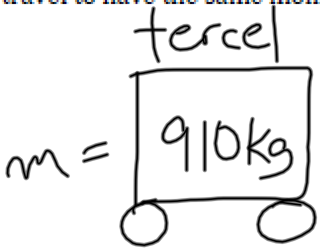
**5. Change in the momentum of the system**

**5.1. Warm up: Calculate the change in momentum**

(a) A 1998 910-kg Toyota Tercel travels at a speed of 32 m/s. (a) At what speed must a 2002 1950-kg Toyota 4Runner travel to have the same momentum? (b) At what speed must a 7.3-kg bowling ball travel to have the same momentum?




$32\ m/s = v$

$p = mv$

$= (910)(32)$

$= 29120\ \frac{kg\,m}{s}$

(p of tercel)


$p = mv$

$v = \frac{p}{m}$

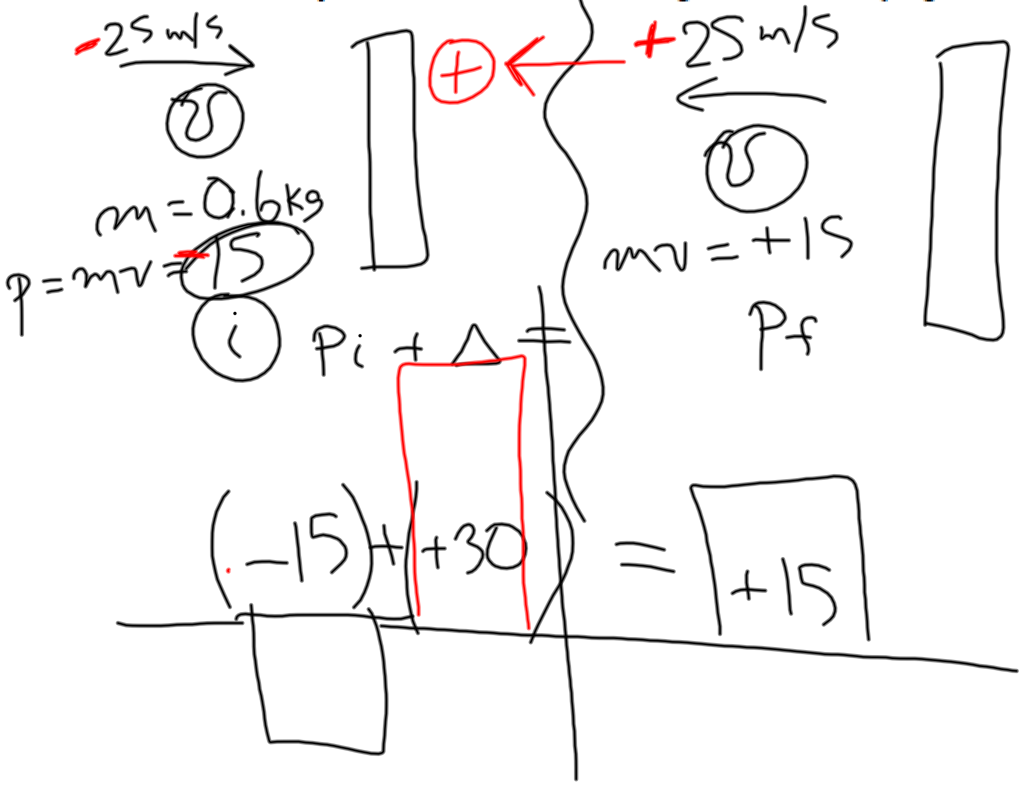
$m = \frac{p}{v}$

$v = \frac{p}{m}$

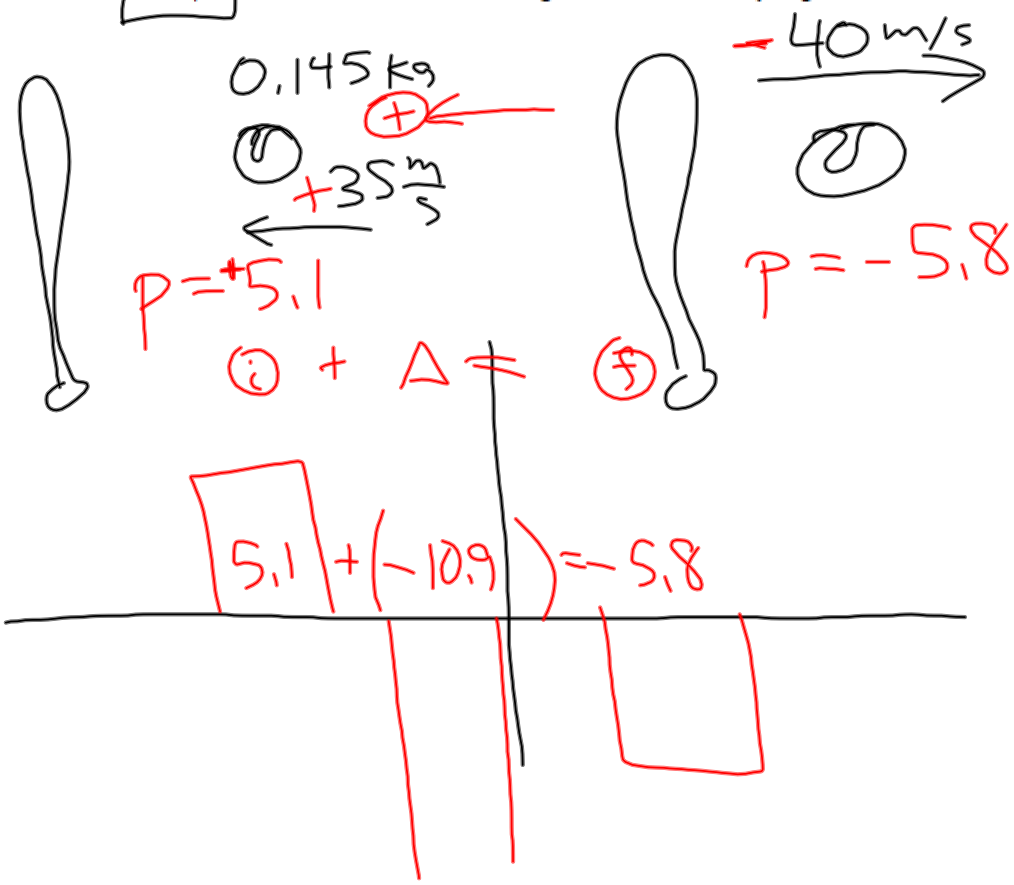
$= \frac{29120\ \frac{kg\,m}{s}}{1950\,kg}$

$= 15\ \frac{m}{s}$

