Roll No. | | | | | | | | | | |

7163

Name of Course	:	**B.Sc. Prog.– (Physics)_NEP: UGCF-2022**
		(with Electronics Science)
Semester	:	**VII**
Name of Paper	:	**Electromagnetic Theory (DSE Paper)**
Unique Paper Code	:	22225147 02
Duration	:	**3 Hours** **Maximum Marks: 90**

Instructions for Candidates

1. **Write your Roll No. on the top immediately on the receipt of this question paper.**
2. **Question No. 1 is compulsory**
3. **Answer any four of remaining five.**
4. **Use of non-programmable scientific calculator is allowed.**

1. Attempt any 6 parts of this question. (6x3)

(i) Assume $\mu = \mu_0$, show that the ratio of the amplitudes of the conduction current density and displacement current density is $\sigma/\omega\varepsilon$ for the applied field $\vec{E} = \overrightarrow{E_0}\cos\omega t$. Using this ratio, determine whether copper ($\sigma \sim 5.8 \times 10^7$ S/m) behaves as a good or poor conductor at optical frequencies.

(ii) Starting with the equation of continuity and using Ohm's law, show that the charge density ρ in a isotropic conductor having conductivity σ obeys the equation $\frac{\partial\rho}{\partial t} + \frac{\sigma}{\epsilon}\rho = 0$. Hence obtain and expression for the relaxation time of charge density.

(iii) Show that in dilute plasma, displacement current leads electric field by $\pi/2$.

(iv) A perpendicularly polarized light propagates from region 1, having parameters ε_{r_1}= 8.5, $\mu_{r_1} = 1$ and $\sigma_1 = 0$ to region 2, (free space) with an angle of incidence of 20^0. Given $E_0{}^i = 1.0 \times 10^{-6}\, V/m$, find $E_0{}^r$ and ${}_0{}^t$.

(v) How can one distinguish between unpolarized and a mixture of unpolarized and elliptically polarized light?

(vi) A conducting medium has conductivity 60 MS/m and $\mu_r = 1$. Assuming permittivity is ε_0 and a time harmonic field at frequency 120 MHz, calculate the magnitude of intrinsic impedance, attenuation constant and phase velocity.

(vii) For a typical step-index (multimode) fibre $n_1 = 1.45$ and fractional refractive index Δ = 0.01. Find its numerical aperture.

2. (a) What are gauge transformations? Discuss Lorentz gauge transformation and derive the wave equation using Lorentz gauge. (10)

(b) A plane wave is incident normal to the surface of seawater ($\mu_r = 1$, $\epsilon_r = 79$, $\sigma = 3$ S/m). The electric field is parallel to the surface and is 1 V/m just inside water. At what depth would it be possible for a submarine to receive a signal, if the receiver required a field intensity of 10 μV/m at 20 kHz? (8)

3. (a) Starting from Maxwell's equations for a linear, homogeneous, isotropic dielectric medium, derive the wave equations for EM waves. Further show that EM waves are transverse in nature and derive the relation for the intrinsic wave impedance in dielectric medium. (12)

(b) Given the formula $\eta^2 = 1-(\omega_p^2/\omega^2)$, where $\omega_p = \sqrt{n_0 e^2/m\epsilon_0}$ Determine the wavelength at which a certain ionized medium will become transparent if the number of free electrons per unit volume in the medium is $n_0 = 5.632 \times 10^{28}$ m^{-3}. (6)

4. (a) Discuss the phenomena of total internal reflection and show that while the electric field vector does penetrate into the second medium but gets damped exponentially while there is no flow of energy into the rarer medium. (10)
(b) What is Brewster's law? Show that at Brewster's angle the reflected wave is plane polarized with the E-field being perpendicular to the plane off incidence. (8)

5. (a) A uniform plane wave is incident normally on a planar boundary between two lossless, non-magnetic regions ($\sigma_1 = \sigma_2 = 0$; $\mu_{r1} = \mu_{r2} = 1$). Find $\varepsilon_{r2}/\varepsilon_{r1}$ if
   (i) 20 % of the incident energy is reflected (R = 0.2)
   (ii) 20 % of the incident energy is transmitted (T = 0.2)
   Assume normal incidence Fresnel relation. (8)

(b) What are retardation plates? Derive the expression for the phase difference between ordinary and extraordinary ray. A plane polarized light (λ= 5890Å) is incident on a plate of a doubly refracting uniaxial crystal cut with faces parallel to optic axis. The values of μ_o and μ_e for the crystal are 1.6583 and 1.5463 respectively. What type of crystal is this? Calculate the least thickness of the plate for which the ordinary extraordinary rays, on emergence from the plate, recombine to form a plane polarize light. (10)

6. (a) What are wave guides? Discuss the construction of step index and graded index fibre. (6)

(b) What are single-mode and multi-mode waveguides? Derive the condition for single-mode and multi-mode waveguide in TE mode for step index planar wave guide. (12)

Physical Constants:

$\varepsilon_0 = 8.85 \times 10^{-12}$ Farad/m, $\mu o = 4\pi \times 10^{7}$ Henry/m

$C = 3 \times 10^{8}$ m/s

UNIVERSITY OF DELHI
DELHI-110007

CORRIGENDUM

Sl. No. of Q.P	:	7163
Unique Paper Code	:	2222514702
Name of the Paper	:	Electromagnetic Theory
Course	:	B.Sc Prog.
Exam	:	12/12/2025 Morning
SEMESTER/YEAR	:	VII
DURATION	:	3 Hour
Maximum Marks	:	90

Announcement for candidates

Sl. No may be read as 7163 and UPC may be read as 2222514702 instead of 2222514701.

Joint Registrar (Secrecy)