Stackable Instructionally-embedded Portable Science (SIPS) Assessments Project

Grade 8 Science

Unit 1 Instructional Framework

Forces and Energy

January 2023

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Unit 1 Overview

Storyline Synopsis:

This unit consists of four instructional segments, each engaging students in multiple science and engineering practices and crosscutting concepts as students make sense of the key disciplinary ideas of forces (including gravitational forces), motion, energy related to mass, and how these concepts can be used to explain phenomena including collisions and changes in motion.

- **Instructional Segment 1:** While engaging in the practice of carrying out investigations, students measure contact forces in different situations and analyze data to support models, explanations, and arguments about force relationships during collisions. Students design initial solutions to the problem of controlling damage during a collision (this initial solution will be revisited again and revised/iterated in Segment 4).
- **Instructional Segment 2:** Students plan and conduct investigations and analyze and interpret data as a basis for developing explanations that describe the relationship between changes in an object's mass and changes in motion. Students develop and use models that include the sum of all forces acting on an object and the object's mass as a basis for predicting changes in the object's motion.
- **Instructional Segment 3:** Students engage with the practices of designing investigations and analyzing data to develop graphical representations of the relationships between mass, velocity, and kinetic energy. Students use these representations as evidence to develop and use models of how kinetic energy changes during collisions. Students use evidence to evaluate different models and use their models to develop solutions to the problem of controlling damage during a collision.
- **Instructional Segment 4:** Students engage in the practice of designing and carrying out investigations to examine the effect and the size of gravitational forces on the motion of objects and the effect of distance on the magnitude of gravitational forces. Students develop models to represent how the variables of distance and mass impact the motion of objects. Students construct explanations and models and engage in arguments from evidence about gravitational interactions. Students use their models, data, and scientific knowledge when refining and presenting their design solutions to the problem of collisions and an egg-drop challenge.

Unit Storyline Framing: *Collisions in Sports: Forces and Motion*

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Stage 1 – Desired Results

Overview of Student Learning Outcomes

The Grade 8 Unit 1 Topic Bundle, "**Forces and Energy**," organizes performance expectations with a focus on helping students build an understanding of the motion of objects and how interactions between objects can be explained and predicted. By building familiarity with ideas related to the study of forces and energy in this unit early in the school year, students are prepared to use this knowledge to explain phenomena and solve design problems when investigating waves and Earth's place in the universe in later related units.

Unit 1 Big Ideas:

PS2.A **Forces and Motion**	1. Forces exerted by two objects on each other are equal in magnitude and opposite in direction. (MS-PS2-1) 2. Changes to an object's motion occur in response to unbalanced forces and depend on the mass of the object and size of the force. (MS-PS2-2)
PS2.B **Types of Interactions**	3. Gravitational force attracts objects to one another; its strength depends on the objects' masses and the distance between them. (MS-PS2-4)
PS3.A **Definitions of Energy**	4. Kinetic energy (energy of motion) is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1)

The SIPS Unit 1 Student Profile describes what students should know and be able to demonstrate prior to and at the culmination of three-dimensional science instruction in Unit 1 to prepare for new and increasingly sophisticated learning opportunities in Unit 2.

Next Generation Science Standards (NGSS) Performance Expectations & Foundation Boxes

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.]

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.]

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.]

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.]

Targeted Scientific Practices	Targeted Disciplinary Core Ideas	Targeted Cross-Cutting Concepts
[SEP-3] 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 many data are needed to support a claim. **(MS-PS2-2)** **[SEP-4] Analyzing and Interpreting Data** • Construct and interpret graphical displays of data to identify linear and nonlinear relationships. **(MS-PS3-1)** **[SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering)** • Apply scientific ideas or principles to design an object, tool, process, or system. **(MS-PS2-1)** **[SEP-7] 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. **(MS-PS2-4)**	**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). **(MS-PS2-1)** • 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. **(MS-PS2-2)** • 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. **(MS-PS2-2)** **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. **(MS-PS2-4)** **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. **(MS-PS3-1)**	**[CCC-3] 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. **(MS-PS3-1)** **[CCC-4] 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. **(MS-PS2-1), (MS-PS2-4)** **[CCC-7] 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. **(MS-PS2-2)**

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Acquisition Goals
Acquisition Goals are multi-dimensional knowledge-in-use statements that integrate aspects of the NGSS dimensions (SEP & DCI or SEP & DCI & CCC) but are smaller in breadth than a performance expectation. Acquisition Goals describe the essential concepts and key skills a student must acquire to obtain mastery of the unit's objectives and emphasize student understanding as rooted in engagement with the science and engineering practices and not in memorization of science facts. The acquisition goals intentionally include SEP and CCC from outside of the unit's PE bundle.
Students will know and be able to . . .
A1. Design a solution to a problem that utilizes the fact that when two objects interact, they exert a force on each other in opposite directions.
A2. Create a model to show the magnitude of the forces exerted by two interacting objects on each other is equal.
A3. Create a model to show the direction of the forces exerted by two interacting objects on each other is opposite.
A4. Construct an explanation that describes the relationship between force and motion to describe phenomena.
A5. Interpret data on how forces sum to give a single force to affect change in motion.
A6. Apply Newton's Third Law to explain a situation involving the motion of two colliding objects. [MS-PS2-1]
A7. 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. [MS-PS2-2]
A8. Engage in argument from evidence that when two objects interact, the force from object one acts on object two, and the force from object two acts on object one; therefore, the forces do not cancel each other.
A9. Use and/or develop a model of all the forces acting on an object to show how the object's motion will change.
A10. Construct an explanation that includes qualitative or quantitative relationships between an object's mass and its change in motion.
A11. Analyze and interpret data to compare the dependence of motion on the relative masses of interacting objects.
A12. Use mathematical and computational thinking to calculate the sum of forces on an object to give a single force that will affect a change in the object's motion.
A13. Apply the scientific idea of kinetic energy (energy of motion) to design an object, tool, process, or system.
A14. Construct an argument supported by empirical evidence and scientific reasoning about the relationship between mass and kinetic energy in order to support or refute an explanation or model.
A15. 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. [MS-PS3-1]
A16. Plan an investigation to gather data that demonstrates the relationship between KE and mass and/or speed.
A17. Develop a model to describe that gravitational force is always (only) attractive (never repulsive).

A18. Develop and/or revise a model to show the relationships between mass and gravitational force.

A19. Model the relationship between force and mass to show that gravity is an attractive force between objects that can act over a distance.

A20. Construct an explanation that includes the qualitative relationship between gravitational force and direction (i.e., always attractive) that describe phenomena.

A21. Apply the principle that gravitational force between objects depends on mass and distance in order to design a process or system.

A22. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. [MS-PS2-4]

A23. Develop and/or use a model to predict how the kinetic energy of an object changes when its mass and/or speed changes.

Cross-curricular Integration

Students develop an understanding of the motion of objects, how interactions between objects can be explained and predicted, and of scientific concepts related to forces and energy by developing models, making observations, and planning and conducting investigations to demonstrate their understanding. Students will use **reading** and **research** skills to acquire **new information** and to **draw on** and **integrate information** from multiple **sources** to **write** or **speak** about the topic and to **construct explanations** with **scientific reasons** and **evidence**. Students will use **mathematical practices** such as **reasoning** and **mathematical concepts** related to **measurement, data collection, constructing and interpreting graphical displays, expressions and equations, and functions** to explain phenomena or create solutions to design problems.

Common Core State Standards for Literacy	Common Core State Standards for Mathematics
Reading Science and Technical Subjects **RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **(MS-PS2-1), (MS-PS3-1)** **RST.6-8.3** Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks. **(MS-PS2-1), (MS-PS2-2)** **RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **(MS-PS3-1)** ***Writing History/Social Studies, Science and Technical Subjects*** **WHST.6-8.1** Write arguments focused on discipline-specific content. **(MS-PS2-4)**	***Mathematical Practice*** **MP.2** Reason abstractly and quantitatively. **(MS-PS2-1), (MS-PS2-2)** ***Expressions and Equations*** **8.EE.A.1** Know and apply the properties of integer exponents to generate equivalent numerical expressions. **(MS-PS3-1)** **8.EE.A.2** Use square root and cube root symbols to represent solutions to equations of the form x2 = p and x3 = p, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that √2 is irrational. **(MS-PS3-1)** **8.F.A.3** Interpret the equation y = mx + b as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. **(MS-PS3-1)**

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<table>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>Students will understand that . . .
EU1. Scientific knowledge such as Newton's three laws of motion can be observed and applied to a variety of situations to design and evaluate solutions to everyday problems.
EU2. Contact and non-contact forces (i.e., electric, magnetic, and gravitational) cause objects to move, accelerate, decelerate, stop, or change directions.
EU3. Scientists analyze and interpret data related to the orbital motion of objects, including large scale structures such as the solar system, to support claims related to how gravitational forces between any two masses are always attractive.
EU4. An object in motion possesses energy, calculated by multiplying its mass by the square of its velocity. The value of energy can change in many interactions.
EU5. Scientists and engineers use a variety of methods and tools to make observations and measurements and to interpret data to develop and test theories about natural phenomena.</td><td>EQ1. How can Newton's three laws of motion be observed and used in everyday life?
EQ2. What underlying forces explain the variety of interactions observed between objects?
EQ3. How are we able to make predictions and explain astronomical phenomena when the interactions cannot be directly observed or measured (e.g., celestial bodies)?
EQ4. How can we plan and carry out an investigation of object(s) to explain the relationships between kinetic energy, mass, and speed?
EQ5. How can I use the skills of a scientist or engineer to investigate forces that may cause changes in motion and energy?</td></tr>
<tr><th colspan="2">Vocabulary</th></tr>
<tr><td colspan="2">• Motion (direction of, change in)
• Reference point
• Force (net, balanced, unbalanced, peak, normal, force pairs, field, contact, noncontact, opposite, direction of, strength, attractive)
• Friction
• Gravity (gravitational interaction, force)
• Inertia
• Mass, massive
• Speed, velocity, acceleration, deceleration, constant, orbital
• Proportional
• Linear/nonlinear
• Displacement, position, direction
• Action/reaction
• Collision
• Elastic, deformation
• Kinetic energy
• Conservation
• System, boundary, criteria, constraint
• Equal and opposite reaction
• Impact
• Variables (dependent, independent, control)</td></tr>
</table>

Stage 2 – Assessment Evidence

Assessment Overview

For each of the acquisition goals listed in the Stage 1 – Desired Results, evidence statements were developed. These statements provide information on what we would expect students to do in order to determine the degree to which students have met the acquisition goals. These acquisition goals and evidence statements were then sequenced into instructional segments. Evidence statements and acquisition goals that were deemed critical were identified and assessment opportunities were developed. For this unit, four instructional segments were identified. An overview of each segment is provided below.

