

**BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)**

CLASS: BTECH
BRANCH: EEE

SEMESTER : III/ADD
SESSION : MO/2025

SUBJECT: EE24205 ENGINEERING ELECTROMAGNETICS

TIME: 3 Hours

FULL MARKS: 50

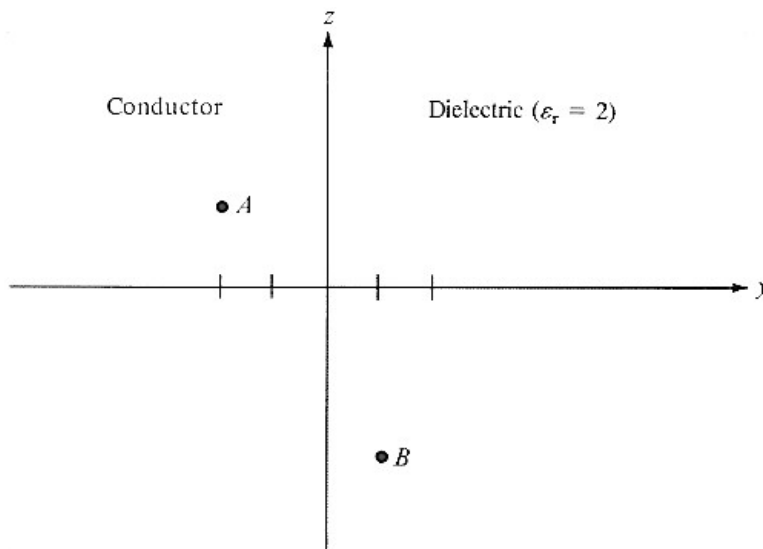
INSTRUCTIONS:

1. The question paper contains 5 questions each of 10 marks and total 50 marks.
 2. Attempt all questions.
 3. The missing data, if any, may be assumed suitably.
 4. Before attempting the question paper, be sure that you have got the correct question paper.
 5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.
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|---|---------|----|-----|
| Q.1(a) i) What is electric field intensity? Write expression for electric field intensity due to a point charge. ii) Point charges $Q_1 = 10 \text{ nC}$, $Q_2 = 15 \text{ nC}$, and $Q_3 = 5 \text{ nC}$ are positioned one at a time and in that order at (1,2,3), (7,6,5), and (10,13,12), respectively. Calculate the energy in the system after each charge is positioned. | [2+3] | 1 | 2,3 |
| Q.1(b) State Ampere's Law. Write mathematical expressions in integral and differential form for static and time varying conditions. Planes $x = 1$ and $y = 4$ carry current $K = 50 a_y$ and $K = -10 a_z \text{ A/m}$, respectively. | [1+2+2] | 1 | 2,3 |

Find H at (-1,5,6).

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|---|-------|---|-----|
| Q.2(a) Write boundary condition for electric field for conductor and dielectric interface. Region $y < 0$ consists of a perfect conductor while region $y > 0$ is a dielectric medium $\epsilon_{1r} = 2$ as in Figure. If there is a surface charge of 5 nC/m^2 on the conductor, determine E and D at
(a) A (-2,4,-1)
(b) B (3,-3,-2) | [2+3] | 2 | 2,3 |
|---|-------|---|-----|



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|---|-------|---|-----|
| Q.2(b) What is displacement current and its significance. A parallel-plate capacitor with plate area of 10 cm^2 and plate separation of 10 mm has a voltage $240 \sin 10^3 t \text{ V}$ applied to its plates. Calculate the displacement current assuming permittivity of material is $\epsilon = 4\epsilon_0$. | [2+3] | 2 | 2,3 |
|---|-------|---|-----|

PTO

- Q.3(a) A plane wave propagating through a medium with $\epsilon_r = 8$, $\mu_r = 2$, $\sigma = 0.0036$ S/m, $\eta = 177.88 \angle 13.47^\circ \Omega$ has $E = 0.5 e^{-x/3} \sin(10^8 t + 1.374x) a_y$ V/m. Determine (a) Wave velocity (b) H field (c) Phase constant (d) Attenuation constant. [5] 4 2,3

$$\alpha = \omega \sqrt{\frac{\mu\epsilon}{2} \left[\sqrt{1 + \left[\frac{\sigma}{\omega\epsilon} \right]^2} - 1 \right]} \quad \eta = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\epsilon}}$$

$$\beta = \omega \sqrt{\frac{\mu\epsilon}{2} \left[\sqrt{1 + \left[\frac{\sigma}{\omega\epsilon} \right]^2} + 1 \right]}$$

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- Q.3(b) A uniform plane wave propagating in a medium has $H = 4 e^{-\alpha y} \cos(10^8 t - \beta y) a_z$ mV/m. If the medium is characterized by $\epsilon_r = 3$, $\mu_r = 25$, and $\sigma = 8$ S/m, find α , β , and η . [5] 4 2,3

- Q.4(a) In free space $y \leq 0$, a plane wave with $E_i = 27 \cos(10^8 t - 0.54y) a_z$ V/m is incident normally on a lossless medium ($\epsilon = 8\epsilon_0$, $\mu = 4\mu_0$, $\beta = 1.8856$) in region $y \geq 0$. Determine the expressions for reflected wave E_r , and transmitted wave E_t . [5] 3 2,3

- Q.4(b) A x-polarized uniform plane wave (E_i, H_i) with a frequency 100MHz propagates in air in the +ive y direction $\beta = 2.094$ rad/m, $\eta = 120\pi \Omega$ and impinges normally on a perfectly conducting plane at $y=0$. Assuming the amplitude of E_i to be 15 mV/m, write the phasor and instantaneous expressions for E_i and H_i of the incident wave. [5] 3 2,3

[Hint: Generalized phasor representation, $E_i(z) = E_{i0} e^{-j\beta z} a_y$ if the wave is incidental along positive z axis.]

- Q.5(a) Discuss retarded magnetic vector potential. Find electric field due to an antenna E if H is $H_\theta = \frac{Idl \sin \phi}{4\pi R^2}$ A/m in spherical coordinate. You can use the formula [1.5 + 3.5] 5 2,3

$$\nabla \times \mathbf{A} = \frac{1}{r^2 \sin \theta} \begin{vmatrix} \mathbf{a}_r & r \mathbf{a}_\theta & r \sin \theta \mathbf{a}_\phi \\ \frac{\partial}{\partial r} & \frac{\partial}{\partial \theta} & \frac{\partial}{\partial \phi} \\ A_r & r A_\theta & r \sin \theta A_\phi \end{vmatrix}$$

- Q.5(b) Discuss antenna pattern. Explain briefly radiation intensity, directivity, and directive gain. [5] 5 2,3

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