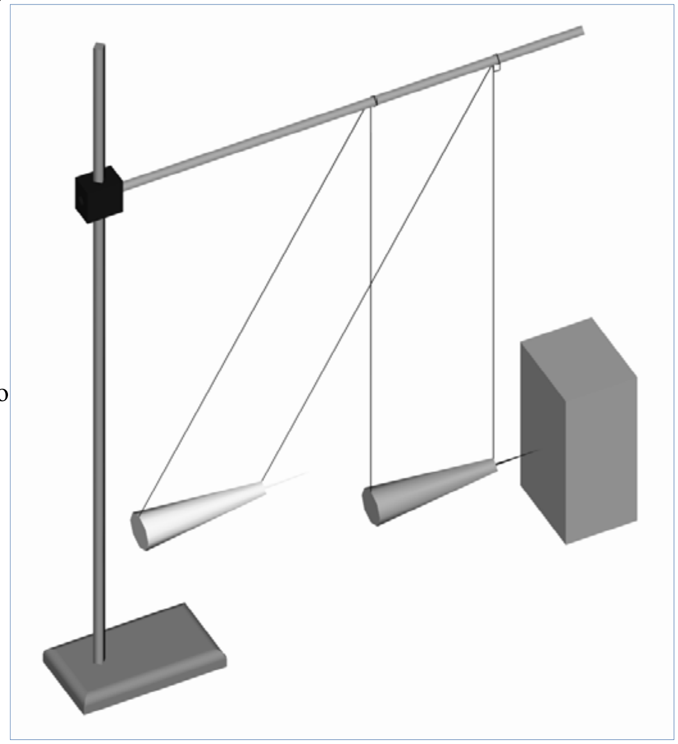
20700 BOUNCING DART

Purpose:

To investigate conservation of momentum in elastic and inelastic collisions, and to establish that elastic collisions transfer more momentum.



Additional Equipment Required:

Meterstick, ring stand, Right angle clamp, Extension bar

Assembly:

Unpack the dart and remove the point. This may require the use of pliers. Clean off any adhesive that may remain on the base of the removed metal tip. Cut the string in half, and tie one length to each screw eye in the dart. Tie the remaining loose ends of the string to one end of the extension bar on the ring stand. The strings should be separated by the same distance as the screw eyes on the dart so that the strings hang parallel to each other.

Assemble the ring stand and attach a right angle clamp near the top of the post. Clamp the end of the extension bar opposite to the dart to the ring stand using the right angle clamp. It might be necessary to add weight to the base of the ring stand using several books, for instance. The dart should now be suspended above the table top. Adjust the strings until the dart lies parallel to the table top. With the dart hanging freely, adjust the height of the extension bar until the dart rests approximately twenty (20) centimeters above the table top.

Place the block of wood on end so that it will stand 30 centimeters tall, and place it directly in front of the freely hanging dart. Mark the location of the block on the table using tape. Note that the dart will swing in the plane of the extension bar and the rod of the ring stand. The dart will also remain parallel to the table top throughout its swing. When releasing the dart, draw it back towards the ring stand the same amount each time, and release it without giving it a push.

Procedure:

Inelastic Collisions: With the nail inserted in the head of the dart, pull the dart back and release it. The dart will strike the block of wood and stick. This is an inelastic collision. Replace the block of wood to its original position, as marked by the tape, and pull the dart back far enough so that the collision will almost knock the target block over. If the block does tip over, try again; but pull the dart back a little less far.

Use a meter stick to measure and record the vertical distance between the release point of the dart and its lowest position as it swings to hit the block, always measuring the same point on the dart.

Elastic Collision: Remove the nail from the dart and release it from the same position found in the previous step, the position that would make the block wobble but not topple. Now what happens? Repeat this step a few times to see that your results are consistent.

Momentum is a vector quantity found by multiplying the scalar quantity ***mass*** by the vector quantity ***velocity.*** The direction of the momentum vector is given then by the direction of the velocity vector. In the usual notation: $\mathbf{p} = mv$ When calculating the change in the momentum of an object, the initial value is subtracted from the final value. This would give the following results: $\mathbf{p}_F - \mathbf{p}_I = m(v_F - v_I)$

For the inelastic collision, the dart was released from rest and after it strikes the block, its final velocity is near zero. What is the change in momentum for this case, assuming that the final velocity of the dart is taken as zero?

Even though the dart is released from rest, the initial velocity we will use for the change in momentum calculation is not zero; it is the velocity of the dart just before it strikes the wooden block. The gravitational potential energy of the dart as it is raised the distance we have measured above the table top becomes the kinetic energy of the dart at the instant it hits the block. This gives us the proper value for initial velocity when we solve for it using the following relationship:

Now we can calculate the the change in momentum. When we look at the elastic collision, we already know what the initial velocity is, since it is the same as before. If the collision were perfectly elastic, what would the final velocity be? What would the direction be? Remembering that the initial and final velocities both have directions, what would the change in momentum be? How does this change in momentum compare with the inelastic case? Does the dart have a larger change in momentum when it sticks (inelastic collision) or when it bounces (elastic collision)? What is the block's change in momentum for each type of collision?

Caution:
The sharpened point of the dart is VERY sharp.
Use extreme care in handling and make sure the
path of the swinging dart is clear of persons and
other obstacles before using the apparatus.

Time Allocation:

To prepare this product for an experimental trial should take less than ten minutes. Actual experiments will vary with needs of students and the method of instruction, but are easily concluded within one class period.

Feedback:

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