St. Philomena's College (Autonomous), Mysore
Question Bank

Programme: M.Sc. Physics
I Semester

Course Title: Electrodynamics and Optics
Course Type: Soft Core
Q.P Code:

Q No.	Question	Marks
1	Write all the four Maxwells's equations for a medium associated with the charge density r and current density **J**.	2
2	Explain what is Lorentz guage.	2
3	Explain what is Coulomb guage.	2
4	What are electromagnetic potentials? Explain.	2
5	Define electric dipole and dipole moment of a system of charges.	3
6	What are retarted potentials? Write expressions for them.	3
7	Define the terms i) dipole and ii) quadrupole.	3
8	Define the terms i) dipole moment and ii) quadrupole moment.	3
9	Explain Brewster's phenomena in optics. Mention its practical application.	5
10	For a plane monochromatic electromagnetic wave propagating in free space show that the magnetic field amplitude $B_0 = E_0 /c$, where E_0 is the amplitude of the electric field and c is the speed of light in vacuum.	5
11	Explain the differences between plane polarized and circularly polarized electromagnetic waves.	5
12	Explain the differences between circularly polarized and elliptically polarized electromagnetic waves.	5
13	Explain the concept of a monochromatic plane electromagnetic wave. Show that for such waves travelling in free space, the frequency $\omega = kc$, where k is the wave number and c is the speed of the wave.	5
14	Using Maxwell's equations obtain the boundary conditions to be satisfied by the electric field of an electromagnetic wave at a boundary separating two dielectric media.	5
15	Using Maxwell's equations obtain the boundary conditions to be satisfied by the magnetic field of an electromagnetic wave at a boundary separating two dielectric media.	5

16	Describe dielectric tensor for a crystalline medium. Show that it may be represented by a real symmetric matrix.	5
17	Explain the concept of Principal Dielectric Axes and Principal Dielectric Constants for crystals. Obtain the expression for the electric energy density in such materials.	5
18	In a crystalline medium show that the vectors **D, H** and **k** are mutually perpendicular. Here **D** and **H** are the field vectors of the electromagnetic wave and **k** is its propagation vector.	5
19	In a crystalline medium show that the vectors **E, H** and **S** are mutually perpendicular. Here **E** and **H** are the field vectors of the electromagnetic wave and **S** is the Poynting vector.	5
20	Describe the term Optic Axis. Hence, explain the differences between uniaxial and biaxial crystals.	5
21	Explain the differences between positive and negative uniaxial crystals using the wave normal surfaces. Mention one application of such crystals.	5
22	What is a Quarter Wave plate? Describe its use in optical experiments.	5
23	Describe the construction and working of a Fabry-Perot Etalon. Mention one of its applications.	5
24	Mention the basic assumptions of Kirchhoff's diffraction theory and, thereby, obtain the Fresnel-Kirchhoff diffraction formula for electromagnetic waves.	5
25	What is Airy Pattern in diffraction theory? Mention its use in optical instruments.	5
26	Explain the significance of multipole expansion of the electrostatic potential in Electromagnetic Theory. Under what conditions will the Quadrupole term become significant?	5
27	Describe Gauge Transformations in electrodynamics. Explain the concept of Gauge Invariance.	5
28	Define Lorentz Gauge. What is its role in electrodynamics? Using this obtain the Coulomb Gauge.	5
29	Explain the concept of Retarded Potentials. In this context what is the principle of causality?	5
30	Draw qualitative plots of the electric and magnetic field pattern of a point charge moving with a constant velocity. Describe the field patterns and point out the differences between these patterns and those for a static point charge and a constant current.	5
31	Calculate the skin depth for 100 MHz frequency of wave in silver. Given the conductivity of silver is $10^7/\Omega$m.	5
32	Write a note on optical classification of crystals.	5
33	Show that the refractive index of the ionized medium containing ne number of electrons is given by $n = \sqrt{\frac{1-81n_e}{f^2}}$, for a wave of frequency f.	5

34 Define optical polarization and give the classification. 5

35 Define the terms (a) Interference (b) Diffraction 5

36 What is birefringence? Define the terms (a) Uniaxial crystal (b) Biaxial crystal 5

37 Show that the charge travelling with uniform speed cannot radiate energy. 5

38 Show that the guage transformations of A and Φ satisfy Lorentz condition. 5

39 Show that the electric field of an ideal electric dipole can be written as, 5

$\vec{E} = \frac{1}{4\pi\varepsilon_0}\left[\frac{3(\vec{p}\cdot\vec{r})\vec{r}}{r^5} - \frac{\vec{p}}{r^3}\right]$ where p is the electric dipole moment.

