Major Types of Conservation of Momentum Problems

Mr. Murray's Physics

Type 1 - Two objects push apart from each other.

(Variations: Something is thrown, launched, or shot; a person starts moving on a boat (or rolling object); a rocket or a balloon.)

Note: In all of these examples there are two objects at rest before that push off of each other (Newton's 3rd law). After the push they are both moving in opposite directions.

Equation: $0 = p_{1a} + p_{2a}$

Ex1 -. Two people on ice skates push against each other. The person on the left is 50 kg, the person on the right is 60 kg. If the person on the right ends up going 3 m/s, how fast is the other person going?

Type 2 - Two objects collide and do not stick together.

(Variations: Only one of the objects is moving before or after; head on collisions; rear end collisions; a projectile shot through an object.)

Note: The direction of the object doesn't matter before or after or if one of them is at rest, just be sure to put in a negative velocity for those moving left and a zero velocity for those at rest.

Equation: $p_{1b} + p_{2b} = p_{1a} + p_{2a}$

Ex2 - A 6 kg object going 3 m/s to the right hits a 4 kg object going 4 m/s to the left. If afterward the 6 kg object ends up going 4 m/s to the left, find out what happens to the 4 kg object.

Type 3 - Two objects collide and stick together.

(Variations: Only one of the objects is moving before or after; head on collisions; rear end collisions; a projectile shot into an object.)

Note: Perfectly inelastic collisions. Only difference between this and Case 2 is that in this case there is only one moving object afterwards, so combine the masses. The velocity will be the same for both.)

Equation: $p_{1b} + p_{2b} = p_{a1+2}$

Ex3 - A 0.25 kg arrow going 35 m/s is shot into a 6 kg target. The target is on wheels, so find how fast it will roll backwards.

Type 4 - An object splits apart.

(Variations: explosions; two objects together and moving push off from each other.)

Note: Simply the opposite of Case 3, if the split occurs only in one direction. If it happens two dimensionally (as in an explosion), you have to do Conservation of Momentum in each direction independently. In the second dimension, the original momentum was zero, so it is actually just Case 1.

Equations: x-dir: $p_{b1+2} = p_{1a} + p_{2a}$; y-dir: $0 = p_{1a} + p_{2a}$

Ex4 - A 200 kg car is rolling at 10 m/s when its fuel tank explodes into 4 pieces. If 40 kg of it goes forward at 25 m/s, 80 kg goes backwards, 30 kg goes to the left at 10 m/s, and a piece goes to the right. Find how much mass is going to the right and how fast it is moving. Also find out how fast the 80 kg piece is moving backwards.

(Solutions on the back.)

Type 1 - Two objects push apart from each other.

Ex 1 - Two people on ice skates push against each other. The person on the left is 50 kg, the person on the right is 60 kg. If the person on the right ends up going 3 m/s, how fast is the other person going?

Equation: $0 = p_{1a} + p_{2a}$

$0 = 50(v_1) + 60(3)$

$-50v_1 = 180$

$-5v_1 = 18$

$v = \frac{18}{-5} = -3.6\ m/s$

the neg. means it is going left, as we knew.

Type 2 - Two objects collide and do not stick together.

Ex2 - A 6 kg object going 3 m/s to the right hits a 4 kg object going 4 m/s to the left. If afterward the 6 kg object ends up going 4 m/s to the left, find out what happens to the 4 kg object.

Equation: $p_{1b} + p_{2b} = p_{1a} + p_{2a}$

$m_1v_{1B} + m_2v_{2B} = m_1v_{1a} + m_2v_{2a}$

$6(3) + 4(-4) = 6(-4) + 4(v_{2a})$

$18 - 16 = -24 + 4v_{2a}$

$2 = -24 + 4v_{2a}$

$26 = 4v_{2a}$

$v_{2a} = \frac{26}{4}$

$v_{2a} = 6.5\ m/s$

the pos. means it's going right.

Type 3 - Two objects collide and stick together.

Ex3 - A 0.25 kg arrow going 35 m/s is shot into a 6 kg target. The target is on wheels, so find how fast it will roll backwards.

assume the target is at rest to begin with.

Equation: $p_{1b} + p_{2b} = p_{a1+2}$

$m_1v_{1b} + m_2v_{2b} = (m_1+m_2)v_a$

$.25(35) + 6(0) = 6.25(v_a)$

$8.75 = 6.25(v_a)$

$v_a = \frac{8.75}{6.25} = 1.4\ m/s$

Type 4 - An object splits apart.

Ex4 - A 200 kg car is rolling at 10 m/s when its fuel tank explodes into 4 pieces. If 40 kg of it goes forward at 25 m/s, 80 kg goes backwards, 30 kg goes to the left at 10 m/s, and a piece goes to the right. Find how much mass is going to the right and how fast it is moving. Also find out how fast the 80 kg piece is moving backwards.

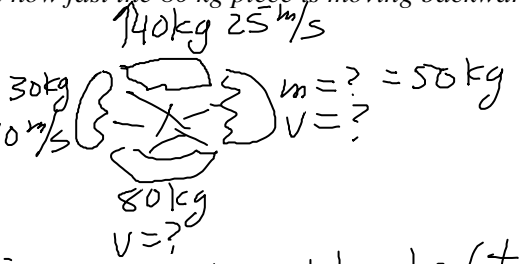
Equations: x-dir: $p_{b1+2} = p_{1a} + p_{2a}$; y-dir: $0 = p_{1a} + p_{2a}$

First find the last mass:

$m_b = m_a \Rightarrow 200 = 30 + 80 + 40 + m$

$200 = 150 + m$

$m = 50\ kg$



in y-dir.

$0 = p_{left} + p_{right}$

$0 = 30(-10) + 50(v)$

$0 = -300 + 50v$

$300 = 50v$

$6\ m/s = v$

going right, as we knew

x-dir. note: the left + right pieces are still moving w/ same initial vel. in x-dir.

$p_{b\,total} = p_{1a} + p_{2a} + p_{3a} + p_{4a}$

$200(10) = 40(25) + 30(10) + 50(10) + 80(v)$

$2{,}000 = 1{,}000 + 300 + 500 + 80v$

$2{,}000 = 1{,}800 + 80v$

$200 = 80v$

$v = 2.5\ m/s$

the back piece is still going forward, just slowly.