Stackable Instructionally-embedded Portable Science (SIPS) Assessments Project

Grade 8 Science
Unit 1 End of Unit Assessment Unpacking Tools
Forces and Energy
August 2023

The SIPS Grade 8 Science Unit 1 End of Unit Assessment Unpacking Tools, Forces and Energy was developed with funding from the U.S. Department of Education under the Competitive Grants for State Assessments Program, CFDA 84.368A. The contents of this paper do not represent the policy of the U.S. Department of Education, and no assumption of endorsement by the Federal government should be made.

SIPS Grade 8 Unit 1 End of Unit Assessment Unpacking Tools

NGSS Performance Expectation: MS-PS2-1 Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.* [Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.] [Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.]

	Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Foundations	**SEP: Constructing Explanations and Designing Solutions** Apply scientific ideas or principles to design an object, tool, process, or system.	**PS2.A: Forces and Motion** For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).	**CCC: Systems and System Models** Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems.
Key Aspects	• Construct an explanation using models or representations. • Apply scientific ideas, principles, and/or use an explanation to support the design of an object, tool, process, or system. • Apply scientific reasoning to show why data or evidence is adequate for the design of an object, tool, process, or system. • Specification of constraints includes consideration of scientific principles and other relevant knowledge, which are likely to limit possible solutions.	• The force exerted on a pair of interacting objects is of the same magnitude but opposite in direction regardless of each object's mass. • Action-reaction pairs of forces do not cancel each other because they are acting on separate objects. • During a collision between two objects, the object with smaller mass has greater acceleration, and the object with greater mass has smaller acceleration, but the action-reaction force between each object is the same magnitude.	• Models are important for testing solutions. • A model of a system under study can be a useful tool not only for gaining understanding of the system but also for conveying it to others. • Models can be used to represent the relationships among parts, or subsystems, of a system as well as how they interact with one another to communicate an engineering design.
Prior Knowledge	• Construct an explanation of observed relationships. • Use evidence to construct or support an explanation. • Apply scientific ideas to solve design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	• Each force acts on one particular object and has both strength and direction. • An object at rest typically has multiple forces acting on it, but these forces add to give zero net force on the object. • Forces that do not sum to zero can cause changes in the object's speed or direction of motion.	**Relationships to SEPs: 6) Constructing Explanations and Designing Solutions and 3) Planning and Carrying Out Investigations** • Models can be used to generate data to test ideas about designed systems, including those representing inputs and outputs. • Model with mathematics to describe a design solution. • Conducting investigations to produce data to support a claim about a design solution model. • Investigations generate relevant patterns of evidence for support of a model.

NGSS Performance Expectation: MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.]

	Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Foundations	**SEP: Planning and Carrying Out Investigations** Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how much data are needed to support a claim.	**PS2.A: Forces and Motion** The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.	**CCC: Stability and Change** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.
Key Aspects	● Identify factors that serve as independent and dependent variables in an investigation. ● Identify the different experimental conditions. ● Identify details of the experimental conditions that will allow appropriate data to be collected to address the purpose of the investigation including appropriate independent and dependent variables. ● Make observations to collect data. ● Make measurements to collect data. ● Use data from an investigation as evidence for an explanation of a phenomenon or support an explanation. ● Identify the purpose of the investigation. ● Identify the evidence needed to address the purpose of the investigation. ● An investigation plan includes a description of data sources and measures to be used, procedures for observing and recording data,	● A system includes the objects interacting within the system (object or group of objects under investigation) as well as the forces acting upon them (which may be external to the system). ● The relative magnitude of the forces exerted onto a system may be balanced or unbalanced. ● There is a relationship between the mass of an object (or system of objects), the sum of the forces acting on that object, and the acceleration that the object experiences. ● The choice of a reference frame is an arbitrary selection based on ease of analysis or best facilitates measurement of mass, motion, and/or force. ● Selection of the appropriate units for measuring mass, force, and motion in light of the relationship among the three and the effect of a reference frame choice.	● Construct explanations of how things change. ● Construct explanations of how things remain stable. ● Explain stability and change in natural or designed systems by examining changes over time and forces at different scales. ● Changes in one part of a system might cause large changes in another part. ● Stability might be disturbed by either sudden events or gradual changes that accumulate over time. ● Students can understand that systems may interact with other systems. ● Systems may have sub-systems and be a part of larger complex systems.

	and, where relevant, a plan for how observations will be sampled. ● Develop, evaluate, and refine a plan for the investigation.			
Prior Knowledge	● Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. ● Evaluate appropriate methods and/or tools for collecting data.	● The patterns of an object's motion in various situations can be observed and measured; when the past motion exhibits a regular pattern, future motion can be predicted from it. ● Some forces act through contact, and some forces act even when the objects are not in contact. ● The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.	**Relationships to SEPs:** **3) Planning and Carrying Out Investigations and 6) Constructing Explanations and Designing Solutions**	● Investigations provide evidence to support a claim related to explanations of stability and change. ● Investigations can provide evidence of how the sum of forces exerted on a system correlate to stability and change of motion. ● Stability and change are ways of explaining how a system functions. ● Stability and change in systems can be explained by examining changes over time and considering forces at different scales.

