What are two dimensional collisions?

How can we solve 2-dimensional collision problems?

In other articles, we have looked at how momentum is conserved in collisions. We have also looked at how kinetic energy is transferred between bodies and converted into other forms of energy. We have applied these principles to simple problems, often in which the motion is constrained in one dimension.

If two objects make a head on collision, they can bounce and move along the same direction they approached from (i.e. only a single dimension). However, if two objects make a glancing collision, they'll move off in two dimensions after the collision (like a glancing collision between two billiard balls).

For a collision where objects will be moving in 2 dimensions (e.g. x and y), the momentum will be conserved in each direction independently (as long as there's no external impulse in that direction).

In other words, the total momentum in the x direction will be the same before and after the collision.

$$\Sigma p_{xi} = \Sigma p_{xf}$$

Also, the total momentum in the y direction will be the same before and after the collision.

$$\Sigma p_{yi} = \Sigma p_{yf}$$

In solving 2 dimensional collision problems, a good approach usually follows a general procedure:

1. **Identify all the bodies in the system**. Assign clear symbols to each and draw a simple diagram if necessary.

2. **Write down all the values you know and decide exactly what you need to find out to solve the problem**.

3. **Select a coordinate system**. If many of the forces and velocities fall along a particular direction, it is advisable to use this direction as your x or y axis to simplify calculation; even if it makes your axes not parallel to the page in your diagram.

4. **Identify all the forces acting on each of the bodies in the system.** Make sure that all impulse is accounted for, or that you understand where external impulses can be neglected. Remember that conservation of momentum only applies in cases where there is no external impulse. However, conservation of momentum can be applied separately to horizontal and vertical components. Sometimes it is possible to neglect an external impulse if it is not in the direction of interest.

5. **Write down equations which equate the momentum of the system before and after the collision.** Separate equations can be written down for momentum in the x and y directions.

6. **Solve the resulting equations to determine an expression for the variable(s) you need.**

7. **Substitute in the numbers you know to find the final value.** Should this require adding vectors, it is often useful to do this graphically. A vector diagram can be drawn and the method of adding vectors head-to-tail used. Trigonometry can then be used to find the magnitude and direction of all the vectors you need to know.

Billiard ball problem

Figure 1 describes the geometry of a collision of a white and a yellow billiard ball. The yellow ball is initially at rest. The white ball is played in the positive-x direction such that it collides with the yellow ball. The collision causes the yellow ball to move off towards the lower-right pocket at an angle of 28° from the x-axis.

The mass of the yellow ball is 0.15 kg and the white ball is 0.18 kg. A sound recording reveals that the collision happens 0.25 s after the player has struck the white ball. The yellow ball falls into the pocket 0.35 s after the collision.

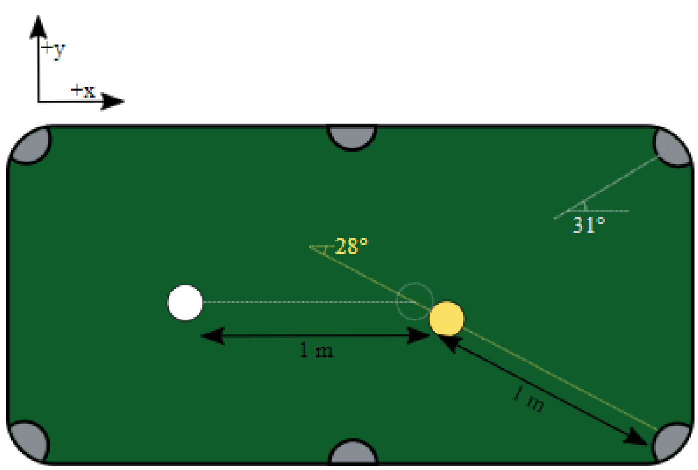

Figure 1: Collision of white and yellow billiard balls.