

Elements of Physics

Motion, Force, and Gravity

Teacher's Guide

Grade Level: 9–12

Curriculum Focus: Physical Science

Lesson Duration: Three class periods

Program Description

Examine Isaac Newton's laws of motion, the four fundamental forces of the universe, and how Einstein revolutionized the way we understand gravity.

Lesson Plan Summary

Students research issues related to space travel and consider whether space exploration is necessary. Based on their findings, they imagine that they serve on an advisory group to NASA and write a research paper assessing whether they think human space travel should continue. Students share their ideas with a partner, who offers feedback.

Onscreen Questions

- How does physics affect your life?
- How are math and physics related?
- How has physics allowed for a safe reentry from space?
- How can the *Colombia* tragedy help NASA prevent similar disasters?

Lesson Plan

Student Objectives

- Research issues related to human space travel.
- Consider the necessity of space exploration.
- Write a well-researched paper about continuing the space shuttle program.

Materials

- *Elements of Physics: Motion, Force, and Gravity* video
- Computer with Internet access
- Print and Web resources about the space program

Procedures

1. Begin the lesson by asking students to write their opinions about the space program. They may consider whether the space program yields important scientific data or is a waste of money that poses a threat to astronauts. Have students put their papers away until the end of the lesson.
2. Give students time in class to watch the program *Elements of Physics: Motion, Force, and Gravity*. Have them pay close attention to the segment "From Space to Earth," which discusses the space shuttle program and the explosion of the *Challenger* space shuttle.
3. After watching the program, ask students to imagine serving on an advisory board to NASA. They have been asked to prepare a well-researched paper with their recommendations about continuing the space shuttle program. Questions students should consider while thinking about this issue include the following:
 - Why is reentry into Earth's atmosphere so difficult? (*The space shuttle is in a fast, free fall state as it returns to Earth's atmosphere. The only force working on it is gravity; air resistance does not slow it down. Its intense speed is dangerous, especially when the shuttle first enters the atmosphere.*)
 - Do we have the scientific expertise to safely launch space shuttles and return them to Earth? (*NASA has done it many times, but space travel still poses risks.*)
 - What changes have been made to the space shuttle program since the *Challenger* tragedy? (*Additional checks and balances have been put into place, and launches are postponed if there is any doubt about the safety of the equipment or if the weather is questionable.*)
 - Is human space exploration necessary? Can probes and other devices do the job just as well as people? (*Opinions will vary.*)
4. Give students time in class to work on their papers. Have students use print and Web resources. The Web sites below are a good starting point:

After the *Columbia* Disaster

- <http://www.cnn.com/2003/TECH/space/02/01/shuttle.columbia/>
- <http://www.cnn.com/SPECIALS/2003/shuttle/>
- http://www.aia-aerospace.org/aianews/articles/2003/oped_02_00_03.pdf
- <http://www.fas.org/sgp/crs/space/RS21408.pdf>

Launch of the July 4, 2006, Space Shuttle *Discovery*

- http://www.nasa.gov/mission_pages/shuttle/main/index.html
- <http://abcnews.go.com/Technology/wireStory?id=2155882>
- <http://news.bostonherald.com/localRegional/view.bg?articleid=146948>

Results from the July 26, 2005, Space Shuttle Mission

- http://www.nasa.gov/returntoflight/multimedia/top30_page1.html



- http://www.space.com/missionlaunches/050710_sts114_countdown.html
5. Have students choose a partner to review their finished papers; they will make revisions based on the feedback.
 6. Conclude the lesson by asking students to refer to their original opinions. Has working on this activity changed their opinions? If so, how? Hold a final class discussion focusing on students' thoughts about the future of the space program.

