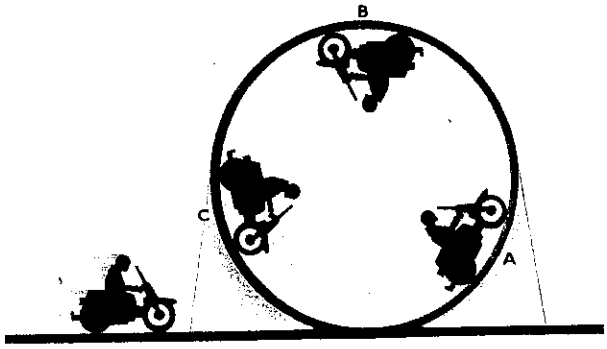
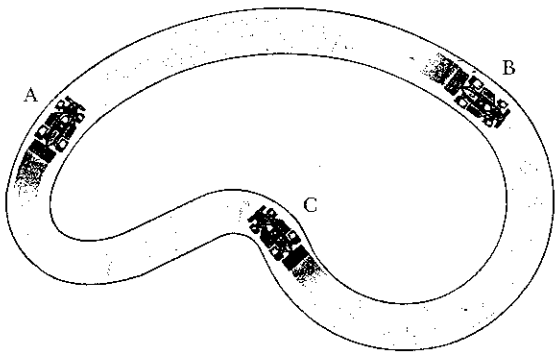
CONCEPTUAL QUESTIONS

Important: Ignore the effects of air resistance in the following questions and exercises.

1. A motorcycle drives through a vertical loop-the-loop at constant speed, as shown in the figure. Draw arrows to show the directions of the instantaneous velocity and the net force on the motorcycle at points A, B, and C.



2. The figure shows a racetrack with identical cars at points A, B, and C. The cars are moving clockwise at constant speeds. Draw arrows indicating the direction of the net force on each car and the instantaneous velocity of each car. In what direction would car A travel if there were an oil slick at point A? Why?



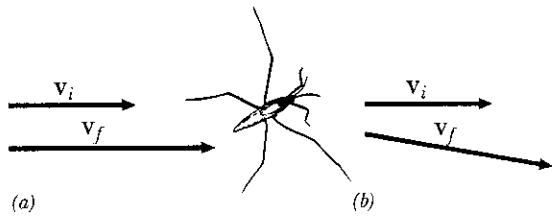
3. What is the force that causes the space shuttle to orbit Earth?

4. What is the force that allows a person on rollerblades to turn a corner? What happens if this force is not strong enough?

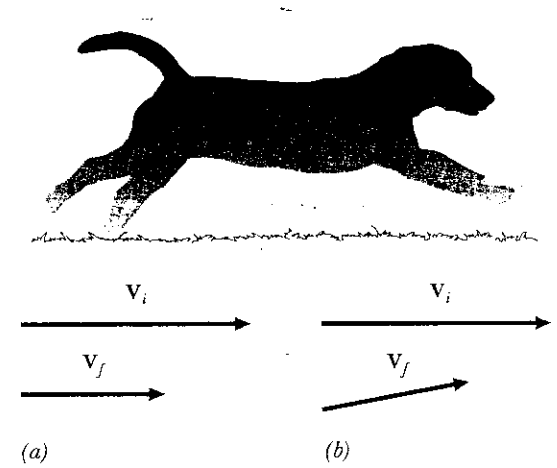
5. Consider the motorcycle in the figure for Question 1 when it is at point B. In which directions do the velocity, change in velocity, acceleration, and net force point?

6. A child rides on a carousel at constant speed. In which direction does each of the following vectors point?
   a. velocity
   b. change in velocity
   c. acceleration
   d. net force

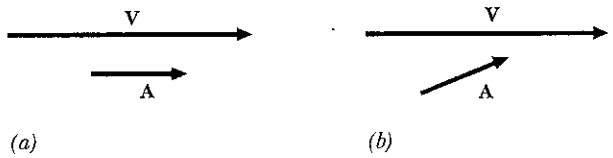
7. A water bug is skittering across the surface of a pond. In each case below, the bug's initial and final velocity vectors are shown for a time interval Δt. For each case find the direction of the bug's average acceleration during this interval.



8. A dog is running loose across an open field. In each case below, the dog's initial and final velocity vectors are shown for a time interval Δt. For each case, find the direction of the dog's average acceleration during this interval.



9. Each case below depicts an object's velocity vector and acceleration vector at an instant in time. State whether the object is (i) speeding up, slowing down, or maintaining the same speed and (ii) turning right, turning left, or moving in a straight line.



10. Each case below depicts an object's velocity vector and acceleration vector at an instant in time. State whether the

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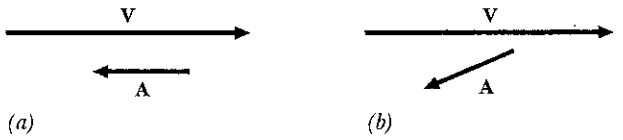


(a) *(b)*

11. Give examples from everyday life in which an object's acceleration is pointed upward and the object is (a) speeding up and (b) slowing down.

