

The Benchmarks for Science Education

1. Everything on or anywhere near the earth is pulled toward the earth's center by gravitational force.
2. Every object exerts gravitational force on every other object. The force depends on how much mass the objects have and on how far apart they are. The force is hard to detect unless at least one of the objects has a lot of mass.
3. The sun's gravitational pull holds the earth and other planets in their orbits, just as the planets' gravitational pull keeps their moons in orbit around them.
4. Changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion will be. The more massive an object is, the less effect a given force will have.
5. An unbalanced force acting on an object changes its speed or direction of motion, or both. If the force acts toward a single center, the object's path may curve into an orbit around the center.
6. Whenever one thing exerts a force on another, an equal amount of force is exerted back on it.

Glossary

Air Resistance - is a force caused by air that tends to oppose or retard motion of an object moving through the air.

Center of Gravity - is the point in or near a body at which the gravitational potential energy of the body is equal to that of a single particle of the same mass located at that point and through which the resultant of the gravitational forces on the component particles of the body acts.

Force - is the capacity to do work or cause physical change that can produce an acceleration of a body in the direction of its application.

Gravity - is a property of matter where the natural force of attraction exerted by a body, such as Earth, upon objects at or near its surface, tending to draw them toward the center of the body. Gravity is the natural force of attraction between any two massive bodies, which is directly proportional to the product of their

masses and inversely proportional to the square of the distance between them.

Inertia - is the quality of matter that causes it to resist change of motion in direction or speed.

Matter - is something that occupies space and can be perceived by one or more senses; a physical body, a physical substance, or the universe as a whole.

Mass - is a measure of the quantity of matter that a body or an object contains. The mass of the body is not dependent on gravity and therefore is different from but proportional to its weight.

Newton's First Law - was formulated by English scientist Sir Isaac Newton, states that an object at rest tends to remain at rest, and an object in motion tends to continue in motion in a straight line unless acted upon by an outside force.

Newton, Sir Isaac, 1642-1727 - is an English mathematician and scientist who formulated the theories of universal gravitation, terrestrial mechanics, and color. The sight of a falling apple supposedly inspired his treatise on gravitation.

Pivot Point - the point about which a body can rotate.

Weight - is the force with which a body is attracted to Earth or another celestial body, equal to the product of the object's mass and the acceleration of gravity.

Trajectory Motion - is the path of a projectile or other moving body through space that may be the result of two or more motions with different directions.

Review and Extension Questions

1. Describe evidence that you believe supports the theory that gravity is a force. What evidence is used by science to support the theory that gravity is a force?
2. What evidence do we have that supports the theory that gravitation is a universal force that each mass exerts on any other mass?
3. Describe evidence that you believe supports the theory that gravitational force depends on how much mass the objects.
4. Describe evidence that you believe supports the theory that gravitational force depends on how far apart objects are.
5. Describe evidence that you believe supports the theory that the greater the force is, the greater the change in motion will be.
6. Describe evidence that you believe supports the theory that the more massive an object is, the less effect a given force will have.
7. Explain how an unbalanced force acting on an object changes its speed or direction of motion, or both.
8. Describe the laws of motion in your own words and how are they used to calculate the effects of forces on the motion of objects.
9. Describe an example of how when one object exerts force on another can result in a force equal in magnitude and opposite in direction is exerted on the first object?

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Science Fundamentals

Gravity Is Attractive

What Is Gravity?

KF524

TEACHER'S GUIDE

Video Purpose

This video is designed to develop students' understanding of the concept of gravity as a property of matter and gravitational force by using common examples that motivate students to learn more. This video may be used to introduce new concepts, to support learning activities, or to assist with summarizing concepts.

Force is usually treated as the originator of motion while an explanation of force is often postponed, but the contact force between a bat and a ball has an entirely different origin than that between the earth and the moon. Investigating gravitational force will help students broaden their understanding of this fundamental property of matter and force of nature. Students have difficulty understanding how weak gravity is compared to electric and magnetic forces. Gravity becomes perceptible only when very large accumulations of matter figure, such as that of a student and the entire earth. To students, gravitational forces seem strong compared to the trivial electric forces on dry hair charged by combing. Students can be led to see quite the opposite: The whole earth is required to pull a hair down by gravity, while only a small amount of charge is needed to force it up electrically against gravity.