(b) Your 0.0567-kg tennis ball traveling at 25 m/s hits a practice wall and rebounds in the opposite direction with the same speed. Determine the ball's change in momentum (magnitude and direction).



(c) A 145-g baseball traveling at 35 m/s is hit by Barry Bonds' bat so that it rebounds in the opposite direction at 40 m/s. Determine the ball's change in momentum (magnitude and direction).



/s ejects its booster segment. Immediately ter the ejection, the larger 800-kg segment ntinues west at 60 m/s. Determine the locity (magnitude and direction) of the ected booster immediately after the ection.

$P_{iR} = 1{,}000\,kg \cdot 40\,m/s = 40{,}000\,\frac{kgm}{s}$

$P_{fR} = 800\,kg \cdot 60\,m/s = 48{,}000\,\frac{kgm}{s}$

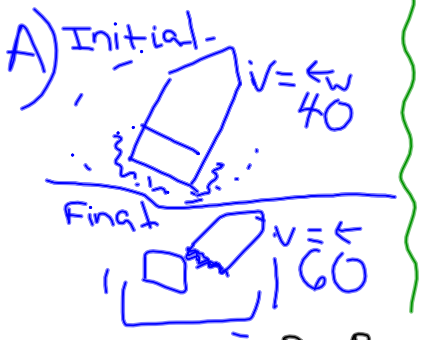
$P_{iB} = 0 \times -40 = 0\,\frac{kgm}{s}$

