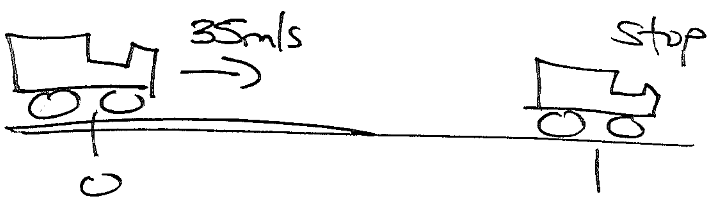
PHYSICS 151
FINAL EXAM

Name: ______________________________

Please answer eight of the following ten questions. Each question is worth five points. Partial credit will be awarded based on the amount of work shown, level of completion, closeness to the correct answer, and decipherability.

#1 A train, initially going $36\,m/s$, decelerates at $1.2\,m/s^2$.

(a.) How long does it take until the train stops?



KNOWN: $X_i = 0$ (FROM Picture)

$V_i = 36\,m/s$

$a = -1.2\,m/s^2$ ← acc. opposite to velocity to slow down

$V_f = 0$ (stops)

UNKNOWN: $X_f = ?$

$\Delta t = ?$ ← part. a

$V_f = V_i + a\Delta t$

$\Rightarrow 36\,m/s = 0 - 1.2\,m/s^2\,\Delta t \Rightarrow \Delta t = \frac{36\,m/s}{1.2\,m/s^2} = 30s$ ~~= 29.166 s = 29s~~

(b.) What distance does the train travel while stopping?

$X_f = ?$ $\therefore X_f = X_i + V_i\Delta t + \frac{1}{2}a\Delta t^2$

$\Rightarrow X_f = 0 + 35\,m/s(30s) + \frac{1}{2}(-1.2\,m/s^2)(30s)^2$

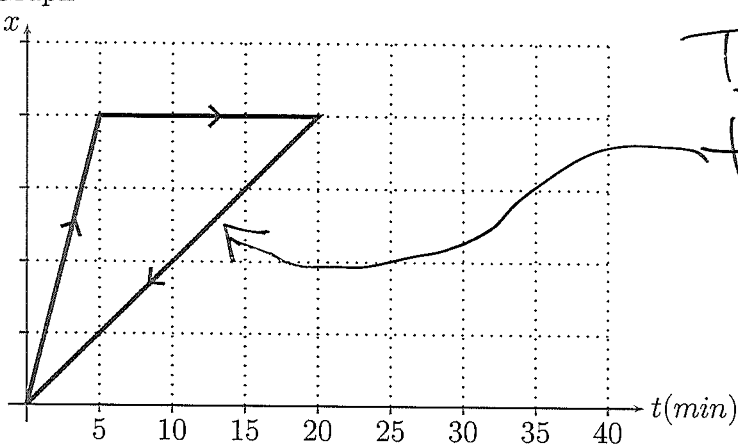
$\Rightarrow X_f = 1050m - 540m = \underline{540m}$

#2 On a test, Bob the physics student is given the following problem: A man leaves his house and runs, with a constant speed, down his street for 5 minutes. He stops and chats to a neighbor for 15 minutes. Deciding that he's too tired to continue, the man walks, with a constant speed, back to his house. (You may assume the man runs faster than he walks.) Bob draws the following position-versus-time graph for the problem.

(a.) Explain what is wrong with Bob's graph.

