## Understanding Concepts

1. Choosing the positive direction of a one-dimensional motion as south, describe the motion of a runner with
   (a) a positive velocity and a positive acceleration
   (b) a positive velocity and a negative acceleration
   (c) a negative velocity and a negative acceleration
   (d) a negative velocity and a positive acceleration
2. State the conditions under which
   (a) average speed exceeds instantaneous speed
   (b) average speed is less than instantaneous speed
   (c) average speed equals instantaneous speed
3. Can a component of a vector have a magnitude greater than the magnitude of the vector? Explain.
4. Describe the motion represented by each graph in **Figure 1**.

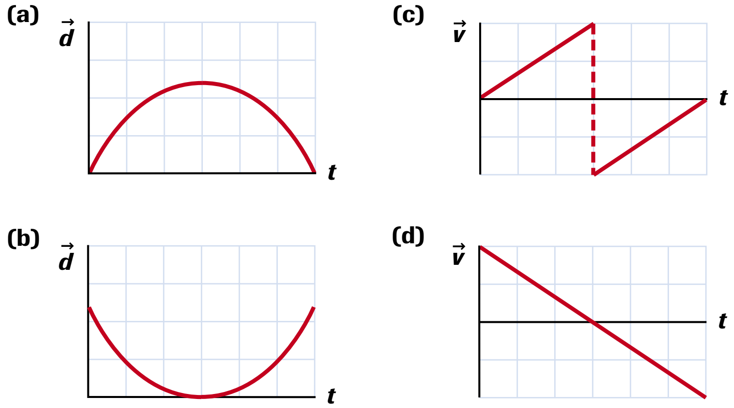


**Figure 1**

5. Would a parachute work on the Moon? Explain your answer.
6. A square is inscribed in a circle as shown in **Figure 2**. One person walks from X to Y along the edge of the square. A second person walks along the circumference. Each person reaches B after 48 s. Calculate
   (a) each person's average speed
   (b) each person's average velocity
7. Compare the horizontal ranges of projectiles launched with identical velocities on Earth and on the Moon.
8. The following objects are dropped from a rooftop: a pencil, a Ping-Pong ball, a piece of paper, and a feather. On a single speed-time graph, sketch the curve for each object, assuming that the objects reach the ground in the order given.

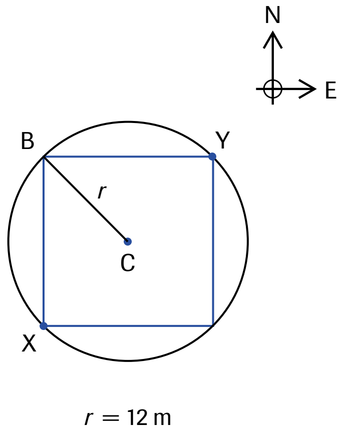


**Figure 2**
For question 6

9. A car of mass $1.2 \times 10^3$ kg travels initially at 42 km/h on the entrance ramp of an expressway, then accelerates uniformly to 105 km/h in 21 s.
   (a) How far, in kilometres, does the car travel in this interval?
   (b) Determine the magnitude of the car's average acceleration, in kilometres per hour per second.
   (c) Calculate the magnitude of the average force needed to cause this acceleration.
10. A billiard ball travels 0.44 m [S] from its original position, bounces off another ball and travels 0.88 m [N], then bounces off the edge of the billiard table, coming to rest 0.12 m from that edge. The entire motion is one-dimensional and takes 2.4 s. Calculate
   (a) average speed of the ball
   (b) the final position of the ball
   (c) the average velocity of the ball
11. A 12-hour clock mounted on a vertical wall has a second hand with a tip that is 14 cm from the centre of the clock.
   (a) What is the average speed of the tip of the second hand?
   (b) Determine the instantaneous velocity of the tip when it passes the 6:00 o'clock position and the 10:00 o'clock position.
   (c) Find the average velocity of the tip between the 1:00 o'clock position and the 5:00 o'clock position.
12. A train is travelling at 23 m/s [E] when it enters a curved portion of the track and experiences an average acceleration of 0.15 m/s$^2$ [S] for 95 s. Determine the velocity of the train after this acceleration.

