MECE 3320
Measurements and Instrumentation Lab
Lab - 1: Measurement of Acceleration due to Gravity

1. Introduction

It is well known that if the effects of air resistance are ignored, any object dropped in the vicinity of Earth's surface will move with constant acceleration '*g*'. The direction of '*g*' is down, towards Earth's center and it's magnitude is approximately 9.8 m / s^2. The motion of freely falling objects is one dimensional motion with constant acceleration. In general, an object moving with an initial velocity v_0 and a constant acceleration *a*, obeys the following kinematic equation [1]:

$$\Delta s = v_0 t + \frac{1}{2} g t^2 \qquad (1)$$

where Δs is the displacement of the object in time *t*. For an object initially at rest falling in a gravitational field, equation (1) reduces to:

$$h = \frac{1}{2} g t^2 \qquad (2)$$

where *h* is the vertical displacement or height. Our experiment is based on equation (2). Namely, if we have means of measuring height and time of the free fall for any object, then the acceleration due to gravity can be easily determined using equation (2).

Equation (2) provides a means to measure *g*. All we need to do is to drop an object through a known distance *h* and then measure the time *t* it takes to fall. If we know both *h* and *t*, we can solve equation (2) for *g*,

$$g = \frac{2h}{t^2} \qquad . \qquad (3)$$

Hence, by measuring the travel distance and the travel time for an object falling from rest, we can measure the gravitational acceleration.

2. Lab Equipment Required

a. Two golf balls

b. Stop watch

c. Measuring tape

3. Experimental Procedure

1. You will drop two types of golf balls from the roof of the high-bay. You will measure the fall time for both types of golf balls. (h: height of the roof above the ground = 11.28m).

2. Each lab group should use one stopwatch or you can use your cell phone to record the time of fall for the golf balls.

3. Walk to the roof of the high-bay and begin your measurements on the 3rd floor.

4. **One group of students in each lab group must remain on the ground floor** to retrieve dropped balls and to record the fall time.

5. The balls should each first be dropped **from rest** from the 3rd floor roof onto the ground floor below. Time the fall time from the roof to the floor. Record this number, **with proper units**, in the table below.

6. Lab partners should take turns dropping the balls so that everyone has dropped both balls once.

7. In total, you will need to drop 16 golf balls (8 – solid golf balls, 8 – wiffle balls).

3. Calculations and Results

a. Record your data in the table below:

Ball type: _____

Trial	t	t^2	g
1			
2			
3			

4			
5			
6			
7			
8			

Average measured value for *g* = _____

b. Plot a graph of h (x-axis) vs. g (y-axis) and comment on the nature of the graph.

c. Use the equations for standard deviation and error in the mean to determine the uncertainty in the time measurements. Note that the general name for the error in the mean is σ_μ.

$$\sigma = \sqrt{\left[\frac{1}{N-1}\sum_{i=1}^{N}\left(\bar{x} - x_i\right)^2\right]} \qquad (4)$$

$$\sigma_\mu = \sigma / N \qquad (5)$$

Using the above equation, determine the standard deviation and the error in mean for '*g*' and time '*t*'.

d. Do your results for the two balls agree within their uncertainties? Do your results indicate that *g* is independent of mass?

e. Do your results match the actual value of *g* (9.80 m/s2) within their uncertainties?

e. The uncertainty that you have calculated is only random (or statistical); if your results don't agree it may indicate the presence of systematic error(s) in the experiment. If you don't understand the difference, then read section 5.5 in your textbook. If your results indicate that systematic error(s) may be present, try to determine some possible sources of systematic error in the experiment.