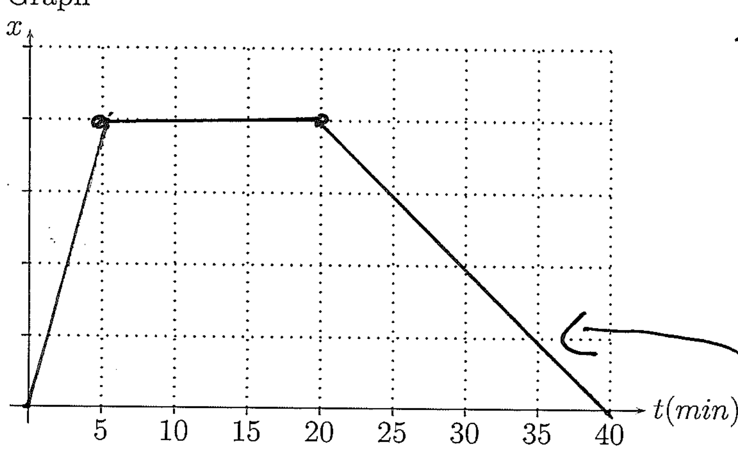
(b.) Draw the correct graph in the space provided

Bob's Graph



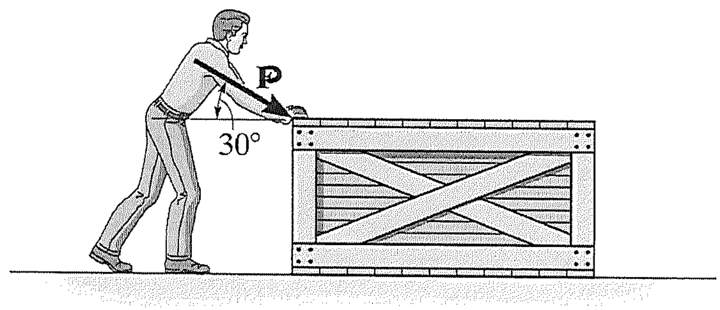
THis is position versus TIME. Bob has the man going BACKWARDS IN TIME! NOT IN the opposite direction.

Correct Graph



THE FIRST TWO pieces of the graph were OK. The last piece Needs to go BACK to x=0 but take longer than 5 minutes. As long as the slope of this line is smaller than the ORIGINAL, it's OK.

#3 A crate is made to slide to the right by a man applying a pushing force at the 30° angle shown. Is the normal force acting on the crate bigger, smaller, or equal to the crate's weight? Explain your answer.



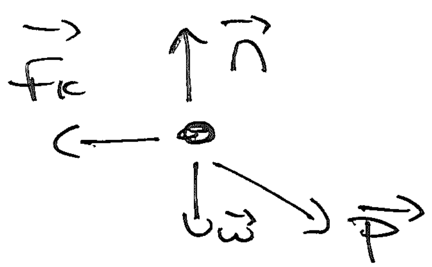
Forces on Crate: $\vec{P}$ at 30° Below Horizontal.

Normal, $\vec{n}$, up (Horizontal Floor)

Probably friction, $\vec{f_k}$, to left

Weight, $\vec{w}$ Down.

Free body Diagram:

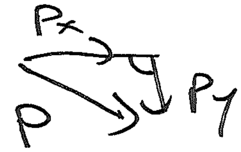


$\sum F_y = ma_y$. No vertical motion ⇒ $a_y = 0$

⇒ $\cancel{f_{k,y}}^{0} + n_y + P_y + w_y = 0$

⇒ $+n + P_y - w = 0$

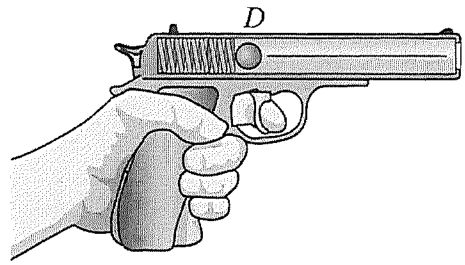
$\vec{P}$'s y-Component points Downward:



⇒ Also Negative. ⇒ $P_y = -|P_y|$ ⇒ $n - |P_y| - w = 0$

⇒ $n = w + |P_y|$ ⇒ Larger than weight.

#4 A 400-N/m spring gun is loaded by pushing a 0.75-kg ball into the barrel and locking it into place. When the trigger is pulled, the ball is released from rest at point D. If the ball hits the ground going $8\,m/s$, how far was the spring compressed? Ignore friction and assume the spring gun is being held $1.5\,m$ above the ground.



