Experiment No: M2

Experiment Name: Projectile Motion

Objective:

1. To determine the initial speed of the object
2. To compare the calculated range with measured range
3. To figure out the relation between applied angle, range of projectile and pinnacle.

Keywords: Parabolic movement, Range, Maximum height.

Theoretical Information:

Projectile motion; constant acceleration in vertical direction and horizontally, it is a compound parabolic movement with constant velocity in two-dimensional plane. The movement of a tennis ball, basketball, the mortar, and the movement of a baseball that was thrown or hit with a bat can be given as examples of the projectile motion. By neglecting the effect of air resistance in these movements, the force acting on the particle during the movement is the gravitational force (g = gravitational acceleration), which is constant and directed towards the surface. In this case; the horizontal and vertical components of acceleration are $a_x = 0$, $a_y = -g$ respectively.

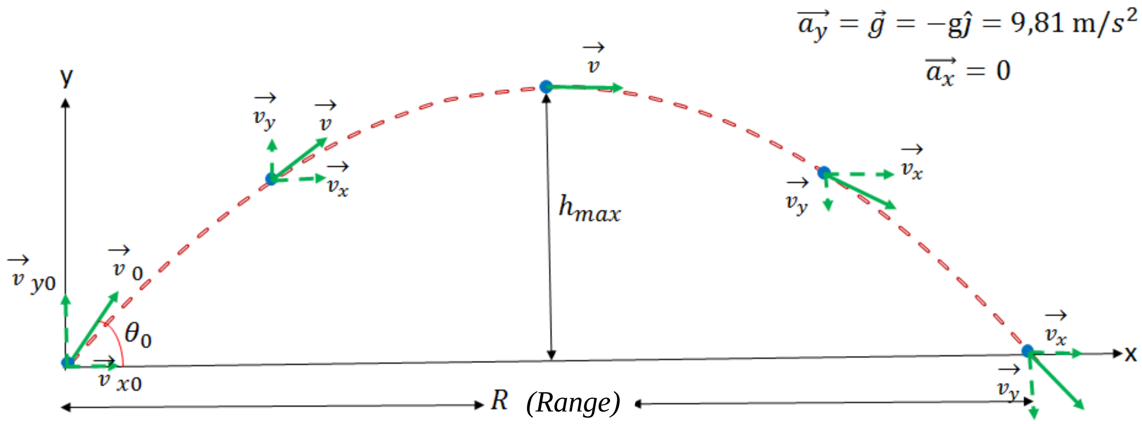

Figure 2.1. Projectile motion of the object.

The object at t= 0, located at position x_0= 0, y_0=0, is defined with initial velocity V_0 and angle of θ_0 with x-axis: The components of V_0 along x and y axes can be expressed as;

$$V_{0_x} = V_0 cos\theta_0 \quad 2.1$$

$$V_{0_y} = V_0 sin\theta_0 \quad 2.2$$

$t \neq 0$ the components of object's velocity are defined as;

$$V_x = V_{0_x} = V_0 cos\theta_0 \quad 2.3$$

$$V_y = V_{0_y} - gt = V_0 sin\theta_0 - gt \quad 2.4$$

Figure 2.1 shows the horizontal and vertical velocities of the object at different points. It is important to note that the vertical velocity of the object at its maximum height is zero.

Time depended position components (horizontal and vertical) of the object are given below;

$$x = V_{0_x} t = V_0 cos\theta_0 t \quad 2.5$$

$$y = V_{0_y} t - \frac{1}{2} g t^2 = V_0 sin\theta_0 t - \frac{1}{2} g t^2 \qquad 2.6$$

By using these equations it can be proved that the object follows a parabolic motion.
To find the t value from Eq. 2.5 and substitute in the Eq. 2.6;

$$t = \frac{x}{V_{0_x}} = \frac{x}{V_0 cos\theta_0}$$

$$y = V_0 sin\theta_0 \frac{x}{V_0 cos\theta_0} - \frac{1}{2} g \left(\frac{x}{V_0 cos\theta_0} \right)^2$$

$$y = x tan\theta_0 - \frac{g x^2}{2 {V_0}^2 cos^2\theta_0} \qquad 2.7$$

this equation is called parabola equation.

To examine projectile motion of the object, the maximum height *(h_{max})* and the range ***(R)*** of the object are critical.

h_{max}: The height of the object when the vertical velocity is zero. The coordinates of the particle are *R /2* and h_{max}. In order to find h_{max}, it is necessary to determine the time (t_h) before the object reaches the maximum point. At maximum height V_y= 0, so time to reach maximum height can be evaluated from Eq. 2.4;

$$t_h = \frac{V_0 sin\theta_0}{g} \qquad 2.8$$

The maximum height expression can be found by substituting t_h in place of *t* and h_{max} for in place of y in Eq. 2.6;

$$h_{max} = V_0 sin\theta_0 t_h - \frac{1}{2} g t_h^2$$

$$h_{max} = V_0 sin\theta_0 \frac{V_0 sin\theta_0}{g} - \frac{1}{2} g \left(\frac{V_0 sin\theta_0}{g} \right)^2$$

$$h_{max} = \frac{1}{2} \frac{V_0^2 sin^2\theta_0}{g} \qquad 2.9$$

R (range): The total path of the object taken along the x-axis by substitute *R* in place of *x* and $2t_h$ in place of t in Eq. 2.5;

$$R = V_{0_x} t = V_0 cos\theta_0 2 t_h$$

$$R = V_0 cos\theta_0 2 \frac{V_0 sin\theta_0}{g}$$

$$R = \frac{V_0^2}{g} \sin 2\,\theta_0 \qquad 2.10$$