TWO DIMENSIONAL MOMENTUM PROBLEMS

Hints -

- Remember that it is MOMENTUM that is conserved, not velocity!
- Do sketch diagrams
- Be prepared to use full vector addition or subtraction. If you use components, momentum is conserved in both sets of components. If you use vector triangles, sin and cos rules are going to be useful.
- Think in terms of "before" and "after"! Find vector statements for the momentum "before" and "after" then equate the vector sums in the diagram.

Example Problem

Two people are skidding along on ice masses 50kg and 70 kg respectively arm in arm at 15 ms^{-1} . They push each other and the 50 kg person now changes direction by 25^0 and speeds up to 20 ms^{-1}.

Find the subsequent velocity of the 70kg person.

Solution

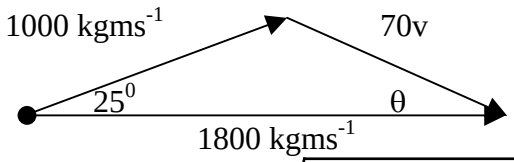
- Start by calculating known momenta and use symbols for unknown values.

- Give yourself directional clues to be translated into the vector diagram

Initial Momentum = (50+70)x15 $kgms^{-1}$ → = 1800 $kgms^{-1}$ →

Final momentum = 50 x 20 $kgms^{-1}$ ↗ + 70v $kgms^{-1}$ ↘

Using conservation of mom^n vectorially



Using cos rule $70v = \sqrt{1000^2 + 1800^2 - 2x1000x1800\cos 25^0}$ (notice the use of a common factor, 1000, to make life easier!)

$= 989\ kgms^{-1}$

$v = 14.1\ ms^{-1}$

Using the sin rule to find the angle θ

$\sin\theta / 1000 = \sin 25^0 / 989$ implies $\theta = 25.3^0$

thus the 70 kg person moves off at 14.1 ms^{-1} changing angle by 25.3^0

1. Two pucks are colliding on an air table. Puck A has a mass of 50gram and is moving at 1 ms^{-1} directly to the right. Puck B has a mass of 100gram and is stationary.

After the collision, Puck A is deflected through an angle of 40^0 and is now moving at 0.3 ms^{-1}. Calculate the speed and direction of Puck B after the collision.

(0.397 ms^{-1} at 14^0 to original dir^n)

2. Linda (45 kg) and Jeff (75kg) are roller-blading along at 5ms^{-1} then push each other, Linda moving off at 6ms^{-1} , at 40^0 to the original path. Find Jeff's new velocity.

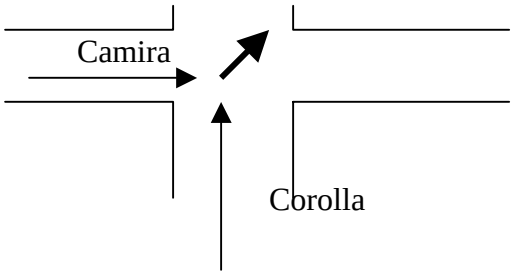
(5.73 ms^{-1} at 23.8^0 to original dir^n)

3. Two skaters, male mass 85kg, female mass 65kg are together at 15 ms^{-1}. They push apart leaving at an angle of 60^0. The male is now travelling at 20ms^{-1}. What is the velocity of the girl?

(13.1 ms^{-1} at 40.9^0 to original dir^n)

4. You have recently purchased (after hours and hours at of work at your local drivein restaurant), an ultra new Corolla (1989) massing in at 1.2 tonnes.

After doing blockies, you are approaching an intersection at 20 ms^{-1} just as the lights are orange.



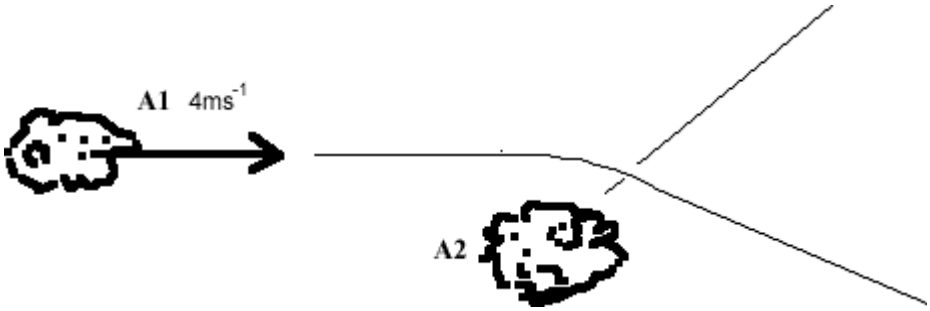
In the centre of the intersection, you are very firmly met and T boned by a Camira at 10 ms^{-1} , mass 1.4 tonnes who anticipated green.

Find the combined speed and direction of the mess for the purposes of insurance.

(10.7 ms^{-1} at 30.2^0 to dir^n of Corolla)

5. Two asteroids pass each other close enough for gravity to change their directions and speeds so that their orbits around the Sun completely alter.

(This process is real and can eventually lead to stray asteroids entering Earth's orbital path enhancing the chance of collision with Earth.)



Asteroid 1 (call it A1) has a mass of 2 x 10^{10} tonnes, and moves from the "left" at 4 ms^{-1} relative to asteroid 2 (A2) of mass 2.5 x 10^{10} tonnes taken as stationary. (1 tonne =10^3 kg)

After passing, A1 is now found to have altered direction by 20^0 and is now at 3.7 ms^{-1}.

a) What is the original total momentum of the system taking A2 as stationary?

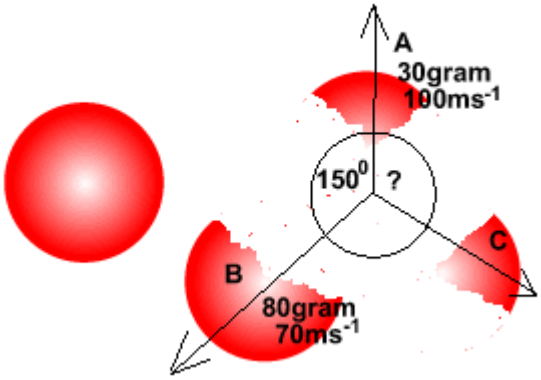
b) Construct an appropriate diagram that will allow you to calculate the momentum of A2 after the collision.

c) Calculate the new speed and direction of A2 relative to its previously stationary state.

(8 x 10^{13} kg ms^{-1}, 1.1 ms^{-1} at 67.5^0 to A1 original dir^n)

6. A stationary ball is packed with gunpowder. Its mass is 150g. It explodes into three pieces, mass A of 30 g, mass B of 80g and mass C of 40g as in the diagram below.

Find the speed and direction of the 40g piece, given the other velocities.



(83.9 ms^{-1} at 123.45^0 to direction of A)