MASTER OF ELECTRICAL ENGINEERING EXAMINATION, 2024

(1-ST YEAR, 1-ST SEMESTER)

FIELD COMPUTATION OF ELECTROMAGNETIC DEVICES

Time: 3 hours Full Marks: 100

Use separate Answer-script for each part (66 marks for this PART-I)

Answer any three questions. All symbols have their usual significance

PART-I (66 Marks)

1. a) What is the **definition of curl?** Derive the **expression for curl** of a vector field **M** using **definition of curl**, written as $\nabla \times \mathbf{M}$ where ∇ is the vector differential operator in Cartesian co-ordinates.

b) Explain $\nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ in terms of Machine design and energy conversion.

c) Explain the importance of the relation $\nabla \times \mathbf{H} = \mathbf{J} + \partial \mathbf{D}/\partial t$ in terms of Machine design and also draw all fields **H,J,D.** **8+8+6=22**

2. a) Considering a typical triangular element and taking a potential function $V_e(x,y) = a+bx+cy$ within the element derive the *element shape functions* when potential at the nodes are known as $V_{e1}(x_1,y_1)$, $V_{e2}(x_2,y_2)$ *and* $V_{e3}(x_3,y_3)$.

b) What do you understand by Magnetic Vector Potential?

Develop the following equation explaining each symbol

$$\nabla \times \left(\frac{1}{\mu}\nabla \times A\right) + \sigma\frac{\partial A}{\partial t} + \sigma\nabla\phi = 0.$$

11+11=22

3 a) What do you understand by Magnetic Energy and Co-energy.

b)Derive an expression for flux linkage with the coil by magnetic circuit method of the cylindrical magnetic device shown in fig. 1.

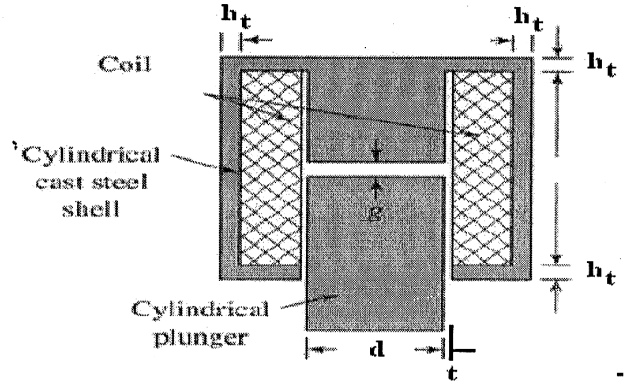


Fig.1

c) Considering linear operation of the cylindrical magnetic device shown in fig. 1, derive an expression of Magnetic Co-energy in the air-gap and the force when plunger-movement is infinitesimal. **5+8+9=22**

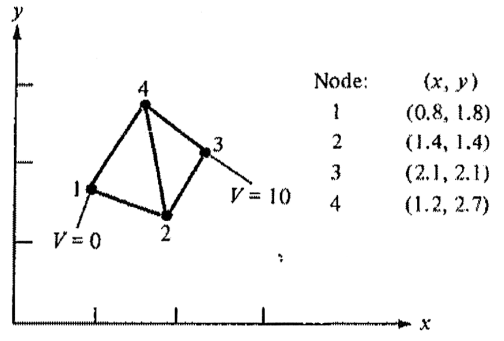
[Turn over

4 a) Using Finite Element Analysis for E.M.Field computation, derive an expression for flux linkage with the coil of the cylindrical magnetic device shown in fig.1.

b) Considering linear operation of the cylindrical magnetic device shown in fig.1,derive an expression of Magnetic Coenergy in the air-gap using E.M.Field computation and apparent inductance as well as the force when plunger-movement is infinitesimal. **11+11=22**

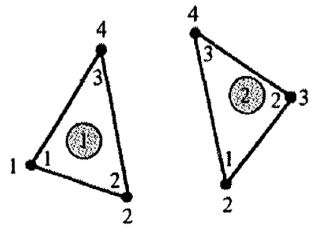
5. a) Consider the operation of an electromagnetic relay shown in Fig.3, where one winding is mounted on a stationary member of iron and a movable member of iron as if attached to a wall of the relay by a spring on one side. Derive the expression for mechanical force if the plunger shown in Fig.3 is allowed to move an infinitesimal distance in the direction of magnetic force acting upon it.

b) Considering a two triangular elements mesh in a x-y plane as shown in fig.2 and using the finite element method, determine the potential within the mesh and in the node 2 and 4. **10+12=22**



Node:	(x, y)
1	(0.8, 1.8)
2	(1.4, 1.4)
3	(2.1, 2.1)
4	(1.2, 2.7)

(a) (a) two-element mesh, (b) local and global numbering of the elements.



(b) **Figure 2**

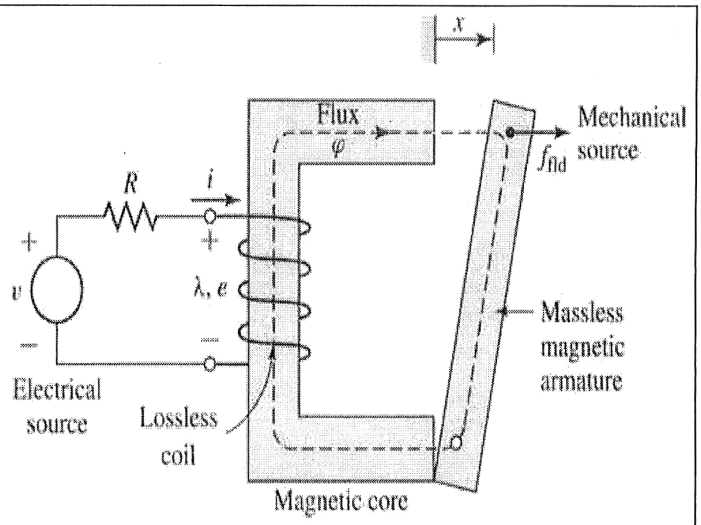


Fig.3

PART – II

[34 marks]

Answer Any Two Questions.

1. With a neat diagram derive an expression for the Specific Permeance of a Parallel Sided slot. 17

2. With a neat diagram derive an expression for the Specific Permeance of Slots with Double Layer Windings. 17

3. For a solid rectangular composite magnetic core derive an expression for eddy currents. 17