SCIENCE TASK ANNOTATION

ANNOTATION KEY

EQUITY	SCENARIOS	SEPs	DCIs	CCCs	SENSE-MAKING	ASSESSMENT PURPOSE
Supporting a wide range of diverse students.	Information provided to elicit performances.	Opportunities to demonstrate science and engineering practices.	Opportunities to demonstrate understanding of disciplinary core ideas.	Opportunities to demonstrate understanding of crosscutting concepts.	Opportunities for reasoning about phenomena and problems.	Highlights how the task features connect to intended assessment use.

UNIT 1: FORCE AND MOTION- "COLLISIONS"

(Whole task.) Across the whole task, the data used in the scenarios is very simplistic and does not reflect the kinds of investigations appropriate to high school because of limited trials and variables, imprecise descriptions of observations, etc. While the focus of this task is not on planning and carrying out investigations, it might be helpful if either the investigations were improved or it was explicitly signaled that these are simplified experiments.

SCENARIOS

Scenario 1: Sam likes riding her bike. As she and her friends were getting ready to ride, Sam wondered why it was so important to wear a helmet.

This wondering—why it is so important to wear a helmet—drives all items in the task. This is a question that can be relevant to many groups of students who have had experiences seeing or riding bikes themselves and can be easily modified for students who connect more readily with other types of activities that could involve collisions, such as roller-skating. While more specific observations prompt the individual questions in the task, there is no specific observation or instance motivating the entire task to begin with—it would be stronger if the task was centered around a specific observation, such as what happens when someone rode a bike and didn't wear a helmet and fell, or choosing amongst different options for a helmet.

SCENARIOS

She knew it was meant to protect her head during a collision or a fall, but did not fully understand how.

By explicitly identifying why investigation in this task is being conducted, this is a nice example of why the scenario might be puzzling or intriguing. This could be improved if the scenario was more problematized—if it was clearer what the uncertainty is, and what aspects of helmet use students would need to address.

SCENARIOS

She decided to try and figure this out by running a few tests.

UNIT 1: FORCE AND MOTION- "COLLISIONS" (CONTINUED)

She made a ball out of playdough and threw it at a nail sticking out of a wall.

When the ball hit the nail, it made a hole in the playdough ball. Sam changed the speed at which she threw the ball and measured the depth of the hole in the ball after each throw. The results are shown in Table 1.

Sam's dad likes to ride and he also wears a helmet, but has a bigger head. To see if that makes a difference, Sam re-did the same experiment, only this time she used a heavier ball. The results are shown in Table 2:

This specific instance—of a ball hitting a nail, causing a hole in the ball—is the specific, observable instance that is being made sense of in this task. Given the scenario described above, it might be difficult for some students to understand what this has to do with figuring out why the experimental set up is related to the helmet question. The scenario would be more comprehensible to students if this was accompanied by a simulation, diagram, or video that described the experimental design and its rationale.

SCENARIOS EQUITY

Table 1

Mass of the Ball (g)	Throw Speed (m/s)	Depth of hole (cm)
10	5.4	0.61
10	6.3	0.74
10	7.9	0.83
10	9.3	0.97

Table 2

Mass of the Ball (g)	Throw Speed (m/s)	Depth of hole (cm)
15	5.4	0.72
15	6.3	0.86
15	7.9	0.96
15	9.3	1.14

Achieve

UNIT 1: FORCE AND MOTION- "COLLISIONS" (CONTINUED)

Item 1

Sam said that **only the mass** affects the force of the collision with the nail. Sam's father said that **only the speed** of the moving object affects the force of the collision. Use the data above to respond to the following questions:

A. Does the data support Sam or her Dad's claim? Why do you think so?

To successfully answer this question, students need to 1) demonstrate that they understand that the size of the hole is directly related to the force of the collision (deeper hole, more forceful; 2) be able to identify simple patterns within and across two data sets: that when mass is kept constant, the force increases with the speed of the moving object, and that when speed is kept constant, more mass results in a more forceful collision. This most closely connects with the 3-5 element of Analyzing and Interpreting data "Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation" because students are identifying straightforward and consistent mathematical relationships.