Instructional Segment 1 focuses on Big Idea 1 and students' ability to conduct investigations, design solutions to problems, and create models, explanations, and arguments about force and motion. Students are formally assessed on designing solutions and informally assessed on developing initial models, explanations, and arguments about force and motion.

Instructional Segment 2 focuses on part of Big Idea 1 and Big Idea 2 and students' ability to consider mass and speed as important factors in understanding forces and motion as they plan/conduct investigations, develop models, and construct explanations. Students are formally and informally assessed on developing models, constructing explanations, planning and conducting investigations, and analyzing and interpreting data all while examining force and motion in the context of objects colliding.

Instructional Segment 3 focuses on Big Idea 4 and students' ability to interpret data and construct explanations about kinetic energy and the relationships between mass, speed, and kinetic energy. Students are formally and informally assessed on their ability to construct explanations, construct and interpret graphical displays of data, plan investigations, and design solutions using the idea of kinetic energy.

Instructional Segment 4 focuses on Big Idea 3 and students' ability to develop models of gravitational interactions and use their knowledge of forces and motion to engage in arguments and develop design solutions. This segment includes informal assessments for modeling.

End-of-Unit Stackable, Instructionally-embedded, Portable Science (SIPS) Assessment:

For the end-of-unit SIPS assessment, students engage in three scenario-based assessment tasks. The tasks focus on the PEs: 8-PS2-1, 8-PS2-2, 8-PS2-4, and 8-PS3-1.

Instructionally-Embedded Assessments

For each instructional segment, descriptions of *informal* and *formal* instructionally-embedded assessments are included based on the acquisition goals and evidence statements deemed critical to assess along an instructional plan. Informal assessments defined as "in-the-moment" assessment opportunities identify student challenges and lack of knowledge or misconceptions and could include class check-ins such as discussion prompts, exit tickets, or graphic organizers. Formal assessments measure how well students perform when engaging with more complex tasks that require integration of the dimensions (SEPs, DCIs, CCCs) in the service of sense-making. They are administered at specific, intentional points in time along an instructional plan before or after a lesson or a series of lessons. Examples include performance tasks, concept maps, research projects, or hands-on tasks.

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Instructionally-embedded Assessments for Use during Instructional Segment 1

Informal Assessment: Investigating Forces Acting on Objects

At various points in time during Segment 1, educators may use informal classroom check-ins (e.g., exit tickets, in-the-moment questions) to gather evidence of students' ability to develop their initial models, explanations, and arguments about forces and motion when objects are interacting (collisions/separations, for example).

Assessment Purpose and Use

- These informal assessments are typically used for formative purposes. The goal is to gauge where students are in their learning, identify what challenges students are facing, and determine the next steps for the class and/or individual students.
- The assessments provide information that can be used either at the class level or the individual student level to help determine what instructional activities will best support students.

Administration Time: 3-5 minutes

Scoring Time: 3-5 minutes

Assessment Type

Informal - Classroom Check-In

Assessment Sub-Type(s)

Discussion prompts

Exit Tickets

In-the-moment Questions

These assessments will assess students' ability to:

- Develop a model for a collision of two interacting objects exerting forces upon one another.
  - Model includes relationships among model elements that are sufficient in capturing the strength and direction of the forces each object exerts upon the other in a system.
- Use a model for a collision of two interacting objects to explain the direction and magnitude of the forces.
- Identify the action-reaction force pair during the collision of two objects and the statement regarding the magnitude of the action-reaction forces involved in the collision.
- Construct an argument supported by empirical evidence and scientific reasoning that the force exerted on a pair of interacting objects is of the same magnitude but opposite in direction regardless of each object's mass.
- Select the appropriate reasoning based on relevant scientific concepts that explains why 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.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):

- Ooof, My Face!
- Equal and Opposite
- Newton's Third Law
- Revising Our Explanation
- Rocketing Off, With Water!

NGSS PEs:	CCSS:	EUs/EQs:	AGs:
MS-PS2-2	RST.6-8.3	EU1/EQ1	A2
	MP.2	EU2/EQ2	A3
		EU5/EQ5	A4
			A6
			A8

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Formal Assessment: Rocketing Off, With Water!

Students design an initial solution to the problem of minimizing damage when two objects interact (i.e., the design challenge introduced in the Unit Entrance/Hook, the launching of a rocket, etc.). In their design solutions, students should articulate that when two objects interact, they exert a force on each other in opposite directions. Students are tasked with designing a solution later in the unit after additional learning, providing an opportunity to compare solutions and show growth.

Assessment Purpose and Use

- This assessment is intended to be administered during or immediately following the lesson, "Rocketing Off, With Water!"
- The results of this assessment can be used to evaluate evidence of student learning during instructional segment 1, to determine if additional reteaching is needed, and to inform planning for segment 2.
- Students are provided with (or choose) a specific problem based on the design challenge introduced in the unit entrance and are asked to find a solution to the problem.
- The purpose of this assessment is to provide an opportunity for students to apply their knowledge to a particular question and find a solution to the problem. It allows them to demonstrate how they would apply concepts over an extended period of time.

Administration Time: 2 Days

Scoring Time: 15 minutes

Assessment Type

Formal - Research Project

Assessment Sub-Type(s)

Hands-on Task

Design Project

This assessment will assess students' ability to:

- Draft statements using the appropriate scientific principle (e.g., magnitudes and directions of forces) and evidence of optimal material selection (to minimize force in the collision & minimize cost) and apply the third law of motion to support the effectiveness of the final design solution to a problem involving the motion of two objects.
- Design a solution to optimize material selection (minimize force in the collision, energy transfer, and minimize cost).
- Refer to the system model to identify how objects are interacting.
- Use the appropriate scientific principle (e.g., action-reaction forces) that supports the effectiveness of the design solution to a problem involving the motion of two objects.
- Apply scientific principles to justify the best design and to provide justification for the selection based on the application of Newton's third law when provided a description of a physical situation involving an interaction between two objects and a list of multiple designs with given criteria.
- Identify the action-reaction force pair during the collision of two objects and the statement regarding the magnitude of the action-reaction forces involved in the collision.
- Identify multiple ways the design can be improved while providing justification for the selection when provided a description of a physical situation involving a collision between two objects and a list of multiple ways to improve the design with given criteria.
- Refer to the mass of objects as a basis for deciding how to decrease the amount of force in a collision.
- Explain how the design identifies which collision would have the least amount of force, based on the mass of objects to design the system model.

- Construct a system model to analyze Newton's third law forces in a collision (force directions).
- Determine the effect of speed within a collision.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Rocketing Off, With Water!	MS PS2-1	MP.2	EU1/EQ1	A1
	MS PS2-2	RST 6-8.1	EU2/EQ2	A6

Instructionally-embedded Assessments for Use during Instructional Segment 2

Informal Assessment: Supporting Claims About the Direction and Magnitude of Forces on Objects in a Collision

At various points in time during Segment 2 of instruction, the teacher can use informal classroom check-ins (e.g., exit tickets, in-the-moment questions, discussion prompts, and graphic organizers) to gather evidence of students' ability to use evidence and reasoning to make and support claims related the direction and magnitude of forces experienced on two objects in a collision and the effect of those forces on the objects' motion.

Assessment Purpose and Use

- These informal assessments are typically used for formative purposes. The goal is to gauge where students are in their learning, identify what challenges students are facing, and determine the next steps for the class and/or individual students.
- The assessments provide information that can be used either at the class level or the individual student level to help determine what instructional activities will best support students.

Administration Time: 3-5 minutes

Scoring Time: 3-5 minutes

Assessment Type

Informal - Classroom Check-In

Assessment Sub-Type(s)

Discussion prompts

Exit Tickets

In-the-moment Questions

Graphic Organizers

These assessments will assess students' ability to:

- Construct an argument supported by empirical evidence and scientific reasoning that 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.
- Use quantitative or qualitative evidence to explain how an object subjected to balanced forces does not change its motion.
- Use quantitative or qualitative evidence to explain how an object subjected to unbalanced forces changes its motion over time.
- Provide an artifact (e.g., calculation, model, explanation, etc.) that demonstrates a correct interpretation of data from forces acting on an object at different scales to predict the change in the object's motion.
- Using evidence, including patterns from other data sets, and referencing the masses of the objects, make a prediction of the force that will be exerted by the first object on the second object.

