2.P.4 Physical Science: Exploring Pushes and Pulls

2.P.4A.1 Analyze and interpret data from observations and measurements to compare the effects of different strengths and directions of pushing and pulling on the motion of an object.

Standard 2.P.4 The student will demonstrate an understanding of the effects of pushes, pulls, and friction on the motion of objects.	
2.P.4A. Conceptual Understanding: An object that is not moving will only move if it is pushed or pulled. Pushes and pulls can vary in strength and direction and can affect the motion of an object. Gravity is a pull that makes objects fall to the ground. Friction is produced when two objects come in contact with each other and can be reduced if needed.	
Performance Indicator	**2.P.4A.1:** Analyze and interpret data from observations and measurements to compare the effects of different strengths and directions of pushing and pulling on the motion of an object.
Science and Engineering Practice	**2.S.1A.4:** Analyze and interpret data from observations, measurements, or investigations to understand patterns and meanings.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator Cause and effect Scale, proportion, and quantity Stability and change

Essential Learning Experiences:
It is essential that students collect data through measurements and observations from investigations and other sources (including simulations and videos) into how pushes and pulls affect the motion of an object.

It is essential that students analyze and interpret data from their investigations in order to describe and compare the effects of different strengths and directions of pushing and pulling on the motion of an object, including the following:

- Pushes and pulls can make objects move faster, slower, stop, or change directions.
- If the strength of a push or pull increases, an object will move faster.
- If the strength of a push or pull decreases, an object will move slower.
- Heavier objects will move slower than lighter objects if the push or pull is the same for both.
- If a push or a pull is applied to a moving object it can change the direction and or speed of the object.
- If the push or pull is in a direction that is not the direction the object is moving, it will change direction.
- If the push or pull is in the same direction as the moving object, the object will speed up.
- If the push or pull is in the opposite direction as the moving object, the object will slow down or stop.
- Magnetism, gravity, and friction are different types of pushes or pulls that can affect motion.

NOTE TO TEACHER: The conclusions from the data analyzed during their investigations can be used by students to develop models to exemplify the effect of pushing and pulling on objects (**2.P.4A.2**), to construct explanations for the relationship between the motion of an object and gravity (**2.P.4A.3**). Additionally, the data collected during investigations to answer questions about the relationship between friction and motion can be used during this analysis (**2.P.4A.4**).

2.P.4 Physical Science: Exploring Pushes and Pulls

NOTE TO TEACHER: Scientific tools used to measure force include: magnets, rulers, measuring tapes, meter sticks.

Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- Students may use the term "force" to describe a push or a pull that affects the motion of an object.
- Students may investigate how the mass of a moving object will have an effect on its motion
- Students may investigate how easy or difficult it is to change the speed and/or direction of an object in motion.

Assessment Guidelines:
The objective of this performance indicator is for students to *analyze and interpret data from observations and measurements* to compare the effect of different strengths and directions of pushing and pulling on the motion of an object; therefore the primary focus of assessment should be for students to collect data using observations and measurements from investigations, simulations, videos, and other means of data collection of different pushes and pulls on objects in order to describe and compare the effects these pushes and pulls have on the speed and direction of objects in motion. This can include, but is not limited to:

- Collecting observational and measurement data of the effects of different pushes and pulls (including different direction and different strength) on the motion of objects.
- Organizing, analyzing, and interpreting the data in order to describe and compare the effects of pushes and pulls on them motion of objects.
- Using their data to describe the way pushes and pulls affect the motion of objects.
- Using their data to compare how different pushes and pulls affect the motion of objects.
- Making and testing predictions regarding the effects of different pushes and pulls on the motion of objects.

Additionally, students should engage in multiple Science and Engineering Practices (SEPs) when interacting with the content outlines in this performance indicator. Further information for the SEPs can be found at this link.

