Ex : FP/I/XI/37/2018

BACHELOR OF SCIENCE EXAMINATION, 2018

(3rd Year, 1st Semester)

PHYSICS (Honours)

Ppaer : HO - 11

Time : 2 hrs

Full Marks : 50
(25 marks for each group)

Use a separate Answer Scripts for each group.

GROUP A

Answer *q.no. 1* and any *two* questions from the rest.

1. Answer any three: **(3 x 3)**

(a) Show for electromagnetic waves travelling in free space the electromagnetic energy is equally shared between the electric and magnetic fields. [3]

(b) Find the electrostatic field at a distance z above the midpoint between two equal and opposite charges q and -q separated at a distance d apart. How the expression gets modified if $z >> d$ and comment on the result. [2+ 1]

(c) Using Maxwell's equations, show that the normal component of electric displacement vector is continuous at the interface between the two dielectrics. [3]

(d) If the earth receives 2 calories / minute/ cm^2 solar energy, estimate the amplitudes of electric and magnetic field of radiation [$\mu_0 = 4\pi \times 10^{-7}$ N/ Amp^2, $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}] [3]

(e) Show for electromagnetic waves travelling in free space the electric and the magnetic fields are in same phase. Does the same condition hold for the electromagnetic waves propagating through dielectric medium? [2 +1]

(f) Show that the conservation of charge is intrinsically taken into account in Maxwell's equations. [3]

2. (a) What makes the concept of displacement current so elegant to understand the propagation of electromagnetic waves ? Hence show that the components of electric and magnetic field vectors satisfy the wave equations that govern the propagation of electromagnetic waves.

(b) A conducting wire made of copper, has radius a and carries a current $I = I_0 \sin \omega t$. Assume the current in the conductor is uniformly distributed and permittivity of the conductor is ε_0 Calculate the ratio between the amplitude of the conduction current and the amplitude of the

displacement current in the conductor. Comment on your result. [Given : f = 1000 Hz, I_0= 1 Amp, a = 2 mm , conductivity of copper (σ) = 5.7×10^7 S/ m ,$\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2 N^{-1} m^{-2}$]

[2 + 2 + 3 +1 = 8]

3. Show that the time average of energy flux density $\langle \vec{S} \rangle$ over a full period or large interval of time is expressed as :

$\langle \vec{S} \rangle = \frac{1}{2} Re(\vec{E} \times \overrightarrow{H^*})$, where $\vec{E}$ and $\vec{H}$ are harmonically varying complex electric and magnetic fields respectively

(b) Show that if a steady current flows through a cylindrical conducting wire , the energy dissipated in the conductor in the form of Joules heat is supplied from the electromagnetic field energy entering into the wire through the lateral or curved surface and not through the end surfaces through which the current flows. [4+ 4 = 8]

4. (a) What is skin depth? Show that for a good conductor the skin depth can be expressed as function of $\frac{\lambda}{2\pi}$, where λ is the wavelength of electromagnetic waves in the conductor.

(b) Find the wavelength and propagation speed in copper for radio waves at 1MHz. [For Copper (σ) = 5.7×10^7 S/ m . Choose $\varepsilon = \varepsilon_0$ and $\mu = \mu_0$] [1+ 3 + 2+ 2 = 8]

5. Obtain the expressions for reflection and transmission coefficients when a linearly polarized light is incident normally at the interface of two homogeneous dielectric media. (Consider the electric field vector to be perpendicular to the plane of incidence). Hence show that the sum of the reflection and transmission coefficients is unity. What happens when two homogeneous dielectric media have same refractive indices? Comment from the reflection and transmission coefficients. [5+ 1 + 2 = 8]

GROUP B

Answer ***q.no. 6*** and any ***two*** questions from the rest.

6. Answer *any* three: 3×3

(a) Briefly explain the doublet structure of sodium D-lines.

(b) What is centrifugal distortion effect in rotational spectroscopy? Define the relevant constant.

(c) What is binding energy of nucleus?

(d) Explain briefly the Larmor precision.

7. (a) Describe the effect of isotopic substitution on rotational spectra of diatomic molecules. The first rotational line of $^{12}C^{16}O$ and $^{13}C^{16}O$ is observed 3.84235 cm^{-1} and 3.67337 cm^{-1} respectively. Calculate the weight of ^{13}C. (b) In Rutherford's scattering one neglects the effect of atomic electrons on the α-particles but in Compton scattering one neglects the effects of nucleus on X-ray – Explain. (c) Why ground state of an atom is always a singlet? 5+2+1

8. (a) Derive the necessary theory of Stern-Gerlach experiment. Why silver was used in the experiment? (b) Intensity of bands obtained from state $v = 1$ to higher states ($v = 2, 3, \ldots$ etc.) in vibrational spectra of molecules are lower than that of fundamental band and increase with temperature – explain. (c) Find out the packing fraction (in MeV/nucleon) of ^{16}O where atomic mass of the same is 15.994915 u. Given that atomic masses of proton and neutron are 1.007825 u and 1.008665 u respectively. 4+2+2

9. (a) What is Raman scattering? Explain the Raman effect in the framework of quantum theory. (b) Give an account of *normal* Zeeman effect on the basis of quantum theory. Show the Zeeman components for $^1D_2$ to $^1P_1$ in a diagram. 4+4