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Question Paper Code : 10294

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2012.

Fourth Semester

Electronics and Communication Engineering

EC 2253/147403/EC 43/10144 EC 404/EC 1253/ 080290021 —
ELECTROMAGNETIC FIELDS

(Regulation 2008)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. Determine the gradient of the scalar field $F = 5r^2 + r \sin\theta$.

2. What is an electric dipole? Write down the potential due to an electric dipole.

3. What is meant by magnetic field intensity?

4. Write down the expression for the torque experienced by a current carrying loop situated in a magnetic field.

5. Express Laplace equation in spherical coordinates.

6. Write the expression for energy stored in an inductor.

7. Define Faraday's law of Electromagnetic induction.

8. Write down instantaneous, average and complex poynting vectors.

9. Determine the skin depth of copper at 60 Hz with $\sigma = 5.8 \times 10^7 S/m$. Given $\mu_r = 1$.

10. What is Brewster angle?

PART B — (5 × 16 = 80 marks)

11. (a) (i) A point charge $Q_1 = 300\mu C$ located at (1, –1, –3) m experiences a force $F_1 = 8a_x - 8a_y + a_z(N)$ due to point charge Q_2 at (3, –3, –2) m. Find the charge Q_2. (8)

(ii) Given that $\vec{D} = \left(\frac{5r^2}{4}\right)\vec{a}_r\left(C/m^2\right)$ in spherical coordinates, evaluate both sides of divergence theorem for the volume enclosed by $r = 4\ m$ and $\theta = \frac{\pi}{4}$. (8)

Or

(b) (i) Derive the expression for potential due to an electric dipole at any point P. Also find electric field intensity at the same point. (10)

(ii) Two point charges, 1.5 nC at (0, 0, 0.1) and –1.5 nC at (0, 0, –0.1), are in free space. Treat the two charges as a dipole at the origin and find potential at P(0.3, 0, 0.4). (6)

12. (a) (i) Find the magnetic field intensity due to a finite wire of carrying a current I and hence deduce an expression for magnetic field intensity at the centre of a square loop. (8)

(ii) Derive the magnetic field intensity in the different regions of co-axial cable by applying Ampere's circuital law. (8)

Or

(b) (i) Obtain the expressions for scalar and vector magnetic potential. (8)

(ii) The vector magnetic potential $\vec{A} = (3y - 3)\vec{a}_x + 2xy\vec{a}_y Wb/m$ in a certain region of free space.

(1) Show that $\nabla.\vec{A} = 0$. (3)

(2) Find the magnetic flux density $\vec{B}$ and the magnetic field intensity $\vec{H}$ at P(2, –1, 3). (5)

13. (a) (i) Write down the Poisson's and Laplace's equations. State their significance in electrostatic problems. (4)

(ii) Two parallel conducting plates are separated by distance 'd' apart and filled with dielectric medium having 'ε_r' as relative permittivity. Using Laplace's equation, derive an expression for capacitance per unit length of parallel plate capacitor, if it is connected to a DC source supplying 'V' volts. (12)

Or

(b) (i) Derive the expression for inductance of a toroidal coil carrying current. (8)

(ii) A solenoid is 50 cm long, 2 cm in diameter and contains 1500 turns. The cylindrical core has a diameter of 2 cm and a relative permeability of 75. This coil is co-axial with a second solenoid, also 50 cm long, but 3 cm diameter and 1200 turns. Calculate L for the inner solenoid; and L for the outer solenoid. (8)

14. (a) (i) Derive the Maxwell's second equation from Faraday's law. (8)

(ii) In a material for which $\sigma = 5.0 s/m$, and $\varepsilon_r = 1$, the electric field intensity is $\overline{E} = 250 \sin 10^{10} tV/m$. Find the conduction and displacement current densities, and the frequency at which both have equal magnitudes. (8)

Or

(b) (i) Explain the following: Poynting vector, average power and instantaneous power. (8)

(ii) In free space, $H = 0.2 \cos(\omega t - \beta x) a_z A/m$. Find the total power passing through a circular disc of radius 5 cm. (8)

15. (a) A uniform plane wave in a medium having $\sigma = 10^{-3} S/m$, $\varepsilon = 80\varepsilon_0$ and $\mu - \mu_0$ is having a frequency of 10 kHz.

(i) Verify whether the medium is good conductor. (3)

(ii) Calculate the following :

(1) Attenuation constant. (2)

(2) Phase constant. (2)

(3) Propagation constant. (2)

(4) Intrinsic impedance. (3)

(5) Wavelength. (2)

(6) Velocity of Propagation. (2)

Or

(b) A uniform plane wave in free space is normally incident on a dielectric having relative permittivity 4 and relative permeability 1. The electric field of incident wave is given by $\overline{E} = E_0 e^{-jz} \overline{a}_x$ to $z < 0$, where E_0 is a real constant. Calculate

(i) Frequency and wave length of incident and transmitted waves. (4)

(ii) Magnetic field of incident wave. (3)

(iii) Transmission coefficient and the expression for the electric field of the transmitted wave. (6)

(iv) Expression for the magnetic field of the transmitted wave. (3)
