Electrodynamics
Course: PYL111/EPL107
Major

Time: 2 hr

Marks: 45

1) All answers should be full of physical reasoning combined with mathematical derivations. Only mathematical derivation without any logic will lead to zero, irrespective if the derivation is correct or not.

2) The teacher won't check a dirty answer-sheet. Make sure to keep your answer sheet neat and clean.

Answer any **three** questions:

1. (a) What is radiation? (b) Two tiny metal spheres separated by a distance s and connected by a fine wire; at a time t the charge on the upper sphere is q(t) and the charge in the lower sphere is –q(t). Suppose that we derive the charge back and forth through the wire, from one end to the other at an angular frequency ω: $q(t)=q_0\cos(\omega t)$. Including the following approximations i.e. (i) the separation distance to be extremely small and (ii) is negligible compared to wavelength (λ) of the EM wave, find an expression for V(r, θ, t) at $r >> \lambda$.
(c) Find an expression for the total power radiated from such a system.

2+5+8

2. (i) Show that the monopole, dipole and quadropole terms of multipole expansion are given by (symbols of usual meaning):

$$V_{mon} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$

$$V_{dip} = \frac{1}{4\pi\varepsilon_0}\frac{\sum \hat{r}_i.\vec{p}_i}{r^2}$$

$$V_{quad} = \frac{1}{4\pi\varepsilon_0}\frac{\frac{1}{2}\sum \hat{r}_i.\hat{r}_j Q_{ij}}{r^3}$$

Where

$$Q_{ij} = \int (3r_i'3r_j' - (r')^2\partial_{ij})\rho(r')d\tau'$$

(ii) What is displacement current? Write down the four Maxwell's equation in free space. Convert these four Maxwell's equations in a polarized matter explaining each and every terms related to bound charge and current.

(2+3+3)+(2+2+3)

3. What are the fundamental properties of the solution of Laplace's equation? (i) Consider a point charge +q placed in air at a distance d from the plane of a semi-infinite di-electric medium with permittivity ε. (a) Find the potential inside and outside of the di-electric. (b) Find the force on the charge q due to the induced charge from the di-electric. (c) Draw the filed lines from the point charge q. (ii) A point dipole of moment $\vec{p}$ is placed at a distance d above an infinite grounded conducting plane. The dipole makes and angle θ with the perpendicular to the conducting plane. Find the torque acting on the dipole. If the dipole is free to rotate, find its equilibrium position.

(2+3+2+3)+5

4. (i) What do you mean by retarded potential? Show that it follows inhomogeneous wave equation and meets Lorentz condition. (ii) Starting from Jefimenko's equations, explain it's physical significance for time-independent situation. (ii) For a moving point charge, using Lienard-Wiechart potentials, find an expression for electric and magnetic fields.

(5)+(2+8)

2+5+10+8 = 25

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