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Learning Connections	**Future Learning Connections (3-5):** **5.P.5A.1** Use mathematical and computational thinking to describe and predict the motion of an object (including position, direction, and speed). **5.P.5A.2** Develop and use models to explain how the amount or type of force (contact and noncontact) affects the motion of an object. **5.P.5A.3** Plan and conduct controlled scientific investigations to test the effects of balanced and unbalanced forces on the rate and direction of motion of objects. **5.P.5A.4** Analyze and interpret data to describe how a change of force, a change in mass, or friction affects the motion of an object.

2.P.4A.2 Develop and use models to exemplify the effects of pushing and pulling on an object.

Standard 2.P.4 The student will demonstrate an understanding of the effects of pushes, pulls, and friction on the motion of objects.	
2.P.4A. Conceptual Understanding: An object that is not moving will only move if it is pushed or pulled. Pushes and pulls can vary in strength and direction and can affect the motion of an object. Gravity is a pull that makes objects fall to the ground. Friction is produced when two objects come in contact with each other and can be reduced if needed.	
Performance Indicator	**2.P.4A.2:** Develop and use models to exemplify the effects of pushing and pulling on an object.
Science and Engineering Practice	**2.S.1A.2:** Develop and use models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator Cause and effect Scale, proportion, and quantity Energy and matter: Flows, cycles, and conservation Stability and change

Essential Learning Experiences:
It is essential that students obtain information from various sources, including investigations, observations, measurements, videos, simulations, and pictures into the different ways pushes and pulls affect an object.

It is essential that students develop that they can use to describe, illustrate, and exemplify the effects of different pushes and pulls on objects. These include the following:

- If the strength of a push or pull increases, an object will move faster.
- If the strength of a push or pull decreases, an object will move slower.
- Heavier objects will move slower than lighter objects if the push or pull is the same for both.
- If a push or a pull is applied to a moving object it can change the direction and or speed of the object.
- If the push or pull is in a direction that is not the direction the object is moving, it will change direction.
- If the push or pull is in the same direction as the moving object, the object will speed up.
- If the push or pull is in the opposite direction as the moving object, the object will slow down or stop.
- Magnetism, gravity, and friction are different types of pushes or pulls that can affect motion.

NOTE TO TEACHER: The information students use to develop their models can come from the data analyzed during their investigations into the effect of pushing and pulling on objects (**2.P.4A.1**) and from the data collected during investigations to answer questions about the relationship between friction and motion (**2.P.4A.4**). Additionally, the models students develop can be used to construct explanations for the relationship between the motion of an object and gravity (**2.P.4A.3**).

NOTE TO TEACHER: Scientific tools used to measure force include: magnets, rulers, measuring tapes, meter sticks.

Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- Students may investigate how mass affects the pushing and pulling of objects.

Assessment Guidelines:
The objective of this performance indicator is for students to *develop and use models* to exemplify the effects of pushing and pulling on an object; therefore the primary focus of assessment should be for students to obtain information from various sources, including investigations, observations, measurements, videos, pictures, and simulations and use this information to develop models that illustrate examples of the different ways that different pushes and pulls can affect an object. This can include, but is not limited to:

- Obtaining information from various sources of examples of different types, strengths, and directions of pushes and pulls on objects (both in motion and at rest).
- Using this information to develop models that illustrate these different examples.
- Using their models to communicate these examples and describing the effects of pushes and pulls on objects.
- Given a model (illustration or example) depicting an object in motion, describing the push or pull that produced the motion depicted in the model.
- Given information, including data, about a push or a pull on an object, illustrating the motion of the object that results from the push or pull.

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Learning Connections	**Future Learning Connections (3-5):** **5.P.5A.1** Use mathematical and computational thinking to describe and predict the motion of an object (including position, direction, and speed). **5.P.5A.2** Develop and use models to explain how the amount or type of force (contact and noncontact) affects the motion of an object. **5.P.5A.3** Plan and conduct controlled scientific investigations to test the effects of balanced and unbalanced forces on the rate and direction of motion of objects. **5.P.5A.4** Analyze and interpret data to describe how a change of force, a change in mass, or friction affects the motion of an object.

2.P.4A.3 Construct explanations of the relationship between the motion of an object and the pull of gravity using observations and data collected.

