Exercise 3.17

**Description:** A major leaguer hits a baseball so that it leaves the bat at a speed of \( v_0 \) and at an angle of \( \alpha \) above the horizontal. You can ignore air resistance. (a) At what two times is the baseball at a height of \( h \) above the point at which it left the bat? ...

A major leaguer hits a baseball so that it leaves the bat at a speed of 29.2 m/s and at an angle of 36.0° above the horizontal. You can ignore air resistance.

**Part A**

At what two times is the baseball at a height of 11.1 m above the point at which it left the bat?

*Give your answers in ascending order separated with comma.*

**ANSWER:**

\[
t_1, t_2 = \frac{v_0 \sin(\alpha)}{9.80} - \sqrt{\left(\frac{v_0 \sin(\alpha)}{9.80}\right)^2 - \frac{2h}{9.80} \frac{v_0 \sin(\alpha)}{9.80}} + \sqrt{\left(\frac{v_0 \sin(\alpha)}{9.80}\right)^2 - \frac{2h}{9.80}} = 0.856, 2.65 \text{ s}
\]

**Part B**

Calculate the horizontal component of the baseball's velocity at an earlier time calculated in part (a).

**ANSWER:**

\[
v_x = v_0 \cos(\alpha) = 23.6 \text{ m/s}
\]

**Part C**

Calculate the vertical component of the baseball's velocity at an earlier time calculated in part (a).

**ANSWER:**

\[
v_y = 9.80 \sqrt{\left(\frac{v_0 \sin(\alpha)}{9.80}\right)^2 - \frac{2h}{9.80}} = 8.78 \text{ m/s}
\]
Part E

Calculate the vertical component of the baseball's velocity at a later time calculated in part (a).

ANSWER:

\[ v_y = -9.80 \sqrt{\left(\frac{v_0 \sin (\alpha)}{9.80}\right)^2 - \frac{2h}{9.80}} = -8.78 \text{ m/s} \]

Part F

What is the magnitude of the baseball's velocity when it returns to the level at which it left the bat?

ANSWER:

\[ v = v_0 = 29.2 \text{ m/s} \]

Part G

What is the direction of the baseball's velocity when it returns to the level at which it left the bat?

ANSWER:

\[ \theta = \frac{\alpha \cdot 180}{\pi} = 36.0^\circ \text{ below the horizontal} \]

Exercise 3.18

Description: A shot putter releases the shot some distance above the level ground with a velocity of 12.0 m/s, 51.0 degree(s)above the horizontal. The shot hits the ground 2.08 s later. You can ignore air resistance. (a) What is the x-component of the shot's...

A shot putter releases the shot some distance above the level ground with a velocity of 12.0 m/s, 51.0 ° above the horizontal. The shot hits the ground 2.08 s later. You can ignore air resistance.

Part A

What is the x-component of the shot's acceleration while in flight?

ANSWER:

\[ a_x = 0 \text{ m/s}^2 \]

Part B
What is the \( y \)-component of the shot's acceleration while in flight?

\[ a_y = -9.80 \text{ m/s}^2 \]

**Part C**

What is the \( x \)-component of the shot's velocity at the beginning of its trajectory?

\[ v_{x0} = 7.55 \text{ m/s} \]

**Part D**

What is the \( y \)-component of the shot's velocity at the beginning of its trajectory?

\[ v_{y0} = 9.32 \text{ m/s} \]

**Part E**

What is the \( x \)-component of the shot's velocity at the end of its trajectory?

\[ v_x = 7.55 \text{ m/s} \]

**Part F**

What is the \( y \)-component of the shot's velocity at the end of its trajectory?

Express your answer using four significant figures.

\[ v_y = -11.06 \text{ m/s} \]

**Part G**

How far did she throw the shot horizontally?

\[ x = 15.7 \text{ m} \]
Part H
How high was the shot above the ground when she released it?

ANSWER:
\[ y = 1.81 \text{ m} \]

Exercise 3.19

Description: In a carnival booth, you win a stuffed giraffe if you toss a quarter into a small dish. The dish is on a shelf above the point where the quarter leaves your hand and is a horizontal distance of 2.1 m from this point (the figure). If you toss the coin ...

In a carnival booth, you win a stuffed giraffe if you toss a quarter into a small dish. The dish is on a shelf above the point where the quarter leaves your hand and is a horizontal distance of 2.1 m from this point (the figure). If you toss the coin with a velocity of 6.4 m/s at an angle of 60° above the horizontal, the coin lands in the dish. You can ignore air resistance.

Part A
What is the height of the shelf above the point where the quarter leaves your hand?

