Worksheet – Projectiles Launched Horizontally

1. A car drives off a wharf at 15 m/s. If the wharf is 25 m above water, calculate:
   a) the time it takes the car to hit the water.
   b) the horizontal distance traveled.
   c) the velocity at which the car hits the water.

2. A golfer practising on a range with a tee 4.9 m above the fairway is able to strike a ball so that it leaves the club with a horizontal velocity of 20 m/s.

   a) What is the acceleration of the ball 0.50 s after being hit?
   b) Calculate the speed of the ball 0.80 s after it leaves the club.

3. A bowling ball of mass 7.5 kg travelling at 10 m/s rolls off a horizontal table 1.0 m high.
   a) Determine the ball’s horizontal velocity just as it strikes the floor.
   b) What is the vertical velocity of the ball as it strikes the floor?
   c) Calculate the velocity of the ball as it reaches the floor.
   d) What time interval has elapsed between the ball leaving the table and striking the floor?
   e) Calculate the horizontal distance travelled by the ball as it falls.
4. A soccer ball is kicked horizontally off a 22.0 m high hill and lands a distance of 35.0 m from the edge of the hill. Determine the initial horizontal velocity of the soccer ball.

5. A ball rolls off a desk at a speed of 3.0 m/s and lands 0.40 seconds later.
   a) How far from the base of the desk does the ball land?
   b) How high is the desk?

6. An airplane is in level flight at a speed of 138 m/s and at an altitude of 1.50 \times 10^3 \text{ meters} when one of its wheels falls off.
   a) How long does it take the wheel to reach the ground?
   b) What horizontal distance will the wheel travel before it strikes the ground?
   c) What will the wheel’s velocity be just before it strikes the ground?

Answer Key

1. a) 2.3 s
   b) 35 m
   c) 26 m/s, 56° below the horizontal

2. a) 9.8 m/s^2 down
   b) 21 m/s

3. a) 10. m/s forward
   b) 4.4 m/s down
   c) 11 m/s, 24° below the horizontal
   d) 0.45 s
   e) 4.5 m

4. 16.5 m/s forward

5. a) 1.2 m
   b) 0.78 m

6. a) 17.5 s
   b) 2.42 \times 10^3 \text{ m}
   c) 2.20 \times 10^2 \text{ m/s, 51° below the horizontal}
1. a) \[ t = \frac{\sqrt{2h}}{g} \]
\[ t = \frac{\sqrt{2(25)}}{9.8} \]
\[ t = 1.51024 \]
\[ t = 1.5 \text{ s} \]

The car will take 1.5 s to hit the water.

b) \[ x = x_0 + \frac{1}{2} a t^2 \]
\[ x = 15(3.3) \]
\[ x = 35 \text{ m} \]

The car traveled a horizontal distance of 35 m.

\[ V_{xf} = V_{yi} + a \cdot t \]
\[ V_{xf} = (-9.8)(3.3) \]
\[ V_{xf} = -23 \text{ m/s} \]

\[ V^2 = 15^2 + 23^2 \]
\[ V^2 = 784 \]
\[ V = 28 \text{ m/s} \]

The car hits the water at a velocity of 28 m/s at an angle of 57° below the horizontal.

\[ R = \frac{35}{18} \]
\[ \theta = 57° \]

2. a) The acceleration of the ball 0.50 s after being hit is 9.8 m/s², down.

b) \[ \dot{y} = \dot{y}_0 + a \cdot t \]
\[ \dot{y} = -9.8(0.80) \]
\[ \dot{y} = -7.84 \text{ m/s} \]
\[ V = V_{yf}^2 + V_{xf}^2 \]
\[ V = 7.84^2 + (20)^2 \]
\[ V = 461.4 \text{ m/s} \]
\[ V = 21 \text{ m/s} \]

The speed of the ball 0.80 s after it was hit was 21 m/s.
3. a) The ball's final velocity just as it strikes the floor is 10 m/s forward.

\[ \begin{align*}
    V_{yf} &= V_{y1} + a \cdot t \\
    V_{y1} &= 0 \\
    a &= -9.8 \text{ m/s}^2 \\
    V_{yf} &= -4.4 \text{ m/s}
\end{align*} \]

\[ t = rt(\frac{-1.6}{-9.8}) \]

\[ t = 0.164 \text{ s} \]

The vertical velocity of the ball as it strikes the floor is 4.4 m/s down.

c) \[ V^2 = V_{x1}^2 + V_{yf}^2 \]

\[ V_{x1} = (10.1) \text{ m/s} \]

\[ V_{yf} = 11.9 \text{ m/s} \]

\[ V = 15 \text{ m/s} \]

10 m/s

\[ \theta = 44.4 \text{ degrees} \]

The velocity of the ball as it reaches the floor is 15 m/s at an angle of 44.4° below the horizontal.

d) See part b) for the calculation of time.

It takes the ball 0.45 s to strike the floor.

e) \[ \frac{d^2}{dx} = V_x \]

\[ \frac{d^2}{dx} = (10.1)(0.45) \]

\[ \frac{d^2}{dx} = 4.5 \text{ m} \]

The ball travels a horizontal distance of 4.5 m.
4. \( t = \sqrt{\frac{2 \cdot \frac{2}{a}}{d}} \)
\( t = \sqrt{\frac{2 \cdot (-22.5)}{-9.8}} \)
\( t = 2.394 \text{ s} \)

The initial horizontal velocity of the soccer ball is 16.5 m/s forward.

5. a) \( \frac{d^2}{dt^2} = v_x t \)
\( \frac{d}{dt} = 3.1 \ (0.4) \)
\( dx = 1.2 \text{ m} \)

The ball lands 1.2 m from the base of the door.

b) \( \frac{d}{dt} = \frac{1}{2} a t^2 \)
\( \frac{d}{dt} = 0.5 \ (9.8)(0.4)^2 \)
\( dx = -0.78 \text{ m} \)

The door is 0.78 m high.

b. a) \( t = \sqrt{\frac{2 \cdot \frac{\Delta x}{d}}{a}} \)
\( t = \sqrt{\frac{2 \cdot 10.5 \times 10^{-3}}{-9.8}} \)
\( t = \sqrt{302.124} \)
\( t = 17.5 \text{ s} \)

It takes 17.5 s for the wheel to reach the ground.

b) \( \frac{d^2}{dt} = v_x t \)
\( \frac{d}{dt} = 138 \ (17.5) \)
\( dx = 2.42 \times 10^4 \text{ m} \)

The wheel will travel \( 2.42 \times 10^3 \text{ m } \) horizontally before it strikes the ground.
c) \[
\begin{align*}
V_{yf} &= \sqrt{V_{yi}^2 + 2a_y d} \\
V_{zi} &= -l + \frac{2a_y d}{\eta} \\
V_{yi} &= -\frac{2u_l - 9.82}{(-1.5 \times 10^5)} \\
V_{yi} &= 4.9 + 0.8 \\
V_{zi} &= -171.1 + 6.7 m/s
\end{align*}
\]
\[
\begin{align*}
V &= \sqrt{V_x^2 + V_{yi}^2} \\
V &= \sqrt{138^2 + 117.1^2} \\
V &= 171 m/s
\end{align*}
\]
\[
\begin{align*}
\tan \theta &= \frac{171}{138} \\
\theta &= 51^\circ
\end{align*}
\]

The bullet's velocity just before it strikes the ground is \(171 m/s\), at an angle of \(51^\circ\) below the horizontal.