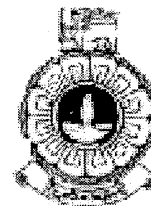


The Open University of Sri Lanka
 B.Sc. /B.Ed. Degree Programme
 Final Examination - 2014/2015
 Applied Mathematics – Level 05
 AMU3185 /AME5185 – Electro-Magnetic Theory & Special Relativity



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 $4\pi\epsilon = \frac{10^{-9}}{9} \text{ Fm}^{-1}$.

- 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

$$16\pi\epsilon_0 mgl^2 = \frac{q^2}{\sin^2 \theta \tan \theta}$$

- (iii) Two pith balls each of mass 10^{-4} kg are suspended in air from the same point by thread of length 10 cm . When each ball carries the same charge, they are found to be 10 cm 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 $\epsilon_0 = 1$.

- 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

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

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

- 6) (i) State the Galilean Transformations.
(ii) Obtain the Lorentz inverse transformations for,

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

$$y' = y$$

$$z' = z$$

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