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Fourth Semester B.E. Degree Examination, Aug./Sept. 2020 Electromagnetic Field Theory

Time: 3 hrs.

Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

- 1 a. State and explain Coulomb's law in vector form. (05 Marks)
- b. Find the divergence and curl of the following vector fields.
 - i) $\vec{A} = 30\vec{a}_x + 2xy\vec{a}_y + 5xz^2\vec{a}_z$
 - ii) $\vec{A} = \left(\frac{150}{r^2}\right)\vec{a}_r + 10\vec{a}_\phi$ (Cylindrical coordinates). (06 Marks)
- c. A line charge density 24 nc/m is located in free space on the line $y = 1, z = 2$.
 - i) Find \vec{E} at $P(6, -1, 3)$
 - ii) What point charge Q_A should be located at $A(-3, 4, 1)$ to cause E_y to be equal to zero at P . (05 Marks)

OR

- 2 a. Derive an expression for electric field due to an infinite line charge with density of ρ_L c/m placed along z -axis, using Gauss's law. (06 Marks)
- b. Find electric flux density at point $P(1, 2, 4)$ due to a point charge of $6 \mu\text{C}$ is located at origin, a uniform line charge density of 180 nc/m lies along the x -axis and a uniform sheet of charge equal to 25 nc/m^2 lies in the $z = 0$ plane. (06 Marks)
- c. A vector field $\vec{D} = \left(\frac{5r^2}{4}\right)\vec{a}_r$ is given in spherical coordinates. Evaluate both sides of Divergence theorem for the volume enclosed between $Q = \frac{\pi}{4}$ and $r = 4$. (04 Marks)

Module-2

- 3 a. Derive an expression for energy expended in moving a point charge in an electric fields. (06 Marks)
- b. Electric field intensity in a perfect dielectric medium is given by $\vec{E} = 4y\vec{a}_x + 4x\vec{a}_y$ V/m. Find the potential difference between the points $A(-1, 4, 0)\text{m}$ and $B(1, 2, 0)\text{m}$ along the freight line path. (04 Marks)
- c. An electric potential is given by $V = x^3y - xy^2 + 3z$ volts. Find :
 - i) V
 - ii) \vec{E}
 - iii) \vec{D}
 - iv) ρ_V at point $P(1, 1, 1)$. (06 Marks)

OR

- 4 a. Starting from principle of charge conservation obtain the point form of continuity equation. (06 Marks)
- b. Determine an equation for the capacitance of coaxial cable of length 'L', radius of inner conductor is 'a' and outer conductor is 'b'. (06 Marks)

- c. The region $y < 0$ contains a dielectric material for which $\epsilon_1 = 2$ and the region $y > 0$ contains a dielectric material for which $\epsilon_2 = 4$. If $\vec{E}_1 = -3\vec{a}_x + 5\vec{a}_y + 7\vec{a}_z$ V/m, find the \vec{E}_2 and \vec{D}_2 in medium 2. (04 Marks)

Module-3

- 5 a. Starting from the point form of Gauss's law, derive the Poisson's and Laplace's equation. (06 Marks)
- b. Find the potential and electric field intensity for the region between two concentric right circular cylinders, where $V = 0$ at $r = 1$ mm and $V = 100$ volts at $r = 20$ mm. (06 Marks)
- c. A current element of $0.05 \vec{a}_x$ A-m is located $P(0, 0, 1)$ m in rectangular coordinates. Find the magnetic field intensity of $A(2, 3, -1.2)$. (04 Marks)

OR

- 6 a. State and explain Ampere's circuital law. (06 Marks)
- b. Explain vector magnetic potential. (04 Marks)
- c. The magnetic field intensity in the region of the rectangle as shown in Fig Q6(c), is given by $H = y^2 \vec{a}_x + 3x \vec{a}_y$ A/m. verify Stoke's theorem.

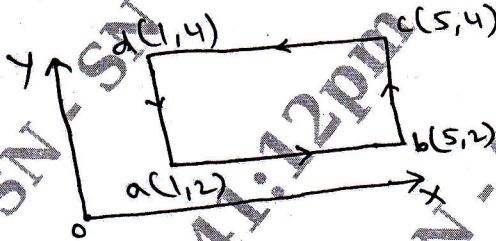


Fig Q6(c)

(06 Marks)

Module-4

- 7 a. Derive an expression for the force on a differential current element placed in a magnetic field. (06 Marks)
- b. In a certain region of space, B is given by $0.1x \vec{a}_x + 0.2y \vec{a}_y - 0.3z \vec{a}_z$ T. Find the total force on the rectangular loop shown in Fig Q7(b), if it lies in the $z = 0$ plane and is bounded by $x = 1$, $x = 3$, $y = 2$ and $y = 5$ m.

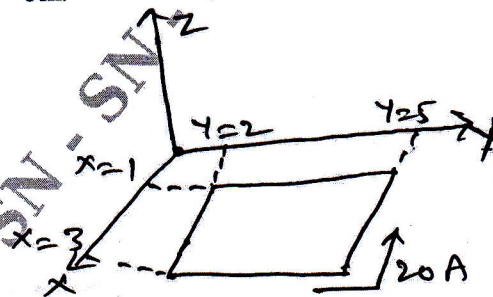


Fig Q7(b)

(10 Marks)

OR

- 8 a. Derive the magnetic boundary conditions at the interface between the two different magnetic materials. (08 Marks)
- b. Calculate the inductance of a solenoid of 400 turns wound on a cylindrical tube of 10cm diameter and 50cm length. Assume that solenoid is in air. (06 Marks)
- c. Define self inductance. (02 Marks)

Module-5

- 9 a. List the Maxwell's equations in integral and point form for time varying fields. (08 Marks)
- b. What is the drawback of Ampere's circuital law? Derive the modified form of Ampere's circulator law to suit the time varying fields. (08 Marks)

OR

- 10 a. Obtain the solution of wave equation for uniform plane wave propagating in free space. (10 Marks)
- b. A 10GHz plane wave travelling in free space has an amplitude of \bar{E} as $E_x = 10V/m$. Find β , η , v , λ and amplitude, direction of H . (06 Marks)
