# Sample Questions Chapter 2: Projectile Motion

1) Chad punts a football with a resultant velocity of 18 m/s at an angle of 48°. The ball leaves the foot at a height of 0.8 m. If the ball experiences a constant vertical acceleration of -9.8 $m/s^2$ while it is in the air, what will the ball's position be after 1.5 s?

   Vertical velocity = V sin (θ) = 18 m/s ( sin (48°)) = 13.4 m/s
   Vertical position = $Y_0 + v_y t + ½ gt^2$ = 0.8 m + 13.4 m/s (1.5 s) + ½ (-9.8 $m/s^2$)$(1.5s)^2$
   = 9.88m above ground level

2) Phil is trying to dunk a basketball and leaves the ground with a vertical velocity of 3.5 m/s.
   a. What is Phil's vertical acceleration immediately after takeoff?

      While airborne, vertical acceleration stays at a constant -9.8$m/s^2$

   b. What is the peak height Phil's center of gravity will attain if it started at 1.2m?

      $$\text{Maximum height} = \frac{{v_y}^2}{-2g} = \frac{(3.5m/s)^2}{-2(-9.8m/s^2)} = 0.625m$$

      Since he began at 1.2 m, we must add 1.2 m to 0.625 m = 1.83 m

   c. How much time elapses before Phil will reach his peak height?

      $$\text{Flight time} = \frac{2v_y}{-g} = \frac{2(3.5m/s)}{-(-9.8m/s^2)} = 0.71 \text{ s}.$$ Since the high point would be half of the flight time, peak height will be attained at 0.36 s

3) A football is thrown by Steve with a vertical velocity of 2 m/s and a horizontal velocity of 20 m/s. Ignoring the effect of air resistance, what will be:
   a. The flight time until the ball returns to the height it was thrown?

      $$\text{Flight time} = \frac{2v_y}{-g} = \frac{2(2m/s)}{-(-9.8m/s^2)} = 0.41 \text{ s}$$

   b. The vertical velocity when the ball returns to the height it was thrown?

      When air resistance is ignored, the vertical velocity when it reaches the height it was thrown will always be the opposite of the release vertical velocity. -2 $m/s^2$

   c. The distance downfield Aaron needs to be to catch the ball at the height it was thrown?

      Horizontal displacement = $v_h$ (Flight time) = 20 m/s (0.41s) = 8.2 m

4) A shot put leaves the throwers hand at 15m/s at an angle of 42° and a height of 1.3m.

a. What will be the shot's flight time?
Vertical velocity = V sin (θ) = 15 m/s ( sin (42°)) = 10.0 m/s
Since the takeoff and landing heights are not equal, we must use the following flight time equation:

$$\text{Flight time} = \frac{-v_y - \sqrt{v_y^{\,2} - 2gh}}{-g} = \frac{-10.0 - \sqrt{10.0^2 - 2(-9.8)1.3}}{9.8} = 2.16\text{ s}$$

b. What will be the shot's maximum height?

$$\text{Maximum height} = \frac{v_y^{\,2}}{-2g} = \frac{(10.0m/s)^2}{-2(-9.8m/s^2)} = 5.1\text{ m} + 1.3\text{ m} = 6.4\text{ m}$$

c. How far will the shot travel from the thrower's hand before it lands (think about why this may be different from the measured distance)?

Horizontal velocity = V cos (θ) = 15 m/s (cos (42°)) = 11.1 m/s
Horizontal displacement = $v_h$ (Flight time) = 11.1 m/s (2.16s) = 24.1 m