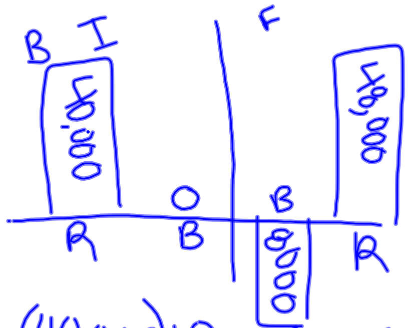
$P_{fB} = 200 \times -40 = -8000\,\frac{kgm}{s}$

$48{,}000\,\frac{kgm}{s} - 8{,}000\,\frac{kgm}{s} = 40{,}000\,\frac{kgm}{s}$

1000 kg rocket
v = 40 m/s ← W
800 kg booster
v = 60 m/s ← W

A) Initial

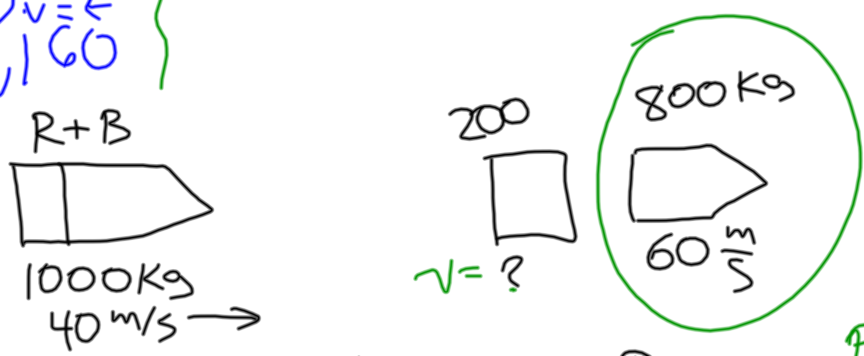


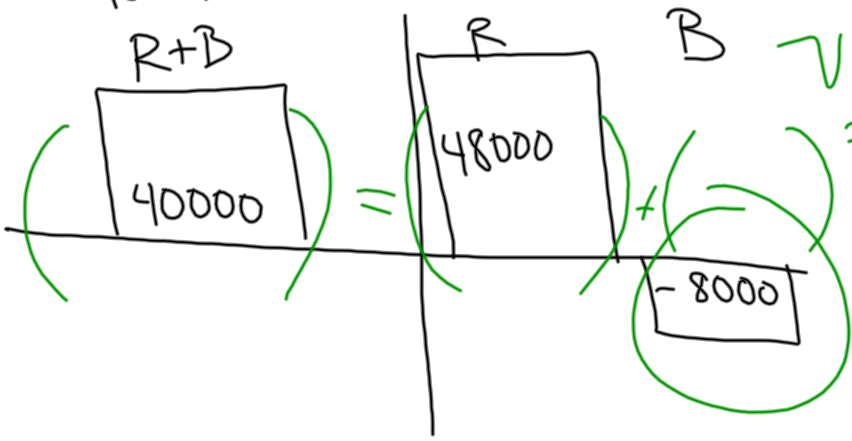




ejected booster travels east at 40 m/s. With the weight of 200kg = -8000 m/s

$(40{,}000) + 0 = -8{,}000 + 48{,}000$

$40{,}000 = 40{,}000$




$v = \frac{P}{m} = \frac{-8000}{200} = -40\,\frac{m}{s}$

**5.1. Warm up: Calculate the change in momentum**

(a) A 1998 910-kg Toyota Tercel travels at a speed of 32 m/s. (a) At what speed must a 2002 1950-kg Toyota 4Runner travel to have the same momentum? (b) At what speed must a 7.3-kg bowling ball travel to have the same momentum?

