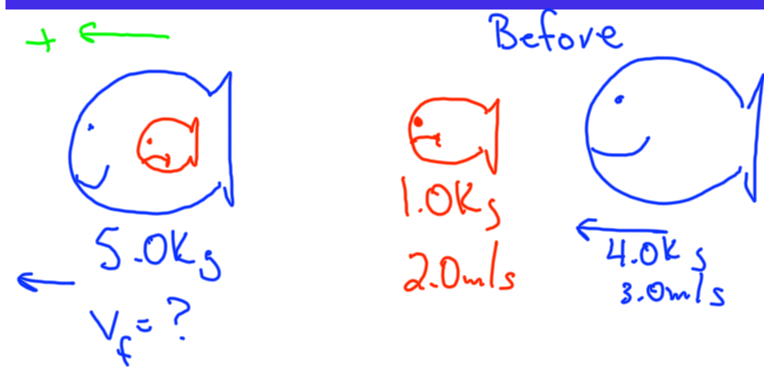
Reminders 08-03-09:

- 8th Webassign due Tue 11:59PM
- Exam 4 Chapters 9-11 Thursday
- Standard Assessment p.255 #2 C, #4 D, #5 C, #& A; ignore material on angular momentum.

Objectives:

- Conservation of Momentum
- Work and Energy

- A big 4.0kg fish moving to the left at 3.0 m/s swallows a small 1.0 kg fish moving to the left at 2.0 m/s. What is the final <u>speed</u> of the big fish? What if the fish were moving in the opposite direction?



$$\Sigma p_i = (4.0\,kg)(3.0\,m/s) + (1.0\,kg)(2.0\,m/s)$$
$$= 14.0\,kg\,m/s$$

$$\Sigma p_i = \Sigma p_f$$
$$14.0\,kg\,m/s = (m_1 + m_2)\,v_f$$
$$V_f = \frac{14.0\,kg\,m/s}{5.0\,kg} = 2.8\,m/s$$

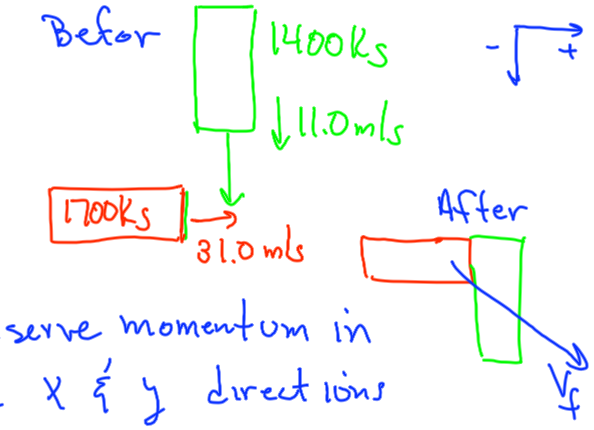
If the fish were moving in opposite directions

$$\Sigma p_i = 12\,kg\,m/s - 2.0\,kg\,m/s$$
$$= 10.0\,kg\,m/s$$

$$\Sigma p_i = \Sigma p_f$$

$$10.0\,kg\,m/s = (m_1 + m_2)\,v_f$$
$$V_f = \frac{10.0\,kg\,m/s}{5.0\,kg} = 2.0\,m/s$$

- A 1400kg car moving south at 11.0m/s is struck by a 1700 kg car moving east at 31.0m/s (i.e. a 2D collision). The cars are stuck together. How do we determine the final velocity of the system immediately after the collision? What external force are we neglecting here?



