NEW SCHEME

EC44

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Fourth Semester B.E. Degree Examination, July/August 2004

BM/EC/EE/TE/ML/IT

Field Theory

Time: 3 hrs.] [Max.Marks : 100

Note: ***Answer any FIVE full questions.***

1. (a) Explain Coulomb's law. Justify that the force field in the region of an isolated charge Q is spherically symmetric. **(4 Marks)**

(b) Develop an expression for the electric field intensity when charge is distributed uniformly over a surface. **(8 Marks)**

A line charge of 2 nc/m lies along y-axis while surface charge densities of 0.1 and $-0.1\ nc/m^2$ exist on the plane Z=3 and Z=–4m respectively. Find the electric field intensity at a point $(1, -7, 2)$.

(c) State and explain Gauss' law and verify it for a point charge.

A point charge Q=30nc is located at the origin in Cartesian coordinates. Find the electric flux density $\vec{D}$ at $(1, 3, -4)m$. **(8 Marks)**

2. (a) Find an expression establishing the relationship between electric field intensity and gradient of potential.

Find the electric field strength $\vec{E}$ at the point $(1, 2, -1)$ given the potential $V = 3x^2y + 2yz^2 + 3xyz$. **(10 Marks)**

(b) Derive an expression for the energy stored in a region of continuous charge distribution.

A parallel plate capacitor for which $C = \in A/d$ has a constant voltage V applied across the plates. Find the stored energy in the electric field. **(10 Marks)**

3. (a) Discuss the three basic principles that apply to conductors in electrostatic fields. Indicate how these principles with a given knowledge of potential field help to calculate certain field quantities.

If the potential field $\vec{V}$ is $\vec{V} = 100(x^2 - y^2)$ find $\vec{E}, V$ at a point $(2, -1, 3)$ and the equation representing the locus of all points having a potential of 300V. **(6 Marks)**

(b) Discuss the behaviour of fields at the interface between a perfect dielectric and a conductor. **(8 Marks)**

(c) State and discuss uniqueness theorem. **(6 Marks)**

4. (a) State and discuss Ampere's circuital law and apply it to the case of an infinitely long co-axial transmission line carrying a uniformly distributed current, to calculate the magnetic field intensity. **(8 Marks)**

(b) If the magnetic field intensity in a region is $\vec{H} = x^2\vec{a}_x + 2yz\vec{a}_y + (-x^2)\vec{a}_z$, find the current density at the origin. **(4 Marks)**

(c) Discuss the concept of vector magnetic potential and arrive at an expression for it.

Given the vector magnetic potential $\vec{A} = x^2\vec{a}_x + 2yz\ \vec{a}_y + (-x^2)\vec{a}_z$, find the magnetic flux density. **(8 Marks)**

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5. (a) Explain the nature of the force when a charged particle is moving through steady electric and magnetic fields.

Find an expression for force on differential current element moving in a steady magnetic field.

Deduce the result to a straight conductor in a uniform magnetic field. **(8 Marks)**

(b) A conductor 4m long lies along the y-axis with a current of 10.0A in the $\vec{a}_y$ direction. Find the force on the conductor if the field in the region is $\vec{B} = 0.05\ \vec{a}_x$ Tesla. **(10 Marks)**

(c) Discuss the magnetic boundary conditions to apply to $\vec{B}, \vec{H}$ *and* $\vec{M}$ at the interface between two different magnetic materials. **(8 Marks)**

6. (a) Discuss the physical significance of displacement current and justify that for the case of a parallel plate capacitor the displacement current is equivalent to conduction current.

Comment on the ratio of magnitudes of conduction current density to displacement current density.

A circular cross-section conductor of radius 1.5mm carries a current $i = 5.5\ sin(4 \times 10^{10} t)\mu A$. Find the amplitude of the displacement current density if $\sigma = 35\ mho/m$ *and* $\in r = 10$. **(10 Marks)**

(b) Derive Maxwell's equations in point form Gauss law for electric and magnetic fields.

Given $\vec{E} = E_m\ sin(\omega t - \beta I)\vec{a}_y$ in free space, calculate $\vec{D}, \vec{B}$ *and* $\vec{H}$. **(10 Marks)**

7. (a) Discuss the propagation of uniform plane waves in a lossless medium.

A uniform plane wave $\vec{E}_y = 10sin(2\pi \times 10^8\ t - \beta x)$ is traveling in x-direction in free space. Find i) Phase constant , ii) Phase velocity and iii) the expression for $\vec{H}_z$. Assume $\vec{E}_z = 0 = \vec{H}_y$. **(10 Marks)**

(b) Define Poynting vector and explain the power flow associated with it.

The electric field intensity at a distance of 10 km in free space from a radio station was found to be 2.2 mv/m. Calculate

i) the power density and ii) The total power radiated from the station.

Assume the radiation to be spherically symmetric. **(10 Marks)**

8. Write notes on :

a) Gauss' divergence theorem **(5 Marks)**

b) Equation of continuity. **(5 Marks)**

c) Solution of Laplace's equation **(5 Marks)**

d) Magnetic circuits. **(5 Marks)**

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