Name: KEY - DO NOT REPRODUCE Due Date:

Assignment 4.02: Projectiles - KEY

1. A cannon is placed on level ground. It is aimed 25 degrees above horizontal. The cannonball leaves the cannon with an initial speed of 300 m/s.

   (a) What is the horizontal component of the initial velocity (v_{ix})?

   $v_{ix} = v_i \cos(\theta) = 300m/s \cos(25°) \approx 271.892$ m/s

   (b) What is the vertical component of the initial velocity (v_{iy})?

   Using up as Positive: $v_{iy} = v_i \sin(\theta) = 300m/s \sin(25°) \approx 126.786$ m/s

   (c) What is the time it takes for the cannonball to reach its maximum height?

   $v_{fy} = v_{iy} + a_y t \longrightarrow t = \frac{v_{fy} - v_{iy}}{a_y} = \frac{0m/s - 126.786m/s}{-9.81m/s^2} \approx 12.924$ s

   (d) What is the maximum height of the cannonball?

   $d_y = v_{iy} t + \frac{1}{2} a_y t^2 = (126.786m/s)(12.924s) + \frac{1}{2}(-9.81m/s^2)(12.924s)^2 \approx 819.294m$

   (e) What is the total time of flight for the cannonball?

   $t_{total} = 2 \times t = 2 \times 12.924s = 25.848s$

   (f) How far from the cannon does the cannonball land?

   $d_x = v_{ix} t + \cancelto{0}{\frac{1}{2} a_x t^2} = (271.892m/s)(25.848s) \approx 7027.864m$

2. A golfer hits a ball on a level golf-course at 35 m/s, 45° above horizontal.

   (a) What is the amount of time it takes the golf-ball to reach its maximum height (hint: find v_{ix} and v_{iy} first).

   $v_{ix} = v_i \cos(\theta) = 35m/s \cos(45°) \approx 24.749$ m/s
   $v_{iy} = v_i \sin(\theta) = 35m/s \sin(45°) \approx 24.749$ m/s
   $v_{fy} = v_{iy} + a_y t \longrightarrow t = \frac{v_{fy} - v_{iy}}{a_y} = \frac{0m/s - 24.749m/s}{-9.81m/s^2} \approx 2.523$ s

   (b) What is the total time the golf ball is in the air?

   $t_{total} = 2 \times t = 2 \times 2.523s = 5.046s$

   (c) How far away does the golf ball land?

   $d_x = v_{ix} t + \cancelto{0}{\frac{1}{2} a_x t^2} = (24.749m/s)(5.046s) \approx 124.873m$

3. Kay is attempting to kick a football through the field-goal posts. She kicks the ball at 18 m/s at a 35° angle to the ground. She is 20 meters from the goal-post.

   (a) What are the initial vertical and horizontal velocities of the football?

   $v_{ix} = v_i \cos(\theta) = 18m/s \cos(35°) \approx 14.745$ m/s
   $v_{iy} = v_i \sin(\theta) = 18m/s \sin(35°) \approx 10.324$ m/s

   (b) How long does it take the football to travel the distance to the goal post? (Hint does this depend on the vertical direction or the horizontal direction?)

   $d_x = v_{ix}t + \cancelto{0}{\frac{1}{2}a_x t^2} \longrightarrow t = \frac{d_x}{v_{ix}} = \frac{20m}{14.745m/s} \approx 1.356s$

   (c) What is the height of the football when it passes the goal-post?

   $d_y = v_{iy}t + \frac{1}{2}a_y t^2 = (10.324m/s)(1.356s) + \frac{1}{2}(-9.81m/s^2)(1.356s)^2 \approx 4.980m$

   (d) Assuming the football is kicked straight, does she score 3 points for her team?

   Yes! (The field-goal crossbar in American Football is 10 feet, or a little over 3 meters high.)

4. Briana is hunting wild turkeys. She sees a turkey sitting on a branch at the top of a tree that is 35 meters away. She aims her bow at a 25°angle, and shoots the arrow with a speed of 65 m/s. The turkey is hit, and falls to the ground. Briana picks up the turkey and takes it home to save for thanksgiving dinner.

   (a) What are the initial vertical and horizontal velocities of the arrow? $v_{ix} = v_i \cos(\theta) = 65m/s \cos(25°) \approx 58.910$ m/s
   $v_{iy} = v_i \sin(\theta) = 65m/s \sin(25°) \approx 27.470$ m/s

   (b) How long does it take for the arrow to hit the turkey?

   $d_x = v_{ix}t + \cancelto{0}{\frac{1}{2}a_x t^2} \longrightarrow t = \frac{d_x}{v_{ix}} = \frac{35m}{58.910m/s} \approx 0.594s$

   (c) How high up was the turkey sitting?

   $d_y = v_{iy}t + \frac{1}{2}a_y t^2 = (27.470m/s)(0.594s) + \frac{1}{2}(-9.81m/s^2)(0.594s)^2 \approx 14.589m$

   (d) How long does the turkey take to fall to the ground?

   For the turkey, using up as positive:
   $d_y = \cancelto{0}{v_{iy}t} + \frac{1}{2}a_y t^2 \longrightarrow t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2\times(-14.589m)}{-9.81m/s^2}} \approx 1.725s$