Video Activities:

1. **Uphill roller** - an object appears to defy gravity and roll up hill is an introductory discrepant (counterintuitive) event designed to arouse interest by conflicting with expectations and understanding and to stimulate interest in other possible explanations.
2. **Ball throwing** - affirms Newton’s first law and offers gravity as an explanation of the arcing path of a thrown ball.
3. **Plop** - provides another example of inertia when the vertical support of a stack of books that are moving horizontally is quickly removed and the books continue their horizontal speed while they begin falling.
4. **Same Speed** - introduces the concept that the force of gravity causes a constant accelerating force on all objects and that air resistance is a hidden force that causes the common conclusion that “heavier things fall faster.”
5. **Satellite Crash** - provides an example of how gravitational forces in the solar system keep planets in orbit around the sun.
6. **The Unreachable Cup** - introduces the concept of center of gravity.
7. **Downward** - shows how to find the center of gravity of an irregular object.

Student Naïve Conceptions

As students grow up they have many experiences for which they form explanations based on a variety of anchoring experiences, such as, jumping and falling, riding swings and bicycles. While these explanations make sense for the student, they may conflict with the results of science investigations, and they are sometimes called naïve conceptions. Student’s naïve conceptions should not be treated as wrong as such but as conceptions based on insufficient analysis of their experiences. The activities in this video are designed to help students recognize their explanations and develop a more analytic view. Students in middle school are usually at different points

in their conceptualization of matter and its properties. Although some students may see weight as a fundamental property of all matter, many students still appear to think of weight simply as “felt weight”—something whose weight they can’t feel is considered to have no weight at all. Some students may have difficulty understanding gravity as a force. They see the phenomenon of a falling body as “natural” without a need for additional explanation or they ascribe to it an internal effort of the object that is falling. When students view weight as a force, they sometimes think it is the air that exerts this force. These naïve conceptions about the causes of gravity can persist if they are not appropriately addressed.

Telling or showing students the explanations that science uses may not change their beliefs. There are several strategies that can be used to facilitate a deeper understanding. Students need to become aware of their own preconceptions about a concept and expose these beliefs by sharing their ideas with other students in small groups in an uncritical environment to help them begin a deeper analysis of their experiences. They should be encouraged to make predictions based on their conceptions before activities begin. This will help students to begin to confront and test their beliefs and provide motivation for looking for other plausible conceptions. Students need to have time to work toward resolving conflicts between their ideas and their observations, thereby accommodating new concepts. Students need opportunities to extend new concepts by trying to make connections between the new concept and other situations in their daily lives. Students should also be encouraged to go beyond these initial steps by choosing additional questions or problems related to the concept to expand their understanding. These strategies are used to organize suggested activities into the following groups: exposing beliefs, committing to outcomes, confronting beliefs, accommodating concepts, extending concepts, and expanding inquiry..

Sample Support Activities

Exposing Beliefs

Use an activity like “Think, Pair, and Share” to have students begin thinking about their explanations of topics, such as, why things fall, and then share their ideas with a partner. Two pairs can then be combined to share their views and each group of four can have a one person share the different explanations. Moving from small to whole group in a secure and uncritical environment gives students an opportunity to see that others are also uncertain and bring a variety of views to their experience.

Committing to Outcomes

Use the different activities in the video as opportunities to have students predict what they think will happen, for example, the introductory “Uphill Roller” activity. Simply stop the video just before the professor releases the funnels and have students share with a partner or write their predictions of what will happen. It is important that they make a verifiable commitment so that they can begin to address their beliefs.

Confronting Beliefs

Have students test their ideas by recreating one of the activities on the video or related activities that they found interesting. For example, pairs of students could construct the “Uphill roller” or other video activities and describe their observations and explanations. Working in small groups, students could then debate their explanations, conduct interviews, and check written materials before presenting their results. This is an opportunity for students to confront their beliefs.

Accommodating Concepts

Students need to begin to question their observations and their discussions to help them process information and begin to make sense of the explanations behind the observations. During this time, students begin to resolve the conflict that may exist between beliefs and observations. Class presentations of observations of activities and explanations along with carefully posed teacher questions

and follow-up small group discussions will assist with the process of accommodating new concepts.

Extending Concepts

Asking students to give examples of where they have seen the concept discussed or demonstrated or giving examples of how they think the concept is connected to other situations will help students extend their understanding of the concept.

Expanding Inquiry

To encourage students to continue thinking about the concept, opportunities should be provided that invigorates them to investigate additional questions and problems that interest them.

Correlations to National Standards

The video activities and content address the following National Science Education Standards or The Benchmarks for Science Education *

National Science Education Standards

1. Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion in the solar system. Gravity alone holds us to the earth’s surface and explains the phenomena of the tides.
2. Gravitation is a universal force that each mass exerts on any other mass. The strength of the gravitational attractive force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.
3. Objects change their motion only when a net force is applied.
4. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship $F = ma$, which is independent of the nature of the force.
5. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.