Impulse and Momentum

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

$* \vec{F} = m\left(\frac{\Delta \vec{V}}{\Delta t}\right) * \Delta t$ (mult. both sides by Δt)

$\boxed{\vec{F} \cdot \Delta t = m \Delta \vec{V}} = m(V_f - V_i)$ $\Delta \vec{V} = V_f - V_i$

$\boxed{P = mV}$ $(kg)\left(\frac{m}{s}\right)$

momentum $\frac{kg\,m}{s}$

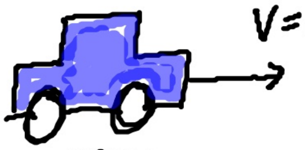
$\Delta P = mV_f - mV_i$

$\Delta P = P_f - P_i$

Impulse ⇒ change in momentum

Practice Problems

#1



$V = 115\ km/h$

m=725 kg

$\vec{V} = 115\ km/h$

m=725 kg

(a) $P = mV$

* convert units first! *

$115 \frac{km}{h} \cdot \frac{1h}{60min} \cdot \frac{1min}{60s} \cdot \frac{1000m}{1km}$

$31.94 \frac{m}{s}$

$P = (725\ kg)(31.94 \frac{m}{s})$

$P = 23{,}200\ N \cdot s$ $\left(\frac{kg\,m}{s}\right)$

(b)

#1
(b) Given:

$p = 23{,}200\ Ns\ \left(\frac{kg\,m}{s}\right)$

$m = 2175\ kg$

Unknown:

$V = \_\_\_\_\ km/h$

Equation:

$\frac{p}{m} = \frac{mV}{m} \Rightarrow V = \frac{p}{m} = \frac{23{,}200\ kg\frac{m}{s}}{2175\ kg} = 10.67\frac{m}{s}$

$10.67\frac{m}{s} \cdot \frac{3600\,s}{1\,h} \cdot \frac{1\,km}{1000\,m}$

38.4 km/h (b)

#2

$\Delta t = 2.0\,s$

$F = 5.0 \times 10^3\ N$ (5000)

$m = 725\ kg$

(a) impulse (Δp) = ____

(b) see picture

Equation:

$\Delta p = p_f - p_i$

$\Delta p = mv_f - mv_i$

$= m(v_f - v_i)$

$\Delta p = m\Delta V$

$\Delta p = F \cdot \Delta t$

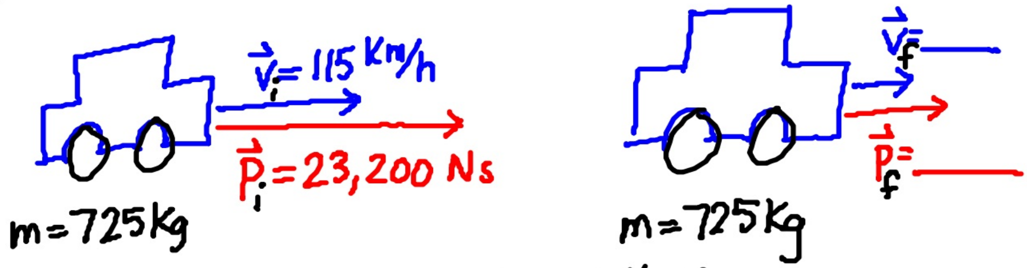
$\Delta p = (5.0 \times 10^3\ N)(2.0\,s)$

$\Delta p = -10{,}000 = -1.0 \times 10^4\ Ns$ (a)

(opposes motion because you are braking)

therefore impulse is negative

#2 (b) Before (initial) After (final)



impulse ⇒ $\Delta p = 1.0 \times 10^4$ Ns

$$\Delta p = p_f - p_i$$

$$+p_i \qquad +p_i$$

$$p_i + \Delta p = p_f$$

$$23,200 - 10,000 = 13,200 = 1.3 \times 10^4 \text{ Ns}$$

p_f

(13,000) Ns

$p_f = 13,000$ Ns

m = 725 Kg

$v_f =$ ___ Km/h

$$\frac{p_f}{m} = \frac{m v_f}{m}$$

$$v_f = \frac{p_f}{m} = \frac{13,000 \frac{\text{Kg m}}{\text{s}}}{725 \text{ Kg}} = 17.93 \frac{\text{m}}{\text{s}}$$