40 Show that the electrosatatic field intensity is irrotational. 5

41 Bring out the concept of retarted and advanced potentials. 5

42 In a certain region of space the electric field **E** is given by, $\vec{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{\rho d\tau}{r^3}\hat{r}.$ 5

Calculate i) curl and ii) divergence of the field

43 If Φ=0, $\vec{A} = A_0 \sin(kx - \omega t)\hat{y}$ find the fields **E** and **B**, here A_0 , k and ω are constants. 5

44 Calculate i) the electric potential and ii) the electric field due to a short dipole of dipole moment (5/3)x10^{-27}C-m at a distance of 1cm from its axis. 5

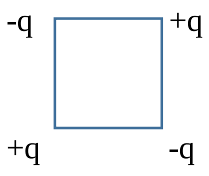
45 Find the fields **E** and **B** due to potentials i) Φ(r,t)=0 and ii) $\vec{A}(r,t) = \frac{-qt\hat{r}}{4\pi\varepsilon_0 r^2}$ 5

46 Show that the guage transformations of **A** and Φ satisfy Lorentz condition if guage functions obey the wave equations. 5

47 Obtain the first Maxwell's equation of the 2nd kind in terms of Φ and **A**. 5

48 Obtain the second Maxwell's equation of the 2nd kind in terms of Φ and **A**. 5

49 Calculate the dipole moment of charge configuration shown in the following diagram: 5



50 Show that the potential due to an arbitrary charge distribution can be explained as a sum of several multipole moments. 10

51 Derive an expression for the electric potential φ(r) due to a dipole at a distance r from the field point. 10

52 Obtain Maxwell's equations in terms of electromagnetic potentials. 10

53 Arrive at the multipole expansion of the scalar potential due to charge distributed arbitrarily in space. 10

54	What are guage transformations? Show that under guage transformations of the potentials φ and **A** the fields **E** and **B** remain invariant though they themselves are non-unique.	10
55	Obtain expressions for the fields **E** and **B** due to a point charge moving with uniform speed along a straight line.	10
56	Starting from Maxwell's equations, discuss how the fields can be described in terms of potentials.	10
57	Obtain the inhomogeneous wave equations satisfying the scalar and vector potentials of charge and current distribution.	10
58	Discuss the motion of retarted potentials. Find the retarted potentials due to a point charge moving arbitrarily in space.	10
59	What are retarted potentials ? Derive expressions for the retarted potentials starting from the Maxwell's equations of the 2nd kind.	10
60	Explain Maxwells' equations in terms of potentials Φ and **A**.	10
61	Derive the expressions for retarted potentials and explain their physical significance.	10
62	Discuss the multipole expansion of a scalar potential due to an arbitrary charge distribution at rest.	10
63	Obtain the expression for Lienard-Weichart potentials due to a oint charge moving with uniform speed.	10
64	Show that the electrostatic potential due to a finite sized body having continuously distributed electric charges may be expressed as a sum of potentials due to all the multipoles that may be constructed. What is the use of such a result?	10
65	Show that the potential due to a dipole is inversely proportional to the square of the distance and directly proportional to the dipole moment. Hence, obtain the expression for the electric field due to the dipole. Describe the electric field pattern.	10
66	Define scalar and vector potentials for space and time varying electromagnetic fields. Using these results, obtain the equations governing the space-time evolution of the two potentials. Show that under Lorentz Gauge these equations get simplified. Point out the advantages of using Lorentz Gauge.	10
67	What are Lienard-Wiechert potentials? Obtain expressions for these potentials for a point charge moving along an arbitrary path with appropriate justifications.	10
68	Starting from the Lienard-Wiechert potentials, obtain the expressions for the electric and magnetic fields of a point charge moving along an arbitrary path. Explain the term "Radiation Field".	10
69	Show that monochromatic plane waves are solutions of the wave equation for electromagnetic waves travelling in vacuum. Show that such waves the fields **E** and **B** and the propagation vector **k** are mutually perpendicular.	10
70	State the boundary conditions satisfied by electromagnetic waves at the boundary separating two different dielectric media. Hence obtain the Fresnel formulae for an	10