12. You get into an elevator at the ground floor and hit the button for the tenth floor. What is the direction of your acceleration right after the elevator starts moving and right before it stops at the tenth floor?

13. A monkey swings from tree to tree on vines. At the bottom of a swing, what force provides (or forces provide) the centripetal force required for the monkey to travel along a circular path?

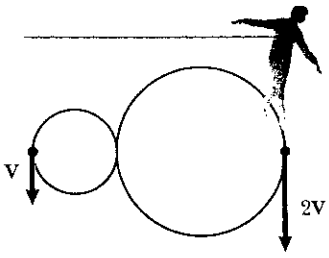
14. A race car is traveling around a banked curve as described in the Feature "Banking Corners." What force provides (or forces provide) the centripetal force required for the race car to travel along its circular path?

***15.** Imagine that you swing a bucket in a vertical circle at constant speed. Will you need to exert more force when the bucket is at the top of the circle or at the bottom? Explain.

***16.** A vine is just strong enough to support Tarzan when he is hanging straight down. However, when he tries to swing from tree to tree, the same vine breaks at the bottom of the swing. How could this happen?

17. You are driving your race car around a circular test track. Which would have a greater effect on the magnitude of your acceleration, doubling your speed or moving to a track with half the radius of curvature? Why?

***18.** A figure skater skates a figure-8 pattern with a small circle and a big circle, as shown in the picture. The big circle has twice the radius of the small circle, and he skates it at twice the speed. Compare the magnitude of his centripetal acceleration on the two circles.

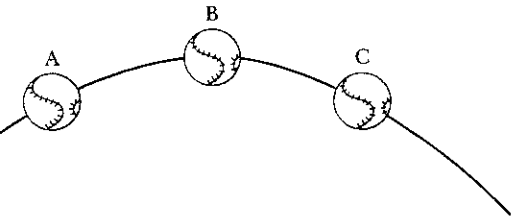


19. A playful astronaut decides to throw rocks on the Moon. What forces act on the rock while it is in the "vacuum"? (We can't say "air"!)

20. A book slides along a frictionless table at a constant velocity and then sails off the edge. Draw a free-body diagram for the book while it is on the table and while it is in the air.

21. A left fielder throws a baseball toward home plate. At the instant the ball reaches its highest point, what are the directions of the ball's velocity, the net force on the ball, and the ball's acceleration?

22. The figure shows the path of a thrown baseball. Draw arrows to indicate the directions of the ball's velocity and acceleration vectors at the three labeled points.



23. A hammer dropped on the surface of the Moon falls with an acceleration of 1.6 (meters per second) per second. Would its acceleration be smaller, larger, or the same if it was thrown horizontally at 6 meters per second? Why?

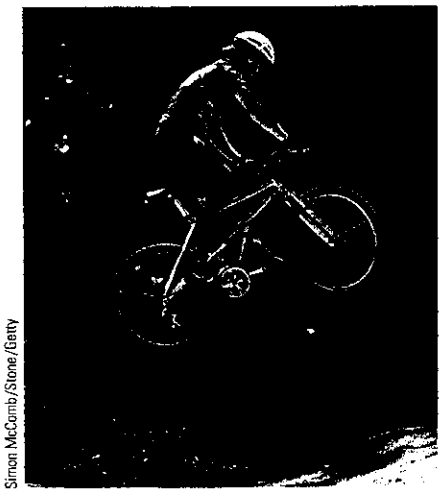
24. A rock dropped from 3.3 meters above the surface of the Moon requires 2.0 seconds to reach the ground. Would it require a shorter, a longer, or the same time if the rock was thrown horizontally from this height with a speed of 12 meters per second? Why?

25. Two identical balls roll off the edge of a table. One leaves the table traveling twice the speed of the other. Which ball hits the floor first? Why?

26. Two balls, one of mass 1 kilogram and one of mass 4 kilograms, roll off the edge of a table at the same time traveling at the same speed. Which ball hits the floor first? Why?

27. A physics student reports that upon arrival on planet X, she promptly sets up the "gorilla-shoot" demonstration. She does not realize that the gravity on planet X is stronger than it is on Earth. Should she modify her procedure? If so, how? If not, why?

28. A fearless bicycle rider announces that he will jump the Beaver River Canyon. If he does not use a ramp, but simply launches himself horizontally, is there any way that he can succeed? Why?



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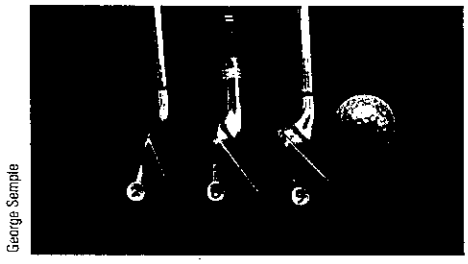
29. In football and soccer, it is often desirable to give up some of the distance a kick travels to gain hang time, the time the ball remains in the air. How does the kicker do this?