13. A projectile lands at the same elevation from which it is launched. At what position(s) in its flight is the speed of the projectile greatest? least?
14. An inflated balloon is released and immediately moves eastward. Explain what causes this motion.
15. In running a 100-m sprint in 10 s, an Olympic-class athlete accelerates to a speed of about 8.0 m/s in the first 2.0 s. Determine the magnitude of the average horizontal force on a 63-kg runner during this interval. What exerts the force?
16. At a certain distance above the surface of Earth, the gravitational force on an object is reduced to 18% of its value at Earth's surface. Determine this distance and express it as a multiple of Earth's radius, $r_E$.
17. A trapeze artist balances in the middle of a tightrope 14.2 m in length. The middle of the rope is 2.3 m below the two secured ends. If the artist's weight is $6.3 \times 10^2$ N [down], determine the magnitude of the tension in the rope.
18. If the speed of a particle in circular motion is decreasing, is the particle's acceleration still toward the centre of the circle? Use a diagram to explain your answer.
19. The magnitude of the maximum centripetal acceleration of a car on a certain horizontal curve is $4.49 \text{ m/s}^2$. For a car travelling at 22 m/s, determine the minimum radius of curvature of this curve.
20. Mars travels in a nearly circular orbit of radius $2.28 \times 10^{11}$ m around the Sun. The mass of Mars is $6.27 \times 10^{23}$ kg. The gravitational force of attraction between Mars and the Sun has a magnitude of $1.63 \times 10^{21}$ N.
    (a) What is the speed of Mars?
    (b) Determine the period of revolution of Mars around the Sun in Earth years.
21. A ride at an amusement park rotates, with circular motion, in the vertical plane 72 times during the 3.0 min of maximum rotation rate. Passengers on the ride are 6.3 m from the centre of the ride. When viewed from the side of the ride so that it is rotating clockwise, determine the instantaneous velocity of a passenger at the following clock positions:
    (a) 3:00 o'clock
    (b) 6:00 o'clock
    (c) 7:00 o'clock
22. Determine the magnitude of the average acceleration during the time interval it takes each object described below to complete half a revolution around the central object.
    (a) A satellite takes 80.0 min to travel once around Earth, in an orbit of diameter $1.29 \times 10^4$ km.
    (b) The Moon travels once around Earth in $2.36 \times 10^6$ s, at an average speed of 1.02 km/s.
23. In pairs figure skating, a female of mass 55 kg spirals in a horizontal circle of radius 1.9 m around a male skater of mass 88 kg. The frequency of revolution is 0.88 Hz.
    (a) Determine the magnitude of the force causing the female skater to maintain her circular motion.
    (b) What is the magnitude of the horizontal force on the male skater?
24. An 18-g rubber stopper is suspended by a 45-cm string from the rear-view mirror of a car. As the car accelerates eastward, the string makes an angle of 5.1° with the vertical.
    (a) Draw an FBD of the stopper in Earth's frame of reference.
    (b) Draw an FBD of the stopper in the car's frame of reference.
    (c) Determine the acceleration of the car.
25. A homeowner drags a garbage can of mass 27 kg along a horizontal sidewalk at a constant speed of 1.8 m/s by applying a force of $1.12 \times 10^2$ N [27° above the horizontal]. What is the coefficient of kinetic friction between the garbage can and the sidewalk?
26. Box A ($m = 2.5$ kg) is connected by a rope that passes over a frictionless pulley to Box B ($m = 5.5$ kg), as shown in **Figure 3**. The coefficient of kinetic friction between the box and the ramp is 0.54. Determine the magnitude of the acceleration of the boxes.

