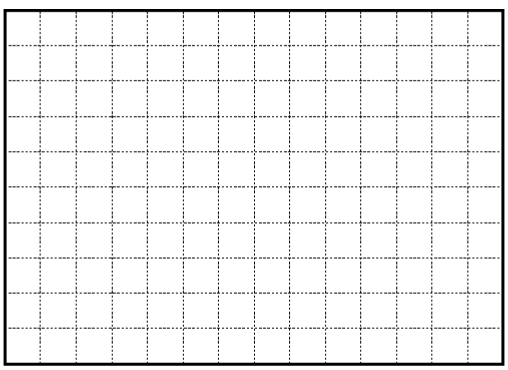
Q1.W7- Physics.- Quarter 1- Revision and summary

Topics covered:

Ch.1- The Science of Physics
Ch.2- Motion in One Dimension
Ch.3- Two-D Motion and Vectors
Ch.4- Forces and Laws of Motion
Ch.5- Work and Energy
Ch.6- Momentum and Collisions

Short Answer

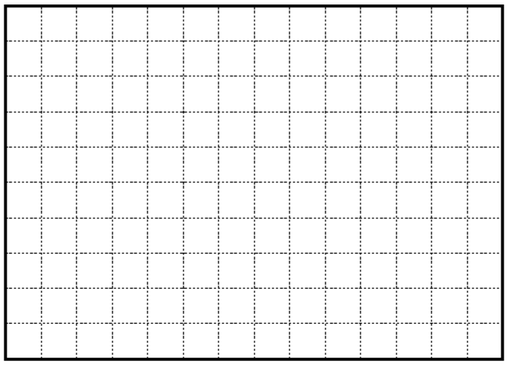
1. Convert 1 μm to meters using scientific notation.



Speedometer reading (km/h)	Time for 100 km trip (h)
20.0	5.00
30.0	3.33
40.0	2.50
50.0	2.00
60.0	1.67
70.0	1.43
80.0	1.25
90.0	1.11
100.0	1.00

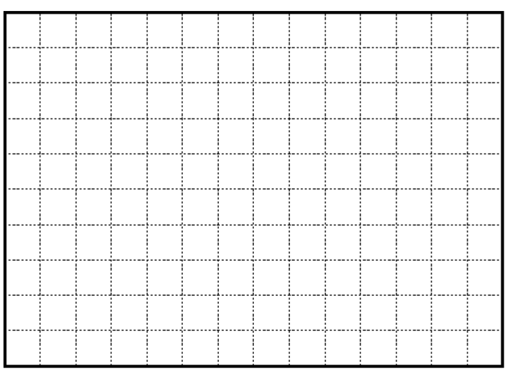
2. Using the data above, construct a graph of the time required to make a trip of 100 km measured at various speeds.
3. What quantity describes the difference between an object’s initial position and the object’s final position?
4. What is the ratio of an object’s displacement to the time interval during which the displacement occurred?

5. Distinguish between the displacement of a traveler who takes a train from New York to Boston and the displacement of a traveler who flies from Boston to New York.
6. What is the magnitude of the displacement of a windup toy that starts its motion from any position and returns to that position?



Time (s)	Displacement (m)
0.0	0.0
2.0	1.0
4.0	2.0
6.0	3.0
8.0	4.0
10.0	5.0

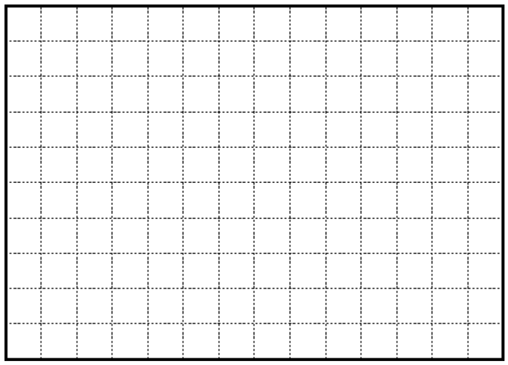
7. Construct a graph of position versus time for the motion of a dog, using the data in the table above. Explain how the graph indicates that the dog is moving at a constant speed.



Time (s)	Displacement (m)
0.0	2.0
5.0	4.0
10.0	6.0

8. Construct a graph of position versus time of a jogger, using the data in the table above. What is the average velocity of the jogger?
9. How can you determine the instantaneous velocity at a given point on a position versus time graph?
10. What is the SI unit of acceleration?

11. Interpret the acceleration unit km/h/s.



12. A motorized scooter starts from rest and accelerates for 4 s at 2 m/s^2. It continues at a constant speed for 6 s. Graph the scooter's velocity versus time. What is the scooter's average velocity for the interval 0–4 s?

13. What must be true about the acceleration for the equation $v_{avg} = \frac{v_i + v_f}{2}$ to be valid?

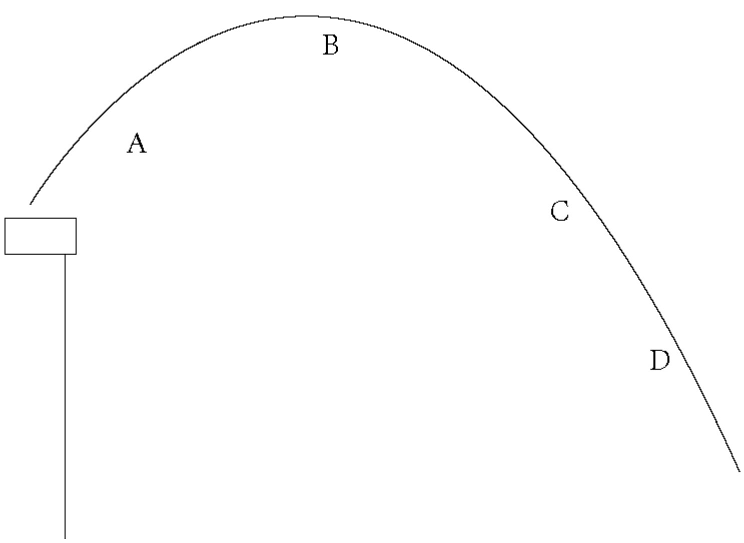
14. What is the magnitude of the acceleration of an object in free fall near Earth's surface?

15. The length of a vector arrow in a diagram is proportional to what property of the vector?

16. Is the quantity $\mathbf{v}_i \Delta t$ a scalar quantity or vector quantity?

17. Breaking a vector into two components is given what term?

18. What is the term for the curved, parabolic path that an object follows when thrown, launched, or otherwise projected near the surface of the Earth?



The figure above shows the path of a ball tossed from a building. Air resistance is ignored.

19. In the figure above, what would happen to the height of the ball's path if it were launched with a greater velocity?

20. In the figure above, what would happen to the width of the ball's path if it were launched with a lesser velocity?

21. Describe the graph of the horizontal component of velocity versus time for the motion of the ball shown in the figure above.

A crew member is walking on a tugboat that is pulling a barge. The tugboat is moving at a constant speed upstream in a river that has a constant downstream current.

22. In the situation above, the velocity of the crew member with respect to the tugboat is $\mathbf{v}_1$. What is the velocity of the crew member with respect to the barge?

23. The newton is the SI unit of what physical quantity?

24. In a free-body diagram of an object, why are forces exerted by the object not included in the diagram?

25. The length of the force vector is proportional to what property of a force?

26. Why is force *not* a scalar quantity?

27. What is the natural tendency of an object that is in motion?

28. If two teams playing tug-of-war pull on a rope with equal but opposite forces, what is the net external force on the rope?

29. When a car is moving, what happens to the velocity and acceleration of the car if the air resistance becomes equal to the force acting in the opposite direction?

30. When a falling object reaches terminal speed (where the acceleration on the object is zero), what is the relationship between $\mathbf{F}_\mathbf{R}$, the force of air resistance on the object, and $\mathbf{F}_\mathbf{g}$?

31. How does the force of static friction on a crate you cannot budge compare to the force you exert on it? Assume that the crate is on a flat surface.

32. How does the coefficient of static friction for two surfaces in contact compare to the coefficient of kinetic friction for the same two surfaces?

33. In the following sentence, is the everyday meaning or the scientific meaning of work intended?
A student works on a term paper.

34. In the following sentence, is the everyday meaning or the scientific meaning of work intended?
A clerk works overtime on Saturdays.

35. Air exerts a force on a leaf as it falls from a tree to Earth. Is the work done on the leaf positive, negative, or zero?

A car travels at a speed of 25 m/s on a flat stretch of road. The driver must maintain pressure on the accelerator to keep the car moving at this speed.

36. Are any forces doing work on the car? Explain your answer.

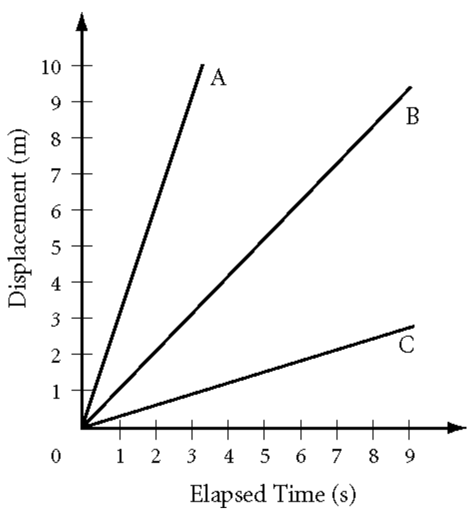
37. The car's engine is doing work on the car, yet the kinetic energy of the car is not changing. What is happening to the energy supplied by the engine?