FROM LAUNCH until hitting GROUND both gravity AND SPRING DO WORK

$$\Rightarrow \tfrac{1}{2}mv_i^2 + mgy_i + \tfrac{1}{2}ks_i^2 = \tfrac{1}{2}mv_f^2 + mgy_f + \tfrac{1}{2}ks_f^2$$

$v_i = 0,\ v_f = 8\,m/s$

$y_i = 1.5\,m,\ y_f = 0$

$s_i = ?,\ s_f = 0$

$$\Rightarrow 0 + (0.75\,kg)(9.8\,m/s^2)(1.5\,m) + \tfrac{1}{2}(400\,N/m)s_f^2 = \tfrac{1}{2}(0.75\,kg)(8\,m/s)^2 + 0 + 0$$

$$\Rightarrow 11.025\,J + (200\,N/m)s_i^2 = 24\,J$$

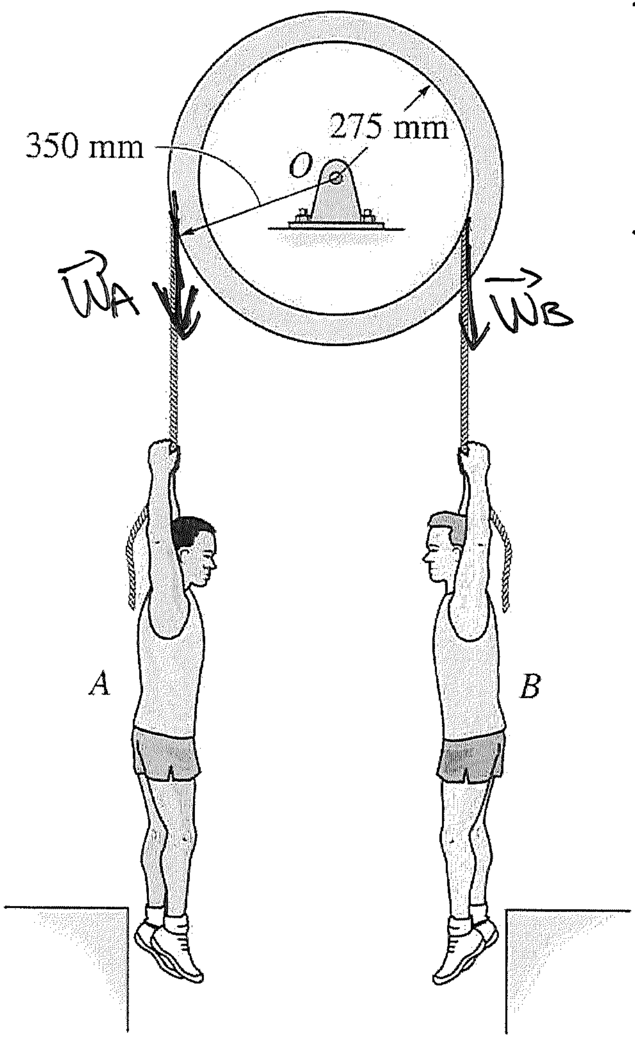
$$\Rightarrow (200\,N/m)s_i^2 = 24\,J - 11.025\,J = 12.975\,J$$

