Course: PHY312, Tutorial 2

1. An electron moves in a 1D crystal with lattice constant a = 5 Å.
   i. Find the wavevector k at the Brillouin zone boundary where Bragg reflection occurs.
   ii. If the electron behaves like a free particle, calculate its energy at this k. (Use free electron mass).

1. Given the energy dispersion relation for a 1D crystal as $E(k) = E_0 - 2t\times\cos(ka)$, where t = 1 eV and a = 0.3 nm, calculate the effective mass of an electron near k = 0. Plot the velocity of an electron as a function of wavevector within the first Brillouin zone.

2. For a free electron, $E(k) = \hbar^2k^2/2m_0$. If a periodic potential modifies this to $E(k) = \hbar^2k^2/2m^*$, where $m^* = 0.1\times m_0$, what does this imply about electron's motion in the crystal?

3. A semiconductor has a bandgap of 2.26 eV.
   i. If you shine photons of wavelength 900 nm, will it excite an electron from the valence band to the conduction band?
   ii. What are the wavelengths that can be transmitted (or reflected) through this semiconductor?
   iii. Comment on the colour of this semiconductor.

4. Compare direct and indirect bandgap semiconductors and give examples of each. Why are direct bandgap materials preferred for optoelectronic devices?