

Gravity in Space

Instructional Objectives

Upon completion of the accompanying activities and the viewing of the instructional video, the students will be able to:

1. explain Einstein's notion of the gravitational field,
2. through analogy of a magnetic field, describe the variation of effect over the gravitational field, and
3. describe the experiment that confirmed Einstein's idea of a gravitational field and astonished scientists.

Synopsis

This program begins with a reminder of the force of gravity. The strength of the tides is shown to students as a force with which they are already familiar. The concept of a thought experiment is introduced and Einstein's famous thought experiments in relativity are presented. With cartoon-like graphics to support them, the underlying concepts of free fall, zero gravity, gravity on earth, and acceleration are developed.

Gravity is described twice pictorially, once with magnetic filings and once with a child on a trampoline. These examples help make the notion of gravity concrete for students.

The "Science Links" segment ends with a summary of how data were gathered that actually supported Einstein's Theory of Relativity. The revelation that gravity can bend light shocked many scientists and is still difficult for many people to comprehend.

The career profile features Ron Felice, a Goddard Space Flight Center Deputy Project Manager. Ron has an engineering background and shows us another approach to science and technology.

Vocabulary

Accelerate - To change velocity, either to speed up, slow down, or change direction. Acceleration is calculated distance divided by time squared; for example, meter/second squared.

Attraction - The capability to cause to draw near or adhere.

Eclipse - The cutting off of all or part of the light of one body by another passing in front of it. Our moon occasionally blocks the sun's light from reaching the earth.



Gravitation - The tendency of matter to attract itself and other matter.

Satellite - A body that revolves about a larger one, for example, a moon of a planet.

Seconds of Arc - There are 360 degrees in a circle. Each degree can be divided into 60 parts called minutes; each minute can be subdivided into 60 parts called seconds. Each of these can be referred to as a second of arc. (Thinking of the hour, minutes, and seconds on a clock is a good way to remember this.)

Simulate - To create a working model that operates or performs as close to the real thing as possible.

Intensity - The measure of effectiveness of a field.

Previewing

Ask the students to describe gravity in their own words. Record these comments on the board.

Ask the students to explain how they can be sure that gravity actually exists.

Discuss why astronauts experience much less gravity when they are orbiting the earth.

Discuss what the students already know about Einstein.

Have a biography of Einstein available in the classroom; it can be quite encouraging to the underachiever.

Ask students to bring in news clippings about the Hubble Space Telescope. Discuss what it has been able to do and what it cannot yet do.

Postviewing

Ask students in pairs or small groups to describe with pictures and words Einstein's two famous thought experiments described in the program.

Have students state why it was so difficult in the early 1900s to gather data to support or discredit Einstein's ideas.

Ask students to tell what they find particularly fascinating about Ron Felice's career and why.

Let students make additional comments on how they think of gravity after watching the program. Record these comments adjacent to their prior comments. Label comments from previewing and postviewing as more like Newton's or Einstein's way of thinking. Discuss the differences in these two points of view.

Active Involvement

Have students working in small groups prepare timelines on flight. The timelines should include landmark airplane flights as well as launching of rockets. The Goddard Space Flight Center in Greenbelt, Maryland is an excellent source for this information. Once the timeline is complete, ask students to describe why Einstein's thought experiments with elevators in space were so revolutionary.

Have the students locate written reports of the measuring of the eclipse in 1919. What kinds of responses were heard to Einstein's claims from scientists around the world?

Have the students research what kind of high school courses are required to go into an engineering field.

Over a period of time, read excerpts from Einstein's biography to the students. Be sure to select one that tells of his childhood stumbling blocks.

Bibliography

For high school readers:

Beiser, Germaine. *The Story of Gravity*. New York: E. P. Dutton & Co., Inc., 1968.

Hodowanac, Gregory. "All About Gravitational Waves? (and a circuit to detect them)." *Audio-Electronics*, vol. 57, p 53 (4), 1986.

"Spacetimequake." *Scientific American*, vol. 252, p. 70 (1), 1985.