SEPs

B. Look closely at the data. What relationships do you notice?

This question gives students an additional, more guided, opportunity to make their data analysis and ability to identify relationships in data visible.

SEPs **EQUITY**

UNIT 1: FORCE AND MOTION- "COLLISIONS" (CONTINUED)

C. Use the data in the two tables to write a scientific explanation for the difference in the depth of the hole in the balls.

To successfully respond to this item, students must: 1) know what is included in a scientific explanation, and 2) connect their analysis of the data presented (3-5 SEP#4) to their understanding of the fact that objects with more mass or that are moving faster hit the nail with more impact to provide an explanation for the difference in depth of the hole in the balls. This requires the integration of SEPs and DCIs to make sense of an observation.

This most closely connects to the MS SEP element "Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena." This is more closely connected to the MS SEP rather than the HS SEP because students are only using a single, simple source of information to support the explanation.

This item also requires students to be able to use part of the DCI PS.2A, which focus on how forces are involved in changes in object motion. Because this question focuses on the relationship between mass, force, and the observable change in the object's shape—rather than on using Newton's second law to predict macroscopic motions—this connects most closely with the MS-level understanding.

SEPs DCIs SENSE-MAKING

It should be noted that this question assumes that students have had sufficient experiences in instruction around how to construct scientific explanations when asked, such that they do not need further information about what should be included. This is entirely acceptable, but just something that users of the task should consider when interpreting student responses, as insufficient responses might reflect gaps in instruction and opportunity to learn.

EQUITY

Achieve

UNIT 1: FORCE AND MOTION- "COLLISIONS" (CONTINUED)

Scenario 2: Sam made two more balls out of playdough and threw them at two walls. She made sure she threw the balls the same speed and made sure the balls had the same mass. When she looked at the balls after the collision the ball that she threw at the first wall was flat on one side. The ball that was thrown at the second wall almost kept its original shape. Here is her data table:

Table 3

Type	Mass of the Ball (g)	Throw Speed (m/s)	Shape of ball
Before thrown	10	0	
Wall 1	10	7.9	
Wall 2	10	7.9	

The inclusion of both a textual description of the observations associated with this experiment as well as a data set that includes visual images of how the ball's shape changed after hitting the wall is a good example of how multiple modalities can support all students in understanding the specific phenomenon under investigation.

SCENARIOS EQUITY

UNIT 1: FORCE AND MOTION- "COLLISIONS" (CONTINUED)

Item 2

Sam compared the data in table 3 to the data in tables 1 and 2. She thought that more information was needed to explain what happened to the balls. Compare the data from all three tables.

Describe how the data made Sam think she needed more information.

Use data from the tables to support your answer.

To successfully respond to this question, students must :

1) compare data across multiple experiments and investigations, and

2) identify inconsistencies between what the data showed in table 3 vs. what she expected based on the first series of investigations. This more closely connects with HS SEP element "Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion." because students are identifying why their previous explanation might need to be revised, with new evidence from a different experiment.

This is also a strong example of sense-making with the SEP because students are using their understanding of data and explanation to construct a new understanding of what happens when objects collide.

SEPs SENSE-MAKING

UNIT 1: FORCE AND MOTION- "COLLISIONS" (CONTINUED)

Scenario 3: Sam decided to use her phone and take a slow-motion video of the same experiment.

Looking at her slow-motions videos, she noticed that the second wall had a layer of foam covering it (much like the inside of the bike helmet). She also noticed that the impact time of the ball was longer on wall 2 with the foam than the wall 1 without the foam.

Without a diagram or the video mentioned, it is difficult to understand this scenario. Language like "the same experiment" when 2 previous experiments were conducted, and using different language to reference "the second wall" and "wall 1 and wall 2" may make it difficult for some students to understand what was observed in scenario 3, limiting the inferences about student understanding. Additionally, new phrases about observations like "impact time" are included without explanation of what that means and how it is observed.

