3-PS2-1 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

> **Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.**
>
> [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.] *[Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.]*

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 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. ---------- ***Connections to Nature of Science*** **Scientific Investigations Use a Variety of Methods** • Science investigations use a variety of methods, tools, and techniques.	**PS2.A: Forces and Motion** 3. Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) **PS2.B: Types of Interactions** 2. Objects in contact exert forces on each other.	**Cause and Effect** • Cause and effect relationships are routinely identified.

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

3.3 Ability to collect the data 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.

3.1.4 Ability to describe how the observations and/or collected data can be used as evidence for the phenomenon under investigation

3.2.2 Ability to describe detailed experimental procedure, including how the data will be collected, how to control variables, the number of trials, the experimental setup and the tools required

3.2.3 Ability to compare and evaluate alternative methods to determine which design provides the evidence necessary to address the purpose of the investigation

3.3.2 Ability to make observations according to the investigation plan

3.3.3 Ability to evaluate the quality of data to determine if the evidence meets the goals of the investigation

Disciplinary Core Idea Assessment Targets

PS2.A.3.a Describe forces acting on objects in terms of both strength and direction

PS2.A.3.b Describe that unbalanced forces acting on an object result in a change of motion – in either speed or direction

PS2.A.3.c Identify forces even when an object is at rest and infer that forces at play are balanced

PS2.A.3.d Predict future motion based on observed patterns of motion and presence of balanced or unbalanced forces

PS2.B.2.a Recognize that objects in physical contact exert forces on each other

PS2.B.2.b Recognize that some forces act on objects without physical contact

PS2.B.2.c Recognize that the gravitational force of Earth pulls objects (near Earth's surface) towards the planet's center

Crosscutting Concept Assessment Target(s)

CCC2 Identify cause and effect relationships

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides observations and/or data from an investigation that sought to measure (qualitatively) the effects of balanced and unbalanced forces on the motion of an object:

- Evaluates whether the data provide sufficient evidence to meet the goal of the investigation (3.1.4, PS2.A.3, and CCC2)
- Selects a subset of the data that best support the goal of the investigation (3.1.4, PS2.A.3, and CCC2)

Task provides a list of experimental plans to answer a question about the effects of balanced and unbalanced forces on the motion of an object:

- Selects the plan that will best provide data to answer the question (3.2.2, PS2.A.3, and CCC2)

Task provides a list of variables in an experiment to answer a question about the effects of balanced and unbalanced forces on the motion of an object:

- Identifies the control, independent, and/or dependent variables (3.2.2, PS2.A.3, and CCC2)

Task provides a flawed experimental plan and/or data generated from an experiment about the effects of balanced and unbalanced forces on the motion of an object:

- Identifies the flaws and refines the plan to better address the purpose of the investigation (3.2.3 and PS2.A.3)
- Uses the data to evaluate and refine the experimental plan (3.2.3 and PS2.A.3)

Task provides an animation of an investigation about the effects of balanced and unbalanced forces on the motion of an object:

- Identifies the observations that provide evidence to support the hypothesis under investigation (3.3.2, PS2.A.3, and CCC2)

Task provides a simulation about the effects of balanced and unbalanced forces on the motion of an object:

- Interacts with the simulation to generate data to support the hypothesis under investigation (3.3.2, PS2.A.3, and CCC2)

Task presents a set of data from an investigation about the effects of balanced and unbalanced forces on the motion of an object:

- Evaluates whether the amount of data (i.e., number of trials) is sufficient to answer the question under investigation (3.3.3, PS2.A.3, and CCC2)

Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

- A force acting on an object initially at rest (e.g., kicking a ball)
- A force acting on an object already in motion (e.g., tapping a rolling marble)
- Combinations of push and pull forces acting on an object initially at rest (e.g., two students pushing on a desk)
- Control of variables
- Number of trials and data points
- Relevance of collected data
- Appropriateness of measuring tools and instruments

Common Misconceptions

Note that the list in this section is not exhaustive.