Standard 2.P.4 The student will demonstrate an understanding of the effects of pushes, pulls, and friction on the motion of objects.	
2.P.4A. Conceptual Understanding: An object that is not moving will only move if it is pushed or pulled. Pushes and pulls can vary in strength and direction and can affect the motion of an object. Gravity is a pull that makes objects fall to the ground. Friction is produced when two objects come in contact with each other and can be reduced if needed.	
Performance Indicator	**2.P.4A.3:** Construct explanations of the relationship between the motion of an object and the pull of gravity using observations and data collected.
Science and Engineering Practice	**2.S.1A.6:** Construct explanations of phenomena using (1) student-generated observations and measurements, (2) results of scientific investigations, or (3) data communicated in graphs, tables, or diagrams.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator Cause and effect Scale, proportion, and quantity Energy and matter: Flows, cycles, and conservation Stability and change

Essential Learning Experiences:
It is essential that students use data from a variety of sources, including investigations, in order to describe the cause and effect relationship between the pull of gravity and the motion of an object, including the following:

- If things go up on Earth, gravity pulls them down.
- Things fall to Earth because they are pulled by Earth's gravity.
- The pull of gravity is everywhere on Earth.
- The pull of gravity holds things down on Earth all the time.
- No matter whether an object is dropped or thrown, it will always fall toward the Earth's surface unless there is a push or pull stronger than the pull of the Earth's gravity.

NOTE TO TEACHER: The data and observations used by students to construct explanations about the effects of gravity on the motion of an object can come from the data analyzed during their investigations into the effect of pushing and pulling on objects (**2.P.4A.1**) and can be used to develop models to exemplify the effect of pushing and pulling on objects (**2.P.4A.2**).

Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- Students may investigate how fast objects fall

Assessment Guidelines:
The objective of this performance indicator is for students to *construct explanations* of the relationship between the motion of an object and the pull of gravity using observations and data collected; therefore the primary

focus of assessment should be for students to collect data from observations and measurements during investigations and use that data to describe the cause and effect relationship between the pull of gravity and motion of an object. This can include, but is not limited to:

- Collecting data from

Additionally, students should engage in multiple Science and Engineering Practices (SEPs) when interacting with the content outlines in this performance indicator. Further information for the SEPs can be found at this link.

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Learning Connections	**Future Learning Connections (3-5):** **5.P.5A.1** Use mathematical and computational thinking to describe and predict the motion of an object (including position, direction, and speed). **5.P.5A.2** Develop and use models to explain how the amount or type of force (contact and noncontact) affects the motion of an object. **5.P.5A.3** Plan and conduct controlled scientific investigations to test the effects of balanced and unbalanced forces on the rate and direction of motion of objects. **5.P.5A.4** Analyze and interpret data to describe how a change of force, a change in mass, or friction affects the motion of an object.

2.P.4A.4 Conduct structured investigations to answer questions about the relationship between friction and the motion of objects.

Standard 2.P.4 The student will demonstrate an understanding of the effects of pushes, pulls, and friction on the motion of objects.	
2.P.4A. Conceptual Understanding: An object that is not moving will only move if it is pushed or pulled. Pushes and pulls can vary in strength and direction and can affect the motion of an object. Gravity is a pull that makes objects fall to the ground. Friction is produced when two objects come in contact with each other and can be reduced if needed.	
Performance Indicator	**2.P.4A.4:** Conduct structured investigations to answer questions about the relationship between friction and the motion of objects.
Science and Engineering Practice	**2.S.1A.3:** With teacher guidance, conduct structured investigations to answer scientific questions, test predictions and develop explanations: (1) predict possible outcomes, (2) identify materials and follow procedures, (3) use appropriate tools or instruments to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. Use appropriate safety procedures.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator Cause and effect Scale, proportion, and quantity Energy and matter: Flows, cycles, and conservation Stability and change

Essential Learning Experiences:
It is essential that students conduct structured investigations into the relationship between friction and the motion of objects. This includes:

- Discussing questions related to what is friction, what causes moving objects to slow down, and how different factors affect the way friction acts on a moving object.
- Making predictions about what will happen to moving objects when different factors that affect friction are changed (see below).

