9-12-16

DOON UNIVERSITY, DEHRADUN

End Semester Examination, First Semester, 2016
Department of Physics, School of Physical Sciences
M.Sc. Physics 2 Year Programme
Course: PHC-403: Electromagnetic Theory

Time Allowed: 3 Hours **Maximum Marks: 100**

Instructions:

1) All questions are compulsory. Read the questions carefully and attempt each part.
2) Number the questions and their sub parts properly.
3) Write proper units wherever applicable.

SECTION: A

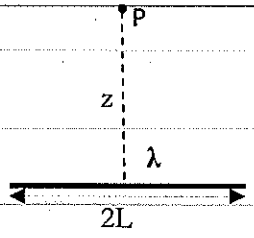
Marks: 6 x 3 = 18

1) Why are metals like Silver used to make good mirrors?
2) Define Brewster's angle.
3) What are the properties of a linear, homogeneous medium?
4) Why is the Electric field inside a conductor zero?
5) Derive the force per unit length between two infinitely long conducting wires carrying current I in opposite directions.
6) How are the following quantities related : (Write only expressions with the quantities labelled properly)
   a) Refractive index (n) and dielectric constant (ϵ_r)
   b) Intensity (I) of Electromagnetic waves (average power transported per unit area) and Poynting vector (S)
   c) Electric field ($\vec{E}$) and Vector potential ($\vec{A}$)
   d) Radiation Pressure (P) and Intensity (I) for a perfectly reflecting surface
   e) Skin depth (d) and imaginary part of wave vector (k_I)
   f) Current density (J) and charge density (ρ)

SECTION: B

Marks: 4 x 8 = 32

7) Find the potential at the point P (at a height z above the line) due to a line charge of length 2**L** and uniform line charge density λ as shown in the figure below.



8) Derive the wave equations for $\vec{E}$ and $\vec{B}$ from the Maxwell's equations. (4+4)
9) A muon is travelling at a speed of 0.6c in the lab frame. It has a lifetime of 10^{-6} seconds in its rest frame. Find the distance it travels in the lab frame before it disintegrates.
10) What are the electromagnetic boundary conditions when EM waves travel from one transparent medium to another? (1.75 + 1.75 + 1.75 + 1.75)

SECTION: C

Marks: 5 x 10 = 50

11) Derive the magnetic field on the axis of a conducting circular loop (radius R, carrying a steady current I) at a distance z from its centre along the axis (by using the Biot Savart law). Using that, find the magnitude of magnetic field at the centre of the loop. (8+2)

12) How do we write the Maxwell equations in terms of the field tensor ($F^{\mu\nu}$) and its dual tensor ($G^{\mu\nu}$)? Using the equation for $F^{\mu\nu}$, taking $\mu=0$, find which Maxwell equation is obtained. Give the name of the obtained equation. (3+6+1)

13) Define Gauge transformation. Show how the Gauge transformations work for the scalar potential (V) and the vector potential ($\vec{A}$). What is the disadvantage of the Coulomb Gauge? (1+8+1)

14) Use Gauss's law to calculate the Electric field inside and outside a spherical shell of radius R having charge Q uniformly distributed on its surface. Using that, comment on the scalar potential (V) inside and on the surface of a spherical shell. (7+3)

15) Two spherical cavities of radii a and b are hollowed out from the interior of a neutral conducting sphere of radius R. At the centre of the cavities are point charges q_a and q_b respectively.
   a) Find the surface charges σ_a, σ_b, and σ_R.
   b) What is the field outside the conductor?
   c) What is the field within each cavity?
   d) What is the force on q_a and q_b?
   e) Which of these answers would change if a third charge q_c is brought near the conductor?

(2+2+2+2+2)