Conserve momentum in the x & y directions

$$\sum p_{ix} = (1700\,kg)(31.0\,m/s) = \sum p_f$$

$$(1700\,kg)(31.0\,m/s) = (m_1 + m_2) v_{fx}$$

$$v_{fx} = \frac{(1700\,kg)(31.0\,m/s)}{3100\,kg} = 17\,m/s$$

$$\sum p_{yi} = -(1400\,kg)(11.0\,m/s) = \sum p_f$$

$$-(1400\,kg)(11.0\,m/s) = (m_1 + m_2) v_{fy}$$

$$v_{fy} = \frac{-(1400)(11.0\,m/s)}{3100\,kg} = -5.0\,m/s$$

$$v_f = \sqrt{(17\,m/s)^2 + (5.0\,m/s)^2} = 18\,m/s$$

$$\theta = \tan^{-1}\left(\frac{-5.0\,m/s}{17\,m/s}\right) = -16^\circ$$

16° south of East

- Examples of work (continued).
  - A horse pulls a cart with a force of 4.0×10^2 N. What is the work done on the cart after it has traveled 11 m?

$$W = Fd = (4.0 \times 10^2 N)(11 m)$$

$$= 4.4 \times 10^3 J$$

– **A block is pulled with a force of 5.0 N through a distance of 3 m. The frictional force acting on the block is 3 N. What is the work done on the block?**

Find F_{net} 1st

$5.0N - 3.0N = 2.0N$

$F_{net} = 2.0N$

$W_{net} = (2.0N)(3.0m) = 6.0J$

or

$W_{5.0N} = 15N$

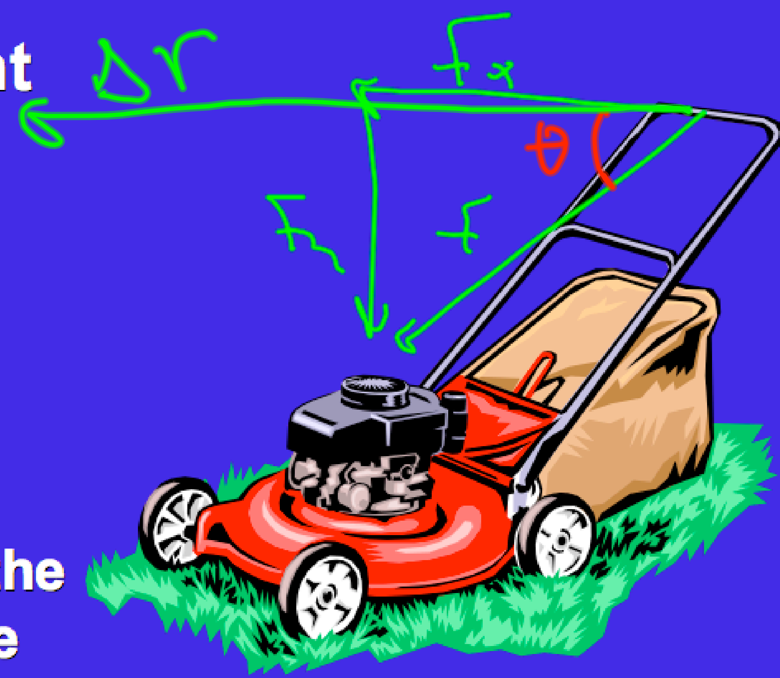
$W_{3.0N} = -9.0N$

$6.0N$

Sum the work done by each force to obtain work done by net force

Work and Energy

- **Only the force in the direction of displacement does work.**
  - **When a mower is pushed the force acting on it has vertical and horizontal components. It is the horizontal component of the force that does work since the mower moves in that direction.**



$$W = F_x \Delta x + F_y \Delta y$$

$$= |\vec{F}||\Delta\vec{r}|\cos\theta$$

– Suppose a horse pulls a cart with a force of 4.0 x 10^2 N. What is the work done per unit time on the cart after it has traveled 11 m in 5 s?

$$W = Fd = (4.0 \times 10^2 N)(11 m)$$

$$= 4.4 \times 10^3 J$$

$$P_{avg} = \frac{4.4 \times 10^3 J}{5 s} = 880 W$$

$$1 J/s = 1 Watt$$

746 Watts = 1 hp

- A 2.0 kg gun fires a 5.0 g bullet. The bullet has a velocity of 6.0 x 10² m/s. Find the recoil velocity of the gun. Note the momentum of the bullet is equal to the momentum of the gun. The bullet causes a lot more damage to us than the gun itself. Why?

