Experiment No. 6
Uniform Acceleration Motion

1. Objectives:

(1) To study the motion of freely falling bodies.
(2) To evaluate the acceleration due to the gravity.

2. Apparatus:

Free falling set with electronic timer, meter stick, two photogates connected to the timer, and steel balls.

3. Theory:

A body under constant acceleration is uniformly accelerated motion. This is when a constant external force is applied to the body. The acceleration is the rate of change of velocity with time. It is positive when the velocity increases, and negative when the velocity decreases. If the only force acting on an object is gravity (neglecting the air resistance), then the object is said to be in "*free fall*". Free-fall motion is a uniformly accelerated motion that, takes place in a vertical direction say the y-axis. Anytime the object moves vertically, either going upwards or going downwards, is said to be Free-fall.

Since the force of gravity near the surface of the Earth is constant, when we look at a specific location, the free-fall acceleration is also constant. This acceleration is directed downward and its magnitude is denoted by g. The accepted value of g is 9.80 m/s^2, but this value varies from location to location on the whole earth.
When an object is in Free-Fall the acceleration is a constant -g, therefore:

$$a_y = -g = \frac{\Delta v_y}{\Delta t} = \frac{v_{yf} - v_{yi}}{t}$$

But since a = -g is constant, the average velocity during any time interval t can be written as:

$$\bar{v}_y = \frac{v_{yf} + v_{yi}}{2}, \quad \text{and}$$

$\bar{v}_y = \dfrac{\Delta y}{\Delta t}$, for objects falling down a distance y in time t

$$\bar{v}_y = \frac{-y}{t},$$

$$\bar{v}_y = \frac{v_{yf} + v_{yi}}{2} = \frac{v_{yi} + v_{yi} - gt}{2} = v_{yi} - \frac{gt}{2}$$

$$-\frac{y}{t} = v_{yi} - \frac{gt}{2}, \qquad y = -v_{yi}t + \frac{1}{2}gt^2$$

The body will be released at initial velocity zero, then

$$y = \frac{1}{2}gt^2$$

It is clear that, when objects of different masses are allowed to fall freely from rest, the objects will fall at identical distances in identical times. They reach the ground with the same final velocity.

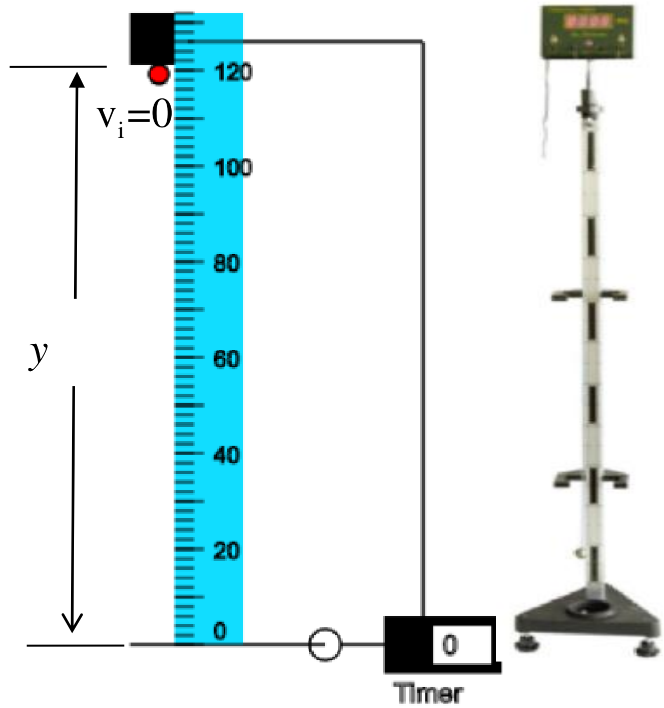
If an object of mass (m) falls freely from rest ($v_{yi} = 0$) then the vertical distance covered in time (t) is given by:

$$y = \frac{1}{2} g t^2$$

The plot of (y) versus (t^2) will give a straight line whose slope S is

$$S = \frac{1}{2} g$$

In this experiment, you will determine the acceleration due to gravity (g) by measuring the free fall distance (y) and the free fall time (t).



4. Procedures:

A. Free Fall time does not depend on distance.

(1) Use a free fall distance of about 0.9 m, make three measurements of the free fall time of the small steel ball, three measurements for the big steel ball, and three others for the big copper ball.
(2) Change the distance and repeat the above measurements.

B. Determination of g from the graph.

(1) Turn the timer switch.
(2) Put the small ball in the ball release mechanism.
(3) Release the ball and record the time.
(4) Measure and record the distance from the bottom of the steel ball to the target pad on the ball receptor.
(5) Take three values of the free fall time for each release and the average time.
(6) Plot y versus t, and draw a smooth curve through the points.
(7) Plot y versus t^2, and draw a smooth curve through the points
(8) Find g from the graph and calculate the error.

Exp. No. 6

Uniform Acceleration motion

Name: …………………………………………………………… Grade: ……………………….………

Student's No.: …………………………………………………. Day and Date: ……….…………..……

Partner's Names: ………………………………………………...…... Sec: ……………………….

Density of steel, ρ_{st} = 7.9 gm/cm^3, copper ρ_{Cu} = 8.23 gm/cm^3

Trial	**Mass of the ball**	t_1	t_2	t_3	$\bar{t}$

Table 1: To show that free fall time does not depend on mass

Table 2: Fill table 2 and use it to determine the acceleration due to gravity g.

Trial	**Mass of the ball**	t_1	t_2	t_3	$\bar{t}$	$\bar{t}^{\,2}$	**Distance y (m)**
1							
2							
3							
4							
5							

(1) From the graph of y versus $\bar{t}^{\,2}$

Find the slope S and g

S = ……………………

g = ……………….…

(2) Calculate the error in g, **Δg=2ΔS**

Question 1: Prove that the covered distance in the gravity of the earth does not depend on the mass of the falling object.

Question 2: Derive the equation $y = \frac{1}{2} g t^2$.