**BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI**
**FIRST SEMESTER 2023-24**
**EEE/INSTR/ECE F212 ELECTROMAGNETIC THEORY**
**COMPREHENSIVE EXAMINATION– PART A (CLOSED BOOK)**

**Date : 09/12/2023** **Duration : 60 Minutes** **Marks : 20**

| **Name :** | **ID :** |
|---|---|

**Instruction**: *Write the correct answer in the space provided, and submit the sheet in 1 hr. Rewritten / struck off answers will not be rechecked.*

1. The gradient of $f = r^2 z \cos(2\phi)$ at $P(1, \pi/4, 2)$ is _____
2. The magnetic field intensity produced by an infinite current sheet of negligible thickness lying in the *XY*-plane is $0.5\mathbf{a}_x - 0.5\mathbf{a}_y$ (A/m). The sheet current density is given by _____ (A/m)
3. The electric potential in vacuum is $V=x+2y$. The electrostatic energy stored in a cube of side 1 m is _____ (J)
4. Given vector $\boldsymbol{M}$ has magnitude $CR^n$ where $R=(x^2+y^2+z^2)^{1/2}$, and $C$ is a constant. The vector is directed radially outward from the origin. If **Div(*M*)**=0, then the value of $\boldsymbol{n}$ is _____
5. An infinite line charge of 10 nC/m lies along the z-axis at (0,0). The electric field strength at (2, 3,1) has magnitude _____(V/m)
6. The relative permittivity of a dielectric material is 6. The electric field intensity required to polarize this material so that $\vec{P} = 10\ a_z$ (C/m$^2$) is _____ (write in terms of $\varepsilon_0$)
7. If $\boldsymbol{J} = 10^4 \sin(\theta)\ a_R$, (A/m$^2$), the current flowing out of the surface of a sphere of radius 0.01 m is _____(A)
8. A charge density of 1 μC/m$^3$ is placed inside a metal block ($\sigma = 4.55\times10^6$ S/m) at $t$=0. After _____ (sec), its value will become 10 % of the initial value.
9. For a low-loss transmission line, *R*, *L*, *C* and *G* are related as _____ and _____
10. The power flow density vector for a resistive wire carrying DC (current) is directed _____ (radially inward / along the wire length / from the wire to ground)

******** END ********

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**EEE/INSTR/ECE F212 ELECTROMAGNETIC THEORY**
**COMPREHENSIVE EXAMINATION PART B (OPEN BOOK)**

**Date : 09/12/2023** **Duration : 120 Minutes** **Marks : 60**

| **Name :** | **ID :** |
|---|---|

**Instructions:** *Show all relevant steps of calculation. Answer all sub-sections of a given question in sequence. Unclear/randomly presented answers will not be evaluated.*

Q1) A parallel plate capacitor is filled with a non-uniform dielectric characterised by $\varepsilon_r = 2+2\times10^6 x^2$, where $x$ is the vertical distance measured from one plate. What is the capacitance of this arrangement? If the plate area is $S$ = 0.02 m$^2$, and spacing $d$ = 1 mm, calculate the capacitance of the arrangement. [8]

Q2) The xerographic copying machine is an important application of electrostatics. It is composed of layers of air and photoconductor arranged between two large conducting electrodes as shown in Figure 1. Given that the upper electrode is maintained at a potential of $V_0$, lower electrode is grounded and the surface charge density at the air-photoconductor interface is zero. Obtain the electric field in both regions. [10]

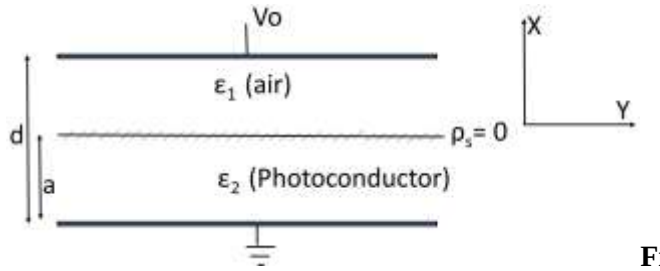


**Figure 1**

Q3) The wave equation in a medium is given by $\nabla^2\hat{H} = (10^5 + j10^5)^2\hat{H}$.

At 100 MHz, answer the following questions.

(a) Comment on the type of the medium
(b) Find its conductivity, phase velocity, wavelength, skin depth and the distance over which the wave will undergo a phase shift of 180$^0$. [12]

Q4) Let the magnetic vector potential $\vec{A} = (3y - z)\boldsymbol{a_x} + 2xz\boldsymbol{a_y}$ produced in air by some current distribution $\vec{J}$. Find the following quantities at point $P$ (2,–1,3),

(a) Divergence of $\vec{A}$

(b) Magnetic flux density
(c) Magnetic field intensity
(d) Current density $\vec{J}$ [8]

Q5) A conducting rectangular loop (single turn) is placed near a very long straight conducting wire in free space carrying DC current *I* as shown in Figure 2. Find the mutual inductance between the wire and loop. Calculate the mutual inductance if *I* = 10 A, *a* = 10 cm, *b* = 5 cm and *d* = 20 cm.

[10]

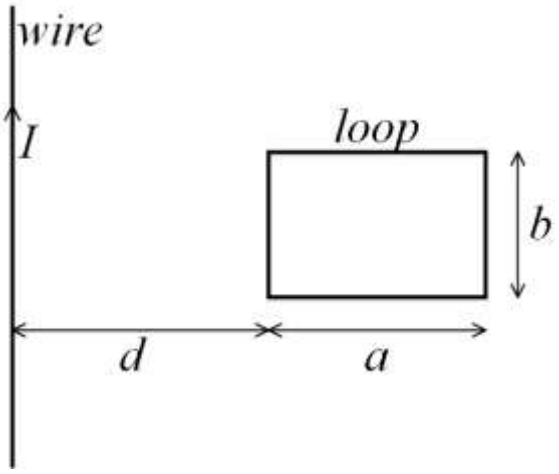


**Figure 2**

Q6) In a lossless medium ($\varepsilon_r$=2, $\mu_r$=2) a uniform plane wave is travelling along the direction of $\vec{k} = \boldsymbol{a_x} + 2\boldsymbol{a_y}$ Given that $\hat{E} = 10e^{j\pi/6}\boldsymbol{a_z}$ $(\frac{\boldsymbol{V}}{\boldsymbol{m}})$ at $(x, y, z) = (0,0,0)$. Calculate the following,

(a) Direction of wave propagation
(b) Angular frequency of the wave
(c) Expression for the electric field $\vec{E}(x, y, z, t)$
(d) Expression for the magnetic field $\vec{H}(x, y, z, t)$
(e) Average Poynting vector for the wave [12]

********* END *********