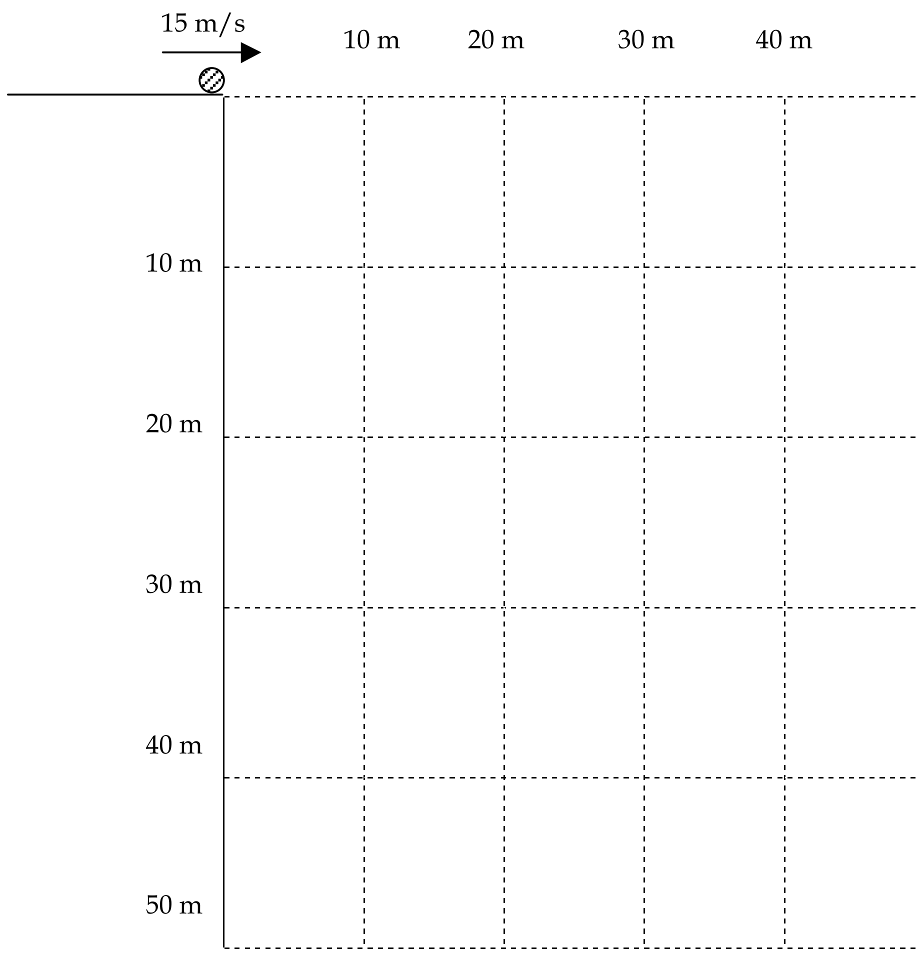
Name____ Date_____________________________

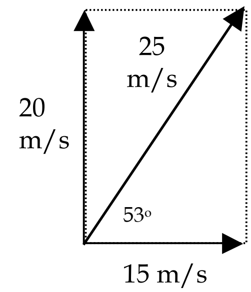
Investigation 7
Projectile Motion and Orbital Motion

1. **Projectile Motion with a Horizontal Velocity**. In projectile motion, the *horizontal* motion and the *vertical* motion are *independent* of each other. (Remember that we are ignoring the effects of air resistance.) In the *horizontal* direction, the ball travels at a *constant velocity* and covers equal distances in equal amounts of time. In the *vertical* direction, the ball travels downward as if it were a *freely falling* body. The actual position of the ball is then a combination of both the horizontal and vertical motions.