$$\Sigma P_i = \Sigma P_f$$

$$0 = (m_g V_g + m_b V_b)$$

$$V_g = \frac{-m_b V_b}{m_g} = \frac{(0.005 kg)(600 \tfrac{m}{s})}{2.0 kg}$$

$$= -1.5 \text{ m/s}$$

$$KE_{bullet} = \frac{1}{2}(.005 kg)(6.0 \times 10^2 \tfrac{m}{s})^2$$

$$= 900 J$$

$$KE_{gun} = \frac{1}{2}(2.0 kg)(1.5 m/s)^2 = 2.2 J$$

$$W_{net} = \Delta KE = Fd$$

bullet has more KE, thus requires more work to stop it. It will cause more damage.

- A gun with a muzzle velocity of 4.0×10^2 m/s horizontally fires a 12 g bullet into a 2.0kg block resting on a frictionless surface. The bullet comes to rest after traveling 15 cm.
  - What is the work done on the bullet by the block in bringing it to a complete stop?
  - What is the force and average power required to stop the bullet?
  - What is the average acceleration of the bullet?
  - What is the work done on the block in this time.

Want W_{bullet}

$$W_{bullet} = \frac{1}{2} m_b v_f^2 - \frac{1}{2} m_b v_i^2$$

find v_f

use conservation of $\vec{p}$ to find v_f

$$\Sigma p_i = \Sigma p_f$$

$$m_b v_{bi} = (m_b + m_B) v_f$$

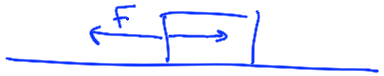
$$v_f = \frac{m_b v_{bi}}{m_b + m_B} = \frac{(.012\,kg)(4.0\times10^2\,\frac{m}{s})}{(2.0\,kg + .012\,kg)}$$

$$= 2.4\,m/s$$

$$W_{bullet} = \frac{1}{2}(.012\,kg)\left[\left(2.4\,\frac{m}{s}\right)^2 - \left(4.0\times10^2\right)^2\right]$$

$$= -960\,J$$

$-Fs = -960\,J$



$\theta = 180^\circ$

$W = |\vec{F}||\vec{s}|\cos\theta$

$F = \dfrac{960\,J}{s} = \dfrac{960\,J}{.15\,m} = \underline{6400\,N}$

magnitude of average force

$P_{avg} = F\,v_{avg}$

If F constant

$v_{avg} = \dfrac{v_i + v_f}{2}$

$P_{avg} = 6400\,N \left[\dfrac{4.0\times10^2\,\frac{m}{s} + 2.4\,\frac{m}{s}}{2}\right]$

$= 1.3\times10^6\,W$

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find a_{avg}

$a = \dfrac{v_f^2 - v_i^2}{2s} = \dfrac{(2.4\,\frac{m}{s})^2 - (4.0\times10^2\,\frac{m}{s})^2}{2(.15\,m)}$