SCENARIOS EQUITY

Item 3:

"Foam" might be confusing to some students. Successfully responding to this question is an easier lift if students have prior understanding of the foam referenced here—and its physical properties—to understand that the foam provides cushioning against deformation (e.g., alternatively, students could interpret foam as something like shaving cream, which wouldn't suggest that the wall the ball is striking is actually made of a different material). If students do not have this understanding, some students may have to make more inferences based on the shape of the ball that are not consistent with their understanding of the scenario, which may mask some students' understanding of the phenomena.

EQUITY CONNECTION TO ASSESSMENT PURPOSE

UNIT 1: FORCE AND MOTION- "COLLISIONS" (CONTINUED)

A. Use this data to draw a model to explain why the ball thrown at wall 2 with the foam did not change its shape as much.

This question requires students to make sense of the observations using a model to apply their understanding of Newton's second law of motion to the phenomenon. Students have to:

1) reason that while balls of the same mass were thrown with the same velocity, the longer impact time on wall 2 with the cushioning foam resulted in a smaller acceleration value—and therefore, a weaker force acting on the ball and less change in shape; and

2) account for the change in the system, between wall 1 and wall 2: that the addition of the foam layer in wall 2 introduces an additional force interaction (ball<->foam and foam <-> wall); and

3) Draw a model that pulls these ideas together and connects them to explain the observation.

This most closely connects to:

- the HS DCI PS.2A "Newton's second law accurately predicts changes in the motion of macroscopic objects" and "if a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system".
- The HS SEP #2 Developing and Using Models elements. The model can surface whether students "develop...a model based on evidence to illustrate relationships between...components of a system".

SEPs **DCIs** **SENSE-MAKING**

B. Describe how your model explains why the ball thrown at wall 2 with the foam did not change its shape as much.

This prompt helps ensure that students understanding reflected in the model is effectively communicated to others, and is a support of the SEP "develop and use models", rather than a different practice. It is unclear from the prompt if students are expected to write a separate response, label their models effectively, or if other approaches to describing their model are appropriate.

SEPs

UNIT 1: FORCE AND MOTION- "COLLISIONS" (CONTINUED)

Scenario 4:

Sam looked at two types of bike helmets. She tested each helmet by putting an egg inside of the helmet and then dropping it to the ground from 12 feet.

This is a strong scenario, and could be an interesting scenario to drive the entire task—if the goal of the entire task had been to choose amongst different bike helmets, the task may have been more coherent and relevant to students.

SCENARIOS

The test results and descriptions of the helmets are written below:

Type	Mass of the Helmet (g)	Thickness of foam (mm)	Egg Test Result
Helmet I	300	5.3	Cracked
Helmet II	400	7.9	Cracked

Achieve

UNIT 1: FORCE AND MOTION- "COLLISIONS" (CONTINUED)

Item 4

The kinds of reasoning required by this item could reveal students' understanding and ability to use the HS CCC element "systems can be designed to cause a desired effect". This is somewhat implicit in this item, but students are more likely to be successful—and more likely to have be able to support their suggested modification with compelling reasoning—if they can intentionally utilize this idea.

CCCs | SENSE-MAKING | CONNECTION TO ASSESSMENT PURPOSE

Choose one helmet.

A. How would you change the design of the helmet in order to keep the egg from cracking?

B. Use scientific ideas about force to explain how your proposed change will keep the egg from cracking.

To successfully respond to this question (both A and B), students have to either 1) use the relationships identified in the rest of the task to make a decision about changing the mass of the helmet, the thickness of the foam, or introducing an alternative change or 2) use their understanding of forces and collisions.

- This most closely connect to the MS SEP #6 element "Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system".
- This does provide ample opportunity for students to use their understanding of the targeted DCIs in service of sense-making.
- It is also possible that this will surface student understanding of CCCs, but students may bring different CCCs, at different levels of sophistication, to the table—this offers an opprtunity to surface student progress toward the CCCs, but not to determine whether students understand specific CCCs.

SENSE-MAKING | SEPs | DCIs | CONNECTION TO ASSESSMENT PURPOSE

This emphasizes the important of student ideas and decision making, supporting some degree of student agency in science.

EQUITY