THE PNG UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL & COMMUNICATIONS ENGINEERING DEPARTMENT

FIRST (1st) SEMESTER (2022)

EE211 ELECTROMAGNETIC FIELD THEORY

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS:

1. You have **TEN (10) MINUTES to** read this paper. Do not write during this allocated time

2.There are **a total of five (5) Questions** in this Exam Booklet**. Answer ANY Two (2) QUESTIONS in PART A and ALL Questions in PART B**

3.All answers must be written in the **Answer Booklet**

4.COMPLETE STUDENT DETAILS ARE TO BE FILLED ON THE ANSWER BOOKLET-DO THIS NOW

5.Only drawing instruments and calculators are allowed on your desk. Textbooks and notebooks are **NOT** allowed

6.If you are found **Cheating** in this Exam, penalties specified by the **University** shall be applied.

7.TURN OFF all your mobile phones and place them on the floor under your seat before you start the examination

PART A. ANSWER ANY TWO QUESTIONS

QUESTION 1

a) Explain with diagrams the addition of three vectors using associative law of vectors

[5 marks]

b) Explain with diagrams and equations the Cross-Product of Two Vectors

[5 marks]

c) A vector field is specified as $G = 24xya_x + 12(x^2 + 2)a_y + 18z^2a_z$. Given two points, P (1, 2, −1) and Q (−2, 1, 3), find:

(i) .G at P

(ii) a unit vector in the direction of G at Q:

(iii) a unit vector directed from Q toward P :

(iv) the equation of the surface on which $|G| = 60$

[15 marks]

[TOTAL 25 Marks]

QUESTION 2

a) The region in which $4<r<5$, $0<\theta<25°$ and $0.9\pi<\varphi<1.1\pi$ contains the volume charge density of $p_v=10(r-4)(r-5)\sin\theta\sin(\theta/2)$. Outside the region $p_v=0$. Find the charge within the region.

[10 marks]

b) A uniform line charge of 16nC/m is located along the line defined by $y=-2$, $z=5$. If $\varepsilon=\varepsilon_o$

(i) Find **E** at P(1,2,3)

(ii) Find **E** at that point in the $z=0$ plane where the direction of **E** is given by

$(1/3)a_y-(2/3)a_z$

[15 marks]
TOTAL 25 Marks]

QUESTION 3

a) Given $V= x^{-2}y + x^2y^2z+ z^{-2}$, find (a) the gradient of V and (b) the values of V and the gradient at point (1,1,1).

[4 marks]

b) A sphere has an inner radius R_o and outer radius R_1. The electric charge inside the shell is ρ_v Coul/m3. Find expressions for the electric field inside the hollow area ($r<R_o$), inside the shell ($Ro<r<R_1$) and outside the sphere ($r>R_1$). Sketch the electric field with the distance from the center of the sphere.

[8 Marks]

c) A *a x b* rectangular coil is placed in the x-y plane (side *a* in parallel to x-axis. The side *b* in parallel to the y-axis, with a magnetic flux density of B in the y-direction. (a) If the coil carries a current I, obtain an expression for the torque on the coil (b) Why are slip rings needed in case of AC motors, which are not required for the DC motor.

[8 Marks]

d) Write down the four Maxwell's equations in integral OR differential form, Define each term in the equations.

[5Marks]
[25 Marks]

PART B. ANSWER ALL QUESTIONS

QUESTION 4

a) Let S = 120 cm2, d = 4 mm, and ε_R = 12 for a parallel-plate capacitor.

(i) Calculate the capacitance:

(ii) After connecting a 40 V battery across the capacitor, calculate E, D, Q, and the total stored electrostatic energy:

(iii) The source is now removed and the dielectric is carefully withdrawn from between the plates. Again calculate E, D, Q, and the energy: With the source disconnected, the charge is constant, and thus so is D:

(iv) What is the voltage between the plates?

[15 Marks]

b) Coaxial conducting cylinders are located at ρ = 0.5 cm and ρ = 1.2 cm. The

region between the cylinders is filled with a homogeneous perfect dielectric. If the inner cylinder is at 100V and the outer at 0V, find:

(i) the location of the 20V equipotential surface:

(ii) $E_{\rho\,max}$:

(iii) ε_R if the charge per meter length on the inner cylinder is 20 nC/m:

[10 Marks]
[Total 25 Marks]

QUESTION 5

a) A dielectric circular cylinder used between the plates of a capacitor has a thickness of 0.2 mm and a radius of 1.4 cm. The dielectric properties are $\epsilon_R = 400$ and $\sigma = 10{-}5$ S/m.

(i) Calculate C:

(ii) Find the quality factor QQF (QQF = ωRC) of the capacitor at f = 10 kHz

(iii) If the maximum field strength permitted in the dielectric is 2 MV/m, what is the maximum permissible voltage across the capacitor?

(iv) What energy is stored when this voltage is applied?

[15 Marks]

b) In free space, let $\rho_v = 200\ \varepsilon_0\ /r^{2.4}$.

(i) Use Poisson's equation to find V (r) if it is assumed that r2Er → 0 when r → 0, and also that V → 0 as r → ∞:

(ii) Now find V (r) by using Gauss' Law and a line integral: Gauss' law applied to a spherical surface of radius r gives:

[10 Marks]
[Total 25 Marks]