

SC 130 Physical Science Laboratory Four: Momentum and Energy

Marble Momentum and Energy

Introduction

This laboratory explores the concepts of conservation of momentum and energy. Equipment needed included marbles, rulers that function as marble tracks, wide masking tape to hold down the track, books to wedge up one end of the track, and stopwatches.

Terminology: Large, shooter marbles are called taws. Small marbles are called ducks. What do you call shooter and player marbles? What do you call marbles?

Questions

Can we show that momentum and energy are conserved in a simple system?

Introduction

Existing theory asserts that both momentum and energy are conserved. In the first part of this three-part laboratory you will explore qualitatively the conservation of momentum. In the second part you will attempt to confirm or disconfirm a finding that momentum is conserved in a simple system. You will be doing another important activity in science – determining whether a result can be reproduced or not. In the third section you will attempt to show that energy as described by physics theory is also conserved. The order in which you do the three parts is not critical, and each group will start with a different part. The theory needed for each part will be introduced with that part.

Part One: Conservation of Marble Momentum

Hypothesis

Marbles in equals marbles out. Speed in equals speed out. Momentum in equals momentum out.

Momentum is defined as the product of mass and velocity (speed). $m_{in} \vec{v}_{in} = m_{out} \vec{v}_{out}$

Marbles are mass, their velocity is a speed in a particular direction.

Procedure

Place a set of five marbles touching each other on the flat stretch of ruler track.. Release a single marble down the ruler ramp. How many marbles come off the end of the track? Release two marbles down the track. How many marbles come off the end of the track? Continue on for three, four, five and more marbles. What happens when the number released exceeds the number on the flat part of the track?

Set up five marbles on the flat part of the track. Release a single marble, but this time give it a gentle extra push to start the marble so it is traveling faster than a simple release. Do more marbles come off the track? Is there a speed difference? Experiment. Play gently – marbles can and do break.

How do the marbles know how many marbles should be "kicked off" the track each time? How do the marbles count? Just how smart is a marble?

Data tables | Data Analysis and Results | Data Display/Diagrams

Design your own. You decide how to best record and present the data you have gathered.

Part Two: Testing for Conservation of Momentum in a Collision

Introduction

Momentum is said to be conserved. This means that the momentum before an event should be equal to the momentum after an event. The other evening I rolled a taw (shooter) marble (19.25 gm) down a ramp into a duck marble (5.20 gm) which was sitting at rest on the flat part of the ramp. The large marble hit the small marble and both then rolled off the end of the track.

To determine whether momentum was conserved, I first released the large marble by itself and timed the marble over the final flat 30 cm of track to determine the large marbles initial speed. Then I ran the collision twice, once to determine the speed of the small marble and once to get the speed of the large marble after the collision. Each time I had to be sure the large marble started from the exact same place on the track. Then I set up my equation:

$$\begin{array}{ccc} \text{before} & & \text{after} \\ m_{\text{big}} \vec{v}_{\text{big}} + m_{\text{small}} \vec{v}_{\text{small}} & = & m_{\text{big}} \vec{v}_{\text{big}} + m_{\text{small}} \vec{v}_{\text{small}} \end{array}$$

$$(19.25 \text{ gm})(40.0 \text{ cm/s}) + (5.20 \text{ gm})(0.00 \text{ cm/s}) = (19.25 \text{ gm})(27.2 \text{ cm/s}) + (5.20 \text{ gm})(39.0 \text{ cm/s})$$

$$770 \text{ gm}\cdot\text{cm/s} = 523.6 \text{ gm}\cdot\text{cm/s} + 202.8 \text{ gm}\cdot\text{cm/s}$$

$$770 \text{ gm}\cdot\text{cm/s} = 726 \text{ gm}\cdot\text{cm/s}$$

The percentage difference in these results is $(770 - 726)/726 = 0.06$ or 6%. This is a good agreement with the theory. The results are never likely to be exactly equal. There are always uncertainties in the measurements. Close enough is good enough in such a simple lab. 10% or less of the difference is good agreement, even 10% to 20% difference would not be an unreasonable difference. Put it this way, I cannot disprove the theory based on my data.

Hypothesis

The sum of the momentums before the collision are equal to the sum of the momentums after the collision.

Procedure

Your task: repeat the experiment using your own measurements and choices of marbles. Suggestion: stick to running larger marbles into smaller marbles. There is a sign issue to deal with when small marbles hit large marbles – the small marble sometimes reverses direction and bounces back up the ramp. Momentum is still conserved, but measuring the velocity of the bounced marble is difficult at

best.

Data tables | Data Analysis and Results | Data Display/Diagrams

Design your own. You decide how to best record and present the data you have gathered.

Part three: Conservation of Potential and Kinetic Energy in a simple system

Introduction

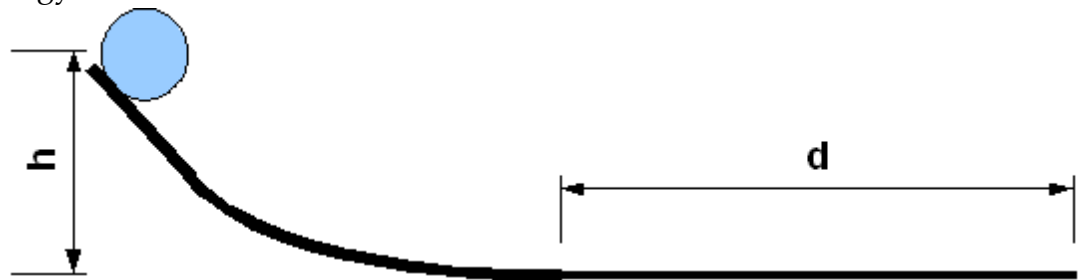
Kinetic energy is defined to be: $\frac{1}{2}mv^2$ where m is mass and v is velocity.

Gravitational potential energy is defined to be: mgh where m is mass, g is the acceleration of gravity, and h is the height of the object. For this laboratory either use your g from last week or use the generally accepted value of 980 cm/s^2 . Your choice.

The theory states that the kinetic energy of a object that falls a distance h should be equal to the lost gravitational potential energy:

$$\frac{1}{2}mv^2 = mgh$$

Obtain the mass of a marble of your choice. Roll the marble down the ramp. Determine the



final velocity by working out the distance d divided by the time t on the flat stretch of track. Measure the height h vertically. Work out the kinetic and gravitational potential energy. Are they equal? d in the diagram above is not used in the formula, it is the distance over which I recommend you determine the speed v of the marble after it has "fallen" a distance h.

Hypothesis

The kinetic energy of a object that falls a distance h is equal to the lost gravitational potential energy.

Data tables | Data Analysis and Results | Data Display/Diagrams

Design your own. You decide how to best record and present the data you have gathered.

Conclusions

Wrap up these three activities with an essay that addresses each of the three activities and the results you observed and measured. Comment on whether the hypotheses held for your team. Discuss anything unusual, new, or different you encountered. Discuss what the conservation of momentum and energy means for you in light of the above activities. Be thorough and complete. Use correct grammar and spelling.