Homework 13

① $\vec{p}_{fox} = \vec{p}_{rabbit}$. $\quad p_{fox} = m_f \cdot \vartheta_f$

$m_r < m_f \Rightarrow \frac{m_r}{m_f} < 1.$ $\quad p_{rabbit} = m_r \cdot \vartheta_r$

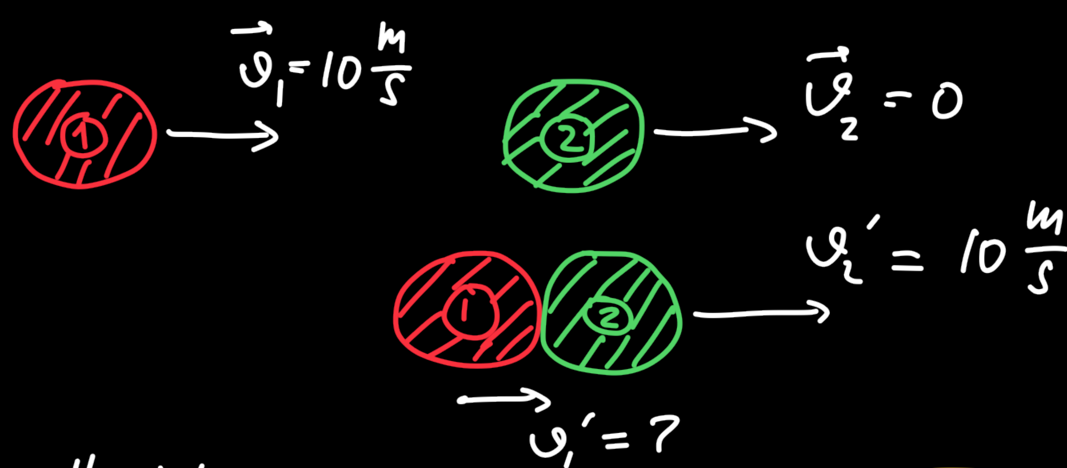
$\rightarrow v_f < \vartheta_r \Rightarrow$ no dinner for the fox!

② $a = 0.2 \frac{m}{s^2}$, $t = 10$ sec.

$\vartheta = \vartheta_0 + a \cdot t \Rightarrow \vartheta - \vartheta_0 = a \cdot t = 2 \frac{m}{s}.$

$\Delta p = m\vartheta - m\vartheta_0 = m(\vartheta - \vartheta_0) = 160\ kg \cdot \frac{m}{s}$

③

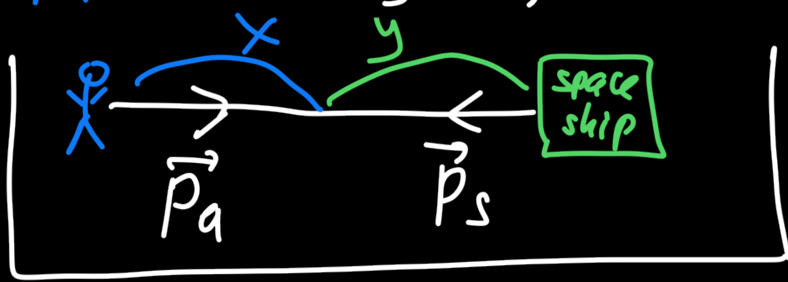


before collision:

$p_{tot} = 100\ kg \cdot m/s$ | $p'_{tot} = 10 \cdot \vartheta_1' + 5 \cdot 10$

$10 \cdot \vartheta_1' = 50\ m/s \Rightarrow \vartheta_1' = 5\ m/s$

(4f) $m = 100\,kg$, $M = 50{,}000\,kg$



$$F_a = F_s$$

$\vec{p}_{total}$ = constant in time!

initially: $v_a = v_s = 0$

$$\Rightarrow p_{total} = 0$$

$$m \cdot v_a = M \cdot v_s$$

$$\frac{v_a}{v_s} = \frac{M}{m}$$

$$\begin{cases} x = v_a \cdot t \\ y = v_s \cdot t \end{cases} \Rightarrow \begin{cases} \frac{x}{y} = \frac{v_a}{v_s} = \frac{M}{m}. \\ x + y = 100\,m \end{cases}$$

Astronaut : $x = 99.8\,m$

Spaceship: $y = 20\,cm$.

Class work

Recap: velocity, acceleration, force, momentum.

$$\vec{v}_{final} = \vec{v}_{initial} + \vec{a} \cdot \Delta t.$$

$$\Delta t = t_{final} - t_{initial}$$

$$\vec{v}_{final} = \vec{v}, \quad \vec{v}_{initial} = \vec{v}_0$$

$$t_{initial} = 0, \quad t_{final} = t.$$

1) $$\boxed{\vec{v} = \vec{v}_0 + \vec{a} \cdot t}$$

2) Newton's second law:

$$\boxed{\vec{F} = m \cdot \vec{a}}$$

3) $$\boxed{\vec{p} = m \cdot \vec{v}}$$

What do we need to change the momentum of a body?

Work ? $F \cdot \Delta \ell$, $\Delta \ell = \ell_2 - \ell_1$

→ Force (will determine how the impulse changes)

+ something else. → time.

From (1):

$$\vec{a} \cdot t = \vec{v} - \vec{v}_0$$

add (2): $\vec{a} = \frac{F}{m}$

$$\frac{F \cdot t}{m} = \vec{v} - \vec{v}_0 \quad | \times m$$

$$F \cdot t = \underbrace{m(\vec{v} - \vec{v}_0)}$$

$$\Delta \vec{p} = m \cdot \vec{v} - m \cdot \vec{v}_0 = \vec{p} - \vec{p}_0.$$

$$\boxed{\Delta \vec{p} = F \cdot t}$$

New physical quantity **Impulse**:

$$\vec{J} = \vec{F} \cdot t$$

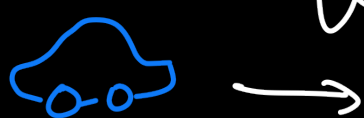
$$\Delta \vec{p} = \vec{J}$$

the change in momentum is equal to the **Impulse**!

$$[J] = \frac{m}{s} \cdot kg = N \cdot s \quad \checkmark$$

$$kg \cdot \frac{m}{s^{2}} \cdot s$$

Ex. 1.



1,500 kg

$v = 20\ m/s$

(~45 mph)

The car comes to a complete stop:

1) Brakes for 10 seconds
2) Hits a wall, stops in 0.1 seconds.

Change in the momentum of the car:

$$\Delta P = 0 - 1{,}500 \cdot 20 \ kg \cdot \frac{m}{s} =$$

$$= 30{,}000 \ kg \cdot \frac{m}{s}$$

1) $\Delta p = F_1 \cdot t_1 \Rightarrow$

$$F_1 = \frac{\Delta P}{t_1} = -\frac{30\,00\not{0}}{\not{10}} N =$$

$$= -3000 \ N$$

2) $\Delta P = F_2 \cdot t_2 \Rightarrow$

$$F_2 = \frac{\Delta P}{t_2} = -\frac{30000}{0.1} N$$

$$= -300{,}000 \ N$$

$$\boxed{F_2 = 100 \cdot F_1}$$