Physics

# 2

I'll use 6m and 30 degrees
(ccw from +x axis)

\[ D_x = 6 \text{m} \cos 30^\circ = +5.2 \text{m} \]

\[ D_y = 6 \text{m} \sin 30^\circ = +3 \text{m} \]

\[ (D \sin \theta) \]

\[ D : \]

\[ D_x = +5.2 \text{m} \]

\[ D_y = +3 \text{m} \]

\[ \vec{V}_v \]

\[ \vec{V}_{vx} = -6.43 \text{ m/s} \]

\[ \vec{V}_{vy} = -7.7 \text{ m/s} \]

b. 

I'll use:

10 m/s

40 degrees

(cw from -y axis)

\[ v_{vy} = v_{vy} \cos \theta \]

\[ -10 \text{ m/s} \cos 40^\circ \]

\[ = -7.7 \text{ m/s} \]

\[ v_{vy} = -10 \text{ m/s} \sin 40^\circ \]

\[ = -6.43 \text{ m/s} \]

\[ \theta = \tan^{-1} \left( \frac{10 \text{ m/s}}{10 \text{ m/s}} \right) = \tan^{-1} \left( \frac{10 \text{ m/s}}{10 \text{ m/s}} \right) = 51.3^\circ \]

\[ \vec{Q} = 6.4 \text{ m}, 51.3^\circ \text{ cw from } -x \text{ axis} \]

\[ Q = \sqrt{Q_x^2 + Q_y^2} \]

\[ = 6.4 \text{ m} \]

\[ Q_x = -4 \text{ m} \]

\[ Q_y = +5 \text{ m} \]

\[ v_{fy} \text{ will be } -100 \text{sin50} \text{ since level ground, don't need this though.} \]

c. 

I'll use:

100 m/s

50 degrees

\[ v_{x} = +100 \text{ m/s} \cos 50^\circ \]

\[ v_{y} = +100 \text{ m/s} \sin 50^\circ \]

a. Time of flight determined by y-dir:

\[ \Delta y = v_{y} t + \frac{1}{2} a_y t^2 \]

\[ \Delta y = (100 \sin 50^\circ) t + \frac{1}{2} (-9.8) t^2 \]

\[ \text{Divide through by } t \]

\[ 0 = (100 \sin 50^\circ) + \frac{1}{2} (-9.8) t \]

\[ t = 15.65 \text{ s} \]

b. 

\[ \text{time of flight determined by y-dir} \]

\[ \Delta y = v_{y} t + \frac{1}{2} a_y t^2 \]

\[ \Delta y = (100 \sin 50^\circ) t + \frac{1}{2} (-9.8) t^2 \]

\[ \text{Divide through by } t \]

\[ 0 = (100 \sin 50^\circ) + \frac{1}{2} (-9.8) t \]

\[ t = 15.65 \text{ s} \]
b. \( \Delta y \), \( v_{i_y} \), \( v_{f_y} \), \( q_y \)

\[ \Delta y = v_{i_y} + 100 \sin 50^\circ \cdot 0 - 9.8 \]

\[ v_{f_y}^2 = v_{i_y}^2 + 2q_y \Delta y \]

\[ \Delta y = +300 \text{ m} \]

will reach maximum height of 300 m above ground

\[ \Delta x = v_{i_x} + \frac{1}{2}a_x t^2 \]

\[ \Delta x = v_{i_x} \]

\[ \Delta x = (100 \cos 50^\circ \text{ m/s})(15.6 \text{ s}) = +1003 \text{ m} \]

\[ \text{time of flight is determined by } y \text{ direction.} \]

In this problem, neither \( \Delta y \) nor \( v_y \) are zero, so I'll use judgment.

