The Open University of Sri Lanka
B.Sc / B.Ed Degree Programme
Applied Mathematics – Level 05
Final Examination – 2007/2008
AMU 3185/AME 5185 – Electro-magnetic Theory & Special Relativity

Duration : Two and half hours

Date : 11. 06. 2008 **Time : 1.30 p.m – 4.00 p.m**

Answer FOUR Questions only

01. **(a)** Define the following terms.

(i) Electric field (ii) Electric force

(iii) Charge density (iv) Steady current

(b) The potential ϕ of a spherical conductor of radius a carrying a charge Q is $\phi = \frac{A}{r} + B$ every where. Show that $\phi = \frac{Q}{r}$ for $r \geq a$.

(c) Two insulated spherical conductors of radii a and b are at a large distance r apart. One conductor carries a charge Q and the other is uncharged. If the conductors are connected by a fine wire, show that the charge on the conductor of radius a will become to $\frac{a(r-b)Q}{(a+b)r-2ab}$.

02. **(a)** Define the term Electric Flux.

(b) State the Gauss' theorem

(c) A rectangular plane surface of width w and length l is placed with its edges parallel to the X and Y axes. If the electric field $\underline{E}$ is everywhere parallel to the Z axis and its magnitude is $\emptyset = wl\left(\frac{al}{2} - b\right)$.

03. **(a)** What do you mean by the word "Electric potential" ?

(b) Briefly explain the term Electric Potential Energy by giving an example.

(c) A charge q is uniformly distributed throughout a non conducting spherical volume of a radius a. Show that the electric potential at a distance r from the centre, where $r < a$, is given by $V = q\left(\frac{3a^2-r^2}{8\pi\varepsilon_0 a^3}\right)$, where ε_0 is the permittivity of the medium.

04. (a) Explain the following terms

(i)Polarization

(ii)Surface charge density

(iii) Capacitance of a conductor

(iv) Current density

(b) Two parallel plates each of area $1m^2$ and separation 5mm are each given equal and opposite charges of $300\mu C$. A sheet dielectric whose dielectric constant is exactly fills the space between the two plates.
Calculate the following

(i) the capacitance of the system
(ii) the resultant electric field intensity in the dielectric.
(iii) the density of the induced charge on the faces of the dielectric.

05. (a) (i) State the Kirchoff's laws for steady current in linear conductors.

(ii) Each member of a series of n points $A_1,A_2...A_n$ is connected to its successor by a wire of resistance ρ and each member of another series of n points $B_1,B_2...B_n$ is connected to its successor by a similar wire. Each pair of corresponding points A_r,B_r $(1 \le r \le n)$ in the two series is connected by a wire of Resistance R. A steady current J enters at A_1 and leaves at B_n. If the current in A_rA_{r+1} is i_r, prove by applying the Kirchoff's Laws to the current , that the current in B_rB_{r+1} is $(J - i_r)$ and hence show that

$i_{r+1} - 2\cosh 2\alpha\, i_r + i_{r-1} = -2J\sinh^2\alpha$, where $1+\frac{\rho}{R} = \cosh 2\alpha$.

(b) (i) State the Biot-Savart's law for steady current

(ii) In cylindrical polar co-ordinates the current density vector is given by $\underline{j} = 10^5(cos^2 2r)\underline{e}_z$ in certain region. Show that the magnetic field at any point (r, θ, z) is given by $\underline{H} = 10^5\left[\frac{r}{4} + \frac{\sin 4r}{8} + \frac{\cos 4r}{32r} - \frac{1}{32r}\right]\underline{e}_\theta$,

where $\underline{e}_\theta$ is the unit vector in the increasing direction of θ at the point $P(r,\theta,z)$.

06. (a) State the Galilean Transformation and the Lorentz transformation

(b) Derive the inverse Lorentz transformation

(c) If the photon traverses the path in such a way that it moves in OXY'plane making an angle θ with x-axis of the system S', Suppose that S' is moving with velocity v relatives to S and c is the velocity of light and u_x, u_y are the velocity components of the photon in x,y axis relatives to the system S. Prove that for the frame S, $u_x^2 + u_y^2 = c^2$.