38. Is kinetic energy a vector quantity or a scalar quantity?

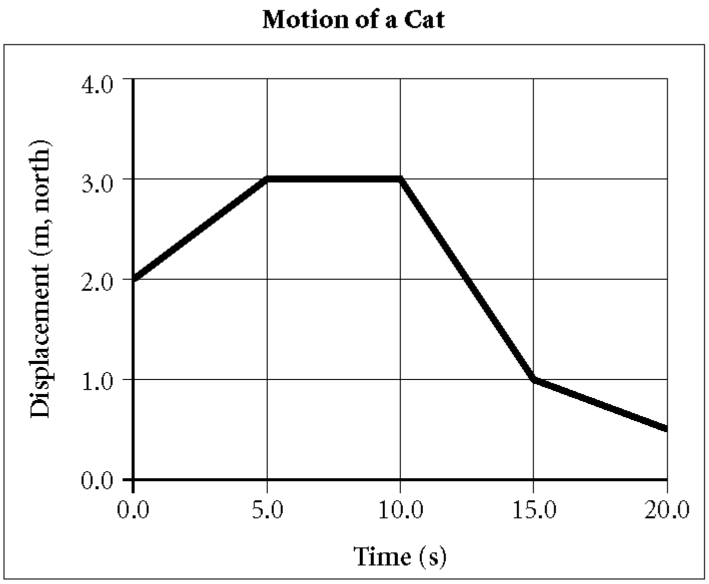
39. Negative work is done on a moving object. How does the kinetic energy of the object change?
40. An object is lowered into a deep hole in the ground. How does the potential energy of the object change?
41. You are analyzing the flight of a projectile through the air. What assumption do you have to make in order to use conservation of mechanical energy in your analysis?
42. Write a symbolic expression of the conservation of mechanical energy.
43. Write an equation that expresses the conservation of mechanical energy in a system where the only forms of mechanical energy are kinetic energy and gravitational potential energy.
44. A pendulum is raised 1.5 cm and allowed to fall. If air resistance is negligible, how high will the pendulum rise on the other side?
45. Is power a vector quantity or a scalar quantity?
46. In terms of energy, what occurs when a machine does work on an object?
47. An ice skater initially skating at a velocity of 3 m/s speeds up to a velocity of 5 m/s. How does the momentum of the skater change?
48. A student walks to class at a velocity of 3 m/s. To avoid walking into a door as it opens, the student slows to a velocity of 0.5 m/s. Now late for class, the student runs down the corridor at a velocity of 7 m/s. At what point in this scenario does the student have the least momentum?
49. A moderate force will break an egg. Using the concepts of momentum, force, and time interval, explain why an egg is more likely to break when it is dropped on concrete than if it is dropped on grass.
50. Describe how the collision affects the total momentum and total kinetic energy of the system.

Problems

1. The mass of Earth is 5.98×10^{24} kg, and the mass of a single proton is 1.673×10^{-27} kg. Assuming Earth is made entirely of protons, use an order-of-magnitude calculation to estimate the number of protons that make up Earth. Then, calculate the exact number of protons and express the answer in scientific notation with the correct number of significant digits.
2. The radius of Earth is 6.37×10^{6} m. The average Earth-sun distance is 1.496×10^{11} m. How many Earths would fit between Earth and the sun if they are separated by their average distance? Use an order-of-magnitude calculation to estimate this number. Then, determine an exact answer and express it in scientific notation with the correct number of significant digits.
3. Suppose a certain type of deciduous tree releases 7500 leaves on average each fall. If the average mass of each leaf is 1.7 g and a 135 000 acre forest has 206 of these trees per acre, how many kilograms of leaves are dropped on the forest floor each fall? Express the answer in scientific notation and with the correct number of significant digits.
4. A hiker travels south along a straight path for 1.2 h with an average speed of 4.1 km/h and then travels north for 1.7 h with an average speed of 4.7 km/h. What is the hiker's displacement for the total trip?



5. The graph above shows displacement versus time. What is the average velocity for line C?



6. The graph above shows the motion of a cat. What is the cat's average velocity during the time interval 0.0–20.0 s?
7. A skater glides off a frozen pond onto a patch of ground at a speed of 2.9 m/s. Here she is slowed at a constant rate of 3.00 m/s^2. How fast is the skater moving when she has slid 0.38 m across the ground?
8. Human reaction time is usually about 0.20 s. If your lab partner holds a ruler between your finger and thumb and releases it from rest without warning, how far can you expect the ruler to fall before you catch it? (Disregard air resistance. $a = -g = -9.81\ m/s^2$.)
9. A rock is thrown straight upward with an initial velocity of 25.4 m/s where the acceleration due to gravity has a magnitude of 9.81 m/s^2. What is the rock's displacement after 2.65 s?
10. A rock is thrown straight upward with an initial velocity of 6.4 m/s in a location where the acceleration due to gravity has a magnitude of 9.81 m/s^2. To what height does it rise?
11. Someone throws a rubber ball vertically upward from the roof of a building 7.58 m in height. The ball rises, then falls. It just misses the edge of the roof, and strikes the ground. If the ball is in the air for 5.32 s, what was its initial velocity? (Disregard air resistance. $a = -g = -9.81\ m/s^2$.)
12. A jogger runs 7.0 blocks due east, 9.0 blocks due south, and another 5.0 blocks due east. Assume all blocks are of equal size. Use the graphical method to find the magnitude of the jogger's net displacement.
13. A cave explorer travels 2.0 m eastward, then 2.4 m northward, and finally 18.0 m westward. Use the graphical method to find the magnitude of the net displacement.
14. A duck waddles 2.3 m east and 7.0 m north. What are the magnitude and direction of the duck's displacement with respect to its original position?
15. A plane flies from city A to city B. City B is 1650 km west and 1170 km south of city A. What is the total displacement of the plane?
16. While following directions on a treasure map, a person walks 66.0 m south, then turns and walks 7.60 m east. Which single straight-line displacement could the person have walked to reach the same spot?

17. A string attached to an airborne kite was maintained at an angle of 65.0° with the ground. If 170 m of string was reeled in to return the kite back to the ground, what was the horizontal displacement of the kite? (Assume the kite string did not sag.)

18. A skateboarder rolls 41.0 m down a hill that descends at an angle of 12.0° with the horizontal. Find the horizontal and vertical components of the skateboarder's displacement.

19. What is the magnitude of the resultant displacement of a dog looking for its bone in the yard if the dog first heads 57.0° north of west for 10.3 m and then turns and heads west for 4.00 m?

20. A hockey puck travels 1.35 m at 22.0° south of east before ricocheting 2.78 m at 78.0° north of east. What is the puck's resultant displacement?

21. A stone is thrown at an angle of 30.0° above the horizontal from the top edge of a cliff with an initial speed of 15 m/s. A stopwatch measures the stone's trajectory time from the top of the cliff to the bottom at 6.30 s. What is the height of the cliff? (Assume no air resistance and that $a_y = -g = -9.81$ m/s^2.)

22. A model rocket flies horizontally off the edge of a cliff at a velocity of 70.0 m/s. If the canyon below is 110.0 m deep, how far from the edge of the cliff does the model rocket land? ($a_y = -g = -9.81$ m/s^2)

23. A fox sees a piece of carrion being thrown from a hawk's nest and rushes to snatch it. The nest is 14.0 m high, and the carrion is thrown with a horizontal velocity of 1.3 m/s. The fox is 8.0 m from the base of the tree. What is the magnitude of the fox's average velocity if it grabs the carrion in its mouth just as it touches the ground? (Assume no air resistance and that $a_y = -g = -9.81$ m/s^2.)

24. A pebble falls vertically from the edge of a cliff 29 m high. After falling 1.1 s, the pebble glances off a small rock protruding from the face of the cliff. The impact with the ledge has negligible effect on the pebble's vertical motion. However, the pebble is deflected perpendicular to the face of the cliff with a horizontal velocity of 5 cm/s. How far from the base of the cliff does the pebble land? (Assume there is no air resistance and that $a_y = -g = -9.81$ m/s^2.)

25. A small airplane flies at a velocity of 106 km/h toward the south as observed by a person on the ground. The airplane pilot measures the velocity of the plane with respect to the air as 129 km/h south. What is the velocity of the wind that affects the plane?

26. A boat moves at 12.00 m/s relative to the water. If the boat is in a river where the current is 9.00 m/s, how long does it take the boat to make a complete round trip of 1400.0 m upstream followed by 1400.0 m downstream?

27. A juggler is strolling along a moving walkway while tossing a ball vertically upward to a height of 3.60 m. The juggler strolls at a constant velocity of +1.20 m/s with respect to the walkway, which moves at a constant velocity of +0.50 m/s with respect to the ground. An observer on the ground passes the juggler and notices that the path of the ball is a parabola with a maximum width of +1.80 m. What is the velocity of the observer with respect to the ground? (Assume no air resistance and that $a_y = -g = -9.81$ m/s^2.)

