Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UPES
End Semester Examination, December 2024

Course: Electromagnetic Theory **Semester: V**
Program: BSc. (Hons) Physics **Time: 03 hrs.**
Course Code: PHYS 3020 **Max. Marks: 100**

Instructions:
1. All questions are compulsory (Q. No. 9 and Q. No. 11 have internal choices).
2. Scientific calculators can be used for calculations.
3. All bold representations are vectors.

SECTION A
(5Qx4M=20Marks)

S. No.		**Marks**	**CO**
Q 1	Define the concept of gauge transformation and its importance.	**4**	**CO1**
Q 2	Discuss the dispersion relation for a dilute plasma in terms of plasma frequency.	**4**	**CO1**
Q 3	Define numerical aperture and acceptance angle for optical fiber.	**4**	**CO1**
Q 4	Define uniaxial and biaxial crystals with examples for each.	**4**	**CO1**
Q 5	If you live 10 km from a 50kW station, what is the peak strength of **E** and **B** in your house?	**4**	**CO1**

SECTION B
(4Qx10M= 40 Marks)

S. No.		**Marks**	**CO**
Q 6	What density of current would produce a magnetic field given by $$\boldsymbol{B} = (\frac{a}{r} + \frac{b}{r}e^{-r} + ce^{-r})\boldsymbol{\varphi}$$ in cylindrical coordinates? Hint: In cylindrical coordinates, Curl **A** = $(\frac{1}{r}\frac{\partial A_z}{\partial \varphi} - \frac{\partial A_\varphi}{\partial z})\hat{r} + (\frac{\partial A_r}{\partial z} - \frac{\partial A_z}{\partial r})\hat{\varphi} + +\frac{1}{r}(\frac{\partial (rA_\varphi)}{\partial r} - \frac{\partial A_r}{\partial \varphi})\hat{z}$	**10**	**CO2**
Q 7	Remember Maxwell's equations and respond to the following questions justifying your answer. (a) If the signs of all the source charges are reversed, what happens to the electric and magnetic fields **E** and **B**?	**5+5 = 10**	**CO3**

	(b) What happens to the charge density ϱ, current density $\boldsymbol{j}$ and to the electric and magnetic fields **E** and **B** (i) if the system is space inverted i.e. $x \rightarrow x' = -x$. (ii) if the system is time reversed i.e. t$\rightarrow$ $t' = -t$.		
Q 8	A point source of light is embedded near the flat surface of a dielectric with index of refraction *n*. Treat the emitted light as a collection of plane waves (light rays) that propagate isotopically away from the source. Find the fraction of light rays that can refract out of the dielectric into the vacuum space above.	**10**	**CO2**
Q 9	Obtain the output state of polarization (SOP) when a left-circularly polarized beam is passed through a quarter wave plate (QWP). **OR** Obtain the polarization state as described by $E_x = a\cos(\omega t - kz)$ $E_y = a\cos(\omega t - kz + \pi/4)$	**10** **10**	**CO3**
SECTION-C **(2Qx20M=40 Marks)**			
Q 10	Imagine a wave in vacuum traveling along the z axis with $\boldsymbol{E} = \hat{\boldsymbol{\imath}} E_0 \cos(kz - \omega t)$ and $\boldsymbol{B} = \hat{\boldsymbol{\jmath}} B_0 \cos(kz - \omega t)$ (i) Show that the surface integrals of $\boldsymbol{E}$ and $\boldsymbol{B}$ obey the Maxwell equations. (ii) Consider the line integrals on three independent planes and write the corresponding equations relating $\frac{\partial E_x}{\partial z}, \frac{\partial E_x}{\partial t}, \frac{\partial B_y}{\partial z}, \frac{\partial B_y}{\partial t}$. Determine the relation between $\boldsymbol{E_0}$ and $\boldsymbol{B_0}$ and ω and k that these imply.	**10+10 = 20**	**CO3**
Q 11	Write the general instantaneous field expressions for the *TE* and *TM* modes. Deduce those for TE_{01} and TM_{12} modes. **OR** Consider time-harmonic $[\exp(-i\omega t)]$ solution to the Maxwell equations in vacuum where the fields are *independent* of the azimuthal angle φ. TEM solutions of this type also have no radial component to the fields: $\boldsymbol{E_r} = \boldsymbol{B_r} = 0$. (a) Show that the conditions stated above decouple the Maxwell curl equations into two subsets, each of which describes a different type of TEM wave. (b) Begin with the Maxwell divergence equations and find general solutions for $\boldsymbol{E}(r, \theta, t)$ and $\boldsymbol{B}(r, \theta, t)$ for each of the two TEM wave types.	**20** **10+10 = 20**	**CO4**