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MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
A Constituent Institution of Manipal University

III SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, NOV/DEC 2016

SUBJECT: ELECTROMAGNETIC THEORY [2104]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 02 December 2016** **MAX. MARKS: 50**

Instructions to Candidates:

- Answer **ALL** questions
- Missing data may be suitably assumed.
- Graph sheets shall be supplied, if required.

1A. State Coulomb's law of electrostatic force of attraction/repulsion. Four Concentrated charges are located at the vertices of a plane rectangle as shown in **Fig.1A**. Determine the magnitude and direction of the resultant force on Q_1. ***(03)***

1B. With neat diagrams, derive the expression for the electric field intensity at a point 'R' meters away from the axis of a uniformly charged straight 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 electric field intensity at a point located 3 cm above the conductor and displaced 3 cm to the right and beyond one end. ***(03)***

1C. Given the following uniform surface charge distribution as in **Fig.1C**:
$100pC/m^2$ at $r = 2m$; $40pC/m^2$ at $r = 3m$ and $-47.5pC/m^2$ at $r = 4m$.
Determine:

- The potential (V) at $r = 5m$ if the potential is zero at infinity.
- Plot $V\ v/s\ r$ for $1 < r < 6m$ if $V = 0$ at infinity. **(use the graph sheet provided)** ***(04)***

2A. A cubical region of space is defined by the surfaces $x = 1.8; y = 1.8; z = 1.8\ and\ x = 2; y = 2; z = 2$ as shown in **Fig. 2A**. If the electric flux density given by $D = 3y^2 a_x + 3x^2 y a_y\ C/m^2$, find the exact value of the total charge enclosed within the cube. ***(03)***

2B. A homogeneous dielectric $(\varepsilon_r = 2.5)$ fills the region 2 $(x < 0)$ while region 1 $(x > 0)$ is free space. For an electric field vector travelling from region 2 to region 1, determine the following:

- If $D_1 = 12a_x - 10a_y + 4\,a_z\ nC/m^2$, find $D_2\ and\ \theta_2$.
- If $E_2 = 12\ \ V/m$ and $\theta_2 = 60^0$, find $E_1\ and\ \theta_1$.

Let the vector E_2 make an angle of $\theta_2 < 90^0$ with the normal to the surface while $\theta_1 < 90^0$ is the angle E_1 makes with the normal to the surface. ***(03)***

2C. Two parallel conducting plates are each 10cm by 10cm and separated by 2mm. The region between the plates is filled with a perfect dielectric for which $\varepsilon_R = (1 + 500x)^2$, where, x is the distance from one plate. Assume a uniform surface charge density of 10 nC/m^2 on the positive plate. Determine the following: ***(04)***

- The total charge (Q_{total})
- $x - component\ of\ electric\ field\ intensity$
- Potential between the plates
- Capacitance of the parallel plate capacitor.

3A. With a neat diagram, derive an expression for the magnetic field intensity, both - inside and outside a solid cylindrical conductor having radius 'a' and carrying a current 'I' with uniform density.

Also sketch its variation with respect to the distance from the conductor axis. ***(03)***

3B. With a neat diagram, state stoke's theorem. Let a certain magnetic field intensity in free space be given as:

$$H = \frac{20(x)a_x + 20(y)a_y}{(x^2 + y^2)} A/m$$

Show that $\nabla . B = 0$. Also determine the current density. ***(03)***

3C. With a neat schematic, derive the expression for force (magnitude as well as direction) between two parallel current carrying conductors' spaced 'D' meters apart. Assume the currents in both the conductors to flow in the same direction.

Filamentary currents of $-25a_z$, $1.0a_z$, $25a_z$ Amperes are located in the $x = 0$ plane at $y = -1.0$, $y = k$ and $y = 1.0$ meters respectively as shown in **Fig.3C**. Determine the force on the 1.0 meter length of $1A$ filament for $-1 < k < 1$.