28. A farmhand attaches a 27 kg bale of hay to one end of a rope passing over a frictionless pulley connected to a beam in the hay barn. Another farmhand then pulls down on the opposite end of the rope with a force of 397 N. Ignoring the mass of the rope, what will be the magnitude and direction of the bale's acceleration if the gravitational force acting on it is 265 N?

29. A warehouse worker pulls on the handles of a 83.0 kg cart with a net force of 111 N an angle of 53.0° above the horizontal. Attached to the cart is a second cart having a mass of 55.0 kg. What is the magnitude of the horizontal acceleration of the less massive cart?

30. An elevator weighing 2.58×10^5 N is supported by a steel cable. What is the tension in the cable when the elevator is accelerated upward at a rate of 3.33 m/s^2? (g = 9.81 m/s^2)

31. A three-tiered birthday cake rests on a table. From bottom to top, the cake tiers weigh 15 N, 8 N, and 6 N, respectively. What is the magnitude and direction of the normal force acting on the base of the second tier?

32. A waitperson pushes the bottom of a glass tumbler full of water across a tabletop at constant speed. The tumbler and its contents have a mass of 0.86 kg, and the coefficient of kinetic friction for the surfaces in contact is 0.46. What force does the waitperson exert on the glass? g = 9.81 m/s^2)

33. A couch with a mass of 1.00×10^2 kg is placed on an adjustable ramp connected to a truck. As one end of the ramp is raised, the couch begins to move downward. If the couch slides down the ramp with an acceleration of 0.79 m/s^2 when the ramp angle is 12.0°, what is the coefficient of kinetic friction between the ramp and the couch? (g = 9.81 m/s^2)

34. How much work is done on a bookshelf being pulled 4.00 m at an angle of 35.0° from the horizontal? The magnitude of the component of the force that does the work is 87.0 N.

35. A worker pushes a box with a horizontal force of 40.0 N over a level distance of 4.0 m. If a frictional force of 27 N acts on the box in a direction opposite to that of the worker, what net work is done on the box?

36. A flight attendant pulls a 60.0 N flight bag a distance of 239.0 m along a level airport floor at a constant speed. A 21.0 N force is exerted on the bag at an angle of 66.0° above the horizontal. How much work is done on the flight bag?

37. A 43.0 N crate starting at rest slides down a rough 7.6 m long ramp inclined at 30° with the horizontal. The force of friction between the crate and ramp is 5.0 N. Using the work-kinetic energy theorem, find the velocity of the crate at the bottom of the incline.

38. A skier with a mass of 84 kg hits a ramp of snow at 32 m/s and becomes airborne. At the highest point of flight, the skier is 4.7 m above the ground. What is the skier’s gravitational potential energy at this point?

39. A 3.62×10^2 N crate is pushed to the top of a 2.53 m ramp, which is inclined at 15.0° with the horizontal. What is the potential energy of the crate?

40. On a given occasion, Old Faithful geyser in Yellowstone National Park shoots water to a height of 47.1 m. With what velocity does the water leave the ground during this eruption? (Assume no air resistance and that g = 9.81 m/s^2.)

41. A bobsled zips down an ice track, starting from rest at the top of a hill with a vertical height of 170 m. Disregarding friction, what is the velocity of the bobsled at the bottom of the hill? (g = 9.81 m/s^2)

42. A pendulum with a mass of 4.0 kg is released from a height of 2.9 cm above the height of its resting position. How fast will the pendulum be moving when it passes through the lowest point of its swing?

43. What is the average power output of a weightlifter who can lift 260 kg to a height of 1.9 m in 1.8 s?

44. Compare the momentum of a 5450 kg truck moving at 8.00 m/s to the momentum of a 2725 kg car moving at 16.0 m/s.

45. Use the impulse-momentum theorem to find the diver’s momentum after falling for 1.29 s.

46. An infant throws 7 g of applesauce at a velocity of 0.5 m/s. All of the applesauce collides with a nearby wall and sticks to it. What is the decrease in kinetic energy of the applesauce?

47. A 5.3×10^{3} kg truck moving at 16 m/s strikes a 1.7×10^{3} kg automobile stopped at a traffic light. The vehicles hook bumpers and skid together at 10.4 m/s. What is the decrease in kinetic energy?

48. A clay ball with a mass of 0.48 kg has an initial speed of 4.08 m/s. It strikes a 3.04 kg clay ball at rest, and the two balls stick together and remain stationary. What is the decrease in kinetic energy of the 0.48 kg ball?

49. A 0.12 kg object makes an elastic head-on collision with a 0.18 kg stationary object. The final velocity of the 0.12 kg object after the collision is 0.048 m/s in the direction opposite its initial movement. The final velocity of the 0.18 kg object after the collision is 0.19 m/s in the same direction as the object which strikes it. What was the initial velocity of the 0.12 kg object?

50. A 19 g marble moves to the right at 3.4 m/s and makes an elastic head-on collision with a 27 g marble. The final velocity of the 19 g marble is 5.1 m/s to the left, and the final velocity of the 27 g marble is 2.8 m/s to the right. What was the initial velocity of the 27 g marble?

Q1.W7- Physics.- Quarter 1- Revision and summary
Answer Section

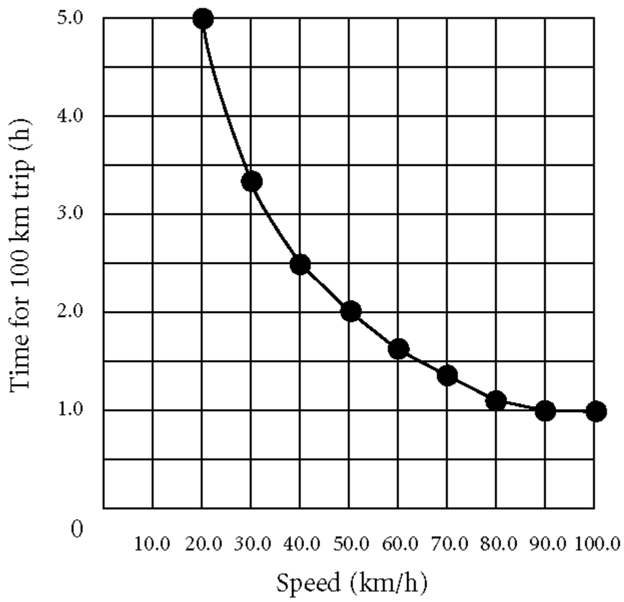
SHORT ANSWER

1. ANS:
   1×10^{-6} m

   Solution

   $$\left(1\ \mu\text{m}\right)\left(\frac{10^{-6}\ \text{m}}{1\ \mu\text{m}}\right) = 1 \times 10^{-6}\ \text{m}$$

2. ANS:



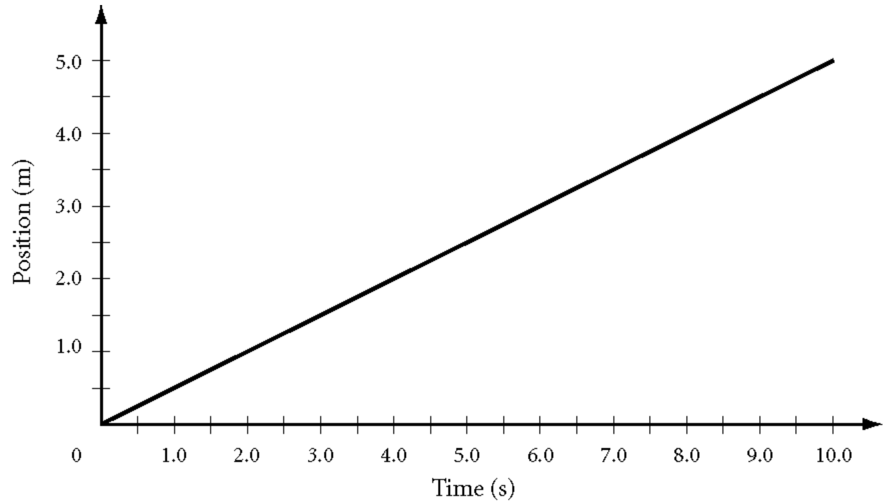
3. ANS:
   displacement

4. ANS:
   average velocity

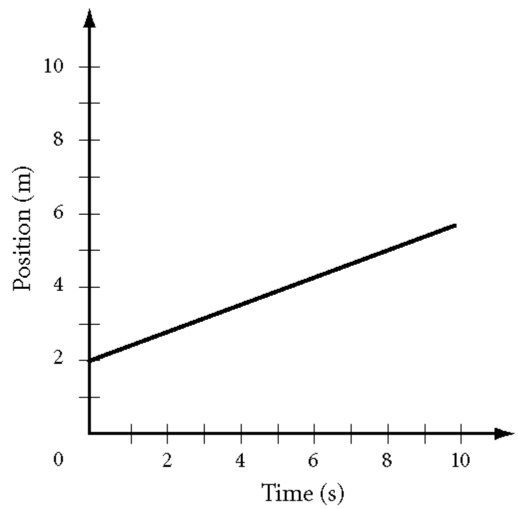
5. ANS:
   The magnitudes of the displacements are equal, but the displacements are in opposite directions. Therefore, one displacement is positive and one displacement is negative.

