Physics 122

Worksheet – Projectiles Launched at an Angle

1. A cannon on a pirate ship was fired at an angle of 30.0°. The cannon ball’s launch speed is 40.0 m/s.
   a) Determine the vertical and horizontal components of the cannon’s velocity.
   b) How long is the cannon ball in the air?
   c) What is the cannon ball’s maximum height?
   d) How far away from the ship does the cannon ball land in the water?
   e) What is the cannon ball’s velocity 2.0 seconds after it is fired?

2. Bubba Newton throws a baseball with a horizontal component of velocity of 25 m/s. It takes 3.00 s to come back to its original height. Calculate the ball’s:
   a) horizontal range
   b) initial vertical component of velocity
   c) initial angle of projection.

3. A bullet is fired at an angle of 60.0° with an initial velocity of 2.00 x 10^2 m/s.
   a) How long is the bullet in the air?
   b) What is the maximum height reached by the bullet?

4. A bouncing ball leaves the ground with a velocity of 4.36 m/s at an angle of 81.0° above the horizontal.
   a) How long did it take the ball to land?
   b) How high did the ball bounce?
   c) What was the ball’s range?
Answer Key

1. a) $v_x = 34.6 \text{ m/s} \quad v_{yi} = 20.0 \text{ m/s}$
   
   b) 4.08 s
   
   c) 20.4 m
   
   d) 141 m
   
   e) 39.8 m/s, 29.5° below the horizontal

2. a) 38 m
   
   b) 14.7 m/s
   
   c) 30.0° above the horizontal

3. a) 35.4 s
   
   b) $1.53 \times 10^3 \text{ m}$

4. a) 0.878 s
   
   b) 0.946 m
   
   c) 0.599 m
a) \( V_x = u \cos \theta \)
\[ V_x = 40.0 \cos 30.0^\circ \]
\[ V_x = 34.6 \text{ m/s} \]

\( V_y = u \sin \theta \)
\[ V_y = 40.0 \sin 30.0^\circ \]
\[ V_y = 20.0 \text{ m/s} \]

The horizontal component of the cannon ball's velocity was 34.6 m/s. The vertical component of the cannon ball's velocity was 20.0 m/s.

b) \( t = \frac{V_y - V_{y_i}}{a} \)
\[ t = \frac{20.0 - 20.0}{-9.8} \]
\[ t = 0.041 \text{ s} \]

\( t_{air} = 2(0.041) \)
\[ t_{air} = 0.085 \text{ s} \]

The cannon ball is in the air for 0.085 s.

c) \( \frac{d_y}{dt} = V_{y_i} t + \frac{1}{2} a t^2 \)
\[ d_{y_i} = 20.0(2.64) + \frac{1}{2}(-9.8)(2.64)^2 \]
\[ d_y = 40.8 - 20.39 \]
\[ d_y = 20.4 \text{ m} \]

The cannon ball's maximum height is 20.4 m.

d) \( dx = V_x t_{air} \)
\[ dx = 34.6 (4.08) \]
\[ dx = 141 \text{ m} \]

The ball lands in the water 141 m from the ship.
e) \[ \vec{v}_y = v_{y1} + at \]
\[ \vec{v}_y = 0 + (-9.8)(2.6) \]
\[ \vec{v}_y = 17.6 \text{ m/s} \]
\[ \vec{v}_x = \vec{v}_x \]
\[ \vec{v} = 34.6^2 + 19.6^2 \]
\[ \vec{v} = 39.8 \text{ m/s} \]
\[ t = \frac{19.6}{39.8} \]
\[ \theta = 29.5^\circ \]

The cannon ball's velocity has a

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The cannon ball's initial vertical component is 14.7 m/s.

The initial angle \( \theta \) projection is 30.0° above the horizontal.
3. a) \[ V_{y1} = V_{51} \sin \theta \]
\[ V_{y1} = 4.36 \text{ m/s} \sin 81^\circ \]
\[ V_{y1} = 4.36 \times 0.981 \text{ m/s} \]
\[ V_{y1} = 4.26 \text{ m/s} \]

\[ V_{yf} = V_{y1} + gt \]
\[ 0 = 1.73 \times 205 + (-9.8) t \]
\[ -173.205 = t \]
\[ t = 17.75 \text{ s} \]

\[ \frac{1}{2} \times 17.75 \times 17.75 = 35.45 \]

The bullet is in the air for 35.45 s.

b) \[ d_y = \frac{V_{y1}^2}{2g} + \frac{1}{2} a t^2 \]
\[ d_y = \frac{4.26^2}{2 \times 9.8} + \frac{1}{2} (-9.8) (17.75)^2 \]
\[ d_y = 3.065 \times 128.5 = 335.121 \]
\[ d_y = 1.83 \times 10^3 \text{ m} \]

The bullet's maximum height is 1.83 \times 10^3 \text{ m}.

4. \[ v = 4.36 \text{ m/s} \]
\[ \theta = 81^\circ \]

a) \[ V_{y1} = V_{51} \sin \theta \]
\[ V_{y1} = 4.36 \times 0.981 \text{ m/s} \]
\[ V_{y1} = 4.3063 \text{ m/s} \]

\[ V_{yf} = V_{y1} + gt \]
\[ 0 = 4.3063 + (-9.8) t \]
\[ -4.3063 = t \]
\[ 0.4395 = t \]

\[ t \text{ to hit} = 0.4395 \times 2 \]
\[ t \text{ to hit} = 0.8785 \]

It will take the bullet 0.8785 s to reach.
4. b) \[ d_y = v_{y1}t + \frac{1}{2}a_y t^2 \]

\[ d_y^2 = 4.3063 (0.439) + \frac{1}{2} (-9.8) (0.439)^2 \]

\[ d_y^2 = 1.8905 \approx 1.9 \text{m} \]

\[ d_y = 0.446 \text{ m} \]

The ball bounces to a height of \( \frac{1}{2} d_y \)

\[ \frac{1}{2} d_y = 0.946 \text{ m} \]

\[ V_x = V \cos \theta \]

\[ V_x = 4.36 \cos 55 \approx 1.9 \text{ m/s} \]

\[ V_x = 0.6821 \text{ m/s} \]

\[ d_x = V_x t \]

\[ d_x^2 = 0.6821 (0.838) \]

\[ d_x = 0.599 \text{ m} \]

The 1.00 s range is 0.599 m