Coins off the Table: 2D

Directions:

Read through the entire experiment first, and then assemble your equipment in a clean space away from pets or children. Although this is a very safe activity, you should always consider safety when performing a lab. When you have finished the experiment, be sure to put everything away and leave the area clean and tidy. Create your data table(s) before starting the lab.

- Fill in the template as you go.
- You will submit your lab data to the wiki this week and be given the opportunity to revise your responses in the template before submitting it next week.
- Longer responses should be typed. Calculations may be done by hand, and you can insert an image into the appropriate spot on the template.

Materials:

- Three coins: two medium and a large.
- Pencil
- Balance
- four sheets of copy/printer paper
- Tape Measure
- A straight edge.
- A protractor.
- Safety glasses
- A plumb line (string with a weight on the end.)
- Tape
- A flat level surface
- A volunteer

Procedure:

1) Tape the edges of the copy paper so they make a large rectangle 22 inches long and 17 inches wide.
2) Place the center of one 17-inch edge directly below the point where the impact will occur and orientate it perpendicular to the direction of travel of the incident coin.
3) Lower a weight on string from the point of impact or use a long straight object to mark the spot on your paper directly below the edge of the table where the impact will occur.
4) Practice sliding a medium mass coin across the table with consistent speed.
   a) Once you feel you can hit the same general area consistently mark where it lands on the paper.

b) You may need a volunteer to help observe.

5) When you are satisfied that you can be reasonably consistent, draw a circle around where the coin is landing.
6) Draw a line from the reference point you made in step 3 to the center of that circle.
7) Measure the length of that line and use the acceleration of gravity and the height of the table to calculate the speed of the coin as it left the table. **Show your work** in the box below: (2 pts)

Length of line: 0.214 m

Acceleration of gravity: -9.8 m/s^2

Height of the table: 0.908 m

$\Delta y = v_{y0}t + (1/2)a_y t^2$

$-0.908\text{ m} = (1/2)(-9.8\text{ m/s}^2)t^2$

$t = \text{sqrt}(((-0.908\text{m})(2))/(-9.8\text{ m/s}^2))$

$t = 0.430$ s

$\Delta x = v_{x0}t + (1/2)a_x t^2$

$0.214\text{ m} = v_{x0}(0.430)$

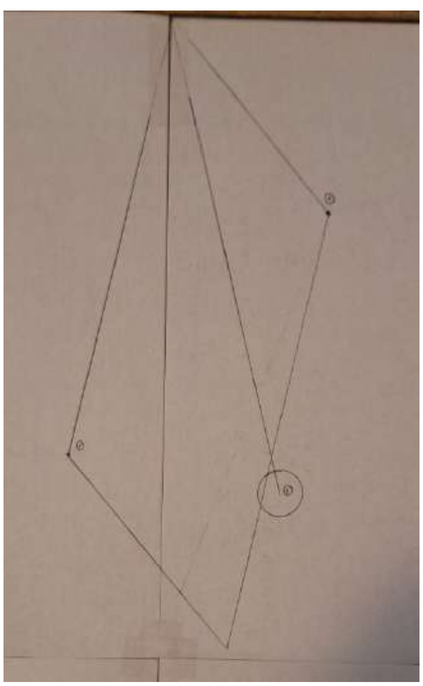
$v_{x0} = 0.498$ m/s

$v_i = 0.498$ m/s

8) Use the mass to calculate its kinetic energy just as it leaves the table. **Show your work** in the box below. (2 pts)

Mass of medium coin: 0.00251 kg $K = (1/2)mv^2$ $K = (1/2)(0.00251)(0.498)^2$ $K = 0.00031$ J