6. ANS:
   zero

7. ANS:
   The dog is moving at a constant speed because the position versus time graph is a straight line with a positive slope.



8. ANS:
+0.40 m/s



Given

x_i = 2.8 m

x_f = 5.2 m

t_i = 2.0 s

t_f = 8.0 s

Solution

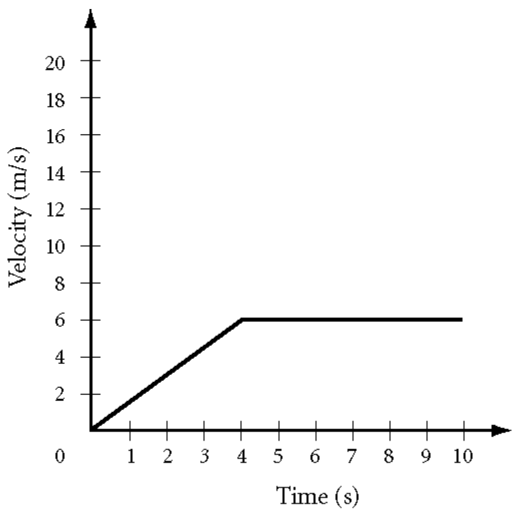
$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} = \frac{5.2\text{ m} - 2.8\text{ m}}{8.0\text{ s} - 2.0\text{ s}} = \frac{2.4\text{ m}}{6.0\text{ s}} = 0.40\text{ m/s}$$

9. ANS:
Calculate the slope of a line drawn tangent to the curve at the point in question.

10. ANS:
meter per second squared

11. ANS:
The unit km/h/s describes how much the velocity changes, measured in km/h, in each second.

12. ANS:
+2.0 m/s



Given
v_i = 0.0 m/s
v_f = 4.0 m/s

Solution

$$v_{avg} = \frac{v_i + v_f}{2} = \frac{0.0\text{ m/s} + 4.0\text{ m/s}}{2} = 2.0\text{ m/s}$$

13. ANS:
The acceleration must be constant.

14. ANS:
9.81 m/s^2

15. ANS:
The length of the vector arrow is proportional to the magnitude of the vector.

16. ANS:
The quantity is a vector quantity.

17. ANS:
resolving the vector

18. ANS:
projectile motion

19. ANS:
The height of the ball’s path would increase.

20. ANS:
The width of the ball's path would decrease.

21. ANS:
The graph of the horizontal component of the velocity versus time is a straight line parallel to the time axis.

22. ANS:
$\mathbf{v}_1$

23. ANS:
force

24. ANS:
Forces exerted by the object do not change its motion.

25. ANS:
magnitude

26. ANS:
A scalar quantity has only magnitude. Force has both magnitude and direction, so it cannot be a scalar quantity.

27. ANS:
The natural condition for a moving object is to remain in motion once it has been set in motion.

28. ANS:
zero

29. ANS:
The acceleration is then zero, and the car moves at a constant velocity.

30. ANS:
The two forces are equal in magnitude and opposite in direction.

31. ANS:
The magnitude of the force of static friction equals the magnitude of the force you exert, and the forces are opposite in direction.

32. ANS:
The coefficient of static friction is larger than the coefficient of kinetic friction for the same two surfaces in contact.

33. ANS:
everyday meaning

34. ANS:
everyday meaning

35. ANS:
negative

36. ANS:
Yes; both the force of the engine and the force of friction are doing work on the car.

37. ANS:
Energy equal in amount to the energy supplied by the engine is lost from the system due to friction.

38. ANS:
Kinetic energy is a scalar quantity.

39. ANS:
The kinetic energy will decrease.

40. ANS:
The potential energy decreases.

41. ANS:
You have to assume that air resistance is negligible.

42. ANS:
$ME_i = ME_f$

43. ANS:
$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f$

44. ANS:
1.5 cm

45. ANS:
Power is a scalar quantity.

46. ANS:
When a machine does work on an object, energy is transferred to that object.

PTS: 1 DIF: II OBJ: 5-4.3

47. ANS:
The skater's momentum increases.

48. ANS:
The student has the least momentum when dodging the opening door.

49. ANS:
Stopping a falling egg requires changing the momentum of the egg from its value at the time of first impact to zero. If the egg hits the concrete, the time interval over which this happens is very small, so the force is large. If the egg lands on grass, the time interval over which the momentum changes is larger, so the force on the egg is smaller.

50. ANS:
The total momentum remains zero, and the total kinetic energy of the system does not change.

PTS: 1 DIF: I OBJ: 6-3.2

PROBLEM

1. ANS:
10^{51} protons; 3.57×10^{51} protons

Given

$m_{Earth} = 5.98 \times 10^{24}$ kg

$m_{proton} = 1.673 \times 10^{-27}$ kg

Solution

Using an order-of-magnitude calculation, the proton number estimate is

$$\frac{\left(10^{24}\text{ kg}\right)}{\left(10^{-27}\text{ kg/proton}\right)} = 10^{51}\text{ protons.}$$

The exact proton number is $\left(5.98 \times 10^{24}\text{ kg}\right)\left(\frac{1\text{ proton}}{1.673 \times 10^{-27}\text{ kg}}\right) = 3.57 \times 10^{51}$ protons.

2. ANS:
10^{4} Earths; 1.17×10^{4} Earths

Given

$R_{Earth} = 6.37 \times 10^{6}$ m

$Average\ Earth\text{–}sun\ distance = 1.496 \times 10^{11}$ m

N_{Earths} between Earth and the sun = ?

Solution

$Diameter_{Earth} = 2\left(R_{Earth}\right) = (2)\left(6.37 \times 10^{6}\text{ m}\right) = 1.27 \times 10^{7}$ m

Therefore, using an order-of-magnitude calculation, the estimate for the number of Earths that would fit between Earth and the sun is $\frac{\left(10^{11}\text{ m}\right)}{\left(10^{7}\text{ m}\right)} = 10^{4}$.

The exact number of Earths is $\frac{\left(1.496 \times 10^{11}\text{ m}\right)}{(2)\left(6.37 \times 10^{6}\text{ m}\right)} = 1.17 \times 10^{4}$.

3. ANS:

3.5×10^8 kg

Given

$N_{leaves/tree} = 7500$ leaves/tree

$m_{leaf} = 1.7$ g/leaf

$size_{forest} = 135\,000$ acres

$N_{trees/acre} = 206$ trees/acre

Solution

Use dimensional analysis to determine mass of leaves in grams dropped on the forest floor each autumn.

$m_{leaves\ dropped\ each\ fall} = (size_{forest})(N_{trees/acre})(N_{leaves/tree})(m_{leaf})$

$= (135\,000 \text{ acres})(206 \text{ trees/acre})(7500 \text{ leaves/tree})(1.7 \text{ g/leaf}) = 3.5 \times 10^{11}$ g

Convert grams of leaves to kilograms.

$$\left(3.5 \times 10^{11} \text{ g}\right)\left(\frac{1 \text{ kg}}{10^3 \text{ g}}\right) = 3.5 \times 10^8 \text{ kg}$$

4. ANS:
3.1 km, north

Given
$v_{avg,1} = -4.1$ km/h
$\Delta t_1 = 1.2$ h
$v_{avg,2} = 4.7$ km/h
$\Delta t_2 = 1.7$ h

Solution
$\Delta x = \Delta x_1 + \Delta x_2 = v_{avg,1}\Delta t_1 + v_{avg,2}\Delta t_2$
$\Delta x = (-4.1 \text{ km/h})(1.2 \text{ h}) + (4.7 \text{ km/h})(1.7 \text{ h})$
$\Delta x = -4.9 \text{ km/h} + 8.0 \text{ km/h} = +3.1 \text{ km} = 3.1$ km, north

5. ANS:
0.33 m/s

Given
$x_i = 0.0$ m
$x_f = 3.0$ m
$t_i = 0.0$ s
$t_f = 9.0$ s

Solution

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} = \frac{3.0\text{ m} - 0.0\text{ m}}{9.0\text{ s} - 0.0\text{ s}} = 0.33\text{ m/s}$$

