Gravitational mass equals inertial mass

Because gravitational field strength equals free-fall acceleration, free-fall acceleration on the surface of Earth likewise depends only on Earth's mass and radius. Free-fall acceleration does not depend on the falling object's mass, because m cancels from each side of the equation, as shown on the previous page.

Although we are assuming that the m in each equation is the same, this assumption was not always an accepted scientific fact. In Newton's second law, m is sometimes called *inertial mass* because this m refers to the property of an object to resist acceleration. In Newton's gravitation equation, m is sometimes called *gravitational mass* because this m relates to how objects attract one another.

How do we know that inertial and gravitational mass are equal? The fact that the acceleration of objects in free fall on Earth's surface is always the same confirms that the two types of masses are equal. A more massive object experiences a greater gravitational force, but the object resists acceleration by just that amount. For this reason, all masses fall with the same acceleration (disregarding air resistance).

There is no obvious reason why the two types of masses should be equal. For instance, the property of electric charges that causes them to be attracted or repelled was originally called *electrical mass*. Even though this term has the word *mass* in it, electrical *mass* has no connection to gravitational or inertial mass. The equality between inertial and gravitational mass has been continually tested and has thus far always held up.

ADVANCED TOPICS

The equality of gravitational and inertial masses puzzled scientists for many years. Einstein's general theory of relativity was the first explanation of this equality. See "General Relativity" in **Appendix J: Advanced Topics** to learn more about this topic.

SECTION REVIEW

1. Explain how the force due to gravity keeps a satellite in orbit.
2. Is there gravitational force between two students sitting in a classroom? If so, explain why you don't observe any effects of this force.
3. Earth has a mass of 5.97×10^{24} kg and a radius of 6.38×10^{6} m, while Saturn has a mass of 5.68×10^{26} kg and a radius of 6.03×10^{7} m. Find the weight of a 65.0 kg person at the following locations:
   a. on the surface of Earth
   b. 1000 km above the surface of Earth
   c. on the surface of Saturn
   d. 1000 km above the surface of Saturn
4. What is the magnitude of g at a height above Earth's surface where free-fall acceleration equals 6.5 m/s^2?
5. **Critical Thinking** Suppose the value of G has just been discovered. Use the value of G and an approximate value for Earth's radius (6.38×10^{6} m) to find an approximation for Earth's mass.