

## Science Grade 5, Quarter 2, Unit 2.1

# Forces and Motion

### Overview

**Number of instructional days:** 18 (1 day = 45 minutes)

#### Content to be learned

- Recognize that a force can be a push or a pull.
- Explain that a force can cause changes in speed.
- Explain that a force can cause changes in direction of motion.
- Show that electric currents and magnets can exert forces on each other.
- Investigate how vibrations in materials set up wavelike disturbances that spread away from the source.

#### Science processes to be integrated

- Experiment, predict, and observe how forces interact with objects within systems.
- Demonstrate and explain the effect of force on objects.

#### Essential questions

- Give a real-life example of a force applied to an object. How could the changes in the object's motion be described and explained?
- How do electric currents and magnets exert forces on each other?
- What effects can be observed when materials vibrate?

## Written Curriculum

### Grade-Span Expectations

#### PS 3 - The motion of an object is affected by forces.

##### **PS3 (5-8) INQ+ POC –8**

*Use data to determine or predict the overall (net effect of multiple forces (e.g., friction, gravitational, magnetic) on the position, speed, and direction of motion of objects.*

**PS3 (5-6)–8 Students demonstrate an understanding of force (e.g., friction, gravitational, magnetic) by...**

**8b** recognizing that a force is a push or a pull.

**8c** explaining that changes in speed or direction of motion are caused by forces.

**8d** showing that electric currents and magnets can exert a force on each other.

##### **PS3 (5-8) SAE+INQ – Local Assessment Only**

*Experiment, observe, or predict how energy might be transferred by means of waves.*

**PS3 (5-6) – LA Students demonstrate an understanding of waves by ...**

**LAA** investigate how vibrations in materials (e.g. pebble in a pond, jump rope, slinky) set up wavelike disturbances that spread away from the source.

### Clarifying the Standards

#### *Prior Learning*

Students in grades K–4 learned how pushing and pulling moves objects. They predicted the direction and described the motion of objects of different weights, shapes, or sizes, when a force was applied. Students described the change in position relative to other objects or background, and investigated and described that different amounts of force can change the direction and/or speed of an object in motion. Students conducted experiments to demonstrate that all objects fall to the earth unless something holds them up.

#### *Current Learning*

Students in grade 5 recognize that a force is a push or pull, and explain that forces cause changes in the speed or direction of motion. Although the standards indicate that recognizing that a force is a push or pull is a new concept, students have investigated the effects of pushes and pulls since kindergarten. Therefore, this concept can be taught at the drill-and-practice level of instruction. Students also show that electric currents and magnets can exert a force on each other, and they investigate how vibrations in materials set up wavelike disturbances that spread away from the source. These concepts have not been addressed in prior grade levels, and should be taught at the developmental level of instruction.

All concepts in this unit of study should be taught from a systems perspective. Students should understand that every system includes structures and processes that interact. For example, when students set up a ramp and ball system, the structures (ramp, ball, floor, or other surface) and processes (the pull of gravity, the resistance force of friction) interact to cause changes in the position and motion of the ball.

In this unit, students should conduct a variety of activities in which they observe that one or more forces (e.g., pushes and pulls, friction, gravity, or magnetism) can affect the speed and direction of an object. Students should design and conduct experiments in order to predict, observe, and explain the effects of these forces on an object's motion. When designing experiments, students should also be asked to select and change a single variable while controlling others in an experiment. Students can create an electromagnet to show the relationship between electricity and magnetism. Then compasses can be set up around the closed circuit in order to show that an electric current can produce a magnetic force. Finally, students will investigate, through demonstrations or activities, how vibrations in materials set-up wavelike disturbances that spread away from the source. Students can drop marbles into a tray of sand from various heights, or touch a vibrating tuning fork to the surface of water in a container.

Teachers should keep in mind that students at this grade level are more capable of collecting quantitative data but should continue to collect and record qualitative data, as well. Determining the speed of fast things and slow things can present a challenge; therefore students should focus on describing changes in speed qualitatively.

### *Future Learning*

In grade 6, students will use data to determine and predict the net effect of multiple forces on an object's position, speed, and direction of motion. They will use data from experimentation and student-generated graphs to compare relative speed of objects.

In grades 7–8, students will measure distance and time for a moving object and use those values and the relationship  $s = d/t$  to calculate speed and graphically represent the data. They also use the equation to solve for any unknown, given the values for the other two variables. Students make and test predictions on how unbalanced forces acting on objects change the speed or direction of motion, or both. They differentiate between mass and weight, and they describe or graphically represent that the acceleration of an object is proportional to the force on the object and inversely proportional to the object's mass. Students differentiate between electromagnetic and mechanical waves. They experiment with light from the sun to observe that it is made up of a mixture of many different colors of light, and they represent in words, diagrams, or other models the visible spectrum as a part of the electromagnetic spectrum, composed of all colors of light.

