

HS-PS2-3 Motion and Stability: Forces and Interactions

California Science Test—Item Content Specifications

# HS-PS2-3 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

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

[Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [*Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.*]

Continue to the next page for the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts.

| Science and Engineering Practices | Disciplinary Core Ideas | Crosscutting Concepts |
| --- | --- | --- |
| Constructing Explanations and Designing Solutions  Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.  Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. | PS2.A: Forces and Motion   1. 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.   ETS1.A: Defining and Delimiting an Engineering Problem   1. Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. *(secondary to HS-PS2-3)*   ETS1.C: Optimizing the Design Solution   1. Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. *(secondary to HS-PS2-3)* | Cause and Effect  Systems can be designed to cause a desired effect. |

## Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

### Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

6E.1 Ability to solve design problems

6E.2 Ability to evaluate and/or refine solutions to design problems

### Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

6E.1.1 Ability to solve design problems by engaging in a systematic, iterative process that results in structures or processes, or the plans for structures or processes

6E.2.1 Ability to compare or critique competing design solutions based on design criteria

6E.2.2 Ability to evaluate and/or refine (optimize) design solutions based on scientific knowledge or evidence

### Disciplinary Core Idea Assessment Targets

#### PS2.A.10

* Identify that the change in momentum of an object during a collision is equal to the change in momentum in the other object(s) involved in the collision
* Recognize that the momentum of an object is the product of its mass and velocity (*p = mv*)
* Understand that to decrease the momentum of an object, an opposing force must be applied
* Understand that for a given decrease in momentum, the magnitude of the opposing force is decreased by extending the time the force is applied, as represented by the equation (*F∆t = m∆v*)

#### ETS1.A.6

* Identify the criteria and constraints involved in an engineering problem, including those set by society
* Identify and determine methods for quantifying criteria and constraints so that design solutions can be evaluated by testing

#### ETS.1.C.5

* Explain that criteria for solving complex real-world problems, such as the minimization of force acting on an object during a collision, may need to be broken down into simpler ones that can be evaluated systematically
* Explain that the prioritization of criteria or constraints (tradeoffs) may be necessary for the selection of a design solution

### Crosscutting Concept Assessment Target(s)

CCC2 Identify systems that are designed to cause a specific effect

## Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides both a description of a problem involving a collision where the force on an object can be minimized using a device and a list of possible features to incorporate into the device:

* Identifies the feature(s) that will enable the device to meet the criteria (6E.1.1, PS2.A.10, and CCC2)

Task provides multiple design solutions that are intended to minimize the force on an object in a collision and the criteria for the design solutions:

* Selects the design solution that best meets the provided criteria (6E.2.1, PS2.A.10, and CCC2)
* Assesses how well each design solution meets the criteria and constraints (6E.2.1, PS2.A.10, and CCC2)
* Identifies tradeoffs or advantages and disadvantages for each design solution (6E.2.1, PS2.A.10, and CCC2)

Task provides two or more design solutions that are intended to minimize the force on an object in a collision, the criteria and constraints for the design solutions, and performance data:

* Identifies the prioritized criteria and/or constraints required for the design (6E.2.1, PS2.A.10, ETS1.A.6, and CCC2)
* Selects one design based on data and criteria (6E2.1, PS2.A.10, ETS1.A.6, and CCC2)

Task provides a device designed to minimize the force on an object involved in a collision, data related to the performance of the device, prioritized criteria or constraints, and possible refinements:

* Selects the refinement that best meets the prioritized criteria or constraints (6E.2.1, PS2.A.10, and CCC2)
* Justifies the selection based on prioritization of criteria (6E.2.1, PS2.A.10, and CCC2)
* Identifies the scientific principle (e.g., impulse-momentum theorem) that supports the effectiveness of the refinement to meet the criteria (6E.2.2, PS2.A.10, and CCC2)

Task provides a list of possible refinements to a prototype device intended to minimize the force on an object during a collision, and data related to the refinements to the device:

* Selects the refinement that best meets the criteria and justifies the refinement using the data (6E.2.2, PS2.A.10, ETS.1.C.5, and CCC2)

## Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

* Seatbelts, bumpers, airbags, bubble wrap (e.g., for an egg inside a toy car)
* Safety or physical activity equipment: helmets, hardhats, baseball mitts, gym mats, safety nets, climbing ropes

## Common Misconceptions

Note that the list in this section is not exhaustive.

* Momentum is a scalar quantity.
* Momentum is the same as force.
* Momentum depends on the acceleration of an object rather than its velocity at a particular moment.
* Momentum is conserved for each object involved in a collision.
* There is no change in momentum to an extremely large or heavy object involved in a collision.

## Additional Assessment Boundaries

None listed at this time.

## Additional References

HS-PS2-3 Evidence Statement [https://www.nextgenscience.org/sites/default/files/evidence\_statement/black\_white/HS-PS2-3 Evidence Statements June 2015 asterisks.pdf](https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/HS-PS2-3%20Evidence%20Statements%20June%202015%20asterisks.pdf)

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12*

Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12 <https://www.cde.ca.gov/ci/sc/cf/documents/scifwappendix1.pdf>

Posted by the California Department of Education, March 2021 (updated February 2024)