

# Gurudas College (University of Calcutta)

M. Sc. Semester 2, Internal Examination, 2020

Subject: PHYSICS

Paper: PHY 421 (Classical Electrodynamics)

Time: 1hr

Full marks: 25

**Answer any five questions from below.**

1. (i) What is the aim of a gauge condition of potentials?  
(ii) State the Coulomb gauge condition.  
(iii) What are the dynamic equations for the scalar and vector potentials under the Coulomb gauge? [2+1+2]

2. (i) State Poynting's theorem for conservation of energy of an electromagnetic field.  
(ii) Define Maxwell's stress tensor  
(iii) State the law of conservation of linear momentum for a system of charges moving in an electromagnetic field. [1+2+2]

3.  $F^{\mu\nu}$  and  $\tilde{F}^{\mu\nu}$  are electromagnetic field tensor and its dual tensor respectively. Find out two Lorentz invariants  $F^{\mu\nu}F_{\mu\nu}$  and  $\tilde{F}^{\mu\nu}\tilde{F}_{\mu\nu}$  in terms of  $\vec{E}$  and  $\vec{B}$  fields. 3+2

4. Action of electromagnetic field in presence of four current  $J^\mu$  is

$$A = \int \left( -\frac{1}{16\pi} F^{\mu\nu} F_{\mu\nu} - \frac{1}{c} J^\mu A_\mu \right) d^4x$$
. Show that this action will remain invariant under gauge transformation  $A'_\mu = A_\mu + \partial_\mu \alpha$  provided the four current is conserved:  $\partial_\mu J^\mu = 0$  and current  $J^\mu$  is localised in finite part of space time.

(where  $\alpha$  is space time dependent gauge parameter)

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5. a) Write down Lorentz gauge condition explaining the symbol. Is this condition Lorentz invariant? Deduce the wave equation involving  $\phi$  and  $\vec{A}$  using this condition.

(Symbols have their usual meaning.)

b) Explain from special theory of relativity, why a uniformly moving charge distribution (velocity is same for all charges) cannot radiate? 3+2

6. a) Why should radiation fields  $\vec{E}$  and  $\vec{B}$  should vary as  $\frac{1}{r}$ ,  $r$  being the distance of the field point from the origin?

b) Starting from retarded potential solution  $\phi$  and  $\vec{A}$  find out  $\vec{B}$  in the free space for the radiation field.

2+3

7. a) Write down Euler's equation of incompressible, viscous & conducting plasma in terms of the mass density ( $\rho$ ), velocity ( $v$ ), thermodynamic pressure ( $P$ ) and magnetic field ( $B$ ).

b) What is 'pinch effect' of plasma?

Write down the expression for the total current of a cylindrically pinched plasma column.

c) Determine the order of magnitude of current required for the purpose of confinement of hot plasma of density  $10^{15}$  particles/cc at temperature  $10^8$  K, pressure 14 atmosphere and magnetic field  $\sim 10^{19}$  K Gauss at the plasma surface.

1+(1+1)+2