$a = -5.3\times10^5\,m/s^2$

to find interaction time use

$\dfrac{W}{\Delta t} = F\,v_{avg}$

or

$F\Delta t = m\Delta v$

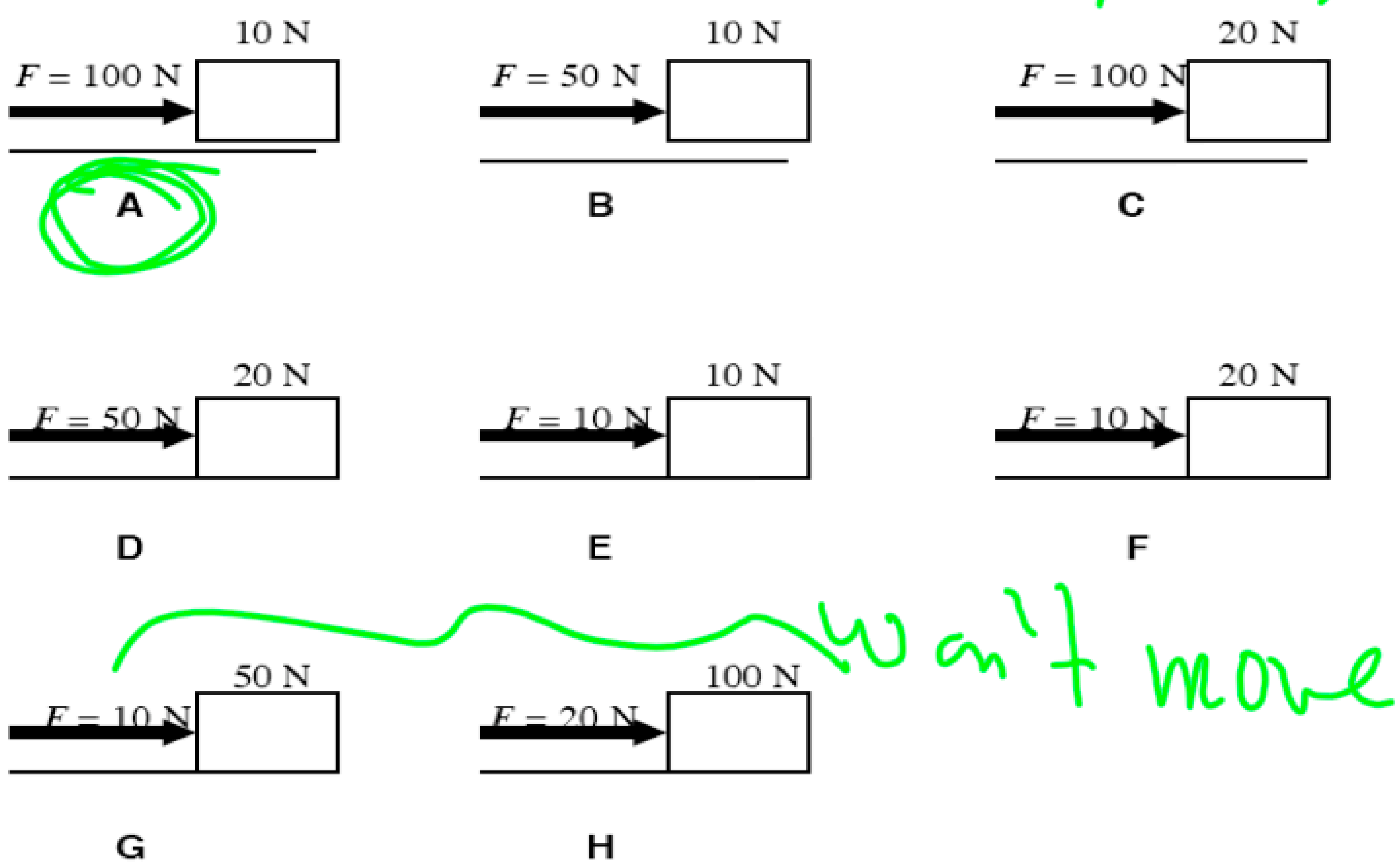
$W_{block} = \frac{1}{2} m_B (v_f^2 - v_i^2)$

$= \frac{1}{2}(2.0\,kg)(2.4\,\frac{m}{s})^2 = 5.7\,J$

Various similar boxes are being pushed for 10 m across a floor by a horizontal force as shown below. The weights of the boxes and the applied horizontal force for each case are given in the indicated figures. The frictional force is 20% of the weight of the box (g = 10 N/kg).

Rank the change in kinetic energy for each box from the greatest change in kinetic energy to the least change in kinetic energy. All boxes have an initial velocity of +10 m/s (+ direction is to the right and - to the left, with –4 < -2).

$W_{net} = F_{net}d = \Delta KE$



Greatest 1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____ Least

Or, all changes in kinetic energy are the same