(1) To find velocity from a position graph, we must look at the slope

i) The slope starts negative $\Rightarrow$ ~~A~~ ~~D~~ ~~F~~ and ii) is more negative at the end than the beginning $\Rightarrow$ ~~B~~ ~~C~~

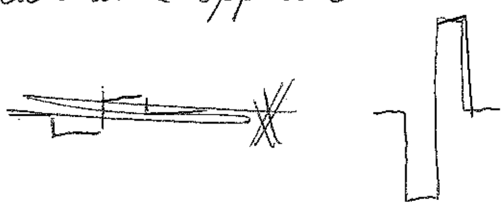
$\boxed{E}$

(2) Once again, we read the slope off the graph. Thus, it must be the case that at $t=0$, $v=0$; $t=1, v<0$; $t=2, v=0$

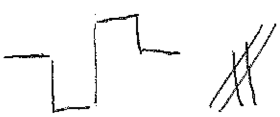
$\Rightarrow \boxed{D}$

Alternatively, in the case of the SHO, you can shift the graph by T/4 to the left to find the derivative

(3) 5 looks like a flat pulse, so the pulses we add together must be equal and opposite. $\Rightarrow$ 1 and 3 $\Rightarrow$ B

A $\Rightarrow$ 

C $\Rightarrow$ 

D $\Rightarrow$ 

(4) Since the pressure has tripled that means that the total rate of collisions has gone up by 3, but the total rate is given by:

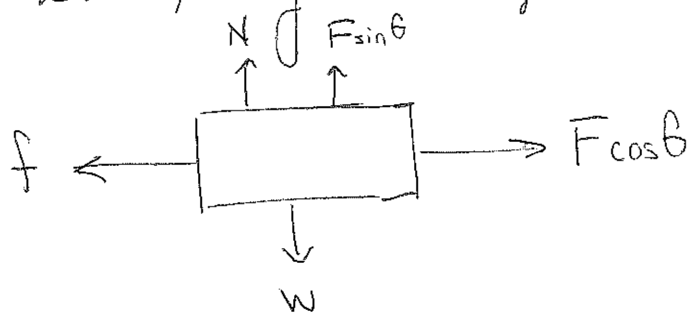
$$R_{TOT} = n\underbrace{r}_{\text{rate for one molecule}}$$

$$R_{TOT} \longrightarrow 3R_{TOT}\,;\; n \longrightarrow 3n$$

$$\Longrightarrow 3R_{TOT} = 3nr' \Longrightarrow r' = \frac{R_{TOT}}{n} = r$$

So r doesn't change!

(5) Decomposing the FBD gives:



Since the block is being pulled at constant speed, the sum of the forces is 0!

$$\Sigma F_x = F\cos\theta - f = 0 \Longrightarrow \underline{F > f}$$

$$\Sigma F_y = F\sin\theta + N - W = 0 \Longrightarrow N = W - F\sin\theta \Longrightarrow \underline{N < W}$$

$$\Longrightarrow \boxed{A}$$

(6) $\boxed{E}$ This is kind of a definition thing

(7) We know that:

$$Q = L_{vap} m \Longrightarrow L_{vap} = Q/m$$

So the chemist needs only to know Q, the heat, and m, the mass.

$$\Longrightarrow \boxed{E}$$

(8) $I_{TOT} = 4I$ since intensities are additive. We also know that the decibel level is given by:

$$\beta = \text{"dB"} = 10 \log\left(I_{TOT}/I_0\right) \Longrightarrow \frac{I_{TOT}}{I_0} = 10^{\beta/10} \Longrightarrow$$

$$= \frac{4I}{I_0} = 10^{\beta/10} \Longrightarrow I = \frac{I_0 10^{\beta/10}}{4} =$$

$$= \frac{(10^{-12}\ W/m^2)}{4} 10^{10.6} =$$

$$= 10^{-2}\ W/m^2$$

(9) $$v_{rms} = \sqrt{3RT_0/m}$$

$$2v = \sqrt{\frac{3RT}{m}}$$

$$\frac{2v}{v} = \sqrt{\frac{\frac{3RT}{m}}{\frac{3RT_0}{m}}} = 2 = \sqrt{T/T_0} \Longrightarrow T = 4T_0$$

~~Note:~~

$$T_0 = 288K \Longrightarrow T = \cancel{456}\ 1152K = \boxed{879°C}$$

(S1) A) Since the wave is at 0 at $t=0$ at your end, and $d=-0.1m$ at your friends end, the wave must look like:

