

HS-PS2-2 Motion and Stability: Forces and Interactions

California Science Test—Item Content Specifications

# HS-PS2-2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

[Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [*Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.*]

| Science and Engineering Practices | Disciplinary Core Ideas | Crosscutting Concepts |
| --- | --- | --- |
| Using Mathematics and Computational Thinking  Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.  Use mathematical representations of phenomena to describe explanations. | PS2.A: Forces and Motion   1. Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. 2. 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. | Systems and System Models  When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. |

## 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.

5.2 Ability to conduct mathematical and/or computational analyses

### 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.

5.2.1 Ability to use the results of computational models (e.g., simulations) to identify patterns in natural and/or design worlds

5.2.3 Ability to use computational models (e.g., simulations) to make predictions for a scientific phenomenon

### Disciplinary Core Idea Assessment Targets

#### PS2.A.9

* Clearly define the reference frame and identify the objects that define the system
* Define momentum *p* as the product of the object’s mass *m* and velocity *v* and mathematically model the net momentum and/or individual momenta of a system of objects based on either the system’s initial or final conditions

#### PS2.A.10

* Recognize, through the analysis of the motion of the objects, that the net momentum of a system remains constant before and after any interactions from the objects within the system
* Balance the losses and gains of momentum across objects in a closed system using mathematical representations
* Attribute changes in the net momentum of a system to the openness of the system (objects in the system can interact with objects external to the system)

### Crosscutting Concept Assessment Target(s)

CCC4 Identify that the boundaries and initial conditions of the system need to be defined when investigation or describing a system

## Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides values for the physical properties of the system and options to complete any missing values or to determine/predict the values before/after the collision:

* Mathematically determines the properties of the system using the conservation of momentum of objects in the system (5.2.2, PS2.A.9, and CCC4)

Task provides a simplified computational model for the collision of two objects that produces an inaccurate prediction. Task also provides data from the actual collision:

* Identifies which ways a model was simplified (e.g., it assumed conservation of momentum, but an outside force was applied) and how it contributed to the difference between predicted and experimental values (5.2.3, PS2.A.10, and CCC4)

## Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

* Two objects traveling in the same direction (but at different velocities) collide and stick together.
* Two objects travelling toward each other collide and stick together.
* A single moving object breaks apart into two separate objects, each with their own mass and velocity.

## Common Misconceptions

Note that the list in this section is not exhaustive.

* Momentum is a scalar physical quantity.
* Momentum is conserved for an individual object, rather than a system.
* Momentum is like a force.

## Additional Assessment Boundaries

None listed at this time.

## Additional References

HS-PS2-2 Evidence Statement [https://www.nextgenscience.org/sites/default/files/evidence\_statement/black\_white/HS-PS2-2 Evidence Statements June 2015 asterisks.pdf](https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/HS-PS2-2%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>

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