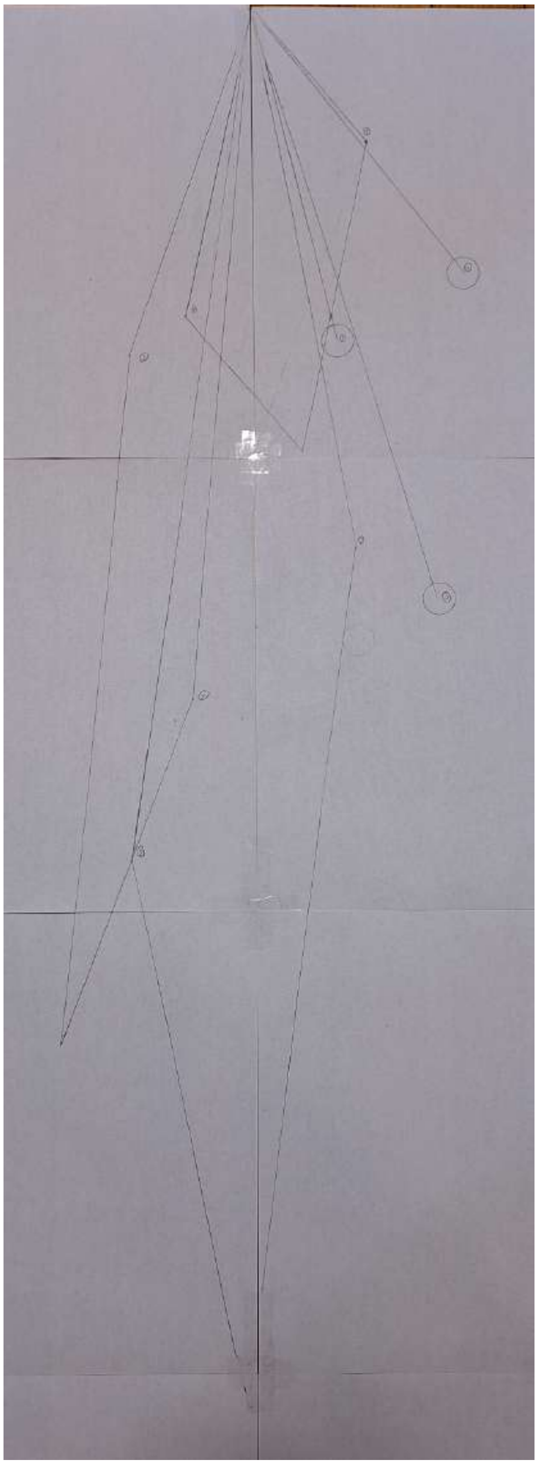
9) Now set a similar mass coin on the edge of the table.
10) Try to strike the target coin on the side to slide the incident coin at the same speed you used when you made the circle.
11) Identify where both coins strike the paper and draw lines from the reference point to each of the points of impact.
12) Construct a parallelogram by replicating those two lines on the ends of each other.
    a) **Insert a picture** of your parallelogram (2 pts):



b) How close does the point of intersection come to the circle you drew? (1 pt)

0.071 m

13) Repeat this experiment **twice** more drawing two more parallelograms. **Insert the picture(s) (4 pts)**:



14) We can determine the initial velocities of each of the coins by dividing their distance by the time of fall. Then calculate the kinetic energy of each coin and compare the sum of their kinetic energy to the original. What percent of the energy was lost in each trial? **Show your work** in the box below. (2 pts)

$t = 0.430$ s $m = 0.00251$ kg $v_{xi1} = v_{i1} = (0.197\text{ m})/(0.430\text{ s}) = 0.458$ m/s $v_{xi2} = v_{i2} = (0.11\text{ m})/(0.430\text{ s}) = 0.256$ m/s $K_1 = (1/2)mv^2 = (1/2)(0.00251\text{ kg})(0.458)^2 = 0.000263$ J $K_2 = (1/2)mv^2 = (1/2)(0.00251\text{ kg})(0.256)^2 = 0.0000819$ J $K_{total} = 0.000263\text{ J} + 0.0000819\text{ J} = 0.000345$ J $K_{original} = 0.00031$ J Percent of energy lost = (((0.000345 J) – (0.00031 J))/(0.00031 J))100 = 11.22%
Percent Momentum lost: $P_{original} = mv_i = (0.00251\text{ kg})(0.498\text{ m/s}) = 0.00125$ kg(m/s) $P_{total} = mv_{i1} + mv_{i2} = m(v_{i1} + v_{i2}) = (0.00251\text{ kg})((0.458\text{ m/s})+(0.256\text{ m/s})) = 0.00179$ kg(m/s) Percent momentum lost: (((0.00179 kg(m/s)) – (0.00125 kg(m/s)))/ (0.00125 kg(m/s)))100 = 43.2%

15) Measure the interior angles of your three parallelograms. Is there any correlation to the angle's measure and the percent energy lost? Should there be? (2 pts)

53°, 20°, 15°

16) Turn the paper over. Remark the reference point below the point of impact.
17) Slide the larger coin, again until you can be consistent and draw a circle around your impact area.
18) Measure the mass of the larger coin and calculate and record its momentum and kinetic energy. **Show your work** in the box below: (2 pts)

