



SCHOOL OF COMPUTING AND ENGINEERING SCIENCES (SCES)
BACHELORS OF ELECTRICAL AND ELECTRONICS ENGINEERING
END OF SEMESTER EXAMINATION

BEE 2204 : ELECTROMAGNETISM

DATE: Monday 9th March 2026.

Time: 11:00-13:00 Hrs

Instructions

1. This examination consists of **FIVE** questions.
2. Answer **Question ONE (COMPULSORY)** and any other **TWO** questions.
3. Vector derivative table is provided. Use it where necessary

QUESTION ONE (30 marks)

- a) Given vectors $\mathbf{A} = a_x + 3a_z$ and $\mathbf{B} = 5a_x + 2a_y - 6a_z$ determine each of the following:
- i. $|\mathbf{A} + \mathbf{B}|$ (2 marks)
 - ii. the component of $\mathbf{A}$ along a_y (2 marks)
 - iii. the angle between $\mathbf{A}$ and $\mathbf{B}$ (2 marks)
 - iv. the component of $\mathbf{A}$ along $\mathbf{B}$ (2 marks)
- b) Points P and Q are located at $(0,2,4)$ and $(-3,1,5)$. Obtain
- i. The position vector $\mathbf{r}_p$ (1 mark)
 - ii. The distance vector from P to Q (2 marks)
 - iii. The distance vector between P and Q (2 marks)
- c) Given a scalar quantity T and a vector quantity $\mathbf{A}$, state why each of these vector derivative operations are not possible:
- i. $\nabla(\nabla T)$
 - ii. $\nabla \cdot (\nabla \cdot \mathbf{A})$
 - iii. $\nabla \times (\nabla \times T)$
- (3 marks)

- d) Given $W = x^2y^2 + xyz$. Compute ∇W and the directional derivative dW/dl in the direction $3a_x + 4a_y + 12a_z$ at point $(2, -1, 0)$ (3 marks)
- e) State the Maxwell's equations in integral form (4 marks)
- f) State **three** factors affecting the magnitude of Coulomb's force (3 marks)
- g) State the boundary conditions for the electric field (2 marks)
- h) If $D = (2x^2 + z)a_x + 4xya_y + xa_z$. Determine the volume of the charge density at $(-1, 0, 3)$. (2 marks)

QUESTION TWO (15 marks)

- a) From Gauss law derive an expression for the
- Poissons law
 - Laplace equation
- (5 marks)
- b) A hollow spherical shell shown in Fig Q1b carries a charge density $\rho = \frac{k}{r}$ in the region $a \leq r \leq b$, determine the electric field strength in the region
- $r < a$ (2 marks)
 - $a < r < b$ (3 marks)
 - $r > b$ (2 marks)

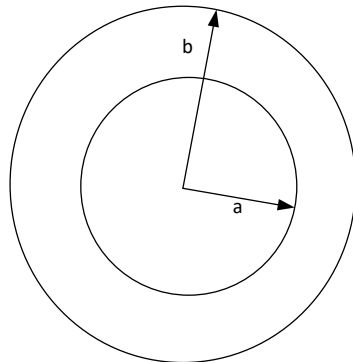


Figure Q1b

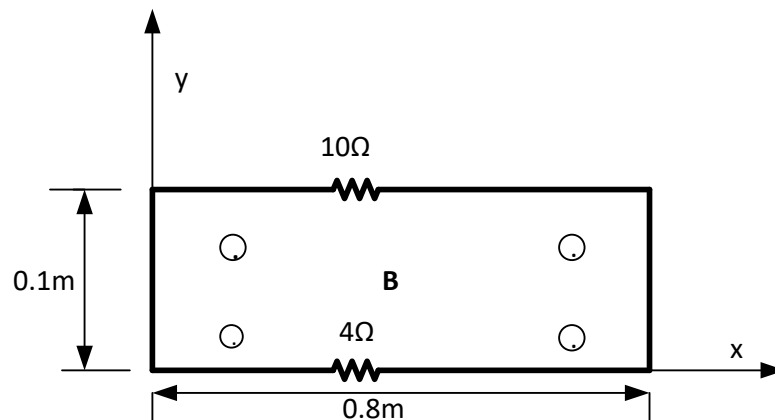
- c) Given that the electric flux density in spherical coordinates given by $\vec{D} = \frac{Q}{\pi r^2} (1 - \cos 3r) a_r$. Determine the charge density. (3 marks)

QUESTION THREE (15 marks)

- a) State **three** factors affecting the force between two charged particles in an electric field
(3 marks)
- b) Three point charges, each with $q = 3nC$ are located at the corners of a triangle in the x-y plane with one corner at the origin, another at $(3cm, 0,0)$ and the third at $(0, 3cm, 0)$. Determine the force acting on the charge located at the origin.
(5 marks)
- c) A parallel plate capacitor has its plates at $x = 0, d$ and the space between the plates is filled with an inhomogeneous material with permittivity $\epsilon = \epsilon_0 \left(1 + \frac{x}{d}\right)$. If the plate at $x = d$ is maintained at V_0 while the plate at $x = 0$ is grounded, determine the
- Electric potential V
(4 marks)
 - Electric field strength E
(3 marks)

QUESTION FOUR

- a) State in words Faradays law of Electromagnetic induction
(2 marks)
- b) The circuit shown in Figure 4(b) exists in a magnetic field $B = 40 \cos(30\pi t - 3y)\mathbf{a}_z \text{ mW/m}^2$. Determine the:
- Induced voltage
(4 marks)
 - The current in the circuit, given that the wires connecting the resistors have negligible resistances
(2 marks)



- c) Distinguish between displacement and conduction current
(2 marks)
- d) In a dielectric ($\sigma = 10^{-4} S/m$, $\mu_r = 1$, $\epsilon_r = 4.5$) the conduction current density is given as $J_c = 0.4 \cos 2\pi \times 10^8 t \text{ A/m}^2$. Determine the displacement current density.
(5 marks)

QUESTION FIVE

- a) State the Maxwell's equations in integral form

- (4 marks)**
- b) Given that $\mathbf{E} = E_0 \cos(\omega t - \beta z) \mathbf{a}_x$ V/m in free space Determine each of the following:
- i. Electric flux density $\mathbf{D}$ **(2 marks)**
 - ii. Magnetic field strength $\mathbf{H}$ **(5 marks)**
 - iii. Magnetic flux density $\mathbf{B}$ **(2 marks)**
- c) State any tow applications of Maxwell's equations **(2 marks)**