Express your answer using two significant figures.

ANSWER:
\[ H = 1.5 \text{ m} \]

Part B
What is the vertical component of the velocity of the quarter just before it lands in the dish?

Express your answer using two significant figures.

ANSWER:
\[ v_y = -0.89 \text{ m/s} \]
Exercise 3.22

Description: A 124-kg balloon carrying a 22-kg basket is descending with a constant downward velocity of \( v_b \). A 1.0-kg stone is thrown from the basket with an initial velocity of \( v_0 \) perpendicular to the path of the descending balloon, as measured...

A 124-kg balloon carrying a 22-kg basket is descending with a constant downward velocity of 23.5 m/s. A 1.0-kg stone is thrown from the basket with an initial velocity of 18.5 m/s perpendicular to the path of the descending balloon, as measured relative to a person at rest in the basket. That person sees the stone hit the ground 15.1 s after it was thrown. Assume that the balloon continues its downward descent with the same constant speed of 23.5 m/s.

Part A

How high was the balloon when the rock was thrown out?

Express your answer with the appropriate units.

ANSWER:

\[ h_0 = v_b t + 0.5 \cdot 9.8 t^2 = 1470 \text{ m} \]

Also accepted: \( v_b t + 0.5 \cdot 9.81 t^2 = 1470 \text{ m} \)

Part B

How high is the balloon when the rock hits the ground?

Express your answer with the appropriate units.

ANSWER:

\[ h_1 = v_b t + 0.5 \cdot 9.8 t^2 - v_b t = 1120 \text{ m} \]

Also accepted: \( v_b t + 0.5 \cdot 9.81 t^2 - v_b t = 1120 \text{ m} \)

Part C

At the instant the rock hits the ground, how far is it from the basket?

Express your answer with the appropriate units.

ANSWER:

\[ d = \sqrt{(v_0 t)^2 + (v_b t + 0.5 \cdot 9.8 t^2 - v_b t)^2} = 1150 \text{ m} \]

Also accepted: \( \sqrt{(v_0 t)^2 + (v_b t + 0.5 \cdot 9.81 t^2 - v_b t)^2} = 1150 \text{ m} \)

Part D
Part E

Just before the rock hits the ground, find its horizontal and vertical velocity components as measured by an observer at rest in the basket.

ANSWER:

\[
|v_h|, |v_v| = v_0, 9.8t = 18.5, 148 \text{ m/s}
\]

Also accepted: \( v_0, 9.8lt = 18.5, 148, v_0, 9.8t = 18.5, 148 \)

Exercise 3.23

Description: The earth has a radius of 6380 km and turns around once on its axis in 24 h. (a) What is the radial acceleration of an object at the earth's equator? Give your answer in \((\text{m/s})^2\). (b) What is the radial acceleration of an object at the earth's...

The earth has a radius of 6380 km and turns around once on its axis in 24 h.

Part A

What is the radial acceleration of an object at the earth's equator? Give your answer in \(\text{m/s}^2\).

ANSWER:

\[
a_{\text{rad}} = 3.40 \times 10^{-2} \text{ m/s}^2
\]

Part B

What is the radial acceleration of an object at the earth's equator? Give your answer as a fraction of \(g\).

ANSWER:

\[
a_{\text{rad}} = 3.40 \times 10^{-3} g
\]

Part C

If \(a_{\text{rad}}\) at the equator is greater than \(g\), objects would fly off the earth's surface and into space. What would the period of the earth's rotation have to be for this to occur?

ANSWER:
Exercise 3.36

Description: A river flows due south with a speed of 2.0 m/s. A man steers a motorboat across the river. The river is 800 m wide. (a) In which direction should the motorboat head in order to reach a point on the opposite bank directly east from the starting...

A river flows due south with a speed of 2.0 m/s. A man steers a motorboat across the river. The river is 800 m wide.

Part A

In which direction should the motorboat head in order to reach a point on the opposite bank directly east from the starting point? (The boat’s speed relative to the water is 4.2 m/s.)

Express your answer using two significant figures.

ANSWER:

\[ \theta = 28^\circ \text{ north of east} \]

Part B

What is the velocity of the boat relative to the earth?

Express your answer using two significant figures.

ANSWER:

\[ v = 3.7 \text{ m/s} \]

Part C

How much time is required to cross the river?

ANSWER:

\[ t = 217 \text{ s} \]

Problem 3.31

Description: (a) A ball is tied to the end of a cable of negligible mass. The ball is spun in a circle with a radius 2.00 m making 7.00 revolutions every 10.0 seconds. What is the magnitude of the acceleration of the ball?

