Coherence and Alignment Among Science Curriculum, Instruction, and Assessment (CASCIA) Project

Grade 8 Unit 1: Forces and Energy

Interpretive Guidance and Instructional Strategies for Educators

October 2023

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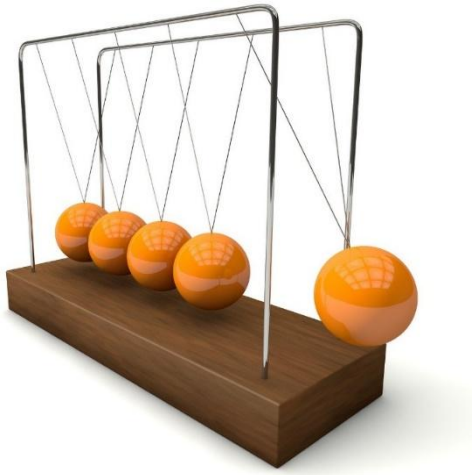
Table of Contents

Purpose

The purpose of this document is to help educators understand their students' performance on the Grade 8 Unit 1 Science Assessment and to provide instructional strategies and resources for planning and adjusting instruction to help students learn, whether it involves reteaching previously addressed concepts and skills from the prior instructional unit or planning additional learning opportunities, interventions, or extensions in the next unit.

Unit Overview

By engaging in this unit, students deepen their knowledge of forces, including gravitational forces, motion, and energy related to mass, and how these concepts can be used to explain phenomena including collisions, the changes in motion that result, and the effect of collisions on objects. Students develop their experience and skills in planning and carrying out investigations and constructing and interpreting graphical displays of data in support of arguments to explain interactions between energy, forces, and motion in a system.



Instructions for Educators

1. Based on your analysis of student work from the assessment, in combination with additional assessment evidence gathered over the course of the instructional unit, consider themes or trends in your students' performance. Refer to your students' scores on the Classroom Roster Report to determine the degree to which students in your classroom require additional instructional support based on their instructional needs levels—red, yellow, or green—for each performance category.
2. For each performance category, use the provided interpretive guidance (i.e., *What These Results Mean*, *Next Instructional Steps*, and *Example Scored and Annotated Student Work* located in the Grade 8 Unit 1 EOU Assessment Scoring Guide) to understand what your students likely know and are able to do and to consider next instructional steps based on their instructional needs levels. Scored and annotated student work samples are provided for each performance category to demonstrate the evidence students might demonstrate in response to each prompt for each possible score point. The student responses represent the full range of score points possible for each prompt based on the scoring rubric.
3. For each performance category, use the *Instructional Strategies and Resources* organized by Universal Design for Learning (UDL) principle to support the design and delivery of accessible instruction and learning opportunities for all students based on their performance on the Grade 8 Unit 1 Assessment and their recommended instructional needs. These instructional recommendations can be selected and used to intentionally plan instruction and learning opportunities for students across the range of instructional needs levels (i.e., red, yellow, green).

Universal Design For Learning

The instructional strategies and resources provided in this document are organized by the Universal Design for Learning (UDL) principles. 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.

Multiple Means of Engagement	*The WHY of Learning* - provide options for recruiting student interest, sustaining effort, and promoting motivation
Multiple Means of Representation	*The WHAT of Learning* - provide options for displaying information, including alternatives for auditory and visual information, use multi-media, clarify vocabulary and symbols, support comprehending text, and guide information processing and visualization
Multiple Means of Action & Expression	*The HOW of Learning* – vary the methods for student responses and collection of evidence of their learning, optimize access to tools and technologies, use multiple tools for construction and composing responses, facilitate managing information and resources, and enhance student capacity for monitoring progress

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 to promote accessible and equitable teaching and learning opportunities. Application of UDL guidelines and principles allows all students to engage with and be provided with multiple means of representing instructional content and expressing what they know and can do which is similarly the purpose of the use of accommodations for students receiving special education, students who have a 504 plan, and emerging Bilinguals.

Performance Category 1: Design the Best Solution to a Problem Involving Energy, Forces, and Motion

Interpretive Guidance for Performance Category 1: Design the Best Solution to a Problem Involving Energy, Forces, and Motion *Task 1, Prompt 2, Parts A & B (6 points); Task 2 Prompt 4 (4 points)*		
Red (0-4 score points earned) ➢ Extensive additional instruction and reteaching of these skills is recommended. ➢ The student needs significant opportunities to reinforce and apply these skills in future learning.	**Yellow (5-8 score points earned)** ➢ Moderate additional instruction on these skills is recommended. ➢ The student needs additional opportunities to strengthen these skills in future learning.	**Green (9-10 score points earned)** ➢ **Minimal to no** additional instruction on these skills is recommended. ➢ The student is ready to extend these skills in future learning.
What These Results Mean		
This student is likely able to: • **Use insufficient information to** evaluate the relative usefulness of a design solution to a presented problem involving energy, forces, and motion, supported with **limited or unrelated** evidence pertaining to **few** specified design parameters. • Solution addresses **few or no constraints** or some constraints are **not accurately analyzed** to address a problem involving energy, forces, and motion**.** • **Attempt to** consider one or two alternative solutions with **procedural or conceptual errors** relating to the relationship among kinetic energy, mass, and velocity **with little to no supporting evidence** of how the solution meets the stated criteria, constraints, and technical feasibility**.**	**This student is likely able to:** • **Accurately** evaluate and **clearly** articulate the relative usefulness of a design solution to a presented problem involving energy, forces, and motion by **clearly** utilizing evidence **relevant** to **most** of the specified design parameters. • Solution connects **some relevant information to a design characteristic(s)** to a problem involving energy, forces, and motion in a way that uses scientific language appropriately to describe the proposed solution. • Demonstrate **partial** understanding of the relationship among kinetic energy, mass, and velocity **by attempting to explain** how the solution meets the stated criteria, constraints, and technical feasibility.	**This student is likely able to:** • **Accurately** evaluate and **clearly** articulate the relative usefulness of a design solution to a presented problem involving energy, forces, and motion by **effectively** utilizing evidence **relevant** to **all** specified design parameters. • Solution connects **all relevant information to design characteristics** to a problem involving energy, forces, and motion in a way that convinces the audience that the proposed solution is the best one available. • Demonstrate **complete and accurate** understanding of the relationship among kinetic energy, mass, and velocity when explaining how the solution meets the stated criteria, constraints, and technical feasibility.

Interpretive Guidance for Performance Category 1:
Design the Best Solution to a Problem Involving Energy, Forces, and Motion

Task 1, Prompt 2, Parts A & B (6 points); Task 2 Prompt 4 (4 points)

Red (0-4 score points earned)	Yellow (5-8 score points earned)	Green (9-10 score points earned)
➢ Extensive additional instruction and reteaching of these skills is recommended. ➢ The student needs significant opportunities to reinforce and apply these skills in future learning.	➢ Moderate additional instruction on these skills is recommended. ➢ The student needs additional opportunities to strengthen these skills in future learning.	➢ **Minimal to no** additional instruction on these skills is recommended. ➢ The student is ready to extend these skills in future learning.
Next Instructional Steps		
Provide opportunities for the student to: • Collaboratively match potential design solutions to meet design requirements. • Identify evidence to make a conclusion about the best solution for a given design requirement. • Given a design solution, identify design requirements not met by the solution from a provided list. • Identify inaccurate or irrelevant evidence (e.g., data) to support an explanation about the formation of a new substance or the conservation of mass. • From a list, identify the correct explanation of a phenomenon using the relationships between kinetic energy, mass, and velocity • From a list, identify the correct explanation of a phenomenon using Newton's third law of motion.	**Provide opportunities for the student to:** • From a list of potential design solutions, identify the most effective design using data provided in a table to justify the selection. • From a list of data with varying degrees of relevance, identify the most relevant pieces of data to support the selection of one design solution over another for a given design requirement. • From the same list of data, identify the most relevant pieces of evidence to support the selection of one design solution over another for a different design requirement. • Practice constructing an explanation of a phenomenon using the relationships between kinetic energy, mass, and velocity by filling in the blanks of an explanation using a word bank.	**Provide opportunities for the student to:** • Evaluate the strengths and limitations of a design solution across each design requirement. Utilize evidence from a table, as well as the relationship between kinetic energy, mass, velocity, and Newton's third law in the evaluation for each design requirement. • Design a procedure to determine the effectiveness of a design solution. Include type of data needed to evaluate strengths and limitations of the design. Connect the methodology to the relationship between kinetic energy, velocity, and mass, as well as Newton's third law.