- If a force is acting on an object, the object will move unless it is immovable.
- An object at rest cannot be acted upon by a force.
- There is a constant force acting on an object in motion.
- A force is something that can be carried with an object and may be used up over time.
- Force is an internal property of objects.
- Gravity prevents objects from flying into space.

- Objects cannot move in the absence of friction.

Additional Assessment Boundaries

None listed at this time.

Additional References

3-PS2-1 Evidence Statement https://www.nextgenscience.org/sites/default/files/

evidence_statement/black_white/3-PS2-1%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

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

Students who demonstrate understanding can:

> **Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.**
>
> [Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paperclips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.] *[Assessment Boundary: Assessment is limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity.]*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. • Ask questions that can be investigated based on patterns such as cause and effect relationships.	**PS2.B: Types of Interactions** 3. Electric, and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.	**Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change.

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.

1.1 Ability to ask and evaluate questions addressing phenomena of the natural world

1.3 Ability to ask and evaluate investigable questions

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.

1.1.1 Ability to ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information

1.3.1 Ability to ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory

1.3.2 Ability to evaluate a question to determine if it is empirically testable and relevant

Disciplinary Core Idea Assessment Targets

PS2.Ba. Recognize that interactions involving electromagnetic forces do not require that the interacting objects physically touch

PS2.Bb. Identify the strength of the force exerted by two objects interacting through electromagnetic force decreases as the distance between them increases

PS2.Bc. Describe forces exerted upon two magnetics in terms of the relative position among magnetic poles

PS2.Bd. Differentiate between permanent magnets and objects that can interact in the presence of magnets but not when the magnet is removed

PS2.Be. Identify the act of charging as a means for causing previously neutral objects to interact via electromagnetic forces

PS2.Bf. Draw comparisons between interactions among permanent/temporary magnets and among charged objects

Crosscutting Concept Assessment Target(s)

CCC2 Identify, test, and use cause and effect relationships to explain change

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides a picture/description of a scenario of two objects in the natural world that interact via electromagnetic forces:

- Identifies (or generates) a question that best considers the cause-and-effect relationship between observable features of the interacting objects (e.g.., their composition, distance, and relative orientation) and of features of the forces (e.g., their strength and direction) (1.1.1, PS2.B.3, and CCC2)

- Identifies a question that best seeks to investigate how the objects are interacting without being in physical contact (1.1.1 and PS2.B.3)

Task provides a picture/description of a scenario in which two objects in the natural world interact via electromagnetic forces and the result is unexpected:

- Identifies (or generates) a question that highlights how the expected cause-and effect-relationship was different from the observed interaction between the two objects (1.1.1, PS2.B.3, and CCC2)

- Identifies (or generates) a question regarding the relative orientation/position of the interacting objects that might be the cause of the unexpected result (1.1.1, PS2.B.3, and CCC2)

- Identifies (or generates) a question regarding a new source of information that would help determine if a suggested cause/effect relationship actually occurred (1.1.1, PS2.B.3, and CCC2)

Task provides observations from an experiment in which two objects interact via electromagnetic forces:

- Asks a question about the experiment that effectively compares the observed cause-and-effect relationship to another instance of objects interacting via a different kind of electromagnetic force (1.3.1, PS2.B.3, and CCC2)

- Asks a question regarding unstated features of the materials used (i.e., size, object composition, relative position, relative orientation) that might serve as alternative explanations for the results(1.3.1, PS2.B.3, and CCC2)

Task provides a question regarding objects interacting via electromagnetic forces:

- Identifies (or generates) a hypothesis that converts the provided question into one that identifies both which variables will be held constant and which will be allowed to vary (1.3.1, PS2.B.3, and CCC2)

- Evaluates the quality of the question in light of a stated set of available resources (e.g., a set of magnets, a compass, and paperclips) that could be used to perform an investigation (1.3.2, PS2.B.3, and CCC2)

Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

- Non-metallic, non-magnetic objects interact after one (or both) have become electrically charged (perhaps via static electricity, like a balloon on hair)

- A permanent magnetic exerts a force on a ferromagnetic metallic object (like a paper clip)

- Two permanent (ferro) magnets exert forces on each other based upon their relative positions

- Students investigate how size affects the magnetic force exerted between two (ferro) magnets

- An electrically neutral object is charged via the triboelectric effect and attracts an electrically neutral object

Common Misconceptions

Note that the list in this section is not exhaustive.