I'll use:
- fired at 5 m/s
- 50 degrees above horizon, 30 m tall cliff
\[ \Delta y = v_{y1} t + \frac{1}{2} a_y t^2 \]

\[ -30 = (5 \sin 50) t + \frac{1}{2} (-9.8) t^2 \]

\[ 3.83 = 5 \sin 50 \]

\[ -4.9t^2 + 3.83t + 30 = 0 \]

\[ t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \]

\[ t = \frac{-3.83 \pm \sqrt{(3.83)^2 - 4(-9.8)(30)}}{2(-4.9)} \]

\[ t = 2.89 \text{ s} \]

I'll use: runs off 5 m/s board 3 m above water

\[ \Delta y = v_{y1} t + \frac{1}{2} a_y t^2 \]

\[ t = 0.78 \text{ s} \]

\[ \Delta x = v_{x1} t = (5 \text{ m/s}) (0.78 \text{ s}) \]

\[ \Delta x = 3.9 \text{ m} \]

\[ 3.9 \text{ m from board horizontally} \]

\[ 3.7 \text{ m from plane} \]

C.) some is initially, \[ 5 \text{ m/s} \]

since x component of velocity cannot change. \[ (a_x = 0) \]

\[ v_{y1}^2 = v_{x1}^2 + 2a_y \Delta y = 50.8 \quad v_{y1} = \pm 7.7 \text{ m/s} \]
\[ V_{f_y} = -7.7 \text{ m/s} \] since makes physical sense, \( V_{f_y} \) is downward.

**e.**

\[ V_{f_x} = +5 \text{ m/s} \]

\[ V_{f} = \sqrt{V_{f_x}^2 + V_{f_y}^2} \]

\[ V_{f} = \sqrt{5^2 + (-7.7)^2} \approx 9.2 \text{ m/s} \]

\[ \theta = \tan^{-1} \left( \frac{1000}{1000} \right) = \tan^{-1} \left( \frac{1 - 7.7}{1 + 5} \right) \]

\[ \theta = 57^\circ \]

**f.**

Any thing involving \( x \) direction would change, but since \( x \) direction can't affect \( y \) direction, nothing involving only \( y \) direction would change.

b, c, e would change \( x \) dir involved

a, d would not change \( y \) dir only

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**#5**

I'll use:

- fired at 35 degrees
- flies horiz 1.3 m in 1.25 s

\[ \Delta x = v_{i_x} t \]

\[ v_{i_x} = \frac{\Delta x}{t} = \frac{1.3}{1.25} = 1.04 \text{ m/s} \]

**Initial speed of cork**

is 1.3 m/s
I'll use: 9 m tall tower, target is 3.5 m from base.

\[ \Delta y = v_{iy} t + \frac{1}{2} g t^2 \]
\[ -9 = 0 + \frac{1}{2} (-9.8) t^2 \]
\[ t = 1.36 \text{s} \]

\[ \Delta x = v_{ix} t \]
\[ v_{ix} = \frac{3.5 \text{m}}{1.36 \text{s}} \]

Initial horizontal speed needed to hit target is 2.6 m/s.

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I'll use: thrown at 6.95 m/s, drops 1.4 m, sideways 8.75 m.

\[ \Delta y = v_{iy} t + \frac{1}{2} g t^2 \]
\[ -1.4 = 0 + \frac{1}{2} (-9.8) t^2 \]
\[ t = 1.33 \text{s} \]

\[ \Delta x = v_{ix} t \]
\[ v_{ix} = \frac{8.75 \text{m}}{1.33 \text{s}} \]

similar to previous problem, but asking for \( v_{ix} \), not \( v_i \).

since don't have \( v_{ix} \), can't figure out \( t \) without \( y \) direction.

But have enough from \( x \) direction to find flight time: travel 8.75 m at 6.95 m/s, so can find time.

\[ \Delta x = v_{ix} t \]
\[ t = \frac{\Delta x}{v_{ix}} = \frac{8.75 \text{m}}{6.95 \text{m/s}} = 1.29 \text{s} \]
$a_y = 7.7 \text{ m/s}^2$ so size of acceleration due to gravity of Zircon (g_zircon) is 1.7 m/s$^2$.