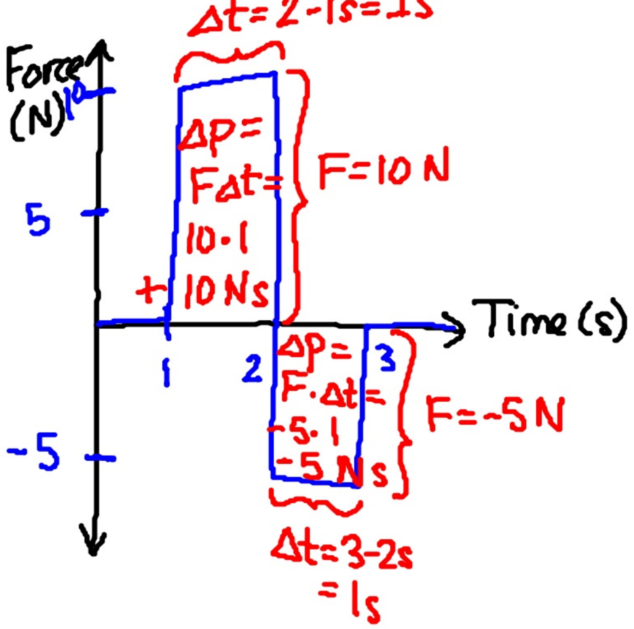
$$17.93 \frac{\text{m}}{\text{s}} \cdot \frac{3600 \text{ s}}{1 \text{ h}} \cdot \frac{1 \text{ Km}}{1000 \text{ m}}$$

64.55 Km/h

65 Km/h $= v_f$

Impulse : Graphically

↳ Force vs. Time



* area under a Force vs. time graph is the impulse (Δp)

$\Delta p = F \cdot \Delta t$

↳ watch your signs!!!

#3

(a)

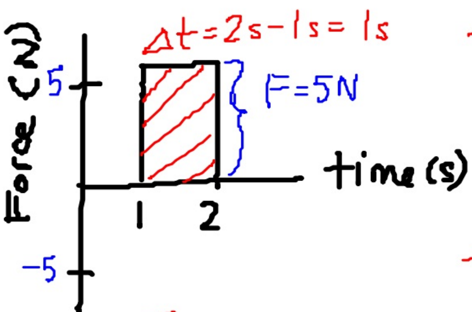
$V_i = 2.0 \frac{m}{s}$

$m = 7.0$ kg

} Calculate $p_i = mV_i$

$p_i = (7.0 kg)(2.0 \frac{m}{s})$

$p_i = 14 \frac{kg\, m}{s}$



calculate impulse (Δp)

$\Delta p = F \Delta t$

$= (5N)(2s - 1s)$

$\Delta p = 5 Ns$

$\Delta p = p_f - p_i = mV_f - mV_i$

$5 Ns = (7.0 kg) V_f - 14 \frac{kg\, m}{s}$ } Solve for V_f

$V_f = 2.7 \frac{m}{s}$ (a)

#3

(b)

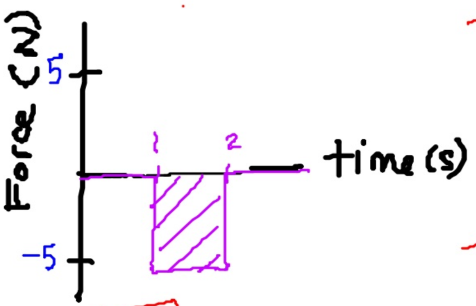
$V_i = 2.0\frac{m}{s}$

$m = 7.0\text{ kg}$

Calculate $p_i = mV_i$

$p_i = (7.0\text{kg})(2.0\frac{m}{s})$

$p_i = 14\ \frac{\text{kg m}}{s}$



calculate impulse (Δp)