	• Practice constructing an explanation of a phenomenon using Newton's third law of motion by filling in the blanks of an explanation using a word bank.	

Instructional Strategies and Resources for Performance Category 1: Design the Best Solution to a Problem Involving Energy, Forces, and Motion *Task 1, Prompt 2, Parts A & B (6 points); Task 2 Prompt 4 (4 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
	***Constructing Explanations and Designing Solutions through Discourse and Modeling*** Provide varied opportunities (stations, small groups, partners, whole class) for students to engage in interactive discourse where they build on each other's ideas, the identification of constraints and criteria, the selection of design characteristics, and refinement of design ideas to see which ones best meet the constraints and criteria of the problem. Opportunities for scientific discourse should be situated in authentic, interest-driven science investigations. ***Culturally Responsive Design Solutions*** Foster asking questions and solving meaningful problems through engineering in local, culturally responsive contexts, drawing from and respecting students' cultural resources, backgrounds, and personal experiences. Provide a range of ways for students to engage in cooperative learning (e.g., think-pair-share, jigsaw, round robin) with diverse groupings of students. Utilize interesting phenomena and relevant contexts to build conceptual understanding applicable to design challenges.	• Basics of Forces and Motion – This interactive simulation supports students in building a conceptual understanding of the basics of forces and motion and provides teaching resources and accompanying activities. [https://phet.colorado.edu/en/simulations/forces-and-motion-basics] • Relationship between mass, velocity, and energy (simple) – This interactive simulation supports students in building a conceptual understanding of the relationship between mass, velocity, and energy and provides teaching resources and accompanying activities. [https://phet.colorado.edu/sims/html/energy-skate-park/latest/energy-skate-park_all.html] • Relationship between mass, velocity, and energy (complicated) – This interactive simulation supports students in building a conceptual understanding of the relationship between mass, velocity, and energy and provides teaching resources and accompanying activities. [https://phet.colorado.edu/sims/cheerpj/motion-series/latest/motion-series.html?simulation=ramp-forces-and-motion] • Exploratorium Snacks – Once you know what your students might find interesting or compelling, situate learning within real-world phenomena. The link opens to the Newton's Law search. The Fan Cart and Whack a Stack are both relevant depending on your students.

Instructional Strategies and Resources for Performance Category 1: Design the Best Solution to a Problem Involving Energy, Forces, and Motion *Task 1, Prompt 2, Parts A & B (6 points); Task 2 Prompt 4 (4 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
		[https://www.exploratorium.edu/search?search_api_fulltext=newton%27s+third+law] • Wonder of Science – Once you know what your students might find interesting or compelling, situate learning within real-world phenomena. [https://thewonderofscience.com/phenomenon/2018/7/8/amazing-rube-goldberg-machines]
	*Modeling and Critiquing Scientific Explanations* Use spoken and written examples to model scientific explanations and encourage students to critique and challenge scientific explanations by identifying strengths and weaknesses in reasoning and evidence.	• Argumentation Evidence Card Sort – This activity is to support students' critical thinking, productive argumentative talk, and ability to argue evidence while sorting it, and to provide a platform that gets students actively involved in a way that promotes respect and safety. [http://energyteacher.org/wp-content/uploads/2018/11/Argumentation.pdf] • Decision Matrix -– This tool supports students as they critique and refine design solutions based on several requirements. [https://www.sciencebuddies.org/cdn/science-fair-projects/engineering-design-process/decision-matrix-worksheet.pdf] • Tug of War – This site provides a routine and videos applying a collaborative routine to help students understand, reason, and appreciate the complexity of situations by determining the strength of their positions, statements, and solutions ('tugs') and reorder order the 'tugs' based on collaborative discussion to create an explanation for their chosen design solution that

Instructional Strategies and Resources for Performance Category 1: Design the Best Solution to a Problem Involving Energy, Forces, and Motion *Task 1, Prompt 2, Parts A & B (6 points); Task 2 Prompt 4 (4 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
		supports students moving from the Decision Matrix to an explanation for their chosen design solution. [https://thinkingpathwayz.weebly.com/tugofwar.html] • Constructing Explanations – This website supports students in their scientific explanations for their chosen design solution. [https://www.calacademy.org/educators/constructing-explanations#:~:text=This%20scaffold%20encourages%20students%20to,follow%2Dup%20experiments%20or%20research.]
	*Vocabulary* Provide varied opportunities for students to learn and apply vocabulary in diverse situations and contexts. Vocabulary retention improves when academic terminology is layered on conceptual understanding. To maximize vocabulary building, support students in building conceptual understanding and then apply the academic terminology using the strategies outlined below. • Build understanding of domain-specific vocabulary using a multi-sensory approach or having students participate in simulations. • Make connections between vocabulary and real-life or future opportunities. ○ Explain, describe, give real-world examples, or provide concrete representations of vocabulary words rather than formal definitions. Vocabulary.com (see Resources) provides explanations of words using real-	• STEM Teaching Tools – Practice Brief 66 – This article provides information to support emerging multilingual learners as they develop language that interprets and explains phenomena. [https://stemteachingtools.org/brief/66] • STEM Teaching Tools – Word Catchers – This article explains how to help students, especially multilingual learners, develop and use science- and phenomena-related words and phrases that support their sensemaking. [https://stemteachingtools.org/assets/landscapes/WordCatchers.pdf] • Vocabulary.com – This website provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students. [https://www.vocabulary.com/] • Text Project – Word Pictures – This site provides Word Pictures that are free for educators use and includes word pictures for core vocabulary and various content areas including science

Instructional Strategies and Resources for Performance Category 1: Design the Best Solution to a Problem Involving Energy, Forces, and Motion *Task 1, Prompt 2, Parts A & B (6 points); Task 2 Prompt 4 (4 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
	world examples. Once signed in, an educator can create word lists for students. ○ Build a vocabulary word wall that students can add to and reference during instruction and self-guided activities or tasks. ○ Have students restate the vocabulary word in their own words. Take this opportunity to help students connect new vocabulary, especially general vocabulary, to prior knowledge. • Read books or watch videos related to vocabulary words and concepts. • Sort words, photographs, or concrete representations into categories. Text Project (see Resources) provides Word Pictures that are free for educators to use. It includes word pictures for core vocabulary and various content areas, including science and social studies. • Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners' experience and prior knowledge. • Define domain-specific vocabulary using both domain-specific and common terms. • Embed visual, non-linguistic supports for vocabulary clarification (pictures, videos, etc.). • Have students create their own glossary of terms.	and social studies. This link will take you to the Word Pictures page where you can select the category of words you want to use. [https://textproject.org/archive/textproject-word-pictures/] • The Science Penguin – This site provides ideas to teach science vocabulary. The vocabulary demonstration activity uses real objects to teach vocabulary terms. [http://thesciencepenguin.com/2013/12/science-solutions-vocabulary.html] • Interactive Word Walls Enliven Vocab Learning – This article includes teaching strategies to support students' use of a word wall to build understanding of key vocabulary. [https://textproject.org/archive/textproject-word-pictures/]