### **Additional Findings**

Students in grades 3–5 continue to describe motion, and they can be more experimental and more quantitative as their measurement skills sharpen. Determining the speed of fast things and slow things can present a challenge to which students will readily respond. They also can work out for themselves some of the general relationships between force and change of motion and internalize the notion of force as a push or pull of one thing on another. By the end of 5th grade, students should know that changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion will be, and the more massive an object is, the less effect a given force will have (*Benchmarks for Science Literacy*, p. 89).

In grades 5–8, the study of motion and the forces causing motion provide concrete experiences on which a more comprehensive understanding of force can be based in grades 9–12. By using simple objects, such as rolling balls and mechanical toys, students can move from qualitative to quantitative descriptions of moving objects and begin to describe the forces acting on the objects. Students' everyday experience is that friction causes all moving objects to slow down and stop. Through experiences in which friction is reduced, students can begin to see that a moving object with no friction would continue to move indefinitely; however, most students believe that the force is still acting if the object is moving or that it is "used up" if the motion stops. Students also think that friction, not inertia, is the principle reason objects

remain at rest or require a force to move. Students in grades 5–8 associate force with motion and have difficulty understanding balanced forces in equilibrium, especially if the force is associated with static, inanimate objects, such as a book resting on the desk (*National Science Education Standards*, pp. 149, 154).

Students tend to think of force as a property of an object (“an object has force,” or “force is within an object”) rather than as a relation between objects. In addition, students tend to distinguish between active objects and those that support, block, or otherwise act passively. Students tend to call the active actions “force,” but do not consider passive actions as “forces.” Students believe constant speed needs some cause in order to be sustained. In addition, students believe that the amount of motion is proportional to the amount of force; that if a body is not moving, there is no force acting on it; and that if a body is moving there is a force acting on it in the direction of the motion. Students also believe that objects resist acceleration from the state of rest because of friction—that is, they confound inertia with friction (*Benchmarks for Science Literacy*, p. 339).

Students have difficulty appreciating that all interactions involve equal forces acting in opposite directions on separate, interacting bodies. Instead students believe that “active” objects (like hands) can exert forces whereas “passive” objects (like tables) cannot. Alternatively, students may believe that the object with more of some obvious property will exert a greater force (*Benchmarks*, p. 339).

## Notes About Resources and Materials

From *Houghton-Mifflin Discovery Works Science*, Grade 4

Activity: Picture a Magnet’s Force, D18

Activity: Magnetic Source, D57

From *Houghton-Mifflin Discovery Works Science*, Grade 5

Activity: Free Falling, (pp. B76–77) (Students focus on the behavior of free-falling objects and should relate the feeling of weightlessness.)

Activity: Bounce or Not to Bounce C42–43

Activity: Roller Coaster Energy C44–45

This website provides worksheet, lessons, animations, videos concerning the topic of force and motion  
<http://www.brainpop.com>.

## Grade 5 Science, Quarter 2, Unit 2.2

# Space Science

### Overview

**Number of instructional days:** 18 (1 day = 45 minutes)

#### Content to be learned

- Use data to identify and compare the size, location, and distance of planets in the solar system.
- Use data to identify and compare the orbits of planets and paths of meteors.
- Use data to compare and contrast composition, atmosphere and surface features of objects in our solar system.
- Describe the apparent motion and position of objects (constellations and planets) in the sky.
- Explain how night and day are the result of the regular and predictable motion of the earth.
- Explain how a year is the result of the regular and predictable motion of the earth around the sun.

#### Processes to be used

- Collect, record, and analyze data to identify and compare the size, location, distance and movement of objects.
- Collect, record, and analyze data to compare and contrast the characteristics of objects.
- Create and use models to understand and explain the relationships within a system.
- Use models to observe and explain regular and predictable changes in motion over time.

#### Essential questions

- How do the size, location, and distances among planets in the solar system compare?
- How do the paths of planets and meteors compare?
- How can the general characteristics, such as the composition, atmosphere, and surface features, of objects in our solar system be described?
- What cycles of change are caused by the predictable motion of the earth?

## Written Curriculum

### Grade Span Expectations

**ESS2 - The earth is part of a solar system, made up of distinct parts that have temporal and spatial interrelationships.**

***ESS2 (5-8) MAS –6***

*Compare and contrast planets based on data provided about size, composition, location, orbital movement, atmosphere, or surface features (includes moons).*

**ESS2 (5-6)-6 Students demonstrate an understanding of characteristics of the solar system by ...**

**6a** identifying and comparing the size, location, distances, and movement (e.g. orbit of planets, path of meteors) of the objects in our solar system.