It is essential that students analyze and interpret the data from their investigations in order to describe the cause and effect relationship between friction and the motion of objects, including the following concepts:

- Friction is a pull that acts against motion, causing objections in motion to slow down.
- When friction is increased, motion decreases more quickly.
- When friction is reduced, motion decreases more slowly but still decreases.
- The following factors influence the effect of friction:
    - Texture of the surface
        - Rough surfaces tend to create more friction.
        - Smooth surfaces tend to create less friction.
    - Lubrication
        - Lubrication, for example oil or grease, reduces the effects of friction.
        - Without lubrication, moving parts of machines would slow down or stop very quickly.

2.P.4 Physical Science: Exploring Pushes and Pulls

NOTE TO TEACHER: The information students use to develop their models (**2.P.4A.2**) can come from the data analyzed during their investigations into the relationship between friction and the motion of objects. Additionally, the data produced from these investigations can be analyzed in order to describe and compare the effects of different pushes and pulls on the motion of objects (**2.P.4A.1**). Finally, the data from these investigations can be used to help define problems and design solutions related to the effects of friction on the motion of objects (**2.P.4A.5**).

NOTE TO TEACHER: Scientific tools used to measure force include: rulers, measuring tapes, meter sticks.

Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- Students may obtain information about different technologies that are used to reduce friction.
- Students may investigate how friction occurs between solids and solids, solids and liquids, solids and gases, liquids and liquids and liquids and gases.
- Students may investigate how the amount of surface area affects the impact of friction on a moving object under different circumstances

Assessment Guidelines:
The objective of this performance indicator is for students to *conducts structured investigations* to answer questions about the relationship between friction and the motion of objects; therefore the primary focus of assessment should be for students to discuss questions about friction and what makes moving objects slow down, make predictions from their questions, and collect observational data from structured investigations in order to describe the cause and effect relationship between friction and the motion of an object. This can include, but is not limited to:

- Discussing questions and proposing ideas (making predictions) about how friction will cause moving objects to slow down.
- Collecting data from investigations into how friction affects motion.
- Using their data to describe how friction is what causes moving objects to slow down and eventually stop.
- Discussing questions and proposing ideas (making predictions) about how doing different things, such as adding lubrication or changing the texture of a surface, will change the way friction cause moving objects to slow down.
- Collecting data from investigations into how changing different things will change the way friction affects motion.
- Using their data to describe how adding lubrication or changing the texture of a surface will increase or decrease the effects of friction on moving objects.

Additionally, students should engage in multiple Science and Engineering Practices (SEPs) when interacting with the content outlines in this performance indicator. Further information for the SEPs can be found at this link.

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Learning Connections	**Future Learning Connections (3-5):** **5.P.5A.1** Use mathematical and computational thinking to describe and predict the motion of an object (including position, direction, and speed).

	5.P.5A.2 Develop and use models to explain how the amount or type of force (contact and noncontact) affects the motion of an object. **5.P.5A.3** Plan and conduct controlled scientific investigations to test the effects of balanced and unbalanced forces on the rate and direction of motion of objects. **5.P.5A.4** Analyze and interpret data to describe how a change of force, a change in mass, or friction affects the motion of an object. **5.P.5A.5** Design and test possible devices or solutions that reduce the effects of friction on the motion of an object.

2.P.4A.5 Define problems related to the effects of friction and design possible solutions to reduce the effects on the motion of an object.

