PONDICHERRY UNIVERSITY-4643037

B.Tech. DEGREE EXAMINATION, NOVEMBER / DECEMBER 2014

Third Semester-Electrical and Electronics Engineering

ELECTROMAGNETIC THEORY, NOV / DEC 2014, 3rd Sem EEE

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**, grey box.
2. State divergence theorem.
   Ans 2. For answer refer: **Page 30, topic 1.6.3**, Take Statement with formula only.
3. Write the expression for potential at p due to the dipole.
   Ans 3. For answer refer: **Page 65** ending. $V_p = \frac{m \cdot \cos\theta}{4\pi\varepsilon_0 r^2}$ (dipole moment $m = Q\ell$).
4. Obtain expression of energy in a capacitor.
   Ans 4. For answer refer: **Page 78, topic 2.10** till $W = \frac{1}{2}CV^2$, with figure 2.32.
5. State Stokes's theorem.
   Ans 5. For answer refer: **Page 28, Topic 1.6.1** fully.
6. State Biot-Savart's Law.
   Ans 6. For answer refer: **Page 107, topic 3.4** grey box till figure 3.6.
7. State Faraday's Law of electromagnetic induction.
   Ans 7. For answer refer: **Page 154, topic 4.2** till $V = N\left(\frac{d\phi}{dt}\right)$.
8. Obtain expression for inductance of solenoid.
   Ans 8. For answer refer: **Page 134, Topic 3.13.1**; $L = \left(\frac{\mu N^2 A}{\ell}\right)$.
9. What is Poynting vector?
   Ans 9. For answer refer: **Page 204,** First grey box.
10. Define Polarization.
    Ans 10. For answer refer: **Page 176, topic 5.2.2**.

PART B – (5 × 11 = 55 marks)

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

UNIT I

11. Find expression for potential at any point due to discrete as well as distributed charges.
Ans 11. Let's take 3 cases, (i). point charge, Q, (discrete charge)
(ii) Infinite line charge, ρ_ℓ (Distributed charge), and
(iii) Infinite surface charge, ρ_s (Distributed charge)
First we need to find electric field using "Gauss's Law", then we need to find the potential.

(a) For answer refer: **Page 32,topic 1.8** till $E = \frac{Q}{4\pi\varepsilon_0 r^2} \cdot \overrightarrow{a_r}$ and refer Page 56, topic 2.1.1 fully.

(b) For answer refer: **Page 39, topic 1.9.3** fully and refer Page 56, topic 2.1.2.
(c) For answer refer: **Page 40, topic 1.9.4** fully and refer page 57, topic 2.1.3.

Or

12. Find the field from point to point due to spherical volume distribution of charge of radius R and density P.
Ans 12. For answer refer: **Page 40, topic 1.9.5**.

Change, $r_1 \rightarrow R$; $\rho_v \rightarrow P$.

UNIT II

13. Obtain expression for electric field produced at point P due to the dipole.
Ans 13. For answer refer: **Page 64, topic 2.5.1** till page 66 end.

Or

14 Obtain expression for capacitance (a) capacitors are connected in series (b) capacitors are connected in parallel.
Ans 14. For answer refer: **Page 77, topic 2.9, 2.9.1 and 2.9.2**.

UNIT III

15. State and explain curl theorem.
Ans 15. For answer refer: **Page 28, topic 1.6.1** till page 30 first 2 lines.

Or

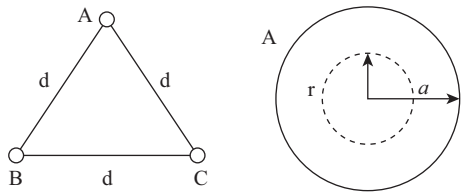
16. Obtain expression for force between current carrying wires in parallel.
Ans 16. For answer refer: **Page 118, topic 3.7.1.1** full page.

UNIT IV

17. Obtain expression for Toroid-inductance.
Ans 17. For answer refer: **Page 123, topic 3.7.4** fully and refer Page 134, topic 3.13.2 fully.

Or

18. Derive expression for inductance of 3-phase, three-wire transmission circuit.
Ans 18. Expression for inductance of 3-phase, 3-wire transmission circuit.