- Provide an appropriate prediction based on the model which articulates the sum of the forces and how the resulting net force would cause no change if the forces were balanced or would change the object's motion if the model shows unbalanced forces.
- Construct an explanation that is appropriate to examine how the sum of the force must change in order to achieve the same change in motion for objects with different masses. (Explanation should include reasoning of why positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame.)

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Revising Our Explanation (Segments 1 and 2)	MS-PS2-2	WHST.6-8.1	EU1/EQ1	A4
• Changing Motion		RST 6-8.1	EU2/EQ2	A6
• Getting to the Bottom of Newton's Second Law				A7*
• Sum of Forces and Changing Motion				A8
• Newton's Laws				A9*
				A10

Informal Assessment: Planning Investigations of Forces Acting on Objects

At various points in time during Segment 2, educators may use informal classroom check-ins (e.g., exit tickets, in-the-moment questions) to gather evidence of students' ability to plan investigations about forces and changing motion.

Assessment Purpose and Use

- These informal assessments are typically used for formative purposes. The goal is to gauge where students are in their learning, identify what challenges students are facing, and determine the next steps for the class and/or individual students.
- The assessments provide information that can be used either at the class level or the individual student level to help determine what instructional activities will best support students.

Administration Time: 3-5 minutes

Scoring Time: 3-5 minutes

Assessment Type

Informal - Classroom Check-In

Assessment Sub-Type(s)

Discussion prompts

Exit Tickets

In-the-moment Questions

Science Journals

These assessments will assess students' ability to:

- Plan an investigation, based on a provided scenario and materials, which provides 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.
- Identify the purpose of the investigation, which includes providing evidence that the change in an object's motion is due to balanced or unbalanced forces acting on the object and the mass of the object.
- Identify the variables that needed to be manipulated (independent), controlled, or measured (dependent) to examine:
  - How the sum of forces impacts the change in motion for objects with different masses, and

- How the forces change in order to achieve the same change in motion for objects with different masses or speeds.
- Describe the experimental procedure necessary to investigate:
  - How the sum of forces exerted on an object determines its type of motion,
  - How the sum of the force must change in order to achieve the same change in motion for objects with different masses, and
  - The impact of the sum of forces on the speed change of an object.
- Identify potential measurement sources of error or gaps in data when examining how the sum of forces impacts the speed change.
- Choose the appropriate units for measuring mass, force, and motion, considering the relationship among the three and the effect of a reference frame choice.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Getting to the Bottom of Newton's Second Law	MS-PS2-2	RST.6-8.3	EU1/EQ1	A7
• Sum of Forces and Changing Motion		MP.2	EU2/EQ2	
			EU5/EQ5	

Formal Assessment: Constructing Explanations Between Force and Motion

Students construct an explanation centered on varying the size of the used ball in the anchoring phenomenon and its impact. The explanation should include a qualitative and/or quantitative relationship between force and motion to describe phenomena.

Assessment Purpose and Use

- This assessment is intended to be used following students' experimentation with forces and motion in the lesson, *Sum of Forces and Changing Motion*, or after they conduct additional experimentation and research in stations during the lesson, *Newton's Laws.*
- Performance tasks generally provide opportunities for students to engage with the practices of the discipline along with the content.
- This task is used to measure how well students perform when provided with a complex task and an opportunity to engage in a meaningful way with the content in the curriculum.

Administration Time: 20 minutes

Scoring Time: 5 minutes

Assessment Type

Formal - Short Performance Task

Assessment Sub-Type(s)

Scenario/Phenomena-based Assessment Task

Other

This assessment will assess students' ability to:

- Use quantitative or qualitative evidence to explain how an object subjected to balanced forces does not change its motion.
- Use quantitative or qualitative evidence to explain how an object subjected to unbalanced forces changes its motion.
- Use quantitative or qualitative evidence to explain how the change in the motion of an object subjected to unbalanced forces depends on the mass of the object.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Sum of Forces and Changing Motion • Newton's Laws • Revising Our Explanation	MS-PS2-1	WHST.6-8.1 MP.2	EU1/EQ1 EU2/EQ2	A4 A10

Formal Assessment: Plan Investigations for Changing Objects' Motion

Students plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object. Provide students with the scenario from the anchoring phenomenon, for example, "How can you determine the ideal size of the soccer ball that will provide the least harm to the athlete upon impact? Write a step-by-step procedure that you carry out to choose the ideal soccer ball. In your procedure, indicate the variables, how you would choose the variables, and how you would control them."

Assessment Purpose and Use

- Performance tasks generally provide opportunities for students to engage with the practices of the discipline along with the content.
- This task is used to measure how well students perform when provided with a complex task and an opportunity to engage in a meaningful way with the content in the curriculum.

Administration Time: 40 minutes

Scoring Time: 1 minute per group

Assessment Type

Formal - Short Performance Task

Assessment Sub-Type(s)

Hands-on Task

Lab/Experiment

This assessment will assess students' ability to:

- Describe the experimental procedure necessary to investigate how the sum of forces exerted on an object determines its type of motion.
- Describe a procedure for carrying out an investigation to examine how the sum of the force must change in order to achieve the same change in motion for objects with different mass.
- Identify the variables that needed to be manipulated (independent), controlled, or measured (dependent) to examine how forces change in order to achieve the same change in motion for objects with different masses.
- Identify dependent (e.g., speed) and independent variables (e.g., sum of forces), as well as what variables should be controlled to examine how the sum of forces impacts the speed change.
- Articulate procedures for determining the impact of the sum of forces on the speed change of an object.
- Identify potential measurement sources of error or gaps in data when examining how the sum of forces impacts the speed change.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Getting to the Bottom of Newton's Second Law • Sum of Forces and Changing Motion	MS-PS2-2	MP.2 RST 6-8.3	EU1/EQ1 EU2/EQ2 EU5/EQ5	A7

Formal Assessment: Analyzing and Interpreting Data about Direction and Magnitude of Forces on Objects in a Collision

Students use the data they collected in their investigation (or data that the teacher provides them) to calculate forces and analyze data related to the direction and magnitude of forces experienced on two objects that interact. Students analyze data that includes the mass of the objects, and students' calculations will require them to sum forces to calculate a single force.

Assessment Purpose and Use

- Performance tasks generally provide opportunities for students to engage with the practices of the discipline along with the content.
- This task is used to measure how well students perform when provided with a complex task and an opportunity to engage in a meaningful way with the content in the curriculum.

Administration Time: 30 minutes

Scoring Time: 5 minutes

Assessment Type

Formal - Short Performance Task

Assessment Sub-Type(s)

Lab/Experiment

Scenario/Phenomena-based Assessment Task

This assessment will assess students' ability to:

- Organize data in a way that facilitates analysis and interpretation of forces and mass to predict motion of two colliding objects.
- Interpret data to determine the motion of an object is determined by the sum of the forces acting on it.
- Interpret data to describe forces at different scales acting upon an object.
- Analyze data to determine how well a design solution to a problem involving a collision of two objects meets the criteria and constraints.
- Calculate the net force acting on an object through analysis of the forces acting upon it.
- Using evidence, including patterns from other data sets, and referencing the masses of the objects, make a prediction of the force that will be exerted by the first object on the second object.
- Provide an artifact (e.g., calculation, model, explanation, etc.) that demonstrates a correct interpretation of data from forces acting on an object at different scales to predict the change in the object's motion.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):

- Getting to the Bottom of Newton's Second Law
- Sum of Forces and Changing Motion

NGSS PEs:	CCSS:	EUs/EQs:	AGs:
MS-PS2-1	MP.2	EU2/EQ2	A5
MS-PS2-2	RST 6-8.1	EU5/EQ5	A11
			A12

Formal Assessment: Modeling Forces on Interacting Objects

Students create a model to predict the motion of an object based on the forces operating on the object. Students' models should represent all the forces acting on the object and show how the object's motion will change after another object collides with it.

Science
Grade: 8 Unit: 1
39 days of instruction

Assessment Purpose and Use

- Performance tasks generally provide opportunities for students to engage with the practices of the discipline along with the content.
- This task is used to measure how well students perform when provided with a complex task and opportunities to engage in a meaningful way with the content in the curriculum.

Administration Time: 40 minutes

Scoring Time: 5 minutes

Assessment Type

Formal - Short Performance Task

Assessment Sub-Type(s)

Hands-on Task

Scenario/Phenomena-based Assessment Task

This assessment will assess students' ability to:

- Develop a model for a collision of two interacting objects exerting forces upon one another.
  - Model includes relationships among model elements that are sufficient in capturing the strength and direction of the forces each object exerts upon the other in a system.
- Develop a model demonstrating all the forces acting on an object.
  - Model includes relationships among model elements that are sufficient in capturing the strength and direction of the forces acting on the object.
  - Model includes a calculation or description of the net force the object will experience based on the new forces being applied to it.
- Provide an appropriate prediction based on the model which articulates the sum of the forces and how the resulting net force would cause no change if the forces were balanced or would change the object's motion if the model shows unbalanced forces.
- Provide an artifact (e.g., calculation, model, explanation, etc.) that demonstrates a correct interpretation of data from forces acting on an object at different scales to predict the change in the object's motion.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):

- Getting to the Bottom of Newton's Second Law
- Sum of Forces and Changing Motion
- Revising Our Explanation

NGSS PEs:	CCSS:	EUs/EQs:	AGs:
MS-PS2-1	RST.6-8.7	EU1/EQ1	A2
	MP.2	EU2/EQ2	A3
	RST.6-8.1	EU5/EQ5	A9
			A12*
			A10*

Instructionally-embedded Assessments for Use during Instructional Segment 3

Informal Assessment: Modeling Kinetic Energy and its Relation to Mass and Speed

Over the course of this segment, students complete multiple activities as they explore the nature of the relationship between kinetic energy, mass, and speed. Students are challenged to develop a model of the relationship between mass, speed, and kinetic energy that can be used to make predictions about how changes to mass or speed will change kinetic energy. During this modeling activity, the teacher conducts informal, formative assessments using in-the-moment questions and exit tickets to check student understanding and modeling skills. These informal assessments will be most useful when used prior to the formal assessment of modeling.

