PH-107 (2017)
Tutorial Sheet 12

***** Problems to be done in tutorial.

Drude, Sommerfeld Model, Band Energy

P101. Find the velocity of copper wire whose cross-sectional area is 1 mm when the wire carries a current of 10 A. Assume that each copper atom contributes one election to the electron gas.

P102*. Using Drude model of an electron gas, calculate the relaxation time for Cu at room temperature given that its free electron density is 8.5×10^{28} m^{-3} and its resistivity is 1.5×10^{-8} Ωm.

P103*. A copper wire of cross-sectional area *3.3×10^{-6} m^2* is carrying a current of *25 A*. One meter length of this wire has a resistance of *5.8×10^{-3} ohms* at room temperature. Calculate the conductivity, average drift velocity of the electrons, electron mobility and mean free path of the electrons in Drude and Sommerfeld models at room temperature. *[Take atomic weight of Cu as 63.5 and density as 8.94 g/cc]*

P104: For Sodium the conductivity at *300 K* is *2.17×10^7 $ohm^{-1}m^{-1}$* and the effective mass of the electron is *1.2* times the mass of the free electron. Calculate the relaxation time and the mean free path. Calculate the drift velocity of the electrons in an electric field of *100V/m*. *[Density of Na = 970 kg/m^3, Atomic weight 23]*

P105*: Use the equation $m(dv/dt+v/\tau) = -eE$ for the electron drift velocity v, show that the conductivity at frequency ω is

$$\sigma(\omega) = \sigma(0)\left[\frac{1+i\omega\tau}{1+(\omega\tau)^2}\right]$$

where $\sigma(0) = ne^2\tau / m$

[Problem from book by Charles Kittel 6.6]

P106: Using the data given and any other constants, evaluate the Fermi energy of the alkali metals.

	Li	Na	K	Rb	Cs
Density (g/cc)	0.534	0.971	0.860	1.530	1.870
Atomic weight	6.939	22.99	39.102	85.47	132.905

P107*: The Fermi energy of Cu is 7.04 eV. Calculate the velocity and de Broglie wavelength of electrons at the Fermi energy of Cu. Can these electrons be diffracted by a crystal?

P108*: The energy of an electron in a band of 1-dimensional solid, as a function of wavenumber k, is given by

$$E(k) = 2 - \cos(ka) \quad for \quad k \in \left[-\pi/a, \pi/a \right]$$

(a) Plot E versus k.

(b) Find the speed (v) and effective mass (m*) of the electron as a function of k.

(c) Plot m* versus k.