   You are on the edge of a cliff and throw a ball in the *horizontal* direction with a velocity of 15 m/s. Calculate how far the ball travels horizontally after one, two, and three seconds, and draw these positions on the diagram below. Also calculate how far the ball travels vertically downward after one, two, and three seconds, and again draw the positions. Note that the *initial vertical velocity* is zero. Now draw the actual position of the ball after one, two, and four seconds (combine the horizontal and vertical motions), and draw a smooth curve to represent the actual path the ball takes.



2. **Projectile Motion at an Angle with the Horizontal**. Remember that velocity is a *vector* quantity and can be represented by an arrow whose length is proportional to the magnitude of the velocity (speed). Also remember that the vector can be "resolved" into components using the parallelogram rule.

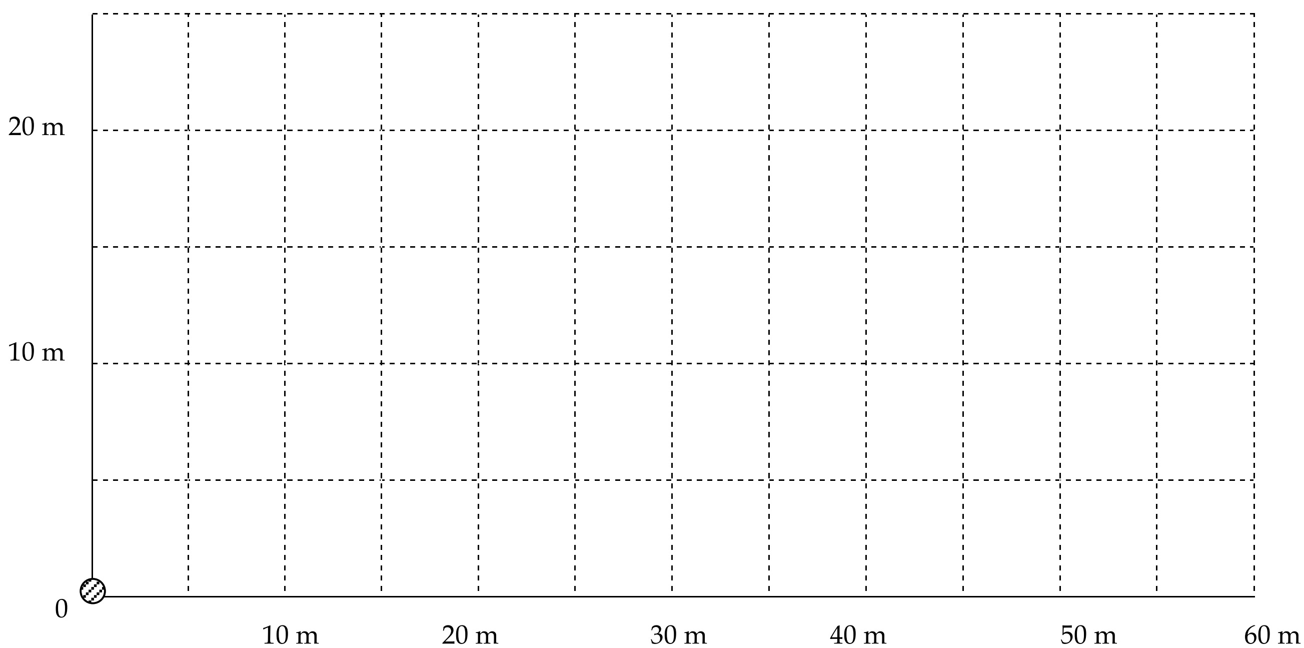


For example, if we throw a ball with a velocity of 25.0 m/s in a direction that is 53° above the horizontal, then this velocity can be resolved into a horizontal velocity component 15.0 m/s and a vertical velocity component of 20 m/s. Refer to the diagram.

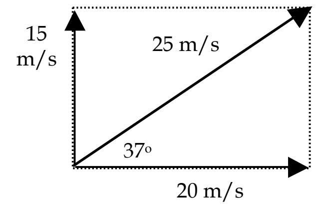
a. The question below uses the data given above.

