BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
FIRST SEMESTER 2022-23
EEE/INSTR/ECE F212 ELECTROMAGNETIC THEORY
COMPREHENSIVE EXAMINATION– PART A (CLOSED BOOK)

Date : 27/12/2022 **Suggested time : 60 Minutes** **Marks : 20**

Name :	**ID :**	**Tut sec :**

Instruction: *Write the correct answer in the space provided, and submit the sheet by 60 Min. Rewritten / struck off answers will not be rechecked.*

(1) The input impedance of a short-circuited transmission line of 15 cm length, with Z_0=60 Ω, and $\gamma = j8.5\ m^{-1}$ is _____ (Ω)

(2) A λ/4 long, lossless 100 Ω transmission line is terminated by 210 Ω load. If the voltage at the load is 80 V, the voltage at the input end is _____(V).

(3) Given $\vec{H} = \frac{2.39\times10^6}{r} cos(\emptyset)\boldsymbol{a_r}$ A/m in free-space. The flux that crosses the region $-\pi/4 \leq \phi \leq \pi/4$, $0 \leq z \leq 1$ m is _____ (Wb)

(4) A current sheet $\vec{J}_s = 9\boldsymbol{a_y}$ (A/m) lies at z =0. Region-1 is z < 0 with μ_{r1}=4 and Region-2 is z > 0 with μ_{r2}=3. If $\vec{H}_2 = 14.5\boldsymbol{a_x} + 8\boldsymbol{a_z}$ (A/m), $\vec{H}_1$=_____ (A/m)

(5) The volume charge density inside a medium ($\sigma = 10^{-4}$ S/m) decrease to one-third of its initial value in 20 μs. The dielectric constant of the medium is _____.

(6) Two homogeneous dielectric regions are given : Region-1 (r < 4 cm, ε_{r1}=3.5) and Region-2 (r > 4 cm, ε_{r2}=1.5). If $\vec{D}_2 = 12\boldsymbol{a_r} - 6\boldsymbol{a_\phi} + 9\boldsymbol{a_z}$ **nC/m²**, $\vec{D}_1$ =_____ (C/m²)

(7) In Q6, the electrostatic energy density stored in Region-1 is _____ (J/m³)

(8) Moist soil has a conductivity of 10^{-3} S/m and relative permittivity of 2.5 at 9 GHz. Thus it can be considered as a _____ medium at 9 GHz. (Conducting / Dielectric / Non-homogeneous/Anisotropic)

(9) At a frequency of 1.6 MHz, the phase velocity of EM wave through Aluminum ($\sigma = 3.82\times10^7$ S/m) is _____(m/s)

(10) Aluminum exhibits _____dispersion for EM waves (Normal /Anomalous /Diamagnetic /Non-linear)

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FIRST SEMESTER 2022-23
EEE/INSTR/ECE F212 ELECTROMAGNETIC THEORY
COMPREHENSIVE EXAMINATION <u>PART B</u> (OPEN BOOK)

Date : 27/12/2022 **Duration : 120 Minutes** **Marks : 60**

Name :	**ID :**	**Tut sec :**

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

Q1) A metal bar of conductivity σ is bent to form a flat 90^0 sector of inner radius *a* and outer radius *b*, and thickness *t* as shown in **Figure 1**. Treating this as a boundary value problem, obtain expression for the resistance between the vertical surfaces at *r*=*a* and *r*=*b*. Given *V*(*r*=*a*)=0 V and *V*(*r*=*b*)=10 V. [15 M]

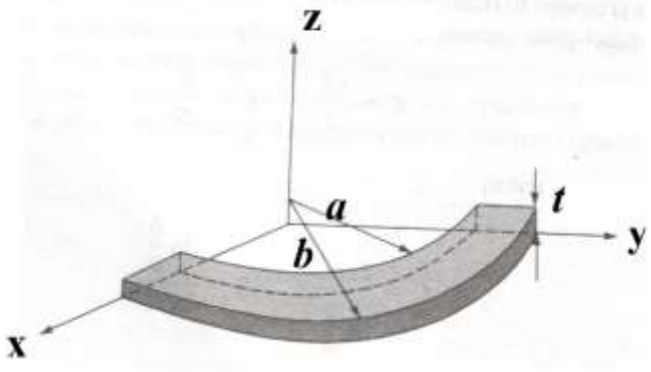

Figure 1

Q2) An EM wave travelling in a medium (ε_r=2, μ_r=2) is represented by the time-harmonic form,

$\vec{E} = 100cos(\omega t + 2y - 4z)a_x \quad (V/m)$. Find the following parameters of the wave.

(a) Polarization (type and sense)
(b) Wavelength
(c) Unit vector in the direction of propagation
(d) Angular frequency
(e) Magnetic field intensity in time-harmonic form
(f) Average power flow density vector [15 M]

Q3) A transmission line circuit is shown in **Figure 2**. Consider two source frequencies, $f_1 = 60\ Hz$, and $f_2 = 500\ kHz$. Answer the following questions.

(a) Find at each frequency, what is the <u>simplest, yet accurate</u> model (lumped element model or distributed element model) for analyzing the given circuit

(b) Find V_{out} at each frequency using the appropriate analysis method (circuit theory or transmission line theory)
(c) Using the result in (b) find the average power delivered to the load at each frequency
[15 M]

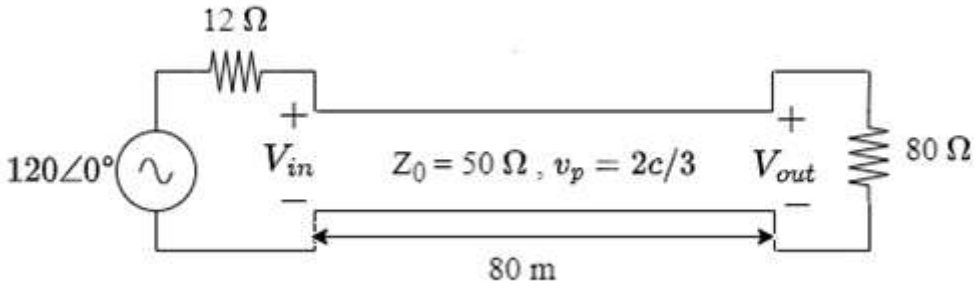

Figure 2

Q4) A uniform plane wave propagating in free-space (ε_0, μ_0, η_0, k_0) is represented by the phasor $\hat{E}_{inc} = 25e^{-jk_0z}\,a_x + j25e^{-jk_0z}\,a_y\ (V/m)$. It is incident at the plane boundary (z=0) of a medium having $\sigma/\omega\varepsilon$ >>100.

(a) Calculate the transmission and reflection coefficients at z=0
(b) Find the expression for the reflected wave $\hat{E}_{ref}$
(c) Identify the polarization (type and sense) of the reflected wave
(d) Obtain the expression for the total electric field intensity $\hat{E}_{tot}$ for $z < 0$ and $z > 0$
(e) Obtain the expression for the total magnetic field intensity $\hat{H}_{tot}$ for $z < 0$ and $z > 0$
(f) Express the current density for all z [15 M]

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