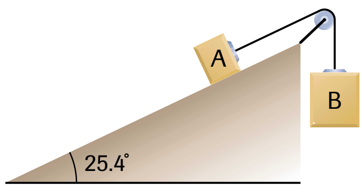


**Figure 3**



An interactive version of the quiz is available online.



GO www.science.nelson.com

27. Determine the magnitude of the apparent weight of a 62-kg person in an elevator when the elevator is
    (a) accelerating at 2.5 m/s$^2$ [up]
    (b) accelerating at 2.5 m/s$^2$ [down]
    (c) moving with zero acceleration at 2.5 m/s [up]

## Applying Inquiry Skills

28. A Ferris wheel at an amusement park close to your school somehow falls off its support and rolls along the ground.
    (a) Determine a reasonable estimate of the number of rotations the wheel would make, travelling in a straight line, to reach the closest capital city of a province other than your own. State all your assumptions and show all your calculations.
    (b) If you were at an amusement park, how would you use indirect measurements to determine the diameter of a Ferris wheel that cannot be accessed directly. Show a sample calculation.
29. Assuming that you have an accurate stopwatch, describe how you could calculate the average acceleration of a car in the distance from the starting position to the end of a straight 100-m stretch of track.
30. You are planning a controlled investigation in which you determine the effect of air resistance on falling objects.
    (a) What objects would you choose to test the effects of air resistance?
    (b) Describe what measurements you would make and how you would make them.
    (c) What safety precautions would you take in conducting your investigation?
31. Draw a sine curve for angles ranging from 0° to 180°. With reference to this curve, explain why there are two possible launch angles corresponding to any horizontal range for a projectile, with one exception. What is that exception?
32. Steel washers connected by a fishing line to a force sensor, labelled A in **Figure 4**, are kept hovering by a heavy U-shaped magnet suspended from a second force sensor, B. The force sensors are connected to a computer such that the force registered by A is negative and the force registered by B is positive.
    (a) If the force registered by A is −0.38 N, what is the force registered by B? Explain the physics principle on which your answer is based.
    (b) Sketch, on a single force-time graph, the dataset the computer program would generate as the force sensor B is slowly raised.

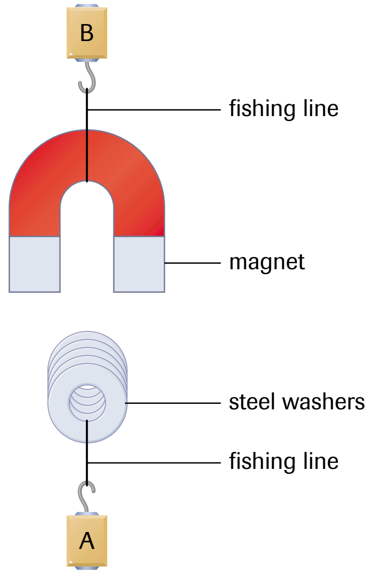


**Figure 4**

33. An experiment is performed in which a varying net force is applied to a dynamics cart; the resulting accelerations are shown in **Table 1**. Plot a graph of the data and use the information on the graph to determine the object's mass.

**Table 1** Data for Question 33

| Net Force (N [forward]) | Acceleration (m/s$^2$ [forward]) |
|---|---|
| 0 | 0 |
| 1.0 | 0.29 |
| 2.0 | 0.54 |
| 3.0 | 0.83 |
| 4.0 | 1.10 |
| 5.0 | 1.42 |
| 6.0 | 1.69 |
| 7.0 | 1.89 |

34. After performing an investigation to determine how the frequency of a rubber stopper in uniform circular motion in the horizontal plane depends on the magnitude of the tension force acting on the stopper, the mass of the stopper, and the radius of the circle, you draw graphs to show the relationships. You are then asked to draw the corresponding graphs by replacing the frequency with the period of revolution as the dependent variable. Draw these graphs.