**6b** comparing the composition, atmosphere, and surface features of objects in our solar system.

**ESS3 - The origin and evolution of galaxies and the universe demonstrate fundamental principles of physical science across vast distances and time**

***No further targets for EK ESS3 at the 5-8 Grade Span***

*The GSEs listed below are assessed at the local level only*

**ESS3 (5-6)–9 Students demonstrate an understanding of the structure of the universe by ...**

**9a** describing the apparent motion/position of the objects in the sky. (e.g. constellations, planets).

**ESS2 – [See above]**

***ESS2 (5-8) SAE+ POC –8***

*Explain temporal or positional relationships between or among the Earth, sun, and moon (e.g., night/day, seasons, year, tides) or how gravitational force affects objects in the solar system (e.g., moons, tides, orbits, satellites).*

**ESS2 (7-8)–8 Students demonstrate an understanding of temporal or positional relationships between or among the Earth, sun, and moon by ...**

**8b** explaining night/day, seasons, years, and tides as a result of the regular and predictable motion of the Earth, sun, and moon.

### Clarifying the Standards

*Prior Learning*

In grades K–2, students demonstrated an understanding of temporal or positional relationships between the sun, earth, and moon by observing that the sun can be seen only in the daytime while the moon can be seen sometimes at night and sometimes during the day. They observed that the sun and moon appear to move slowly across the sky, and that the moon looks slightly different from day to day. Students also

observed that there are more stars in the sky than can easily be counted, but they are not scattered evenly and not all the same in brightness.

In grades 3–4, students observed that the sun, moon, and stars appear to move slowly across the sky, and observed that the moon looks slightly different from day to day, but looks the same again in about four weeks. They recognized that the rotation of the earth on its axis every 24 hours produces the day/night cycle, and that it takes approximately 365 days for the earth to orbit the sun. Students recognized that the sun is the center of our solar system, that the earth is one of several planets that orbit the sun, and that the moon orbits the earth. Students also recognized that throughout history, people have identified patterns of stars that we call constellations.

### *Current Learning*

At the developmental level of instruction, students will use data to identify and compare the size, location, and distance of planets in the solar system, and to identify and compare the orbits of planets and paths of meteors. Students will also use data to compare and contrast composition, atmosphere and surface features of objects in our solar system, and explain how a year is the result of the regular and predictable motion of the earth around the sun.

At the reinforcement level of instruction, students describe the apparent motion and position of objects (constellations and planets) in the sky, and they explain how night and day are the result of the regular and predictable motion of the earth.

Many of the concepts are abstract, and not directly observable, therefore collecting and using data, and creating and observing models are important process skills in this unit of study. Students will use data to identify, compare, and contrast various features of each planet in our solar system by conducting research on the general characteristics of various planets within our solar system. Students will be able to describe the apparent motion of the constellations and planets in the sky by using student-made as well as purchased models, such as a planisphere. By doing activities to model the earth's rotation on its axis and its revolution around the sun, students can explain that the night/day cycle and yearly cycle are the result of the regular and predictable motion of the earth.

Students have been exposed to these vocabulary words before, however, following the unit, students should understand the following terms: *axis, rotation, revolution, constellation, star, planet, meteor, and comet.*

In previous grades, students learned that the patterns of stars are called constellations. In fifth grade, they learn that, like the moon, sun, and other stars, the constellations, appear to move across the sky. In previous grades students learned that the earth's revolution around the sun causes the 365-day year, and that the earth rotates on its axis every 24 hours, causing the day/night cycle. In fifth grade, students recognize that these motions are regular and predictable.

### *Future Learning*

In grade 6, students will use models to recreate the phases of the moon and to describe the relative motion and position of the earth, sun, and moon. They will explain seasons and tides as a result of the regular, predictable motion of the earth, sun, and moon, and they will define the earth's gravity as a force that pulls any object on or near the earth toward its center without touching it. Students will demonstrate an understanding of the structure of the universe by identifying the sun as a medium-sized star located near the edge of a disk-shaped galaxy of stars.

In grades 7–8, students will identify major discoveries from different scientists and cultures and will describe how these discoveries have contributed to our understanding of the solar system. They will use

or create a model of the earth, sun, and moon system to show rotation and revolution, and to recreate the phases of the moon. Students will explain night/day, seasons, year, and tides as a result of the regular and predictable motion of the earth, sun, and moon. They will describe the relationship between mass and the gravitational force between objects, and the relationship between distance and the gravitational force between objects. Students will explain that the sun's gravitational pull holds the earth and other planets in their orbits, just as the planet's gravitational pull keeps their moons in orbit. They will also describe the universe as containing many billions of galaxies, and each galaxy as containing many billions of stars.