6. ANS:
   7.5×10^{-2} m/s, south

   Given
   x_i = 2.0 m
   x_f = 0.5 m
   t_i = 0.0 s
   t_f = 20.0 s

   Solution
   $$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} = \frac{0.5\text{ m} - 2.0\text{ m}}{20.0\text{ s} - 0.0\text{ s}} = \frac{-1.5\text{ m}}{20.0\text{ s}} = -7.5 \times 10^{-2}\text{ m/s}$$

   $$v_{avg} = 7.5 \times 10^{-2}\text{ m/s, south}$$

7. ANS:
   2.5 m/s

   Given
   v_i = 2.9 m/s
   a = –3.00 m/s^2
   Δx = 0.38 m

   Solution
   $$v_f^{\,2} = v_i^{\,2} + 2a\Delta x$$

   $$v_f = \sqrt{v_i^{\,2} + 2a\Delta x} = \sqrt{(2.9\text{ m/s})^2 + 2(-3.00\text{ m/s}^2)(0.38\text{ m})}$$

   $$v_f = \sqrt{8.4\text{ m}^2/\text{s}^2 - 2.3\text{ m}^2/\text{s}^2} = \sqrt{6.1\text{ m}^2/\text{s}^2}$$

   $$v_f = 2.5\text{ m/s}$$

8. ANS:
   at least 0.20 m

   Given
   $a = -g = -9.81$ m/s^2
   Δt = 0.20 s
   v_i = 0.0 m/s

   Solution
   $$\Delta x = v_i \Delta t + \tfrac{1}{2} a (\Delta t)^2$$

   $$\Delta x = (0\text{ m/s})(0.20\text{ s}) + \tfrac{1}{2}(-9.81\text{ m/s}^2)(0.20\text{ s})^2 = -0.20\text{ m}$$

9. ANS:
32.9 m

Given
$a = -g = -9.81 \text{ m/s}^2$
$v_i = 25.4 \text{ m/s}$
$\Delta t = 2.65 \text{ s}$

Solution

$$\Delta x = v_i \Delta t + \tfrac{1}{2} a(\Delta t)^2$$

$$\Delta x = (25.4 \text{ m/s})(2.65 \text{ s}) + \tfrac{1}{2}(-9.81 \text{ m/s}^2)(2.65 \text{ s})^2$$

$$\Delta x = 67.3 \text{ m} - 34.4 \text{ m}$$

$$\Delta x = 32.9 \text{ m}$$

10. ANS:
2.1 m

Given
$a = -g = -9.81 \text{ m/s}^2$
$v_i = 6.4 \text{ m/s}$
$v_f = 0.0 \text{ m/s}$

Solution
$$v_f^{\,2} = v_i^{\,2} + 2a\Delta x$$

$$\Delta x = \frac{v_f^{\,2} - v_i^{\,2}}{2a} = \frac{(0.0 \text{ m/s})^2 - (6.4 \text{ m/s})^2}{(2)(-9.81 \text{ m/s}^2)} = 2.1 \text{ m}$$

11. ANS:
24.7 m/s

Given
$a = -g = -9.81 \text{ m/s}^2$
$\Delta x = -7.58 \text{ m}$
$\Delta t = 5.32 \text{ s}$

Solution
$$\Delta x = v_i \Delta t + \tfrac{1}{2} a(\Delta t)^2$$

$$v_i = \frac{\Delta x}{\Delta t} - \frac{1}{2} a\Delta t = \frac{-7.58 \text{ m}}{5.32 \text{ s}} - \frac{(-9.81 \text{ m/s}^2)(5.32 \text{ s})}{2}$$

$$v_i = -1.42 \text{ m/s} + 26.1 \text{ m/s} = 24.7 \text{ m/s}$$

12. ANS:

15.0 blocks

Solution
Students should use graphical techniques. Their answers can be checked using the techniques presented in Section 2.

$$d = \sqrt{(12.0\ \text{blocks})^2 + (9.0\ \text{blocks})^2} = 15.0\ \text{blocks}$$

13. ANS:
16.2 m

Solution
Students should use graphical techniques. Their answers can be checked using the techniques presented in Section 2.

$$d = \sqrt{(16.0\ \text{m})^2 + (2.4\ \text{m})^2}$$

$$d = \sqrt{256\ \text{m}^2 + 5.8\ \text{m}^2}$$

$$d = \sqrt{262\ \text{m}^2}$$

$$d = 16.2\ \text{m}$$

14. ANS:
7.3 m at 72° north of east

Given
$\mathbf{d_1}$ = 2.3 m east = +2.3 m
$\mathbf{d_2}$ = 7.0 m north = +7.0 m

Solution

$$\Delta x = d_1 = 2.3\ \text{m}$$

$$\Delta y = d_2 = 7.0\ \text{m}$$

$$d^2 = \Delta x^2 + \Delta y^2$$

$$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(2.3\ \text{m})^2 + (7.0\ \text{m})^2}$$

$$d = \sqrt{5.3\ \text{m}^2 + 49\ \text{m}^2}$$

$$d = \sqrt{54\ \text{m}^2}$$

$$d = 7.3\ \text{m}$$

$$\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{7.0\ \text{m}}{2.3\ \text{m}}\right) = 72°$$

$$\mathbf{d} = 7.3\ \text{m at } 72° \text{ north of east}$$

15. ANS:
2020 km, 35.3° south of west

Given
$\mathbf{d}_1$ = 1650 km west = –1650 km
$\mathbf{d}_2$ = 1170 km south = –1170 km

Solution
$$\Delta x = d_1 = -1650\text{ km}$$
$$\Delta y = d_2 = -1170\text{ km}$$
$$d^2 = \Delta x^2 + \Delta y^2$$
$$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(-1.65 \times 10^3\text{ km})^2 + (-1.17 \times 10^3\text{ km})^2}$$
$$d = \sqrt{2.72 \times 10^6\text{ km}^2 + 1.37 \times 10^6\text{ km}^2}$$
$$d = 2.02 \times 10^3\text{ km} = 2020\text{ km}$$
$$\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{-1170\text{ km}}{-1650\text{ km}}\right) = 35.3°$$
d = 2020 km at 35.3° south of west

16. ANS:
66.5 m at 83.4° south of east

Given
$\mathbf{d}_1$ = 66.0 m south = –66.0 m
$\mathbf{d}_2$ = 7.60 m east = +7.60 m

Solution
$$\Delta x = d_2 = 7.60\text{ m}$$
$$\Delta y = d_1 = -66.0\text{ m}$$
$$d^2 = \Delta x^2 + \Delta y^2$$
$$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(7.60\text{ m})^2 + (-66.0\text{ m})^2}$$
$$d = \sqrt{57.8\text{ m}^2 + 4360\text{ m}^2}$$
$$d = \sqrt{4420\text{ m}^2}$$
$$d = 66.5\text{ m}$$
$$\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{-66.0\text{ m}}{7.60\text{ m}}\right) = -83.4°$$
d = 66.5 m at 83.4° south of east

17. ANS:
72 m

Given
d = 170 m, θ = 65.0°

Solution

$d_x = d\cos\theta = (170\text{ m})(\cos 65.0°)$

$d_x = (170\text{ m})(0.423)$

$d_x = 72\text{ m}$

18. ANS:

d_x = 40.1 m, d_y = –8.53 m

Given

d = 41.0 m, θ = –12.0°

Solution

$d_x = d\cos\theta = (41.0\text{ m})(\cos(-12.0°))$

$d_x = (41.0\text{ m})(0.978)$

$d_x = 40.1\text{ m}$

$d_y = d\sin\theta = (41.0\text{ m})(\sin(-12.0°))$

$d_y = (41.0\text{ m})(-0.208)$

$d_y = -8.53\text{ m}$

19. ANS:

12.92 m

Given

d_1 = 10.3 m at 57.0° north of west

d_2 = 4.00 m west

d_1 = 10.3 m θ_1 = 57.0°

d_2 = 4.00 m θ_2 = 0.0°

Solution

$\Delta x_1 = d_1 \cos \theta_1 = (10.3\text{ m})(\cos\ 57.0°)$

$\Delta x_1 = (10.3\text{ m})(0.545)$

$\Delta x_1 = 5.61\text{ m}$

$\Delta y_1 = d_1 \sin \theta_1 = (10.0\text{ m})(\sin\ 57.0°)$

$\Delta y_1 = (10.3\text{ m})(0.839)$

$\Delta y_1 = 8.64\text{ m}$

$\Delta x_2 = 4.00\text{ m}$

$\Delta y_2 = 0.00\text{ m}$

$\Delta x_{tot} = \Delta x_1 + \Delta x_2 = -5.61\text{ m} + 4.00\text{ m} = 9.61\text{ m}$

$\Delta y_{tot} = \Delta y_1 + \Delta y_2 = 8.64\text{ m} + 0.00\text{ m} = 8.64\text{ m}$

$d^2 = (\Delta x_{tot})^2 + (\Delta y_{tot})^2$

$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(9.61\text{ m})^2 + (8.64\text{ m})^2}$

$d = \sqrt{92.4\text{ m}^2 + 74.6\text{ m}^2}$

$d = \sqrt{167\text{ m}^2}$

$d = 12.92\text{ m}$

20. ANS:
2.87 m at 50.4° north of east

Given
$d_1 = 1.35\text{ m}$ $\quad \theta_1 =$ 22.0° south of east = –22.0°
$d_2 = 2.78\text{ m}$ $\quad \theta_2 =$ 78.0° north of east = +78.0°

