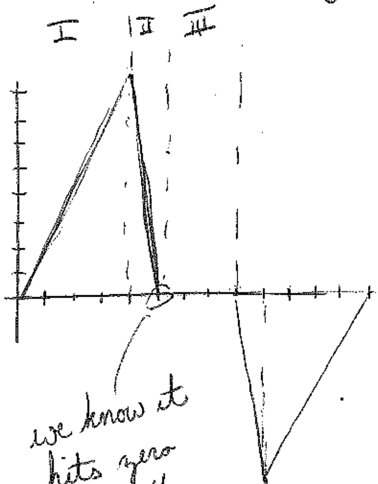
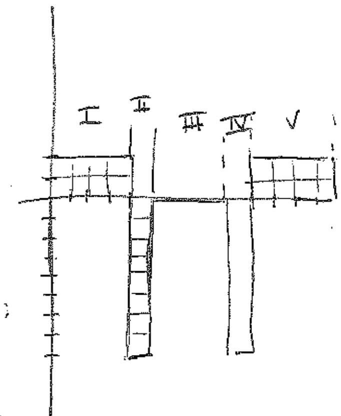
(1) I ~~thing~~ think the ~~be~~ best way to go about this is to first make the velocity graph from this:



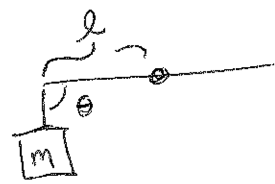


we know it hits zero since the area adds to zero

thus we know, we should have a period when the object is going forward (I, II). Followed by a period of it not moving (III); ~~then~~ followed by a period of it moving back to the starting point (IV, V).

(2) The torque is given by:

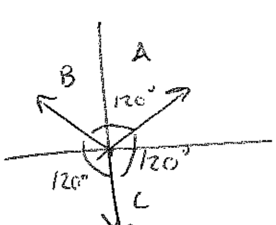
$\tau = mgl\sin\theta$



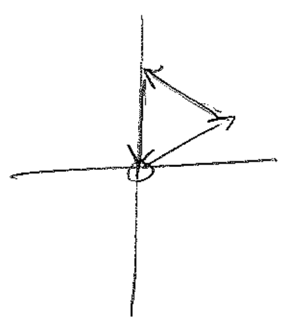
thus as the plank goes from horizontal to vertical, θ goes from ~~θ~~ 90° to 180°. Thus, the torque first decreases. Then, as the plank goes past vertical, ~~theta~~ goes ~~from 180°~~ to ~~theta~~ $\theta > 180°$, and thus the magnitude of the torque increases again

$\Longrightarrow$ $\boxed{E}$

(3)



$\Longrightarrow$ $\vec{A}+\vec{B}+\vec{C} =$



$= \vec{0}$

$\boxed{D}$

(4) We know $v_s = 331\,\text{m/s}\sqrt{T/273\,K}$, and $v_{rms} = \sqrt{\frac{3RT}{m}}$

$$\Longrightarrow \frac{v_s}{v_{rms}} = \frac{331\,\text{m/s}\sqrt{T/273\,K}}{\sqrt{\frac{3RT}{m}}} = 331\,\text{m/s}\sqrt{\frac{T/273\,K}{\frac{3RT}{m}}} = 331\,\text{m/s}\sqrt{\frac{m}{(273\,K)(3R)}}$$

$$\Longrightarrow v_s = \alpha v_{rms} \; ; \quad \alpha \equiv \sqrt{\frac{m}{(273\,K)(3R)}} \text{ (a constant)}$$

$$\Longrightarrow \boxed{B}$$

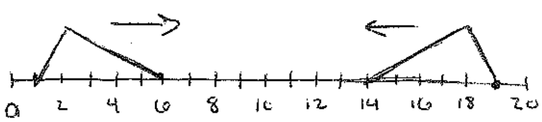
(5) Frequency is how close together the wavefronts – the lines in this pic – are; with the frequency being higher the closer together the wavefronts are.

$\Longrightarrow$ E

(6) Newton's 3rd law! ~~if you feel~~ There must be equal and opposite forces!

