Name__________________________ Period _____
Partners_________________________ date________

Free Falling

Acceleration, *a*, is a vector: *a* = (magnitude of *a*) + its direction.

$$A = \frac{v_f - v_i}{t}$$

Objects can have a wide variety of accelerations, with different magnitudes and directions. The *acceleration due to gravity* is the acceleration an object has when it is in "free fall," that is, when only the force of gravity acts on it. If you throw a ball into the air upwards or downwards, the instant after it leaves your hand, we say the ball is in "free fall," whether *it is moving up or down.*

The acceleration due to gravity is a constant 9.8 m/s^2.

Picture the path a ball takes as you throw it straight up in the air. As soon as it leaves your hand it starts to slow down (neg. acceleration) until it reaches the top of its flight and then it speeds up as it returns. Many students make the mistake of thinking that at the top of the flight, when the velocity is zero, the acceleration will be zero also. But, stop and think. The velocity can only be zero for one point in time. During the time increment on either side of the zero velocity point, the object will be moving, and will therefore have velocity. And, acceleration is the change in velocity divided by time.

I.

"Free fall" acceleration is called *the acceleration due to gravity*. It has a special symbol: *g*. *g* is relatively constant as long as you are near the Earth's surface.

"true or actual" value of *g* = ________ m/s^2

To write *g* as a vector, technically speaking you should add a direction (+ or -) to this magnitude. Rewrite *g* here with its magnitude and correct sign:

g = ________ m/s^2

Sometimes physicists simply say that the acceleration due to gravity g = 9.8 m/s^2, without giving its sign (the direction is understood to be "down," or negative), because they all know it is downward.

Suppose a ball is thrown upward. How much speed (in units of m/s) does it lose each second on the way up?

Suppose a ball is falling downward. How much speed (in units of m/s) does it gain each second on the way down?

II A.

In this part of the lab, you will calculate an experimental value for the acceleration due to gravity dropping a tennis ball a known distance and measuring the time it takes to fall. **Time your own drops. Each partner should collect their own data and record it in their table.** Have your lab partner drop the ball from the balcony ten different times.

trial #	time (s)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

1) What is the displacement of the ball? d = ___________ m

2) What was the average of the ten trials? t = ______ s

You know the ball's displacement, *d*. You know how much time it takes to fall. (Use the average time as your best value.)

3) What is the initial speed of the ball? v_i = ____________ m/s

4) A derived formula from acceleration is: $\mathbf{d = \frac{1}{2} * g * t^2}$. Use this formula to determine an experimental acceleration due to gravity.

5) We know the actual g is 9.8 m/s^2. What is the percent error between your value and the accepted value? (*To calculate percent error* - you subtract your value from the accepted value and then divide that number by the accepted value then multiply by 100.)

II B.

Using the acceleration formula we can also calculate the velocity of the ball as it hit the floor. Calculate the final velocity of the ball as it falls. Show your work (equation used, substitution of values with units, and answer with units) in the space below. By rearranging the acceleration formula, we can solve for the final velocity.

$$\mathbf{v_f = (g * t) + v_i}$$

How fast would the ball be traveling after 5 seconds if it was dropped from a higher location?

How far would the ball travel in those 5 seconds?

III.

Next, we are going to use the value of *g* (acceleration due to gravity) to measure your reaction time. *Reaction time* is the time between when you see something happen and when you react to it. Using a stop watch do measure this would be unproductive since starting and stopping the watch also depends on your reaction time. In this part of the lab, your partner will drop a ruler, and you will try to catch it as quickly as possible. The time between when they drop it, and when you catch it, is your reaction time. We will calculate the time it took for you to react using formula we used in part IIA.

The formula for calculating the distance an object will travel in free fall is: $\mathbf{d = \frac{1}{2} * g * t^2}$

You will be instructed on how to drop the ruler fairly.
When you catch the ruler, read off how far it has dropped in *cm*, and record in the table at right. Do 10 trials for each partner. Each partner must record their own data in their own table and use their own data for their own calculation.

trial #	**distance (cm)**
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

1) average distance *d* = ______ cm

2) Convert your average distance in *cm* to *m*. *d* = ________ m

Now think of your ruler as an object in free fall. As it falls, its acceleration is *g*. For the calculation below, **use the actual value of *g*.** Add the negative sign to *g* to show its direction. Since the ruler was dropped, you know v_i for the ruler. From your data, you know the distance it fell—the average *d*, in m. Add a negative sign to *d* also to show that it is a downward displacement.

3) Calculate the time the ruler is in free fall, from the time it is released until you catch it. (this is your reaction time) Show your work. Use the formula above the data table.

Reaction time =________________________

Now that you know your reaction time, go back to the beginning of the lab and add 2x this amount to your average drop time for the tennis balls. Recalculate the experimental acceleration due to gravity and list it below. Show your work.

New value for g = _________________

Also, recalculate the percent error with this new time value taken into consideration.

New percent error = _______________________