

The Ball Bearing Bounce

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Curriculum Connection: SPH 4U-1 (Physics, 11U) — Kinematics

This was an exciting activity to undertake as the students did the calculations first, then we headed down to the cafeteria to try the equipment out and see if our calculations were correct. Kids were high-fiving each other when they achieved the desired and expected results and it was a real motivating factor.

Purpose

To accurately predict the landing spot of a horizontally projected sphere (ball bearing).

Equipment

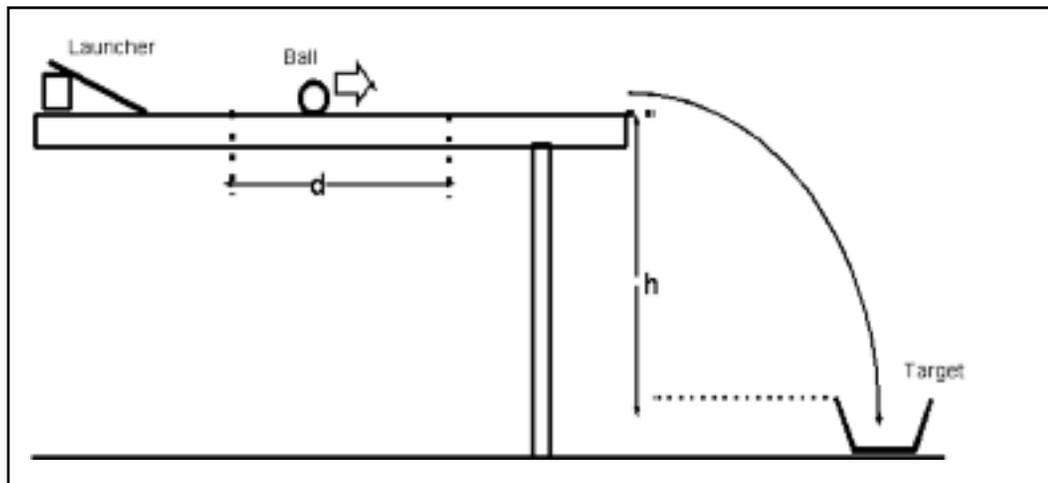
- ball bearing
- metre stick
- stopwatch
- string & paper clip (serves as a weight)
- masking tape
- grooved launcher (consisting of the metal plate and a ruler) — assembly details follow
- metal plate (from the old “refraction of particles kit” — 30 cm x 35 cm but can use any similar-sized piece of metal or wood)
- calculator
- styrofoam soup bowl or cup partially filled with sand

Method

The activity may be done in groups of 3 or 4, depending on the size of your class. We started in the classroom, doing the calculations, then we moved into the cafeteria to allow for more space. We usually attracted spectators, which made the activity even more engaging for the class.

1. Devise a launcher using materials from the equipment list, including a grooved ruler or plastic, the metal plate, and textbooks. For an example, see: http://www.staples.ca/en/Westcott-KleenEarth-Recycled-Ruler-12-inch-30-cm/product_792040_2-CA_1_20001.





2. Find a starting point on the launcher that gives a reasonable velocity. Put two pieces of tape 50 – 100 cm apart on the table near or on the ball's path so that it is easy to measure the time it takes the ball to roll between the two spots. This is "d" (the distance) in the diagram above. The distance that you choose needs to be a compromise.
 - If the "d" is too small you will have difficulty obtaining an accurate reading for the time it takes for the ball to travel the distance, and this will affect your velocity calculation. In other words, if "d" is too small there will be a problem with human reaction time and your stopwatch.
 - If "d" is too long, it is too big a distance and the ball may not maintain a constant velocity. i.e. friction may cause the ball to slow down and once again your velocity calculation may be affected. We are looking for a compromise distance and time that are easy to measure accurately.
3. Measure the time it takes the ball to cross "d". It may be a good idea to do several trial runs and calculate the average. Record the data clearly in a table.
4. Calculate the velocity, v, of the ball as it rolls across the table.
 - Note the ball's highest velocity (v1) is at the bottom of the ramp. It slows a bit as it continues to travel due to friction. By the time it has crossed "d" it is moving slower (v2) The velocity that you calculate is the average velocity:

$$\frac{v_1 + v_2}{2} = v_{average}$$

This is the ball's instantaneous velocity approximately half way along "d" assuming constant acceleration. In order for the ball to leave the table at the calculated speed, the distance from the bottom of the ramp to the edge of the table should be "d/2"
5. Carefully measure the vertical distance from the top of the table to the top of the styrofoam soup bowl or cup (target) This is shown as "h" in the diagram. Record this value.



6. Calculate the time it will take for the ball to fall from the top of the table to the top of the target. Show this calculation clearly.
7. Calculate the horizontal distance that the ball will travel as it falls to the top of the target. Show this calculation.
8. Locate the point on the floor directly below where the ball will leave the table. You can do this by making a small "plumb bob" with a string and a weight (such as a paper clip).
9. Determine exactly where to place the target (soup bowl or cup) so the ball will roll off the table and land in it.
10. While you wait for the grand launch, review your calculations. Remember that all your calculations are based on a "perfect" system but there will be a small amount of friction. You may want to think about this when you place your target on the ground.

IMPORTANT NOTE

Your ball cannot roll off the table until it is your team's turn to launch. You will be given a small stick to put across the edge of the table to prevent the ball from flying off as you do your practice runs.

If your team violates the above rule, you will be disqualified from the official launch.

Marking

1. This is a group lab graded out of 20.
2. **CALCULATIONS:** You will be given 10 marks if all your calculations are clearly shown (with units) and if they are reasonable (i.e. within 10cm of where the calculation predicted where the target should be). Only one set of calculations per group has to be handed in.
3. **ACCURACY:** You will be given 10 marks if your projectile lands in the bowl or cup when launched (if the ball misses the bowl slightly to the right or left it will still count).

BONUS ! BONUS !

If you feel very confident, you may choose to replace the styrofoam soup bowl with a styrofoam coffee cup. If your ball lands in (or directly beside) it you will be given 15 marks instead of 10. However, if you miss, your accuracy mark will be zero. Are you a gambler ???