Since there's only one max $\Rightarrow$ $6m = \frac{3}{4}\lambda \Rightarrow \boxed{\lambda = 8m}$

By looking at the graph, one can see it returns to it's starting position after $\boxed{\text{4 seconds}}$ that is it's period

$$v = \lambda f = \lambda/T = 8m/4sec = \boxed{2 m/s}$$

B) ~~[illegible]~~ the equation for this is:

$$A\sin\left(\frac{2\pi}{\lambda}x + \omega t - \phi\right) = A\sin\left(\frac{2\pi}{\lambda}x + \frac{2\pi}{T}t - \phi\right)$$

Here ϕ is 0 since it starts out looking like a ~~[illegible]~~ sine function, leaving

$$(0.1m)\sin\left(\frac{2\pi}{8m}x + \frac{2\pi}{4sec}t\right)$$

(S2) A) The two biggest frequency shifts are when the speaker and listener are moving away, and towards each other simultaneously. Before calculating Doppler shift, we must find the speed at which the edge of the platform moves.

$$v_s = \omega_s r = \left(\frac{2rev}{sec}\right)\left(\frac{2\pi rad}{rev}\right)(2m) = 8\pi m/s \cong 25.1 m/s$$

$$v_r = \omega_r r = \left(\frac{1rev}{sec}\right)\left(\frac{2\pi rad}{rev}\right)(2m) = 4\pi m/s \cong 12.6 m/s$$

Now, the formula for Doppler shift is:

$$f = \frac{v + v_r}{v - v_s} f_0 \quad \text{w } v_r/v_s \text{ pos if the things moving towards each other.}$$

$$f_{max} = \frac{340 m/s + 25.1 m/s}{340 m/s - 12.6 m/s}(1000Hz) = 1100 Hz$$

$$f_{min} = \frac{340 m/s - 25.1 m/s}{340 m/s + 12.6}(1000 Hz) = 890 Hz$$

(52) (cont.) B) The highest pitched sound comes ~~at~~ when both the speaker and listener are at the bottom. The speaker and person must go through 3/4 of it period to get there.

For the speaker: $\frac{3}{4}T_S = \frac{3}{4f_S} = \frac{3}{8}$ sec

For the person: $\frac{3}{4}T_R = \frac{3}{4f_R} = \frac{3}{4}$ sec

Thus the delay for the speaker is

$$\Delta t = t_R - t_S = \boxed{\frac{3}{8}\text{ sec}}$$

(41) A) $PV = nRT$

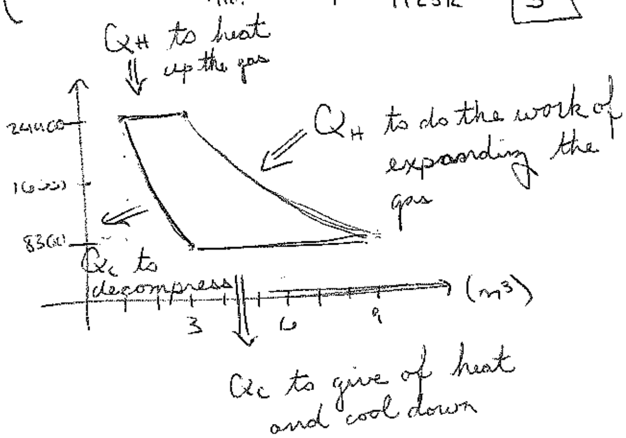
$$\Longrightarrow T = \frac{PV}{nR}$$

$$T_D = T_A = \frac{(24900\text{ Pa})(1\text{ m}^3)}{(8\text{ mol})(8.314\text{ J/mol}\cdot\text{K})} = \boxed{374\text{ K} = T_{cold}}$$

$$T_C = T_B = T_{HOT} = \frac{(24900\text{ Pa})(3\text{ m}^3)}{(8\text{ mol})(8.314\text{ J/mol}\cdot\text{K})} = \boxed{1123\text{ K}}$$

B) $$\eta_{carnot} = 1 - \frac{T_{cold}}{T_{HOT}} = 1 - \frac{374\text{ K}}{1123\text{ K}} = \boxed{\frac{2}{3}}$$

C)



D) A → B: $\Delta E_{TH} = nC_V\Delta T = (\frac{3}{2})(8\text{ mol})(8.314\text{ J/mol})(1123\text{ K} - 374\text{ K}) = ~~74,600\text{ J}~~$

$= 74,600\text{ J}$

$W_{on} = -\int P\,dV = -P\Delta V$ [for isobaric]