$p = mv$

sketch
read
sketch
read

$p_{tercel} = mv$
$= (910\ kg)(32\ \frac{m}{s})$
$= 29120\ \frac{kg\ m}{s}$

Bowling ball

$\frac{29120 = 7.3x}{7.3}$

3989 m/s

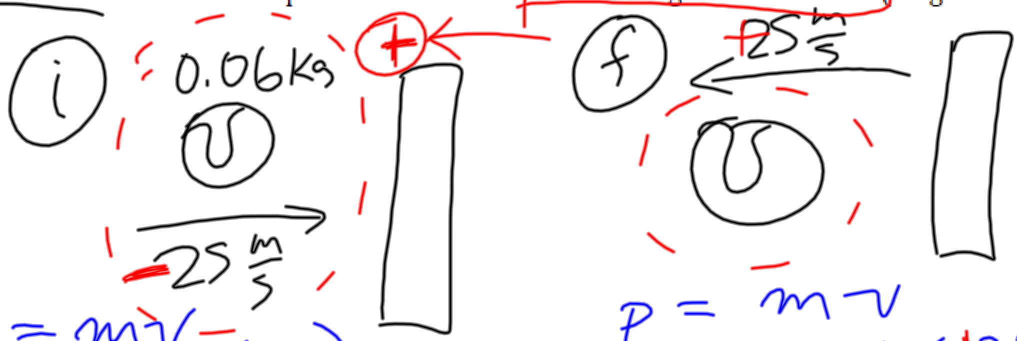
$\frac{29120 = 1950x}{1950}$

$x = 14.93\ m/s$ speed of 2002 car

$\frac{p}{m} = v$

$v_{4r} = \frac{p}{m}$
$= \frac{29120}{1950}$
$= 15\ \frac{m}{s}$

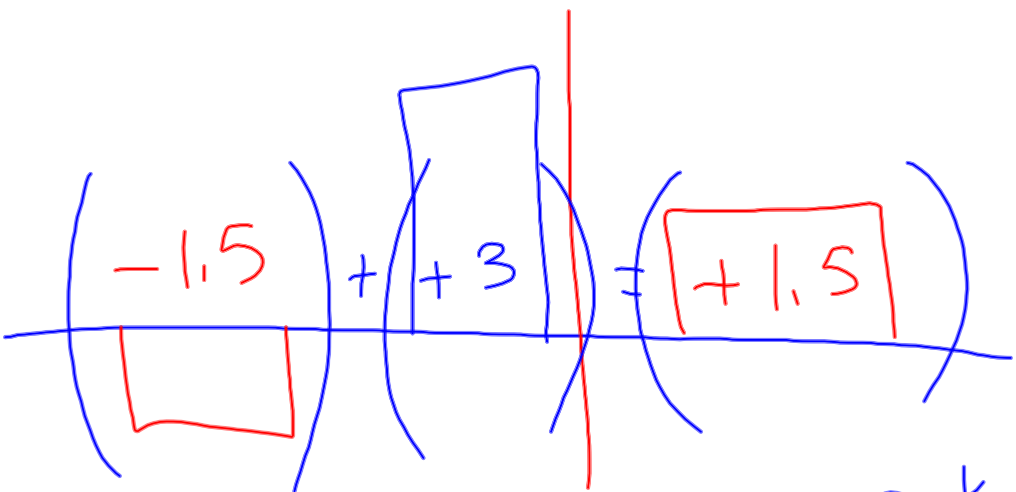
(b) Your 0.0567-kg tennis ball traveling at 25 m/s hits a practice wall and rebounds in the opposite direction with the same speed. Determine the ball's change in momentum (magnitude and direction).




$P_{ball} = mv = (0.06)(-25) = -1.5 \frac{Kg\,m}{s}$

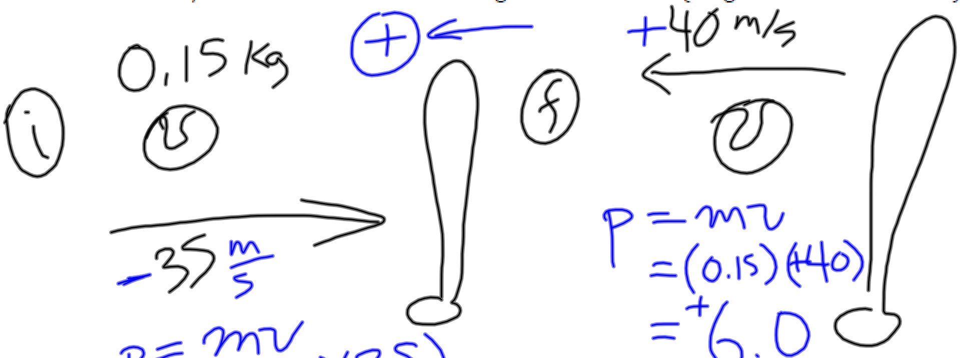
$p = mv = (0.06)(+25) = +1.5 \frac{Kg\,m}{s}$