30. The irons used in golf have faces that make different angles with the shaft of the club. How does this affect the distance traveled and maximum height of the golf ball?



George Semple

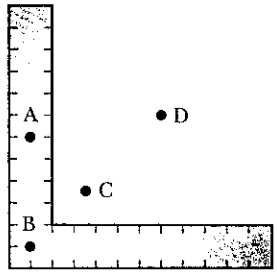
31. If Earth exerts a gravitational force of 5 newtons on the apple while it is in orbit, what force does the apple exert on Earth?

32. Is the size of the gravitational force that Earth exerts on the apple in orbit smaller than, larger than, or the same size as the force the apple exerts on Earth? Why?

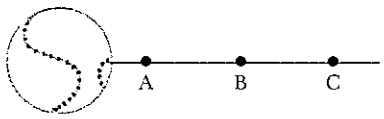
33. We know that Earth orbits the Sun in a nearly circular orbit. Draw a free-body diagram for Earth.

34. Draw a free-body diagram for our fictitious apple in orbit near the Earth's surface.

35. A carpenter's square is tossed through the air. As it tumbles, only one point follows a simple parabolic path. In the following picture, which of the four labeled points most likely represents this point? Why?



36. A tennis ball and a softball are fastened together by a light rigid rod as shown. When this arrangement is thrown tumbling through the air, which of the labeled points is most likely to follow a parabolic path? Why?



EXERCISES

1. Find the size and direction of the change in velocity for each of the following initial and final velocities:
- **a.** 5 m/s west to 10 m/s west
- **b.** 10 m/s west to 5 m/s west
- **c.** 5 m/s west to 10 m/s east

2. What is the change in velocity for each of the following initial and final velocities?
- **a.** 75 km/h right to 100 km/h right
- **b.** 75 km/h right to 100 km/h left

3. What are the size and direction of the change in velocity if the initial velocity is 3 m/s south and the final velocity is 4 m/s west?

4. What is the change in velocity of a car that is initially traveling west at 50 km/h and then drives 120 km/h toward the north?

5. A migrating bird is initially flying south at 8 m/s. To avoid hitting a high-rise building, the bird veers and changes its velocity to 6 m/s east over a period of 2 s. What is the bird's average acceleration (magnitude and direction) during this 2-s interval?

6. A fox is chasing a bunny. The bunny is initially hopping east at 8 m/s when it first sees the fox. Over the next half second, the bunny changes its velocity to west at 12 m/s and escapes. What was the bunny's average acceleration (magnitude and direction) during this half-second interval?

7. A cyclist turns a corner with a radius of 50 m at a speed of 20 m/s.
- **a.** What is the cyclist's acceleration?
- **b.** If the cyclist and cycle have a combined mass of 120 kg, what is the force causing them to turn?

8. A 60-kg person on a merry-go-round is traveling in a circle with a radius of 3 m at a speed of 3 m/s.
- **a.** What acceleration does the person experience?
- **b.** What is the net force? How does it compare with the person's weight?

9. Earth orbits once around the Sun every 365 days at an average radius of 1.5×10^{11} m. Earth's mass is 6×10^{24} kg.
- **a.** How many seconds does it take Earth to orbit the Sun?
- **b.** What distance does Earth travel in one year?
- **c.** What is Earth's average centripetal acceleration?
- **d.** What is the average force that the Sun exerts on Earth?

10. Given that the distance from Earth to the Moon is 3.8×10^8 m, that the Moon takes 27 days to orbit Earth, and that the mass of the Moon is 7.4×10^{22} kg, what is the acceleration of the Moon and the size of the attractive force between Earth and the Moon?

11. A baseball is hit with a horizontal speed of 22 m/s and a vertical speed of 14 m/s upward. What are these speeds 1 s later?

12. What are the horizontal and vertical speeds of the baseball in the previous exercise 2 s after it is hit?

13. A bowling ball rolls off the edge of a giant's table at 15 m/s. If it takes 4 s for the ball to hit the ground, how far does it land from the base of the table? What is the height of the table?

14. Angel Falls in southeastern Venezuela is the highest uninterrupted waterfall in the world, dropping 979 m (3212 ft). Ignoring air resistance, it would take 14 s for the water to fall from the lip of the falls to the river below. If the water lands 50 m from the base of the vertical cliff, what was its horizontal speed at the top?

15. A tennis ball is hit with a vertical speed of 10 m/s and a horizontal speed of 30 m/s. How long will the ball remain in the air? How far will the ball travel horizontally during this time?

16. If a baseball is hit with a vertical speed of 30 m/s and a horizontal speed of 6 m/s, how long will the ball remain in the air? How far will it go?

17. Given that the radius of Earth is 6400 km, calculate the acceleration of an apple in orbit just above Earth's surface.

Kevin Schafer/Stone/Getty

Exercise 14

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