$$\Rightarrow s_i = \pm\sqrt{\frac{12.975\,J}{200\,N/m}} = \pm 0.2547\,m$$

Compressed $\Rightarrow$

$\underline{s_i = -0.25\,m}$

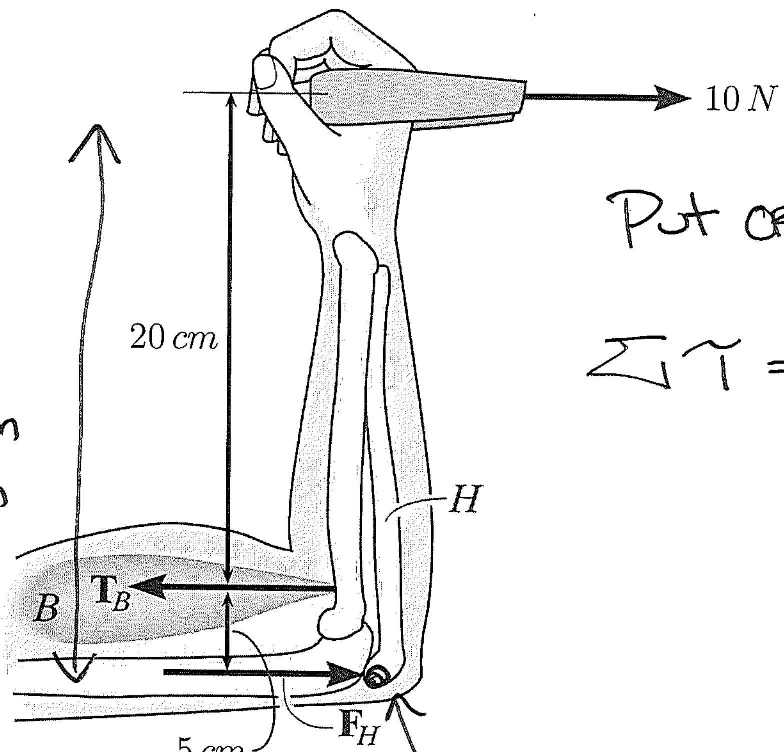
#5 Anthony and Bobby, who have identical masses, are hanging from a large-yet-frictionless pulley by ropes. Anthony's rope is farther from the pulley's center than Bobby's rope. If released from rest, will the pulley rotate clockwise, counterclockwise, or stay at rest. Explain how you determined your answer.



Even though Anthony and Bobby exert the same force on the pulley (due to their weight), Anthony will exert a larger <u>torque</u> since his force is farther from the axis of rotation. Anthony's weight is trying to spin the wheel counterclockwise.

$\Rightarrow$ Counterclockwise.

#6 One day while in physical therapy, Stanley is using elastic bands to aid his recovery from a broken arm. At one time during his workout, Stanley is holding the elastic band stationary while it is pulling on his hand with a horizontal force of $10\,N$. If Stanley's bicep and humerus are at the distances shown, what are the magnitudes of the horizontal forces, F_H and T_B, that they are exerting? Ignore all weights in your calculations.



20cm + 5cm = 25cm = 0.25m

O

0.05m

Put origin at Humerus.

$$\sum \tau = 0 \Rightarrow \cancel{\tau_H}^{\,0} + \tau_B - \tau_F = 0$$

zero distance

Due to 10N force tries to rotate clockwise ⇒ Negative

Horizontal forces ⇒ $0.05\text{m}\, T_B - 0.25\text{cm}\,(10\text{N}) = 0$

$$\Rightarrow T_B = \frac{0.25\text{m}}{0.05\text{m}}(10\text{N}) = 5(10\text{N}) = 50\text{N}$$

$$\sum F_x = 0 \Rightarrow F_H - T_B + 10\text{N} = 0 \Rightarrow F_H - 50\text{N} + 10\text{N} = 0$$

$$\Rightarrow F_H - 40\text{N} = 0 \Rightarrow \underline{F_H = 40\text{N}}$$

#7 Describe a process in which an object's entropy decreases but that does not violate the second law of thermodynamics. Explain what is essential about this process that keeps the second law intact.

Any process IN which a Non-isolated System's Entropy decreases is FINE.

So any type OF cleaning OR Neatly piling is good.