Part A

A ball is tied to the end of a cable of negligible mass. The ball is spun in a circle with a radius 2.00 m making 7.00 revolutions every 10.0 seconds. What is the magnitude of the acceleration of the ball?
Problem 3.47

Description: In fighting forest fires, airplanes work in support of ground crews by dropping water on the fires. A pilot is practicing by dropping a canister of red dye, hoping to hit a target on the ground below. (a) If the plane is flying in a horizontal path...

In fighting forest fires, airplanes work in support of ground crews by dropping water on the fires. A pilot is practicing by dropping a canister of red dye, hoping to hit a target on the ground below.

Part A

If the plane is flying in a horizontal path at an altitude of 88.0 m above the ground and with a speed of 62.0 m/s, at what horizontal distance from the target should the pilot release the canister? Ignore air resistance.

Take free fall acceleration to be $g$.

ANSWER:

$$x = v\sqrt{\frac{2h}{g}} = 263 \text{ m}$$

Problem 3.59

Description: A snowball rolls off a barn roof that slopes downward at an angle of 40 degree(s). The edge of the roof is 14.0 m above the ground, and the snowball has a speed of 7.00 m/s as it rolls off the roof. Ignore air resistance. Assume the coordinate...

A snowball rolls off a barn roof that slopes downward at an angle of 40°. The edge of the roof is 14.0 m above the ground, and the snowball has a speed of 7.00 m/s as it rolls off the roof. Ignore air resistance. Assume the coordinate origin is at the point on the roof where the snowball rolls off and that the positive $x$ direction is to the right and the positive $y$ direction is upwards.
Part A

How far from the edge of the barn does the snowball strike the ground if it doesn't strike anything else while falling?

ANSWER:

\[ x = 6.93 \text{ m} \]

Part B

Draw \( x - t \) graphs for the motion in part A.

ANSWER:
Part C

Draw $y - t$ graphs for the motion in part A.

**Plot points at** $t = 0 \, \text{s}, t = 0.4 \, \text{s}, t = 0.8 \, \text{s}, t = 1.0 \, \text{s}, t = 1.3 \, \text{s}$.

**ANSWER:**

Part D

Draw $v_x - t$ graphs for the motion in part A.

**ANSWER:**
Part E

Draw $v_y - t$ graphs for the motion in part A.

ANSWER:
A man 1.9 m tall is standing 4.0 m from the edge of the barn. Will he be hit by the snowball?

ANSWER:

- Yes
- No

Problem 3.65

Description: A 76.0-kg boulder is rolling horizontally at the top of a vertical cliff that is 20 m above the surface of a lake, as shown in the figure. The top of the vertical face of a dam is located 100 m from the foot of the cliff, with the top of the dam...

A 76.0-kg boulder is rolling horizontally at the top of a vertical cliff that is 20 m above the surface of a lake, as shown in the figure. The top of the vertical face of a dam is located 100 m from the foot of the cliff, with the top of the dam level with the surface of the water in the lake. A level plain is 25 m below the top of the dam.

Part A

What must be the minimum speed of the rock just as it leaves the cliff so it will travel to the plain without striking the dam?

Express your answer using two significant figures.

ANSWER:

\[ v_{0x} = 49 \text{ m/s} \]

Part B

How far from the foot of the dam does the rock hit the plain?

Express your answer using two significant figures.

ANSWER:

\[ L = 50 \text{ m} \]
Problem 3.75

Description: Two soccer players, Mia and Alice, are running as Alice passes the ball to Mia. Mia is running due north with a speed of $v_M$. The velocity of the ball relative to Mia is $v_b$ in a direction 30.0 degree(s) east of south. (a) What is the magnitude of...

Two soccer players, Mia and Alice, are running as Alice passes the ball to Mia. Mia is running due north with a speed of 6.90 m/s. The velocity of the ball relative to Mia is 7.60 m/s in a direction 30.0° east of south.

Part A

What is the magnitude of the velocity of the ball relative to the ground?

Express your answer to three significant figures and include the appropriate units.

ANSWER:

$$v = \sqrt{\left(\frac{v_b}{2}\right)^2 + \left(-v_b\cos\left(\frac{\pi}{6}\right) + v_M\right)^2} = 3.81\frac{\text{m}}{\text{s}}$$

Part B

What is the direction of the velocity of the ball relative to the ground?

Express your answer to three significant figures and include the appropriate units.

ANSWER:

$$\theta = \tan^{-1}\left(\frac{-v_b\cos\left(\frac{\pi}{6}\right) + v_M}{v_b}\right) \cdot 180 = 4.79\degree \text{ north of east}$$