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# MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
*(A constituent Institution of MAHE, Manipal)*

## III SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
## MAKE UP EXAMINATIONS, DECEMBER 2017
### SUBJECT: ELECTROMAGNETIC THEORY [ELE 2104]
REVISED CREDIT SYSTEM

**Time: 3 Hours** **Date: 30th December 2017** **Max. Marks: 50**

**Instructions to Candidates:**
- Answer **ALL** the questions.
- Missing data may be suitably assumed.

**1A.** State Coulomb's law of electrostatic force of attraction/repulsion.

Three equal positive charges of $4 \times 10^{-9}\ C$ each are located at the three corners of a square of side 20 $cm$. With the help of a neat sketch, determine the magnitude and direction of the electric field at the vacant corner point of the square. ***(04)***

**1B.** With neat diagrams, derive the expression for the electric field intensity at a point situated above a uniformly charged conductor having a charge density of 'λ' C/m.

A straight conductor of length 12 cm carries a uniformly distributed charge of $0.3 \times 10^{-6} C/cm$. Determine the magnitude and direction of the field intensity at a point located 3 cm above the conductor and displaced 3 cm to the right and beyond one end. ***(03)***

**1C.** A thin circular ring of radius $'\boldsymbol{a}'$ has a total charge $'+\boldsymbol{Q}'$ distributed uniformly over it.

a) Derive the expression of the electric field intensity at point P which is $'x'$ meters from the centre on the axis of the ring
b) Determine the force on a charge $'q'$ at the point P which is $'x'$ meters from the centre on the axis of the ring
c) Determine the force on the charge $'q'$ placed at the centre of the ring

***(03)***

**2A.** A circular disc of radius '$a$' is uniformly charged with $\rho_s\ {}^{C}/_{m^2}$. If the disc lies on the $z = 0$ plane with its axis along the $z - axis$, prove that at point $(0,0,h)$:

$$E = \frac{\rho_s}{2\varepsilon_0}\left\{1 - \frac{h}{(h^2 + a^2)^{1/2}}\right\} a_z V/m$$

***(04)***

**2B.** Let $D = 6xyz^2 a_x + 3x^2z^2 a_y + 6x^2yz a_z\ C/m^2$. Through suitable evaluation of the divergence theorem, determine the total charge enclosed by a region which is bound by $1 \le x \le 3;\ 0 \le y \le 1;\ -1 \le z \le 1$.

***(03)***

**2C.** The plane $z = 0$ separates air $(z \geq 0, \mu = \mu_0)$ from iron $(z \leq 0, \mu = 200\mu_0)$. Given that: $\bar{\boldsymbol{H}} = 10a_x + 15a_y - 3a_z\ A/m$, in air:

a) Determine the magnetic flux density in iron.
b) Calculate the angle between the field vector and the interface in iron. ***(03)***

**3A.** In a certain region of space, $\bar{B} = 0.1xa_x + 0.2ya_y - 0.3za_z\ T$. Determine the total force on a rectangular loop as shown in **Fig. Q. 3A**, if it lies in the $z = 0$ plane and is bound by $x = 1; x = 3;\ \ y = 2\ and\ y = 5\ cm$. ***(04)***

**3B.** A toroidal core has an average radius of 10 cm with a cross sectional radius of 1 cm. If the core was made of steel ( $\mu_R = 1000$) and the coil wound on it has 200 turns, calculate the amount of current that should flow so as to produce a magnetic flux of $0.5mWb$ in the core. ***(03)***

**3C.** A solenoid of length '$\boldsymbol{l}$' and radius '$\boldsymbol{a}$' consists of '$\boldsymbol{N}$' turns of wire through which current '$\boldsymbol{I}$' flows. With a neat diagram and suitable explanation, prove that at point '$\boldsymbol{P}$' along its axis, $\boldsymbol{H} = {[nI(cos\theta_2 - cos\theta_1)]}/{2}\ a_z$

Where: $n = N/l, \theta_1$ and $\theta_2$ are the angles subtended at P by the end turns. ***(03)***

**4A.** With neat diagram, derive and explain the expressions for the induced electro motive force where the magnetic flux through a circuit changes with time and the circuit is in motion as well. ***(04)***

**4B.** With appropriate explanations, derive Poynting theorem and show that total power leaving a volume is equal to rate of decrease in energy stored in electric and magnetic fields minus the ohmic power dissipated ***(03)***

**4C.** Let $\bar{E} = (1000a_x + 400a_z)e^{-j10y}\ V/m$ for a 250 $MHz$ uniform plane wave propagating in a perfect dielectric. If the maximum amplitude of the magnetic field intensity is 3 $A/m$, determine the following:

a) Relative permittivity of the dielectric
b) Relative permeability of the dielectric
c) $\bar{E}(x, y, z, t)$ ***(03)***

**5A.** A lossy dielectric is characterized by $\varepsilon_R = 2.5, \mu_R = 4\ and\ \sigma = 10^{-3}S/m$ at 10 $MHz$. For a uniform plane wave propagating along the positive z-axis in the dielectric (having propagation constant $= \gamma$) at the said frequency, let $\bar{E} = 20e^{-\gamma z}a_x\ V/m$ at $z = 0$. Determine:

a) Attenuation constant b) Phase constant c) Wave velocity
d) wavelength e) Intrinsic impedance f) $\bar{E}(2,3,4, t = 10ns)$ ***(04)***

