1169/T2/200

Q1 a) $y_1 = A\sin(kx - \omega t)$ and $y_2 = A\sin(kx + \omega t + \phi)$ (ϕ may have any value including zero)

b) i) For an estimation, treat the cable as an ideal stretched string, fixed at the ends. The possible standing wave resonances have

$\lambda = 2L, L, 2L/3, \ldots\ldots \lambda_n = 2L/n$

$$f_n = \frac{v}{\lambda_n} = \frac{n}{2L}\sqrt{\frac{T}{\mu}} \qquad \mu = \frac{m}{L} = \frac{\pi r^2 L.\rho}{L} = \rho\pi r^2.$$

$$f_n = \frac{n}{2L}\sqrt{\frac{T}{\rho\pi r^2}} = \frac{n}{2*8}\sqrt{\frac{7\ 10^3}{5600\pi\ (.0040)^2}} = n * 9.9\text{ Hz}$$

Resonant frequencies $\cong$ 10, 20, 30, 40, 50 Hz

ii) A resonator can store energy in large vibrations from a continuous supply by a low power source. e.g. the wind exerts a small force on the cable, but over minutes it stores substantial energy. This vibration may be transmitted to other parts of the structure. If they too have resonances at any of these frequencies, potentially dangerous vibrations may be set up.

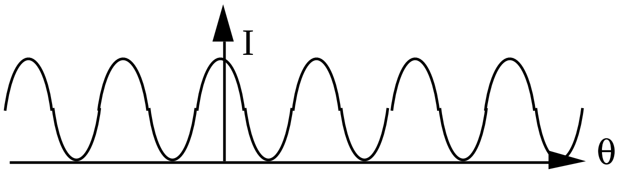
Q2 i) $I \equiv \dfrac{P}{A} = \dfrac{P}{4\pi r^2} = 640\ \mu\text{W.m}^{-2}$

ii) $\beta_I \equiv 10 \log_{10}\dfrac{I}{I_o} = 88\text{ dB}$

b) $f = f_o\dfrac{c + v_o}{c - v_s} \quad \therefore\ 1 - \dfrac{v_s}{c} = \dfrac{f_o}{f} \quad \therefore\ v_s = c\left(1 - \dfrac{f_o}{f}\right) = 84\text{ ms}^{-1}.$

c) $v = \sqrt{\dfrac{B_{ad}}{\rho}} = \sqrt{\dfrac{\gamma P}{\rho}} = \sqrt{\gamma\dfrac{NRT}{V}\dfrac{V}{NM}} = \sqrt{\gamma\dfrac{RT}{M}} \qquad \dfrac{v_{He}}{v_{Ar}} = \sqrt{\dfrac{M_{Ar}}{M_{He}}} = 3.2$

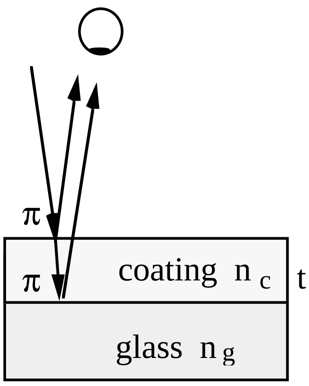
3a i)



ii) 1st minimum $\dfrac{d \sin\theta}{\lambda} = \pi$ $\quad\therefore\ \theta = \sin^{-1}\dfrac{\pi\lambda}{d} \quad \left(\cong \dfrac{\pi\ \lambda}{d}\right)$

iii) For one antenna, $I = KA^2$ where A is amplitude
on axis, the signals are in phase so the amplitudes add,
$I_T = K(2A)^2 = 4I$.
Intensity is reduced by a factor of 4.

b)



If the film has a value of refractive index intermediate between that of the glass and that of the external medium, then there will be a phase change of π at the two reflections shown. For normal incidence, these two rays will have a phase difference of π if

optical pathlength difference = $\lambda/2$

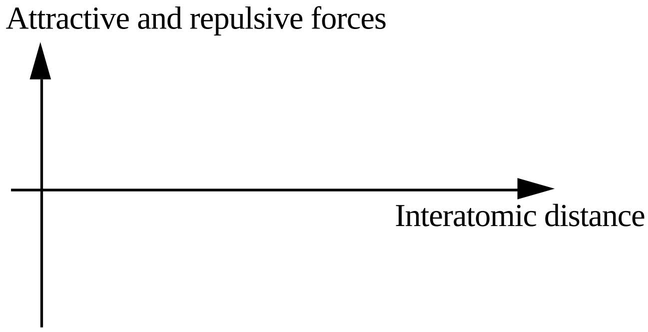
$2tn = \lambda/2 \quad \therefore \quad t = \lambda/4n = 100$ nm

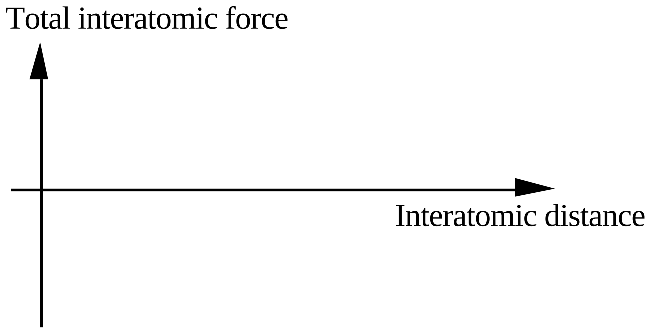
Q4) $x = L_1 - L_2 = L_{1o}(1 + \alpha_1\Delta T) - L_{2o}(1 + \alpha_2\Delta T) = L_{1o} - L_{2o} + L_{1o}\alpha_1\Delta T - L_{2o}\alpha_2\Delta T$

$x = x_o + (L_{1o}\alpha_1 - L_{2o}\alpha_2)\Delta T$ If $x = x_o$ independent of T, then

$(L_{1o}\alpha_1 - L_{2o}\alpha_2) = 0$ so $L_{1o}/L_{2o} = \alpha_2/\alpha_1$ or $L_1/L_2 = \alpha_2/\alpha_1$

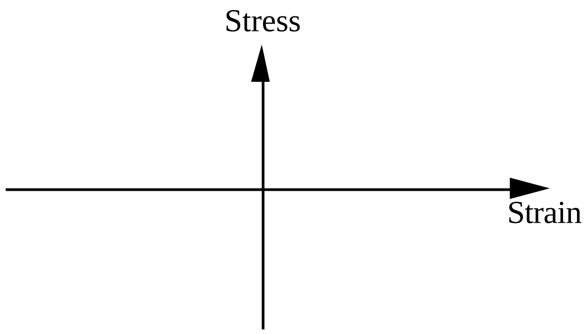
5a





5b

Stress is the force per unit area.
Strain is the proportional change in dimension (e.g. $\varepsilon_y \equiv \delta y/y$)



Q6

i) Total surface energy $= 4\pi r^2 S$

ii) Work done against $P = \int P dV = \frac{4}{3}\pi r^3 P$

iii) $W = 4\pi r^2 S + \frac{4}{3}\pi r^3 P$ where $P < 0$ for cavitation

$dW = 8\pi r S + 4\pi r^2 P$ bubble expands indefinitely (cavitates) if $dW \leq 0$

ie if $8\pi r S \leq -4\pi r^2 P$ so $r_{crit} = \frac{2S}{P}$

iv) At the sharp end of the crack, the stress is concentrated on a small number of intermolecular bonds. (Alternative explanations possible)