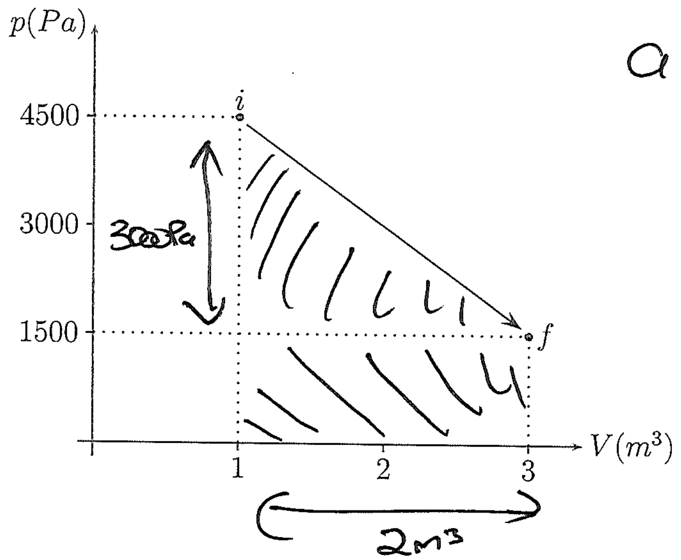
#8 An ideal gas with $N = 5 \times 10^{23}$ particles undergoes the following process from some initial to final state. **Hint:** The Boltzmann constant is $1.38 \times 10^{-23}\ J/K$.

(a.) The gas's change in temperature, $T_f - T_i$, is zero. Explain how this can be determined.

(b.) Is this an isothermal process? Explain why or why not.

(c.) How much heat was involved in this process?

(d.) Did the gas absorb or emit heat? Explain how you know.



a.) Ideal gas EQN

$pV = NK_BT$

$P_iV_i = (4500\,Pa)(1\,m^3) = 4500\,J$

$P_fV_f = (1500\,Pa)(3\,m^3) = 4500\,J$

$\Rightarrow T_i = T_f$

b.) NOT ISOTHERMAL. Constant T $\Rightarrow$ pV is constant for all points Between INITIAL AND FINAL. So pV diagram is A Curve, NOT a straight line.

ΔE_{TH} doesn't depend on path so $\Delta T = 0 \Rightarrow \Delta E_{TH} = 0$

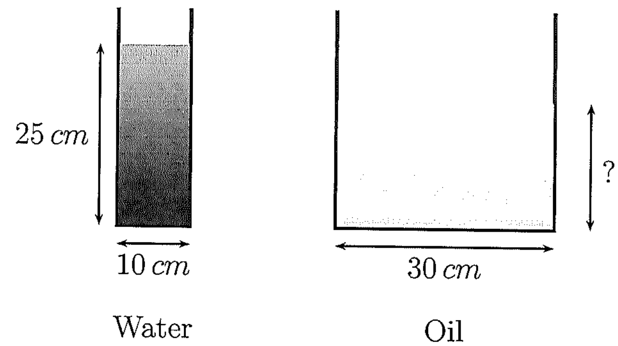
c.) $Q - W_{gas} = \frac{3}{2} NK_B \Delta T$. $\quad \Delta E_{TH} = 0 \Rightarrow Q - W_{gas} = 0 \Rightarrow Q = W_{gas}$

$W_{gas} = \text{area} = \text{Triangle} + \text{Rectangle} = \frac{1}{2}(2\,m^3)(3000\,Pa) + 2\,m^3(1500\,Pa)$

$\Rightarrow W_{gas} = 3000\,J + 3000\,J = 6000\,J \Rightarrow Q = 6000\,J$

d.) Positive Q $\Rightarrow$ GAS absorbed Heat.

#9 A container is filled with water to a depth of 25 cm. A second container, of a different size, is going to be filled with oil. To what depth should the oil container be filled in order to make the pressure at its bottom equal to the pressure at the bottom of the water container? Both containers are open to the air. Water's density is $1\, g/cm^3$ and oil's density is $0.9\, g/cm^3$.



Widths Do Not matter!

