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GSE/D-21 790

ELECTRICITY, MAGNETISM AND ELECTROMAGNETIC THEORY

Paper II

Time : Three Hours] [Maximum Marks : 40

Note : Attempt *Five* questions in all, selecting at least *one* question from each Unit. Q. No. **1** is compulsory. All questions carry equal marks.

Section A

1. Attempt all parts :

(a) Let $\vec{r}$ denotes the position vector of any point in three dimensional space and $|\vec{r}| = r$. Find $\vec{\nabla}.\vec{r}$ and $\vec{\nabla} \times \vec{r}$. **2**

(b) For a ferromagnetic material, permeability μ and H are related as : **2**

$$\mu = \left[\frac{0.4}{H} + 12 \times 10^{-4}\right] \text{ henry/metre}$$

For B to be 1 tesla, find the value of H in ampere/meter.

(c) Name the vector which is associated with directional energy flux in an electromagnetic wave. **1**

(d) In a series LCR circuit, by how much, quality factor of a series resonant circuit increase when inductor is increased to four times its value and capacitance is reduced to one fourth of its value ? **2**

(e) Show that curl of gradient of a scalar function is always zero. **1**

Section B
Unit I

2. (a) Verify Gauss's divergence theorem for the function $\vec{F} = \left(4xz\hat{i} - y^2\hat{j} + yz\hat{k}\right)$ over the surface S of the cube bounded by the planes $x = 0$, $x = 1$, $y = 0$, $y = 1$, $z = 0$ and $z = 1$. **4**

(b) Deduce an expression for the electrical pressure acting normally outward on the surface of a charged conductor. **4**

3. (a) Evaluate : **3**

$$\nabla.\left[r\nabla\left(\frac{1}{r^3}\right)\right]$$

(b) State and prove Stokes' theorem. **3**

(c) Write down the characteristics of the gradient of a scalar field. **2**

Unit II

4. (a) Give Langevin's theory of paramagnetism and hence prove that magnetic suceptibility χ_{para} of paramagnetic substance is inversely proportional to absolute temperature. **7**

(b) Write down Gauss's law in vector form in magnetostatics. **1**

5. (a) Explain in detail Domain theory of ferromagnetism. **3**

(b) Derive Ampere's law for steady current in differential form. **3**

(c) Distinguish between hard and soft magnetic materials. **2**

Unit III

6. (a) Derive Maxwell's equation from Faraday's law. **3**

(b) The magnetic field of an electromagnetic wave is given by :

$$\vec{B} = 1.6\times10^{-6}\cos\left(2\times10^{7}z + 6\times10^{15}t\right)\left(2\hat{i}+\hat{j}\right)\text{Wbm}^{-2}$$

Find the associated electric field in volt m^{-1}. **2**

(c) Define Poynting Vector. What does it represent ? Give its unit. **3**

7. (a) Derive the boundary conditions satisfied by $\vec{H}$ and $\vec{D}$ at the interface of two media. **5**

(b) A lamp emits monochromatic green light uniformly in all directions. The lamp is 3% efficient in converting electrical power to electromagnetic waves and consumes 100 W of power. Find the amplitude of the electric field associated with the electromagnetic radiation at a distance of 5 m from the lamp. **3**

Unit IV

8. (a) Determine the impedance and phase difference between the current and e.m.f. in an a.c. circuit containing resistance and inductance using j-operator. **5**

(b) Define quality factor and show that :

$$Q = R\sqrt{\frac{C}{L}}$$

for a parallel resonant circuit. **3**

9. (a) Determine impedance and phase difference between current and e.m.f. in an a.c. circuit containing resistance and capacitance using j-operator. **4**

(b) Calculate quality factor for a series resonant circuit. **4**