

## Phy 100's Lab – Work: Comparison and Relationship between 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 plastic ruler is set on top of the wooden blocks and that the ruler is secured with tape at both ends. This will be your ramp. (The tape should be applied as to not interfere with a ball rolled down the ramp.) Make sure the higher end is roughly 8 cm vertically above the lab bench and the lower end is about 10 cm horizontally from the edge of your bench.

2) Use the plumb line and plumb bob to find the spot on the floor that is directly below the edge of the lab bench. Mark that spot by placing the edge of a piece of masking tape right at the point of the hanging bob. Then align a meter stick with the hanging plumb line and measure the 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 securely to the floor so the spot where the ball hits is about 3 cm in from the nearest edge of the paper. Lay a piece of carbon paper, dark side down, on top of your blank paper so that the ball makes an obvious mark when landing. *After the first mark, the white paper cannot be moved again, but the carbon can be shifted to anywhere it's needed.*

4) Now place the ball again 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 have?

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 the ball rolled from the 8 cm mark 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 the instant it left the table?

6) Continue to roll the steel ball, three times each, from the 16, 24, and 30 cm markings on the ramp. Be sure to label each of the points of impact on the white paper appropriately with "S16", "S24", and "S30".

7) Obviously, the height,  $y$  that the ball fell vertically from the edge of the bench to the floor is the same every time. Likewise, the exact same vertical acceleration,  $g$  acts on it 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. Why doesn't changing the speed at which the ball leaves the table affect this time?

Use the measurement of table height,  $y$  you made in step 2, and  $g = 9.803 \text{ m/s}^2$  in the following equation to calculate the time,  $t$  the ball should've been in the air. This is the flight 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 distance,  $X$  to each impact mark from the tape you placed below the edge of the table, and record it in the table below. These are the "ranges" of your "projectiles" and can be larger only when the ball has been given more energy to fly further, right? Then take the average of each group of 3 to get a single representative measurement of the distance.

| Roll      | S8 | S16 | S24 | S30 |
|-----------|----|-----|-----|-----|
| 1         |    |     |     |     |
| 2         |    |     |     |     |
| 3         |    |     |     |     |
| Avg.<br>X |    |     |     |     |

9) Since each S group took the same amount of time to reach the floor, but still achieved different X 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 a certain time means higher speed*).

10) Let's do some quick calculating to verify your answer above. Find the average speed of each group rolled from the same height by using  $v = \frac{d}{t}$ . where d is your average horizontal X 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 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 | S30 |
|---|----|-----|-----|-----|
| v |    |     |     |     |

11) An 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 without some reason). Where did this kinetic energy come *from*?

12) An object raised up vertically against a gravitational force has gravitational potential energy (GPE), as when the ball was lifted onto the ramp a new height, h above the table top. It is calculated by  $GPE = mgh$ . If all of that initial GPE became horizontal KE before the ball flew off of the table, then  $\frac{1}{2}mv^2 = mgh$  or, solving this 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 | S30 |
|-----|----|-----|-----|-----|
| $h$ |    |     |     |     |

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 | S30 |
|-----|----|-----|-----|-----|
| 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 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 use any values of  $v$  from step 10!!*** Solve for the new  $v$ ! 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 speeds of different masses released into freefall together.)

|                  | S8 | S16 | S24 | S30 |
|------------------|----|-----|-----|-----|
| $v_{\text{new}}$ |    |     |     |     |

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 above (found by assuming that ideally ALL of the potential energy became kinetic energy), you'll see that they are somewhat different. Is one set of velocities consistently bigger? Does it appear that all of the GPE truly became KE as we supposed it would? What evidence do you have? How might some energy that should've generated a more rapid motion of the ball have been lost? When you rolled the ball, did any energy escape as sound waves? If so, describe the source. Mention multiple possibilities and justify.