Assessment Purpose and Use

- These informal assessments are typically used for formative purposes. The goal is to gauge where students are in their learning, identify what challenges students are facing, and determine the next steps for the class and/or individual students.
- The assessments provide information that can be used either at the class level or the individual student level to help determine what instructional activities will best support students.

Administration Time: 3-5 minutes
Scoring Time: 3-5 minutes
Assessment Type
Informal - Classroom Check-In
Assessment Sub-Type(s)
In-the-moment Questions
Discussion prompts
Exit Tickets

This assessment will assess students' ability to:

- Develop a model for the relationship of kinetic energy with mass and speed from available scientific principles and data.
- Identify the elements of a model that characterize:
  - The relationship between kinetic energy and the mass of an object (KE ∝ m), and
  - The relationship between kinetic energy and the speed of a moving object (KE ∝ v2).
- Describe the relationship between model elements by characterizing a pattern that shows:
  - When the mass of an object increases/decreases the kinetic energy increases/decreases (linearly), and
  - When the speed of an object increases/decreases the kinetic energy increases/decreases by the square of the speed.
- Articulate a prediction for the kinetic energy of an object, based on data patterns that highlight the relationship that kinetic energy is linearly proportional to mass and that kinetic energy is proportional to the square of the speed of a moving object.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Modeling Kinetic Energy	MS-PS3-1	RST.6-8.7	EU4/EQ4	A13*
		MP.2	EU5/EQ5	A14
				A15*
				A23

Formal Assessment: Kinetic Energy vs. Mass/Speed Investigation

Using provided materials, students plan an investigation to gather data that demonstrates the relationship between KE and mass and/or speed.

Assessment Purpose and Use

- Performance tasks generally provide opportunities for students to engage with the practices of the discipline along with the content.

Administration Time: 2 days
Scoring Time: 15 minutes
Assessment Type
Formal - Extended Performance Task

- This task is used to measure how well students perform when provided with a complex task and is an opportunity to engage in a meaningful way with the content in the curriculum.

Assessment Sub-Type(s)

Scenario/Phenomena-based Assessment Task

Hands-on Task

Lab/Experiment

Sample Formative Assessment Task: [“Kinetic Energy vs. Mass/Speed Investigation”]

This assessment will assess students’ ability to:

- Construct an argument supported by empirical evidence and scientific reasoning that increasing the object’s mass results in a directly proportional increase of the object’s kinetic energy.
- Construct an argument supported by empirical evidence and scientific reasoning that increasing the object’s speed results in an increase of the object’s kinetic energy proportional to the square of its speed.
- Identify the purpose of the investigation, which includes providing evidence to describe the relationship between kinetic energy and mass and/or speed.
- Identify dependent and independent variables, as well as what variables should be controlled to examine a problem involving the relationship between kinetic energy and mass and/or speed.
- Select and determine which instruments will provide accurate and precise data to carry out an investigation regarding how changing the speed and/or mass affect the motion and kinetic energy of an object.
- Describe the experimental procedure necessary to investigate how changing the speed and/or mass affect the motion and kinetic energy of an object.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):

- Investigating How Speed and Mass Affect the Motion and Energy of an Object
- Moving Energy
- Modeling Kinetic Energy

NGSS PEs:	CCSS:	EUs/EQs:	AGs:
MS-PS2-2	RST.6-8.3	EU4/EQ4	A13*
MS-PS3-1	RST.6-8.1	EU5/EQ5	A14
			A15*
			A16

Formal Assessment: Graphing KE vs. Mass and KE vs. Speed

After an investigation that examines the impact of changing the mass and speed of an object to determine the impacts on the object’s KE, students construct and interpret graphical displays of data to describe the relationships of (a) kinetic energy to the mass of an object and (b) kinetic energy to the speed of an object. Using their data and graphical displays as evidence, students support a claim about the relationship between kinetic energy and mass.

Assessment Purpose and Use

- Performance tasks generally provide opportunities for students to engage with the practices of the discipline along with the content.

Administration Time: 40 minutes

Scoring Time: 10 minutes

Assessment Type

Formal - Short Performance Task

- This task is used to measure how well students perform when provided with a complex task and is an opportunity to engage in a meaningful way with the content in the curriculum.

Assessment Sub-Type(s)
Scenario/Phenomena-based Assessment Task

This assessment will assess students' ability to:

- Construct an argument supported by empirical evidence and scientific reasoning that increasing the object's mass results in a directly proportional increase of the object's kinetic energy.
- Construct an argument supported by empirical evidence and scientific reasoning that increasing the object's speed results in an increase of the object's kinetic energy proportional to the square of its speed.
- Interpret data to compare the relationship between kinetic energy and mass to the relationship between speed and kinetic energy.
- Generate a visual display of data by assigning axes in a graphical display that characterize a relationship that kinetic energy is different among moving objects of different mass.
- Transform data from a table into a graph to show the linear relationship between kinetic energy and the mass of a moving object.
- Interpret data from a graphical display(s) to characterize and describe a linear relationship between the mass of the moving object and its kinetic energy, which is as the mass of the moving object increases, the kinetic energy increases as a linear relationship.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Investigating How Speed and Mass Affect the Motion and Energy of an Object	MS-PS3-1	RST.6-8.7	EU4/EQ4	A14
		WHST.6-8.1	EU5/EQ5	A15
		MP.2		
		8.EE.A.1		

Formal Assessment: Modeling Kinetic Energy

Students build models to represent the relationships between kinetic energy and mass and between kinetic energy and speed. Students use their models to describe (predict) how the kinetic energy of an object will change because of changes in its mass and speed.

Assessment Purpose and Use

- This assessment is intended to be used during the lesson, *Modeling Kinetic Energy*.
- Performance tasks generally provide opportunities for students to engage with the practices of the discipline along with the content.
- This task is used to measure how well students perform when provided with a complex task and is an opportunity to engage in a meaningful way with the content in the curriculum.

Administration Time: 40 minutes
Scoring Time: 10 minutes
Assessment Type
Formal - Short Performance Task
Assessment Sub-Type(s)
Scenario/Phenomena-based Assessment Task

This assessment will assess students' ability to:

- Develop a model for the relationship of kinetic energy with mass and speed from available scientific principles and data.

- Identify the elements of a model that characterize:
  - The relationship between kinetic energy and the mass of an object (KE ∝ m), and
  - The relationship between kinetic energy and the speed of a moving object (KE ∝ v2).
- Describe the relationship between model elements by characterizing a pattern that shows:
  - When the mass of an object increases/decreases the kinetic energy increases/decreases (linearly), and
  - When the speed of an object increases/decreases the kinetic energy increases/decreases by the square of the speed.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Modeling Kinetic Energy	MS-PS3-1	WHST.6-8.1	EU4/EQ4	A23
		MP.2	EU5/EQ5	
		8.EE.A.1		
		8.EE.A.2		
		8.F.A.3		

Formal Assessment: Racing Ahead

Students are tasked with building a mechanical race car, such as a spool racer (STEAMwork Design + Build - Spool Racers w/ Christina (nationalchildrensmuseum.org)) or mousetrap car (How to Make A Mousetrap Car | HST Physics Project (homesciencetools.com)). After completing their car, students experiment with the design to improve the car's performance. Students draw diagrams of their design and make notes on kinetic energy in action, changes in energy, and places where energy is lost. Students race their cars to see how their designs compare, and then write about which cars are best able to convert the stored energy in the car into kinetic energy, and why.

Assessment Purpose and Use

- This assessment is intended to be used as a culminating investigation at the end of the segment.
- The results of this assessment can be used to evaluate evidence of student learning during instructional segment 3, to determine if additional reteaching is needed, and to inform planning for segment 4.
- Performance tasks generally provide opportunities for students to engage with the practices of the discipline along with the content.
- This task is used to measure how well students perform when provided with a complex task and is an opportunity to engage in a meaningful way with the content in the curriculum.

Administration Time: 40 minutes

Scoring Time: 40 minutes

Assessment Type

Formal - Extended Performance Task

Assessment Sub-Type(s)

Extended Project

This assessment will assess students' ability to:

- Design and present a prototype design solution that addresses appropriate scientific ideas in the context of the problem that involves KE.
- Describe how their design solution uses scientific principles of kinetic energy (and its relation to mass and speed) to satisfy the problem's criteria and constraints.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Investigating How Speed and Mass Affect the Motion and Energy of an Object	MS-PS3-1	WHST.6-8.1	EU4/EQ4	A13
• Moving Energy		MP.2	EU5/EQ5	
• Modeling Kinetic Energy		8.EE.A.1		
		8.EE.A.2		
		8.F.A.3		

Instructionally-embedded Assessments for Use during Instructional Segment 4

Informal Assessment: Modeling Gravitational Interactions

Throughout this segment, students explore the nature of gravitational interactions, the relationships with mass and distance, and their effects on motion. Students develop and use models of these gravitational forces, including the relationships between gravitational force, mass, and distance.

Assessment Purpose and Use

- These informal assessments are typically used for formative purposes. The goal is to gauge where students are in their learning, identify what challenges students are facing, and determine next steps for the class and/or individual students.
- The assessments provide information that can be used either at the class level or the individual student level to help determine what instructional activities will best support students.