8. I'll use: push with 14 N on 12.5 kg cart for 3 seconds

9. 

a.) 2 forces:

b.) the forces on the brick are:

- force on brick from earth (weight AKA force of gravity) (size: mg dir: downward)
- force on brick from hind (this is a normal force to the hind is a surface)

N acts up to, away from surface in this case that is upward.

c.) Yes, they are equal & opposite... if the brick is at rest, then $a_y = 0$. $F_{net, y} = mg$, so $F_{net, y} = 0$.

if the net force in the $y$ direction is zero, then all $y$ forces must cancel. So N and mg must be of equal size.

$$F_{net, y} = 0$$

$$N + mg = 0$$
d.) No, they are not.

- action-reaction pair of forces always acts on 2 different objects
  (if A exerts force on B, then B exerts force on A)

since N and mg both act on the brick, they cannot be. So what
is each of their action-reaction pair?

\[ \begin{align*}
  (\text{force on brick from head}) & \rightarrow \quad N \\
  (\text{force on head from brick}) & \quad \downarrow m \\
  \text{action reaction pair} & \\
  \downarrow N & \quad (\text{force on brick from earth}) \\
  \quad \downarrow \text{(force on earth from brick)} & \quad \text{action reaction pair}
\end{align*} \]

- another way to think of it is that action-reaction pairs are always equal in size, opp. in dir.

but in this problem, N and mg are only coincidentally equal in size since the brick is at rest. If
the brick were accelerating upward, for instance,

\[ N > mg \]

#10 Answered most of this above...

a) / b) some two forces: N, mg

c) No. These forces, while in opposite directions, will not be equal in size. In
order to accelerate upwards, need F \( \uparrow \) \( \text{Fet} \) upwards, so \( N > mg \)

Here, it is very evident why \( N > mg \), and action-reaction
pairs are always of the same size, so N \& mg are definitely not.
a.) force on child from parent is \( \text{some size (opp dir)} \) as force on parent from child.

This is an action-reaction pair.

b.)

\[
\begin{align*}
\mathbf{F}_{\text{net}} &= M_a \\
\mathbf{F}_{\text{net}} &= m \mathbf{a}
\end{align*}
\]

Each feels the same size force (opp dir),

but since parent's mass is greater, her acceleration will be less.

c.)

\[
\begin{align*}
\mathbf{F}_{\text{parent}} &= -\mathbf{F}_{\text{child}} \\
\mathbf{a}_{\text{parent}} &= -\mathbf{a}_{\text{child}} \\
m_{\text{parent}} \mathbf{a}_{\text{parent}} &= -m_{\text{child}} \mathbf{a}_{\text{child}}
\end{align*}
\]

I'll use:

\[
\begin{align*}
\mathbf{a}_{\text{child}} &= +2.6 \text{ m/s}^2 \\
m_{\text{child}} &= 16 \text{ kg} \\
m_{\text{parent}} &= 64 \text{ kg}
\end{align*}
\]

\[
\mathbf{a}_{\text{parent}} = -0.65 \text{ m/s}^2
\]

Parent has acceleration of size \( 0.65 \text{ m/s}^2 \)

Indeed less than child's. (opp dir of child)

\[
\begin{align*}
\text{In fact, since parent's mass is quadruple the child's} \\
(64 \text{ kg} = 4 \times 16 \text{ kg})
\end{align*}
\]

\[
\text{The parent's acceleration is one-fourth the child's} \\
0.65 \text{ m/s}^2 = \frac{1}{4} \times 2.6 \text{ m/s}^2
\]

Same sized force on each.

\[
\begin{align*}
\mathbf{F}_{\text{child}} &= m_{\text{child}} \mathbf{a}_{\text{child}} \\
\mathbf{F}_{\text{parent}} &= m_{\text{parent}} \mathbf{a}_{\text{parent}} \\
\mathbf{F}_{\text{parent}} &= (4m_{\text{child}}) \left( \frac{\mathbf{a}_{\text{child}}}{4} \right) = m_{\text{child}} \mathbf{a}_{\text{child}}
\end{align*}
\]