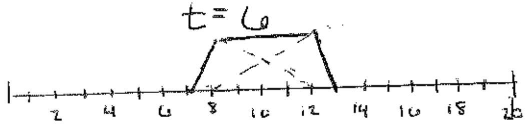
$\Longrightarrow \boxed{E}$

(7) $t=0$



Since they are moving towards each other at 1 m/s, we must move ~~each~~ each by 6 meters ~~to find~~

$t=6$



Since waves add, this ends up looking like (the dark outline)

$\Longrightarrow$ C

(8) $\beta = 105 = 10\log(I/I_0)$

$\Longrightarrow 10.5 = \log(I/I_0)$

$\Longrightarrow 10^{10.5} = I/I_0$

$\Longrightarrow I = 10^{10.5} I_0 = 10^{-1.5}\ W/m^2$

We know $IA = P$ (constant)

$\quad \hookrightarrow$ area of sphere

$\Longrightarrow I_{10} A_{10} = I_{40} A_{40}$

$\Longrightarrow I_{40} = I_{10}\left(\frac{10m}{40m}\right)^2$

$= 10^{-1.5}\left(\frac{100}{1600}\right)\frac{W}{m^2}$

$= 1.98E-3\ W/m^2$

$\Longrightarrow \beta = 10\log\left(1.98E-3\,W/m^2 / I_0\right) =$

$= 93 \Longrightarrow \boxed{C}$

(9) For a tube ~~closed~~ open at both ends:

$\lambda_n = \frac{2L}{n},\ n = 1, 2, \ldots$

For a tube closed at one end:

$\lambda_n = \frac{4L}{(2n-1)},\ n = 1, 2, \ldots$

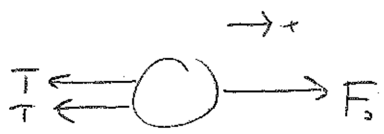
We want λ_1 to be the same for both pipes

For the open pipe, $\lambda_1 = \frac{2L}{1} = 2(0.5m) = 1m$

For the half-open pipe $\lambda_1 = 1m = \frac{4L}{1} \Longrightarrow L = \frac{1m}{4} = 0.25m \Longrightarrow \boxed{A}$

⊗

51) A) For this, we should draw a free-body diagram of the pulley



$$\Rightarrow \sum F_x = F_s - T - T = 0$$

$$\Rightarrow F_s = k(x - x_0) = 2T$$

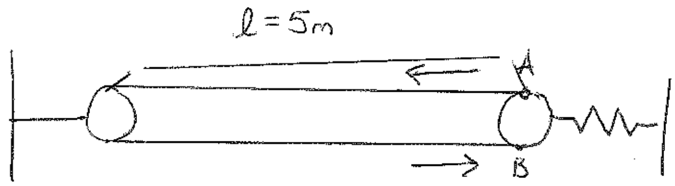
$$\Rightarrow T = \frac{k}{2}(x - x_0)$$

$$= \left(\tfrac{1}{2}\right)(200\,N/m)(2m - 0.5m)$$

$$= \boxed{150N}$$

B) $v_s = \sqrt{T/\mu} = \sqrt{150N / 0.02\,kg/m} = \boxed{86.6\,m/s}$

c) This situation is analogous to the swimming in a stream w. a current. In this case the pulse is the "swimmer" and the rope is the "stream". The movement of the rope – given by rω – is working ~~the~~ with the pulse on top, and against the pulse on the bottom.



$$\Rightarrow V_{top} = V_s + r\omega = 86.6\,m/s + (20\,\tfrac{rad}{sec})(0.5m) = 96.6\,m/s$$

$$V_{bot} = V_s - r\omega = 86.6\,m/s - (20\,\tfrac{rad}{sec})(0.5m) = 76.6\,m/s$$

$$\Delta x = \ell = v\Delta t$$

$$\Rightarrow \Delta t = \ell/v$$

$$\Delta t_{top} = 5m / 96.6\,m/s = 0.0518s$$

$$\Delta t_{bot} = 5m / 76.6\,m/s = 0.0653s$$

time dif: $\Delta t_{bot} - \Delta t_{top} = \underline{0.0135s}$ (top first)

