1. (25 points)
The crystal structure of copper is face-centered cubic (fcc) of lattice parameter $a$ to be determined by X-ray diffraction ($\lambda = 17.89$ nm) at room temperature ($T=293K$). Distance between (hkl) planes of simple cubic is given as:

$$d = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

(i) Determine the conditions on Miller indices of the diffraction peaks. What are the Miller indices of the first peak (i.e. smallest Bragg’s angle $\theta$)?
(ii) The $\theta$ of the first peak is measured to be 25.38°. What is the lattice parameter of copper?
(iii) The coefficient of linear thermal expansion is $1.91 \times 10^{-5} \text{ K}^{-1}$. Where will be the first peek at $T=1200K$?

2. (25 points)
The relation between frequency $\nu$ and wavelength $\lambda$ for surface tension waves on a liquid of density $\rho$ and surface tension $\sigma$ is

$$\nu^2 = \frac{2\pi\sigma}{\rho\lambda^3}$$

(i) What is the density of state $D(\omega)$? Note that it is a two dimensional system. Assume the area of the surface to be A.
(ii) Obtain the analogue of the Debye $T^3$ law for the surface contribution to the heat capacity of liquid helium very near to absolute zero. You can assume a cutoff frequency $\omega_D$, similar to the Debye frequency we used in 3D crystal.