Instructional Strategies and Resources for Performance Category 1: Design the Best Solution to a Problem Involving Energy, Forces, and Motion *Task 1, Prompt 2, Parts A & B (6 points); Task 2 Prompt 4 (4 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
	*Presenting Information in Different Modalities* Provide information using a variety of multimedia (e.g., videos, interactives, simulations), informational texts, and formats to teach and reinforce disciplinary core ideas related to mass, speed, kinetic energy, and Newton's laws of motion.	• Data Classroom – This site provides a searchable resource library to teach data skills in math and science. Search 'velocity' to find relevant datasets and lesson plans. [https://about.dataclassroom.com/] • CODAP – This site presents a web-based data tool as a platform to help students summarize, visualize, and interpret data to advance their skills to use data as evidence to support a claim Search 'velocity, speed, and mass' to find relevant datasets and lesson plans. [https://concord.org/our-work/research-projects/codap/] • CK-12 – This site presents 'Flexi' which is an AI Student Tutor tailored to students' unique interests and learning levels to address students' questions. [https://www.ck12.org/student/]
	*Scaffolds for Communicating through Scientific Explanation* Provide scaffolds for explanatory writing and discussions to describe a phenomenon or support a design solution (e.g., sentence frames, graphic organizers, norms for whole class discussion, roles for students during small group activities) to support communicating in science-specific ways that may seem unnatural for students.	• National Science Foundation – Tools for Ambitious Science Teaching – This website discusses a tool that provides scaffolds for writing that support learners in constructing explanations with evidence. These take the form of sentence frames, guides for how to help English learners practice final explanations, norms for whole-class discussion that are developed by students, roles that students can take in small group activities, and others. [https://ambitiousscienceteaching.org/orientation-ambitious-science-teaching/]

Instructional Strategies and Resources for Performance Category 1: Design the Best Solution to a Problem Involving Energy, Forces, and Motion *Task 1, Prompt 2, Parts A & B (6 points); Task 2 Prompt 4 (4 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
		• The Right Question Institute – This site provides techniques and strategies to build student agency through explanation using the 'Question Formulation Technique' and 'The Right Question Strategy 'to support students as they formulate explanations to their own questions centered in the complex systems in which they live. [https://rightquestion.org/] • Kialo – This website provides a tool to support critical thinking and debate using a visual format to follow the logical structure of an argument (pros and cons) and facilitates collaborative student discussions. Map the logic of an explanation or argument to facilitate thoughtful and purposeful discourse. There are hundreds of provided discussions to explore or create your own. [https://www.kialo-edu.com/]
	*Expressing Learning in Multiple Modalities* Provide multiple, flexible options for students to communicate their explanations and learning in class. • Use technologies that facilitate student participation and communication, such as discussion boards, podcasts, or blogs. • Allow students to choose a multi-modal project they would like to complete to demonstrate their learning, such as a poster presentation, debate, short film, lab report, blog,	• Flip – A video discussion app where students can connect with short videos and build community around topics and questions that teachers create or with communities around the world. [https://edtechbooks.org/onlinetools/flipgrid] • Interactive Whiteboard – This site provides a 'web whiteboard' to sketch, brainstorm, and share ideas for teachers and students to collaboratively model and demonstrate conceptual understanding and to support revising thinking. [https://webwhiteboard.com/]

Instructional Strategies and Resources for Performance Category 1: Design the Best Solution to a Problem Involving Energy, Forces, and Motion *Task 1, Prompt 2, Parts A & B (6 points); Task 2 Prompt 4 (4 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
	infographic, drawing, poetry, writing and performing a song, creating a game, etc. • Provide a variety of ways in which students can "write" to respond to questions (e.g., traditional form of writing, with sentence starters, using pictures, etc.).	• Infographic Maker – This site provides presentation software, 'Infographics', that can include a collection of imagery, data visualization like pie charts and bar graphs, and minimal text to provide an understandable overview of a topic and to summarize learning with charts, graphs, and diagrams. [https://venngage.com/blog/infographics-maker?utm_source=google&utm_medium=cpc&utm_campaign=&utm_content=&utm_term=infographic%20maker&match=e&campaignid=19558960020&adgroupid=143879091486&gad=1&gclid=Cj0KCQjw9fqnBhDSARIsAHlcQYSnvSGACgz1oEBmzQLMma1B3UbfY5Ieynj1ZD6Y7st4Cmtmf7rpiVcaAlEYEALw_wcB] • SIOP Protocol – This website provides a tool for teachers to collect data about how your instruction supports multilingual learners in the classroom. [https://www.ocmboces.org/tfiles/folder1602/Copy%20of%20SIOP%20Observation%20Form.pdf]

Performance Category 2: Use Experimental Features of an Investigation to Explain the Interactions Between Objects

Interpretive Guidance for Performance Category 2: **Use Experimental Features of an Investigation to Explain Interactions Between Objects** *Task 1, Prompt 2, Parts C & D (3 points); Task 2, Prompt 1 (2 points); Task 3, Prompt 4 (3 points)*		
Red (0-3 score points earned) ➢ Extensive additional instruction and reteaching of these skills is recommended. ➢ The student needs significant opportunities to reinforce and apply these skills in future learning.	**Yellow (4-6 score points earned)** ➢ Moderate additional instruction on these skills is recommended. ➢ The student needs additional opportunities to strengthen these skills in future learning.	**Green (7-8 score points earned)** ➢ **Minimal to no** additional instruction on these skills is recommended. ➢ The student is ready to extend these skills in future learning.
What These Results Mean		
This student is likely able to: • Determine variables, controls, and data to **attempt an** explanation of how the materials in a design solution function to solve a design problem based on the relationship of kinetic energy to the mass of an object and to the speed of an object **with little to no** supporting evidence. • **Attempt** to evaluate at **least one (1) alternative solution** with **major conceptual or procedural errors.** • **Attempt to** support a claim regarding the usefulness of materials in a design solution with a **mostly inaccurate** explanation of the relationship among velocity, mass, or kinetic energy of an object.	**This student is likely able to:** • Make **basic** connections among **variables, controls, and appropriate data** to generate a **partial explanation** of how the materials in a design solution function to solve a design problem based on the relationship of kinetic energy to the mass of an object and to the speed of an object **mostly supported** by evidence with **some minor errors**. • Evaluate **at least one (1) alternative solution** for technical feasibility. Support a claim regarding the usefulness of materials in a design solution with a **vague but mostly accurate** explanation of the relationship among velocity, mass, or kinetic energy of an object.	**This student is likely able to:** • Make **accurate connections** based upon **scientific reasoning** to explain how the materials in a design solution function to solve a design problem based on the relationship of kinetic energy to the mass of an object and to the speed of an object while **clearly** communicating the effectiveness of the solution. • **Critically** evaluate **all** alternative design solutions by analyzing each for technical feasibility. • Support a claim regarding the usefulness of materials in a design solution that **explains why or how** that solution is effective by applying a **clear and complete** explanation of the relationship among velocity, mass, or kinetic energy of an object.

Interpretive Guidance for Performance Category 2: Use Experimental Features of an Investigation to Explain Interactions Between Objects *Task 1, Prompt 2, Parts C & D (3 points); Task 2, Prompt 1 (2 points); Task 3, Prompt 4 (3 points)*		
Red (0-4 score points earned) ➢ Extensive additional instruction and reteaching of these skills is recommended. ➢ The student needs significant opportunities to reinforce and apply these skills in future learning.	**Yellow (5-8 score points earned)** ➢ Moderate additional instruction on these skills is recommended. ➢ The student needs additional opportunities to strengthen these skills in future learning.	**Green (9-10 score points earned)** ➢ **Minimal to no** additional instruction on these skills is recommended. ➢ The student is ready to extend these skills in future learning.
Next Instructional Steps		
Provide opportunities for the student to: • From a given force diagram model, select the most accurate and complete explanation of interacting forces within a phenomenon, using Newton's laws of motion, from a range of explanations. • Collaboratively critique and revise incomplete explanations of a phenomenon based on Newton's third law or the relationship between kinetic energy, velocity, and mass, using force diagrams or data provided in a table as needed.	**Provide opportunities for the student to:** • From a given force diagram model, develop a complete and accurate explanation of a phenomenon resulting from the interaction of forces according to Newton's laws of motion. • Evaluate the strength of an explanation of a phenomenon based on Newton's third law and/or the relationship between kinetic energy, velocity, and mass, using force diagrams or data provided in a table as needed.	**Provide opportunities for the student to:** • Compare and refine models of a wide range of phenomena due to various interacting forces using Newton's third law of motion. • With and without using models and/or data, compare and refine explanations of a wide range of phenomena focusing on explicitly applying Newton's third law of motion and/or the relationship between kinetic energy, velocity, and mass.

