Free Fall

PHYS 1301

Introduction

In the absence of any other forces, such as air resistance, objects that fall towards the ground due to gravity all do so with the same acceleration relative to the ground – this is called free fall. This experimental fact was established by Galileo and is accounted for in Newton's model of gravity by assuming (inexplicably) the equivalence of gravitational mass, on which the force of gravity pulls, and inertial mass, which is intrinsic resistance to acceleration, whatever its cause. The modern view explains it with the Equivalence Principle, which states that a freely falling reference frame is equivalent to an inertial reference frame (such as one in deep space far from the effects of gravity of any other forces). Einstein's model of gravity incorporates the Equivalence Principle, so there is no gravitational force and an object freely falling towards the Earth is at rest relative to an inertial reference frame, which can be imagined falling with the object. As such, there is no acceleration relative to this inertial reference frame and the object's inertial mass is irrelevant. An object of a different inertial mass will behave in the same wave relative to the same frame.

In this lab you will measure the distance and time of freely falling masses, to the extent that this can be achieved in a lab where the air cannot be removed. This will allow you to assess whether masses accelerate, calculate this acceleration due to gravity, g, in Dallas, and assess the extent to which objects of different mass fall with the same acceleration.

Equipment

Behr free fall apparatus (metal rod, rod clamps, ball bearing clamp, timer, DC transformer, timer pad), one small one large ball bearing.

Procedure

Supply DC electrical power to the timer and turn it on.

Load the small ball bearing in the clamp at the top of the Behr freefall apparatus. It is critical that you perform this operation **gently** so that you do not alter the height of the clamp from one trial to the next.

Measure the height d from the bottom of the ball bearing to the timer pad on the floor using the two-meter stick. Do this more than once independently and average the results.

Reset the timer.

Release the ball bearing. The timer will begin counting thousandths of a second, and will stop when the ball bearing strikes the pad on the floor. Record the freefall time t.

       Reload the ball bearing, reset the timer, and repeat for several trials, average the results.

       Repeat the above steps for the larger ball bearing.

       Move the clamp to approximately half the previous height and repeat the measurements for the small ball bearing.

Questions

1. Comparing the timing results with the small ball bearing at the two different heights, what can you deduce qualitatively about the speed of the ball as it falls?

2. Using the larger height, for both the large and small ball calculate the acceleration g from the Galileo's formula

$$g = 2\, d\, /\, t^2$$

Use the longest and shortest times t you recorded to make a random error estimate on your values of g.

3. Is your free-fall acceleration in agreement with the standard value 9.80 m/s^2 ± 0.01 m/s^2 (do the error ranges overlap?)

2. Is your free-fall acceleration for different inertial masses in agreement? (do their error ranges overlap?)

3. Based on your everyday experience of falling objects, how might you expect air resistance to affect results in this experiment compared to true free fall.

Conclusions
Summarize what you learnt from your data in this experiment.