$= -(24900\text{ Pa})(3\text{ m}^3 - 1\text{ m}^3) = -49,800\text{ J} \Longrightarrow W_{by} = -W_{on} = 49,800\text{ J}$

$\Delta E_{TH} = W_{on} + Q \Longrightarrow Q = \Delta E_{TH} - W_{on}$

$= 74,600\text{ J} - (-49,800\text{ J}) = 124,000\text{ J}$

Since $Q > 0$, this goes in the Q_H ~~colum~~ column

(L1) D) (cont.) $B \longrightarrow C$: $\Delta E_{TH} = nC_V \Delta T$

$$= (8\,mol)(\tfrac{3}{2}R)(0)$$

$$= 0$$

$$W_{on} = -nRT\ln(V_f/V_i)$$

$$= -(8\,mol)(8.314\,J/mol\cdot K)(1123K)\ln(8m^3/3m^3)$$

$$= \underline{-82{,}100J}$$

$$\Longrightarrow W_{by} = -W_{on} = 82{,}100J$$

$$\Longrightarrow Q = \Delta E_{TH} - W_{on} = +82{,}100J$$

Once again, since $Q > 0$, it goes in the Q_H column.

Follow this same template for the last two parts of the cycle.

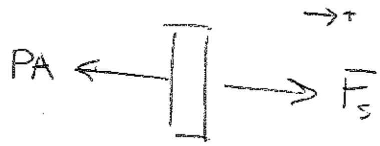
$$\cancel{E)\ \eta = \frac{\Sigma Q_H}{\Sigma W_{by}}} = \frac{\cancel{124{,}000J + 82{,}100J}}{49{,}800J\ \cancel{+ 82{,}100J - 49{,}800J - 27{,}400J}} =$$

$$E)\ \eta = \frac{\Sigma W_{by}}{\Sigma Q_H} = \frac{49{,}800J - 49{,}800J + 82{,}100J - 27{,}400J}{124{,}000J + 82{,}100J} = \boxed{0.27}$$

F) *No since the line goes above the isotherm, the temp would be above 1123K, and thus require more heat from the hot reservoir.*

Since $\eta = \frac{W_{by}}{Q_H}$, denomonator would get bigger η gets smaller!

① a) *This is just a force balancing problem, so let's begin w. a F.B.D. of the cap*



$$\sum F_x = F_s - PA = m(0)$$

$$\cancel{= k(4.0m - 3.6m) - (10^5 N/m^2)(2m^2) = 0}$$

$$\cancel{\Longrightarrow k}$$

$$= k(x - x_0) - PA = 0$$

$$\Longrightarrow k = \frac{PA}{(x - x_0)}$$

$$= \frac{(10^5 Pa)(2m^2)}{(4.0m - 3.6m)}$$

$$\boxed{= 5E5 N/m}$$

b) *Recall that the speed of sound in a string is given by:*

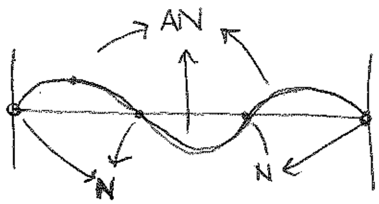
$$v = \sqrt{T\ell/m} = \cancel{\sqrt{}}$$

$$= \sqrt{\frac{k(x - x_0)\ell}{m}}$$

$$= \sqrt{\frac{(5E5)(0.4m)(4m)}{0.05kg}}$$

$$= 4{,}000 m/s$$

c)



D) We begin this problem by finding the frequency of the 3^{rd} harmonic. To do this, we ~~fix~~ use the relation:

$$\lambda_n f_n = v$$

$$\Longrightarrow f_n = v/\lambda_n$$

$$= v/(2L/n)$$

$$= \frac{vn}{2L}$$

$$= \frac{(4000\,m/s)(3)}{(2)(4.0\,m)}$$

$$\cancel{= 1500\,N}$$

$$= 1500\,Hz$$

~~Now, before we can apply the same thinking to the gas, we must find the speed of waves in ~~that medium~~ the gas. For an ideal gas:~~

$$\cancel{v_s = \sqrt{\frac{\gamma RT}{m}}}$$

$$v_s = \lambda_n f_n = \frac{2L}{n} f_n$$

$$\Longrightarrow n = \frac{2L}{v_s} f_n$$

$$= \frac{(2)(4\,m)(1500\,Hz)}{400\,m/s} = \boxed{30}$$