Collision Balls

Conservation of Momentum And Kinetic Energy Apparatus

5 Steel Balls Suspended from a Frame (see Pictures)

The Experiment

The apparatus consists of a row of five identical steel balls suspended from a frame, as shown. Without actually performing the experiment, imagine one of the balls to be held aside and then released so that it collides with the row of *four* remaining balls. If each ball has a mass of one unit and the velocity of the incident ball just before the collision is one unit, what is the initial momentum of the system before the collision?

What would you expect the total momentum of the system to be *after* the collision?

Bearing in mind that all balls have the same mass, suggest *three* different possible outcomes of the collision which conserve momentum.

Now perform the experiment to determine which (if any) of your stated outcomes actually occurs. Repeat many times. Do you always obtain the same outcome? If so, describe it briefly.

Repeat the exercise for the following two cases:

(a) Two balls held aside and released.

(b) Three balls held aside and released.

What do you think would happen if *four* balls were held aside and released? In this case only one ball is left with which to collide! Make a prediction and then test it experimentally.

In each case many outcomes satisfied the law of conservation of momentum but in practice only *one* actually occurs. There must be some other law (or laws) which describes the restriction of the possibilities to this one outcome.

The Dutchman, Christiaan Huygens, determined that another quantity—the *scalar* quantity mv^2, summed over all the objects involved in the collision—must also be conserved. For mathematical convenience, however, it has become the practice to halve the quantity mv^2, the result ($\frac{1}{2}mv^2$) being called the *kinetic energy*. Thus Huygens' original statement is equivalent to saying that the total kinetic energy of the system is conserved.

Check that in each collision which you studied, the *actual* outcome conserved kinetic energy whereas the other outcomes did not.

Questions:

You should have observed in each case not a single collision but a whole sequence of collisions as the balls at each end alternately fall back. Are these collisions all identical? Why does the motion not continue indefinitely? Would it continue indefinitely if, (a) all air were evacuated from the apparatus, (b) the experiment were performed in space? Give reasons.