TMG – 12

B.Sc. (Semester – V) Examination, April 2019
PHYSICS (Paper – IV)
Electromagnetic Theory – I

Duration : 2 Hours | Max. Marks : 80

Instructions: *1)* ***All*** *questions are* ***compulsory****. Internal choices are available.*
2) Figures to the ***right*** *indicate* ***full*** *marks.*
3) Symbols have their ***usual*** *meaning, unless otherwise stated.*
4) Use of calculator is ***allowed****.*

Given : Permittivity of free space, $\varepsilon_0 = 8.854\times10^{-12}$ C²/Nm².

1. Answer **any four** of the following. **(4×4=16)**
   a) Given a vector function $\vec{A} = x^2\hat{i} + yz\hat{j} - 2z\hat{k}$, find its
      i) divergence and ii) curl.
   b) A point charge –2 μ C is situated at the origin. Calculate the electric potential at (1, 2, 3).
   c) State the first and second theorems of properties of solution of Laplace's equation.
   d) Dielectric slab with dielectric constant 3 is introduced between two parallel plates. If the electric field strength inside is 10^6 V/m, calculate the magnitude of polarization produced.
   e) What are polar and non-polar dielectric ? What is induced dipole ?
   f) Calculate the energy density of a medium of dielectric constant 3 placed in uniform electric field of 4 V/m.

2. Answer **any four** of the following. **(4×4=16)**
   a) Calculate gradient of scalar function $\phi = x^2y^3z^4$ at (1, –1, 1).
   b) Show that the scalar function, $\phi = 3x^2 + 8y - 3z^2$ can represent the electrostatic potential in a charge free region.
   c) Using differential form of Gauss' law, obtain Poisson's equation.
   d) Dielectric constant of the glass is 4. Determine the value of electric susceptibility.

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e) What are ferroelectric materials ? Ferroelectric slab may serve as basic element of memory device. Explain.

f) A parallel plate capacitor consists of two plates of area 500 cm^2 separated by a thin sheet of mica of thickness 5 mm. The dielectric constant of mica is 6.5. Calculate its capacitance.

3. A) Show that $\vec{\nabla}\cdot(\vec{A}\times\vec{B}) = (\vec{\nabla}\times\vec{A})\cdot\vec{B} - (\vec{\nabla}\times\vec{B})\cdot\vec{A}$. 6

OR

A) If $\vec{w}$ is a constant vector and $\vec{r}$ is a position vector then show that $\vec{\nabla}\times(\vec{w}\times\vec{r}) = 2\vec{w}$. 6

B) Show that $\nabla^2 r^n = n(n+1)\, r^{n-2}$, where r is the magnitude of the position vector. 6

4. A) A point charge q is kept near infinite grounded conducting plane. Use method of images to find the expression for potential and induced charge. 6

OR

A) Find the solution of Laplace's equation in spherical coordinates using zonal harmonics, assuming potential to be independent of Azimuthal angle. 6

B) Derive an expression for electric field due to a dipole. 6

5. A) Show that polarization of dielectric medium give rise to volume density of charge $\int_p = -\vec{\nabla}\cdot\vec{P}$ and surface charge density $\sigma_p = \vec{P}\cdot\hat{n}$. 6

OR

A) Deduce boundary conditions to be satisfied by the electric field vector and magnetic field vectors at the interface of two different media. 6

B) State and prove integral form of Gauss' law in dielectric. 6

6. A) Derive Clausius-Mossoti equation for the molecular polarisability of non-polar molecules in dielectric. 6

OR

A) Derive Langevin formula for effective dipole moment of polar molecules. 6

B) Obtain an expression for the electrostatic energy of group of point charges. 6