**5B.** Consider a uniform plane wave propagating along the positive z-axis as shown in **Fig. Q 5B.** Let region 1 $(z < 0)$ have a conductivity, permeability as well as permittivity of $\sigma_1, \mu_1\ and\ \varepsilon_1$ respectively while region 2 $(z > 0)$ has its conductivity, permeability as well as permittivity as $\sigma_2, \mu_2\ and\ \varepsilon_2$ respectively. For a normal incidence at the interface $(z = 0)$, prove with appropriate explanations that: ${E_{ro}}/{E_{io}} = \Gamma = {[\eta_2 - \eta_1]}/{[\eta_2 + \eta_1]}$ ***(03)***

**5C.** A uniform plane wave $\bar{E} = 50\sin(\omega t - 5x)a_y V/m$ in a lossless medium $(\mu = 4\mu_0, \varepsilon = \varepsilon_0)$ encounters a lossy medium $(\mu = \mu_0,\ \varepsilon = 4\varepsilon_0, \sigma = 0.1S/m)$ normal to the x-axis. Determine:

a) The reflection and transmission coefficients

b) The reflected wave $(E_r\ and\ H_r)$ **(03)**

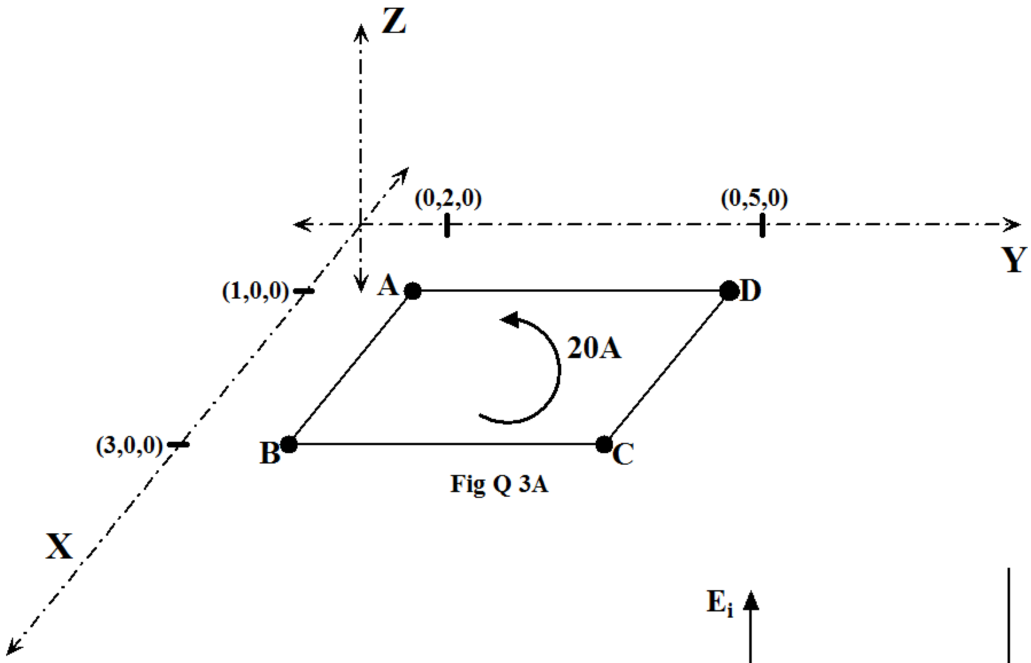


Fig Q 3A

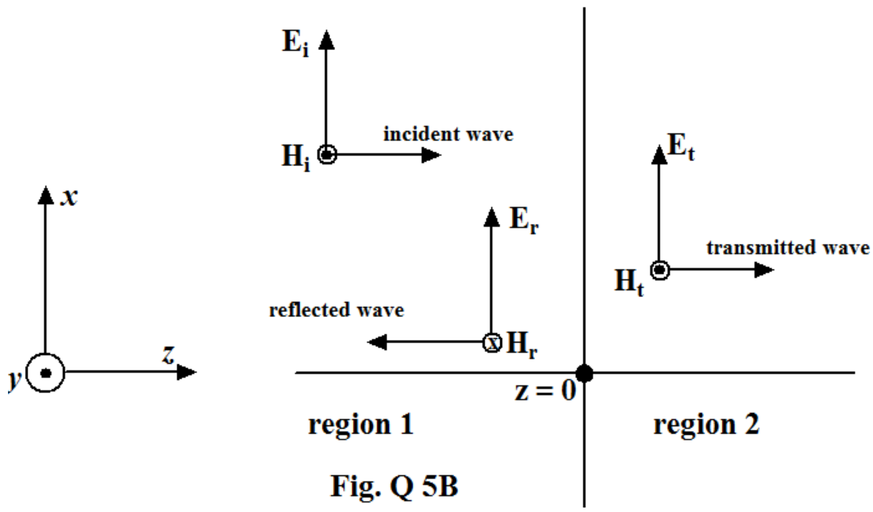


Fig. Q 5B