**Phys 135A College Physics I**

**Activity 5: Projectile Motion**

So far, we have dealt with one dimensional kinematics. In one dimension, we are—by now—very familiar with cases with or without a (constant) acceleration. It is now high time that we apply our knowledge to analyze the motion of objects that move both vertically and horizontally in the close vicinity of Earth’s surface. Such motion is called projectile motion. It involves two dimensions, vertical and horizontal. Please note that the vertical motion involves a constant acceleration of g, but the horizontal motion does not involve any acceleration at all (unless one talks about missiles!). We can analyze this situation by breaking it down to its horizontal and vertical components, and treating them separately, until it is time to recombine the two analyses. Since we have learned how to deal with vectors in two dimensions, we should not have any difficulty.

With all this in mind, we can write the following two sets of **kinematics equations for projectile motion**, one for the horizontal motion, and one for the vertical motion.

|  |  |
| --- | --- |
| Horizontal ( | Vertical |
|  |  |

**Example 1**: A movie stunt driver on a motorcycle speeds horizontally off a 50 m-high cliff. How fast must the motorcycle leave the cliff top if it is to land on level ground below, 90 m from the base of the cliff, where the cameras are?

**Example 2**: **(a)** In the above question determine position and the velocity vectors both for the horizontal and vertical motions at . Fill in the table below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| t (s) | x (m) | y (m) | vx(m/s) | vy(m/s) |
| 0 |  |  |  |  |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3.19 |  |  |  |  |

**(b)** Draw the velocity vectors for those times in the figure to scale. Using the parallelogram method indicate the resultant vector for each.

**Example 3**: A football’s kicked at an angle with a velocity of 20.0 m/s. Calculate

1. the maximum height,
2. the time of travel before the football hits the ground,
3. how far away it hits the ground,
4. the velocity vector at the maximum height, and
5. the acceleration vector at maximum height. Assume the ball leaves the foot at ground level.

For the rest of this activity, we will use a simulation program for projectile motion. To open the program, type the following web address in the URL locator of your computer and enter: <http://phet.colorado.edu/sims/projectile-motion/projectile-motion_en.html>

**Investigation 1**- A cannon ball on top of a tower 15 m high is shot horizontally at a target 30 m away from the base of the tower. With what initial speed must the ball be fired if it is to hit the target? Do it by calculation. Then plug the parameters into the simulation program and see whether you got it correctly. Show your calculations and results below.

**Investigation 2**- Adjust the height of the cannon ball to 5 m, its initial angle to 35°, and initial speed to 15 m/s. Calculate where it will be horizontally from the position of the cannon. Place the target mark there and start the program. Show your calculations and results below. Does the simulation result agree with your calculation?

**Investigation 3**- In the above question, is there a second launch angle that would hit the same target point, if you keep everything else the same? Calculate and then try! Show your calculations and results below.