

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

California Science Test—Item Content Specifications

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

Students who demonstrate understanding can:

Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object.

[Clarification Statement: Emphasis is on balanced (Newton’s First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton’s Second Law), frame of reference, and specification of units.] [*Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*]

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 |
| --- | --- | --- |
| Planning and Carrying Out Investigations  Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.  Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.  Connections to Nature of Science  Scientific Knowledge is Based on Empirical Evidence  Science knowledge is based upon logical and conceptual connections between evidence and explanations. | PS2.A: Forces and Motion   1. The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. 2. All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. | Stability and Change  Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. |

## 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.

3.1 Ability to clarify the goal of the investigation and identify the evidence needed to address the purpose of the investigation

3.2 Ability to develop, evaluate, and refine a plan for the investigation

### 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.

3.1.2 Ability to identify relevant independent and dependent variables and to consider possible confounding variables or effects

3.1.3 Ability to describe what and how much data need to be collected to provide sufficient evidence for the purpose of the investigation

3.2.1 Ability to decide how to observe and/or measure relevant variables, considering the level of accuracy and precision required and the kinds of instrumentation and techniques best suited to making such measurements

3.2.2 Ability to describe a detailed experimental procedure (e.g., number of trials, identify the control) and experimental setup

### Disciplinary Core Idea Assessment Targets

#### PS2.A.6

* Identify the objects interacting within a system (object or group of objects under investigation) as well as the forces acting upon them (which may be external to the system)
* Describe the relative magnitude and direction of the forces exerted onto a system and whether or not they balance each other
* Describe the relationship between the mass of an object (or system of objects), the sum of the forces acting on that object, and the acceleration that the object experiences
* Describe the balance of the forces exerted on an object (or system of objects) based on the measurement of the object’s motion

#### PS2.A.7

* Describe how the choice of a reference frame is an arbitrary selection based on ease of analysis
* Choose a reference frame for the investigation that best facilitates measurement of mass, motion, and/or force
* Choose the appropriate units for measuring mass, force, and motion in light of the relationship among the three and the effect of a reference frame choice

### Crosscutting Concept Assessment Target(s)

CCC7 Construct explanations of stability and change in natural or designed systems by examining the changes over time and forces at different scales

## Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides a simulation that allows students to manipulate the mass of an object in a system and the magnitude of forces exerted on various components of the system:

* Identifies the system and all the external objects interacting with the system, affecting its motion (3.1.2, PS2.A.6, and CCC7)
* Identifies that if the external forces exerted by objects in a specific direction balance each other, then the system’s motion in that direction remains unchanged (3.1.2, PS2.A.6, and CCC7)
* Identifies that if opposing external forces exerted by objects do not balance each other, then the system’s speed and/or direction of motion changes (3.1.2, PS2.A.6, and CCC7)

Task provides a scenario where two groups, using alternative methods, investigate how the sum of forces exerted on a system correlate to its types of motion:

* Compares and evaluates the methods used to determine which group, if any, correctly addresses the goal of the investigation (3.1.3, PS2.A.6, and CCC7)

Task provides a list of materials/measuring tools (e.g., metersticks, stopwatches, electric balances, force probes or spring scales, slow motion video camera) to carry out an investigation regarding forces and motion:

* Selects and determines which instruments will provide accurate and precise data and identifies any gaps in data (3.2.1, PS2.A.7, and CCC7)

Task provides a scenario where different students describe the detailed experimental procedures they used to investigate how the sum of forces exerted on an object determines its type of motion:

* Selects the most appropriate experimental procedure that targeted the investigation based on an appropriate choice of instruments and an appropriate choice of a reference frame for analysis (3.2.2, PS2.A.7, and CCC7)

## Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

* Motion graphs of specific physical situations (position vs. time or velocity vs. time)
* Graph of acceleration vs. unbalanced force or unbalanced force vs. mass
* Cart put into motion by unbalanced forces (e.g., pushed by a spring-loaded plunger or pulled on a string)
* Cart-pulley-mass system on a ramp
* Sliding block pulled by a spring scale

## Common Misconceptions

Note that the list in this section is not exhaustive.

* Different types of motion—rest, constant velocity, and constant acceleration—are the same.
* If speed increases, then acceleration must be increasing as well.
* Contact/field forces and net forces are the same.
* Forces must be exerted on a system in order for the system to maintain motion.
* If the sum of all forces adds to zero, then the object must be at rest.
* Any force on an object must be in the direction of movement.
* Individual forces, not their sum, determine the motion of an object.
* If an object is moving, the sum of all forces cannot equal zero.
* Constant speed, not constant acceleration, results from constant force.
* An object can have a force within it that keeps it moving.

## Additional Assessment Boundaries

None listed at this time.

## Additional References

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