Phy 100's Lab - Comparison and Relationship between Different Energies

Name____ **Course & Section**______

Lab Partner___________________________________ **Date** ______________

Please read each step carefully and make sure you understand it.

1) Check to be sure that the 30 cm end of the rigid, grooved plastic ruler is set on top of the wooden blocks and that the ruler is secured with a screw or tape at both ends. This will be your ramp. (Secure carefully such that a ball rolled down the ramp cannot make contact with screws or tape.) Make sure the higher end is roughly 8 cm vertically above the lab table and the lower end is about 10 cm horizontally from the edge of your table.

2) Use the plumb bob to precisely mark the spot on the floor that is directly below the point on the edge of the lab table where the ball rolls off after rolling down the ramp. Mark that spot by placing the edge of a piece of masking tape on the floor parallel to the edge of the table and immediately beneath the sharp metal point of the freely hanging bob. Then, align a meter stick with the hanging plumb line and measure the vertical height, y of the top of your lab bench from the floor in cm, and record it below in meters.

y =

3) Place the steel ball bearing in the groove at the 8 cm mark on the ramp, and let it go. It should roll down the ramp, across the 10 cm of open tabletop, then fall down to the floor. See where it hits the floor, and tape a piece of blank paper to the floor so the spot where the ball repeatedly hits is about 3 cm beyond the edge of the paper nearest the table. Place a piece of carbon paper, dark side down, on top of your blank paper so that the ball will land on it when rolled from the ramp. No need to tape the carbon paper, which can be shifted as needed, but *DON'T move the white paper once a ball landing mark has been made*.

4) Place the center of the ball again precisely at the 8 cm mark on the ramp and hold it there. In this position, it is not moving. What type of energy does the ball currently possess?

5) Let the ball go, and watch where it hits the carbon paper. Underneath that spot, there will be a black dot on the white paper. Identify this spot as made from the 8 cm start by writing "S8" next to it on the white paper. Do this two more times, and identify successive spots on the white paper. What type of energy did the ball have at the bottom of the ramp that caused it to roll off of the table?

6) Roll the steel ball three times from each of the 16, 24, and 28 cm markings on the ramp. Be sure to label each of the points of impact on the white paper appropriately with "S16", "S24", and "S28".

7) Obviously, the height, y that the ball fell vertically from the edge of the table to the floor is the same every time. Likewise, the exact same vertical acceleration, g acts on the ball every time it falls, therefore the clock time it takes for the ball to fall from the edge of the table to the floor should also be identical for every roll…, regardless of the starting point on the ramp and regardless of how fast the ball speeds horizontally off of the table. Why?

Use the precise measurement of table height, y you took in step 2, and $g = 9.803\ m/s^2$ in the following equation to calculate the time, t the ball should've been in the air. This is the fall time of any mass dropped from height, y near the surface of the earth. Write your entire calculation below with correct units, not just the result.

$$t = \sqrt{\frac{2y}{g}}$$

8) Now measure the horizontal distance to each impact mark from the tape you placed on the floor below the edge of the table, and record it in the chart below in meters. These are the "ranges" of your "projectiles" and can be larger only when the ball has been given more energy to fly further, right? This distance DOES depend on how fast the ball speeds off of the table, right? Discuss with your partner. Take the average of each group of 3 to get a single representative measurement of the distance.

Roll	S8	S16	S24	S28
1				
2				
3				
Avg.				

9) Since each S group took the same amount of time to reach the floor, but still achieved different horizontal ranges, which S group do you think had the highest horizontal speed when they flew off the edge of the table? (*Remember: longer distance travelled in the same time means higher speed)*.

10) Now that you've made a prediction, let's do some quick calculating. Find the average speed of each group above, by using $v = \frac{d}{t}$. "d" is your average horizontal distance from the table, and t is the time it should take for the ball to travel that distance. The result you calculate is the average horizontal velocity. Was any force present to change this horizontal speed while the ball was in the air? Was your prediction verified by the calculations? Use the space for your calculations, but be sure to record your results in the table.

	S8	S16	S24	S28
v				

11) Any object in motion has kinetic energy (KE), therefore the ball had a certain kinetic energy when it left the table top, where $KE = \frac{1}{2}mv^2$. The Law of Conservation of Energy states that energy doesn't simply appear, it must come from somewhere (in other words, motion does not start or change without some reason). Where did this kinetic energy come *from*?

12) An object raised up vertically against a gravitational force is given gravitational potential energy (GPE), as when the ball was lifted onto the ramp a small height, h above the table top. It is calculated by $GPE = mgh$. If all of that initial GPE on the ramp became merely horizontal KE at the bottom of the ramp (before the ball flew off of the table), then the GPE at the start equals the KE at the bottom of the ramp and $\frac{1}{2}mv^2 = mgh$ or, solving for velocity we get: $v = \sqrt{(2gh)}$

Use the digital balance to take the mass of the ball and record it below, in grams and kilograms.

Steel Ball mass:

13) Measure each vertical height, h that the ball was lifted in direct opposition to gravity in order to get it up onto the ramp.

	S8	S16	S24	S28
h				

14) Calculate GPE for each different h. This is the initial amount of energy available due to gravity before you let go of the ball. Once the ball rolls to the bottom of the ramp, h becomes zero and the GPE is all gone, having transformed into the KE that propels the ball off of the edge of the table.

	S8	S16	S24	S28
GPE				

15) Using the GPE's you've just found and the idea that $KE = \frac{1}{2}mv^2 = GPE$, let's now try a new & different (theoretical!) way to figure out how much horizontal velocity, v each group of rolls had. Remember, KE is set equal to the GPE values above, m is the mass of the ball and v is the speed we're looking for. ***Do not insert any values of v from step 10!!*** Solve for each theoretical v! Record your results below. Note that mass cancels out and v depends only on g & h! Why does this make sense? (The answer is illustrated by the behavior of different masses released into freefall together.)

	S8	S16	S24	S28
v_{new}				

16) Since energy doesn't simply appear and then disappear, the KE of the ball as it rolled off the table must've come from the GPE it possessed when raised up against gravity. However, if you find the percent difference between the velocities found in step 10 (using real-life distance and time measurements) and the new values in step 15 above (found by assuming that ideally ALL of the potential energy became kinetic energy), you'll see that they are somewhat different (about 20% is typical.) Which are greater, the real experimental velocities or the idealized theoretical? Does it appear that all of the GPE truly became KE as we supposed it would? What numeric evidence do you have? How might some energy that should've generated a more rapid motion of the ball have been lost? Mention more than one possibility and justify.