Narlikar, Jayant V. *The Lighter Side of Gravity*. San Francisco: J. H. Freeman & Co., 1982.

Thomsen, Dietrick E. "Intimations of Gravity Waves." *Science News* Vol. 131, p. 8(1), 1982.

For middle school readers:

Branley, Franklyn M. *Gravity is a Mystery*. New York: Thomas Y. Crowell Co., 1987.

Kaufman, William J, III. "Listening for the Whisper of Gravity Waves." *Science* 80, vol. 1, p. 64 (6), 1980.

White, Jack R. *The Hidden World of Forces*. New York: Dodd, Mead and Co., Inc., 1987.

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See for Yourself: Experiments/Projects



Free Fall

► MATERIALS:

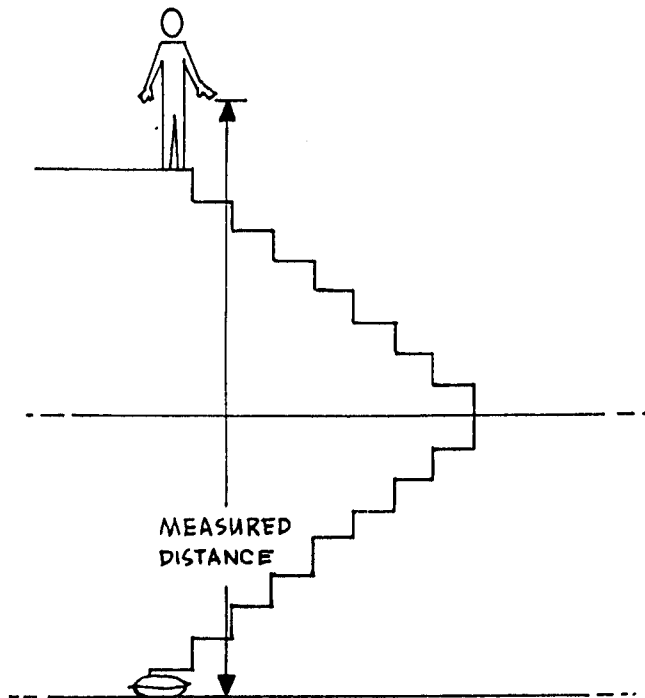
- ball bearing (metal)
- marble, same size as ball bearing
- tape measure or meter stick
- stopwatch
- tray of sand or pillow
- double staircase

► DIRECTIONS:

Students should work in groups of three or more.

Be careful no one is in the way when you do this experiment.

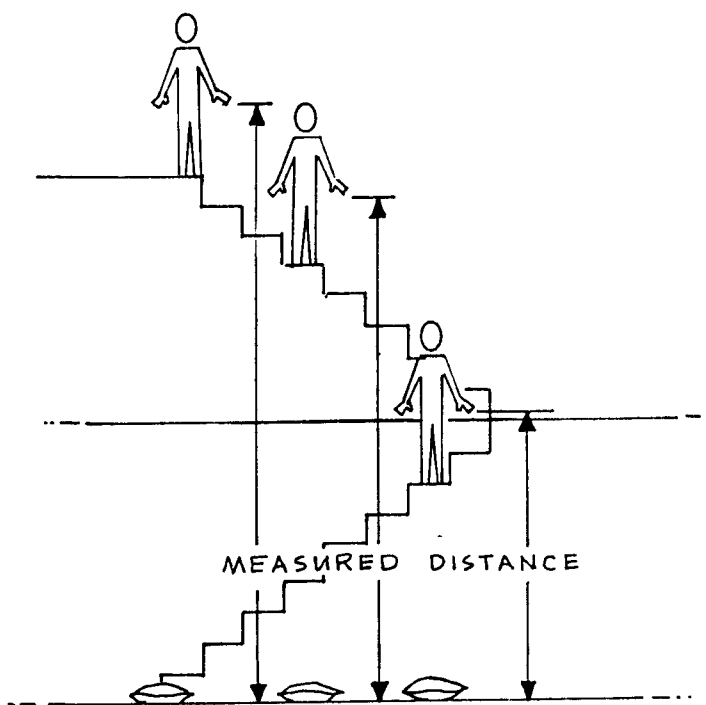
1. To prepare for the experiment, decide on three locations from which the ball bearing will be dropped. Measure the distance the ball will be dropped at each location and record.



