Conservation of Momentum

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Topic

Conservation of momentum

Time

1 hour

Safety

Please click on the safety icon to view the safety precautions.

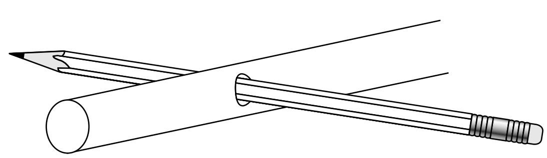
Materials

- sheet of paper, 8 ½ 2 11 in.
- 8 small marbles
- one large marble
- ruler with a center groove
- masking tape
- book or other object about 3 cm thick
- two pencils
- hole punch

Procedure

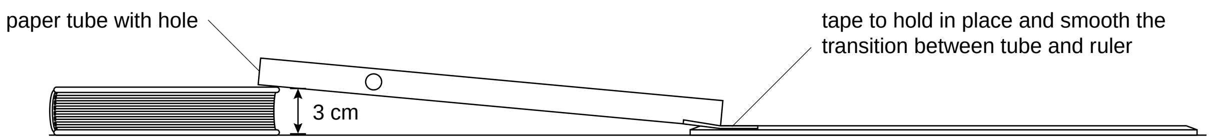
1. Roll the piece of paper lengthwise so that you have an 11-in. tube that is just slightly larger in diameter than one small marble. The marble should be able to roll through the tube easily without sticking, but the tube should be narrow enough to keep the marble from moving much from side to side. You may find it helpful to get a smooth tube to roll the paper around two pencils held together side by side. Put a piece of tape around the tube in the middle to hold it together.
2. Remove the pencils, and punch two holes on opposite sides of the tube about 5 cm down from one end. If your hole punch will not reach down that far, you will have to carefully squeeze the tube together and punch through both sides at once. The holes should be large enough for a pencil to fit easily through them. You may have to punch several times in one area to make a large enough hole. Test the fit with a pencil, making sure that the pencil can slide in and out without sticking (figure 1).

Figure 1



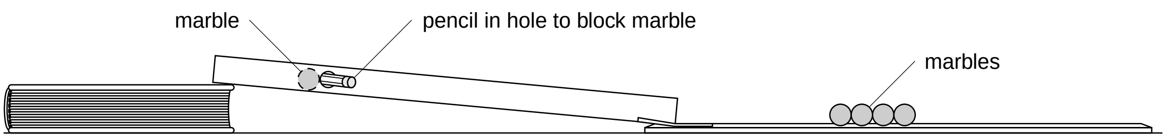
3. Tape the end of the tube farthest from the holes to the end of a ruler. Be sure one piece of tape goes inside the tube to hold the bottom of the tube to the top of the ruler and that the tube is positioned so that the holes are visible on either side.
4. Place the other end of the tube on a book or other solid object that will raise it about 3 cm (figure 2).

Figure 2



5. Put four small marbles on the middle of the ruler; set one marble on the groove in the center of the ruler, and line up the others on the side towards the tube. Make sure all the marbles are touching. Put the pencil through the holes in the tube, just far enough to block the opening of the tube. Place a fifth small marble in the top end of the tube so that the pencil holds it in place (figure 3).

Figure 3



6. Record on the data table the number of marbles on the ruler and the number in the tube. Then make a guess about what you think will happen when you release the marble in the tube so that it rolls down and runs into the marbles on the ruler. Will the marbles on the ruler move? Will the marble from the tube keep moving in the same direction it is going in? Will it roll back toward the tube? Predict how many marbles, if any, will roll off the end of the ruler after the collision, and record your prediction on the data table.

DATA TABLE

Trial	No. of marbles in tube	No. of marbles on ruler	No. of marbles moving off ruler	
			Prediction	Result
1	1	4		
2	2	3		
3				
4				
5				
6				
7				
8				

7. Gently pull out the pencil and allow the marble in the tube to roll down and run into the marbles on the ruler. Observe and record on the data table how many marbles move off the end of the ruler.

   Note: If marbles get knocked off the side of the ruler, check to be sure the tube is pointing straight down the ruler. Move the tube from side to side as needed to align it with the ruler.
8. Set three small marbles on the ruler, and put the pencil back through the holes in the tube. Put two small marbles in the tube. Write down a prediction about how many marbles will move off the end of the ruler when you release the marbles from the tube, then let them go and record the results.
9. Repeat the experiment several more times, using different numbers of small marbles in the tube and on the ruler. Record the setups, predictions, and results on the data table.
10. Place the large marble on the ruler and roll one small marble down the tube at it. Note the results.
11. What happened when you rolled one small marble down the tube to collide with the four on the ruler? How many marbles moved off the ruler?
12. What happened when you rolled two marbles down to collide with three?
13. Was there any apparent relationship between the number of marbles you rolled down the tube and the number that ran off the end of the ruler?
14. What happened when you rolled the small marble at the big one?
15. Was there anything different about the way the large marble rolled off the ruler when it was hit with a small marble, compared with what happened when you used only small marbles?
16. Consider this equation: Momentum = mass 2 speed. How did the mass of the marbles rolling down the tube compare with the mass of the marbles that rolled off the ruler in the first two trials? Was there anything noticeably different about the speed with which the large marble rolled off the ruler when it was struck with one small marble?
17. How do your answers to question 6 relate to the law of the conservation of momentum?

What's Going On

The marble from the tube stopped after it collided with the other marbles. One marble moved off the end of the ruler. Then, two marbles moved off the end of the ruler. In each case, the number of marbles that rolled off the ruler was equal to the number that rolled down the tube, unless there were fewer marbles on the ruler than in the tube, in which case all the marbles rolled off the ruler and the ones from the tube did not come entirely to rest. When the small marble collided with the big one, the small one came to rest and the big one moved off slowly. The big marble moved more slowly than the small marbles.

The mass of the marbles that rolled off the ruler was equal to the mass of the marbles in the tube. The large marble rolled off at a slower speed than that of the small marble that struck it. By the law of the conservation of momentum, the product of mass 2 speed, momentum, should be the same before and after the collision. In trials 1 and 2 of the data table, the marbles that moved off the ruler had the same mass and apparently about the same speed as those that hit them, as the law predicts. The fact that the larger marble moved more slowly when it was struck by the small marble also supports the law. The small marble moving down the tube has less mass than the large marble at rest on the ruler. Before the collision, only the small marble is moving. After the collision, only the large marble is moving. Thus, if the combined mass 2 speed of the two marbles is to remain the same before and after the collision, the large marble with more mass will have to move with less speed than the small marble with less mass that collided with it.

Connections

A moving object is said to have momentum—the product of its mass and the speed at which it moves. The momentum of a rolling ball is equal to the ball's mass times its speed. If the ball collides with a group of other balls, a change will take place in the motion of the balls, but the law of the conservation of momentum predicts that the total momentum among all the balls will remain the same. In this procedure, you made some predictions and observations based on this law.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say "be careful with hot liquids" or "don't cut yourself with the knife" does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don't use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.

- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don’t dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES