Astronauts in orbit experience apparent weightlessness

Astronauts floating in a space shuttle are experiencing apparent weightlessness. Because the shuttle is accelerating at the same rate as the astronauts are, this example is similar to the elevator in **Figure 13(c).** The force due to gravity keeps the astronauts and shuttle in orbit, but the astronauts *feel* weightless because no normal force is acting on them.

The human body relies on gravitational force. For example, this force pulls blood downward so that the blood collects in the veins of your legs when you are standing. Because the body of an astronaut in orbit accelerates along with the space shuttle, gravitational force has no effect on the body. This state can initially cause nausea and dizziness. Over time, it can pose serious health risks, such as weakened muscles and brittle bones. When astronauts return to Earth, their bodies need time to readjust to the effects of the gravitational force.

So far, we have been describing apparent weightlessness. Actual weightlessness occurs only in deep space, far from stars and planets. Gravitational force is never entirely absent, but it can become negligible at distances that are far enough away from any masses. In this case, a star or astronaut would not be pulled into an orbit but would instead drift in a straight line at constant speed.

extension

Integrating Health

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SECTION REVIEW

1. Compare Ptolemy's model of the solar system with Copernicus's. How does Kepler's first law of planetary motion refine Copernicus's model?
2. Does a planet in orbit around the sun travel at a constant speed? How do you know?
3. Suppose you know the mean distance between both Mercury and the sun and Venus and the sun. You also know the period of Venus's orbit around the sun. How can you find the period of Mercury's orbit?
4. Explain how Kepler's laws of planetary motion relate to Newton's law of universal gravitation.
5. Find the orbital speed and period of Earth's moon. The average distance between the centers of Earth and of the moon is 3.84×10^8 m.
6. **Critical Thinking** An amusement park ride raises people high into the air, suspends them for a moment, and then drops them at the rate of free-fall acceleration. Is a person in this ride experiencing apparent weightlessness, true weightlessness, or neither? Explain.
7. **Critical Thinking** Suppose you went on the ride described in item 6, held a penny in front of you, and released the penny at the moment the ride started to drop. What would you observe?