USN | | | | | | | | | | EC44

Fourth Semester B.E. Degree Examination, Dec. 07 / Jan. 08

Field Theory

Time: 3 hrs. Max. Marks:100

Note : *Answer any FIVE full questions.*

1 a. State and explain Gauss' law. How are Gaussian surfaces chosen? **(06 Marks)**

b. Find the force on a 100 μC charge at (0, 0, 3) m if four like charges of 20 μC are located on the x and y axes at ± 4 m. **(08 Marks)**

c. A uniform line charge, infinite in extent, with $\rho_l = 20 nC/m$, lies along the z axis. Find $\vec{E}$ at (6, 8, 3) m. **(06 Marks)**

2 a. Given the electric flux density $\vec{D} = 5\sin\theta\hat{a}_\theta + 5\sin\phi\hat{a}_\phi$, find the charge density at (0.5m, $\pi/4$, $\pi/4$) (Spherical coordinates). **(06 Marks)**

b. Find the work done in moving a point charge $Q = 5\mu C$ from origin to (2m, $\pi/4$, $\pi/2$) in spherical co-ordinates in the field

$$E = 5e^{-r/4}\hat{a}_r + \frac{10}{r\sin\theta}\hat{a}_\phi.$$
(06 Marks)

c. Given that the energy W_E in an electric field due to distributed charge density ρ_V throughout a volume V is given by

$$W_E = \frac{1}{2}\int_V \rho_V V dv$$

Show that an equivalent expression for the stored energy is

$$W_E = \frac{1}{2}\int_V \varepsilon E^2 dv$$
(08 Marks)

3 a. State and explain divergence theorem when applied to the electric flux density $\vec{D}$. **(05 Marks)**

b. There exists a spherical volume charge of radius a with uniform charge density ρ_V.

Obtain electric field intensity $\vec{E}$, and sketch it as a function of radius r. Verify the divergence theorem for $r < a$ and $r > a$. **(15 Marks)**

4 a. Derive the Poisson's equation. **(05 Marks)**

b. Find the maximum torque on an orbiting charged particle if the charge is 1.602×10^{-19}C, the circular path has a radius of 0.5×10^{-10} m, the angular velocity is 4.0×10^{16} rad/s and the magnetic flux density $B = 0.4\times10^{03} T$. **(05 Marks)**

c. Find the potential function and the electric field intensity for the region between two concentric right circular cylinders, where V = 0 at r = 1 mm and V = 150 V at r = 20 mm, if $\varepsilon_r = 3.6$ (neglect fringing). Find the surface charge density on each cylinder. Determine the capacitance between the conducting cylinders per meter length. **(10 Marks)** the variation of the magnetic field $\vec{H}$ as a function of radius r. **(12 Marks)**

6 a. State and explain the Lorentz force equation. **(06 Marks)**

b. A condutor of length 2.5 m located at z = 0, x = 4 m carries a current of 12 A in the $-\hat{a}_y$ direction. Find the uniform $\vec{B}$ in the region if the force on the conductor is 1.2×10^{-2} N in the direction $\frac{\left(-\hat{a}_x+\hat{a}_z\right)}{\sqrt{2}}$. **(08 Marks)**

c. A solenoid with $N_1=1000$; $r_1=1$ cm and $l_1=50$ cm is concentric within second coil of $N_2=2000$, $r_2=2$ cm and $l_2=50$ cm. Find the mutual inductance assuming free-space conditions. **(06 Marks)**

7 a. Derive the wave-equation for free space. **(10 Marks)**

b. Current I flows through a conductor of length L. Obtain the magnetic field $\vec{H}$, at the center of the loop when the conductor is made to form a circular loop. **(05 Marks)**

c. A radial magnetic field $\vec{H}=\frac{2.239\times10^6}{r}\cos\phi\,\hat{a}_r$ A/m exists in free space. Find the magnetic flux φ crossing the surface defined by $-\frac{\pi}{4}\le\phi\le\frac{\pi}{4}$, $0\le z\le1$ m. **(05 Marks)**

8 a. State and explain the Poynting's theorem. **(05 Marks)**