Solution

$$\Delta x_1 = d_1 \sin \theta_1 = (1.35)(\cos(-22.0°))$$

$$\Delta x_1 = d_1 \sin \theta_1 = (1.35)(0.927)$$

$$\Delta x_1 = 1.25 \text{ m}$$

$$\Delta y_1 = d_1 \cos \theta_1 = (1.35 \text{ m})(\sin(-22.0°))$$

$$\Delta y_1 = (1.35 \text{ m})(-0.375)$$

$$\Delta y_1 = -0.510 \text{ m}$$

$$\Delta x_2 = d_2 \cos \theta_2 = (2.78 \text{ m})(\cos 78.0°)$$

$$\Delta x_2 = (2.78 \text{ m})(0.208)$$

$$\Delta x_2 = 0.578 \text{ m}$$

$$\Delta y_2 = d_2 \sin \theta_2 = (2.78 \text{ m})(\sin 78.0°)$$

$$\Delta y_2 = (2.78 \text{ m})(0.978)$$

$$\Delta y_2 = 2.72 \text{ m}$$

$$\Delta x_{tot} = \Delta x_1 + \Delta x_2 = 1.25 \text{ m} + 0.578 \text{ m} = 1.83 \text{ m}$$

$$\Delta y_{tot} = \Delta y_1 + \Delta y_2 = -0.510 \text{ m} + 2.72 \text{ m} = 2.21 \text{ m}$$

$$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(1.83 \text{ m})^2 + (2.21 \text{ m})^2}$$

$$d = \sqrt{3.35 \text{ m}^2 + 4.88 \text{ m}^2}$$

$$d = 2.87 \text{ m}$$

$$\theta = \tan^{-1}\left(\frac{2.21 \text{ m}}{1.83 \text{ m}}\right) = 50.4°$$

d = 2.87 m at 50.4° north of east

21. ANS:
148 m

Given
$\mathbf{v}_i$ = 15 m/s at 30.0° above the horizontal
Δt = 6.30 s
g = 9.81 m/s^2

Solution

$$v_{i,y} = v_i \sin \theta = (15 \text{ m/s})(\sin 30.0°) = 7.5 \text{ m/s}$$

$$\Delta y = v_{i,y}\Delta t + \tfrac{1}{2} a_y(\Delta t)^2 = (7.5 \text{ m/s})(6.30 \text{ s}) + \tfrac{1}{2}(-9.81 \text{ m/s}^2)(6.30 \text{ s})^2$$

$$\Delta y = 47 \text{ m} - 195 \text{ m} = -148 \text{ m}$$

$$h = 148 \text{ m}$$

22. ANS:

3.31×10^2 m

Given
$\mathbf{v}$ = 70.0 m/s horizontally
Δy = −110.0 m

Solution

$$v_{i,x} = v_x = 70.0 \text{ m/s}$$

$$v_{i,y} = 0$$

$$\Delta y = \tfrac{1}{2} a_y (\Delta t)^2$$

$$(\Delta t)^2 = \frac{2\Delta y}{a_y}$$

$$\Delta t = \sqrt{\frac{2\Delta y}{a_y}} = \sqrt{\frac{2(-110.0 \text{ m})}{(-9.81 \text{ m/s}^2)}} = \sqrt{22.4 \text{ s}^2} = 4.73 \text{ s}$$

$$\Delta x = v_x \Delta t = (70.0 \text{ m/s})(4.73 \text{ s}) = 3.31 \times 10^2 \text{ m}$$

23. ANS:
3.4 m/s

Given
$v_{carrion} = v_c$ = 1.3 m/s horizontally
Δy = −14.0 m
d = 8.0 m

Solution

$$\Delta x_{fox} = d - \Delta x_c$$

$$\Delta x_{fox} = v_{fox} \Delta t$$

$$\Delta x_c = v_c \Delta t$$

$$v_{fox} \Delta t = d - v_c \Delta t$$

$$v_{fox} = \frac{d}{\Delta t} - v_c$$

$$\Delta y_c = \tfrac{1}{2} a_y (\Delta t)^2$$

$$(\Delta t)^2 = \frac{2\Delta y_c}{a_y}$$

$$\Delta t = \sqrt{\frac{2\Delta y_c}{a_y}} = \sqrt{\frac{2(-14.0 \text{ m})}{(-9.81 \text{ m/s}^2)}} = \sqrt{2.85 \text{ s}^2} = 1.69 \text{ s}$$

$$v_{fox} = \frac{d}{\Delta t} - v_c = \frac{8.0 \text{ m}}{1.69 \text{ s}} - 1.3 \text{ m/s} = 4.7 \text{ m/s} - 1.3 \text{ m/s} = 3.4 \text{ m/s}$$

24. ANS:

7 cm

Given
$\Delta y = -29$ m
$v_x = 5$ cm/s
$\Delta t = 1.1$ s

Solution
$\Delta x = v_x \Delta t_2$

$\Delta t_2 = \Delta t_1 - \Delta t$

$\Delta y = \frac{1}{2} a_y (\Delta t_1)^2$

$$\Delta t_1 = \sqrt{\frac{2\Delta y}{a_y}} = \sqrt{\frac{2(-29\text{ m})}{(-9.81\text{ m/s}^2)}} = \sqrt{5.9\text{ s}^2} = 2.4\text{ s}$$

$\Delta t_2 = 2.4\text{ s} - 1.1\text{ s} = 1.3\text{ s}$

$\Delta x = v_x \Delta t_2 = (5\text{ cm/s})(1.3\text{ s}) = 7\text{ cm}$

25. ANS:
23 km/h north

Given
$\mathbf{v_{pg}}$ = velocity of plane to ground = 106 km/h south
$\mathbf{v_{pa}}$ = velocity of plane to air = 129 km/h south

Solution
$v_{pg} = v_{pa} + v_{ag}$

$v_{ag} = v_{pg} - v_{pa}$

$v_{ag} = 106\text{ km/h} - 129\text{ km/h} = -23\text{ km/h}$

$v_{ag} = 23$ km/h north

26. ANS:
5.34×10^2 s

Given
$\mathbf{v_{rg}}$ = velocity of river to ground = 9.00 m/s downstream
$\mathbf{v_{br}}$ = velocity of boat to river = 12.00 m/s
Δx_1 = 1400.0 m downstream
Δx_2 = −1400.0 m downstream

Solution
downstream
$\mathbf{v_{bg}}$ = velocity of boat to ground = $\mathbf{v_{br}} + \mathbf{v_{rg}}$

$v_{bg} = 12.00\text{m/s} + 9.00\text{ m/s} = 21.00\text{ m/s}$

$$\Delta t_1 = \frac{\Delta x_1}{v_{bg}} = \frac{1400.0 \text{ m}}{21.00 \text{ m/s}} = 66.67 \text{ s}$$

upstream

$\mathbf{v}_{bg} = \mathbf{v}_{br} + \mathbf{v}_{rg}$

$$v_{bg} = -12.00 \text{ m/s} + 9.00 \text{ m/s} = -3.00 \text{ m/s}$$

$$\Delta t_2 = \frac{\Delta x_2}{v_{bg}} = \frac{-1400.0 \text{ m}}{-3.00 \text{ m/s}} = 467 \text{ s}$$

$$\Delta t = \Delta t_1 + \Delta t_2 = 66.67 \text{ s} + 467 \text{ s} = 5.34 \times 10^2 \text{ s}$$

27. ANS:
0.649 m/s opposite the direction of the moving sidewalk

Given

$\mathbf{v}_{bj}$ = horizontal velocity of ball relative to the juggler's hand = 0.0 m/s

$\mathbf{v}_{jw}$ = velocity of juggler's hand relative to the walkway = +1.20 m/s

$\mathbf{v}_{wg}$ = velocity of walkway relative to the ground = +0.50 m/s

Δy = distance that ball falls from top of path = –3.60 m

Δx_{bO} = width of parabola noticed by observer = +1.80 m

Solution

$\mathbf{v}_{bg} = \mathbf{v}_{bj} + \mathbf{v}_{jw} + \mathbf{v}_{wg}$

$\Delta x_{bg} = v_{bg}\Delta t$

$$v_{bg} = (0.0 \text{ m/s}) + (1.20 \text{ m/s}) + (0.50 \text{ m/s}) = 1.70 \text{ m/s}$$

$$\Delta t = 2\Delta t_1 = 2\sqrt{\frac{2\Delta y}{a_y}} = 2\sqrt{\frac{2(-3.60 \text{ m})}{(-9.81 \text{ m/s}^2)}} = 2\sqrt{0.734 \text{ s}^2} = 1.71 \text{ s}$$

$$\Delta x_{bg} = v_{bg}\Delta t = (1.70 \text{ m/s})(1.71 \text{ s}) = 2.91 \text{ m}$$

$$\Delta x_{bO} = \text{horizontal displacement of ball to observer} = \Delta x_{bg} + \Delta x_{Og}$$

$$\Delta x_{Og} = \Delta x_{bO} - \Delta x_{bg} = 1.80 \text{ m} - 2.91 \text{ m} = -1.11 \text{ m}$$

$$v_{Og} = \frac{\Delta x_{Og}}{\Delta t} = \frac{-1.11 \text{ m}}{1.71 \text{ s}} = -0.649 \text{ m/s}$$

v_{Og} = 0.649 m/s opposite the direction of the moving sidewalk

28. ANS:
4.9 m/s^2, upward

Given

$F_{applied,y}$ = 397 N

F_g = 265 N

m = 27 kg

Solution

$$\Sigma F_y = F_{applied,y} - F_g = ma$$

$$a = \frac{F_{applied,y} - F_g}{m} = \frac{397\text{ N} - 265\text{ N}}{27\text{ kg}} = 4.9\text{ m/s}^2$$