Also sketch the variation of $|\bar{F}|$ versus $'k'$ for its variation from $-1 < k < 1$. ***(04)***

4A. There exists a boundary between two magnetic materials at $z = 0$ having permeabilities $\mu_1 = 7\mu_0$ H/m and $\mu_2 = 5\mu_0$H/m for region 1 ($z > 0$) and region 2 ($z < 0$) respectively. There exists a surface current of density $k = 10a_x\ A/m$ at the boundary $z = 0$. For a field $B_1 = (2a_x - 10a_y + 8a_z)mT$ in region 1, determine the flux density B_2 in region 2. ***(03)***

4B. Calculate the self-inductance of a coaxial cable of inner radius "a" and outer radius "b" if the space between the inner conductor and outer conductor is filled with an inhomogeneous material having $\mu = 2\mu_0/(1 + \rho)$. ***(03)***

4C. A conducting bar PQ can slide freely over two conducting rails as shown in **Fig.4C**. Calculate the induced voltage in the bar

- If the bar is stationed at $y = 8cm$ and $B = 4\cos(10^6 t)\ a_z mWb/m^2$.
- If the bar slides at a velocity $u = 20a_y\ m/s$ and $B = 4a_z mWb/m^2$.
- If the bar slides at a velocity $u = 20a_y\ m/s$ and $B = 4\cos(10^6 t - y)\ a_z mWb/m^2$. ***(04)***

5A. From the basic concepts of Maxwell's equations, derive the wave equations along with expressions for its attenuation and phase constants for an uniform plane wave travelling in a linear, homogenous, charge free lossy dielectric medium ***(03)***

5B. For Pyranol 1467 at 10^8 Hz, the conductivity $\sigma = 2.5 \times 10^{-3}\ \mho/m$, $\varepsilon_R = 4$ and $\sigma/\omega\varepsilon = 0.1$, determine the attenuation constant, phase constant, the wavelength and velocity of propagation of the uniform plane wave at 10^8 Hz. Also determine the intrinsic impedance of the medium. ***(03)***

5C. In free space ($z \leq 0$), a plane wave with $H_i = 10\cos(10^8 t - \beta z)\ a_x mA/m$ is incident normally on a lossless medium ($\varepsilon = 2\varepsilon_0, \mu = 8\mu_0$) in region $z \geq 0$. Determine the expressions for the reflected wave (H_r, E_r) as well as the transmitted wave (H_t, E_t). ***(04)***

