The Open University of Sri Lanka

B.Sc. /B.Ed. Degree Programme

Final Examination - 2014/2015

Applied Mathematics – Level 05

AMU3185 /AME5185 – Electro-Magnetic Theory & Special Relativity

Duration: - Two Hours

Date: 30th October 2015 **Time: 1.30 p.m. - 3.30 p.m.**

Answer Four Questions Only.

You may, wherever necessary, assume that $4\pi\varepsilon = \frac{10^{-9}}{9}\text{Fm}^{-1}$.

1) (i) State Coulomb's law, used in electrostatics.

(ii) Two identical balls, each of mass m and carrying a charge q are suspended from the same point by two weightless strings each of length l. If the angle made by each string with the vertical is θ, show that

$$16\pi\varepsilon_0 mgl^2 = \frac{q^2}{\sin^2\theta\tan\theta}$$

(iii) Two pith balls each of mass $10^{-4}kg$ are suspended in air from the same point by thread of length $10cm$. When each ball carries the same charge, they are found to be $10cm$ apart. Calculate the charge on each ball.

2) (i) Define following terms, as accurately as possible

a) Electric field
b) Flux intensity
c) Electric potential
d) Zero potential.

(ii) The electric potential V at the point (r,θ,ϕ) is given by, $V = \frac{10}{r^2}\sin\theta\cos\phi$.

a) Find the electric flux density D at $\left(2,\frac{\pi}{2},0\right)$.

b) Calculate the work done in moving a $10\mu C$ charge from point $A\left(1,\frac{\pi}{6},\frac{2\pi}{3}\right)$ to $B\left(4,\frac{\pi}{2},\frac{\pi}{3}\right)$.

3) (i) State Gauss's law, used in electromagnetic theory.
(ii) A spherical volume charge density distribution is given by,

$$\rho=\begin{cases}\rho_0\left(1-\frac{r^2}{a^2}\right) & ;r\geq a\\ 0 & ;r<a\end{cases}$$

a) Calculate the total charge Q.

b) Find the electric field intensity E at a point outside the charge distribution.

c) Find the electric field intensity E at a point inside the charge distribution.

d) Show that the Electric field intensity is maximum, when $r=0.745a$.

4) (i) Write down Poisson's and Laplace's equations in Cartesian, cylindrical and spherical coordinates.

(ii) Find the Laplacian of the following scalar field, $W=10r\sin^2\theta\cos\phi$.

(iii) The potential in a certain region is described by the expression,

$V(x,y)=V_0\exp\left(-\left(x^2+y^2\right)\right)$. Calculate the volume charge density $\rho(x,y)$ using Poisson's equation assuming that $\varepsilon_0=1$.

5) (i) State Biot-Savart's law, used in electromagnetic theory.

(ii) Calculate the magnetic field intensity H at (3m, -6m, 2m) due to a current element of length 2mm located at the origin (in free space) that carries a current 16mA in the +y direction.

(iii) In a certain conducting region the magnetic field intensity H, is given by

$$H = yz(x^2 + y^2)\underline{a}_x - y^2xz\underline{a}_y + 4x^2y^2\underline{a}_z \; Am^{-1}.$$

Show that $\nabla.B = 0$ where B is magnetic flux intensity.

6) (i) State the Galilean Transformations.

(ii) Obtain the Lorentz inverse transformations for,

$$x' = \alpha x - \alpha vt$$

$$y' = y$$

$$z' = z$$

$$ct' = -\frac{\alpha v}{c^2}x - \alpha t.$$