- **PSP1-HS-1**. Analyze data to support the claim that Newton's Second Law of Motion 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 time 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.
  - Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.

Criteria	Advanced Understanding of Standard (4)	Proficient Understanding of Standard (3)	Approaching and Understanding of Standard (2)	Beginning, Does Not Meet Standard (1)	Non-Performance (0, M, I)
Calculate (using Newton's 2nd Law) the force, mass, acceleration of any given object (if given two of three variables)	Student can calculate the value of any variable in Newton's Second Law by measuring two of the variables and calculating the third showing all calculations and including units.	If given two variables the student can calculate the value of the third variable showing all work and including correct units.	If given two variables the student can calculate the value of the third, shows work, but is missing the units.	If given two variables the student cannot calculate the third, does not show work, and does not include units.	Not enough evidence to determine performance.
Interpret a Velocity vs. Time graph to describe the motion of an object depicted in the graph.	Student can translate a Velocity vs. Time graph into a sentence or paragraph that details the motion of the object using terms accelerating, decelerating, at rest, or accelerating or decelerating at an increasing or decreasing rate.	Student can translate a Velocity vs. Time graph into a sentence or paragraph that details the motion of the object using terms accelerating, decelerating, at rest.	Student can translate a Velocity vs. Time graph into a sentence or paragraph that details the motion of the object using terms accelerating, decelerating, at rest with some inconsistencies or errors.	Student cannot translate a Velocity vs. Time graph into a sentence or paragraph detailing the motion of the object using terms accelerating, decelerating, at rest.	Not enough evidence to determine performance.
Construct a Velocity vs. Time graph if given information of how an object's motion changes over time.	Student can collect or measure information about the motion of an object and translate it into a graph of velocity vs. time.	If given information about an objects speed and direction (velocity) the student can translate it into a graph of velocity vs. time.	If given information about an objects speed and direction (velocity) the student can translate it into a graph of velocity vs. time but the graph is incomplete or contains errors.	If given information about an objects speed and direction (velocity) the student cannot translate it into a graph of velocity vs. time.	Not enough evidence to determine performance.

- **PSP1-HS-2**. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is not net force on the system.
  - Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of Newton's First Law of Motion (Inertia)
  - Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.

Criteria	**Advanced Understanding of Standard (4)**	**Proficient Understanding of Standard (3)**	**Approaching and Understanding of Standard (2)**	**Beginning, Does Not Meet Standard (1)**	**Non-Performance (0, M, I)**
Student understands the Law of Conservation of Momentum	A student understands that momentum can move from one object to another but it is not lost. An advanced student recognizes this law applies to closed systems (no outside, unbalanced forces)	A student understands that momentum can move from one object to another but it is not lost.	A student knows what momentum is (m * v) but cannot describe what it means to say momentum is conserved.	Student does not know what momentum is and cannot make a statement in terms of what it means to say momentum is conserved.	Not enough evidence to determine performance.
Student can calculate momentum for a single object and collisions between objects (P=MV and $M_1V_1 = -(M_2V_2)$)	Student correctly calculates the momentum of a single object and for the momentum change for two <u>or more</u> objects in collisions including correct units on all numbers.	Student correctly calculates the momentum of a single object and for the momentum change for two objects in collisions including correct units on all numbers.	Student can correctly calculate the momentum of a single object including correct units but cannot calculate the momentum change of two objects in a collision.	Student cannot calculate momentum for a single object nor for two objects in a collision.	Not enough evidence to determine performance.
Student understands the law of Inertia	Student can describe Inertia as an object's tendency to resist changing its state of motion recognizing that it takes a sufficiently large force to overcome inertia and cause a change in motion. An advanced student recognizes that mass and inertia are directly related.	Student can describe Inertia as an object's tendency to resist changing its state of motion recognizing that it takes a sufficiently large force to overcome inertia and cause a change in motion.	Student can describe Inertia as an object's tendency to resist changing its state of motion but does not recognize that it takes a sufficiently large force to overcome inertia and cause a change in motion.	Student cannot describe inertia as a tendency of an object to resist changing its state of motion.	Not enough evidence to determine performance.

- **PSP1-HS-3**. Apply scientific and engineering ideas 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.
  - Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.