Administration Time: 3-5 minutes

Scoring Time: 15 minutes

Assessment Type

Informal - Classroom Check-In

Assessment Sub-Type(s)

Exit Tickets

In-the-moment Questions

Discussion prompts

Graphic Organizers

Concept Map

This assessment will assess students' ability to:

- Develop and/or use models to describe that gravitational force is always attractive.
- Use models to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
- Develop and/or use models to describe the relationships among mass, distance, and gravitational force.
- Develop a model with relevant components to represent systems of massive objects and their interactions (i.e., mass, strength of interaction, distance).

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Simulating Gravity	MS-PS2-4	RST.6-8.1	EU2/EQ2	A17

RST.6-8.7	EU3/EQ3	A18
WHST.6-8.1	EU5/EQ5	A19
		A20*
		A21*
		A22*

Formal Assessment: Constructing and Presenting Arguments about Gravitational Interactions

Students are presented with data/evidence from a novel phenomenon, such as a penny and a feather falling in an airless tube, and are asked to construct arguments about the gravitational interactions and relationships between variables affecting the force of gravity.

Assessment Purpose and Use

- Typically used to provide a measure of how well students are able to engage with the concepts taught in the curriculum. Questions are generally tied closely to the concepts as they are taught in the curriculum.
- While they can provide formative information, they are generally not designed to provide in-depth information for each of the concepts and instead provide an overview of student performance across a range of concepts.

Administration Time: 20 minutes

Scoring Time: 3-5 minutes per student

Assessment Type

Formal - Quiz

Assessment Sub-Type(s)

Scenario/Phenomena-based Assessment Task

This assessment will assess students' ability to:

- Construct a sound argument that contains a claim, evidence from the data provided, and reasoning that links the evidence/data to the claim that as mass increases, the magnitude of gravitational force increases.
- Identify evidence/data that supports a claim regarding the relationship between the mass of objects interacting via gravitational forces, the magnitude of that force, and its direction.
- Select the appropriate reasoning based on relevant scientific concepts that explains why the data provided supports a claim regarding the relationship between the mass of objects interacting via gravitational forces, the magnitude of that force, and its direction.
- Identify and use multiple valid and reliable sources of evidence to construct an explanation of the qualitative relationship between gravitational force and direction.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Simulating Gravity	MS-PS2-4	WHST.6-8.1	EU2/EQ2	A20
• Revising Our Explanation		RST.6-8.1	EU3/EQ3	A21*
				A22

Formal Assessment: Modeling Changes in Motion

Students develop an explanatory model of applied forces (i.e., model the direction & magnitude of forces) when two objects interact (e.g., when two objects collide) that includes Newton's laws and energy considerations. Students also consider how the force of gravity is involved in the collision.

Science
Grade: 8 Unit: 1
39 days of instruction

Assessment Purpose and Use

- Performance tasks generally provide opportunities for students to engage with the practices of the discipline along with the content.
- This task is used to measure how well students perform when provided with a complex task and an opportunity to engage in a meaningful way with the content in the curriculum.

Administration Time: 40 minutes

Scoring Time: 5 minutes

Assessment Type

Formal - Extended Performance Task

Assessment Sub-Type(s)

Scenario/Phenomena-based Assessment Task

This assessment will assess students' ability to:

- Develop a model for a collision of two interacting objects exerting forces upon one another.
  - Model includes relationships among model elements that are sufficient in capturing the strength and direction of the forces each object exerts upon the other in a system.
- Develop a model demonstrating all the forces acting on an object.
  - Model includes relationships among model elements that are sufficient in capturing the strength and direction of the forces acting on the object.
  - Model includes a calculation or description of the net force the object will experience based on the new forces being applied to it.
- Provide an appropriate prediction based on the model which articulates the sum of the forces and how the resulting net force would cause no change if the forces were balanced or would change the object's motion if the model shows unbalanced forces.
- Provide an artifact (e.g., calculation, model, explanation, etc.) that demonstrates a correct interpretation of data from forces acting on an object at different scales to predict the change in the object's motion.
- Use quantitative or qualitative evidence to explain how an object subjected to balanced forces does not change its motion.
- Use quantitative or qualitative evidence to explain how the change in the motion of an object subjected to unbalanced forces depends on the mass of the object.
- Construct an explanation that is appropriate to examine how the sum of the force must change in order to achieve the same change in motion for objects with different mass.
- Use quantitative or qualitative evidence to explain how the change in the motion of an object subjected to unbalanced forces depends on the mass of the object.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):

- Ooof, My Face! (Segment 1)
- Revising Our Explanation (Segments 1 through 4)

NGSS PEs:	CCSS:	EUs/EQs:	AGs:
MS-PS2-1	RST.6-8.1	EU1/EQ1	A2
MS-PS2-2	RST.6-8.7	EU2/EQ2	A3
	MP.2	EU5/EQ5	A4
			A9
			A10
			A22

Formal Assessment: Designing Solutions to a Problem Involving a Collision

This assessment is the final presentation of the design project for the unit. Criteria for evaluating students' design projects include not only the success or failure of the design solution, but also the scientific reasoning connecting class content with design choices and revisions. The assessment should emphasize the design process itself and the application of content knowledge over the success or failure of the device. Student presentations may include either a physical demonstration or video of the device and should include a discussion of each of the major topics in the unit and how they informed the engineering design process.

Assessment Purpose and Use

- Students are provided with (or choose) a specific research topic and asked to explore this topic.
- The purpose of this assessment is to provide an opportunity for students to apply knowledge to a particular question or to demonstrate their ability to research a specific topic. It allows them to demonstrate how they would apply concepts over an extended period of time.

Administration Time: 120 minutes

Scoring Time: 15 minutes

Assessment Type

Formal - Research Project

Assessment Sub-Type(s)

Design Project

Extended Project

Hands-on Task

Sample Formative Assessment Task: "Designing Solutions to a Problem Involving a Collision"

This assessment will assess students' ability to:

- Refer to the mass of objects as a basis for deciding how to decrease the amount of force in a collision.
- Design a solution to optimize material selection (minimize force in the collision & minimize cost).
- Apply Newton's third law of motion to justify and identify the best design and to provide justification for the selection based on the application of Newton's third law of motion when provided a description of a physical situation involving a collision between two objects and a list of multiple designs with given criteria.
- Identify multiple ways the design can be improved while providing justification for the selection when provided a description of a physical situation involving a collision between two objects and a list of multiple ways to improve the design with given criteria.
- Identify which collision would have the least amount of force, based on the mass of objects.
- Refer to the system model to identify how objects are interacting to design the system model.
- Construct a system model to analyze Newton's third law forces in a collision (force directions).
- Determine the effect of speed within a collision.
- Identify the action-reaction force pair during the collision of two objects and the statement regarding the magnitude of the action-reaction forces involved in the collision.
- Use the appropriate scientific principle (e.g., action-reaction forces) that supports the effectiveness of the design solution to a problem involving the motion of two objects.

Stage 1 & Stage 3 Associations:

Stage 3 Connection(s):	NGSS PEs:	CCSS:	EUs/EQs:	AGs:
• Applying Understanding of Forces and Kinetic Energy to a Design a Project	MS-PS2-1	RST.6-8.1	EU1/EQ1	A1
	MS-PS2-2	RST.6-8.7	EU2/EQ2	A3
	MS-PS2-4		EU4/EQ4	A4
				A6
				A13
				A21

Guidance for Equitable Assessments for Diverse Learners

How do we optimize accessibility for diverse learners and why is this important? *Designing Equitable Assessments for Diverse Learners* provides steps to planning and developing equitable assessments that incorporate the principles of Universal Design for Learning (UDL) and the elements of Universally Designed Assessments (UDA). Both UDL and UDA are designed to promote access to instruction and/or assessment to the widest range of students. This includes, but is not limited to, students with varying abilities, cultures, primary languages, background knowledge, and interests. For more information about equitable assessment design and use, and why it is important, view *Chapter 4: Fairness and Accessibility* of the Strengthening Claims-based Interpretations and Uses of Local and Large-scale Science Assessment Scores (SCILLSS) Digital Workbook on Educational Assessment Design and Evaluation: Creating and Evaluating Effective Educational Assessments.

Stage 3 – Learning Plan

Learning Plan Rationale

The learning plan is based on an articulation of learning goals (i.e., NGSS PEs, CCSS, EUs/EQs, and acquisition goals (defined in Stage 1) distributed over four instructional segments. These learning goals are used in Stage 2 to identify and describe the assessments that will be used to assess (to collect evidence of) students' learning throughout the course of the unit and instruction. The lessons in Instructional Segments 1 through 4 are designed to ensure students have opportunities to acquire and apply the learning goals in Stage 1. The instructional segments in both Stage 2 and Stage 3 are similar in terms of the learning goals they represent. Assessments listed in Stage 2 for a segment might use (assess) fewer learning goals than are present in the respective Stage 3 but will not use additional learning goals (unless they were taught in a prior segment).

Unit Entrance

The unit opening will focus on students experiencing and discussing a phenomenon that sparks their interest and curiosity. To do so, the class engages with an "anchor phenomenon" and generates questions based on that phenomenon, posting their questions to the "driving question board." Some of the questions added to the driving question board can be used by the teacher to transition into Instructional Segment 1, by framing the lessons (and segment) as a means by which to investigate and answer some of the questions that students generate based on the anchor phenomenon.

Throughout the unit (e.g., at the conclusion of each instructional segment) the teacher returns to the driving question board and has students reflect on their recent learning, and which questions they can now answer based on their learning in the prior segment. Following this reflection, the teacher uses the driving question board again, this time identifying remaining unanswered (or partially answered) questions that can motivate the activities and investigations that will be the focus of the next instructional segment.