Instructional Strategies and Resources for Performance Category 2: Use Experimental Features of an Investigation to Explain Interactions Between Objects *Task 1, Prompt 2, Parts C & D (3 points); Task 2, Prompt 1 (2 points); Task 3, Prompt 4 (3 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
	*Investigation and Data Collection through Discourse* Provide varied opportunities (stations, small groups, partners, whole class) for students to engage in interactive discourse where they build on each other's ideas to determine and describe methodology suited to identify variables and controls and gather the type and amount of evidence needed for an investigation to explain interactions between objects. Opportunities for scientific discourse should be situated in authentic, interest-driven science investigations. *Culturally Responsive Scientific Investigations* Foster systematic and careful approaches to experimental planning and design that are culturally responsive, drawing from and respecting students' cultural resources, backgrounds, and personal experiences. Provide a range of ways for students to engage in cooperative learning (e.g., think-pair-share, jigsaw, round robin) with diverse groupings of students that allow students to design experimental features of an investigation and collect and analyze evidence that supports their conceptual understanding of the interactions between objects (i.e., Newton's laws and the relationship between energy, mass, and velocity).	• Talk Activities Flowchart – This flowchart can be used to structure activities so that students' talk is more equitable, scientific, and focused on sensemaking in support of a classroom culture focused on curiosity and learning. [https://stemteachingtools.org/sp/talk-flowchart] • STEM Teaching Tools – Practice Brief 48 – This article discusses how teachers can use tools to scaffold student science talk and includes Talk Resource Tools to foster shifts in science classroom talk. [https://stemteachingtools.org/brief/48] • 3-2-1 Bridge – This site provides a routine to help students understand their own process of conceptual learning that includes strategies to be used before, during, and after instruction with varied learning experiences related to diverse topics or concepts. [https://pz.harvard.edu/sites/default/files/3-2-1%20Bridge_2.pdf] • Strategies for Investigations | Science Notebooking – This website describes how notebooks can help students plan and carry out hand-on investigation from collecting data to constructing explanations to deepen students' thinking. [https://ca.pbslearningmedia.org/resource/strategies-for-investigations/science-notebooking/] • Collaborative Classroom – This website provides scaffolding techniques for Multilingual Learners to provide instruction that

Instructional Strategies and Resources for Performance Category 2: Use Experimental Features of an Investigation to Explain Interactions Between Objects *Task 1, Prompt 2, Parts C & D (3 points); Task 2, Prompt 1 (2 points); Task 3, Prompt 4 (3 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
		supports content and language acquisition simultaneously. [https://www.collaborativeclassroom.org/blog/scaffolding-techniques-english-language-learners-part-1/] • STEM Teaching Tools – Practice Brief 55 – This article explains why it is crucial to make cultural diversity visible in STEM education. [https://stemteachingtools.org/brief/55] • Stem Teaching Tool – Practice Brief 17: Beyond the Written C-E-R: Supporting Classroom Argumentative Talk about Investigations – This article explains why it is important to explore a variety of argumentation practices and how to foster discussions where students coordinate claims and evidence and includes resources for creating and scaffolding evidence-based discussion environments. [https://stemteachingtools.org/brief/17]
	***Modeling and Critiquing Scientific Investigations*** Use spoken and written examples to model scientific investigations and encourage students to evaluate and refine data collection strategies and data analyses by identifying strengths and weaknesses in the investigation design and the data to be generated to explain relationships between kinetic energy, mass, and speed of an object and to support a claim regarding the relationship between the speed of objects, gravitational forces, and the kinetic energy objects possess as they reach Earth's surface.	• Building Thinking Classrooms – These instructional practices support building a culture of critical thinking in your classroom. [https://www.buildingthinkingclassrooms.com/about-btc] • Tug for Truth -– This activity provides a visual to anchor a whole class collaboration around analyzing a claim through evidence, as well as analyzing the relevance and potency of evidence for a given argument. [https://pz.harvard.edu/sites/default/files/Tug%20for%20Truth_0.pdf]

Instructional Strategies and Resources for Performance Category 2: Use Experimental Features of an Investigation to Explain Interactions Between Objects *Task 1, Prompt 2, Parts C & D (3 points); Task 2, Prompt 1 (2 points); Task 3, Prompt 4 (3 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
		• The Argumentation Toolkit – This toolkit provides information and activities that can be used to support students' analyzing the quality, relevance, and sufficiency of data. [https://argumentationtoolkit.lawrencehallofscience.org/argument-elements/evidence/] • Teach Newton's Laws of Motion – This site provides STEM lessons and hands-on investigations that can promote students' evaluation of design processes, variables, and data collection to explain phenomena related to Newton's laws of motion. [https://www.sciencebuddies.org/blog/newton-laws-science-lessons?from=Blog] • The Wonder of Science – This site provides phenomena, videos, and three-dimensional learning plans organized by NGSS PE codes that can be used to design lessons and instruction and support discourse about collisions, forces, mass, the motion of an object, kinetic energy, and gravitational interactions. [https://thewonderofscience.com/phenomenal]
	*Vocabulary* Provide varied opportunities for students to learn and apply vocabulary in diverse situations and contexts. Vocabulary retention improves when academic terminology is layered on conceptual understanding. To maximize vocabulary building, support students in building conceptual understanding and then apply the academic terminology using the strategies outlined below.	• STEM Teaching Tools – Practice Brief 66 – This article discusses how to support emerging multilingual learners as they develop language that interprets and explains phenomena. [https://stemteachingtools.org/brief/66] • STEM Teaching Tools – Word Catchers – This site provides guidance on developing Word Catchers that are designed to help students, especially multilingual learners, develop and use science-and phenomena-related words and phrases that

Instructional Strategies and Resources for Performance Category 2: Use Experimental Features of an Investigation to Explain Interactions Between Objects *Task 1, Prompt 2, Parts C & D (3 points); Task 2, Prompt 1 (2 points); Task 3, Prompt 4 (3 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***

	• Build understanding of domain-specific vocabulary using a multi-sensory approach or having students participate in simulations.
	• Make connections between vocabulary and real-life or future opportunities.
	  ○ Explain, describe, give real-world examples, or provide concrete representations of vocabulary words rather than formal definitions. Vocabulary.com (see Resources) provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students.
	  ○ Build a vocabulary word wall that students can add to and reference during instruction and self-guided activities or tasks.
	  ○ Have students restate the vocabulary word in their own words. Take this opportunity to help students connect new vocabulary, especially general vocabulary, to prior knowledge.
	• Read books or watch videos related to vocabulary words and concepts.
	• Sort words, photographs, or concrete representations into categories. Text Project (see Resources) provides Word Pictures that are free for educators to use. It includes word pictures for core vocabulary and various content areas, including science and social studies.
		support their sensemaking and explanations of phenomena. [https://stemteachingtools.org/assets/landscapes/WordCatchers.pdf]
		• Vocabulary.com – This website provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students. [https://www.vocabulary.com/]
		• Text Project – Word Pictures – This site provides Word Pictures that are free for educators to use. Their site includes word pictures for core vocabulary and various content areas including science and social studies. [https://textproject.org/archive/textproject-word-pictures/]
		• The Science Penguin – This site provides ideas to teach science vocabulary. The vocabulary demonstration activity uses real objects to teach vocabulary terms. [http://thesciencepenguin.com/2013/12/science-solutions-vocabulary.html]
		• Interactive Word Walls Enliven Vocab Learning – This article provides teaching strategies to support students' use of a word wall to build understanding of key vocabulary. [https://www.middleweb.com/37209/interactive-word-walls-enliven-vocab-learning/]

