Science 10 Honours Projectiles

Objects that are launched are called projectiles. The motion of a projectile is described in terms of its position, velocity, and acceleration. These are all vector quantities.

The horizontal and vertical velocities of a projectile are independent.

For the horizontal motion, $\vec{d}_x = \vec{v}_x t$ and $\vec{v}_{xf} = \vec{v}_o$

The equations for an object falling with constant acceleration, $\vec{g}$, describe the vertical motion.

$\vec{d}_y = \vec{v}_{yo} t + \frac{1}{2} \vec{g} t^2$ and $\vec{v}_{yf} = \vec{v}_{yo} + \vec{g} t$

Using these equations we can analyse the motion of projectiles.

A stone is thrown horizontally at 15 m/s from the top of a cliff 44 m high. How long does it take the stone to reach the bottom of the cliff? How far from the base of the cliff does the stone strike the ground?

A car traveling at 72 km/h drives off a cliff 400 m high.

a. How long did it take to hit the ground?
b. How far from the base of the cliff does it hit the ground?
c. How fast is it going when it hits the ground?

Practice:

1. A stone thrown horizontally at a speed of 5.0 m/s from the top of a cliff 78.4 m high.
    a. How long does it take the stone to reach the bottom of the cliff?
    b. How far from the base of the cliff does the stone strike the ground?
    c. What are the horizontal and vertical components of the velocity of the stone just before it hits the ground?

2. A steel ball rolls with a constant velocity across a tabletop 0.95 m high. It rolls off and hits the ground 0.352 m horizontally from the edge of the table. How fast was the ball rolling?

3. A ball is thrown horizontally at 10.0 m/s. It is in the air for 5.00 s.
    a. How far does it fall vertically?
    b. How far does it travel horizontally?
    c. How fast is it moving vertically when it hits the ground?
    d. What is its velocity when it hits the ground?

4. A bullet is fired horizontally at 300 m/s from a height of 2.00 m. How far does it go before it hits the ground?

Some Practice for You: Please answer these on a separate piece of paper

1. What is the velocity of a freely falling object after each of these times?
    a. 2.0 s b. 4.0 s c. 6.0 s d. 15 s

2. How long does it take a freely falling object to reach each of these velocities?
    a. 24.5 m/s b. 88.2 m/s c. 63.7 m/s d. 100 km/h

3. How far does a freely falling object fall in each of these times?
   a. 1.0 s b. 2.0 s c. 3.0 s d. 5.83 s

4. The CN tower in Toronto is 533.33 m high.
   a. How long would it take a rock dropped from the top to reach the ground?
   b. How fast would the rock be moving as it hit the ground (in m/s and km/h)?
   c. Would the rock actually reach the speed calculated in b? Discuss.

5. A ball-bearing is shot horizontally at 30 m/s and falls for 5.0 s.
   a. How far does it fall vertically?
   b. How far does it travel horizontally?
   c. How far is it from its starting point after 5.0 s?

6. A car goes off a cliff horizontally at 49 m/s and falls for 5.0 s.
   a. What is the vertical velocity of the car after 5.0 s?
   b. What is the horizontal velocity of the car after 5.0 s?
   c. What is the actual velocity of the car after 5.0 s?

<u>Angle Projectiles</u>

A ball is thrown with an initial velocity is 4.47 m/s at an angle of 66° above the horizontal. Find how long it took the ball to land and how high the ball flew.

A player kicks a football from ground level with a velocity of 27.0 m/s at an angle of 30.0° above the horizontal. Calculate:
   a. its hang time (the time the ball is in the air)
   b. the distance the ball travels before it hits the ground
   c. its maximum height

1. A soccer player kicks a ball with a velocity of 27.0 m/s at an angle of 60.0° from the horizontal or 30.0° from the vertical. Calculate:
   a. its hang time
   b. the distance the ball travels before it hits the ground
   c. its maximum height

2. Jason spits a peach pit horizontally with a 7.0 m/s velocity out of an elevator cage.
   a. If the elevator is not moving, how long will it take the pit to reach the ground 17 m below?
   b. How far (horizontally) from the elevator will the pit land?
   c. He spits the next pit when the elevator is at the same height but moving upward at a constant 8.5 m/s velocity. How long will it take this pit to land?
   d. How far away will this pit land?

More Practice for You

1. An arrow is shot at a 30.0° angle with the horizontal. It has a velocity of 49 m/s.
   a. How high will the arrow go?
   b. What horizontal distance will it travel?

2. Trailing by two points, and with only 2.0 s remaining in a basketball game, Teryn makes a jump-shot at an angle of 60° with the horizontal, giving the ball a velocity of 10 m/s. The ball is released at the height of the basket, 3.05 m above the floor. Yes! It's a swish.
   a. How much time is left in the game when the basket is made?
   b. Shots made outside the a semicircle of 6.02 m radius from a spot directly beneath the basket are awarded 3 points, while those inside score 2 points. Did Teryn tie the game of did she put the team ahead?

3. Jenna tries to make a half-court jump-shot, releasing the ball at a height of the basket. Assuming the ball is launched at 51.0°, 14.0 m from the basket, what velocity must Jenna give the ball?

Some Practice for You: Answers

1. a. *20 m/s* b. *39 m/s* c. *59 m/s* d. *1.5×10^2 m/s* 2. a. *2.5 s* b. *9.0 s* c. *6.5 s* d. *2.8 s* 3. a. *4.9 m* b. *20 m* c. *44 m* d. *1.7×10^2 m* 4a. *10 s* b. *1.0×10^2 m/s, 3.7×10^2 km/h* c. no, friction 5. a. *1.2×10^2 m* b. *1.5×10^2 m* c. *1.9×10^2 m* 6a. *49 m/s* b. *49 m/s* c. *69 m/s*

More Practice for You: Answers

1. a. *31 m* b. *2.1×10^2 m* 2a. *0.2 s* b. ahead, 9 m 3. *11.8 m/s*