BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ENGINEERING AND PHYSICS

PROGRAMME BACHELOR OF SCIENCE HONOURS DEGREE IN ELECTRONIC ENGINEERING

COURSE CODE: EEE2210/EEE3201 (2) NARRATION: ELECTROMAGNETIC THEORY

DURATION: 3 HOURS TOTAL MARKS: 100

INSTRUCTIONS TO CANDIDATES NOV 2024

1. Answer any **FIVE (5) questions**
2. The question paper **contains SEVEN (7)** questions
3. Each question carries **20 marks**
4. **Special Requirements:** Scientific Calculator, rule, pen, pencil

Constants

$\mu_o = 4_\pi \, x \, 10^{-7} \, H/m, \; \varepsilon_o = 8.854 \, x \, 10^{-12} \, F/m$

1(a)(i) Find the gradient of $T = x^2 lny + z^3$ [2]

(ii) Find the divergence of $\vec{V} = (x+y)\hat{x} + (y+z)\hat{y} + (z+x)\hat{z}$ [2]

(iii) Find the curl of $\vec{V} = x = (x+y)\hat{x} + (y+z)\hat{y} + (z+x)\hat{z}$ [4]

(b) Two vectors are represented by $\vec{A} = 2\hat{\imath} + 2\hat{\jmath}$, $\vec{B} = 3\hat{\imath} + 4\hat{\jmath} - 2\hat{k}$. Find the dot and cross-products and the angle between the vectors. Show that A x B is at a right angle to A. [7]

(c) Three field quantities are given by

$P = 2\boldsymbol{a}_x - \boldsymbol{a}_z,$

$Q = 2\boldsymbol{a}_x - \boldsymbol{a}_y + 2\boldsymbol{a}_z$

$R = 2\boldsymbol{a}_x - 3\boldsymbol{a}_y + \boldsymbol{a}_z$

(d) Determine (i) **Q.R** x **P** [5]

2(a) State two properties of charges [2]

(b) $Q_1 = \frac{1}{9}\mu C$ is located at the origin and Q_2=100mC is located at (8,6,0) in free space. Find F_2 and F_1. [6]

(c) For a linear, homogeneous material medium, derive Poisson's and Laplace's equations from Gauss' law. [8]

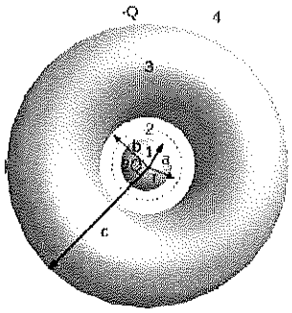
(b) A charge of 12 C has velocity of $5\boldsymbol{a}_x$ + $2\boldsymbol{a}_x$ - $3\boldsymbol{a}_x$ m/s. Determine **F** on the charge in the field of (a) **E** = $18\boldsymbol{a}_x$ + $5\boldsymbol{a}_y$ + $10\boldsymbol{a}_z$V/m (b) $\boldsymbol{B} = 4\boldsymbol{a}_x + 4\boldsymbol{a}_y + 3\boldsymbol{a}_z$ wb/m^2. [4]

3(a)A current element 4 cm long is along y-axis with a current of 10 mA flowing in y-direction. Determine the force on the current element $\boldsymbol{a}_x$ due to the magnetic field

$H = \frac{5a_x}{\mu}$ [4]

(b) Find the magnetic field intensity at (0,4,0), caused by the following source. $\boldsymbol{Id\ell} = 64\times10^{-3}$ Am at O(0,0,0) [2]

(c)Let us consider a solid conducting sphere of radius a carrying a net positive charge $2Q$ (see Fig. below).



The charge distributions on both the sphere and the shell are characterized by spherical symmetry around their common center

Suppose a conducting spherical shell of inner radius b and outer radius c is concentric with the solid sphere and it carries a net negative charge $-Q$.

(i) Find the electric field in the regions labeled 1, 2, 3, and 4. [8]

(ii)What is the charge distribution on the shell when the entire system is in electrostatic equilibrium? [2]

(d) Two small identical conducting spheres have charges of $2\,x\,10^{-9}$ and $-0.5\,x\,10^{-9}$ C respectively.

(i) When they are placed 4 cm apart what is the force between them? [2]

(ii) If they are brought into contact and then separated by 4 cm. What is the force between them? [2]

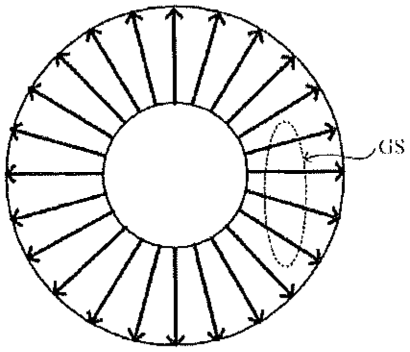
4(a)What is the significance of the Biot-Savart Law? [2]

(b) Determine and justify the direction of the force on a moving positive charge if $\vec{B} = B_o\hat{a}_z$ and the charge moves in

(i) the $\hat{a}_z$ direction [2]

(ii) the $\hat{a}_y$ direction. [2]

(c) A Gaussian surface is set up inside a coax cable between the inner and outer conductors, but it does not surround the inner conductor, as sketched in Figure below.



Gaussian surface for coax

(i) What is the net electric flux from this Gaussian surface? Why? [2]
(ii) Is the electric field zero inside this Gaussian surface? Why or why not? [2]
(iii)Is the electric field zero inside this Gaussian surface? Why or why not? [2]
(d) Develop the expression for the resistance of a wire or resistor with the aid of the fig. below Assume the conductivity and the current density are uniform throughout the volume of the material. Interpret the meaning of the dependencies in the resulting equation. [8]

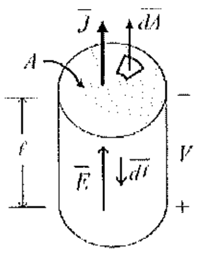


Figure for developing resistance.

5(a) A load impedance of 40 + j70 Ω terminates a 100 Ω transmission line that is 0.3λ long. Using the Smith Chart, find
i. the reflection coefficient at the load, [2]
ii. the reflection coefficient at the input to the line, [2]
iii. the input impedance, [2]
iv. the standing wave ratio on the line, and [2]
v. the return loss. [2]
(b) A lossy cable with R = 2.5 Ω/m, L = 10 mH/m, C = 10 pF/m and G = 0 operates at f = 1GHz. Find the attenuation constant of the line. [4]
(c) Calculate the voltage reflection coefficient for the case where $Z_L = 80 - j10)$ Ω and Z_o. [4]
(d)Write down Gauss Law for electric field [2]

6(a) Using circuit diagrams, differentiate a lossy line from a loss less line. [6]

(b) Write down Maxwell's four equations and briefly explain the meaning/significance of each. [8]

(c) Derive the area of a rectangle of length a and height b. [4]

(d) If H= 4 sin(6283t+2z) a_x A/m. Find the amplitude of the displacement current density if

the conductivity is zero

7(a) A sensitive electronic circuit must be shielded from a low frequency magnetic field of known direction. Conceptually design an enclosure to accomplish this magnetic shielding and explain how shielding is achieved. [5]

(b) Write the boundary conditions at the interface between two perfect dielectrics. [2]

(c) Name the two basic concepts involved in EM waves. [2]

(d) Write Maxwell's equation for time varying fields. [1]

(e)(i) What is the significance of displacement current? [2]

(ii) Distinguish between conduction and displacement currents. [2]

(f) Discus similarities between Biot-Savart law for magnetism and Coulomb's law for Electrostatics [5]

END OF PAPER