PONDICHERRY UNIVERSITY-3623016

B.Tech. DEGREE EXAMINATION, APRIL 2013

Third Semester-Electronics and Communication Engineering

ENGINEERING ELECTROMAGNETICS

Time: Three hours | Maximum : 75 marks

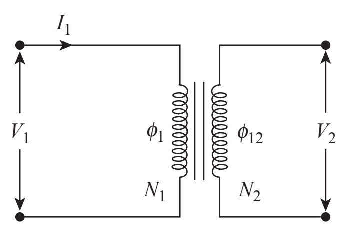
PART A — (10 × 2 = 20 marks)

Answer ALL questions. All questions carry equal marks.

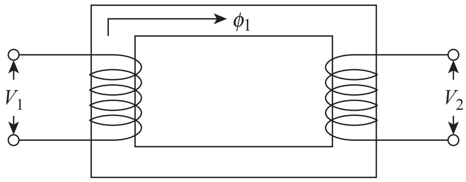
1. Define electric field intensity.
   Ans 1. For answer refer: **Page 32, topic 1.8** greyed box with formula for E.
2. State Coulomb's Law.
   Ans 2. For answer refer: **Page 32, topic 1.7**, with diagram and formula.
3. What is meant by displacement current?
   Ans 3. For answer refer: **Page 68, topic 2.6.3**.
   The current that flows through a capacitor is called the displacement current $I_D = C\left(\frac{dV}{dt}\right)$.
4. State Continuity equation.
   Ans 4. For answer refer: **Page 87, topic 2.12.2** with diagram and page 88 eq (I) only.
5. State Ampere's circuital law.
   Ans 5. For answer refer: **Page 112, topic 3.6** grey box.
6. Write the equation in point form for Ohm's Law.
   Ans 6. For answer refer: **Page 68, topic 2.6.2** $J_c = \sigma E$.
7. Define self inductance and mutual inductance.

   Ans 7. Let a voltage source V_1 set up a flux ϕ_1 per turn in the primary of the transformer taking current I_1.

   Then self Inductance is given by $L = \left(\frac{N\phi_1}{I_1}\right)$

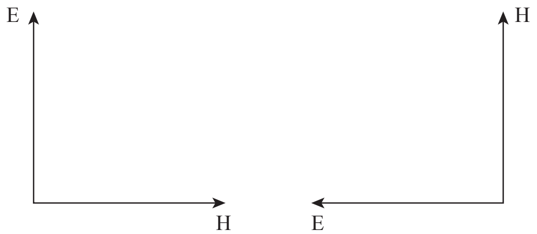


   Let the flux linking the secondary be ϕ_{12} per turn, then mutual inductance is given by, $M = \left(\frac{N_2\phi_{12}}{I_1}\right)$.



8. What are the conditions to be satisfied for a linearly polarized uniform plane wave?
Ans 8. For answer refer: Conditions to be satisfied for a linearly polarized uniform plane wave are the following:

For answer refer: **Refer Page 172, Topic 5.1.2** points (i), (ii), (iii) and (iv). E vector is the reference vector for the plane of polarization. "Vertical polarization" would mean that the E vector is in vertical direction and "horizontal polarization" means that the E vector is in the horizontal direction.



(a) Vertical polarization (b) Horizontal polarization.

9. Write down Maxwell's equation in integral form.
Ans 9. For answer refer: **Page 155; topic 4.3**; section (b) Integral form.

10. What is meant by Polarization?
Ans 10. For answer refer: **Page 176; topic 5.2.2**; grey box.

PART B – (5 × 11 = 55 marks)

Answer ALL questions, One from each Unit. All questions carry equal marks.

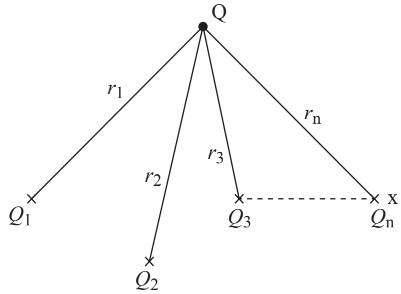
UNIT I

11. State the Principle of superposition as applied to electric potential and derive a general expression for the resultant potential due to point, line, surface and volume charges composing the systems.
Ans 11. Principle of superposition:
The principle state that if there are "N" charges $Q_1, Q_2, Q_3 ......Q_n$ located, respectively at, $r_1, r_2, r_3 ....r_n$ the resultant force F on a charge Q located at point "r" is the vector sum of the force exerted on Q by each of the charges $Q_1, Q_2, Q_3 ......Q_n$.

