

Tutorial 1: Electrostatics and Magnetostatics

- Solutions to boundary-value problems
- Magnetic shell, uniformly magnetized sphere;
- Ferromagnetic materials, hysteresis, energy loss.

Q1:

A uniformly magnetized sphere of radius R has magnetization $\vec{M} = M_0 \hat{Z}$. If the scalar magnetic potentials inside and outside the sphere are given as under

$$\phi_m = \frac{M_0}{3} Z \quad ; \quad r \leq R$$

$$\text{and } \phi_m = \frac{M_0}{3} \frac{R^3}{r^2} \cos \theta \quad ; \quad r > R$$

where, r, θ are two spherical coordinates, find the magnetic field inside and outside the sphere.

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2018

Q2:

Consider two point particles of charge q each, separated by a distance d , and travelling at non-relativistic velocity $\vec{v}$. If the line joining the two charges is perpendicular to $\vec{v}$, then write an expression for the magnetic force between the two particles, and illustrate the direction of the force on each particle.

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Q3:

A current sheet having $\vec{K} = 9.0 a_y \text{ A m}^{-1}$ is located at $z = 0$. The interface is between the region 1, $z < 0$, $\mu_{r1} = 4$, and region 2, $z > 0$, $\mu_{r2} = 3$. Given that $\vec{H}_2 = 14.5 a_x + 8.0 a_z \text{ A m}^{-1}$. Find $\vec{H}_1$ and $\vec{B}_1$.

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Q4:

A spherical shell of radius R , carrying a uniform surface charge σ , is set spinning at angular velocity ω about its axis. Find the vector potential it produces at point $\vec{r}$.

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Q5.

Consider a uniformly magnetized sphere of radius a and magnetization $\vec{M} = M_0 \hat{z}$ surrounded by a vacuum region. Obtain an expression for scalar magnetic potential for $r < a$.

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Q6.

Obtain the general boundary conditions for fields E , B , D and H at a boundary between two different media carrying charge density σ or a current density K .

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Q7.

Find the magnetic field strength (H) at the centre of a square current loop of side L .

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Q8.

A rectangular coil consists of 50 closely wrapped turns and has dimensions of $0.5 \text{ m} \times 0.4 \text{ m}$. It carries a current of 1.5 A . If a uniform magnetic field $B = 0.1 \text{ T}$ is applied such that the direction of the magnetic field makes an angle of 60° with respect to the plane of the coil, what is the torque exerted on the coil by the magnetic field?

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Q9.

A parallel plate capacitor having circular plates of radius 10 cm is being charged. If the electric field at any instant within the capacitor changes at the rate $5.0 \text{ V m}^{-1} \text{ s}^{-1}$, calculate the magnetic intensity $|\vec{H}|$ inside the capacitor.

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Q10.

Consider a long straight wire of length L carrying a current I . Determine the magnetic vector potential $\vec{A}$ at a point P located at distance x from the wire.

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