	electromagnetic wave polarized in the plane of incidence. Comment on the variation of the reflection and transmission coefficients with the angle of incidence.	
71	State the boundary conditions satisfied by electromagnetic waves at the boundary separating two different dielectric media. Hence obtain the Fresnel formulae for an electromagnetic wave polarized perpendicular to the plane of incidence. Comment on the variation of the reflection and transmission coefficients with the angle of incidence.	10
72	Write down Maxwell's equations for electromagnetic waves propagating in a conducting medium. Show that the electric and magnetic fields decrease exponentially with the distance of propagation and the two fields are out of phase. Explain the significance of Skin Depth.	10
73	For electromagnetic waves in an anisotropic dielectric medium, show that the vectors **D, H** and **k**, and the vectors **E, H** and **S** are mutually perpendicular sets of vectors. Here **D, E, H** and **B** are the electromagnetic field vectors, **k** is the propagation vector and **S** is the Poynting vector. Define ray velocity and phase velocity and obtain the relation between them. Hence, define ray refractive index.	10
74	For light waves propagating in crystals, obtain the Fresnel's equation for wave normal. Show that this equation predicts two modes of propagation for light in crystals.	10
75	What are uniaxial crystals? Using Fresnel's equation, show that two modes of different phase velocities can travel in the crystal. Describe positive and negative uniaxial crystals and mention one application of such crystals.	10
76	What are biaxial crystals? Using Fresnel's equation, describe the different modes of propagation of light in such crystals. Show that the two optic axes lie in a plane	10
77	For Young's double slit experiment, obtain the formula for the location of the bright and dark fringes and the intensity distribution. Hence, show that the fringe width is constant.	10
78	Obtain the expression for the optical path difference between two adjacent rays reflected from the two parallel surfaces of a thin glass plate. Explain the resultant two beam interference fringe pattern formed.	10
79	Discuss the interference pattern formed due to multiple reflections of a ray of light incident on a glass plate with perfectly parallel surfaces. Draw a qualitative plot of the transmission coefficient. Explain the significance of Finesse Factor.	10
80	Describe a Fabry-Perot Etalon. Obtain an expression for the resolving power of such a device. Explain its utility in spectroscopy.	10
81	Write down the Fresnel-Kirchhoff diffraction formula and, hence, obtain the amplitude for the diffracted wave in the Fraunhofer approximation.	10
82	Write down the Fraunhofer diffraction formula for a circular aperture and, hence, obtain the expression for the diffraction pattern. Describe the special features of the fringe pattern.	10

83	Discuss with relevant theory the propagation of a plane monochromatic wave through a conducting medium.	10
84	Explain the construction and working of a Fabry - Perot Etalon.	10
85	Obtain the expression for the resolving power of a Fabry - Perot Etalon.	10
86	Discuss the theory of multiple beam interference with a plane parallel plate	10
87	Give the general theory of interference of two plane monochromatic waves.	10
88	Discuss with necessary theory the propagation of plane electromagnetic wave in an ionized medium.	10
89	Using Helmholtz-Kirchoff equation arrive at te Fresnel-Kirchoff integral equation.	10
90	Discuss the theory of Fraunhofer diffraction due to a circular aperature.	10
91	Derive Fresnel's formulae for the case when electromagnetic wave incident perpendicular to the plane of incidence.	10
92	Derive Fresnel's formulae for the case when electromagnetic wave incident parallel to the plane of incidence.	10
93	Discuss with necessary theory the propagation of light through an uniaxial crystal.	10
94	Discuss with necessary theory the propagation of light through a biaxial crystal.	10
95	Derive an expression for the electric potential $\Phi(r)$ due to a dipole at a distance r from the field point.	10