Instructional Strategies and Resources for Performance Category 2: Use Experimental Features of an Investigation to Explain Interactions Between Objects *Task 1, Prompt 2, Parts C & D (3 points); Task 2, Prompt 1 (2 points); Task 3, Prompt 4 (3 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
	• Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners' experience and prior knowledge. • Define domain-specific vocabulary using both domain-specific and common terms. • Embed visual, non-linguistic supports for vocabulary clarification (pictures, videos, etc.). • Have students create their own glossary of terms.	
	*Presenting Information in Different Modalities* Provide information using a variety of multimedia (e.g., videos, interactives, simulations), informational texts, and formats to teach and reinforce disciplinary core ideas related to how interactions between objects can be explained and predicted.	• How to Analyze Kinetic & Potential Energy Graphs – This video defines and explains the relationship between potential energy, kinetic energy, mass, and position. Pauses between topics allow time for student discussion. [https://www.youtube.com/watch?app=desktop&v=SeykSc_A0L4] • CK-12 Physical Science for Middle School – This site covers NGSS-aligned core physical science concepts and includes simulations, real-world examples, videos, and activity sheets with which students can engage individually or as a class and includes opportunities to independently assess their understanding of key concepts. The content is organized by chapters and sections. See Chapter 9. Objects in Motion, 10. Forces, and 11. Newton's Laws of Motion. [CK-12 Physical Science for Middle School | CK-12 Foundation (ck12.org]

Instructional Strategies and Resources for Performance Category 2: Use Experimental Features of an Investigation to Explain Interactions Between Objects *Task 1, Prompt 2, Parts C & D (3 points); Task 2, Prompt 1 (2 points); Task 3, Prompt 4 (3 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
		• PheT Sims:Skate Park – This interactive simulation lets students explore and manipulate the relationships between different forms of energy, friction, gravity, and mass and can be used by individual students or to support whole class instruction. [https://phet.colorado.edu/sims/html/energy-skate-park/latest/energy-skate-park_en.html] • Science Projects Newtons' Laws – This website provides a searchable field for the selection of science projects that can be used to support students' understanding of Newton's Laws. [https://www.education.com/science-fair/?q=Newtons%20Laws] • Newton's Laws | DIY Science Time – This website provides resources including a video and support materials for teachers and students to explore Newton's three laws of motion with activities and includes Spanish captions and Descriptive Video for visually impaired users. [https://ca.pbslearningmedia.org/resource/newtons-laws-video/diy-science-time/]
	*Scaffolds for Communicating through Explanation* Provide scaffolds for designing investigations to provide evidence to explain a phenomenon or support a design solution (e.g., sentence frames, graphic organizers, norms for whole class discussion, roles for students during small group activities) to support communicating in science-specific ways that may seem unnatural for students.	• National Science Foundation – Tools for Ambitious Science Teaching – This website discusses a tool that provides scaffolds for writing that support learners in constructing explanations with evidence. These take the form of sentence frames, guides for how to help English learners practice final explanations, norms for whole-class discussion that are developed by

Instructional Strategies and Resources for Performance Category 2: Use Experimental Features of an Investigation to Explain Interactions Between Objects *Task 1, Prompt 2, Parts C & D (3 points); Task 2, Prompt 1 (2 points); Task 3, Prompt 4 (3 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
		students, roles that students can take in small group activities, and others. [https://ambitiousscienceteaching.org/orientation-ambitious-science-teaching/] • Model Teaching – CER Checklist and Graphic Organizer – This website provides an introduction to Claim-Evidence-Reasoning (CER) to help students make connections with science concepts and labs and includes downloadable resources and writing templates. [https://www.modelteaching.com/education-articles/writing-instruction/claim-evidence-reasoning-cer] • Stem Teaching Tool – Practice Brief 17 – This article provides additional teacher practices to support students' ability to use argumentation beyond Claim-Evidence-Reasoning (CER) through classroom discussions that require students to make evidence-based claims and collectively build understanding. [https://stemteachingtools.org/brief/17]
	***Expressing Learning in Multiple Modalities*** Provide multiple, flexible options for students to communicate their investigation designs and the connections to different science ideas, such as how kinetic energy is proportional to the mass of the moving object and learning in class. • Use technologies that facilitate student participation and communication, such as discussion boards, podcasts, or blogs.	• STEM Teaching Tools – Multiple Means of Action and Expression – This article provides considerations for engaging students through multiple means of action and expression. [https://stemteachingtools.org/sp/multiple-means-of-action-and-expression] • Chalk Talk – This routine provides ideas for fostering students' ability to consider each other's ideas, questions, or problems through 'silent collaboration'—responding by recording

Instructional Strategies and Resources for Performance Category 2: Use Experimental Features of an Investigation to Explain Interactions Between Objects *Task 1, Prompt 2, Parts C & D (3 points); Task 2, Prompt 1 (2 points); Task 3, Prompt 4 (3 points)*		
Instructional Strategies and Resources		
	Instructional Strategies	***Resources***
	• Allow students to choose a multi-modal project they would like to complete to demonstrate their learning, such as a poster presentation, debate, short film, lab report, blog, infographic, drawing, poetry, writing and performing a song, creating a game, etc. • Provide a variety of ways in which students can "write" to respond to questions (e.g., traditional form of writing, with sentence starters, using pictures, etc.)	reactions and ideas in writing. Use this routine to support students as they analyze the features of an experiment. [https://pz.harvard.edu/sites/default/files/Chalk%20Talk_1.pdf] • Stop Motion Studio – This website provides a tool for creating movies or animations that can be used to support explanations of science concepts related to moving objects. [https://www.cateater.com/] • Digital Lab Notebook-– This site provides a digital notebook that can be saved as a copy and offers students a digital option for recording lab results, writing lab reports, journaling, drawing, planning, or creative writing. [https://virtualscienceteachers.org/virtual-labs/]

Performance Category 3: Analyze Data to Describe Interactions Between Objects

Interpretive Guidance for Performance Category 3: Analyze Data to Describe Interactions Between Objects *Task 2, Prompt 2 (3 points); Task 2, Prompt 3 (4 points); Task 3, Prompt 3 (4 points)*		
Red (0-3 score points earned) ➢ Extensive additional instruction and reteaching of these skills is recommended. ➢ The student needs significant opportunities to reinforce and apply these skills in future learning.	**Yellow (4-6 score points earned)** ➢ Moderate additional instruction on these skills is recommended. ➢ The student needs additional opportunities to strengthen these skills in future learning.	**Green (7-8 score points earned)** ➢ **Minimal to no** additional instruction on these skills is recommended. ➢ The student is ready to extend these skills in future learning.
What These Results Mean		
This student is likely able to: • **Attempt to represent** provided data in a graph. • Provide some quantitative data to support an **incomplete or inaccurate** explanation of the relationship of kinetic energy to the mass and speed of an object, as well as the relationship between the height of an object and the kinetic energy the object has as it falls to the ground. • **Attempt** to describe a relationship or pattern among variables in the data with **major conceptual or procedural errors**.	**This student is likely able to:** • Accurately represent **some** provided data in a graph accurately, using **simple** mathematical thinking, as necessary. • Provide adequate quantitative data to support a **reasonable** explanation of the relationship of kinetic energy to the mass and speed of an object, as well as the relationship between the height of an object and the kinetic energy the object has as it falls to the ground. • Describe the relationship between variables and identify patterns (qualitative or quantitative) among variables represented in the data but analyses include **some minor errors**.	**This student is likely able to:** • **Accurately represent** provided data in a graph, **using mathematical thinking,** as necessary. • Provide **thorough** quantitative data to support a **complete and accurate** explanation of the relationship of kinetic energy to the mass and speed of an object, as well as the relationship between the height of an object and the kinetic energy the object has as it falls to the ground. • **Mathematically describe** the relationship between variables and **identify patterns** (qualitative or quantitative) among variables represented in the data.