(52) A) $PV = nRT \implies T = \frac{PV}{nR}$

$$T_A = \frac{(12450\,Pa)(2\,m^3)}{(12\,mol)(8.314\,J/mol\cdot K)}$$

$= 250K$

Similarly,

$T_B = 750K$

$T_C = 250K$

$\implies T_H = 750K$

$T_C = 250K$

B) $\eta_{carnot} = 1 - \frac{250K}{750K} = \frac{2}{3} = \frac{W_{by}}{Q_H}$

$\implies Q_H\left(\frac{2}{3}\right) = W_{by}$

$\frac{(2)(1000J)6}{3} = \boxed{|4000J|}$

C) The steps to these tables are:

1. Find all temps (if you haven't already)
2. Calculate $\Delta E_{TH} = nC_v\Delta T$
3. Calculate $W_{on} = -\int PdV$ [there are formulas for all these]
4. $Q = \Delta E_{TH} - W_{on}$
5. Fill in the rest of the rest of the table using the following rules:
   i) $W_{on} = -W_{by}$
   ii) $Q > 0 \implies Q$ in Q_H column, — in Q_C
   $Q < 0 \implies |Q|$ in Q_C column, — in Q_H

(52) c) (cont.) Without further ado:

(2) A → B: $\Delta E_{TH} = \frac{3}{2} nR\Delta T$

$\cancel{= \frac{3}{2} nR}$

$= \left(\frac{3}{2}\right)(12\,mol)(8.314\,J/mol\cdot K)(\overset{750K}{\cancel{???}} - 250K)$

$= 74800J$

B → C = $\Delta E_{TH} = \frac{3}{2}(12\,mol)(8.314\,J/mol\cdot K)(250K - 750K)$

$= -74800J$

C → A = $\Delta E_{TH} = \frac{3}{2} nR\Delta T$

$= 0$ since isotherm

(3) A → B: $W_{on} = -P\Delta V$ (since P constant)

$= -(12450\,Pa)(6m^3 - 2m^3)$

$= -48,900J$

B → C: $W_{on} = 0$ [since V is constant]

C → A: $W_{on} = -nRT\ln(V_f/V_i)$ [since isotherm]

$= -(12\,mol)(8.314\,J/mol\cdot K)(250\,K)\ln\left(\overset{2}{\cancel{6}}m^3/6m^3\right)$

$= +27,400J$

(4) A → B: $74800J - (-48,900J) = 124,700J$

B → C: $-74,800J - (0) = -74800J$

C → A: $0 - 27,400J = -27,400J$

(5)

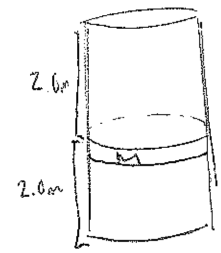
	Q	W_{on}	ΔE_{TH}	Q_H	Q_C	W_{by}
A → B	124,700J	-48,900J	74,800J	124,700J	—	48,900J
B → C	-74,800J	0 ~~27,400~~ J	-74,800J	—	74,800J	0J
C → A	-27,400J	27,400J	0	—	27,400J	-27,400J

1)

$k = 1.0E4$ $\quad h = 4.0m$

$K = 2.0 \, W/m \cdot K$ $\quad M = 5E3kg$

$A = 0.5m^2$ $\quad x_0 = 2.0m$



A) For this part, we need to do a FBD and do force balancing:

PA

$\uparrow \qquad \overset{+}{\uparrow}$

$|M = 5E3kg| \implies \sum F_y = PA - Mg = M(0)$

$\downarrow$

Mg

$$\implies PA = Mg$$

$$\implies P = \frac{Mg}{A}$$

$$= \frac{(5E3kg)(10m/s^2)}{0.5m^2}$$

$$\boxed{= 1E5 \, N/m^2}$$

B) This part of the problem asks you to ~~recognize~~ recognize that energy ~~fo~~ from gravity and spings can be sources of work on a gas, but first we must find the number of moles.

