**Objective:** to investigate collisions of objects, and the conservation of momentum

**Equipment:** various balls, motion sensors, meter stick, 2m sticks (as an alley), ruler, balance, protractor, stop watch

**Background:** Definition in words and equation:

Velocity:

Momentum:

Conservation of momentum:

Kinetic energy:

Conservation of energy:

Impulse:

Elastic collision:

Inelastic collision:

**Procedure:** We will do a variety of experiments and computer activities to investigate the idea of collisions in general. SAFETY FIRST!

1. Two balls with equal mass (m). One begins at rest, and the other is at velocity \( v \).
   After the elastic collision they have velocities \( v_1 \) and \( v_2 \).
Prediction:

In billiards this is called ______________________

a) Try two billiard balls or two hard rubber balls
b) Try Newton’s cradle (1, 2, 3, 4, 5 balls drawn aside to start with)

Conclusion:

2. Two balls of unequal masses (m = small ball, M = bowling ball). One begins at rest, and the collision is head-on.
Prediction when the large mass begins at rest:

Try a bowling ball and a small ball.

Prediction when the small mass begins at rest:

Try a bowling ball and a small ball.

Conclusion:

3. Analyze the attached paper record of a collision which was not head-on. The balls had equal masses, say m = 1. The dots are at equal time intervals, say one dot per second. For each of the three traces determine the velocity.

v1 ___________________ v2 ___________________ v3 ___________________

Decide on a coordinate system. (Note that the collision will be easiest to analyze if one of the axes coincides with one of the traces.) Your ___ axis coincides with which velocity vector? _______
The other axis will be 90 degrees from the first axis. Draw it lightly.
Calculate the x and y components of each of the three velocities.
Calculate the momenta of each of these components.

<table>
<thead>
<tr>
<th>Object</th>
<th>X component of velocity (or momentum)</th>
<th>Y component of velocity (or momentum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ball 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ball 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Is the x momentum conserved? To what percentage?

Is the y momentum conserved? To what percentage?

4. Look up information on car seatbelts and air bags meant to prevent injuries in a collision. Be as quantitative as possible.

5. List types of collision which are beneficial, and collisions which are not beneficial.