Interpretive Guidance for Performance Category 3: Analyze Data to Describe Interactions Between Objects *Task 2, Prompt 2 (3 points); Task 2, Prompt 3 (4 points); Task 3, Prompt 3 (4 points)*		
Red (0-4 score points earned) ➢ Extensive additional instruction and reteaching of these skills is recommended. ➢ The student needs significant opportunities to reinforce and apply these skills in future learning.	**Yellow (5-8 score points earned)** ➢ Moderate additional instruction on these skills is recommended. ➢ The student needs additional opportunities to strengthen these skills in future learning.	**Green (9-10 score points earned)** ➢ **Minimal to no** additional instruction on these skills is recommended. ➢ The student is ready to extend these skills in future learning.
Next Instructional Steps		
Provide opportunities for the student to: • Represent provided energy, velocity, and mass data related to a given phenomenon in a graph that has been both set up (with scale and axes labels) and started (with data points) using written or oral procedural supports provided for areas of struggle. • Identify the correct statement from a list of statements written in simple, non-academic terms about the relationship between energy, velocity, and mass variables within the context of the given phenomenon based on data from a graph or table.	**Provide opportunities for the student to:** • Represent provided energy, velocity, and mass data related to a given phenomenon in a graph that has been set up (with scale and axes labels) using written or oral procedural supports as needed. • Identify the correct statement from a list of statements written in grade-level academic terms about the relationship between energy, velocity, and mass variables within the context of the given phenomenon based on data from a graph or table.	**Provide opportunities for the student to:** • Independently represent provided or self-collected energy, velocity, and mass data related to a given phenomenon in a graph using blank graph paper. • Generate a statement written in grade-level academic terms about the relationship between energy, velocity, and mass variables within the context of the given phenomenon based on data in a graph or a table.

Instructional Strategies and Resources for Performance Category 3: Analyze Data to Describe Interactions Between Objects *Task 2, Prompt 2 (3 points); Task 2, Prompt 3 (4 points); Task 3, Prompt 3 (4 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
	*Data Analysis Through Discourse* Provide varied opportunities (stations, small groups, partners, whole class) for students to engage in interactive discourse where they build on each others' ideas to optimize the use of a range of tools for tabulation, graphical representation, visualization, and statistical analysis to analyze and interpret data. Opportunities for scientific discourse should be situated in authentic, interest-driven science investigations. *Culturally Responsive Use of Data* Foster data interpretation and informed design decisions that are culturally responsive, drawing from and respecting students' cultural resources, backgrounds, and personal experiences. Provide a range of ways for students to engage in cooperative learning (e.g., think-pair-share, jigsaw, round robin) with diverse groupings of students.	• A Discourse Primer for Science Teachers –This site presents the "whys" and "hows" of using classroom talk to improve student learning and identify struggling learners. [https://tedd.org/wp-content/uploads/2014/03/PRIMER-Discourse-in-Science-Classrooms.pdf] • Talk Activities Flowchart – This flowchart can help structure activities so that students' talk is more equitable, scientific, and focused on sensemaking in support of a classroom culture focused on curiosity and learning. [https://stemteachingtools.org/sp/talk-flowchart] • Fostering Student-Driven Scientific Discourse – This article presents a brief explanation of student discourse listing the reasons for its use in science, classroom norms, and types of classroom discourse. [https://www.discoveryeducation.com/info/scientific-discourse/] • How to Analyze Kinetic & Potential Energy Graphs – This video defines and explains the relationship between potential energy, kinetic energy, mass, and position. Pauses between topics allow time for student discussion. [https://www.youtube.com/watch?app=desktop&v=SeykSc_A0L4]

	***Modeling and Critiquing Scientific Results*** Use spoken and written examples to model scientific interpretation of data including significant features and observable patterns and/or relationships between variables by identifying strengths and weaknesses such as sources of error.	• Interpreting Data and Looking for Relationships – This video shows a high school teacher engaging students in multidimensional learning using a digital media resource for ideas about how to engage students in interpreting data representation and building consensus. The teacher models scientific interpretation and allows students to look for and explain the patterns. [https://rmpbs.pbslearningmedia.org/resource/rttt12.math.graphstories/interpreting-stories-and-graphs/]
	***Promoting Engagement through Interactive, Collaborative Games*** Use interactive games and collaborative formats to reinforce disciplinary core ideas related to science ideas about how interactions between objects can be explained and predicted.	• Make a Zipline – This website provides a cooperative learning activity for designing a zipline from simple materials to deliver a marble to a target. Activity reinforces Newton's First Law as well as potential and kinetic energy. The activity offers opportunities for scientific discourse and for students to support arguments about the interactions between objects. [https://www.nasa.gov/sites/default/files/atoms/files/edu_on-target.pdf]
	***Vocabulary*** Provide varied opportunities for students to learn and apply vocabulary in diverse situations and contexts. Vocabulary retention improves when academic terminology is layered on conceptual understanding. To maximize vocabulary building, support students in building conceptual understanding and then apply the academic terminology using the strategies outlined below. • Build understanding of domain specific vocabulary using a multi-sensory approach or having students participate in simulations. • Make connections between vocabulary and real-life or future opportunities. ○ Explain, describe, give real-world examples, or provide concrete representations of vocabulary words rather	• STEM Teaching Tools – Practice Brief 66 – This article discusses how to support emerging multilingual learners as they develop language that interprets and explains phenomena. [https://stemteachingtools.org/brief/66] • Vocabulary.com – This site provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students. [https://www.vocabulary.com/] • Text Project – Word Pictures – This site provides Word Pictures that are free for educators to use. Their site includes word pictures for core vocabulary and various content areas including science and social studies. This link will take you to the Word Pictures page where you can select "TextProject Word Pictures," "Physical Science" and "Forces Around Us."

	than formal definitions. Vocabulary.com (see Resources) provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students. ○ Build a vocabulary word wall that students can add to and reference during instruction and self-guided activities or tasks. ○ Have students restate the vocabulary word in their own words. Take this opportunity to help students connect new vocabulary, especially general vocabulary, to prior knowledge. • Read books or watch videos related to vocabulary words and concepts. • Sort words, photographs, or concrete representations into categories. Text Project (see Resources) provides Word Pictures that are free for educators to use. It includes word pictures for core vocabulary and various content areas, including science and social studies. • Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners' experience and prior knowledge. • Define domain-specific vocabulary using both domain-specific and common terms. • Embed visual, non-linguistic supports for vocabulary clarification (pictures, videos, etc.). • Have students create their own glossary of terms.	[http://textproject.org/classroom-materials/textproject-word-pictures/] • The Science Penguin – This site provides ideas to teach science vocabulary. The vocabulary demonstration activity uses real objects to teach vocabulary terms. [http://thesciencepenguin.com/2013/12/science-solutions-vocabulary.html] • Interactive Word Walls Enliven Vocab Learning – This article with teaching strategies to support students' use of a word wall to build understanding of key vocabulary [https://www.middleweb.com/37209/interactive-word-walls-enliven-vocab-learning/]

	***Presenting Information in Different Modalities*** Provide information using a variety of multimedia (e.g., videos, interactives, simulations), informational texts, and formats to teach and reinforce disciplinary core ideas related to how interactions between objects can be explained and predicted.	• Potential and Kinetic Energy – This simulation, 'PhET Sims: Skate Park' demonstrates the conservation of energy in a dynamic bar graph as a skateboarder moves up and down a ramp. It can be used for individual review or small group investigation and discussion. The simulation is available in Spanish. [https://view.genial.ly/60701e23a838df0d7dd30565] • Kinetic and Potential Energy – This lesson gives examples of kinetic and potential energy. The formula for kinetic energy is explained. [https://www.teachengineering.org/lessons/view/cub_energy_lesson01] • Newton's Law of Gravity – This text explains universal gravitation and the reason behind varying gravitational forces. [https://flexbooks.ck12.org/cbook/ck-12-middle-school-physical-science-flexbook-2.0/section/10.7/primary/lesson/newtons-law-of-gravity-ms-ps/]
	***Scaffolds for Communicating Data*** Provide scaffolds for analyzing and interpreting data to be used as evidence to support scientific conclusions to explain a phenomenon or support a design solution (e.g., sentence frames, graphic organizers, norms for whole class discussion, roles for students during small group activities) to support communicating in science-specific ways that may seem unnatural for students.	• National Science Foundation – Tools for Ambitious Science Teaching – This website discusses a tool that provides scaffolds for writing that support learners in constructing explanations with evidence. These take the form of sentence frames, guides for how to help English learners practice final explanations, norms for whole-class discussion that are developed by students, roles that students can take in small group activities, and others. [https://ambitiousscienceteaching.org/orientation-ambitious-science-teaching/] • Model Teaching – CER Checklist and Graphic Organizer – This site provides an introduction to Claim-Evidence-Reasoning (CER) and downloadable resources and writing templates.