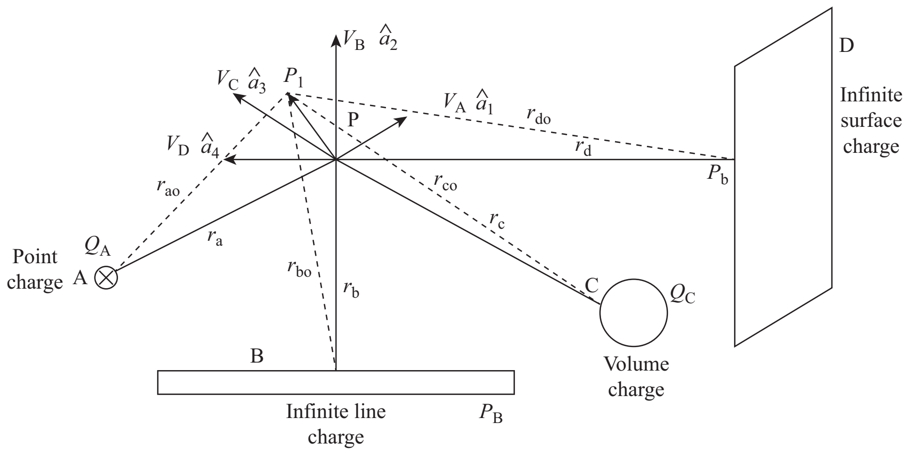
$$\vec{F} = \vec{F_1} + \vec{F_2} + \vec{F_3} .... + \vec{F_n}$$

$$\vec{F} = \frac{QQ_1}{4\pi\varepsilon_0 r_1^2}\hat{a}_1 + \frac{QQ_2}{4\pi\varepsilon_0 r_2^2}\hat{a}_2 + \cdots + \frac{QQ_N}{4\pi\varepsilon_0 r_n^2}\hat{a}_n$$

$$= \left(\frac{Q}{4\pi\varepsilon_0}\right)\left[\frac{Q_1}{r_1^2}\hat{a}_1 + \frac{Q_2}{r_2^2}\hat{a}_2 + \cdots + \frac{Q_N}{r_n^2}\hat{a}_n\right]$$



Electric potential is scalar, when subjected to multiple force of attraction or expulsion, we have to use algebraic summation. Let's consider a unit positive charge kept at point P.



Page 56, topic 2.1.1, 2.1.2, 2.1.3, derive V_{AB} for point charge, infinite line charge and infinite surface charge. Give the summation of all the voltages as resultant.

Or

12. Express the field $D = \left(x^2 + y^2\right) - 1\left(xa_x + ya_y\right)$ in cylindrical components and Evaluate both sides of the divergence theorem for the region bounded by $\rho = 2, \quad 0 \le \phi \le 0.2\pi, \quad z = 5$ and $D = 0.5$ Ap.

Ans 12. Part of the similar problem solved in page 13, problem 1.1.

$$D = (x^2 + y^2)\ a_z - 1(xa_x + ya_y)$$

$$= (x^2 + y^2)\ a_z - x\ a_x - y\ a_y$$

$$D = -x\, a_x - y\, a_y + (x^2 + y^2) a_z$$

To transform from rectangular to cylindrical coordinates, we have,

$$\begin{bmatrix} A_\rho \\ A_\phi \\ A_z \end{bmatrix} = \begin{bmatrix} \cos\phi & \sin\phi & 0 \\ -\sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} A_x \\ A_y \\ A_z \end{bmatrix}$$

$$= \begin{bmatrix} \cos\phi & \sin\phi & 0 \\ -\sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} -x \\ -y \\ (x^2 + y^2) \end{bmatrix}$$

$$= \begin{bmatrix} -x\cos\phi - y\sin\phi + 0 \\ +x\sin\phi - y\cos\phi + 0 \\ 0 + 0 + (x^2 + y^2) \end{bmatrix}$$

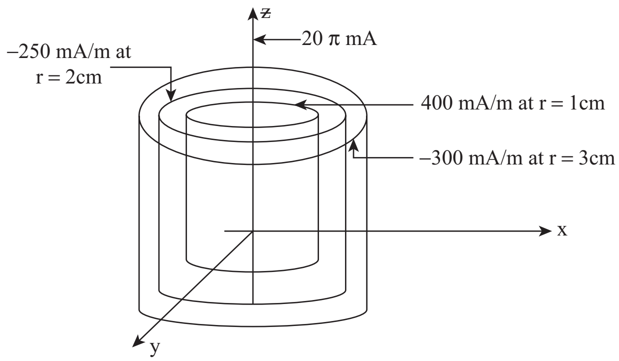
$$\begin{bmatrix} A_\rho \\ A_\phi \\ A_z \end{bmatrix} = \begin{bmatrix} -(x\cos\phi + y\sin\phi) \\ (x\sin\phi - y\cos\phi) \\ (x^2 + y^2) \end{bmatrix}$$