### **Additional Research Findings**

In grades 3–5, students should begin to develop an inventory of the variety of things in the universe. Planets can be shown to be different from stars in two essential ways—their appearance and their motion. When a modest telescope or pair of binoculars is used instead of the naked eyes, stars only look brighter—and more of them can be seen. The brighter planets, however, clearly are disks (not very large disks, except in good-sized telescopes, but impressive enough after seeing a lot of stars). The fixed patterns of stars should be made more explicit, although learning the constellation names is not important in itself. When students know that the star patterns stay the same as they move across the sky (and gradually shift with the seasons), they can then observe that the planets change their position against the pattern of stars (*Benchmarks for Science Literacy*, p. 62).

Students can also learn some of the earth's relation to the sun, moon, and other planets. Films, computer simulations, planetariums, and telescopic observations will help. It is essential that all students, sometimes working in small groups, make physical models and explain what the models show. At the same time, students can begin learning about scale (counting, comparative distances, volumes, times, etc.) in readily understood activities and readings that will interest students. However, scale factors larger than thousands, and even the idea of ratios, may be difficult before students reach early adolescence (*Benchmarks*, p. 67).

An important point to be made along the way is that we cannot determine how the solar system is put together just by looking at it. Diagrams show what the solar system would look like if people could see it from far away (a feat that cannot be accomplished). Telescopes and other instruments do provide information, but a model is needed to make sense out of the information. In making diagrams to show the relative sizes of the planets and the distances of the planets from the sun, students may try to combine them using a single scale—and quickly become frustrated. Perhaps this frustration can lead to a discussion of the general limits of graphic methods (including models and photographs) for showing reality. In any case, at this stage a rough picture of the organization of the solar system is enough (*Benchmarks*, p. 67).

By the end of grade 5, students should know that the patterns of stars in the sky stay the same, although they appear to move across the sky nightly, and different stars can be seen in different seasons. Stars are like the sun, some being smaller and some larger, but so far away that they look like points of light. Planets change their positions against the background of stars, the earth is one of several planets that orbit the sun, and the moon orbits the earth (*Benchmarks*, p. 63). Like all planets and stars, the earth is approximately spherical in shape. The rotation of the earth on its axis every 24 hours produces the day/night cycle. To people on earth, this turning of the planet makes it seem as though the sun, moon, planets, and stars are orbiting the earth once a day (*Benchmarks*, p. 68).

The ideas that “the sun is a star” and that “the earth orbits the sun” appear counter-intuitive to elementary-school students. These ideas are not likely to be believed or even understood in elementary grades. Whether it is possible for elementary students to understand these concepts, even with good teaching, needs further investigation (*Benchmarks*, p. 335).

Student ideas about the shape of the earth are closely related to their ideas about gravity and the direction of “down.” They cannot accept that gravity is center-directed if they do not know the earth is spherical. Nor can they believe in a spherical earth without some knowledge of gravity to account for why people on the “bottom” do not fall off. Research suggests teaching the concepts of spherical earth, space, and gravity in close connection to each other. Some research indicates that students can understand basic concepts of the shape of the earth and gravity by 5th grade if the students’ ideas are directly discussed and corrected in the classroom (*Benchmarks*, p. 335).

Explanations of the day/night cycle, phases of the moon, and seasons are very challenging for students. To understand these phenomena, students should first master the idea of a spherical earth, itself a challenging task. Similarly, students must understand the concept of light reflection and how the moon gets its light from the sun, before they can understand the phases of the moon. Finally, students may not be able to understand explanations of any of these phenomena before they reasonably understand the relative size, motion, and distance of and among the sun, moon, and earth (*Benchmarks*, pp. 335, 336).

## Notes About Resources and Materials

From *Houghton-Mifflin Discovery Works*, Grade 5:

- Activity: Making a Planisphere B8–9  
*\*Omit pages B10–11 about star patterns*
- What the Stars Appear to Move, B12–14 (Explains motion of constellations and planets in the sky. It also explains night/day and years. It touches upon seasons, which will be covered in sixth grade.)  
*\*Omit B15–23*
- Comets and Meteors, B24–26 (Use as background information to discuss the path of a meteor.)
- Activity: When to Go Planet Watching, B30–31
- Activity: Comparing Planetary Distances, B32–33
- Reference pages B34–35 (For planet distance from the sun and period of revolution, however, use other sources to find more current information, such as [www.kidsastronomy.com](http://www.kidsastronomy.com).)  
*\*Omit pages B36–41*
- Activity, Measuring Planet Sizes, pages B42–43
- Reference pages B44–B50 (For information on characteristics of planets, such as temperature, composition, and atmosphere. More current information can and should be found online.)  
*\*Omit chapters 3 and 4.*

### Websites

- Kidsastronomy.com  
<http://www.kidsastronomy.com/>