## Making Connections

35. A pole vault jumper clears the crossbar set at a height of 6.0 m above the mat.
    (a) Determine the time interval for the first 45 cm on the way down.
    (b) Determine the time interval for the last 45 cm before reaching the mat.
    (c) Explain why the jumper appears to be in "slow motion" near the top of the jump.
36. A swimmer steps off the edge of a diving board and falls vertically downward into the water. Describe the velocities and accelerations of the swimmer from the initial position until impact.
37. If you drop a stone into a deep well and hear a splash 4.68 s after dropping the stone, how far down is the water level? Neglect air resistance and assume that the speed of the sound in air is $3.40 \times 10^2$ m/s.
38. A certain volleyball player can jump to a vertical height of 85 cm while spiking the volleyball.
    (a) How long is the player in the air?
    (b) What is the player's vertical take-off speed?
39. A person's terminal speed with an open parachute ranges from 5.0 m/s to 10.0 m/s. You are designing a training facility in which people practise landing at the same speeds they would when parachuting. What range of heights will you specify for the practice platforms?
40. Explain why an east-to-west trans-Canada airplane flight generally takes longer than a west-to-east flight.
41. Water moving horizontally at 2.0 m/s spills over a waterfall and falls 38 m into a pool below. How far out from the vertical wall of the waterfall could a walkway be built so that spectators stay dry?
42. A motorist's reaction time can be crucial in avoiding an accident. As you are driving with a velocity of 75.0 km/h [N], you suddenly realize that there is a stalled vehicle in your lane 48.0 m directly ahead. You react, applying the brakes to provide an acceleration of 4.80 m/s$^2$ [S]. If you manage to just avoid a collision, what is your reaction time?
43. **Figure 5** shows a time-exposure photograph in which the stars and planets visible appear to be travelling in circles around a central star (the North Star, Polaris).

**Figure 5**
The North Star is almost directly above Earth's North Pole.

    (a) Explain the observed motion of the stars and planets in the photograph. (Include the concepts related to frames of reference.)
    (b) How can you estimate how long the exposure time was?
    (c) Would people in Australia be able to take this photograph or a similar one? Explain your answer.
44. In answering a newspaper reader's question, "Why does a shower curtain move inward while water is spraying downward?" a physicist replies, "The air being dragged downward by the water must be replaced by air from somewhere else."
    (a) With reference to the appropriate principle, provide a more technical explanation to the reader's question.
    (b) If you were answering the question in a newspaper article, what other examples or demonstrations could you describe to help the readers understand the situation?

45. In the exciting sport of kite surfing (**Figure 6**), a specially designed power kite propels the pilot across the water on kite boards. The pilot can rise high into the air for several seconds, performing amazing aerial stunts. Would you expect the power kite to be designed to have good streamlining? Explain your answer.

46. A remote-sensing satellite travels in a circular orbit at a constant speed of $8.2 \times 10^3$ m/s.
    (a) What is the speed of the satellite in kilometres per hour?
    (b) Determine the altitude in kilometres of the satellite above Earth's surface.
    (c) What is remote sensing? Give some practical uses of a remote-sensing satellite.

47. In the future, video games and simulations of sports activities will become more realistic, as designers become better able to apply the physics principles presented in this unit. Describe some ways in which these games and simulations could become more realistic.

48. In testing a model of a looping roller coaster, an engineer observes that the current design would result in a zero normal force acting on the passengers at the top of the loop.
    (a) If the radius of the loop is 2.1 m, what is the speed of the model coaster at the top of the loop?
    (b) Explain why and how the coaster design should be changed.

49. (a) Why will artificial gravity be needed on a space mission to Mars by humans?
    (b) Describe how artificial gravity could be created on such a mission.

## Extension

50. In a basketball game, a ball leaves a player's hand 6.1 m downrange from the basket from a height of 1.2 m below the level of the basket. If the initial velocity of the ball is 7.8 m [55° above the horizontal] in line with the basket, will the player score a basket? If not, by how much will the ball miss the basket?

**Figure 6**
Kite surfing is a dangerous and physically demanding sport.