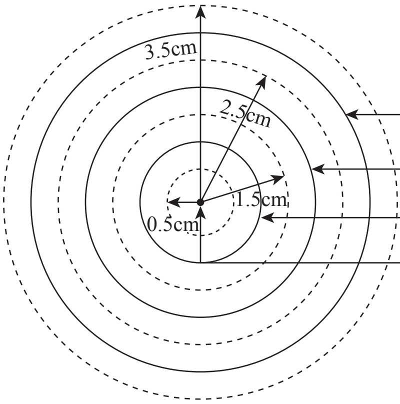
UNIT II

13. Obtain the boundary conditions between two dielectrics which are subjected to an electro static field.
Ans 13. For answer refer: **Page 80, topic 2.11**, till page 81 before the greyed problem.

Or

14. An infinite filament on the Z axis carries 20π mA in the a_Z direction. Three uniform cylindrical current sheets are also present: 400 mA/m at ρ=1cm, -250mA/m at ρ=2cm and ρ=300mA/m at ρ=3cm. Calculate $H\phi$ at p = 0.5, 1.5, 2.5 and 3.5 cm. we find $H\phi$ at each of the required radii by applying Ampere's circuital law to circular paths of those radii : the paths are centered on the Z axis. so at ρ 1 = 0.5 cm.
Ans 14.





At $\rho = 0.5\times10^{-2}$ m

By Ampere's law, we have, $\oint H\cdot d\ell = I$

$$H\cdot 2\pi(0.5)\times10^{-2} = 20\pi \text{ mA}$$

$$H = \frac{20\pi\times10^{-3}}{\pi\times10^{-2}} = 2\text{ A/m.}$$

At $\rho = 1.5\times10^{-2}$ m, $\oint H\cdot d\ell = I$

$$H\times 2\pi(1.5\times10^{-2}) = 20\pi + 400\text{ mA}$$

$$H = \frac{462.83\text{ mA}}{2\pi(1.5\times10^{-2})} = 4.91\text{ A/m.}$$

At $\rho = 2.5\times10^{-2}$ m

$$\oint H\cdot d\ell = I$$

$$H\cdot 2\pi(2.5\times10^{-2}) = 20\pi + 400 - 250 = 212.83\times10^{-3}\text{ A}$$

$$H = \frac{212.83\times10^{-3}}{2\pi(2.5\times10^{-2})} = 1.35\text{ A/m.}$$

At $\rho = 3.5\times10^{-2}$ m

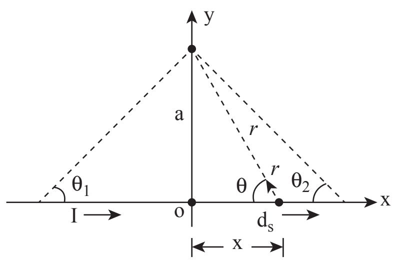
$$\oint H\cdot d\ell = I \qquad H\cdot\ell = I$$

$$H\cdot 2\pi(3.5\times10^{-2}) = 20\pi + 400 - 250 - 300$$
$$= -87.17$$

$$H = \frac{-87.17\times10^{-3}}{2\pi(3.5\times10^{-2})} = -0.4\text{ A/m.}$$

UNIT III

15. A thin, straight wire carrying a current I is placed along the x-axis, as shown in Figure 1. Evaluate the magnetic field at point P. Note that we have assumed that the leads to the ends of the wire make canceling contributions to the net magnetic field at the point P.



Ans 15. For answer refer: **Page 116, topic 3.7.1**, till Page 117 end. Change $h \to a$.

Or

16. Write neat sketches, derive boundary conditions for two different media field in the magnetic field.
Ans 16. For answer refer: **Page 132, topic 3.12**, till eq. (I) in page 133.

UNIT IV

17. Derive the expression to calculate the inductance of a coaxial conductor.
Ans 17. For answer refer: **Page 135, topic 3.13.3**, till Page 136 L_{eq}.

Or

18. Find the gradient of the scalar field W=10r $\sin^2\theta\cos\varphi$.

Ans 18. For answer refer: **Page 51, problem (8) (c)**, $W = 10r\sin^2\theta\cos\phi$.

UNIT V

19. Derive the Maxwell's equations in both point form and integral form.
Ans 19. For answer refer: **Page 163, topic 4.5.2,** till page 166 $\nabla \cdot B = 0$.

Or

20. Derive the poynting theorem from the Maxwell's equation for the general case.
Ans 20. For answer refer: **Page 204, topic 5.8** poynting theorem, till Page 205, before topic 5.8.1.