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- **3 points:** Students thoroughly researched issues related to human space travel; carefully considered the necessity of space exploration; and wrote a well-researched paper about continuing the space shuttle program.
- **2 points:** Students researched issues related to human space travel; considered the necessity of space exploration; and wrote a satisfactorily researched about continuing the space shuttle program.
- **1 point:** Students had difficulty or did not research issues related to humans space travel; had difficulty considering the necessity of space exploration; and did not complete or write a paper about continuing the space shuttle program.
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Vocabulary

air resistance

Definition: The upward force on an object in motion that has the effect of reducing the speed at which the object is moving

Context: As an object gains speed, it encounters more air resistance, which is what causes it to slow down.

atmosphere

Definition: The protective layer of gases that surrounds Earth

Context: Once the space shuttle enters Earth's atmosphere, it becomes subject to air resistance as well as gravity.

free fall

Definition: The state in which only gravity is acting on an object in motion

Context: During a free fall, an object accelerates because no other force is acting on it to counteract the effects of gravity.



gravity

Definition: The force that pulls objects downward

Context: In an unbalanced state, the force of gravity causes objects to accelerate at a rate of 9.8 meters per second.

space shuttle

Definition: A reusable vehicle designed to transport crew and equipment into space that can also serve as a base for repairing satellites and other objects in space

Context: Without the space shuttle, the International Space Station would not have the supplies and staff it needs to function.

Academic Standards

National Academy of Sciences

The National Science Education Standards provide guidelines for teaching science as well as a coherent vision of what it means to be scientifically literate for students in grades K–12. To view the standards, visit this Web site:

<http://books.nap.edu/html/nses/html/overview.html#content>.

This lesson plan addresses the following national standards:

- Physical Science: Motions and forces
- Science and Technology: Abilities of technological design; Understandings about science and technology

Mid-continent Research for Education and Learning (McREL)

McREL's Content Knowledge: A Compendium of Standards and Benchmarks for K–12 Education addresses 14 content areas. To view the standards and benchmarks, visit

<http://www.mcrel.org/compendium/browse.asp> .

This lesson plan addresses the following national standards:

- Science: Physical Sciences – Understands forces and motion
 - Technology – Understands the nature and uses of different forms of technology
 - Language Arts: Viewing – Uses viewing skills and strategies to understand and interpret visual media; Writing: Uses the general skills and strategies of the writing process, Gathers and uses information for research purposes; Reading: Uses reading skills and strategies to understand and interpret a variety of informational texts
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DVD Content

This program is available in an interactive DVD format. The following information and activities are specific to the DVD version.

How To Use the DVD

The DVD starting screen has the following options:

Play Video—This plays the video from start to finish. There are no programmed stops, except by using a remote control. With a computer, depending on the particular software player, a pause button is included with the other video controls.

Video Index—Here the video is divided into sections indicated by video thumbnail icons; brief descriptions are noted for each one. Watching all parts in sequence is similar to watching the video from start to finish. To play a particular segment, press Enter on the remote for TV playback; on a computer, click once to highlight a thumbnail and read the accompanying text description and click again to start the video.

Curriculum Units—These are specially edited video segments pulled from sections of the video (see below). These nonlinear segments align with key ideas in the unit of instruction. They include onscreen pre- and post-viewing questions, reproduced below in this Teacher's Guide. Total running times for these segments are noted. To play a particular segment, press Enter on the TV remote or click once on the Curriculum Unit title on a computer.

Standards Link—Selecting this option displays a single screen that lists the national academic standards the video addresses.

Teacher Resources—This screen gives the technical support number and Web site address.

Video Index

I. The Father of Science (4 min.)

Explore important contributions of early scientists in the field of physics and take a closer look at Galileo's observations regarding falling objects.

II. Sir Isaac's Apple (7 min.)

Gravity, and discover why objects on Earth fall to the ground while planets remain in orbit.

III. Einstein's Force (3 min.)

Discover Albert Einstein's theory of relativity and learn the basics behind the complicated idea of a space-time continuum.

IV. From Space to Earth (35 min.)

Learn about the tragic loss of the space shuttle Columbia and its crew and take an inside look at the physics that go into designing a shuttle fit for space flight.