Mass of large coin: 0.00565 kg

Acceleration of gravity: -9.8 m/s^2

Height of the table: 0.908 m

$t = 0.430$ s

$\Delta x = v_{x0}t + (1/2)a_xt^2$

$0.155 \text{ m} = v_{x0}(0.430)$

$v_{x0} = 0.360$ m/s

$v_i = 0.360$ m/s

$K = (1/2)mv^2 = (1/2)(0.00565 \text{ kg})(0.360)^2 =$ 0.000366 J

$P = mv = (0.00565 \text{ kg})(0.360 \text{ m/s}) =$ 0.00203 kg(m/s)

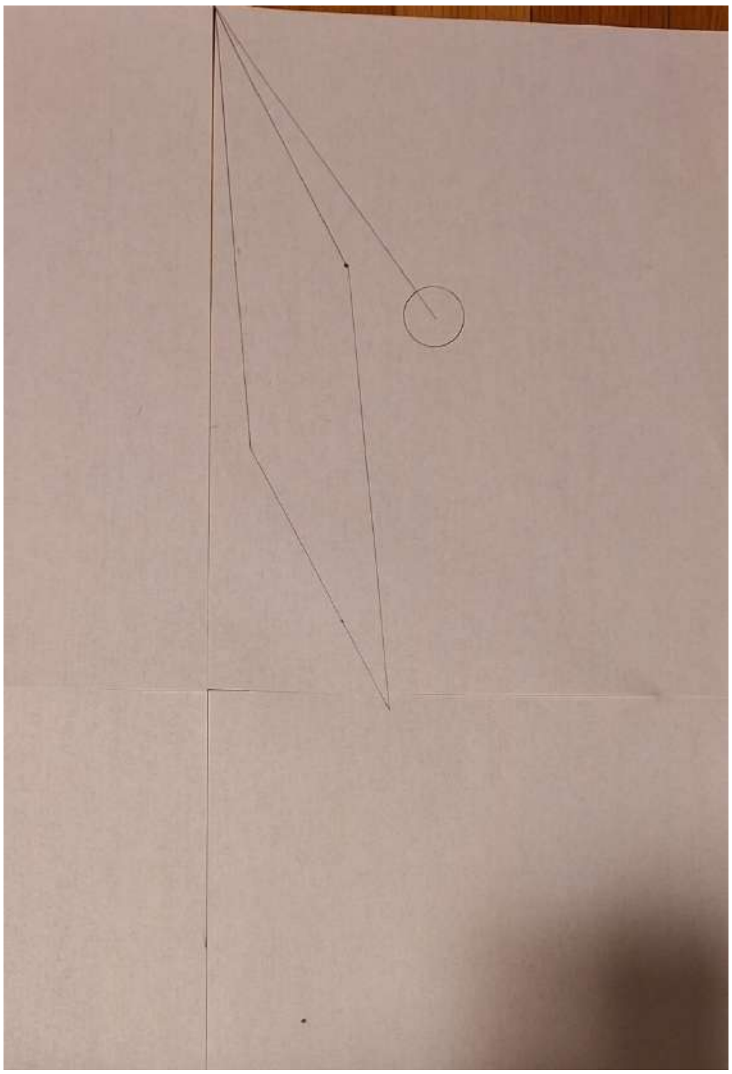
19) Use the medium coin as your target. Find the point of impact and draw lines from the reference point to their point of impact. Now you must shorten the line connecting the medium coin impact point to the reference point by finding the ratio of the mass of the medium coin to the mass of the larger coin and shorten that line proportionally.

Ratio: mass of medium coin/mass of large coin = (0.00251 kg)/(0.00565 kg) = 0.444

Original length of line connecting the medium coin impact to the reference point: 0.41 m

Shortened length of line: 0.182 m

20) With that new line construct your parallelogram, and **comment on how close it falls to your circle**. (1 pt)



Distance from point of intersection to the circle: 0.161 m

21) Calculate the kinetic energies of the two coins and compare them to the kinetic energy of the coin before it collided. **Show your work: (2 pts)**

SEE WHAT VALUE TO USE FOR RANGE OF COIN

21. Insert a picture of you with the lab setup: (2 pts)

Analysis Questions (8 pts total– 2 pts each)

a. What does the parallelogram you drew represent?

b. Why did you have to adjust the length of the less massive coin?

c. Do you think this proved momentum was conserved? Why or why not?

d. What was the significance of measuring the parallelogram's interior angle? What should it have been?

e. Was kinetic energy conserved? On what do you base your answer?