For each of the 4 collisions between two carts, consider the force profile on the bumper of one cart:

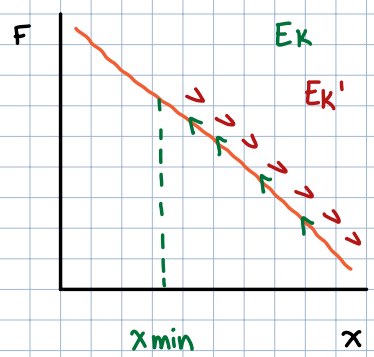
Spring Bumper

x_{min} ⇒ Minimum separation

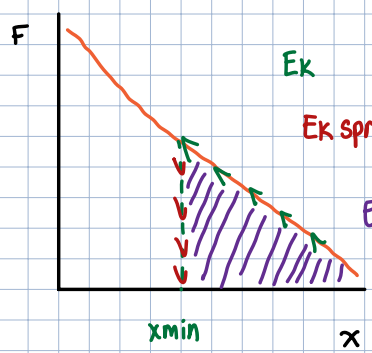
(carts get closer)

(maximum compression)

1) Total Elastic Collision



2) Total Inelastic Collision



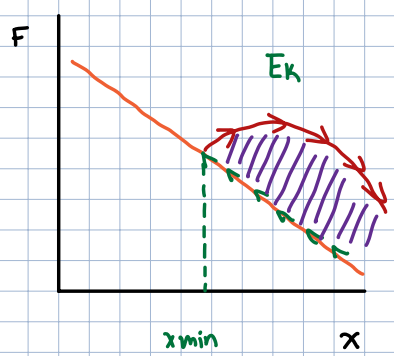
Ek spring (stays in the system)

Energy loss

3) Partial Elastic Collision

E loss due to spring

4) Explosion



E gained

2D Collisions

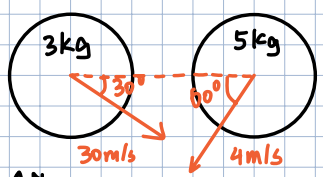
Example:

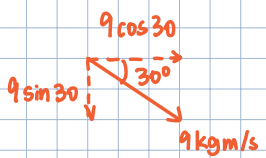
Two objects collide as shown.

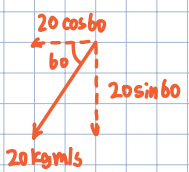
a) What is the missing velocity?

Before

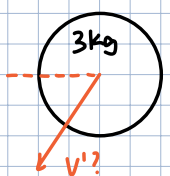
Not total inelastic

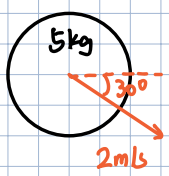


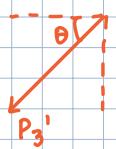


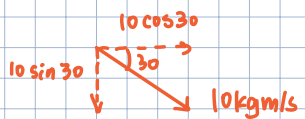


After









$\vec{P} = \vec{P}'$

$\vec{P}_3 + \vec{P}_5 = \vec{P}_3' + \vec{P}_5'$

$9\cos 30[R] + 9\sin 30[D] + 20\cos 60[L] + 20\sin 60[D] = \vec{P}_3' + 10\cos 30[R] + 10\sin 30[D]$

$\vec{P}_3 = 10.9[L] + 16.8[D]$ $\quad \sqrt{10.9^2 + 16.8^2}$

$\vec{P}_3 = 20.02[L\ 57.13D]$ $\quad \tan^{-1}\left(\frac{16.8}{10.9}\right)$

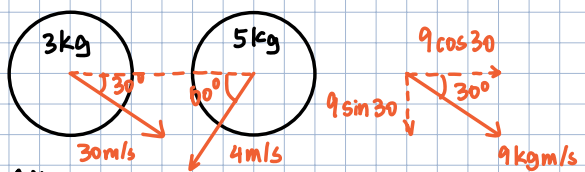
$\vec{V}_3'$? $\quad P_3' = m_3 V_3'$

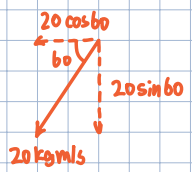
$20 = 3V_3'$

$V_3' = 6.67 m/s$

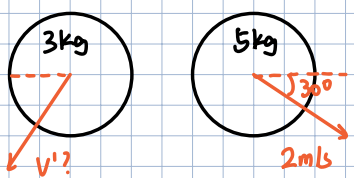
What type of Collision is it?

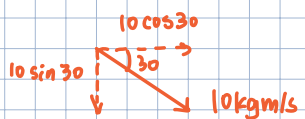
Before





After





E_T

$E_{K3} + E_{K5}$

$\frac{1}{2}m_3v_3^2 + \frac{1}{2}m_5v_5^2$

$\frac{1}{2}3(3)^2 + \frac{1}{2}(5)(4)^2$

53.3J

E_T'

$E_{K3}' + E_{K5}'$

$\frac{1}{2}(3)(6.67)^2 + \frac{1}{2}(5)(2)^2$

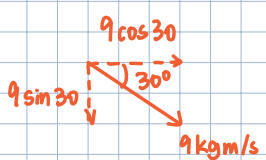
76.7J

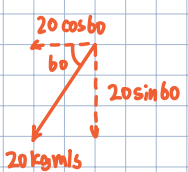
$E_T' > E_T$ ∴ Collision is an explosion

0.1s

If they collided for 100ms, what force was felt by each object?

$\vec{I} = \boxed{\vec{F}\Delta t = \Delta\vec{p}} = m\Delta\vec{v}$





$\vec{F}_5\Delta t = \Delta\vec{P}_5$

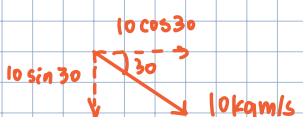
$\vec{F}_5\Delta t = \vec{P}_5' - \vec{P}_5$

$\vec{F}_5(0.1) = 10\sin30[D] + 10\cos30[R] - (20\sin60[D] + 20\cos60[L])$

$\vec{F}_5(0.1) = 12.3[U] + 18.7[R]$

$\vec{F}_5 = 123[U] + 187[R]$

$\vec{F}_5 = 223N[R33.4U]$



$\vec{F}_3 = 223N[L33.4D]$