(M1-2) Projectiles

Aim of experiment

Determination of maximum height and the range of a projectile

Apparatus

A Specially Devised Launcher Attached to a Protractor- A Horizontal Meter Ruler - Vertical Sliding ruler.

Theory of experiment

For a projectile launched at an angle, θ, to the horizontal, it rises upwards to a peak, *h* while moving horizontally to maximum horizontal distance, $d=R$, called range. Upon reaching the peak, the projectile falls with a motion that is symmetrical to its path upwards to the peak.

If a projectile launched with initial velocity v_o at angle θ with the horizontal, one considers the equations,

$$x = v_0 t\cos(\theta)$$

$$y = v_0 t\sin(\theta) - \frac{1}{2}gt^2$$

If *t* is eliminated between these two equations the following equation is obtained:

$$y = \tan(\theta)\cdot x - \frac{g}{2v_0^2\cos^2\theta}\cdot x^2$$

This equation is the equation of a parabola. Since g, θ, and v_0 are constants, the above equation is of the form

$$y = ax + bx^2$$

in which $a = \tan(\theta)$ and $b = (g/(2v_o^2\cos^2\theta))$ are constants. This is the equation of a parabola, so the path is parabolic. The axis of the parabola is vertical.

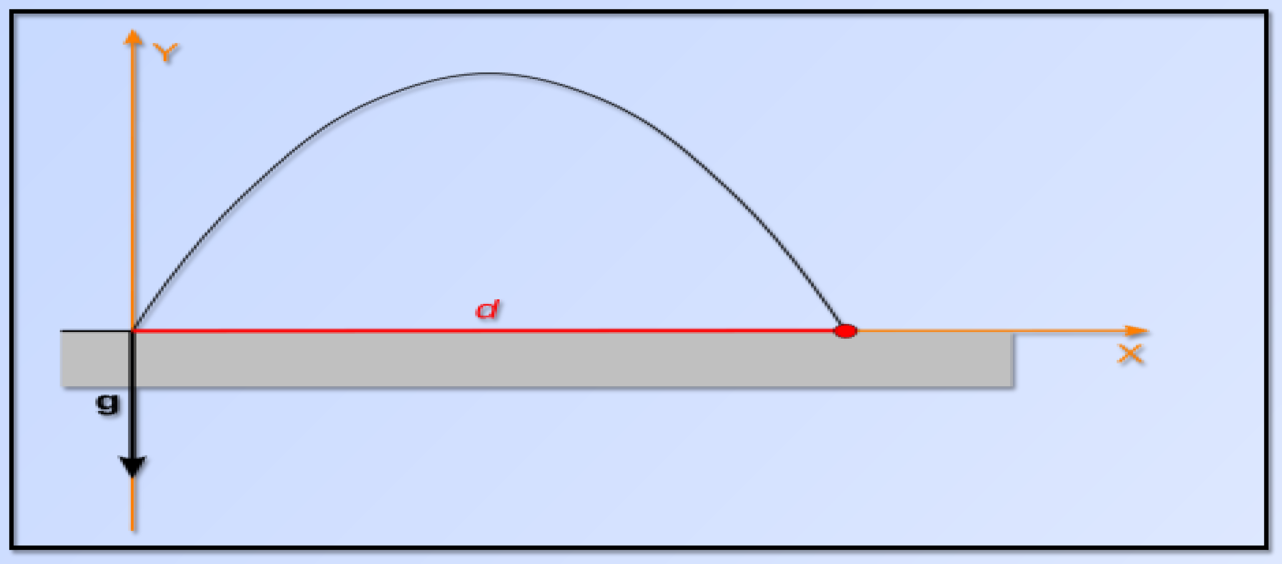

Figure 1. The trajectory of a projectile launched at angle Θ with horizontal x-axis

The highest height which the object will reach is known as the peak of the object's motion. The increase of the height will last, until , that is,

$$0 = v_0\sin(\theta) - gt_h$$

Time to reach the maximum height:

$$t_h = \frac{v_0\sin(\theta)}{g}$$

From the vertical displacement of the maximum height of projectile:

$$h = v_0 t_h\sin(\theta) - \frac{1}{2}gt_h^2$$

$$h = \frac{v_0^2\sin^2(\theta)}{2g}$$

The relation between the range (*R*) on the horizontal plane and the maximum height (*h*) reached at $t_d/2$ is:

$$h = \frac{R\tan\theta}{4}$$

Important note is the Range and the Maximum height of the Projectile does not depend upon mass of the launched body. Hence Range and Maximum height are equal for all those bodies which are thrown by same velocity and direction. Air resistance does not affect displacement of projectile.

The horizontal range d of the projectile is the horizontal distance the projectile has travelled when it returns to its initial height (y = 0).

$$0 = v_0 t_d\sin(\theta) - \frac{1}{2}gt_d^2$$

Time to reach ground:

$$t_d = \frac{2v_0\sin(\theta)}{g}$$

From the horizontal displacement the maximum distance of projectile:

$$d = v_0 t_d\cos(\theta)$$

So

$$d = \frac{v_0^2}{g}\sin(2\theta)$$

Note that d has its maximum value when

$$\sin 2\theta = 1$$

which necessarily corresponds to

$$2\theta = 90°$$

or

$$\theta = 45°$$

(M1-2) Projectiles

Procedures

1. Adjust the launcher at a fixed angle, say 50^o.
2. Adjust the horizontal meter ruler at zero position with the launcher.
3. Move the vertical meter ruler at a horizontal distance, x.
4. Launch the projectile ball and record the ball height distance at the distance x.
5. Repeat for different x- distances and record the height, y.
6. Repeat step 5 two more times at same horizontal distances.
7. Plot the relation between the horizontal distances , x versus the height, y.
8. Determine the range,d, and maximum height, h, at such angle.
9. Calculate h and d and compare to the measured values.
10. The experiment can be repeated for different angles. Notice that the largest R will be at 45^o

Results

x (m)												
y_1(m)												
y_2(m)												
y_3(m)												
y_{av}(m)												

Θ= h =

d=

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