Reminders 03-23-10:

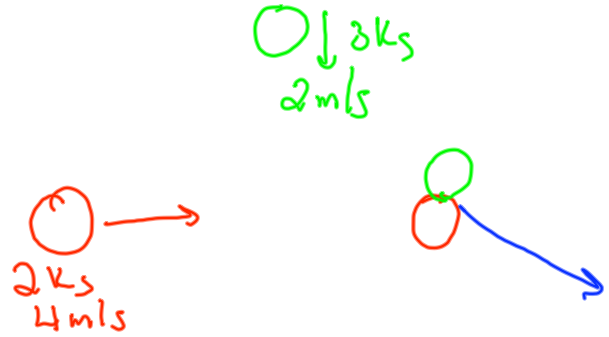
-POW 8 Due Thursday
-Exam 3 Ch 7,8, and 9 March 25. No Makeups.

Objectives:

-2D Completely inelastic Collisions Example
-Center of Mass Frame
-Impulse Momentum
-Rockets

Example:
A 3 kg particle traveling south at 2 m/s has a perfectly inelastic collision with a 2 kg particle traveling east at 4 m/s. What is the magnitude and direction of the final momentum?

Only problem solving change:
Conserve momentum along vector components



Conserve mom. in x & y dir.

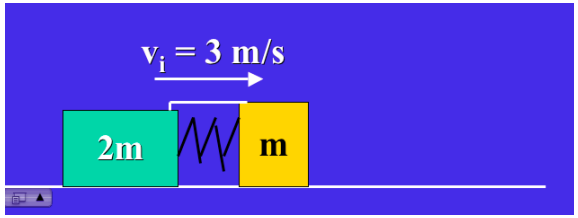
$$p_{ix} = (2\,kg)(4\,m/s) = 8\,kg\,m/s = (m_1+m_2)v_{fx}$$

$$v_{fx} = \frac{8}{5}\,m/s$$

$$p_{iy} = -6\,kg\,m/s = p_{fy} = (m_1+m_2)v_{fy}$$

$$v_{fy} = -\frac{6}{5}\,m/s$$

$$\theta = \tan^{-1}\frac{-6/5}{8/5} = -37°$$



Choose lab frame

$p_i = (3m)(3m/s) = p_f$

$9m = 2m v_g + m v_o$

$9 = 2v_g + v_o$

$v_o - v_g = 6 \quad v_o = v_g + 6$

$9 = 2v_g + v_g + 6$

$= 3v_g + 6$

$3 = 3v_g \quad v_g = 1\,m/s \quad v_o = 7\,m/s$

Choose frame moving at 3m/s

$p_i = 0 = p_f$

$0 = 2m v_{gm} + m v_{om}$

$0 = 2v_{gm} + v_{om}$ but $v_o = v_g + 6$

$= 2v_{gm} + v_{gm} + 6$

$0 = 3v_{gm} + 6$

$v_{gm} = -2\,m/s \quad v_{om} = 4\,m/s$

convert to lab frame

$v_{gL} = v_{gm} + 3 = 1\,m/s$

$v_{oL} = v_{om} + 3 = 7\,m/s$

A particle of mass 1 kg has velocity 2 i + j m/s and a second particle of mass 2 kg has velocity i – 2 j. What is the velocity of the center of mass? If the particles collide elastically, what will be the velocity of the center of mass after the collision?

$$V_{cm} = \frac{\sum m_i \vec{v}_i}{\sum m} = \frac{(1\,kg)(2\hat{i}+\hat{j})\frac{m}{s} + 2kg\,(\hat{i}-2\hat{j})\frac{m}{s}}{3kg}$$

$$= \frac{(4\hat{i}-3\hat{j})\,kg\,\frac{m}{s}}{3kg}$$

$$= \left(\frac{4}{3}\hat{i} - \hat{j}\right)\frac{m}{s}$$

Doesn't change after the collision

Particle 1 has mass 4m and speed 2 m/s. It has a head-on elastic collision with particle 2 of mass m which is initially at rest. What are the speeds of the particles after the collision?

