

HS-PS2-4 Motion and Stability: Forces and Interactions

California Science Test—Item Content Specifications

# HS-PS2-4 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

Use mathematical representations of Newton’s Law of Gravitation and Coulomb’s Law to describe and predict the gravitational and electrostatic forces between objects.

[Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [*Assessment Boundary: Assessment is limited to systems with two objects.*]

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 |
| --- | --- | --- |
| Using Mathematics and Computational ThinkingMathematical 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.Connections to Nature of ScienceScience Models, Laws, Mechanisms, and Theories Explain Natural PhenomenaTheories and laws provide explanations in science.Laws are statements or descriptions of the relationships among observable phenomena. | PS2.B: Types of Interactions9. Newton’s law of universal gravitation and Coulomb’s law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.10. Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. | PatternsDifferent patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. |

## 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.

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

5.2.4 Ability to use critical mathematical skills to compare simulated effects in computational models to real-world observations to identify limitations of computational models

5.2.5 Ability to use mathematical and statistical tools to analyze trends and patterns in data from scientific investigations

### Disciplinary Core Idea Assessment Targets

#### PS2.B.9

* Identify the system of objects that are being represented
* Identify and describe the gravitational attraction between two objects as the product of their masses divided by the separation distance squared
* Identify and describe the electrostatic force between two objects as the product of their individual charges divided by the separation distance squared
* Predict the change in the gravitational and/or electrostatic force between objects when properties of the system are changed
* Understand that the ratio of the gravitational force and the electrostatic force between two objects with a given charge and mass is independent of distance

#### PS2.B.10

* Understand that the gravitational and electrostatic forces can be described by fields that permeate all of space
* Identify that the field strength associated with a massive and/or charged object goes to zero as the distance from the object becomes very large

### Crosscutting Concept Assessment Target(s)

CCC1 Identify different patterns at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena

## Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides a description or presentation of observations from a simulation portraying two objects of given charge or mass:

* Identifies the magnitude and direction of specific attractive or repulsive forces (5.2.2, PS2.B.9, and CCC1)
* Identifies (if electrostatic) the charge (magnitude and sign) of an unknown object based on interactions with other charged objects (5.2.2, PS2.B.9, and CCC1)
* Identifies if the simulation is depicting an electrostatic or gravitational interaction based on interactions with other objects of known mass and/or charge (5.2.2, PS2.B.9, and CCC1)

Task provides an interactive simulation portraying two objects of given charge or mass:

* Identifies any shortcomings or limitations of the simulation, using the law of universal gravitation (5.2.4, PS2.B.9, and CCC1)
* Identifies any shortcomings or limitations of the simulation, using Coulomb's law (5.2.4, PS2.B.9, and CCC1)
* Identifies correct behavior of a simulation based on extreme case analysis (separation = 0 or separation = infinity) (5.2.4, PS2.B.9, and CCC1)

Task provides data generated from either scientific investigations or values of mass, charge, and separation distance:

* Identifies that the ratio between gravitational and electric forces between objects with a given charge and mass is a pattern that is independent of distance (5.2.5, PS2.B.10, and CCC1)
* Identifies whether the interaction is an electrostatic or gravitational force interaction (5.2.5, PS2.B.10, and CCC1)

## Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

* A system of two objects or point charges
* A system of two massive objects where one orbits the other
* Changes in the magnitude of gravitational forces between two massive objects
* Changes in the magnitude of electrostatic forces between two charged particles

## Common Misconceptions

Note that the list in this section is not exhaustive.

* Gravitational forces only apply to objects near the surface of a planet, not between planets or stars.
* Gravitational forces are stronger than electrostatic forces between charged particles.
* In a two-object system, the more massive object (or object with the greater charge) exerts a greater force on the other object.
* A gravitational force acting between two objects depends solely on the distance between the objects and not the masses of the objects.

## Additional Assessment Boundaries

None listed at this time.

## Additional References

HS-PS2-4 Evidence Statement [https://www.nextgenscience.org/sites/default/files/evidence\_statement/black\_white/HS-PS2-4 Evidence Statements June 2015 asterisks.pdf](https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/HS-PS2-4%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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