Kinematics – Projectile Motion

1. For projectiles without air resistance, both horizontal and vertical motions are constant acceleration, so the equations $v = v_o + a*t$ and $s = s_0 + v_0t + (1/2)a*t^2$ apply. Write, in BG units, the horizontal and vertical forms of these equations for projectile motion. For the horizontal equation(s), use "x" for s. For the vertical equation(s), use "y" for s and -32.2 ft/s^2.

2. A football is kicked from ground level with initial speed 90 feet/sec at angle of 53.1 degrees above the horizontal.
   a) Determine the initial horizontal and vertical velocities. Make up the positive "y" direction and right the positive "x" direction.
   b) Use one of the equations from problem 1 to find how long the ball remains airborne (i.e. find the time when the ball returns to ground level).
   c) Find the ball's horizontal range (i.e., the distance the ball travels horizontally before hitting the ground).
   d) Find the time at which the ball reaches its maximum height.
   e) Determine the maximum height reached by the ball.

3. Repeat problem 2 if the ball has the same initial speed but is kicked at an angle of 36.9 degrees above the horizontal.

4. <u>Conceptual projectile work.</u> Assume negligible air resistance.
   a) For projectile motion, the horizontal component of an object's velocity _____.
   b) For projectile motion, the horizontal component of an object's acceleration _____.
   c) For projectile motion, the vertical component of an object's velocity _____.
   d) For projectile motion, the vertical component of an object's acceleration _____.
   e) A pebble is thrown horizontally. At the same time, a rock is dropped from the same height. The time the pebble remains airborne is _____ the rock's airborne time.
   f) A pebble is thrown horizontally. At the same time, a rock is dropped from the same height. The rock's velocity at impact is _____ the pebble's velocity at impact.
   g) A pilot drops a package from a plane flying horizontally and north at constant speed. True or false: when the package hits the ground the plane will be further north.
   h) A player kicks a soccer ball in a high arc towards the opponent's goal. When the ball is at its maximum height, which (if any) of the following are zero? Horizontal velocity, horizontal acceleration, vertical velocity, vertical acceleration.
   i) A ball is thrown at an initial velocity of 20 m/sec and an angle of 60 degree above the horizontal. What is the ball's velocity at the exact top of its trajectory?
   j) Projectile 1 is fired at an angle of 20 degrees above the horizontal; projectile 2 is fired at an angle of 70 degrees above the horizontal. Projectile 1's horizontal range is _____ the range of projectile 2.
   k) To maximize the range of a projectile fired from ground level. The projectile should be fired at an angle of _____ degrees above the horizontal.

<u>Some possible answers:</u> is zero, remains constant, increases, decreases, the same as, less than, more than, true, false.

5. A cannon ball is fired with initial speed 37 meters/sec at 32 degrees above the horizontal from a 180-meter-high cliff. At the base of the cliff is seawater.

a) Determine the ball's location and velocity 1 second after it is fired. Give the magnitude and direction of the velocity; specify the direction in degrees relative to the horizontal.

b) Determine the ball's location and velocity 4 seconds after it is fired. Give the magnitude and direction of the velocity; specify the direction in degrees relative to the horizontal.

c) At what time does the ball reach its maximum height? What is the ball's velocity at that height? Give the magnitude and direction of the velocity; specify the direction in degrees relative to the horizontal.

d) How long does the ball remain airborne? What is the ball's velocity (magnitude and direction) when it hits the water/