total (i) + Δ = total (f)




$\Delta P_{ball} = P_f - P_i = +3 \frac{Kg\,m}{s}$

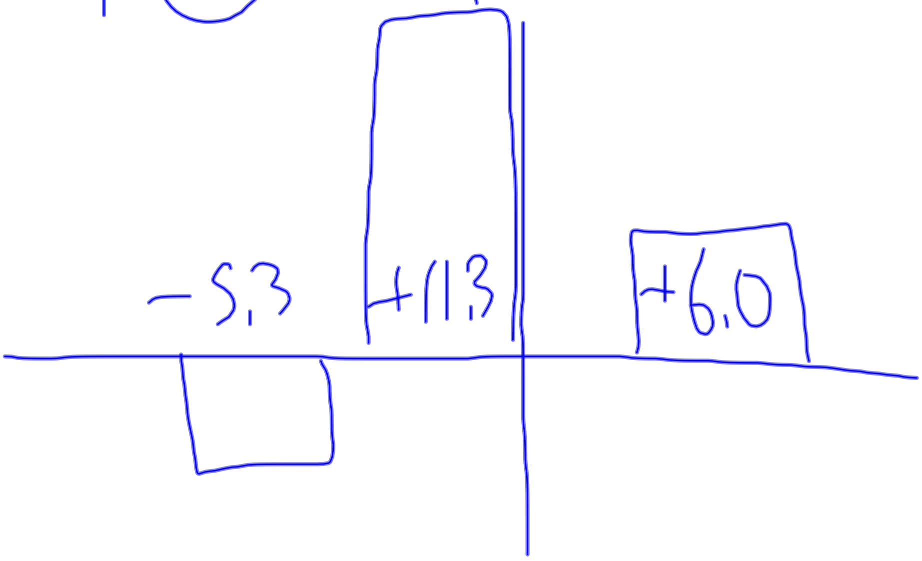
(c) A 145-g baseball traveling at 35 m/s is hit by Barry Bonds' bat so that it rebounds in the opposite direction at 40 m/s. Determine the ball's change in momentum (magnitude and direction).



