Projectile Motion

Aim

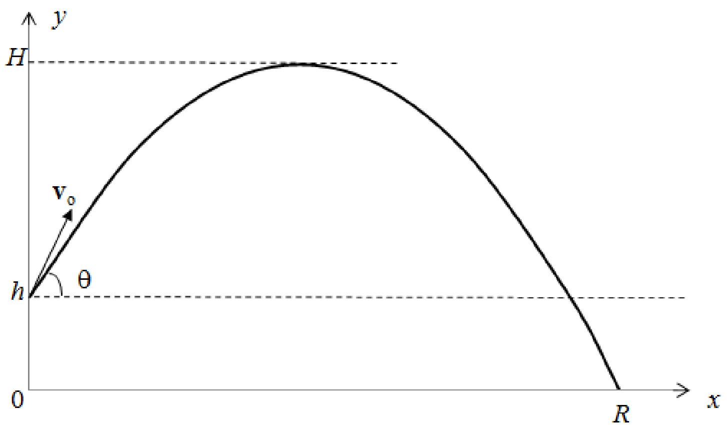
Theory

For a given initial velocity, $\mathbf{v}_o$, and initial position, $\mathbf{s}_o$, the position of a particle, **s**, as a function of time, undergoing constant acceleration, ***a***, is given by:

$$\mathbf{s} = \mathbf{s}_o + \mathbf{v}_o t + \frac{1}{2}\boldsymbol{\alpha} t^2 \qquad (1)$$

Bold letters represent vectors. Eq.(1) is a vector equation and can be decomposed into its *x*, *y* and *z* components.

The motion of projectile is in a plane, thus, we need only two components, say, *x* and *y*.



When the object hits the floor the *x* and *y* positions are $x = R$ and $y = 0$, see the figure above. Hence,

$$R \approx \frac{\upsilon_o^2 \sin 2\theta}{g}$$

$$t_f \approx \frac{2\upsilon_o \sin\theta}{g}$$

$$H = h + \frac{\upsilon_o^2 \sin^2\theta}{2g}$$

Procedure

1- Select a type of environment from the right of the simulator. Gravity changes according to the environment.
2- Select the velocity (υ_o), angle of projection (θ) and height of the cannon from the slider (*h*).
3- After clicking the fire button, the user can view the motion of the projectile and also record the time of flight (t_f), and range (*R*) of the projectile.
4- Measure the maximum height (H) by tape.

Variable Region

1. The 'Choose Environment' combo box helps you to choose the type of environment that the simulation has to be performed. As the environment changes the gravity also change.
2. The 'Velocity' slider helps you to fix the velocity of the projectile.
3. The 'Angle of Projection' slider helps you to fix the angle of the projection of the projectile.

1. Dependence of maximum height, range and time of flight on projection angle, for fixed initial velocity.

Table (1)

υ_o = ……………. m/s **h = ………… m**

Student Trail	θ (Deg)	*H* (m)	*R* (m)	t_f (s)	sinθ	$\sin^2\theta$	sin(2θ)
1							
2							
3							
4							

2. Dependence of maximum height, range and time of flight on initial velocity at a fixed angle.

Recopy appropriate data from Table (1).

Table (2) **θ = …….°** ***h*** **= ………… m**

Student Trail	υ_o (m/s)	*H (m)*	*R (m)*	t_f (s)	υ_o^2 $(m/s)^2$
1					
2					
3					
4					
5					
6					
7					

Plots

Use Microsoft Excel to do calculations and graph plots.

Open an excel file and save it in your name. Write Tables (1) and (2) each in a sheet. Do the calculations in both tables, then,

1- Use Table (1) to plot the following graph ***R*** versus **sin(2θ)**, and calculate **g**
2- Use Table (2) to plot the following graphs ***H*** versus $\mathbf{v_o^2}$ and again calculate **g.**
3- Compare your results with the theoretical value of **g.**

Self-Evaluation

Answer the following:

1. If we account for air resistance, how would the distance the ball fly change?
   Ans.…………………………………………………………………………………………

2. The projectile has maximum value of time of flight, when it is projected at an angle of projection

   (1) 0º (2) 5º (3) 90º (4) 180º

3. The maximum height reached by a particle is independent of:
   (1) Angle of projection
   (2) Initial velocity
   (3) Acceleration of the projectile
   (4) Mass of the projectile

4. What are the sources of error? How can you reduce them? Explain.

5. Which part gives a result closer to the value of g?