Biyani's Group of Girls' Colleges

M.Sc. Physics (P)

Sub. : Classical Electrodynamics

Time Allowed : 3 Hour | Max. Marks : 100

UNIT- I

1. (a) Write the relations connectivy P,V & E in electrostatics. Similarly Write the relation connectivy $J^{\rightarrow}, E^{\rightarrow}$ & $B^{\rightarrow}$ in magnostatics.
   (b) Derive the expression for energy of a electric field continuous charge distribution.

OR

2. (a) What is meant by an electrical image? A conductivy sphere is placed in uniform electric field. Calculate the field intensity & the surface charge density by method of electrical image.
   (b) Derive the expression of green's theorem. Also derive green function of the sphere.

UNIT- II

3. Write short note on :-
   (i) Biot -Savarat's law
   (ii) Amperee's law in differential form
   (iii) Electric dipole moment
   (iv) Polarization

OR

4. Write short Note on :-
   (i) Magnostatics
   (ii) Manetic moment
   (iii) Vector potenticl
   (iv) Shielding effect

UNIT- III

5. (a) Derive & discuss the electrostatic energy dielectric medium.
   (b) Carry out multiple expansion of the energy of a change distribution in an external field.

OR

6. (a) Derive & obtain the expression for electric & magnetic fields inside a perfect conductor.
   (b) Derive the expression for poynting vector & deduce the conservation of energy in electrodynamics.

UNIT- IV

7. (a) Discuss the propagation of plane electromagnetic waves in conductors & obtain the expression of plasma frequency.
   (b) Define the expression of superposition of waves in one dimension & group velocity.

OR

8. (a) Derive the Larmor's formula for power radiated from an occeluated charge moving with non-relativistic velocity.
   (b) Derive the expression of Lienard-Wiechart potential for a point charge.

UNIT- V

9. (a) Define magneto -hydrodynamics & deduce the equation for M.H.D.
   (b) Establish the transformation E^4 equation of electromagnetic fields under Loraentz transformations & prove that the quantity $E^{\rightarrow}, E^{\rightarrow}$ is invariant.

OR

10. (a) Starting from the expression for Lienard Wiechart potentials for a point charge obtain expression for electric & magnetic fields due to an arbitrarily accelerated point charge. Derive the larmor's formula for power radiated from an acculated charge moving with non-relativistic velocity.

UNIT- V

11. (a) Discuss plasma oscillations to obtain expressions for dispersion equation for the longitudinal and transverse electromagnetic force.
   (b) Explain the short wavelength limit for plasma oscillations & Debye screening distance.

OR

(a) What is radiative damping ? Discuss radiative damping of a charged harmonic oscillator & calculate its level shift & like shift ?

(b) Discuss the scattering of electromagnetic radiations by a single non -relativistic charged particle bound by a symmetric force.

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UNIT- I

1. (a) Prove Green's theorem and apply green's theorem to determine potential in certain bounded space containing continuous charge distribution.

   (b) The charge density on the surface of a conductor is .... Find the force per unit area on its surface.

   (c) The time average potential of a neutral hydrogen atom is given by

   $$\phi = q\frac{e^{-ar}}{r}\left(1+\frac{1}{2}ar\right)$$

   Where q is the charge on a proton and a is a constant. Find the charge distribution in the hydrogen atom.

OR

(a) Using the method of electrical images. Find out the potential due to a point charge q and a grounded conducting sphere and determine the surface charge density σ on the sphere. Find the force acting on the point charge. Discuss the variation of the force with distance of the point charge.

(b) Using the expression for the force on a metallic surface in terms of surface charge density σ and integrating over the whole sphere. Show that the total force on th sphere is the same as force on the point charge obtained above.

UNIT- II

2. (a) State Biot-Savart law. Using Biot-Savart law for current distribution in certain space derive the two basic differential equation for $\underset{B}{\rightarrow}$ in magnetostatics.

(b) *Derive an expression for the force and the torque in terms of magnetic moment of a localized current distribution in an external magnetic field and hence obtain an expression for the potential energy of the current distribution on the steady state.*

(c) *Describe the boundary conditions for B and H at the interface between two homogeneous magnetics.*

OR

(a) Derive an expression for the scalar potential for hard ferromagnetics in the case when $\underset{j}{\rightarrow} = 0$ *and the magnetitation* $\underset{M}{\rightarrow}$ *is given*

(b) Derive an expression for the magnetic field $\underset{H}{\rightarrow}$ *and the flux density* $\underset{B}{\rightarrow}$ *inside and outside a sphere with permanent magnetzation . Draw the lines of force showing* $\underset{B}{\rightarrow}$ *and* $\underset{H}{\rightarrow}$

(c) Define vector potential and derive poisson's equation for the vector potential in magnetostatics and hence write its general solution in terms of current density.

UNIT- III

3. *(a) Consider a spherical cavity inside an infinite dielectric. There is uniform electric field in the dielectric. Detrmine the electric field inside and outside the cavity.*

   (b) Obtain an expression for the electrostatic energy density in a dielectric medium. Determine the change in energy when a dielectric with linear response is placed in an electric field whose sources are fixed.

