Ex./FP/H-11/GR-A/36/2019

BACHELOR OF SCIENCE FINAL EXAMINATION, 2019

(3rd Year, 1st Semester)

PHYSICS (HONOURS)

Paper - HO - 11

Time : Two hours Full Marks : 50

(25 marks for each group)

Use a separate answer script for each group.

GROUP - A

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

1. Answer any ***three*** questions : 3x3=9

   (a) Estimate the electrostatic field at a distance z about the midpoint between two equal charges "+q" separated at a distance "d" apart. How does the expression of the electrostatic field get modified in the limit $z >> d$? Comment on the result. 2+1

   (b) In cse of electromagnetic waves propagating in free space, show that the Poynting's vector equals the energy density (u) times the velocity of the wave. 3

   (c) Show that the equation of continuity $\vec{\nabla}.\vec{j} + \frac{\partial p}{\partial t} = 0$ is ingrained in the Maxwell's equation. [Here all the symbols carry usual meanings'. 3

   (d) Using Maxwell's equation, show that the normal component of electric field and tengential component of magnetic induction are continuous at the interface between the two media. 3

(Turn over)

(e) Are the electric field $\left(\vec{E}\right)$ and magnetic induction $\left(\vec{B}\right)$ vectors represented by scalar and vector potentials V and $\vec{A}$ respectively, unique ? Comment on your answer. 2+3

2. (a) What is displacement current ? Why Maxwell modified the Ampere's cricuital law for steady current to include displacement current ?

(b) A high voltage power line made of Aluminium has a radius of 20 mm and carries a sinusoidal current of amplitude 1000 Amp at frequency(υ) 60 Hz. The conductivity of Aluminium 3.6×10^7 S/m. Assuming the permittivity of Aluminium is same as that of free space, calculate the amplitude of displacement current in the power line. Comment on your result. [$\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2N^{-1}m^{-2}$]

2+3+3=8

3. (a) Show that any initial charge density in a conductor will dissipate in a characteristic time $\tau = \frac{\in}{\sigma}$, where $\in$ is the dielectric constant and σ is the conductivity of the material. Hence write the Maxwell's electromagnetic field equations in conducting medium.

(b) For the electromagnetic waves propagating through conducting medium, estimate the relative phase between the electric $(\vec{E})$ and magnetic $(\vec{H})$ field vectors.

9. (a) What is magnetic moment ? Derive an expression for *Bohr magneton.*

(b) The average spacing between successive rotational lines of CO molecule is $3.8626 cm^{-1}$. Find the transition that gives the most intense spectral line at room temperature (300K). Derive the necessary formula.

(c) Show that the probability of α-particle scattering per unit solid angle has the dimension of area. $2^1/_2+3^1/_2+2=8$

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(c) Show that for a good conductor, the electromagnetic field energy is not equally shared between electric $(\vec{E})$ and magnetic $(\vec{H})$ fields, but is almost entirely magnetic in nature. 2+1+2+3=8

4. (a) 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 :

$\langle \vec{S} \rangle = \frac{1}{2}\mathrm{Re}(\vec{E} \times \vec{H}^*)$, 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 and surfaces through which the current flows.

(c) Find from Poynting flow, the mean value of the intensity of the magnetic field in air at a distance of 100cm from a radiating source of power 10 KW. [$\mu_0 = 4\pi \times 10^{-7}$ N/Amp^2, $\varepsilon_0 = 8.85 \times 10^{-12}$ C^{2}N^{-1}m^{-2}] 3+3+2=8

5. Obtain the expressions of Fresnel coefficients for linearly polarized light incident obliquely at the interface of two homogeneous dielectric media. (Consider the electric field vector to be perpendicular to the plane of incidence). Estimate the reflection and transmission coefficients. Hence show that the sum of the reflection and transmission coefficients is unity. 4+3+1=8

(Turn over)

GROUP - B

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

6. Answer any ***three*** questions : 3x3=9
   (a) What are the consequences of breakdown of the Born-Oppenheimer approximation ?
   (b) Write down the Pauli Exclusion Principle and discuss its implications.
   (c) Why do the plots of packing fraction and binding fraction with mass number have complementary appearance ?
   (d) Show that for Hydrogen atom a state with principle quantum number n is n^2 fold degenerate and also explain the origin of the degeneracy in this system.

7. (a) What do you mean by *LS*- and *jj*-coupling ? When do they occur ?
   (b) What information do you obtain by studying the *binding fraction curve* ?
   (c) Irradiation of CCl_4 by 435.8 nm radiation yields Raman lines at 440.0, 441.9 and 444.7nm. Calculate the Raman shift for line in the middle. $2^1/_2+3+2^1/_2=8$

8. (a) Derive the expression for Land g-factor considering the interaction of orbital and spin angular momenta.
   (b) Explain mass defect.
   (c) What is hot band ? Obtain wave number for the hot band transition from n = 1 to n = 2. 4+2+2