15. Conservation of momentum

m_A = mass of astronaut
v_A = velocity of astronaut
m_W = mass of wrench
v_W = velocity of wrench

initial momentum $= 0$
final momentum $= m_A v_A + m_W v_W$

initial momentum = final momentum

$$0 = m_A v_A + m_W v_W$$

$$v_W = \frac{-m_A}{m_W} v_A$$

$$= -\left(\frac{100\,kg}{1\,kg}\right)(1\ m/s)$$

$$= -100\ m/s$$

16. Collision is elastic only if kinetic energy after collision is same as that before collision

Before: $E_k = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2$

$= \frac{1}{2}(10 kg)(20 m/s)^2 + \frac{1}{2}(10 kg)(20 m/s)^2$

$= 4000 J$

After: $E_k' = \frac{1}{2} m_1 v_1'^2 + \frac{1}{2} m_2 v_2'^2$

$= \frac{1}{2}(10 kg)(5 m/s)^2 + \frac{1}{2}(10 kg)(5 m/s)^2$

$= 250 J$

$E_k' < E_k$, so collision is <u>inelastic</u>

17. Yes.

Example: $m_1 = m_2 \qquad v_2 = -v_1$

$$\text{Total momentum} = m_1 v_1 + m_2 v_2$$

$$= m_1 v_1 - m_1 v_1$$

$$= 0$$

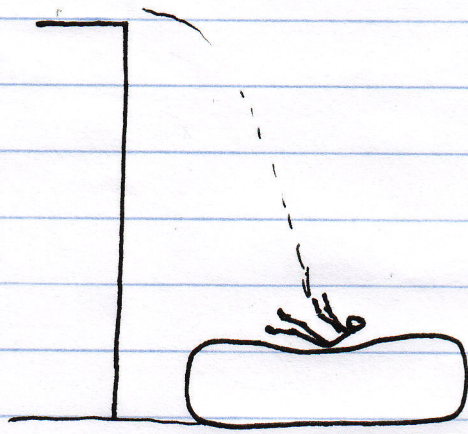
$$\text{Total Kinetic energy} = \tfrac{1}{2} m_1 v_1^2 + \tfrac{1}{2} m_2 v_2^2$$

$$= \tfrac{1}{2} m_1 v_1^2 + \tfrac{1}{2} m_1 v_1^2$$

$$= m_1 v_1^2.$$

$$\neq 0$$

18.



a) $\text{impulse} = F\Delta t$

$= \Delta p$ by Newton's 2nd Law

$$\left[\begin{aligned} F &= ma \\ &= m\frac{\Delta v}{\Delta t} = \frac{\Delta mv}{\Delta t} \\ &= \frac{\Delta p}{\Delta t} \end{aligned}\right]$$

$\Delta p = p_{initial} - p_{final}$

$= mv - 0$

$= (100\,kg)(30\,m/s)$

$= 3000\ kg\,m/s$

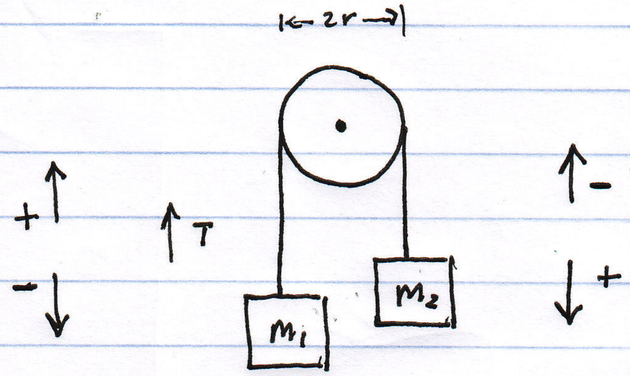
b) $F = \dfrac{\text{impulse}}{\Delta t}$

$= \dfrac{3000\ kg\ m/s}{1\ sec}$

$= 3000\ kg\ m/s^2$

$= 3000\ N$

19.



a) First define directions: The left side moving upward = +
So right side moving downward = +

Newton's 2nd Law

$$m_1 a_1 = T - m_1 g \qquad a_1 = a_2 = a$$
$$m_2 a_2 = m_2 g - T$$

adding equations:

$$(m_1 + m_2)a = (m_2 - m_1)g$$

$$a = \frac{m_2 - m_1}{m_1 + m_2} g$$

$$= \frac{40kg - 60kg}{40kg + 60kg} g$$

$$= -0.2\, g$$

$$= -1.96\ m/s^2 \leftarrow$$

19 b) If mass of pulley is much larger than masses of blocks, can assume that the contributions of the blocks to the momentum of inertia of the system can be ignored.

Angular version of Newton's 2nd Law:

$$I\alpha = \tau$$

r = radius of pulley

$$= m_1 g r - m_2 g r$$

[Counter clockwise is always the "+" angular direction]

$$\alpha = \frac{(m_1 - m_2) g r}{I}$$

$$I = \tfrac{1}{2} m_p r^2$$

$$= \frac{2(m_1 - m_2)}{m_p r} g$$

angular acceleration

linear acceleration $a = \alpha r$

$$a = \frac{2(m_1 - m_2)}{m_p} g$$

$$= \frac{2(60\,kg - 40\,kg)}{2000\,kg} 9.8\,m/s^2$$

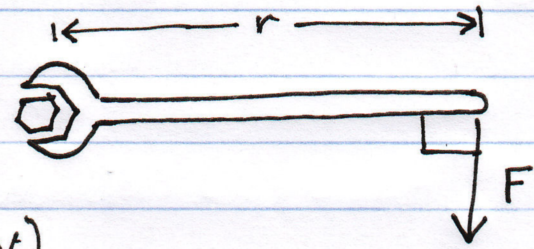
$$= 0.196\ m/s^2$$

From definition of directions, ~~clock~~ counterclockwise rotation is equivalent to negative acceleration. So

$$a = -0.196\ m/s^2$$

20. $\vec{\tau} = \vec{r} \times \vec{F}$

$\tau = rF$ when forces is applied at 90° to r



$500\ Nm = r(250N)$

$r = \dfrac{500\ Nm}{250\ N}$

$= 2\ m$ ⇐