**Level 3 Condensed Matter Physics- Part II**
**Weekly problem 1**

(1) Find the composition of $Ga_xIn_{1-x}As$ such that its lattice constant matches that of InP. What is the band gap at that composition? [4 marks]

You may use the following. GaAs: $a = 5.65$ Å, $E_g = 1.42$ eV. InAs: $a = 6.06$ Å, $E_g = 0.36$ eV. InP: $a = 5.87$ Å, $E_g = 1.27$ eV. The bowing parameter for the alloy $Ga_xIn_{1-x}As$ is $b = 0.475$ eV.

(2) The energy of an electron in the conduction band of a two-dimensional semiconductor is given by:

$$E(\mathbf{k}) = Ak^2 + Bk_x^2$$

where $A$ and $B$ are positive constants and $\mathbf{k} = (k_x, k_y)$ is the wavevector. Derive expressions of the effective mass in $k_x$ and $k_y$ directions. [4 marks]

(3) Silicon is made up of two interpenetrating face centred cubic (fcc) lattices displaced by a (¼,¼,¼) fractional lattice vector. Derive the (fractional) position coordinates of all 8 atoms in the unit cell. [2 marks]