Free Fall

1 Introduction

One of the most intuitive observations is that all objects dropped near the earth's surface will move toward it. We understand from our basic knowledge that this is due to the gravitational pull of earth. What is less intuitive is that all dropped objects in the absence of air resistance accelerate with the same rate regardless of its mass. In this experiment, we will investigate these two observations and the motion of freely falling objects with further details.

2 Objective

1. To determine the gravitational acceleration of freely falling object.
2. To study the relation between the time of falling and the mass of the object.

3 Theory

"A freely falling object is any object moving freely under the influence of gravity alone, regardless of its initial motion. Objects thrown upward or downward and those released from rest are all falling freely once they are released. Any freely falling object experiences an acceleration directed downward, regardless of its initial motion."[1]. This constant acceleration is approximately equal to 9.8 m/s^2 at sea level.

Due to the constant acceleration of gravity, we can describe the free fall motion using the model of a particle under constant acceleration in one dimension. However, we should note that the motion takes place in the vertical direction and the acceleration is directed downwards. If down is assumed to be the positive direction, then the equations of motion can be written as (neglecting air resistance),

$$\Delta y = v_i t + \frac{1}{2} g t^2 \tag{1}$$

$$\Delta y = \frac{1}{2}(v_f + v_i) t \tag{2}$$

$$v_f = v_i + gt \tag{3}$$

$$v_f{}^2 - v_i{}^2 = 2g\Delta y \tag{4}$$

[1] Serway Jewett, 2007, p.37

where,

- Δy: Vertical displacement (height) (m).
- v_i: Initial velocity, the velocity at the start of the acceleration (m/s).
- v_f: Final velocity, the velocity at the end of the acceleration (m/s).
- g: Is the acceleration of gravity (m/s^2).
- t: Time, this is the period of acceleration.

4 Equipment

Steel ball – contact plate – holding magnet – holding magnet adapter with a release mechanism – electronic stop clock – stand base – rods – scale – connecting leads.

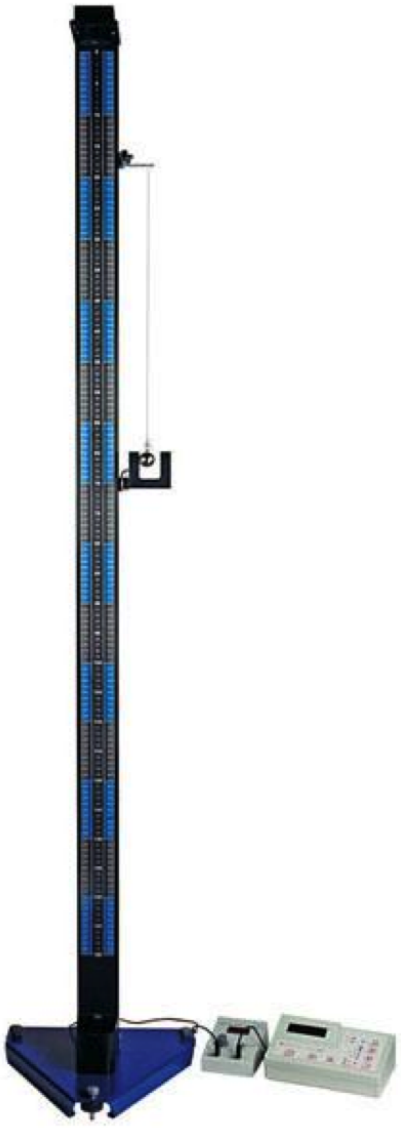

Figure 1: Free Fall apparatus

5 Procedure

Part A:

1. Set the equipment and hold the steel ball using the holding magnet at a certain height.
2. Release the ball and read the time the ball took traveling the vertical distance, then reset the stop clock and reattach the ball and read the time again , you should take three readings of the time then find the average time the ball has traveled.
3. Reduce the height and repeat the previous steps.
4. Tabulate your data.

Δy (cm)	Δy (m)	t_1 (s)	t_2 (s)	t_3 (s)	t_{avg} (s)	${t_{avg}}^2$ (s^2)
10						
20						
30						

5. Plot a graph between the time squared (y-axis) and the height or displacement of ball (x-axis)
6. Draw the best line and find its slope.
7. Calculate the gravitational acceleration from the slope using equations of free fall (eq. 1).
8. Find the percentage error.

Part B:

1. Preform steps from 1 to 3 of the previous part on the small ball.
2. Record your measurements in the following table:

Δy (cm)	Δy (m)	t_1 (s)	t_2 (s)	t_3 (s)	t_{avg} (s)
10					
20					
30					

3. Compare between the time of falling for both balls.

Δy (cm)	t_{avg} (s) big ball	t_{avg} (s) small ball
10		
20		
30		

4. Write a conclusion about the relation between the time of falling and the mass of the object.