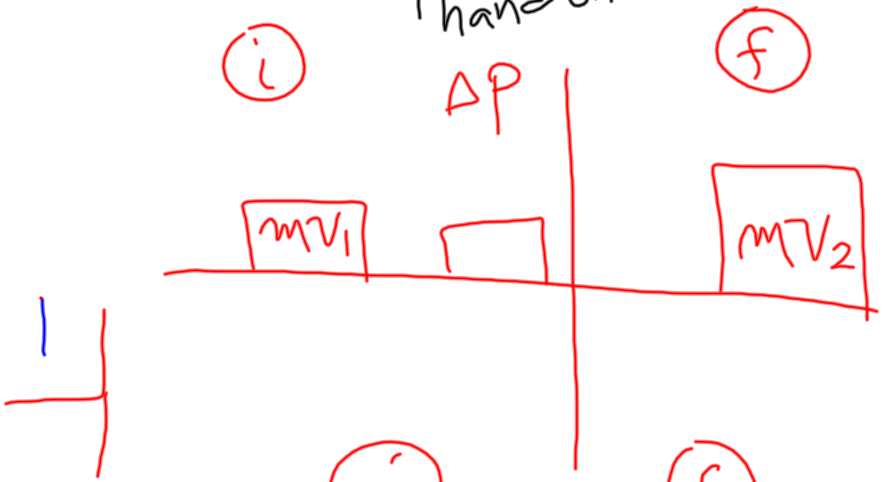

$p = mv$
$= (0.15)(-35)$
$= -5.3 \frac{kg\,m}{s}$

$p = mv$
$= (0.15)(+40)$
$= +6.0$

$p_{(i)} + \Delta p = p_{(f)}$




$i + \Delta = f$
$\Delta = f - i$
$= +6 - (-5.3)$
$= +11.3$


$$(i) + \Delta p = (f)$$

$$\Delta p = f - i$$

$$\Delta p = mv_2 - mv_1$$

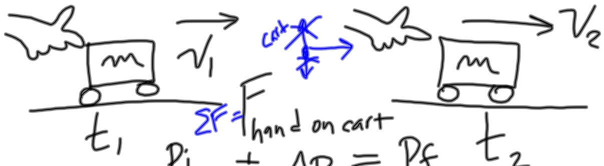
$$a = \frac{\Sigma F}{m}$$

$$\frac{\Delta v}{\Delta t} = a$$

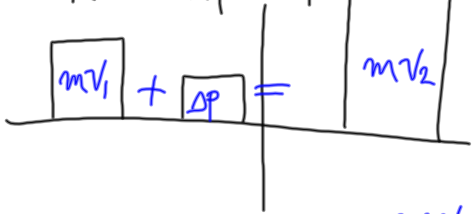
$$mv_2 - mv_1 = F_{\text{hand on c}}(t_2 - t_1)$$

J

Jaedy




$p_i + \Delta p = p_f$




$$\Delta p = mv_2 - mv_1$$

$$\Delta p = F_{hand\ on\ cart}\,\Delta t$$

$$a = \frac{\Sigma F}{m} \qquad a = \frac{\Delta v}{\Delta t}$$

$$\frac{\Sigma F}{m} = \frac{\Delta v}{\Delta t}$$

$$\Delta t\,\frac{F_{hand\ on\ cart}}{m} = \frac{\Delta v}{\Delta t}\,m$$

$$(F_{hand\ on\ cart})(\Delta t) = m\Delta v$$
$$= m(v_2 - v_1)$$
$$= mv_2 - mv_1$$
$$= p_2 - p_1$$
$$= \Delta p$$

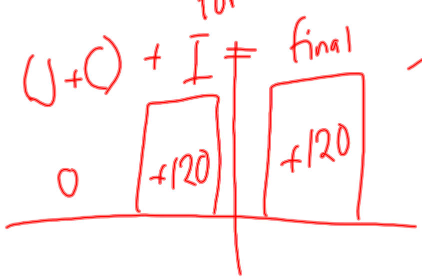
**HW 6.2**

$$(\Sigma F)(\Delta t) = \Delta p = \text{"Impulse"} = I$$

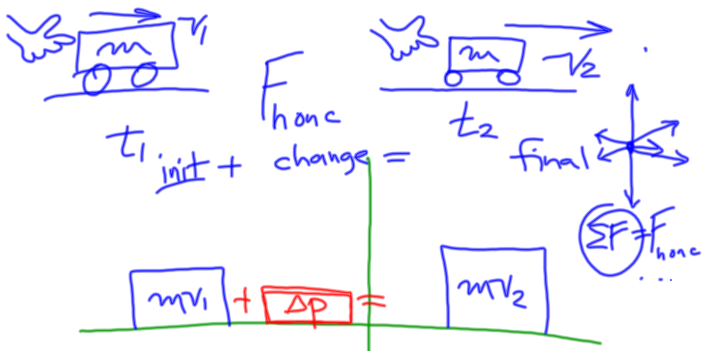
$$(\text{total } p(i)) + I = (\text{total } p(f))$$