Criteria	Advanced Understanding of Standard (4)	Proficient Understanding of Standard (3)	Approaching and Understanding of Standard (2)	Beginning, Does Not Meet Standard (1)	Non-Performance (0, M, I)
Student can design a device to minimize the force experienced upon impact.	Student can design a device to minimize the force experienced upon impact by applying newton's second law equation F=MA. The advanced student also recognizes that it is the rate of deceleration that is the most important determining factor.	Student can design a device to minimize the force experienced upon impact by applying newton's second law equation F=MA	Student can design a device to minimize the force experienced upon impact but cannot apply newton's second law equation F=MA	Student cannot design a device to minimize the force experienced upon impact.	Not enough evidence to determine performance.
Student can evaluate a device that minimizes the force experienced upon impact.	Student can evaluate a device to minimize the force experienced upon impact by applying newton's second law equation F=MA. The advanced student can predict the force experienced with an assumed impulse. Also, advanced students can relate newton's first and third laws to the evaluation of their device.	Student can evaluate a device that minimizes the force experienced upon impact by identifying the strengths and limitations of the device and predicting/measuring its performance. (mass, velocity)	Student can evaluate a device that minimizes the force experienced upon impact by identifying the strengths and limitations of the device but cannot predicting its performance or measure its velocity.	Student cannot evaluate a device that minimizes the force experienced upon impact.	Not enough evidence to determine performance.
Student can refine a device they constructed to further minimize the force experienced upon impact.	Student can identify strengths and weaknesses of their device and make improvements to its performance. Advanced students will be able to specify how the impulse component of newton's second law is used in the refinement process.	Student can identify strengths and weaknesses of their device and make improvements to its performance.	Student can identify strengths and weaknesses of their device but cannot make improvements to its performance.	Student cannot refine a device that minimizes the force experienced upon impact.	Not enough evidence to determine performance.

- **PSP1-HS-4**. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
  - Clarification Statement: Emphasis on both quantitative and conceptual descriptions of gravitational and electric fields.
  - Assessment Boundary: Assessment is limited to systems with two objects.

Criteria	**Advanced Understanding of Standard (4)**	**Proficient Understanding of Standard (3)**	**Approaching and Understanding of Standard (2)**	**Beginning, Does Not Meet Standard (1)**	**Non-Performance (0, M, I)**
Student can understand that mass and distance are the determining factors of force strength in newton's law of gravitation.	Student can describe mass and distance as the factors that determine the force of gravity. Advanced students can show that the distance has a larger affect than mass because it is a squared term.	Student can describe mass and distance as the factors that determine the force of gravity.	Student knows what distance and mass are but cannot relate them to the strength of the gravitational force.	Student does not understand the factors that determine the strength of gravity	Not enough evidence to determine performance.
Student can solve for force, mass, or distance using newton's law of gravitation.	Student can solve for force, mass, or distance correctly a majority of the time with correct units included. Advanced students understand that the gravitational constant does not change and is the factor that relates mass and distance.	Student can solve for force, mass, or distance correctly a majority of the time with correct units included.	Student can solve for force, mass, or distance correctly a some of the time but does not included correct units.	Student cannot solve for force, mass, or distance and does not use units.	Not enough evidence to determine performance.
Student understands that charge and distance are the determining factors of force strength in Coulomb's law	Student can describe charge and distance as the factors that determine the electrostatic force. Advanced students can show that the distance has a larger affect than charge because it is a squared term.	Student can describe charge and distance as the factors that determine the electrostatic force.	Student knows what distance and charge are but cannot relate them to the strength of the electrostatic force.	Student does not understand the factors that determine the strength of force of charge.	Not enough evidence to determine performance.
Student can calculate force, charge, or distance using Coulomb's law	Student can solve for force, charge, or distance correctly a majority of the time with correct units included. Advanced students understand that the Coulomb's law constant relates charge and distance and can change depending on the medium in which the charge exists.	Student can solve for force, charge, or distance correctly a majority of the time with correct units included.	Student can solve for force, charge, or distance correctly a some of the time but does not included correct units.	Student cannot solve for force, charge, or distance and does not use units.	Not enough evidence to determine performance.

- **PSP1-HS-5**. 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.
  - Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.

Criteria	Advanced Understanding of Standard (4)	Proficient Understanding of Standard (3)	Approaching and Understanding of Standard (2)	Beginning, Does Not Meet Standard (1)	Non-Performance (0, M, I)
Student can plan and conduct an investigation showing that electricity can create a magnetic field.	Student successfully plans and conducts an investigation in which a device is built and used to demonstrate that electricity can create a magnetic field. Students should relate the strength of the device to the voltage, number of coils, and the metal in the core. Advanced students use the "right-hand-rule" to determine where the north and south poles are located.	Student successfully plans and conducts an investigation in which a device is built and used to demonstrate that electricity can create a magnetic field. Students should relate the strength of the device to the voltage, number of coils, and the metal in the core.	Student plans and conducts an investigation to build a device but unsuccessfully constructs the device and does not show evidence that electricity can be used to create a magnetic field. Student cannot relate the strength of the device to the voltage, number of coils, and the metal in the core.	Student cannot plan and conduct an investigation showing that electricity can create an magnetic field.	Not enough evidence to determine performance.
Student can plan and conduct an investigation showing that a moving magnet can generate an electric current.	Student successfully plans and conducts an investigation in which a device is built and used to demonstrate that a moving magnet can generate an electric current. Advanced students relate the amount of electricity generated to the number of wire coils and the size of the magnet used.	Student successfully plans and conducts an investigation in which a device is built and used to demonstrate that a moving magnet can generate an electric current.	Student plans and conducts an investigation to build a device but unsuccessfully constructs the device and does not show evidence that a moving magnet can create an electric current.	Student cannot plan and conduct an investigation showing that a moving magnet can generate an electric current.	Not enough evidence to determine performance.

