CARMEL COLLEGE OF ARTS, SCIENCE & COMMERCE FOR WOMEN, NUVEM - GOA.

SEMESTER END EXAMINATION, August 2020
B. Sc Semester: V (old course) PHYSICS (Paper IV) -Electromagnetic Theory – I

Total Marks: 30   *Date: 07/07/2020*   *Duration: 2 Hours*   *Total No of pages: 02*
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Instructions: 1) All questions are compulsory.
2) Figures to the right indicate marks.
3) Symbols have their usual meaning, unless otherwise stated.
4) Draw illustrated diagrams if necessary to support your answers.
5) Use of log tables and non programmable calculators is allowed.
6) Permittivity of free space ϵ_0 =8.854x10^{-12} C^2/N.m^2

Q I. Answer any **five** of the following.   **(5 x 2 marks = 10)**

a) Give the concept of line integral, and surface integral.

b) Write Laplace's equation in one independent variable in spherical coordinates as a
function of r and obtain its solution.

c) State coulomb's law. Express the same in mathematical form. Write an expression
for Electric Field due to continuous charge distribution.

d) What are polar and non-polar molecules? What is meant by an induced dipole?

e) Give the general idea of method of electrical images used to find electric potential
in the space outside conductors placed near a charge distribution.

f) What is the effect of temperature on polarizability of polar molecules? What is
Curie temperature?

g) What are the basic properties of conductors?

h) Write Gauss' law in dielectric medium. Define dielectric constant.

Q II. Answer any **four** from the following   **(4 x 5 marks = 20)**

1) Give the physical significance of gradient of a scalar field and derive an
expression for the same in terms of del operator.

2) (i) Three equal charges 1 coulomb each are placed in three corners of a square of side 10 cm. Using Coulomb's law, find the magnitude and direction of the Electric field at the fourth corner of the square.

ii) Two small identical conducting spheres have charges of 2.0 and 0.5 µC respectively. When they are placed 4 cm apart, what is the force between them? State and explain Gauss' law in Electronics.

3) An uncharged conducting sphere is placed in a previously uniform electric field E_0. Using zonal harmonics find the potential at any point external to the field.

4) A dielectric sphere of radius 'a' is placed in a region of space containing initially uniform electric field E_0. Using zonal harmonics determine electric field inside the dielectric sphere.

5) Derive Clausius Mossotti equation for molecular polarizability of a dielectric material.

6) Derive an expression for energy density of large electrostatic field in terms of field vectors **E** and **D**.

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SEMESTER END EXAMINATION, JUNE 2020
B. Sc Semester: V old course PHYSICS (Paper IV) -Electromagnetic Theory – I

Total Marks: 80   Date: Duration: 2 Hours   Total No of pages: **3**
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Instructions: 1) All questions are compulsory.
 2) Figures to the right indicate marks.
  3) Symbols have their usual meaning, unless otherwise stated.
 4) Draw illustrated diagrams if necessary to support your answers.
5) Use of log tables and non programmable calculators is allowed.
              6) Permittivity of free space ϵ_0 =8.854x10^{-12} C^2/N.m^2

Q 1. Answer any **four** of the following.   **(4 x 4 marks = 16)**

a) State Gauss' Divergence Theorem. Explain its importance with one example.

b) When is a vector said to be solenoidal?   When is it said to be irrotational ?

c) State Gauss' law in electrostatics. Apply this law to find the electric field near a plane sheet of charge of infinite extent.

d) Write Laplace's equation in one independent variable in spherical coordinates as a function of position r and obtain its solution.

e) (i) State Gauss law in dielectric. Express the same in integral and differential forms.
   (ii) Why do an uncharged conductor and a charge attract each other when placed near one another?

 (f) What are polar and non polar molecules? What is meant by an induced dipole?

Q 2. Answer any **four** of the following.   **(4 x 4 marks = 16)**

a) What do you mean by the gradient of a scalar function? Express the same in terms of del operator.

b) Two small identical conducting spheres   have charges of 2.0 and 0.5 μC respectively. When they are placed 4 cm apart, what is the force between them? If they are brought into contact and then separated by 4 cm what is the force between them?

c) Prove that two solutions of Laplace's equation obeying same boundary conditions differ at the most by a constant.

d) One of the zonal harmonic solution to Laplace's equation is given by $\varphi_n(r, \theta) = C_n r^{-(n+1)} P_n(\theta)$ for all n>0, where $P_0=1$, $P_1=\cos\theta$. Write the solutions for n = 0 and n = 1. What do these solutions represent?

e) What are permanent dipoles? What is Curie temperature

f) Two identical air capacitors are connected in series and the combination is maintained at a constant potential difference of 60 V. Find the voltage across each capacitor. A dielectric sheet of dielectric constant 9 and of thickness equal to the air gap is introduced inside one of the capacitors so as to fill the gap completely, and a constant potential difference of 60 V across the combination is maintained. Calculate the voltage across each capacitor.

Q 3.
A) Explain the concepts of line integral, and surface integral and volume integral.

6

OR

A) Prove the following.   **6**

(i) $\nabla \times \nabla\varphi = 0$
Where φ is a scalar and **F** is a vector.

(ii) $(\boldsymbol{u}.\boldsymbol{\nabla})\boldsymbol{r} = \boldsymbol{u}$
Where $\boldsymbol{u}$ is any vector and $\boldsymbol{r}$ is a position vector.

B) State and prove Curl Theorem due to Stoke.   **6**

Q 4.
A) Show that electrostatic potential due to an arbitrary charge distribution may be considered as the sum of the potentials due to monopole, dipole, quadrupole and higher order multipoles.   **6**

OR
A) What is an electric dipole? Obtain an expression for electric field due to a dipole.

6

B) Using the method of electrical images find the electric field due to a point charge placed near a conducting sphere.   **6**

Q 5.
A)Explain the phenomenon of polarization when a dielectric material is subjected to an external electric field.   **6**

OR

A)

(i) Define susceptibility and dielectric constant. What are linear dielectrics? **6**

(ii) Calculate volume and surface density of polarization charges in a dielectric sphere of radius 'a' having polarization $\mathbf{P} = k\,\mathbf{R}$ where k isa constant and $\mathbf{R}$ is position vector with origin at the center of the sphere. **6**

(B) Obtain an expression for potential due to a polarized dielectric material in terms of surface polarization and volume polarization charge densities. **6**

Q 6.

A) Derive Langevin-Debye formula for molecular polarizability for polar molecules.

6

OR

A) Obtain an expression for potential energy of a group of point charges in vacuum.

6

B) What do you mean by energy density in an electrostatic field? Show that energy density of an electrostatic field is $U = \frac{1}{2}\mathbf{E}\cdot\mathbf{D}$ **6**