Suppose you throw a ball with a velocity of 25 m/s at an angle of 53°. You can resolve this vector into horizontal and vertical components, and you can use the components to calculate separately the distance the ball travels in the horizontal direction and the vertical direction. The actual positions of the ball are the combinations of the horizontal and vertical positions.

Calculate how far *horizontally* the ball travels in one, two, three, and four seconds, and draw these positions on the horizontal axis in the diagram below. Calculate how far *vertically* above the ground the ball is after one, two, three, and four seconds, and draw these positions on the vertical axis in the diagram below. Now draw the actual position of the ball (combine the horizontal and vertical motions), and draw a smooth curve to represent the actual path the ball takes.

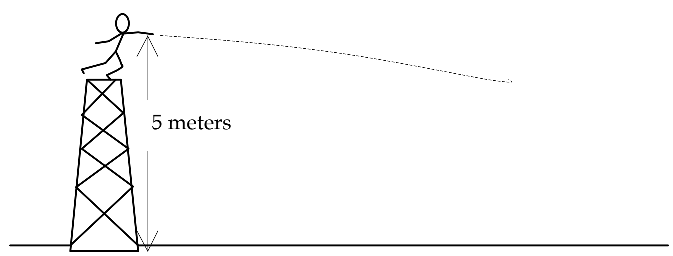


b. Repeat the above calculations and graph the positions of the ball on the above graph when the velocity with which the ball is thrown is still 25 m/s, but the angle at which it is thrown is 37°. The components of the velocity are 20 m/s in the horizontal direction and 15 m/s in the vertical direction. (This is a little harder than part a – but interesting.)



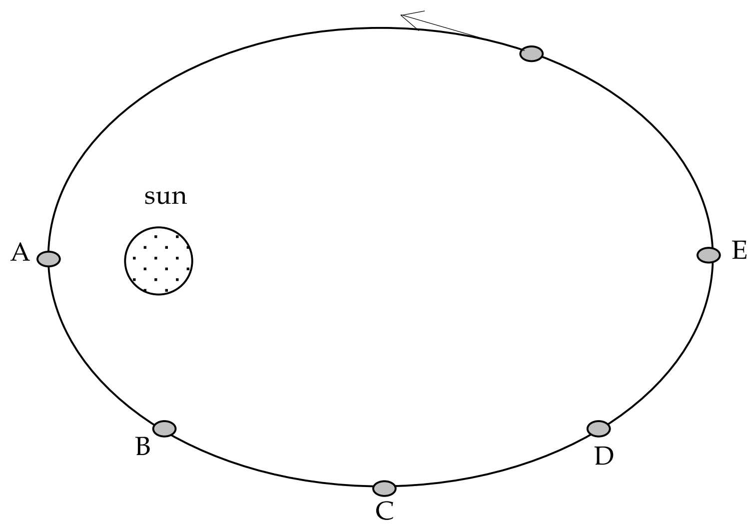
c. Do you notice anything interesting about the path of the two balls? Can you generalize?

3. **Projectile to Orbital Motion.** A physics student is at the top of a tower. In the first case, she drops a ball from a height of 5 meters, and in subsequent cases she throws the ball at varying speeds in the horizontal direction from a height of 5 meters. Complete the following table.



	Ball Dropped	Ball Thrown at 5 m/s	Ball thrown at 20 m/s	Ball thrown at 200 m/s	Ball thrown at 8 km/s
Time to Hit the Ground					
Horizontal Distance Traveled before Hitting Ground					

4. **Orbital Motion.** The diagram below shows five different positions of a planet as it orbits the sun.



a. For the planet in positions A, B, C, D, and E, rank from highest to lowest

1) the gravitational force on the planet

2) the speed of the planet

3) the potential energy of the planet

4) the total energy of the planet (KE + PE)

b. Is the time it takes the planet to travel from A to B the same as, less than, or greater than the time it take to go from D to E? Explain how you can tell.

c. Is the time it takes the planet to travel from A to C the same as, less than, or greater than the time it take to go from D to E? Can you tell?