HS PHYSICS: FORCE AND MOTION

Introduction:

The task asks students to use their understanding of analyzing and interpreting data, constructing explanations, and ideas about what happens when objects collide to make sense of an investigation conducted by a [fictional] student named Sam about why it is so important to wear helmets when bike riding. Throughout the task, students are asked to consider aspects of Sam's experimental design, collected data, and conclusions as a mechanism to elicit students' sense-making. This task is intended to be used as an assessment of student understanding of an unpacked "part" of a performance expectation (the learning performance described).

STANDARDS:

This task is intended to assess a learning performance (LP) that was derived from the following NGSS PEs:

HS PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

LPs:

- Students will analyze patterns in data to explain the relationship between mass, change in velocity and the force of a collision.
- Students will develop a model to explain the relationship between the duration of impact/deceleration and the force during a collision.
- Students will analyze data from two competing designs to evaluate which design minimizes the force on the same object during a collision.

ANNOTATION KEY

EQUITY Supporting a wide range of diverse students.

SCENARIOS Information provided to elicit performances.

SEPs Opportunities to demonstrate science and engineering practices.

DCIs Opportunities to demonstrate understanding of disciplinary core ideas.

CCCs Opportunities to demonstrate understanding of crosscutting concepts.

SENSE-MAKING Opportunities for reasoning about phenomena and problems.

ASSESSMENT PURPOSE Highlights how the task features connect to intended assessment use.

✓ STRENGTHS

The **scenario is grounded in specific sets of observations** that students have to make sense of throughout the task.

The scenario **builds over time, introducing new information to students as they need it**—this provides some additional support and scaffolding for students, and serves to cue students toward the relevant features of the phenomenon/scenario for a given question or set of questions.

The task includes **opportunities for students to make their own ideas** as an important and meaningful part of completing the task.

The task elicits evidence multiple times of students **using the SEPs Analyzing and Interpreting Data, Constructing Explanations, and Developing Models in service of sense-making** by asking students to connect practice to specific aspects of the phenomenon/scenario being addressed.

The task **requires that students use SEPs, CCCs, and DCIs together to make sense of the observations provided in the scenario.**

Questions 4 and 5 of this task provides students with an **opportunity to meaningfully use CCCs** to respond to the item.

The task **set-up and scoring guidance allow for students to make facets of their understanding visible, rather than only focusing on right and wrong answers**—and demonstrate how this can be possible even when there are clear right and wrong answers.

! OPPORTUNITIES FOR IMPROVEMENT

The task scenarios, while simple, **rely on text-heavy modalities (data tables, written text)**—given that the scenario builds and is rather complex, it might be difficult for students to fully understand the scenario without images, diagrams, videos, etc being used to convey the phenomena being addressed.

While CCCs might be involved, **this task does not fully support interpreting student responses relative to** how they are progressing toward the targeted CCCs.

The task is highly dependent on students' using **written language** to convey their thinking in open-ended questions, which might obscure some students' abilities.

How does this task support all students?

✓ In addition to the strengths identified above, this task is focused on specific observations that are grounded in a relatively common experience that many students will be able to connect with—wearing helmets while riding a bike. The task introduces information gradually, as students need it, serving to support student thinking by cueing students toward the most relevant information. The task also provides opportunities for students to make their thinking, and not simply right and wrong answers, visible, which both supports students as well as supports teachers in better interpreting student progress.

! The task relies rather heavily on students' language abilities. While this is not necessarily a weakness, it would be helpful if both students and teachers were better supported in **distinguishing between students science understanding and their abilities to communicate that understanding.** Across the items in this task, students are frequently asked to both 1) make a claim/select a position (e.g., Item 1a: does the data support Sam's or her dad's claim?), which inherently reflects their thinking processes, and 2) describe (presumably through written words) why they chose that option or why the data supports that claim (e.g., Item 1A: why do you think so?). It is clear why questions include this second prompt: while increasing the language load, this clearly pushes students to make their reasoning—and, as a result, their ability to integrate practices with scientific understanding—visible. However, it might be helpful to include supports for non-written justifications (e.g., through a video or communication with the teacher or peers, in a context that is less concerned with independent student responses), or to include more questions that would require student reasoning to successfully answer, such that educators would have sufficient evidence to be comfortable with student understanding of the targeted concepts without the need for a written justification (e.g., give student more/increasingly complex data sets that require similar practice/DCI integration and have them make similar claims about what conclusions are supported by the data).

What are the major takeaways?

SUMMARY POINTS:

- Overall, this task requires students to sense-make using the SEPs and DCIs together. While parts of questions might foreground an SEP or DCI, the emphasis in each question on students' reasoning requires at least 2D integration throughout the task.
- The task frequently foregrounds parts of the SEPs, namely data analysis and how the data can be used as evidence to support a claim. The task provides examples of different ways tasks frequently engage SEPs and CCCs related to sense-making.
- Throughout the task, the data and experimental design used are very simplistic, and might not be reflective of the kinds of investigations appropriate to end-of-high school expectations. For example, the investigations described in Scenarios 1 and 2 appear to involve a single trial per variable; the observations described are highly simplistic and follow a very clear-cut pattern, and each item focuses on a single variable without opportunities to consider the limitations or implications of multiple variables together/simple experimental design. In addition to potentially signaling inappropriate expectations, these limitations in the sophistication of the experimental design and data presented limit the sophistication of SEPs, CCCs, and DCIs students must use to address the task.

SUGGESTED IMPROVEMENTS

1. The scoring guidance was modified to reflect when student responses are providing evidence of MS-level expectations, and when student responses were providing evidence of HS-level expectations.
2. The task scenario included a more engaging reason for students [or the fictional Sam] to engage in this task—something that really prompts students to understand why this is important to figure out. This could involve moving the final ask—choosing and improving a helmet design—to become more of a driver of the task, or emphasizing the importance of helmets to preventing injury, etc.
3. The task—and particularly the task scenarios—were modified to provide more opportunities for students to engage CCCs. For example, the task could provide students with more complex data such that they need to organize the data into graphs and charts to identify the appropriate patterns; students could be given sets of data related to helmet design and performance in the context of item 4, requiring students to use test data to inform redesign of the helmets; or students could be asked what kind of data they would want to acquire to inform the helmet redesign. In these examples, students would be required to use their understanding of MS or HS-level patterns expectations to reason a response to the item.

How should this task be used?

This task can be used as a helpful check on student understanding of parts of the SEP analyzing and interpreting data and DCI PS2. Teachers using this task in HS should note that this task will not fully assess the targeted standards, because it is intentionally designed to assess parts of those standards.