Problem Sheet - 5

1. A circular loop of radius 'a' is placed in the yz plane with its centre at origin. The loop carries a current I and the magnetic induction $\vec{B} = k\vec{i}$ acts on it, where k is a constant. Discuss how the force on an elementary arc ds varies along the circumference. What is the total torque about y axis ?

2. What currents are there in a bar magnet (i) none, (ii) bound, (iii) free? For a bar magnet, write down Amperes law in differential form. Hence show that in this case, $\vec{H}$ can be related to a scalar potential.

3. You are given two parallel circular loops of radii 'a' and 'b'; a<<b. The centre of the small loop lies at a distance 'r' above the centre of the larger loop. Find the flux in the smaller loop due to current I in the other loop. Will this be equal to the flux in the larger loop due to current I in the smaller one? If so, why?

4. Obtain Ohm's law between emf and current, starting from the current density $\vec{j}$ in the circuit and the electrical conductivity σ.

5. A 100W, 200V electric lamp has to be connected to the AC mains with rms voltage 400V and frequency 50Hz. What capacity must be added in series with the lamp to obtain the normal glow for which the lamp has been constructed?

6. Show that a non-uniform magnetisation $\vec{M}$ is equivalent to a bound current density $\vec{J_b} = \vec{\nabla} \times \vec{M}$ throughout the magnetised object.

7. Explain with necessary theory the method of producing uniform magnetic field in the laboratory.

8. State the boundary conditions for $\vec{B}$ and $\vec{H}$ at the interface of two media of different magnetic permeabilities assuming no free current.

9. What is a magnetic circuit? Deduce the fundamental equation of a magnetic circuit.

10. A metallic disc of radius 'a' is rotated about its axis with a constant angular velocity ω in a uniform magnetic field $\vec{B}$ perpendicular to its plane. Calculate the potential difference between the rim and the centre of the disc.

11. Prove the following relation for a thermocouple using thermodynamics: $\sigma_A - \sigma_B = -T\frac{d^2E}{dT^2}$.