$\Delta p = F\Delta t$

$= (-5N)(2s - 1s)$

$\Delta p = -5\text{ Ns}$

$\Delta p = p_f - p_i = mV_f - mV_i$

$-5\text{ Ns} = (7.0\text{kg})V_f - 14\ \frac{\text{kgm}}{s}$

Solve for V_f

$V_f = 2.7\frac{m}{s}$ (a)

#4

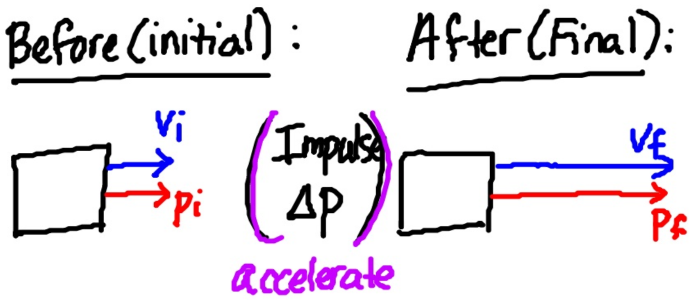
$m = 240.0\text{ kg}$

$V_i = 6.00\frac{m}{s}$

$V_f = 28.0\frac{m}{s}$

$\Delta t = 60.0s$

(a)



Impulse $\Rightarrow \Delta p = m\Delta V = \underbrace{mV_f}_{P_f} - \underbrace{mV_i}_{P_i}$

(b) $\Delta p = (240.0\text{Kg})(28.0\frac{m}{s}) - (240.0\text{Kg})(6.00\frac{m}{s})$

$\Delta p = 5280\ \frac{\text{kg m}}{s}$

5.28×10^3

3 SF

#4(c)

F = ___ N

$F\Delta t = m\Delta V = mV_f - mV_i = \Delta P$

$\frac{F\Delta t}{\Delta t} = \frac{\Delta P}{\Delta t}$

$F = \frac{\Delta P}{\Delta t} = \frac{5280\ Ns}{60.0\ s} = 88.0\ N$

88.0 N — 3 SF!

(c)

#5

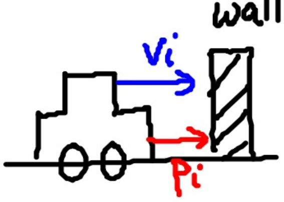
$m_p = 60.0\ kg$

$\Delta t = 0.20\ s$

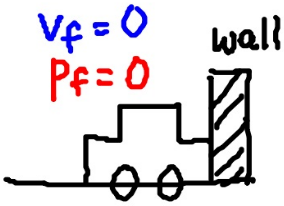
$v_i = 94\ km/h\ (26\ m/s)$

$v_f = 0\ km/h\ (0\ m/s)$

Before:



After:



F = ___ N

$\frac{F\Delta t}{\Delta t} = \frac{\Delta P}{\Delta t}$

$F = \frac{\Delta P}{\Delta t} = \frac{P_f - P_i}{\Delta t}$

$F = \frac{mV_f - mV_i}{\Delta t}$

$F = \frac{(60)(0) - (60)(26)}{(0.20)}$

F = −7800 N — 2 SF!

(a)

#5 (b)

$F_g = mg$

$F_g = F$ → from part (a)

$g = -9.8\ m/s^2$

$\frac{F_g}{g} = \frac{mg}{g}$

$m = \frac{F_g}{g} = \frac{-7800\ N}{-9.8\ \frac{m}{s^2}} = 795.92\ Kg$

$m = 8.0 \times 10^2\ kg$ (b)

$\Delta p = p_f - p_i = mv_f - mv_i = m(v_f - v_i) = m\Delta V = F\Delta t$

$p = mV$