- **PSP2-HS-1**. Create a computational model to calculate the change in energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
  - Clarification Statement: Emphasis is on explaining the meaning of the mathematical expressions used in the model.
  - Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.

Criteria	**Advanced Understanding of Standard (4)**	**Proficient Understanding of Standard (3)**	**Approaching and Understanding of Standard (2)**	**Beginning, Does Not Meet Standard (1)**	**Non-Performance (0, M, I)**
Student understands that in a closed system energy is conserved. (law of conservation of energy)	Student demonstrates that if a system is closed the total amount of energy remains the same while energy changes from one form to another. Advanced students recognize the difference between a closed an open system.	Student demonstrates that if a system is closed the total amount of energy remains the same while energy changes from one form to another.	Student understands that energy changes from one form to another but cannot show how energy is conserved during this process (in a closed system)	Student cannot state how/why energy is conserved in closed system.	Not enough evidence to determine performance.
Student can create an energy transformation diagram showing that energy can change form but the total energy remains the same.	Student can track energy transformation from a source to its end use by drawing/labeling an energy diagram. Advanced students can show that any energy that appears to be "lost" is accounted for by including friction/heat in their diagram.	Student can track energy transformation from a source to its end use by drawing/labeling an energy diagram.	Student can draw an energy flow diagram but the diagram includes errors or incorrect transformations.	Student cannot show/track the flow of energy as it transforms from one form to another.	Not enough evidence to determine performance.
Student can show that the amount of work that can be done by any closed system is limited by the available energy. (work-energy theorem)	Student can use the work-energy theorem to show that the amount of work done depends on the energy available in a closed system. Advanced students can apply the work-energy theorem to examples not directly shown in class.	Student can use the work-energy theorem to show that the amount of work done depends on the energy available in a closed system.	Student can describe what the work-energy theorem states but cannot use it to show how much work can be done given an amount of available energy.	Student cannot demonstrate that work done depends on the amount of energy available.	Not enough evidence to determine performance.

- **PSP3-HS-1**. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves travelling 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.
    - Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.

Criteria	**Advanced Understanding of Standard (4)**	**Proficient Understanding of Standard (3)**	**Approaching and Understanding of Standard (2)**	**Beginning, Does Not Meet Standard (1)**	**Non-Performance (0, M, I)**
$V = f \times \lambda$ Student understands that the velocity of a wave depends on its frequency and its wavelength.	Student can solve the wave-velocity equation for velocity, frequency, or wavelength if given two of three variables. Student includes units with numbers. Advanced students can also show how the velocity equation for a wave is really the same as the velocity equation for an object by tracking the units.	Student can solve the wave-velocity equation for velocity, frequency, or wavelength if given two of three variables. Student includes units with numbers.	Student can solve the wave-velocity equation if given two of three variables but does so with frequent errors and/or does not include units.	Student cannot solve the wave-velocity equation for velocity, frequency, or wavelength if given two of three variables	Not enough evidence to determine performance.
Student can demonstrate that the velocity of a wave can increase or decrease based on the medium through which it travels.	Student can describe the fact that the velocity of a wave also depends on the medium in which it is moving through and/or the density, temperature, elasticity, and other properties of the medium. Advanced students recognize that waves are differentiated from each other based on frequency and wavelength whereas the speed of the wave traveling through a medium is affected by the properties of the medium itself (temperature, density, elasticity, etc.)	Student can describe the fact that the velocity of a wave also depends on the medium in which it is moving through and/or the density, temperature, elasticity, and other properties of the medium.	Student can describe the fact that the velocity of a wave also depends on the medium in which it is moving through but cannot comment specifically about how this relates to the density, temperature, elasticity, and other properties of the medium.	Student cannot describe the fact that the velocity of a wave also depends on the medium in which it is moving through and/or the density, temperature, elasticity, and other properties of the medium.	Not enough evidence to determine performance.