Curriculum Units

1. Galileo's Observations and Equations

Pre-viewing question

Q: Do you think two objects of different amounts will fall at the same speed?

A: Answers will vary.

Post-viewing question

Q: What does Galileo's formula " $v = gt$ " indicate?

A: The formula " $v = gt$ " means change in velocity equals acceleration multiplied by time. Galileo determined that when objects fall, their speed changes at a constant rate. The rate of acceleration, or change in velocity per unit of time is a consistent 9.8 meters per second per second.

2. Newton's Laws of Physics

Pre-viewing question

Q: What might happen if Earth's gravity were reduced?

A: Answers will vary.

Post-viewing question

Q: Describe Newton's three laws of motion.

A: Newton's first law of motion says that an object's natural tendency is to continue what it is doing unless acted on by an outside force. This is the law of inertia.

The second law describes how an object accelerates or changes direction when a force is applied to it, depending on the net force. This law also states that the acceleration from a specific force always moves in the direction of that force and that the larger the mass of an object, the greater the force needed to move it.

The third law says that for every action there is an equal and opposite reaction.

3. Relativity and Space-Time

Pre-viewing question

Q: What do you know about Albert Einstein?

A: Answers will vary.

Post-viewing question

Q: What is the space-time continuum?

A: Einstein put forth the idea of a four-dimensional universe. The three dimensions of space are length, width, and height, and time is the fourth. Einstein said that the mass of an object actually distorts space-time. In his theory, planets orbit around the sun because they are moving through the distortions of space-time that have been created by the mass of the sun.



4. Successful Mission, Tragic Reentry

Pre-viewing question

Q: What is necessary for a successful space shuttle launch?

A: Answers will vary.

Post-viewing question

Q: What was the mission of the space shuttle *Columbia*?

A: The space shuttle's mission was to perform 80 experiments dedicated to physical, life, and space sciences.

5. Operating a Space Shuttle

Pre-viewing question

Q: What skills are required to design and build airplane, automobile, or other vehicle?

A: Answers will vary.

Post-viewing question

Q: What kind of force does it take to push a space shuttle into orbit and keep it there?

A: Nearly four million pounds of rocket fuel are necessary to push the shuttle into orbit so it can reach a speed great enough to counteract the Earth's gravitational pull. To stay in orbit, the shuttle must be traveling about 18,000 miles a year, or roughly five miles every second.

6. Challenges of Leaving Space

Pre-viewing question

Q: What are some purposes and outcomes of space travel?

A: Answers will vary.

Post-viewing question

Q: What might be the most challenging aspect of engineering reentry into Earth's atmosphere?

A: Answers will vary.

7. Thermal Protection

Pre-viewing question

Q: What are some effects of high temperatures on airborne craft?

A: Answers will vary.

Post-viewing question

Q: Describe the function and major aspects of the space shuttle's thermal protection system.

A: Because the space shuttle encounters heat up to 3,000 degrees Fahrenheit during reentry to Earth's atmosphere, it requires a reusable thermal protection system. The system includes more than 20,000 ceramic tiles made of silica fibers that can withstand temperatures of about 2,300 degrees Fahrenheit. The tiles protecting the bottom of the shuttle are coated with a black, glass-based liquid; they radiate heat and keep the heated plasma from sticking to the surface. And to protect the aluminum wings and other sensitive areas, engineers developed nonporous panels

of RCC, or reinforced carbon carbon. T-seals made of RCC and insulation material provide additional thermal protection.

8. Landing a Shuttle

Pre-viewing question

Q: What skills might be required to land an airplane, hot-air balloon, or other airborne vehicle?

A: Answers will vary.

Post-viewing question

Q: Why must a space shuttle maintain a level flight path?

A: If the shuttle's angle of attack is too low, not enough drag is created and the vehicle would hit the runway too fast, overshooting the landing site or crunching its landing gear at touchdown. At too high an angle, the shuttle's weight would slow it down too quickly, its wings would cease to generate lift, and it would fall from the sky well before reaching the runway.