Standard 2.P.4 The student will demonstrate an understanding of the effects of pushes, pulls, and friction on the motion of objects.	
2.P.4A. Conceptual Understanding: An object that is not moving will only move if it is pushed or pulled. Pushes and pulls can vary in strength and direction and can affect the motion of an object. Gravity is a pull that makes objects fall to the ground. Friction is produced when two objects come in contact with each other and can be reduced if needed.	
Performance Indicator	**2. P.4A.5:** Define problems related to the effects of friction and design possible solutions to reduce the effects on the motion of an object.
Science and Engineering Practice	**2.S.1B.1:** Construct devices or design solutions to solve specific problems or needs: (1) ask questions to identify problems or needs, (2) ask questions about the criteria and constraints of the devices or solutions, (3) generate and communicate ideas for possible devices or solutions, (4) build and test devices or solutions, (5) determine if the devices or solutions solved the problem, and (6) communicate the results.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator Cause and effect Scale, proportion, and quantity Energy and matter: Flows, cycles, and conservation Stability and change

Essential Learning Experiences:
It is essential that students obtain information from different sources, including investigations, observations, measurements, informational texts, videos, to identify and describe problems related to the effects of friction on the motion of objects, specifically problems where you would want to reduce friction.

It is essential that students engage in the design process to design and test different solutions to solving different problems about the effects of friction on moving objects, including the following steps:

- Asking questions about the nature of the problems related to friction and motion. Information related to friction might include the following:
    - Friction is a pull that acts against motion, causing objections in motion to slow down.
    - When friction is increased, motion decreases more quickly.
    - When friction is reduced, motion decreases more slowly but still decreases.
- Designing devices or devising solutions to these problems. Solutions might include the following:
    - Texture of the surface
        - Rough surfaces tend to create more friction.
        - Smooth surfaces tend to create less friction.
    - Lubrication
        - Lubrication, for example oil or grease, reduces the effects of friction.
        - Without lubrication, moving parts of machines would slow down or stop very quickly.
- Testing their devices or solutions in order to collect data related to reducing the effects of friction on moving objects.

- Analyzing and interpreting their data to determine if their solutions are successful based on reducing the effects of friction on moving objects.
- Using their data to refine and retest their designs (if necessary).
- Communicating their solutions.

NOTE TO TEACHER: The data from student investigations into the relationship between friction and the motion of objects (**2.P.4A.4**) can be used to help define problems and design solutions related to the effects of friction on the motion of objects.

Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- Students may obtain information about different technologies that are used to reduce friction.
- Students may design and test solution to problems related to how friction occurs between solids and solids, solids and liquids, solids and gases, liquids and liquids and liquids and gases.
- Students may design and test solutions based on how the amount of surface area affects the impact of friction on a moving object under different circumstances.
- Students may define problems related to the need to increase the effects of friction and design solutions that increase the effects of friction instead of decreasing them.

Assessment Guidelines:
The objective of this performance indicator is for students to *define problems* related to the effects of friction and *design solutions* that reduce the effects on the motion of an object; therefore the primary focus of assessment should be for students to use information about different situations involving friction and motion and define the problems related to the need to reduce the effects of friction on moving objects. Students should also design and, if possible, test their solutions based on how effectively they are able to reduce the effects of friction on the speed of a moving object. This can include, but is not limited to:

- Obtaining information about different scenarios related to motion and friction and identifying and describing the problems that need to be overcome in order to effectively reduce friction.
- Using information about the problems they have defined to design and test different solutions to solve the problems of reducing friction.
- Analyzing the interpreting data from their design tests in order to evaluate how effective their solutions were at reducing the effects of friction.
- Where appropriate, redesigning and retesting their solutions.
- Communicating their solutions, including why they were successful at reducing friction.

Additionally, students should engage in multiple Science and Engineering Practices (SEPs) when interacting with the content outlines in this performance indicator. Further information for the SEPs can be found at this link.

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Learning Connections	**Future Learning Connections (3-5):** **5.P.5A.1** Use mathematical and computational thinking to describe and predict the motion of an object (including position, direction, and speed). **5.P.5A.2** Develop and use models to explain how the amount or type of force (contact and noncontact) affects the motion of an object.

	5.P.5A.3 Plan and conduct controlled scientific investigations to test the effects of balanced and unbalanced forces on the rate and direction of motion of objects. **5.P.5A.4** Analyze and interpret data to describe how a change of force, a change in mass, or friction affects the motion of an object. **5.P.5A.5** Design and test possible devices or solutions that reduce the effects of friction on the motion of an object.