Anchor Phenomenon

In this unit, the anchor phenomenon is about collisions. These compelling situations can be used as a starting point for a discussion about collisions in various situations, the effects of those collisions on an object's motion, and the factors that affect the forces and corresponding changes in motion.

There are several possible anchoring phenomena that the teacher may want to consider. Some examples are:

- The teacher may start with an image (or video) of a soccer ball colliding with a player's face. Video of ball/face collision: https://youtu.be/On1CsbTwlDs?t=155.
- The Artemis Mission and Orion Spacecraft: The Orion spacecraft is used as part of the Artemis missions, seeking to return a human to the moon. This will require landing on both the moon and Earth and bringing an object down to Earth so that it collides safely. Information on the NASA mission, including images and videos: https://www.nasa.gov/exploration/systems/orion/index.html and https://www.nasa.gov/artemis/videos.
- Motor vehicle safety/accidents. Crash tests and automobile safety equipment help keep people safe in the event of an accident. For example: https://www.youtube.com/watch?v=VEHC2iJ3Ufg or https://www.youtube.com/watch?v=fPF4fBGNK0U.

Science
Grade: 8   Unit: 1
39 days of instruction

Unit Framing

General Framing

In this unit, the anchor phenomenon is used to introduce and contextualize a unique situation that involves students Constructing Explanations and Designing Solutions to apply their physical science knowledge to explain the situation. Students begin work on the explanation at the end of Instructional Segment 1 and complete it at the end of Instructional Segment 4.

Framing for SIPS Instructional Framework

When returning to the driving question board after each segment, teachers will pay particular attention to questions that can advance students' progress in developing their explanation of the situation. Finally, students apply their learning to an engineering challenge, designing a vessel to protect an egg as part of the egg drop challenge.

Example Driving Questions

Potential driving questions that students might generate based on their observations of the anchor phenomenon and/or discussion of the unique situation (using the ball example):

- *Is the ball changing shape, or only the player's face?*
- *Does a volleyball change shape when it hits the ground or when a volleyball player hits it with her hands?*
- *Which sports use helmets and which don't?*
- *What is the purpose of wearing a helmet?*
- *What happened to the ball after this picture?*
- *How could you minimize the impact on the player?*

Problematization / Investigative Strategy for the Unit

Following the discussion of the image(s), the teacher introduces the goal of explaining the situation and how these explanations can help us develop solutions. Because investigations and experiments on collisions (between a human and a ball, Earth, cars, or other examples) are not feasible to do in a classroom context, students use different examples as models of the human and of the colliding object (For example, a pair of toy cars rolling down ramps).

Instructional Segment 1

Learning Investigations and Sample Lessons

Stage 1 Associations	
NGSS PE's: MS-PS2-1 **CCSS:** MP.2, RST.6-8.3, RST.6-8.7, WHST.6-8.1 **EUs/EQs:**	**Estimated Classroom Time: 400 minutes** **Ooof, My Face!** • 5Es: Engage • Estimated Time: 50 minutes • AGs: A1*, A2* A3*, A6 Students are introduced to the anchoring phenomenon and the goal of developing a multi-modal scientific explanation and design solution to the problem it presents. The teacher presents students with a unique situation, such as a soccer ball striking a person in the face, which introduces the problem of injuries to the player due to the impact of the ball. Students watch a video or examine images of the situation and draw pictures of the

EU1/EQ1 **EU2/EQ2** **EU5/EQ5** **AGs:** **A1** **A2** **A3** **A4** **A6** **A8**	situation. Then, students add representations of forces (often arrows are used, but students should decide), labels, and other relevant information to help explain all the forces and interactions taking place. It is not expected that students have a complete understanding of the situation and the force pairs. These initial models should be documented by the teacher and can be used as information for future lesson modifications. Students should keep their models with the intention of revising them over the learning experience. **Equal and Opposite** • 5Es: Explore, Explain • Estimated Time: 100 minutes • AGs: A1*, A2*, A3*, A4, A6*, A8 Building on the prior lesson, this lesson will introduce students to the idea of equal and opposite forces as students measure forces with spring scales. If necessary, the teacher models how a spring scale (or probe) operates. Spring scales should be in Newtons. If it is in kilograms, students must convert it to Newtons using weight = mass x acceleration due to gravity. For the purposes of this activity, multiplying by 10 for “g” is appropriate (weight = 10 x mass(kg)). Scientific probes which measure force can also be used. Using stations around the room, the teacher can set up several situations with spring scales to provide students with the opportunity to experiment. Students should explore the stations and record quantitative and qualitative data in a science notebook. After the conclusion of these activities, students work in small groups to identify and apply specific vocabulary to these activities and discuss what they observed and experienced. The teacher facilitates a class-wide conversation about key takeaways from the lesson. Students should recognize that in each situation, the interacting objects each experience the same magnitude of force being applied to them, but they are in different directions. Students should also recognize that the forces do not cancel each other out because they are on different objects. Students document this understanding as part of a smaller explanation (possibly using a C-E-R activity/scaffold) in their science notebook to demonstrate their understanding of these force relationships. **Newton’s Third Law** • Explore, Explain • Estimated Time: 100 minutes • AGs: A1*, A2*, A3*, A6*, A8 Newton’s third law can be a difficult concept that is not readily apparent after the lab. Students may struggle with many of the concepts. Using stations, students engage with multiple short hands-on activities, videos, reading passages, and other media to further explore the concept of equal and opposite forces. This also provides students with a chance to check their understanding with a field of experts outside the classroom. As students work through the stations, they should record key takeaways and notes in their

	science journals. They also fill out a C-E-R organizer based on a claim that when two objects interact, the force from object one acts on object two and vice versa. **[See Sample Lesson: *Newton's Third Law*]** **Revising Our Explanation** • 5Es: Explain, Evaluate • Estimated Time: 50 minutes • AGs: A1*, A2*, A3*, A4, A6, A8 Students revisit their initial explanation concerning the anchoring phenomenon. Students revise their explanation of the event and consider what could be done to limit the forces involved in the impact. Students should use what they have learned about Newton's third law to inform their design (for example: adding arrows that are equal but opposite to the different interacting objects on their diagram). Students share their current thinking with peers, give each other feedback, and revise their explanations based on the feedback. **Rocketing Off, With Water!** • Elaborate • Estimated time: 100 minutes • AGs: A1 A2, A3, A6, A8 Students are provided with instructions on how to create a water-powered rocket using a 2L bottle and crafting supplies (https://www.nasa.gov/stem-ed-resources/water-rocket-construction.html). Students are challenged to create a rocket that will fly the highest or longest, then return to Earth. In small groups, students design and build their rocket and use what they have learned about Newton's third law to justify their choices. In addition to changing the physical design of the rocket, students should also decide how much water and air they would like in the bottle. After everyone has designed and built their rocket, the class will test them in a large open area. Then, students write a reflection on what worked well for everyone and what did not work well while connecting the experience back to Newton's third law.
Instructional Segment 2	
Learning Investigations and Sample Lessons	
Stage 1 Associations **NGSS PE's:** **MS-PS2-1** **MS-PS2-2** **CCSS:** **MP.2** **RST.6-8.1** **RST.6-8.3**	**Estimated Classroom Time: 550 minutes** **Changing Motion** • 5Es: Engage • Estimated Time: 50 minutes • AGs: A4, A9, A10*, A11 To introduce the concepts of changing motion and forces, students experiment with a simple circular motion apparatus to collect observational data. This activity is based on a uniform circular motion experiment that is above grade expectations: https://learning.hccs.edu/faculty/kam.chu/phys1401/lab-handout/lab-7-circular-motion.

RST.6-8.7 **WHST.6-8.1** **EUs/EQs:** **EU1/EQ1** **EU2/EQ2** **EU5/EQ5** **AGs:** **A1*** **A2** **A3** **A4** **A5** **A6** **A7** **A8** **A9** **A10** **A11** **A12**	Instead of having students hang masses, students can use a spring scale and experiment with the results of changing the motion. Before the activity, the teacher facilitates a talk with students about the motion of the rubber stopper. Using scaffolding questions, the teacher supports students in understanding that the motion of the stopper is not constant but constantly changing. Students experiment with the apparatus to find relationships between the force shown on the spring scale and the changing motion. Students should find that the motion changes more when the force is larger, or the stopper changes direction faster while maintaining a constant speed. **Getting to the Bottom of Newton's Second Law** • 5Es: Explore • Estimated Time: 200 minutes • AGs: A4, A7, A10, A11 For this activity, students experiment with a ramp and a single rolling object (toy car). Students are provided with a timer, meter stick, spring scale or force probe, ramp material, rolling object, and supports to construct a ramp. The teacher should provide additional materials that may not be necessary for students (extra rolling objects, extra measurement tools). Students who need additional support may have fewer extra materials. All students should design their experiment with the most minimal scaffolds possible. Students plan an experiment to find the relationship between force, the change in motion, and acceleration. (Note: calculating acceleration from data is above grade level.) Students may need support with measuring or calculating the change in motion (acceleration). To help students, the teacher could provide the equation to find acceleration or ask students to use the time to the bottom for the change in motion. For acceleration, students can use acceleration = 2(distance)/(time^2). If students use the time to the bottom, they may need support seeing that the shorter the time, the faster the object is traveling, meaning a larger change in motion. Students should measure the force using the scale before releasing the toy car. The force on the spring scale/meter will be the net force when students release the car. Students draw a design of their experiment and write up a plan with expected outcomes. Peers and the teacher should provide feedback on their design before they begin their testing. Students run their experiments and collect the data. Working in small groups, students analyze their data. Students who are not familiar with scatter plots may need support around their creation. A common misconception is that students should create a line graph with lines connecting the dots. Students should not connect the dots, as these data points are separate trials and not a continuation of a single event. Instead, they should plot their data points and then add a line that represents the best fit. Student data should support the conclusion that there is a linear relationship between acceleration and the force, a = (constant) x force. The teacher should encourage students to look at the mass of the rolling object as it should be close to the slope of the line.

