14155 Collision in 2D

Purpose:

To demonstrate the laws of conservation of momentum and conservation of energy in elastic and inelastic collision experiments. For "Collision in 1-D" place target on track end.

Required Additional Accessories:

One	(1)	Meter stick
Four	(4)	Sheets of carbon paper
Four	(4)	Sheets of paper
One	(1)	Protractor
One	(1)	Drawing Compass or "Parallel Glider"
		Tape

Discussion:

In this experiment we will investigate what happens when two bodies collide and move off in different directions. To do this, we will use two steel balls of equal mass, one of which will roll down an incline and make a glancing collision with the second ball that rests on a support. As long as air resistance can be neglected, objects projected with different horizontal velocities will strike the ground at the same time. If either ball has a vertical component of velocity this statement is no longer true. With this in mind, it is essential that the target ball be positioned at the same height as the ball leaving the end of the track. Can you predict how your experiment might be affected by having the target ball positioned lower or higher than the ball on the track?

The momentum of each ball can be determined from its mass and velocity. The relative velocity of each ball can be found by measuring the distance from a point on the floor directly below the target ball's support post to the place where the ball first strikes the floor. Multiplying this by the mass gives the relative momentum of that ball, which can be drawn as a vector having the same direction as the relative velocity. All momentum vectors must be drawn to the same scale and must fit on the assembled paper. It is useful to catch the ball on the first bounce to avoid a confusing record.

Procedure:

To assemble the apparatus, use a "C" clamp to fasten the flat plate of the launching ramp to a lab bench or table top. The ramp should be positioned so that the launched ball will be projected away from the table and land on a hard floor. The flat base plate must extend over the edge of the table far enough to allow the pendulum to reach the paper on the floor.

Place one of the ½" steel balls (the target) in the depression at the top of the set screw. This will be the target support post. Insure that the ramp is directly aligned with the support. Place the second steel ball (the incident ball) at the lower end of the ramp. By moving the set screw up or down, align the center of the target ball with the center of the incident ball. To check the alignment, **move the ramp slightly to one side** and then let the incident ball roll down the ramp and strike the target ball. If a single "click" is heard, then the balls have struck the floor at the same time and they are correctly aligned. More than one click would mean that the incident ball also hits the support post. This would be an undocumented interaction. Use the nut to lock the set screw in place on the target support.

Construct the plumb line by tying one end of the thread to the bottom of the set screw. Attach the other end of the thread to the eye of the screw eye and adjust the length of the string so that the tip of the screw eye rests just a few millimeters above the floor. Tape four pieces of paper together. Do not overlap the edges of the paper. (Or secure a large piece of wrapping paper) Position this paper on the floor in front of the apparatus with its short side centered below the point of the plumb bob. Tape the paper to the floor to prevent its moving during the experiment. Check that both the incident and the target ball will fall on the paper after the collision. Relocate the paper if necessary and tape it down again. Tape the four pieces of carbon paper together in the same way and place this over the tracing paper with the carbon side down. Mark the paper at the tip of the plumb bob, after it has stopped swinging.

To investigate the collision between the two steel balls, place the target ball on the support post and release the second ball from the top of the ramp so that it strikes the target ball. Be very careful that you do not move the position of the ramp after the experiment has begun! Repeat this procedure about 10 times, always releasing the incident ball from the same height. As mentioned before, catch each ball on the first bounce to avoid confusing the record.

It is then necessary to find the place where a ball strikes the floor without colliding with any object. Wind the set screw all the way down. Place one of the steel balls at the top of the ramp touching the stop. Release the ball without pushing it down the ramp or giving it any spin. There should be no sound as it passes over the retracted support post. Repeat this procedure about 10 or 20 times. This should result in a close pattern of marks on the tracing paper where the ball struck the floor. Draw a tight circle around this pattern. It gives you an understanding of the reproducibility of your results as well as a range for experimental error. What is the percent error in the initial relative velocity of the ball?

Draw a circle around the marks made on the carbon paper by the incident ball after the collision. Label the circle 1-I. Draw a circle around the marks made by the target ball; label this 1-T.

After completing the collisions, draw a vector on the paper from the point marked directly beneath the support post to the center of the circle of points formed by releasing the single ball (no collision). What does this represent? How did you account for the mass of the ball? See the explanatory note below. Next, draw vectors from the point directly beneath the support post to the center of each pair of circles formed by the colliding balls. Make a proper representation of the momentum vectors involved. How does the vector sum of each pair of momentum vectors compare with the momentum of the incident ball when it rolls down the track without a collision. What does this tell you about the conservation of momentum?

Now change the position of the ramp to provide a different collision. Check again to make sure that the support post is not hit by the incident ball and that the ramp position is not changed during each subsequent experiment. Make 10 trials of the collision and of the incident ball by itself, as before. Draw circles around the carbon marks, as before, labeling 2-I, 2-T, and 2-NC. Again, make a proper representation of the momentum vectors installed. This process can be repeated any number of times. If the original paper becomes too cluttered, another piece of wrapping paper or taped pieces can be prepared instead.

Repeat the experiment using a glass ball as the target ball. Now, how will you account for the mass of the balls. Remember that velocity is not a conserved property of collisions, only momentum is.

Explanatory Note:

Multiplying a relative velocity vector by the mass of the ball may give a momentum vector that is too long to be drawn on the paper. When the magnitude of all the momentum vectors have been found, divide each one by the same scale factor that will allow all the plotted vectors to fit on the paper. For instance, dividing each by 200 may allow the largest drawing that will not fall off the available space on the paper. Complete a parallelogram to compare the vector sum of the collision pairs with the original momentum vector.

Inelastic Collisions:

In this experiment, you will perform a perfectly inelastic collision in which the colliding objects become one unit after the collision. You will use the same basic setup as the previous collision experiments. The only difference will be the target. Place the hollow ball on the screw at the end of the track. Adjust the screw so that the center of the hollow ball is on a line with the center of the steel ball. Try a practice run. The steel ball should stick inside the hollow ball. It can be assisted by putting a piece of masking tape in the hole of the wooden ball. This should help trap the steel ball in the wooden ball. Adjust the height of the hollow ball if necessary.

Collision in 1-D

The apparatus can also be used for the study of in-line or one dimensional collisions. In this application, the support "tee" needs to be lowered and the target ball placed on the lower part of the track itself. If the base is properly leveled, shimming if necessary, the target ball will sit very near the end of the track with no tendency to roll off or to roll away from the end. A collision of balls of equal mass should find the incident ball arrested and the target projected. In the case of a low mass target, both would be projected. Some scattering is to be expected for many reasons and vectors would still be the most complete way to analyze the collision, but simple signed numbers might suffice for introductory purposes, if the scattering is small.

Time Allocation:

No prior assembly is required for this product, and less than five minutes to set it up. Individual experiment times will vary depending on needs of students and methods of instruction. Individual data gathering can take up to fifteen minutes and the analysis usually a bit longer, but normally will not exceed one class period. Provide adequate drawing tools for the constructions.

Feedback:

If you have a question, a comment, or a suggestion that would improve this product, you may call our toll free number.