40N for 3s

$I_{chrison\,j} = (40N)(3s) = 120\ \frac{kg\,m}{s}$




$v = \frac{p}{m} = \frac{+120}{80} = 1.5\ \frac{m}{s}$




$a = \frac{\Sigma F}{m}$ $\Delta p = mv_2 - mv_1$

$\frac{\Delta v}{\Delta t} = a$

$$\Delta p = F_{honc}(t_2 - t_1)$$

$\frac{\Sigma F}{m} = \frac{\Delta v}{\Delta t}$ $\frac{F_{honc}}{m} = \frac{mv_2 - mv_1}{t_2 - t_1}$

what we know ~ $a = \frac{\Sigma F}{m}$ and $a = \frac{\Delta v}{\Delta t}$

$\Delta p = mv_2 - mv_1$

$\Delta p = F_{honc}(t_2 - t_1)$

SO... $\frac{\Sigma F}{m} = \frac{\Delta v}{\Delta t}$ so... $\frac{F_{honc}}{m} = \frac{mv_2 - mv_1}{t_2 - t_1}$

NOW/Then

↓

we, cross, multiply ... yay!?

$F_{honc} \times (t_2 - t_1) = m(v_2 - v_1)$

the end...

OR is it...

$$\Sigma F_{ext} \Delta t = \Delta p = \text{"Impulse"} = I = \left[\frac{kg\,m}{s}\right]$$

$$\Sigma p_i + \Delta p = \Sigma p_f$$

$$\Sigma p_i + I = \Sigma p_f$$

$$\Sigma p_i + \Sigma F_{ext} \Delta t = \Sigma p_f$$

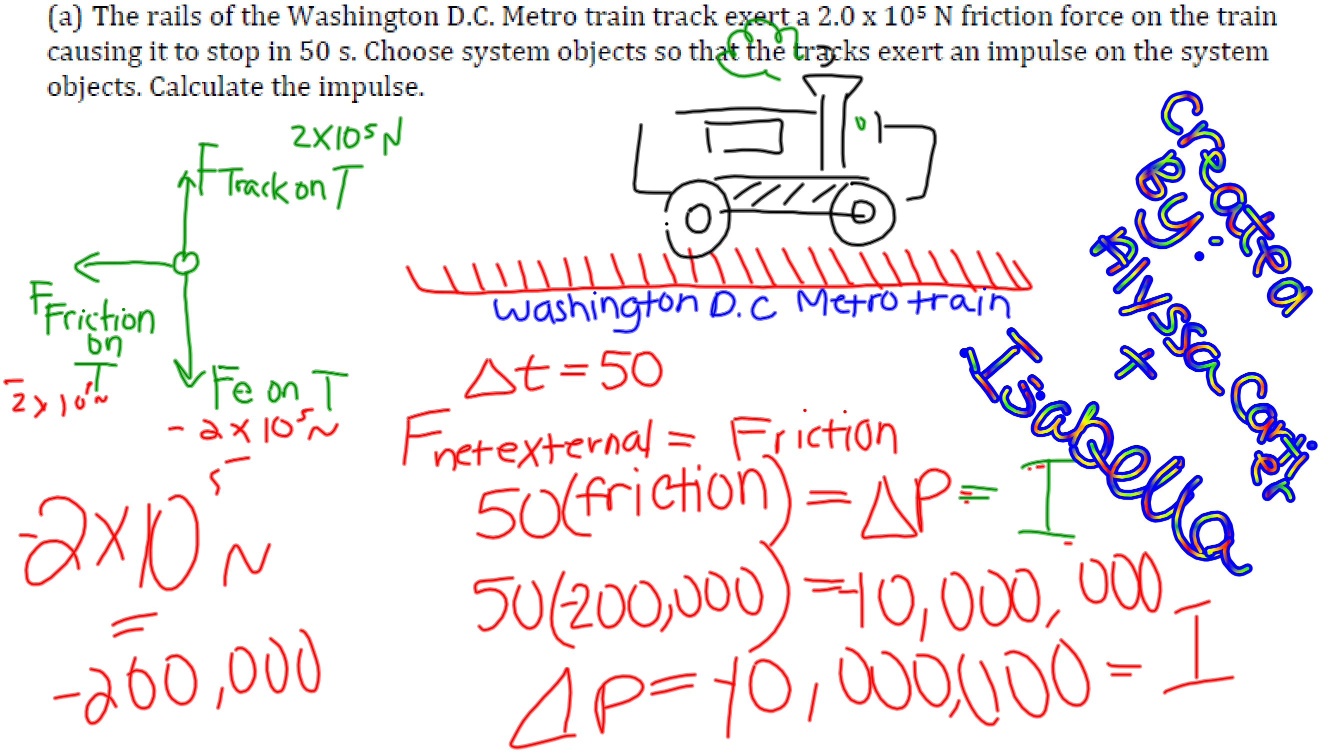
(total initial momentum) + (total external force on sys obj)(time interval of force) = (total final momentum)