NGSS Performance Expectation: MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]

	Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Foundations	**SEP: Analyzing and Interpreting Data** Construct and interpret graphical displays of data to identify linear and nonlinear relationships.	**PS3.A: Definitions of Energy** Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.	**CCC: Scale, Proportion, and Quantity** Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.
Key Aspects	● Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. ○ Construct a graphical display of data sets to identify relationships. ○ Analyze and Interpret graphical displays of data to identify linear relationships. ○ Analyze and Interpret graphical displays of data to identify nonlinear relationships. ● Use graphical displays of large data sets to identify temporal and spatial relationships. ● Analyze and interpret data to determine similarities and differences in findings. ● Construct and interpret a scatter plot or line graph for two quantitative variables. ● Determine whether a linear relationship is negative or positive and whether the linear relationship appears strong or weak. ● Construct and interpret a line graph to describe changes over time of a quantitative variable.	● Motion energy is called kinetic energy. ● Kinetic energy is proportional to the mass of the moving object. ● Kinetic energy and mass have a linear relationship. ● Kinetic energy is proportional to the square of the speed of the object. ● Kinetic energy and speed have a nonlinear relationship. ● A system of objects may also contain stored (potential) energy, depending on their relative positions.	• Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or small. • Proportional relationships among different types of quantities provide information about the magnitude of properties and processes. • Scientific relationships can be represented through the use of algebraic expressions and equations. • Phenomena that can be observed at one scale may not be observable at another scale.
Prior Knowledge	● Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships.	● The faster a given object moves, the more energy it possesses. ● Energy can be moved from place to place by moving objects or through sound, light, or electric currents.	**Relationships to SEPs:** **4) Analyzing and** • Observable phenomena exist from very short to very long time periods. • Standard units are used to measure and describe physical quantities such as weight,

	• Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.	• Temperature is a measure of energy (6th grade). • The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. ○ The temperature/kinetic energy of the system depends on the types and amounts of matter present. ○ Temperature/kinetic energy depends on the states of matter (speed of particles).	**Interpreting Data and** **7) Engaging in Argument from Evidence**	time, temperature, and volume. • The concept of Scale, Proportion, and Quantity figures prominently in taking measurements of structures and phenomena, and these fundamental observations are usually obtained, analyzed, and interpreted quantitatively. • Understanding the relative magnitude of some properties or processes, is necessary to explain the relationships among different types of quantities. • Proportional relationships may be used as evidence to support an argument or claim.

NGSS Performance Expectation: MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. [Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.] [Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws.]

	Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)	
Foundations	**SEP: Engaging in Argument from Evidence** Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	**PS2.B: Types of Interactions** Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.	**CCC: Systems and System Models** Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems.	
Key Aspects	• Construct scientific arguments. • Compare, evaluate, and critique competing arguments. • Identify evidence/data that supports a claim.	• Gravitational interactions are always attractive, require at least two interacting objects, and are directed toward the center of mass of the other object. • All gravitational interactions (gravitational forces) require a system of two or more objects. • For the same distance, the force between two objects increases or decreases directly with an increase or decrease in the mass of the interacting objects. • For the same masses, the force between two objects increases or decreases inversely with the distance between the two interacting objects. • Some effects of gravitational interactions may only be observable in interactions between very massive objects.	• Systems and system models are used by scientists and engineers to investigate natural and designed systems. • Use models to represent systems and their interactions, such as gravitational interactions between two masses. • Some phenomena (e.g., gravitational forces) can only be observed through the observation of simulations, the use of models, or the analysis of data. • Consideration of flows into and out of the system is a crucial element of system design. • Models can be valuable in predicting a system's behaviors.	
Prior Knowledge	• Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships. • Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.	• Objects in contact exert forces on each other. • Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. • The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.	**Relationships to SEPs:** **7) Engaging in Argument from Evidence and** **4) Analyzing and Interpreting Data**	• Models such as force diagrams can be used to represent and identify the relative magnitude and direction of the force each object exerts on the other. • Data analysis serves to interpret quantitative measures of masses, distances, and

				gravitational forces based upon models. • Models may be used to analyze relationships (e.g., linear or nonlinear) across or within systems (e.g., How does [subsystem A] relate to [subsystem B]?).