	Students write a lab write-up for their experiment which includes their analysis and conclusion in which they explain how their data supports their findings. Students return to their toy car and ramp setup to revise their design and create an experiment to see how varying mass impacts the acceleration of different objects when the same force is applied. Students need to vary the ramp to ensure that the same force is applied each time with the different masses. Students may make an error here and keep the ramp angle constant, but this would result in a different net force. The acceleration will be close to the same if you keep the angle of the ramp the same. Students review their data again, graph their data, and find a trend line for the data. Students use this data to write an analysis and conclusion to explain their findings. The teacher engages students in a class discussion of the findings of each experiment and how those findings support a mathematical model for Newton's second law, F = ma (or a = F/m). Students revisit their explanatory model to revise and add information based on what they have learned in the two experiments. **[See Sample Lesson:** *Getting to the Bottom of Newton's Second Law***]** **Sum of Forces and Changing Motion** • 5Es: Explore, Evaluate • Estimated Time: 150 minutes • AGs: A5, A7, A9*, A12 Having explored the impact of one force, students now explore the impact of two forces by adding a dragging force to their apparatus. Students consider their initial experiment and create a modification to their design. For example, students may use a weight/mass hanging from a string over a pulley and attach it to the car. Students could split the string and tie a spring scale in between to measure the dragging force, or they can calculate the dragging force using the mass of the hanger. To keep the mass constant, students need to move any mass from the hanger to the car, and vice versa. The total mass of the string, scales, hanger, and car is the total mass. Students re-run their experiment, making sure to measure the force pulling down and the drag force before the experiment starts. Using this data, they can calculate the new Net Force, graph their data, and then see how this new net force relates to the change in motion they have measured, like the previous experiment. Students should write a conclusion that explains their results. **Newton's Laws** • 5Es: Explore, Explain • Estimated Time: 100 minutes • AGs: A4, A6, A9, A10, A11, A12 Part of understanding science is verifying results with others in the field. To learn more about Newton's laws and to verify their own understanding, students visit multiple stations around the classroom, each providing additional information about Newton's laws. Students record notes from each station in their science journals. Stations should

	provide opportunities for diverse learning experiences such as videos, reading passages, digital simulations, and simple hands-on activities. To provide students with options and choices, the teacher may want to create extra stations and provide additional resources at each station. Students rotate through the stations, documenting their learning and making conclusions about the relationship between an object's mass and change in motion. **Revising Our Explanation** • 5Es: Explain, Evaluate • Estimated Time: 50 minutes • AGs: A1*, A2, A3, A6*, A8*, A10 Students revisit their revised explanation concerning the anchoring phenomenon. Students revise their explanation of the event and consider what could be done to limit the forces involved in the impact. Students should use what they have learned about Newton's second law to inform their design and consider adding or changing arrows to represent the different sizes of forces acting on the objects involved in the collision. For example, students may decide to change the lengths of the arrows to represent the sizes of the forces and may want to add different lengths of arrows to indicate the size and direction of accelerations. Students share their current thinking with peers, give each other feedback, and revise their explanations based on the feedback.
Instructional Segment 3	
Learning Investigations and Sample Lessons	
Stage 1 Associations **NGSS PE's:** **MS-PS3-1** **MS-PS2-1** **CCSS:** **MP.2** **8.EE.A.1** **8.EE.A.2** **8.F.A.3** **RST.6-8.1** **RST.6-8.3** **RST.6-8.7** **WHST.6-8.1** **EUs/EQs:** **EU1/EQ1** **EU2/EQ2**	**Estimated Classroom Time: 400 minutes** **Investigating How Speed and Mass Affect the Motion and Energy of an Object** • 5Es: Engage, Explore • Estimated Time: 150 minutes • AGs: A13*, A14, A15, A16 Collisions involve more than just forces; the colliding objects possess energy which is released in different forms during the collision. In this investigation, students copy the important experiment of French Physicist and Philosopher Émilie du Châtelet (https://www.wowstem.org/post/émilie-du-châtelet-kinetic-energy-experiment). Instead of telling students this, the teacher presents students with the challenge and asks them to brainstorm ideas on how to find the amount of energy something has when it crashes into Earth. As a class, students brainstorm ideas to model the experimental design process. Students first drop a mass from different heights into clay, and then measure the distance traveled into the clay. This will allow them to qualitatively compare the speed and energy. Speed can be calculated by using V = √(gh) where g is 10 m/s^2 and h is the height. The depth of the collision will provide students with a way of measuring the energy after each fall. After conducting the experiment with a constant mass and changing height, students should repeat the process but vary the mass and keep the height constant. A version of the NOVA movie, Einstein's Big Idea can also be found at https://youtu.be/V64toYdH9hU. The segment on Émilie du Châtelet begins at 55:00.

EU4/EQ4	
EU5/EQ5	
AGs:	
A1*	
A6	
A13*	
A14	
A15	
A16*	

Ideally, students design their own experiment for this setup, but that can be challenging. One idea may be to present students with an introduction using the PBS special Einstein's Big Idea, which provides an interesting introduction and shows the experiment in action. A modification could be asking students to create their own energy experiment to verify findings using different materials.

After collecting the data, students graph their data in a scatter plot. They should find a linear relationship between mass and energy. Students may struggle with recognizing the non-linear pattern between speed and energy. Many students will plot a trend line and not see the curve. Before students write their analysis and conclusion, the teacher should facilitate a discussion about the data. If possible, students can post their data points in a shared spreadsheet and the teacher can plot the data points and use the scatterplot to drive the discussion. The teacher facilitates a class discussion where students use evidence from the graph and work to find the pattern. At some point, the teacher may need to introduce the idea of non-linear patterns and should share several graphs that show non-linear relationships (cyclical wave patterns from weather, population curves, etc.).

Moving Energy

- 5Es: Explore
- Estimated Time: 100 minutes
- AGs: A13*, A14

Using stations, students engage with multiple short hands-on activities, videos, reading passages, and other media to explore the relationship between mass and kinetic energy (KE) further. This provides students with a chance to check their understanding with a field of experts outside the classroom. As students work through the stations, they record key takeaways and notes in their science journals. They also fill out a C-E-R organizer based on a claim about the relationship between mass and kinetic energy. The teacher can refer to the resource list for potential sources for simulations, reading passages, and videos. Students could also read about kinetic energy in core textbooks. As students conduct their research on KE, they should record key takeaways in science journals. To make this activity more challenging, students could be tasked with conducting research on their own. For students who need accommodations, the teacher may consider different levels of reading, reducing the resources to the most essential, and providing multiple paths of understanding the content.

Modeling Kinetic Energy

- 5Es: Explain, Evaluate
- Estimated Time: 100 minutes
- AGs: A13*, A14, A15*, A16*, A23

Students create a set of models that demonstrate the relationship between mass and kinetic energy, and the relationship between speed and kinetic energy. Students' models should be informed by their data and data analysis from prior investigations in this unit. Students are tasked with creating two models:

	• Model 1 should explain how balls with different masses moving at similar speeds will have different kinetic energies. • Model 2 should show how a ball will have different values of kinetic energy depending on its speed. Students use their models to make new predictions. Using a rubric that the teacher provides to help students evaluate their models, students assess how their model demonstrates the relationship of mass, speed, and kinetic energy in a similar scenario. For example, if a model compares the kinetic energy of a baseball and a softball, then students discover how the model predicts the kinetic energy of a soccer ball moving at a similar speed. Students use their findings to advance a claim about the relationships between mass, speed, and kinetic energy and use their model as evidence to support their claim. **Revising Our Explanation** • 5Es: Explain, Evaluate • Estimated Time: 50 minutes • AGs: A1*, A6, A13*, A23* Students revisit their revised explanation concerning the anchoring phenomenon. Students revise their explanation of the event and consider what could be done to limit the energy and energy transfer in the impact. Students should use what they have learned about kinetic energy to inform their explanation. For example, identifying ways in which kinetic energy is transferred to other sources and the effects of the collision are reduced. Students share their current thinking with peers, give each other feedback, and revise their explanations based on the feedback.
Instructional Segment 4	
Learning Investigations and Sample Lessons	
Stage 1 Associations **NGSS PE's:** **MS-PS2-1** **MS-PS2-2** **MS-PS2-4** **CCSS:** **MP.2** **WHST.6-8.1** **RST.6-8.1** **RST.6-8.7**	**Estimated Classroom Time: 500 minutes** **Engaging with Gravity** • 5Es: Engage • Estimated Time: 100 minutes • AGs: A9, A21* In this lesson, students begin with a small activity using water flowing from a hole in a cup at different heights. Students observe and develop questions regarding gravitational interactions that use previous knowledge of forces and motion. • Part 1– Poke a hole in the cup on the side near the bottom, cover the hole with a finger, fill the cup with water, remove the finger, and observe the motion of the water. • Part 2 – Cover a hole with a finger, fill the cup with water, drop the cup, and observe differences in the motion of water.