Consider 3 conductors "A", "B" and "C" placed symmetrically at the corner of equilateral triangle of side "d".
Let the radius of each conductor be "a".
For an Infinitely long conductor, we know that

$$H = \left(\frac{I}{2\pi r}\right); \qquad \Rightarrow B = \mu H = \left(\frac{\mu I}{2\pi r}\right). \quad \text{(Refer section 3.6.1.1)}$$

Internal flux linkage of conductor "A" is given by, $H = \left(\frac{I'}{2\pi a^2}\right) r$ (Refer section 3.6.1.3)

$$I' = \left(\frac{I}{\pi a^2}\right)(\pi r^2) \cdot = \frac{Ir^2}{a^2}$$

(ie)
$$H = \left(\frac{Ir^2}{a^2}\right) \cdot \left(\frac{r}{2\pi a^2}\right) = \frac{Ir^3}{2\pi a^4}$$

$$B = \mu H = \frac{\mu I r^3}{2\pi a^4}$$

Total Internal flux linking the conductor $\phi = \int_0^a \frac{\mu I r^3}{2\pi a^4}\, dr = \frac{\mu I}{2\pi a^4} \int_0^a r^3\, dr$

$$\phi = \left(\frac{\mu I}{2\pi a^4}\right)\left[\frac{r^4}{4}\right]_0^a = \frac{\mu I}{2\pi a^4}\left(\frac{1}{4}\right)\left[a^4 - 0\right]$$

$$\phi = \frac{\mu I \cancel{a^4}}{2\pi \cancel{a^4} 4} = \left(\frac{\mu I}{8\pi}\right)$$

$$L_{Ai} = \left(\frac{\phi}{I}\right) = \left(\frac{\mu}{8\pi}\right) = \left(\frac{\mu_0 \mu_r}{8\pi}\right).$$

L_{Ai} = Internal Inductance of Conductor "A".
External flux linkage of conductor A,

$$\phi_{Ae} = \int_a^d \left(\frac{\mu I}{2\pi r}\right) dr = \left(\frac{\mu I}{2\pi}\right) \int_a^d \left(\frac{dr}{r}\right).$$

$$= \left(\frac{\mu I}{2\pi}\right)\left[\ell n\, r\right]_a^d = \left(\frac{\mu I}{2\pi}\right)\left[\ell n\, d - \ell n\, a\right]$$

$$\phi_{Ae} = \left(\frac{\mu I}{2\pi}\right)\left[\ell n\left(\frac{d}{a}\right)\right]$$

$$\Rightarrow \quad L_{Ae} = \left(\frac{\phi_{Ae}}{I}\right) = \left(\frac{\mu}{2\pi}\right)\left[\ell n\left(\frac{d}{a}\right)\right]$$

Total Inductance of conductor "A" is the summation of internal and external inductances. Hence we have, total inductance $L_A = L_{A_i} + L_{A_e}$

$$L_A = \frac{\mu_0 \mu_r}{8\pi} + \frac{\mu_0}{2\pi}\ell n\left(\frac{d}{a}\right)$$

$$L_A = \left(\frac{\mu_0}{2\pi}\right)\left[\left(\frac{\mu_r}{4}\right) + \ell n\left(\frac{d}{a}\right)\right]$$

$$L_B = \left(\frac{\mu_0}{2\pi}\right)\left[\left(\frac{\mu_r}{4}\right) + \ell n\left(\frac{d}{a}\right)\right]$$

$$L_C = \left(\frac{\mu_0}{2\pi}\right)\left[\left(\frac{\mu_r}{4}\right) + \ell n\left(\frac{d}{a}\right)\right]$$

Total Inductance, $L = L_A + L_B + L_C$

$$L = \left(\frac{\mu_0}{2\pi}\right)\left[\left(\frac{3\mu_r}{4}\right) + 3\ell n\left(\frac{d}{a}\right)\right].$$

UNIT V

19. Obtain expression for wave equation for a conducting medium and explain wave propagation in free space.
Ans 19. For answer refer: **Page 176 , topic 5.3** till eq (I) in page 177. Refer Page 179, topic 5.3.3 till eq(4).

For answer refer: **Page 181, topic 5.4** till eq " $E = C_1 e^{-j\beta X} + C_2 e^{j\beta X}$ ".

Or

20. Obtain expression for Maxwell's equation from ampere's Law.
Ans 20. For answer refer: **Page 163, topic 4.5.2** Maxwell's Eq (I) only, till Page 164-Statement: "The MMF ……. enclosed by the path."