COLLEGE OF ENGINEERING & TECHNOLOGY

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Course : **Electronic Materials**
Course Code : **EC311**

Sheet (6)
Magnetic properties

[1] Consider a rectangular loop of wire carrying current I. From the torque produced by a homogeneous magnetic field Perpendicular to one pair sides, show that the current is equivalent to a magnetic dipole $\mu = SI$ where S is the area of the loop. Do the same for a Circular current.

[2] From the rules governing the use of quantum number, show that the H,L and M shells in an atom can accommodate at most respectively 2,8 and 18 electron.

[3] Using Curie's law find X if $N=10^{26}$ m^{-3}, T=100k.

[4] The inverse of the magnetic susceptibility of gadolinium metal above its Curie Temp. was found to be equal to $5.82*10^{3}$ cm^{3}/g at 600K and $1.35*10^{4}$ cm^{3}/g at 1000K calculate θ (Curie temp.). Plot $1/\chi$ as a function of T.

[5] Consider a spinning spherical shell of charge (e) and mass (m) uniformly distributed over its surface. Show that the ratio of the magnetic moment to the angular momentum e/2m (i.e. the g factor is unity).

[6] In a diamagnetic substance of atomic no. Z=10 and the no. of atoms per unit volume $N=10^{29}$ m^{-3}, and the average square of the electron $\langle r^{2} \rangle$ is 10^{-20} m^{2}, calculate the magnetic susceptibility, calculate the magnetization and relative permeability for $B=10W/m^{2}$.

[7] A bar of metallic Iron is of length 10cm and cross section of 1 cm^{2} and density 10^{23} $atoms/cm^{3}$, the magnetic moment of each atom is $1.8*10^{-19}$ $a.cm^{2}$.

a) Determine the Susceptibility of Iron at 300K. Treat over T_c as paramagnetic.
b) What is the dipole moment of the bar if we use (χ) as in (a) in flux 10^{3} G.
c) Find the magnetization and dipole moment of the bar if all atoms aligned in one domain (saturation).

EXTRA

(1)Consider an electron in a circular orbit around a Hydrogen atom, with radius r and angular frequency ω. Describe ω in terms of e, m and r without worrying about quantum restrictions. Now apply magnetic field H perpendicular to the orbital plane, thus charging the balance of centrifugal force and centripetal forces because of the Lorentz force. Show that to first order in H, the angular frequency is shifted by an amount $\Delta\omega = (eH/2m)$. This result is known as the *Larmor Theorem*, and is central to the classical theory of diamagnetism. How large a magnetic field be necessary to make $\Delta\omega$ as large as 1 percent of the orbit frequency of an electron in helium atom.

(2)Consider an atomic electron in circular motion of radius ρ and frequency ω. The atom is placed in a magnetic field B normal to the orbit of the electron.

a) Determine the magnetic moment of the atom in the absence of the field.

b) Determine the magnetic moment of the atom in the presence of the field.

(c) If the magnetic Susceptibility of an ensemble of density $2.8*10^{28}$ atoms per cubic meter is -10^{-6}, determine the atomic radius.