$$V_{cm} = \frac{4m(2) + 0}{5m} = \frac{8}{5}\ m/s$$

$$V_{1i\,cm} = \left(2 - \frac{8}{5}\right)\frac{m}{s} = +\frac{2}{5}\ m/s \qquad V_{1f\,cm} = -\frac{2}{5}\ m/s$$

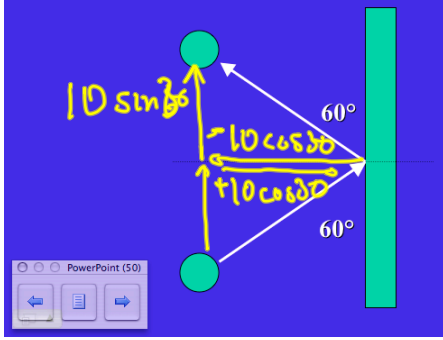
$$V_{2i\,cm} = 0 - \frac{8}{5}\ m/s = -\frac{8}{5}\ m/s \qquad V_{2f\,cm} = +\frac{8}{5}\ m/s$$

Go back to lab frame

$$V_{1f} = \left(\frac{2}{5} + \frac{8}{5}\right)$$

Example: Textbook Problem

A 3 kg steel ball strikes a wall with a speed of 10 m/s at an angle of 60° with the surface. It bounces off with the same speed and angle. If the ball is in contact with the wall for 0.2 s, what is the average force exerted on the ball by the wall?



V_y does not change

V_x changes direction

Δp due to ΔV_x only

$$\Delta V_x = V_{fx} - V_{ix} = -10\cos 30 - 10\cos 30$$
$$= -20\cos 30$$

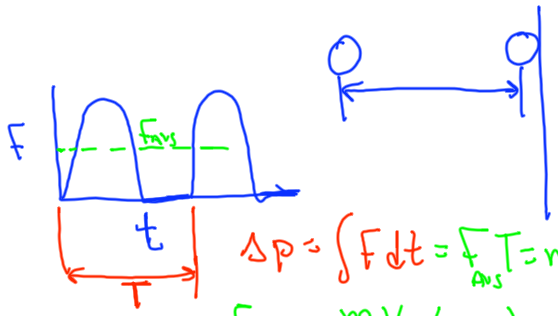
$$\Delta p = m\Delta V_x = 3(-20\cos 30)$$
$$= -60\cos 30$$

$$F = \frac{\Delta p}{\Delta t} = -\frac{60\cos 30}{0.2} = -300\cos 30$$

$$F = -260\,N = \text{wall on ball}$$

$$F_{\text{ball on wall}} = +260\,N$$

Water emerges from a hose at 10 m/s horizontally and strikes a wall. It then dribbles down. The flow rate is 1.5 kg/s. What is the average force on the wall.

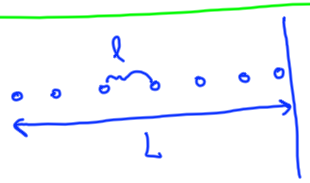


$$\Delta p = \int F\,dt = F_{avg}\,T = mv$$

$$F_{avg} = \frac{mv}{T} = \left(1.5\frac{kg}{s}\right)\cdot 10\frac{m}{s} = 15N$$

# of drops in distance L

$\frac{L}{l}$



total mass $m\frac{L}{l}$ each drop has speed v_0

$p_i = m\frac{L}{l}v_0$

How long does it take for entire stream to hit wall

$\frac{L}{v_0}$

$$F = \frac{m\frac{L}{l}v_0}{L/v_0} = m\frac{v_0^2}{l} = m\left(\frac{v_0}{l}\right)v_0$$

What is l/v_0 time between drops hitting wall.

$$F = \frac{m\,v_0}{\frac{l}{v_0}} = \frac{mv_0}{T} = \left(1.5\frac{kg}{s}\right)\left(10\frac{m}{s}\right)$$

$$= 15\,N$$