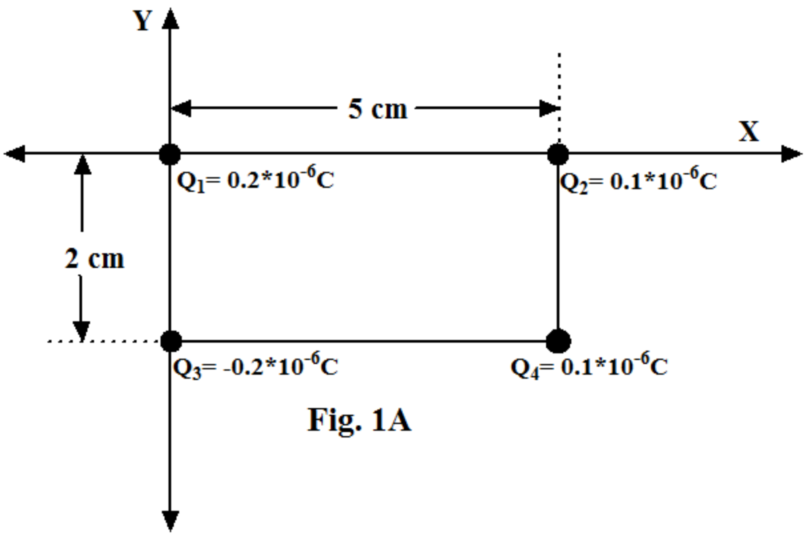

Fig. 1A

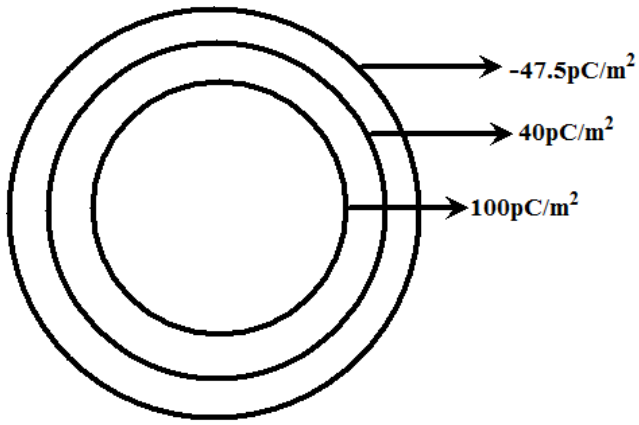

Fig. 1C

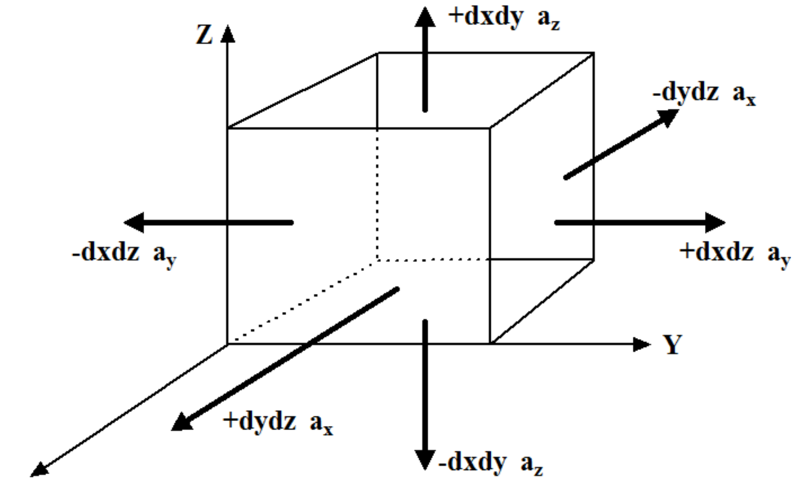

Fig 2A

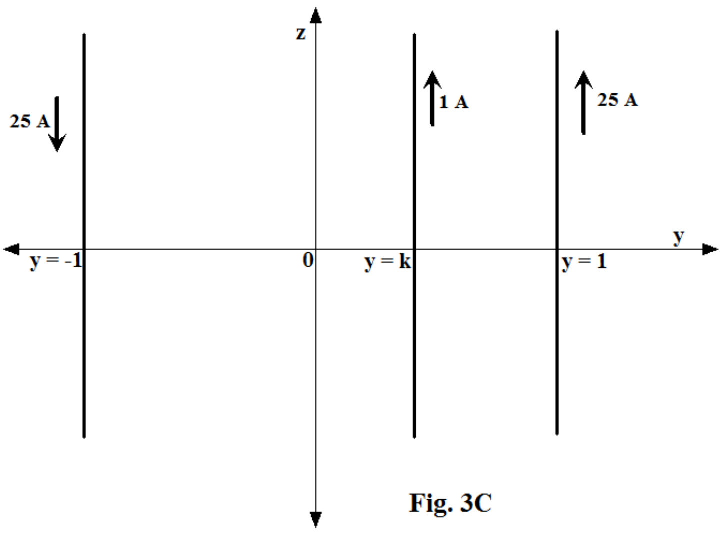

Fig. 3C

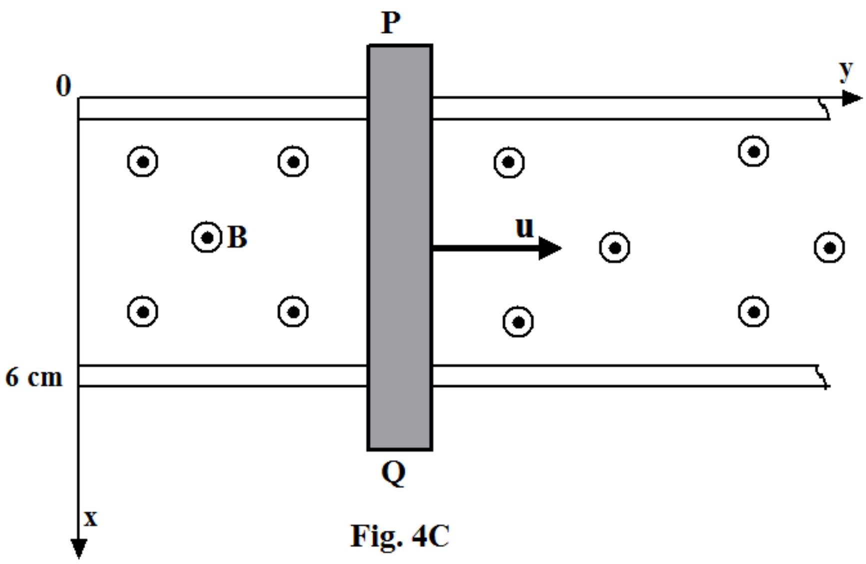

Fig. 4C