a $= 4.9\text{ m/s}^2$, upward

29. ANS:

0.484 m/s^2

Given

$F_{applied} = 111\text{ N}$

$\theta = 53.0°$

$m_1 = 83.0\text{ kg}$

$m_2 = 55.0\text{ kg}$

Solution

$$\Sigma F_x = F_{applied,x} = m_T a_x$$

$$F_{applied,x} = F_x \cos\theta \qquad m_T = m_1 + m_2$$

$$a_x = \frac{F_x \cos\theta}{m_1 + m_2} = \frac{(111\text{ N})(\cos 53.0°)}{(83.0\text{kg} + 55.0\text{ kg})}$$

$$a_x = \frac{F_x \cos\theta}{m_1 + m_2} = \frac{(111\text{ N})(0.602)}{(83.0\text{kg} + 55.0\text{ kg})}$$

$$a_x = 0.484\text{ m/s}^2$$

30. ANS:

3.46×10^5 N

Given

$F_g = 2.58 \times 10^5$ N

$g = 9.81\text{ m/s}^2$

$a = +3.33\text{ m/s}^2$

Solution

$$F_{net} = F_T - F_g = ma = \frac{F_g}{g}a$$

$$F_T = F_g + \frac{F_g}{g}a$$

$$F_T = 2.58 \times 10^5\text{ N} + \frac{(2.58 \times 10^5\text{ N})(3.33\text{ m/s}^2)}{9.81\text{ m/s}^2}$$

$$F_T = 2.58 \times 10^5\text{ N} + 8.76 \times 10^4\text{ N}$$

$$= 3.46 \times 10^5\text{ N}$$

31. ANS:
14 N, upward

Given
$F_{g,1} = 6$ N
$F_{g,2} = 8$ N
$F_{g,3} = 15$ N

Solution
$F_{net,y} = \Sigma F_y = F_n - F_{g,1} - F_{g,2} = 0$
$F_n = F_{g,1} + F_{g,2} = 6\text{ N} + 8\text{ N} = 14\text{ N}$
$\mathbf{F_n}$ = 14 N, upward

32. ANS:
3.9 N

Given
$m = 0.86$ kg
$\mu_k = 0.46$
$g = 9.81\text{ m/s}^2$

Solution
$F_{net,y} = F_n - F_g = 0$

$F_n = F_g$

$F_{net,x} = F_{applied} - F_f = 0$

$F_{applied} = F_f$

$F_f = \mu_k F_n = \mu_k F_g = \mu_k mg = (0.46)(0.86\text{ kg})(9.81\text{ m/s}^2) = 3.9\text{ N}$

$F_{applied} = F_f = 3.9\text{ N}$

33. ANS:
0.131

Given
$m = 1.00 \times 10^2$ kg
$a_x = 0.79\text{ m/s}^2$
$\theta = 12.0°$
$g = 9.81\text{ m/s}^2$

Solution

$$\Sigma F_y = F_N - F_{g,y} = 0$$

$$F_N = F_{g,y} = mg\cos\theta$$

$$\Sigma F_x = F_{g,x} - F_f = F_{net,x} = ma_x$$

$$F_f = F_{g,x} - ma_x$$

$$F_f = \mu_k F_N = \mu_k mg\cos\theta$$

$$F_{g,x} - ma_x = \mu_k mg\cos\theta$$

$$F_{g,x} = mg\sin\theta$$

$$\mu_k = \frac{F_{g,x} - ma_x}{mg\cos\theta} = \frac{mg\sin\theta - ma_x}{mg\cos\theta} = \frac{\sin\theta}{\cos\theta} - \frac{a_x}{g\cos\theta}$$

$$\mu_k = \frac{\sin 12.0°}{\cos 12.0°} - \frac{0.79\ \text{m/s}^2}{(9.81\ \text{m/s}^2)(\cos 12.0°)}$$

$$\mu_k = \frac{0.208°}{0.978} - \frac{0.79\ \text{m/s}^2}{(9.81\ \text{m/s}^2)(0.978)}$$

$$\mu_k = 0.213 - 0.082$$

$$\mu_k = 0.131$$

34. ANS:
348 J

Given
$F = 87.0\ \text{N}$

$d = 4.00\ \text{m}$

Solution
$W = Fd = (87.0\ \text{N})(4.00\ \text{m}) = 348\ \text{J}$

35. ANS:
52 J

Given
$F_w = 40.0\ \text{N}$

$F_k = 27\ \text{N}$

$d = 4.0\ \text{m}$

Solution
$$W_{net} = F_{net}d = \left(F_w - F_k\right)d = [40.0\ \text{N} - 27\ \text{N}](4.0\ \text{m})$$

$$W_{net} = (13\ \text{N})(4.0\ \text{m}) = 52\ \text{J}$$

36. ANS:
2040 J

Given

$F = 21.0\ \text{N}$

$d = 239.0\ \text{m}$

$\theta = 66.0°$

Solution

$W = Fd\cos\theta = (21.0\ \text{N})(239.0\ \text{m})(\cos 66.0°)$

$W = (21.0\ \text{N})(239.0\ \text{m})(0.407)$

$W = 2.04 \times 10^3\ \text{J}$

37. ANS:
6.2 m/s

Given

$v_i = 0\ \text{m/s}$

$F_g = 43.0\ \text{N}$

$\theta = 30.0°$

$d = 7.6\ \text{m}$

$F_k = -5.0\ \text{N}$

$g = 9.81\ \text{m/s}^2$

Solution

$$W_{net} = \Delta KE$$

$$W_{net} = F_{net}d = \left(F_g \sin\theta - F_k\right)d$$

$$\Delta KE = KE_f - KE_i = \tfrac{1}{2}mv_f^{\,2} - 0 = \tfrac{1}{2}mv_f^{\,2}$$

$$F_g = mg$$

$$m = \frac{F_g}{g}$$

$$\left(F_g \sin\theta + F_k\right)d = \tfrac{1}{2}mv_f^{\,2} = \tfrac{1}{2}\left(\frac{F_g}{g}\right)v_f^{\,2}$$

$$v_f = \sqrt{\frac{2dg\left(F_g \sin\theta + F_k\right)}{F_g}}$$

$$v_f = \sqrt{\frac{(2)(5.0\text{ m})(9.81\text{ m/s}^2)\left[(43.0\text{ N})(\sin 30.0°) + (-5.0)\right]}{43.0\text{ N}}}$$

$$v_f = \sqrt{\frac{(2)(5.0\text{ m})(9.81\text{ m/s}^2)[16.5\text{ N}]}{43.0\text{ N}}}$$

$$v_f = \sqrt{38\text{ m}^2/\text{s}^2}$$

$$v_f = 6.2\text{ m/s}$$

38. ANS:
3.9×10^{3} J

Given
$m = 84$ kg

$h = 32$ m

$g = 9.81$ m/s^2

Solution
$$PE = mgh = \left(84\text{ kg}\right)\left(9.81\text{ m/s}^2\right)(4.7\text{ m}) = 3.9 \times 10^3\text{ J}$$

39. ANS:
237 J

Given
$F_g = mg = 3.62 \times 10^2$ N

$d = 2.53$ m

$\theta = 15.0°$

Solution

$h = d\sin\theta$

$PE = mgh = F_g d\sin\theta = \left(3.62\times10^2\ \text{N}\right)(2.53\ \text{m})(\sin 15.0°)$

$PE = \left(3.62\times10^2\ \text{N}\right)(2.53\ \text{m})(0.259)$

$PE = 237\ \text{J}$

40. ANS:
30.4 m/s

Given

$h = 47.1\ \text{m}$

$g = 9.81\ \text{m/s}^2$

Solution

$KE_i = PE_{g,f}$

$\frac{1}{2}mv_i{}^2 = mgh$

$v_i = \sqrt{2gh} = \sqrt{(2)\left(9.81\ \text{m/s}^2\right)(47.1\text{m})}$

$v_i = \sqrt{924\ \text{m}^2/\text{s}^2}$

$v_i = 30.4\ \text{m/s}$

41. ANS:
57 m/s

Given

$h = 170\ \text{m}$

$g = 9.81\ \text{m/s}^2$

Solution

$KE_f = PE_{g,i}$

$\frac{1}{2}mv_f{}^2 = mgh$

$v_f = \sqrt{2gh} = \sqrt{(2)\left(9.81\ \text{m/s}^2\right)(170\ \text{m})}$

$v_f = \sqrt{3300\ \text{m}^2/\text{s}^2}$

$v_f = 57\ \text{m/s}$

42. ANS:
0.75 m/s

Given

$h = 2.9 \text{ cm} = 2.9 \times 10^{-2} \text{ m}$

$g = 9.81 \text{ m/s}^2$

Solution

$ME_i = ME_f$

$mgh_i = \frac{1}{2} m v_f^{\,2}$

$v_f = \sqrt{2gh} = \sqrt{(2)\left(9.81 \text{ m/s}^2\right)\left(2.9 \times 10^{-2} \text{ m}\right)}$

