SECTION 2

# Newton's Law of Universal Gravitation

## SECTION OBJECTIVES

- **Explain how Newton's law of universal gravitation accounts for various phenomena, including satellite and planetary orbits, falling objects, and the tides.**
- **Apply Newton's law of universal gravitation to solve problems.**

**gravitational force**

*the mutual force of attraction between particles of matter*

## GRAVITATIONAL FORCE

Earth and many of the other planets in our solar system travel in nearly circular orbits around the sun. Thus, a centripetal force must keep them in orbit. One of Isaac Newton's great achievements was the realization that the centripetal force that holds the planets in orbit is the very same force that pulls an apple toward the ground—**gravitational force.**

### Orbiting objects are in free fall

To see how this idea is true, we can use a thought experiment that Newton developed. Consider a cannon sitting on a high mountaintop, as shown in **Figure 6.** The path of each cannonball is a parabola, and the horizontal distance that each cannonball covers increases as the cannonball's initial speed increases. Newton realized that if an object were projected at just the right speed, the object would fall down toward Earth in just the same way that Earth curved out from under it. In other words, it would orbit Earth. In this case, the gravitational force between the cannonball and Earth is a centripetal force that keeps the cannonball in orbit. Satellites stay in orbit for this same reason. Thus, the force that pulls an apple toward Earth is the same force that keeps the moon and other satellites in orbit around Earth. Similarly, a gravitational attraction between Earth and our sun keeps Earth in its orbit around the sun.

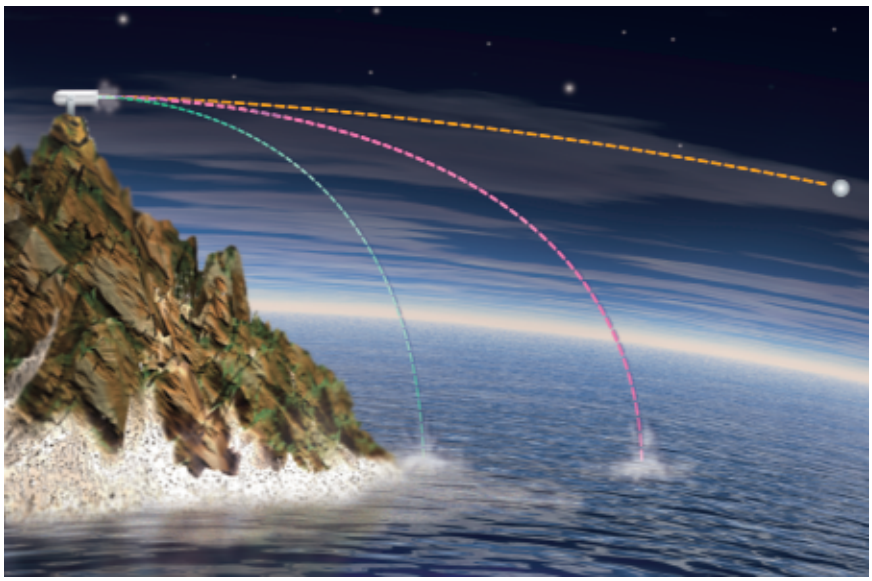

**Figure 6**
Each successive cannonball has a greater initial speed, so the horizontal distance that the ball travels increases. If the initial speed is great enough, the curvature of Earth will cause the cannonball to continue falling without ever landing.