$$\cancel{\Delta E_{TH} = Q + W_{on} = -Q_c + Mg\Delta Y - \tfrac{1}{2}k(\Delta Y)^2}$$

$$PV = PA\ell = nRT$$

$$\cancel{\implies n = \frac{RT}{PA\ell}}$$

$$\cancel{= (8.314 \, J/mol \cdot K)(301K)}$$

$$\implies n = \frac{PA\ell}{RT} = \frac{(1E5 \, Pa)(0.5m^2)(2m)}{(8.314 \, J/mol \cdot K)(301K)}$$

$$\boxed{= 40 \, mol}$$

$$\Delta E_{TH} = W_{on} + Q = Mg\Delta Y - \tfrac{1}{2}k(\Delta Y)^2 - Q_c = \tfrac{3}{2}nR\Delta T$$

$$\implies \Delta T = \frac{2}{3nR}\left[Mg\Delta Y - \tfrac{1}{2}k(\Delta Y)^2 - Q_c\right]$$

$$\Delta T = -180K$$

$$\implies T_f = 301K - 180K = \boxed{121K}$$

(L1) (cont.) We are told that the volume, $V = A\ell$, remains constant. At the start of the problem, we know:

$$V = (0.05m^2)(2m) = 0.1m^3$$

Thus, we have:

$$0.1m^3 = A\ell \implies A(\ell) = \frac{0.1m^3}{\ell}$$

We know the expression for heat transfer is:

$$\frac{Q}{\Delta t} = K\left(\frac{A}{\ell}\right)\Delta T$$

$$= K\left(\frac{0.1m^3}{\ell^2}\right)\Delta T$$

$$= (2\,W/m \cdot K)\left(\frac{0.1m^3}{(3m)^2}\right)(181K)$$

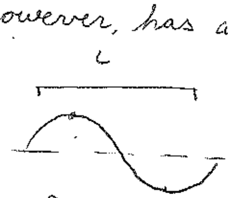
$$\boxed{= 4\,J/s}$$

(12) $L = 0.2\,m$ $\quad m = 0.05\,kg$

$V_s = 340\,m/s$

$f = 34\,Hz$

A) We know that there are anti-nodes at $l = 1/4 L$ and $l = \frac{3}{4}L$. ~~The first harm~~ In this case longest wavelength $\iff$ lowest harmonic. Since the first harmonic has its only antinode at $l = 1/2 L$, it is ruled out. The second harmonic, however, has antinodes at the correct locations, so it must be that, ie:



~~B) $v = \lambda f = (0.2m)(34\,Hz) =$~~

B) $v = \lambda f = \sqrt{T/\mu}$

$$\implies \lambda^2 f^2 = T/\mu = \frac{Tl}{m}$$

$$\implies \frac{\lambda^2 f^2 m}{l} = T$$

$$= \frac{(0.2m)^2 (34\,Hz)^2 (0.05\,kg)}{0.2m}$$

$$\boxed{T = 11.6\,N}$$

C) $f' = \left(\frac{V_s + V_r}{V_s - V_s}\right) f_o$, but since the ~~sourck~~ source is not moving, $V_s = 0$ and this becomes

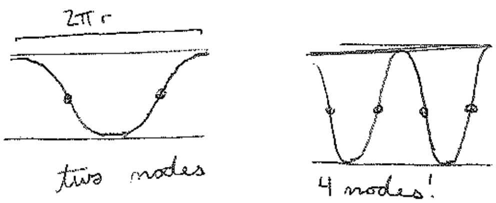
$$f' = \left(\frac{V_s + V_r}{V_s}\right) f_o$$

$$= \left(\frac{340\,m/s + 20\,m/s}{340\,m/s}\right)(34\,Hz) =$$

$$= \boxed{36\,Hz}$$

~~L2 A) We know there are anti-nodes at $l = 1/4\,L$, and $l = 3/4\,L$~~

L2 (cont.) D) One can view the tunnel as a tube of length $2\pi r$ will two open ends, in which only the odd ~~numb~~ modes are permitted.



$$\Longrightarrow \lambda = 2\pi r/2 = \underline{\pi r}$$

We also know:

$$v = \lambda f = \pi r f$$

$$\Longrightarrow r = \frac{v}{\pi f} = \frac{340\,m/s}{\pi\,(34\,Hz)} = \boxed{3.18\,m}$$