		[https://www.modelteaching.com/education-articles/writing-instruction/claim-evidence-reasoning-cer] • Collecting and Analyzing Data – This website presents ways to use the science notebook to collect and analyze data helping students make scientific meaning from results. [https://www.calacademy.org/educators/collecting-and-analyzing-data]
	***Expressing Learning in Multiple Modalities*** Provide multiple, flexible options for students to communicate their results and present data evidence to support their conclusions and learning in class. • Use technologies that facilitate student participation and communication, such as discussion boards, podcasts, or blogs. • Allow students to choose a multi-modal project they would like to complete to demonstrate their learning, such as a poster presentation, debate, short film, lab report, blog, infographic, drawing, poetry, writing and performing a song, creating a game, etc. • Provide a variety of ways in which students can "write" to respond to questions (e.g., traditional form of writing, with sentence starters, using pictures, etc.)	• Exploring Energy: Kinetic and Potential – This website presents a lesson about kinetic and potential energy that provides background information and a slide presentation necessary for students to write about themselves as energy superheroes. In addition, a post-quiz, associated activities, and vocabulary/definitions are available. [https://www.teachengineering.org/lessons/view/ucd_energy_lesson02] • Science Notebook Corner – This website offers a variety of topics relating to students using science notebooks for lab reports, journaling, drawing, planning, or creative writing. [https://aptv.pbslearningmedia.org/collection/science-notebook-corner/] • Engineering Design and Practices | PBS Learning Media – This site explores processes used by engineers to identify and solve problems including defining problems, planning, and carrying out investigations, analyzing and interpreting data, and designing solutions. [https://ca.pbslearningmedia.org/subjects/engineering--technology/engineering-design-and-practices/?rank_by=recency]

Performance Category 4: Support Arguments About Interactions Between Objects, Forces, and Energy

Interpretive Guidance for Performance Category 4: Support Arguments About Interactions Between Objects, Forces, and Energy		
Red (0-6 score points earned) ➢ Extensive additional instruction and reteaching of these skills is recommended. ➢ The student needs significant opportunities to reinforce and apply these skills in future learning.	**Yellow (7-10 score points earned)** ➢ Moderate additional instruction on these skills is recommended. ➢ The student needs additional opportunities to strengthen these skills in future learning.	**Green (11-13 score points earned)** ➢ **Minimal to no** additional instruction on these skills is recommended. ➢ The student is ready to extend these skills in future learning.
What These Results Mean		
This student is likely able to: • Make an **attempt to** represent provided information in a model, utilizing a **vague and inaccurate** explanation of Newton's First and Third Law. • Provide an **attempt** to support an argument with a **partial and inaccurate** explanation of the relationship between variables in the system. • Provide a **partial and inaccurate** explanation of invisible gravitational interactions between objects with **major conceptual errors** related to the relationship between mass and gravity.	**This student is likely able to:** • **Accurately** represent provided information in a model, utilizing a **vague but accurate** explanation of Newton's First and Third Law. • Provide reasoning that **attempts** to link the argument with evidence with a partial **and mostly accurate** explanation of the relationship between mass and gravitational force, as well as the mathematical relationship between kinetic energy, mass, and velocity, depending on the system. • Provide a **partial** explanation of invisible gravitational interactions between objects, comparing to observed motion, using the relationship between mass and gravity **with minor conceptual errors**.	**This student is likely able to:** • **Accurately and clearly** represent provided information in a model, **utilizing a clear and explicit** explanation of Newton's First and Third Law. • Provide reasoning that **accurately and clearly links the argument with evidence** by explaining the relationship between mass and gravitational force, as well as the mathematical relationship between kinetic energy, mass, and velocity, depending on the system. • Provide a **complete and accurate** explanation of invisible gravitational interactions between objects, comparing them to observed motion, using the relationship between mass and gravity.

Interpretive Guidance for Performance Category 4: Support Arguments About Interactions Between Objects, Forces, and Energy *Task 1, Prompt 1 (6 points); Task 3, Prompt 1 (4 points); Task 3, Prompt 2 (3 points)*		
Red (0-4 score points earned) ➢ Extensive additional instruction and reteaching of these skills is recommended. ➢ The student needs significant opportunities to reinforce and apply these skills in future learning.	**Yellow (5-8 score points earned)** ➢ Moderate additional instruction on these skills is recommended. ➢ The student needs additional opportunities to strengthen these skills in future learning.	**Green (9-10 score points earned)** ➢ **Minimal to no** additional instruction on these skills is recommended. ➢ The student is ready to extend these skills in future learning.
Next Instructional Steps		
Provide opportunities for the student to: • Select the most accurate and complete force diagram model of a phenomenon from a range of models. • Match conclusions about the relative energy (either gravitational potential or kinetic) of a system or set of systems to the correct system diagram. • Collaboratively model new systems based on new parameters to the system (i.e., increase the gravitational potential energy of the system by changing mass)	**Provide opportunities for the student to:** • From a given force diagram model, develop a complete and accurate explanation of a phenomenon resulting from the interaction of forces according to Newton's laws of motion. • From a list of conclusions about the relative energy (either gravitational potential or kinetic) of a system or set of systems, identify the most accurate statements using the generalized relationship between variables • Independently model new systems, annotating with rationale based on new parameters to the system (i.e., increase the gravitational potential energy of the system by changing mass)	**Provide opportunities for the student to:** • Compare and refine models of a wide range of phenomena due to various interacting forces using Newton's third law of motion. • Researching a novel phenomenon related to relative energy (either gravitational potential or kinetic), generate a model comparing systems and annotate with the relationship between variables.

Instructional Strategies and Resources for Performance Category 4: Support Arguments About Interactions Between Objects, Forces, and Energy *Task 1, Prompt 1 (6 points); Task 3, Prompt 1 (4 points); Task 3, Prompt 2 (3 points)*		
Instructional Strategies and Resources		
	Teaching Strategies	***Resources***
	*Argumentation through Discourse* Provide varied opportunities (stations, small groups, partners, whole class) for students to engage in interactive discourse where they build on each other's ideas to coordinate claims, evidence, and reasoning in a scientific argument. Opportunities for scientific discourse should be situated in authentic, interest-driven science investigations. *Culturally Responsive Argumentation* Foster argumentation that is culturally responsive, drawing from and respecting students' cultural resources, backgrounds, and personal experiences. Provide a range of ways for students to engage in cooperative learning (e.g., think-pair-share, jigsaw, round robin) with diverse groupings of students.	• Stem Teaching Tool – Practice Brief 17: Beyond the Written C-E-R: Supporting Classroom Argumentative Talk about Investigations – This article explores how C-E-R scaffolds can help students compose a written argument for an investigation. [https://stemteachingtools.org/brief/17] • Talk Activities that can Scaffold Argumentation – and Talk Activities Flowchart – This tool highlights those talk formats and explains when, how, and why to use each talk format in support of student investigations. PDF available in Spanish. [http://stemteachingtools.org/brief/35] • Smithsonian Science Education Center: Techniques for Encouraging a Culture of Argumentation in Your Classroom – – This article discusses avenues for creating a culture of argumentation in a science classroom. [https://ssec.si.edu/stemvisions-blog/techniques-encouraging-culture-argumentation-your-classroom] • The Lawrence Hall of Science: Practicing Oral Discourse Skills – This site provides teachers with a 'Collection of Reteaching Loops' including reading arguments, writing (basic components, relevant evidence, reasoning), and discourse. [https://argumentationtoolkit.lawrencehallofscience.org/wp-content/uploads/sites/10/2022/08/SG5-Practicing_Oral_Discourse_Skills.pdf]

