**	
	0.5 With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**	

Strand: PS1.A.3			
Topic: Thermodynamics			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles.** ○ Students will be able to apply the Specific Heat Capacity equation to a substance to determine the amount of heat energy gained or lost. ○ Explain in depth how particles behave in a phase change. ○ Students can describe a scenario in which the differences between temperature and thermal energy are exhibited. ○ Students will convert between the Celsius, Fahrenheit and Kelvin scales. **The student exhibits no major errors or omissions.**		● Students will be able to apply the specific heat capacity equation. ● Students will be able to explain why evaporation is a cooling process or how particles behave during a phase change. ● Given a graph, identify the direction of energy flow and its purpose.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	

Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students will be able to compare specific heat capacities of certain substances. ● Students will be able to understand the behavior of particles before, during, or after a phase change. ● Students can define thermal energy and temperature, as well as recognize critical points on Celsius and Fahrenheit scales. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Given a data table, students can identify substances as having low or high SHC's ● If a substance has a low specific heat capacity it will undergo a faster temperature change than one with a high SHC. ● Students can explain the particle arrangement of the different states of matter. ● Be able to identify the different phase changes. ● Students are able to identify the differences between thermal energy and temperature in an everyday example.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: PS3.B.1			
Topic: Thermodynamics			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).** ○ Students can explain the behavior of particles when they gain or lose energy. The amount of energy gained is equal to the energy lost by the other object. ○ Be able to express the amount of heat transferred between the object and find the final temperature when Heat is transferred **The student exhibits no major errors or omissions.**		● Students can solve sample problems by applying the thermal energy equation. ● Be able to use the Heat gained= heat lost equation. ●
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students can define the principle of thermal equilibrium. ● Students will understand how heat can be transferred and can recognize examples of the 3 methods of heat transfer.		● Students can list examples in which thermal equilibrium occurs. ● Given Illustrations of heat transfer can

	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		identify which type of transfer has occurred.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: PS4.A.1			
Topic: Waves			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** ○ Students will be able to determine the speed of a wave by finding the frequency and wavelength. ○ Students should understand that frequency and wavelength are inversely proportional. ○ Be able to identify and explain factors that determine the speed of sound in a given medium. **The student exhibits no major errors or omissions.**		● Be able to find the speed, wavelength, and frequency of a wave. ● Know that the speed stays the same unless you change the medium. ● Find the wavelength or speed of a sound wave. ● Explain Doppler Effect. ● Be able to identify the overtones of a standing waves ● Find the frequency and speed from the overtone.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**		● Identify the crest, trough, amplitude and wavelength, frequency, period.

	● Students will be able to explain the characteristics and behaviors of various types of waves. ● Students will be able to identify the characteristics and behaviors of sound waves. ● Be able to identify the overtones in a standing wave. ● Students will be able to describe how sound waves interact with each other. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Identify the type of wave (transverse or compressional). ● Know the parts of a sound wave and explain the sound that is produced as a result of those characteristics. ● Know the following key terms: Reflection, refraction, diffraction, resonance, standing waves, constructive and destructive interference.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: PS4.A.2			
Topic: Waves			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other** ○ Students should understand that frequency and wavelength are inversely proportional. ○ Understands that white light is composed of all of the different colors of light. **The student exhibits no major errors or omissions.**		● Can determine the type of electromagnetic radiation based on the model provided (i.e. radio, UV, microwave, etc..) ● Knows what happens when white light is passed through a prism.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Knows the different waves that make up the electromagnetic spectrum and their properties. ● Knows that E.M. waves can travel through mediums as well as through a vacuum. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Can identify a particular wave when given its properties or uses.

	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		