2. Start at the highest point (see diagram). Have one of you carry the ball bearing to the first location. The person with the stopwatch on the ground will say ready. The person at the top will release the ball bearing as soon as s/he hears the cue. When the ball strikes the pillow or the sand tray, the third student will *hit* and the stopwatcher stops the watch

immediately. The time is recorded for the first location. Practice this process a few times. When you begin to get pretty consistent numbers on the timing, you are ready to begin recording numbers for the experiment.

3. Release the ball bearing from each location three times, recording each time (see diagram).



4. You need to calculate the mean time for the ball bearing to strike the ground from each location. The mean time is the sum of all the times divided by the

$$\text{MEAN TIME} = (\text{TIME}_1 + \text{TIME}_2 + \text{TIME}_3) / 3$$

number of trials. In this case, the number of trials is three. It is the number of times you released the ball bearing from the same location. Calculate the mean time for the ball bearing to strike the ground for each of the three locations. Record your answers.

5. To calculate the acceleration due to gravity (g) we need to use the measured distance and the mean time squared. Complete a table with the following column headings.

Location	Distance	2 x Distance	Mean Time	(Mean Time) ²
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6. Fill in the table calculating 2 x Distance and mean time squared (mean time x mean time) for each location.

$$\text{ACCELERATION due to gravity (g)} = (2 \times \text{DISTANCE}) / \text{TIME}^2$$

7. Following the equation above, calculate the acceleration due to gravity (g) at each location. Record.
8. What do you notice about these answers?
9. Why do you think this is the case?
10. Repeat steps 2-8 using the marble. Record all responses as done previously.
11. Compare your answers for the acceleration due to gravity for the ball bearing and the marble. What did you find out?
12. If you wanted to carry this experience further, what would you do? If materials are available, continue the experiment.

Science Career Profile

RON FELICE

Deputy Project Manager for Flight Operations for
the Hubble Space Telescope Project
Goddard Space Flight Center
Education: B.S. Electrical Engineering



Chief Responsibilities

The organization that Ron Felice heads is responsible for conducting all in-flight science and operations for the observatory as well as for the maintenance, operations, and staffing of the ground system necessary to support these activities. Prior to launch in April of 1990, Ron's group was responsible for the purchase and development of the ground systems located at Goddard Space Flight Center and the Space Telescope Science Institute. This group made sure that qualification and operational tests were carried out.

Ron is responsible for making presentations to higher levels of management within the agency and for making sure the flow of information from Goddard Space Flight Center to and from the Space Telescope Science Institute is regular and without interruption. This information flow occurs most frequently by electronic means, with computers communicating with other computers.

A Typical Day

Ron's typical day is spent establishing plans and coordinating information between Goddard Space Flight Center and the Space Telescope Science Institute. Goddard Space Flight Center uses "mission plans" to organize their activities. The Space Telescope Science Institute has "science aspects" which do the same thing. Ron spends much of his time being sure the two are coordinated and in synchronization. For example, if a scientist needs to study a particular star or object in the sky, Ron must let Goddard know about this. That way, Goddard will make sure that the Hubble Space Telescope is ready for the observations the scientists want to make. Ron is in contact with both locations all day long.

Career Viewpoint

Growing up, Ron was a serious musician. He played both the piano and trombone and was able to work his way through college playing with a dance band. Today, Ron believes the artistic side of him compliments the scientific/engineering side. This balance of the creative and the analytical helps him to be a good problem solver.

All his life, Ron has pursued a wide variety of interests. As an engineer for NASA, he traveled to many locations throughout the world. Exposure to different cultures and different ways of thinking has given him the confidence and perspective to pursue his dreams. He believes you should strive for what you want, and you may turn your fantasy into reality.

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