	***Modeling and Critiquing Scientific Arguments*** Use spoken and written examples to model scientific arguments and encourage students to critique and challenge scientific arguments by identifying strengths and weaknesses in reasoning and evidence.	• Student-Friendly Video on Scientific Argumentation – This brief, animated video explains scientific argumentation in simple terms. Non-examples are also provided. [https://concord.org/blog/student-friendly-video-on-scientific-argumentation/] • Argumentation and Practical Work – This website provides examples of how practical work in the classroom can be used alongside argumentation. Section 5 of this document (page 14) offers an example of how students can critique arguments. [https://www.nuffieldfoundation.org/sites/default/files/files/Argumentation%20Introduction.pdf]
	***Promoting Engagement through Interactive, Collaborative Games*** Use interactive games and collaborative formats to reinforce disciplinary core ideas related to science ideas about mass, speed, kinetic energy, and Newton's laws of motion.	• Forces and Motion: Utah Wilderness Challenge – This site instructional game in which students can earn medallions by completing each level. Includes the topics of force, gravity, inertia, velocity, acceleration, and graph interpretation. [https://view.genial.ly/5facdb62f73eb10d450e1ea8] • Action-Reaction Rocket – This website Student cooperative learning activity for building a simple balloon rocket and relating its motion to Newton's Laws of Motion. Discussion questions allow students to discuss alternate design solutions. This activity is available in English and Spanish. [https://www.teachengineering.org/sprinkles/view/cub_rocket_sprinkle1] • Wordwall Interactive Games -This site offers quick interactive games to reinforce the concepts and vocabulary pertaining to forces and motion. All grade levels are included, so scroll until you find an appropriate level. [https://wordwall.net/en-us/community/force-and-motion-games]

	*Vocabulary*
	Provide varied opportunities for students to learn and apply vocabulary in diverse situations and contexts. Vocabulary retention improves when academic terminology is layered on conceptual understanding. To maximize vocabulary building, support students in building conceptual understanding and then apply the academic terminology using the strategies outlined below.
	• Build understanding of domain specific vocabulary using a multi-sensory approach or having students participate in simulations.
	• Make connections between vocabulary and real-life or future opportunities.
	  ○ Explain, describe, give real-world examples, or provide concrete representations of vocabulary words rather than formal definitions. Vocabulary.com (see Resources) provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students.
	  ○ Build a vocabulary word wall that students can add to and reference during instruction and self-guided activities or tasks.
	  ○ Have students restate the vocabulary word in their own words. Take this opportunity to help students connect new vocabulary, especially general vocabulary, to prior knowledge.
	• Read books or watch videos related to vocabulary words and concepts.
	• Sort words, photographs, or concrete representations into categories. Text Project (see Resources) provides Word Pictures that are free for educators to use. It includes word
		• STEM Teaching Tools – Practice Brief 66 – This article explains how to support emerging multilingual learners as they develop language that interprets and explains phenomena. [https://stemteachingtools.org/brief/66]
		• Vocabulary.com – This site provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students. [https://www.vocabulary.com/]
		• Text Project – Word Pictures – This site provides Word Pictures that are free for educators to use. Their site includes word pictures for core vocabulary and various content areas including science and social studies. This link will take you to the Word Pictures page where you can select "TextProject Word Pictures," "Physical Science," and "Forces Around Us." [http://textproject.org/classroom-materials/textproject-word-pictures/]
		• The Science Penguin – This site provides ideas to teach science vocabulary. The vocabulary demonstration activity uses real objects to teach vocabulary terms. [http://thesciencepenguin.com/2013/12/science-solutions-vocabulary.html]
		• Interactive Word Walls Enliven Vocab Learning – This article with teaching strategies to support students' use of a word wall to build understanding of key vocabulary [https://www.middleweb.com/37209/interactive-word-walls-enliven-vocab-learning/]

	pictures for core vocabulary and various content areas, including science and social studies. • Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners' experience and prior knowledge. • Define domain-specific vocabulary (e.g., predator) using both domain-specific and common terms. • Embed visual, non-linguistic supports for vocabulary clarification (pictures, videos, etc.). • Have students create their own glossary of terms.	
	***Presenting Information in Different Modalities*** Provide information using a variety of multimedia (e.g., videos, interactives, simulations), informational texts, and formats to teach and reinforce disciplinary core ideas related to mass, speed, kinetic energy, and Newton's laws of motion.	• PhET Sims: Collision Lab – This interactive simulation explores velocity, mass, and kinetic energy as they relate to collisions. May be used as a teacher demonstration with student participation or as an individual student activity. [https://phet.colorado.edu/sims/html/collision-lab/latest/collision-lab_all.html] • Newton's Laws of Motion – This video includes fun experiments that can be repeated at home. Experiments cover all three of Newton's Laws of Motion as well as Conservation of Energy. The instruction is aimed at students from Grade 3 to Grade 8. Closed caption with Spanish options as well as descriptive video option for visually impaired. The website includes links to teacher resources and a student notebook. [https://aptv.pbslearningmedia.org/resource/newtons-laws-video/diy-science-time/] • Forces and Motion Bellringers – These photos, videos, and questions can be used to promote student engagement or inform formative assessment development. [https://virtualscienceteachers.org/bell-ringers-motion-and-stability-forces-and-interactions/] • Newton's 3rd Law of Motion – This video of astronauts re-learning Newton's 3rd Law by trial and error in microgravity.

		Closed caption available. [https://aptv.pbslearningmedia.org/resource/phy03.sci.phys.mfw.asrnt/newtons-third-law-of-motion-astronauts-in-outer-space/]
	***Scaffolds for Communicating through Argumentation*** Provide scaffolds for argumentative writing and discussions to justify or describe a phenomenon or support a design solution (e.g., sentence frames, graphic organizers, norms for whole class discussion, roles for students during small group activities) to support communicating in science-specific ways that may seem unnatural for students.	• National Science Foundation – Tools for Ambitious Science Teaching – This website discusses a tool that provides scaffolds for writing that support learners in constructing explanations with evidence. These take the form of sentence frames, guides for how to help English learners practice final explanations, norms for whole-class discussion that are developed by students, roles that students can take in small group activities, and others. [https://ambitiousscienceteaching.org/orientation-ambitious-science-teaching/] • Model Teaching – CER Checklist and Graphic Organizer – This site provides an introduction to Claim-Evidence-Reasoning (CER) and downloadable resources and writing templates. [https://www.modelteaching.com/education-articles/writing-instruction/claim-evidence-reasoning-cer] • Bozeman Science: Engaging in Argumentation - In this video, Paul Andersen explains how to have your students engage in argumentation in the science classroom [https://www.youtube.com/watch?v=L96LiRDWgmI] • Stem Teaching Tool – Practice Brief 25: Equitable Argumentation – This article describes how supporting multiple modes of expression can increase ways that students communicate their arguments. [https://stemteachingtools.org/brief/25] • Argument Writing Rubric for 8th Grade – This rubric follows the CER framework and will help teachers identify any weaknesses in their students' argumentative writing.

		[https://www.education.com/worksheet/article/argument-writing-rubric-for-8th-grade/]
	***Expressing Learning in Multiple Modalities*** Provide multiple, flexible options for students to communicate their arguments and learning in class. • Use technologies that facilitate student participation and communication, such as discussion boards, podcasts, or blogs. • Allow students to choose a multi-modal project they would like to complete to demonstrate their learning, such as a poster presentation, debate, short film, lab report, blog, infographic, drawing, poetry, writing and performing a song, creating a game, etc. • Provide a variety of ways in which students can "write" to respond to questions (e.g., traditional form of writing, with sentence starters, using pictures, etc.)	• Digital Lab Notebook – This digital notebook offers students a digital option for recording lab results, writing lab reports, journaling, drawing, planning, or creative writing, and can be saved as a copy. [https://virtualscienceteachers.org/virtual-labs/] • 32 Fun Technology Activities for Middle School – These activities include labs, project ideas, and creative ways to use technology to help students communicate their arguments and learning in class. [https://www.teachingexpertise.com/classroom-ideas/fun-technology-activities-for-middle-school/] • The Secret to Great Middle School Presentations – This article is written by an ELA teacher who allows students to teach one another in innovative ways through less formal presentations. [https://www.edutopia.org/article/secret-great-middle-school-presentations/]