OR

(a) Using expressions for $\underset{E}{\rightarrow}$ *and* $\underset{B}{\rightarrow}$ *in terms of potentials justify that different components of* $\underset{E}{\rightarrow}$ *and* $\underset{B}{\rightarrow}$ *must be expressed as components of contravariant antisymmetric tensor of rank two. Reduce inhomogeneous maxwell's equations to covariant form.*

(b) An electromagnetic wave propagating along a direction has electric field with amplitude E_o *along x-direction. Evaluate various components of the energy-monentum stress tensor and determine the pressure exerted by the electromagnetic wave on the* $x - y$ *plane.*

UNIT- IV

4. (a) Obtain an expression for the group velocity in terms of refractive index and discuss its variation in the regions of normal and anomalous dispersion can group velocity exceed C ? Discuss.

   (b) Define nonlocality in time in the relation between $\underset{D}{\rightarrow}$ and $\underset{E}{\rightarrow}$. Show that nonlocality disappears in a nondispersive medium.

   (c) Define electromagnetic field tensor and using tensor transformation equations for tensors of rank two derive the transformation equations for

different components of $\underset{E}{\rightarrow}$ and hence write the transformation equations for $\underset{E}{\rightarrow}$ in the vector form.

OR

(a) Starting from the solution of the wave equation for four potential derive Lienard-wiechert potential for an electron.

(b) Show that the power radiated by relativistic charged particle with acceleration parallel to velocity is maximum in the direction.

$$Q_{max.} \approx \frac{1}{2}$$

Find the direction of maximum radiation from an electron with total energy 2 Mev.

5. (a) What do you understand by an instability ? Describe instabilities of a pinched plasma column and discuss how each instablility can be suppressed.

(b) Discuss the physical significance of the term

(i) $\nabla.\left(\rho \underset{V}{\rightarrow}\right)$ in the equation of continuity

(ii) $\underset{J \times B}{\longrightarrow\rightarrow}$ in the force equation

(c) Find out the time in which a magnetic field with scale length of variation equal to 2m, reduces to $\frac{1}{e}$ of its initial value in a plasma having conductivity 2×10^4 mho/m.

(a) Starting with the model of harmonically bound electron in an atom, derive an expression for the displacement of the electron and hence derive an expression for the scattering cross-sectiotn. Discuss the variation of the scattering cross section with frequency in various frequency ranges.

(b) When is it necessary to include the radiation reaction force in the equation of motion of a charged particle ? Explain you answer with one example.

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UNIT- I

1. (a) Establish Gauss law for an electrostatic field. Deduce laplace & poisson Equations.

   (b) Determine the potential due to a conducting those placed in a uniform electric field. Interpret the two terms in expression of the potential. Derive expressions for the induced charge density on the sphere & the electric field in the vicinity of the sphere. Discuss the nature of electric field.

OR

(a) Derive he expression for energy of an electric field of continuous charge distribution.

(b) Obtain Green function for the sphere & give general solution for the potential in electrostatic boundary.

UNIT-II

2. (a) The magnetic scalar & vector potentials of a current are given by

$\Psi_m = \frac{\mu o}{4\pi}\left(\frac{m.r}{r^1}\right)$ $A = \frac{\mu o}{4\pi}\frac{m\times r}{r'^3}$

Using these expressions prove that

$B = \frac{\mu o}{4\pi}\left[\frac{3(m.r)}{r^5} - \frac{m}{r'^3}\right]$

(b) What do you mean by vector potential ? Obtain an expression for the poisson equation of magnetostatics.

OR

(a) Explain magnetic shielding & illustrate your answer by giving an example of permeable shell being placed in a uniform magnetic field.

(b) Drive an expression for energy stored in magnetic field.

UNIT-III

3. (a) Derive and discuss the electrostatic energy in dielectric media.

(b) Carry out multiple expansion of the energy of charge distribution in an external field.

OR

(a) Derive the expression for poynting vector a deduce the conservation of energy electrodynamics.

(b) What are four potentials ? obtain electromagnetic field tensor ?

UNIT-IV

4. (a) How would the mopagation of plane electromagnetic waves take place in conductors ? Find expressions for plasma frequency ?

(b) Discuss the superposition of waves in an dimension and find an expression for group velocity .

OR

(a) Derive an expression for Lienord-Wiechart potential for a point charge.

(b) How does relativistic generalization of lermor's formula help in designing an election synchroteam.

UNIT-V

5. (a) What do you understand by the pinch effect ? Derive an expression for the provere in a cylindrical plasma column as a function of distance from the axis. Hence obtain an expression for the average pressure in the column.

(c) Find the Alfven wave velocity in a hydrogen plasma with e^- density 10^{20} m^{-3} & immersed in a magnetic induction of a Tesla.

OR

(a) What requirements must the radiation force satisfy ? Derive an expression for the radiation reaction force on a charge using the consecution of energy.

(b) Derive the integro-differential equation of motion including radiation damping & explain how it overcome the difficulties with Abraham Lorentz equation.