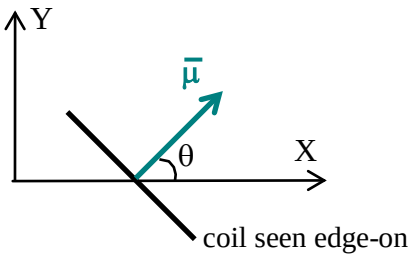
ELECTRIC AND MAGNETIC FIELDS

ASSIGNMENT 9

Q1 40 marks, Q2 25marks, Q3 35 marks

Q1 A 10-turn square coil of wire has sides of length 7 cm and carries a current of 1.5 A.



(a) What is the magnitude of the magnetic moment vector of the coil?

The plane of the coil is inclined to the x-axis, with an angle θ between the magnetic moment vector and the x-axis, as shown. A magnetic field of magnitude 1.6 T points along the +x axis.

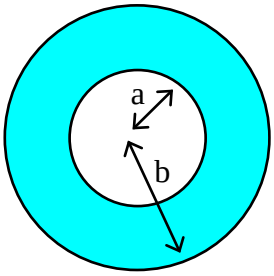
(b) Find the magnitude and direction of the torque on the dipole.

(c) The dipole can rotate about an axis parallel to the z-axis, and it comes to rest in it equilibrium position. Draw a sketch showing the orientation of the dipole moment vector in the equilibrium position.

(d) Starting from the equilibrium position, an external torque is applied in order rotate the dipole. Find the work needed to rotate it through 60^0.

Hint: The work done when a torque τ is applied over an angle dθ is τdθ.

Q2 A long copper pipe has inner radius a and outer radius b. It carries a current which is uniformly distributed over its cross sectional area between a and b, with current density (i.e., current per unit area) equal to J. Use Ampere's Law to show that the magnitude of the magnetic field as a function of radial distance r from the axis is given by



$$B = \frac{\mu_0 J(r^2 - a^2)}{2r} \qquad \text{for } a < r < b$$

and

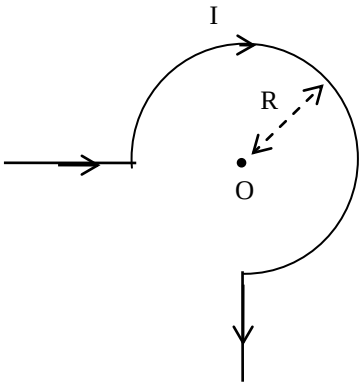
$$B = \frac{\mu_0 J(b^2 - a^2)}{2r} \qquad \text{for } r > b.$$

Sketch the variation of B with radial distance, starting from r = 0.

Q3 (a) Use the Biot Savart Law,

$$d\bar{\mathbf{B}} = \frac{\mu_o I}{4\pi r^2}\left[d\bar{\mathbf{L}} \times \hat{\mathbf{r}}\right],$$

to show that the magnetic field, **B**, at the centre, O, of the shaped wire carrying a current I, as shown, is given by



$$\overline{\mathrm{B}} = \frac{3\mu_o I}{8R}\hat{\mathrm{a}}$$

where $\hat{\mathbf{a}}$ is a unit vector perpendicular to the plane of the coil.

In which direction does $\hat{\mathbf{a}}$ point (into or out of the paper)?

(b) A current loop consists of two circular arcs of radii R_1 and R_2, and two straight sections as shown. Show that the magnetic field, **B**, at O is

$$\overline{\mathrm{B}} = \frac{3\mu_0 I(R_2 - R_1)}{8R_1R_2}\,\hat{\mathrm{a}}\ .$$