SB/HCV

PHY 103: General Physics 2 (2014 – 2015, Semester – I)

Department of Physics, Indian Institute of Technology - Kanpur

Assignment- 13

(ONLY the *ed questions 5,7 and 12 will be DONE in the tutorial)

1. The magnetic moment of an iron atom in metallic iron is $2.2\mu_B$. Take the density of iron to be $7.9\,\text{g/cm}^3$ and its atomic mass $56\,\text{g/mol}$. Find the saturation magnetization of iron.
2. Find the magnetic field due to the spin angular momentum of an electron at a distance of 0.1 nm on its spin axis.
3. A cobalt piece shows magnetization of $1.5\times10^5\,\text{A/m}$. The density of cobalt is $8.9\times10^3\,\text{kg/m}^3$ and its atomic mass is 58.9g/mole. Find the average magnetic moment per atom in units of Bohr magneton.
4. A tightly wound long solenoid of radius R having n turns per unit length carries a current I. A disk of small thickness t and radius only slightly less than that of the solenoid, is kept inside the solenoid coaxially with it. The disk has magnetization m_0 along the common axis. Find the value of $\mathbf{H}$ on the axis of the disk at a distance x from its center. What would be the value of $\mathbf{H}$ if the disk is removed?
5. *A cylindrical bar magnet of length L and cross-sectional area A $\left(\ll L^2\right)$ is uniformly magnetized to have a magnetization $\mathbf{M}_0$ along its length. Find the magnetic field $\mathbf{B}$ due to the magnet at a point on its axis (a) at a distance r from the center of the magnet with $r \gg L$, (b) just outside the ends of the magnet and (c) at the center of the magnet. Assume the length L of the magnet to be large as compared to its thickness.
6. A long circular cylinder of radius R carries a magnetization $\mathbf{M} = ks^2\phi^2$, where k is a constant, s is the distance from the axis and $\hat{\phi}$ is the usual azimuthal unit vector. (a) Find the bound volume current density. (b) Using Ampere's law for B-field find the magnetic field inside the cylinder. (c) From these results, find the value of H-field inside the cylinder.
7. *A cylindrical material has length and radius both equal to L. It is uniformly magnetized along its axis and the magnetization is M. Find the magnetic field at the center.
8. An infinite hollow cylinder of inner radius a and outer radius b has a frozen-in magnetization $\mathbf{M} = \frac{C}{s}\hat{\varphi},$ in cylindrical (s,ϕ,z) coordinates with C as a constant and the z-axis along the axis of the cylinder. (a) Find the surface and volume bound current densities. (b) Find the H-field everywhere.
9. The H and B fields in a uniformly magnetized large piece of material are $H_0\hat{k}$ and $B_0\hat{k}$. It has got a small cavity. Find the B- field and H- field at the center of the cavity if the cavity has the shape of (a) a very thin but long cylinder with its axis

parallel to $\hat{k}$, (b) a sphere of small radius R and (c) a thin but wide disk with its axis parallel to $\hat{k}$.

10. A current I flows down a long straight copper wire of radius a, distributed uniformly over its cross section. (a) What is the magnetic field at a distance s from the axis ? (b) Find the bound current in the wire.

11. A large slab of a material with $\mu_r = 2.5$ fills up the region $0 < z < 2\,\text{m}$. The H- field in this region is $10y\hat{k} - 5x\hat{j}$ in SI units. Find (a) the free current density, (b) the bound current density and (c) the magnetization in the slab.

12*. The region $y \le x + 2$ is filled with a medium with relative permeability $\mu_r = 1.5$ The H-field here is $\mathbf{H} = 2\hat{i} + 6\hat{j} + 4\hat{k}$. All quantities are in SI units. Calculate the B- field in the region $y \ge x + 2$. There is no free current anywhere and the region $y > x + 2$ is air.