6.2 a

### 6.2. Warm up

Practice reasoning with the change in momentum or "impulse": $I = \Delta p = F_{\text{net external}} \Delta t$

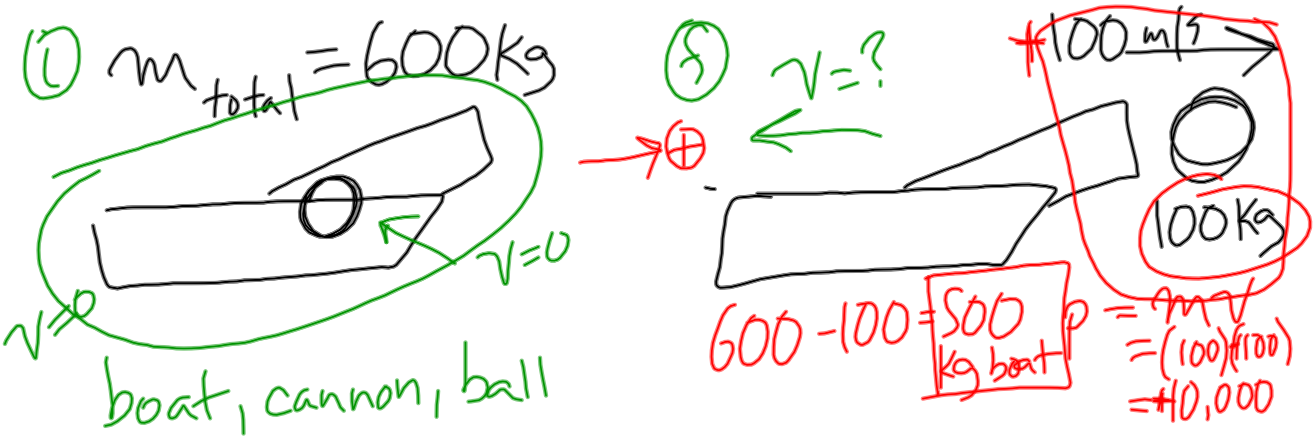
(a) The rails of the Washington D.C. Metro train track exert a 2.0 x $10^5$ N friction force on the train causing it to stop in 50 s. Choose system objects so that the tracks exert an impulse on the system objects. Calculate the impulse.



$$(F)(\Delta t) = (\Delta p)$$

$$[N][s] = \left[\frac{Kg\,m}{s}\right]$$

$$\left[\frac{Kg\,m}{s^{2}}\right][s] = \left[\frac{Kg\,m}{s}\right]$$




total init + change = total final

boat+cannon + (ball) + $\Delta p$ = boat/cannon ball

0 + 0 + 0 = -10 000 | +10 000

Final p of boat!

$m_{boat} = 500$ kg

$p = mv$

$v = \frac{p}{m}$

$= \frac{(-10{,}000)}{500}$

$= -20 \frac{m}{s}$


Boat at rest

$M = 10kg$

$V = 0$

$P = 0$

Bullet

$m = .05Kg$

$\vec{v} = 2\ m/s$

10.05

$\frac{.1}{.05} = 2$

$.05 \times 2 = .1$

$$\begin{array}{r} 10.05 \\ \times\ 2 \\ \hline 20.10 \end{array}$$

bullet + cart + Δ = bullet + cart

$\frac{20.1}{.05}$

$(20.1) + 0 + 0 = (-20.1)$

$V$ of Bullet $= 402\ m/s$

1/18/12

Block 7A

By: Sarah Brown and Jasmine Bouless