$P_{water} = P_0 + \rho_{water}\, g\, d_{water} \quad P_{oil} = P_0 + \rho_{oil}\, g\, d_{oil}$

Both open to air $\Rightarrow$ P_0 = atmospheric pressure for both

$P_{water} = P_{oil} \Rightarrow \cancel{P_0} + \rho_{water}\, g\, d_{water} = \cancel{P_0} + \rho_{oil}\, g\, d_{oil}$

$\Rightarrow \rho_{water}\, \cancel{g}\, d_{water} = \rho_{oil}\, \cancel{g}\, d_{oil} \Rightarrow (1 g/cm^3)(25 cm) = \left(\frac{0.9g}{cm^3}\right) d_{oil}$

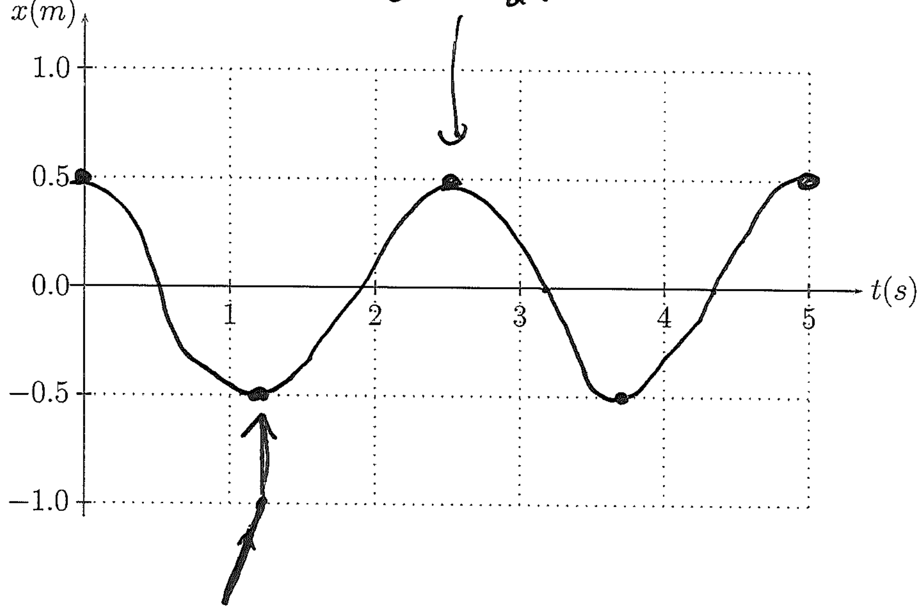
$\Rightarrow d_{oil} = \left(\frac{1 g/cm^3}{0.9 g/cm^3}\right)(25 cm) = 1.1111\ (25 cm) = 27.777 cm$

$= \underline{28 cm}$

#10 A mass connected to a 350-N/m spring undergoes simple harmonic motion with an amplitude of 0.5 m and frequency of 0.4 Hz.

(a.) Plot the position versus time for the mass. Assume the mass started from rest at a position of 0.5 m. For full points, your graph should show the position at every given time value.

after one period back at 0.5m



$f = \frac{1}{T} \Rightarrow$

$T = \frac{1}{f} = \frac{1}{0.4Hz}$

$= 2.5s$

$\Rightarrow$ Two cycles on graph

at Half a period $= \frac{2.5s}{2} = 1.25s$

at maximum distance to left $\Rightarrow$ at $-0.5m$

(b.) What is the mass of the object?

SHM $\Rightarrow T = 2\pi\sqrt{\frac{m}{K}} \Rightarrow 2.5s = 2\pi\sqrt{\frac{m}{350N/m}}$

$\Rightarrow \sqrt{\frac{m}{350N/m}} = \frac{2.5s}{(2\pi)} = 0.3979s \Rightarrow \frac{m}{350N/m} = (0.3979s)^2$

$\Rightarrow m = 350\frac{N}{m}(0.1583s^2) = 55.41\,kg = \underline{55\,kg}$

Unit: $\frac{N}{m} \cdot s^2 = \frac{\frac{kg \cdot \cancel{m}}{\cancel{s^2}}}{\cancel{m}} \cdot \cancel{s^2} = kg$