EUs/EQs: **EU1/EQ1** **EU2/EQ2** **EU3/EQ3** **EU5/EQ5** **AGs Goals:** **A1** **A6*** **A8** **A17** **A18** **A19** **A20** **A21** **A22**	• Questions to ask – What was different about the motion of the water? What forces were acting on the water when you were holding it with a finger over the hole? After removing the finger? When dropping a full cup? Then students create a Notice/Wonder chart by discussing what they know and need to know about gravity to answer the question: *What factors affect the size of the force of gravity on an object*? **Simulating Gravity** • 5Es: Explore • Estimated Time: 150 minutes • AGs: A17, A18, A19, A20, A22 To start, students manipulate a simple simulation and generate a theory about the factors that impact gravity. As a class, discuss what variables appear to be changing as they manipulate the model. Students should choose a variable (mass or distance) to explore and write a predicted relationship as a theory to be tested. From this, they should write up a plan to test their theory using a more complex simulation. Students compare their investigation plans with each other and receive teacher and/or peer feedback on their selection of variables and planned evidence to collect. Then, students conduct their investigation. Students summarize their data by graphing results. Students compare results and make and defend claims about the relationship between the force of gravity, mass, and distance. Next, students look at outside evidence from various sources that may help support or refute their findings obtained from the lesson 'Simulating Gravity' so that they can revise their understanding if needed. Information could include the value of *g* and its dependence on the distance from the center of the Earth, masses of the sun, planets, and their moons. Students should record their thoughts and key takeaways in their scientific journals. **Revising Our Explanation** • 5Es: Explain, Evaluate • Estimated Time: 50 minutes • AGs: A1*, A6*, A8, A21, A22 Students revisit their revised explanation concerning the problem presented in the anchoring phenomenon: reducing the impact of the ball. Students use the SEP of constructing explanations and designing solutions to revise their explanation of the event and consider how the force of gravity is involved in the collision. Students should use what they have learned about gravity to inform their explanation. For example, if using the NASA Orion capsule as an anchoring event, students should consider how the force of gravity will be different between the Earth and the moon. Students share their current thinking with peers, give each other feedback, and revise their explanations based on the feedback.

	The teacher instructs students how to engage in scientific argumentation from evidence. Students engage in argumentation to defend (support) their explanations which they have been refining over the entire unit. Students present their arguments to each other and discuss which qualitative and quantitative data collected during prior investigations support (or refute) the argument. **Applying Understanding of Forces and Kinetic Energy to a Design Project** • 5Es: Elaborate • Estimated Time: 200 minutes • AGs: A1, A6*, A21 Having learned about and analyzed a real-life situation, students are now faced with the engineering challenge of protecting an "egg-stronaut" as it returns to earth. Students are presented with the engineering problem: protecting the egg as it collides with the earth. This is the classic egg-drop engineering activity. To start, the teacher should provide some information about the challenge and design constraints. These constraints could include the materials, the size, the weight, the cost, or other constraints that make sense. From there, students work in small groups on the engineering process to design a prototype, which they share with the class for feedback. After students design their prototype, they should build and test their prototype and make revisions. Students present their final prototype to the class and explain using information from the unit, their reasoning, and how they met the set constraints. After presenting their work, all students should demonstrate their prototype and determine as a class which designs they think are best. Students should write a short essay explaining which prototype they think was the best and give reasons why.

Accessibility and Differentiation for Diverse Learners
"Universal Design for Learning (UDL) is a framework to improve and optimize teaching and learning for all people based on scientific insights into how humans learn" (CAST, 2022). Taking time to reflect on prior instruction when planning for accessible, differentiated, and culturally responsive instruction for diverse learners and culturally diverse classrooms serves to identify ways to improve future instructional practices. The UDL Guidelines provide a framework for this reflection. The guidelines include three principles, Multiple Means of Engagement, Multiple Means of Representation, and Multiple Means of Action & Expression as ways to focus on variety and flexibility in instructional practices. By examining instruction and instructional materials through the lens of each of these principles, we can identify and thus reduce or remove barriers to diverse learners. Providing Multiple Means of Engagement (e.g., allowing choices, authentic scenarios, varying demands, and clear goals), broadens the opportunities for gaining and sustaining students' interest and cognitive engagement in learning the content. Providing Multiple Means of Representation (e.g., variety of presentation modes, clarifying vocabulary, activating background knowledge) allows for students to receive and comprehend the content. Providing Multiple Means of Action & Expression (e.g., a variety of methods to respond to instruction, and a variety of ways to interact with the instructional materials) helps students to use their strengths and abilities to access the instructional materials and express what they understand. Accommodations are typically reserved for students receiving special education, students who

have a 504 plan, and English Learners can be made available to all students using the UDL principles, thus allowing all students to benefit from the accommodations.

The SIPS Grade 8 Unit 1 Instructional Framework Differentiation Strategies and Resources support educators' intentional planning of accessible, differentiated, and culturally responsive instruction for all students aligned to the specific performance expectations in focus for this unit.

Core Text Connections

- Newton's Third Law (Read) | Physics | CK-12 Foundation (ck12.org)
  [https://www.ck12.org/physics/Newtons-Third-Law/lesson/Newtons-Third-Law-MS-PS/]
- Newton's Third Law of Motion (nasa.gov)
  [https://www.grc.nasa.gov/www/k-12/rocket/newton3r.html]
- Newton's Third Law of Motion: Definition, Application - Embibe
  [https://www.embibe.com/exams/newtons-third-law-of-motion/]
- 15 Examples of newton's third law of motion - DewWool
  [https://dewwool.com/newtons-third-law-examples/]
- Energy and Physical Science, Reading Comprehension Passages (readworks.org)
  [https://www.readworks.org/article/Energy-and-Physical-Science/d55cb7f0-e838-46dc-b7b0-3c12bf515f2c#!articleTab:content/contentSection:9b1089cb-5688-45cb-9990-0229e63a1247/]
- Crashing, Jumping, Falling, Eighth Grade Reading Passage (readworks.org)
  [https://www.readworks.org/article/Crashing-Jumping-Falling/5346c7b1-a435-484b-835a-aec446f2701e#!articleTab:content/]
- Dynamics of Flight (readworks.org)
  [https://www.readworks.org/article/Dynamics-of-Flight/2f44df6d-1e39-4b70-bba7-c974132e5529#!articleTab:content/]
- Satellites and Gravity, Sixth Grade Reading Passage (readworks.org)
  [https://www.readworks.org/article/Satellites-and-Gravity/db9d5a7e-11d6-4e3b-a2b5-7a24b288803b#!articleTab:content/]
- Rockets and Space Vehicles (readworks.org)
  [https://www.readworks.org/article/Rockets-and-Space-Vehicles/2e645081-42c3-4156-a47c-9d7e44277c4d#!articleTab:content/contentSection:35962535-e520-4cbb-83b4-f6f0ca0d24ae/]
- How Soccer Can Help Us Understand Physics, Sixth Grade Reading Passage (readworks.org)
  [https://www.readworks.org/article/How-Soccer-Can-Help-Us-Understand-Physics/6471285a-9014-40c5-8539-bca48a3adc29#!articleTab:content/]
- Why Don't People on the Other Side Fall Off?, Sixth Grade Reading Passage (readworks.org)
  [https://www.readworks.org/article/Why-Dont-People-on-the-Other-Side-Fall-Off/23c73b4b-20da-45d8-8833-b0dd7745ff92#!articleTab:content/]
- Improving Technology, Informational Texts (readworks.org)
  [https://www.readworks.org/article/Improving-Technology/a161b7b9-bb77-4ea4-921f-7cd077668ac9#!articleTab:content/contentSection:41e56718-fc5f-4362-91cf-d16626f80bf5/]
- Energy and Physical Science, Reading Comprehension Passages (readworks.org)

[https://www.readworks.org/article/Energy-and-Physical-Science/d55cb7f0-e838-46dc-b7b0-3c12bf515f2c#!articleTab:content/contentSection:b800b419-85a0-49d5-9bfc-3b8788b45049/]

- Energy Screams, Sixth Grade Reading Passage (readworks.org)
  [https://www.readworks.org/article/Energy-Screams/44c32492-7bb8-4ae0-9bce-df64e420e866#!articleTab:content/]
- CK-12 Physical Science for Middle School | CK-12 Foundation (ck12.org)
  [https://flexbooks.ck12.org/cbook/ck-12-middle-school-physical-science-flexbook-2.0/]

Instructional Resources

Stage 3 Instructional Resources:

Segment 1

- Water Rocket Construction | NASA
  [https://www.nasa.gov/stem-ed-resources/water-rocket-construction.html]

Segment 2

- Uniform Circular Motion Handout
  [https://learning.hccs.edu/faculty/kam.chu/phys1401/lab-handout/lab-7-circular-motion]

Segment 3

- Émilie du Châtelet - Kinetic Energy Experiment (wowstem.org)
  [https://www.wowstem.org/post/%C3%A9milie-du-ch%C3%A2telet-kinetic-energy-experiment]
- (1) Einstein's Big Idea - YouTube
  [https://www.youtube.com/watch?v=V64toYdH9hU]
- Einstein's Big Idea | NOVA | PBS
  [https://www.pbs.org/wgbh/nova/video/einsteins-big-idea/]

Segment 4

- Gravity Force Lab: Basics (colorado.edu)
  [https://phet.colorado.edu/sims/html/gravity-force-lab-basics/latest/gravity-force-lab-basics_en.html]
- Gravity Force Lab (colorado.edu)
  [https://phet.colorado.edu/sims/html/gravity-force-lab/latest/gravity-force-lab_en.html]
- Egg Drop Project
  [https://docs.google.com/presentation/d/1vElJbdK5EI5uchTxrE3rjEGF6OVG1mSRL4z9CQJMMqw/edit#slide=id.p]