- Charged objects never interact with neutral objects.

- All metals are attracted to magnets.

- All silver-colored items are attracted to a magnet.

- Larger magnets are always stronger magnets.

Additional Assessment Boundaries

None listed at this time.

Additional References

3-PS2-3 Evidence Statement

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* *(PDF)*

5-PS1-4 Matter and Its Interactions

Students who demonstrate understanding can:

> **Conduct an investigation to determine whether the mixing of two or more substances results in new substances.**
>
> [Clarification Statement: Examples of combinations that do not produce new substances could include sand and water. Examples of combinations that do produce new substances could include baking soda and vinegar or milk and vinegar.]

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 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.	**PS1.B: Chemical Reactions** 2. When two or more different substances are mixed, a new substance with different properties may be formed.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change.

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.

3.2 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.

3.2.1 Ability to decide how to measure and observe relevant variables, including considering the level of accuracy and precision required, and the kinds of instrumentation and techniques best suited to making such measurements to reduce both random and systematic error

3.2.2 Ability to describe detailed experimental procedure, including how the data will be collected, how to control variables, the number of trials, the experimental set up, and the equipment and tools required

3.2.3 Ability to compare and evaluate alternative methods and to refine the plan to produce more accurate, precise, and useful data to address the experimental question

Disciplinary Core Idea Assessment Targets

PS1.B.2a Identify how a change in observed qualitative properties (e.g., state of matter, color, texture, and odor) of two substances after mixing may indicate that new substances may have formed

PS1.B.2b Identify how a change in measured quantitative properties (e.g., mass/weight) of two substances after mixing may indicate that new substances may have formed

PS1.B.2c Distinguish between physical and chemical changes

Crosscutting Concept Assessment Target(s)

CCC2 Identify and test cause and effect relationships to explain change

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides a context along with an incomplete list of measuring tools that may be used to determine whether the mixing of two or more substances results in new substances:

- Evaluates the list of measuring tools and correctly identifies gaps in the list that are relevant to the purpose of the investigation (3.2.1, PS1.B.2, and CCC2)

Task provides a context along with a list of measuring tools that may or may not be useful for determining whether the mixing of two or more substances results in new substances:

- Selects the relevant measuring tools to provide the evidence necessary to address the purpose of the investigation (3.2.1, PS1.B.2, and CCC2)

Task provides a context and a list of relevant and irrelevant experimental procedures for determining whether the mixing of two or more substances results in new substances:

- Identifies the procedure that provides the evidence necessary to address the purpose of the investigation (3.2.2, PS1.B.2, and CCC2)

Task provides a context and a question related to whether the mixing of two or more substances results in new substances:

- Identifies the properties to observe or measure that would be useful to the investigation (3.2.2, PS1.B.2, and CCC2)

Task provides a context along with a list of variables that may be controlled in an investigation to determine whether the mixing of two or more substances results in new substances:

- Identifies the variable to manipulate, the variable to measure, and/or the variable(s) to control (3.2.2, PS1.B.2, and CCC2)

Task provides both flawed and acceptable experimental methods to determine whether the mixing of two or more substances results in new substances:

- Compares and evaluates the alternative methods to determine which design is appropriate to the investigation (3.2.3, PS1.B.2, and CCC2)

Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

- Change in color
- Change in state or texture
- Formation of a precipitate

- Production of a gas
- Change in mass in an open system

Common Misconceptions

Note that the list in this section is not exhaustive.

- Physical changes are irreversible.
- When matter dissolves or evaporates, it ceases to exist.

Additional Assessment Boundaries

None listed at this time.

Additional References

5-PS1-4 Evidence Statement (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* (PDF)