

Department of Physics, IIT, Delhi  
Major Examination, 2007-2008. PHL 552: Electrodynamics  
All Questions are compulsory

Date: 28-04-2008

Full Marks: 60

Time: 2 hrs

**Q.1** A capacitor made from parallel circular plates, of radius  $a$  and separation  $s$ , is inserted into a long straight wire carrying current  $I$ . As the capacitor charges up, find the induced magnetic field midway between the plates, at a distance  $r$  ( $r < a$ ) from the center. Find the magnitude and direction of the momentum density of the electromagnetic field. Show all necessary calculations and express the answer only in terms of the given quantities. (15)

**Q.2** Suppose  $yz$  plane serves as an interface between two linear media. A plane wave of frequency  $\omega$ , travelling in the  $x$  direction, approaches the interface from the left side. If the polarization vectors of the transmitted and the reflected waves are  $\hat{n}_T = \cos\theta_T \hat{y} + \sin\theta_T \hat{z}$  and  $\hat{n}_R = \cos\theta_R \hat{y} + \sin\theta_R \hat{z}$ , respectively, use the relevant boundary conditions to prove that  $\theta_T = \theta_R = 0$ . (15)

**Q.3** A particle of rest mass  $m_0$  whose total energy is twice its rest energy collides with an identical particle at rest. If they stick together, what is the mass of the composite particle? What is its speed? (10)

**Q.4** Find all the elements of the Maxwell stress tensor for a monochromatic plane wave travelling in the  $x$  direction and linearly polarized in the  $y$  direction. Justify whether the obtained result is physically sensible. How is the momentum flux density related to the energy density? (10)

**Q.5** A square loop of wire (side  $a$ ) lies on a table near a very long wire which carries a current  $I$ . Find the flux of  $\vec{B}$  through the loop. The loop is now pulled directly away from the wire, at speed  $v$ . What emf is generated? In which direction (clockwise or counter clockwise) does the current flow in the loop? (10)