$v_f = \sqrt{2gh} = \sqrt{5.7 \times 10^{-1} \text{ m}^2/\text{s}^2}$

$v_f = 0.75 \text{ m/s}$

43. ANS:
2.7 kW

Given

$m = 260 \text{ kg}$

$d = 1.9 \text{ m}$

$\Delta t = 1.8 \text{ s}$

$g = 9.81 \text{ m/s}^2$

Solution

$$P = \frac{W}{\Delta t} = \frac{Fd}{\Delta t} = \frac{mgd}{\Delta t} = \frac{(260 \text{ kg})\left(9.81 \text{ m/s}^2\right)(1.9 \text{ m})}{1.8 \text{ s}} = 2.7 \times 10^3 \text{ W} = 2.7 \text{ kW}$$

44. ANS:
They have the same momentum. $\left(4.36 \times 10^4 \text{ kg} \bullet \text{m/s}\right)$

Given

$m_1 = 5450 \text{ kg}$

$v_1 = 8.00 \text{ m/s}$

$m_2 = 2725 \text{ kg}$

$v_2 = 16.0 \text{ m/s}$

Solution

$p_1 = m_1 v_1 = (5450 \text{ kg})(8.00 \text{ m/s}) = 4.36 \times 10^4 \text{ kg} \bullet \text{m/s}$

$p_2 = m_2 v_2 = (2725 \text{kg})(16.0 \text{ m/s}) = 4.36 \times 10^4 \text{ kg} \bullet \text{m/s}$

$p_1 = p_2$

45. ANS:
$708 \text{ kg} \bullet \text{m/s}$ downward

Given

$m = 56.0\ \text{kg}$

$\Delta t = 1.29\ \text{s}$

$\mathbf{p_i} = 0\ \text{kg} \bullet \text{m/s upward}$

$\mathbf{g} = 9.81\ \text{m/s}^2 \text{downward} = -9.81\ \text{m/s}^2$

Solution

$\mathbf{F} = m\mathbf{g} = (56.0\ \text{kg})(-9.81\ \text{m/s}^2) = -549\ \text{N} = 549\ \text{N downward}$

$\mathbf{F}\Delta t = \Delta\mathbf{p} = \mathbf{p_f} - \mathbf{p_i}$

$\mathbf{p_f} = \mathbf{F}\Delta t + \mathbf{p_i} = (-549\ \text{N})(1.29\ \text{s}) + (0\ \text{kg} \bullet \text{m/s}) = -708\ \text{kg} \bullet \text{m/s}$

$\mathbf{p_f} = 708\ \text{kg} \bullet \text{m/s downward}$

46. ANS:
9×10^{-4} J

Given

$m = 7\ \text{g} = 7 \times 10^{-3}\ \text{kg}$

$v_i = 0.5\ \text{m/s}$

$v_f = 0\ \text{m/s}$

Solution

$KE_i = \frac{1}{2} m v_i^2 = \frac{1}{2}(7 \times 10^{-3}\ \text{kg})(0.5\ \text{m/s})^2 = 9 \times 10^{-4}\ \text{J}$

$KE_f = \frac{1}{2} m v_f^2 = \frac{1}{2}(7 \times 10^{-3}\ \text{kg})(0\ \text{m/s})^2 = 0\ \text{J}$

$\Delta KE = KE_i - KE_f = 9 \times 10^{-4}\ \text{J} - 0\ \text{J} = 9 \times 10^{-4}\ \text{J}$

47. ANS:
3.0×10^{4} J

Given

$m_1 = 5.3 \times 10^3\ \text{kg}$

$m_2 = 1.7 \times 10^2\ \text{kg}$

$v_{1,i} = 16\ \text{m/s}$

$v_{2,i} = 0\ \text{m/s}$

$v_f = 10.4\ \text{m/s}$

Solution

$$KE_i = \frac{1}{2}m_1 v_{1,i}^{\ 2} + \frac{1}{2}m_2 v_{2,i}^{\ 2} = \frac{1}{2}\left(5.3\times10^3\ \text{kg}\right)(16\ \text{m/s})^2 + \frac{1}{2}\left(1.7\times10^2\ \text{kg}\right)(0\ \text{m/s})^2 = 6.8\times10^5\ \text{J}$$

$$KE_f = \frac{1}{2}\left(m_1 + m_2\right)v_f^{\ 2} = \frac{1}{2}\left(5.3\times10^3\ \text{kg} + 1.7\times10^3\ \text{kg}\right)(10.4\ \text{m/s})^2$$

$$KE_f = \frac{1}{2}\left(7.0\times10^3\ \text{kg}\right)(10.4\ \text{m/s})^2$$

$$KE_f = 3.8\times10^5\ \text{J}$$

$$\Delta KE = KE_i - KE_f = 6.8\times10^5\ \text{J} - 3.8\times10^5\ \text{J} = 3.0\times10^4\ \text{J}$$

48. ANS:
4.0 J

Given

$m_1 = 0.48\ \text{kg}$

$m_2 = 3.04\ \text{kg}$

$v_{1,i} = 4.08\ \text{m/s}$

$v_{2,i} = 0\ \text{m/s}$

Solution

$$KE_i = \frac{1}{2}m_1 v_{1,i}^{\ 2} + \frac{1}{2}m_2 v_{2,i} = \frac{1}{2}\left(0.48\ \text{kg}\right)(4.08\ \text{m/s})^2 + \frac{1}{2}\left(3.04\ \text{kg}\right)(0\ \text{m/s})^2 = 4.0\ \text{J}$$

$$KE_f = \frac{1}{2}\left(m_1 + m_2\right)v_f^{\ 2} = \frac{1}{2}\left(0.48\ \text{kg} + 3.04\ \text{kg}\right)(0\ \text{m/s})^2 = 0\ \text{J}$$

$$\Delta KE = KE_i - KE_f = 4.0\ \text{J} - 0\ \text{J} = 4.0\ \text{J}$$

49. ANS:
0.23 m/s forward

Given

$m_1 = 0.12\ \text{kg}$

$m_2 = 0.18\ \text{kg}$

$\mathbf{v_{2,i}} = 0\ \text{m/s}$

$\mathbf{v_{1,f}} = 0.048\ \text{m/s backward},\ v_{1,f} = -0.048\ \text{m/s}$

$\mathbf{v_{2,f}} = 0.19\ \text{m/s forward},\ v_{2,f} = 0.19\ \text{m/s}$

Solution

$$m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} = m_1\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}}$$

$$\mathbf{v_{1,i}} = \frac{m_1\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}} - m_2\mathbf{v_{2,i}}}{m_1}$$

$$\mathbf{v_{1,i}} = \frac{(0.12\text{kg})(-0.048\text{ m/s}) + (0.18\text{ kg})(0.19\text{ m/s}) - (0.18\text{ kg})(0\text{ m/s})}{0.12\text{ kg}}$$

$$\mathbf{v_{1,i}} = \frac{-5.8 \times 10^{-3}\text{kg} \bullet \text{m/s} + 3.4 \times 10^{-2}\text{ kg} \bullet \text{m/s}}{0.12\text{ kg}}$$

$$\mathbf{v_{1,i}} = \frac{2.8 \times 10^{-2}\text{ kg} \bullet \text{m/s}}{0.12\text{ kg}}$$

$$\mathbf{v_{1,i}} = 0.23\text{ m/s forward}$$

50. ANS:
3.2 m/s to the left

Given

$m_1 = 19\text{ g} = 1.9 \times 10^{-2}\text{ kg}$

$m_2 = 27\text{ g} = 2.7 \times 10^{-2}\text{ kg}$

$\mathbf{v_{1,i}} = 3.4\text{ m/s right}; v_{1,i} = 3.4\text{ m/s}$

$\mathbf{v_{1,f}} = 5.1\text{ m/s left}; v_{1,f} = -5.1\text{ m/s}$

$\mathbf{v_{2,f}} = 2.8\text{ m/s right}; v_{2,f} = 2.8\text{ m/s}$

Solution

$$m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} = m_1\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}}$$

$$\mathbf{v_{2,i}} = \frac{m_1\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}} - m_1\mathbf{v_{1,i}}}{m_2}$$

$$v_{2,i} = \frac{(1.9 \times 10^{-2}\text{ kg})(-5.1\text{ m/s}) + (2.7 \times 10^{-2}\text{ kg})(2.8\text{ m/s}) - (1.9 \times 10^{-2}\text{ kg})(3.4\text{ m/s})}{2.7 \times 10^{-2}\text{ kg}}$$

$$v_{2,i} = \frac{-9.7 \times 10^{-2}\text{ kg} \bullet \text{m/s} + 7.6 \times 10^{-2}\text{ kg} \bullet \text{m/s} - 6.5 \times 10^{-2}\text{ kg} \bullet \text{m/s}}{2.7 \times 10^{-2}\text{ kg}}$$

$$v_{2,i} = \frac{-8.6 \times 10^{-2}\text{ kg} \bullet \text{m/s}}{2.7 \times 10^{-2}\text{ kg}}$$

$$v_{2,i} = -3.2\text{ m/s}$$

$$\mathbf{v_{2,i}} = 3.2\text{ m/s to the left}$$