ELECTRICAL SCIENCE

***Time**: Three Hours*

***Maximum Marks**: 100*

Answer five questions, taking ANY TWO from Group A, any two from Group B and all from Group C.

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches.

Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (a) State and explain Coulomb's law. Define permittivity, absolute permittivity and relative permittivity. 6

   (b) A negative point charge of 1 μC is situated at x = 0 in free space. Calculate electric field intensity at a point on positive x axis 3 m from origin. 6

   (c) Derive an expression for the energy stored in the electric field when a capacitor C is charged to a potential difference of V. 8

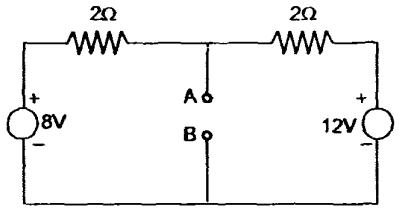
2. (a) State and explain Faraday's law of electromagnetic induction. Show that principles of operation of both d.c. generators and transformers are based on Faraday's law. 6

   (b) A steel ring, 20 cm mean diameter and circular cross-section of diameter 2.5 cm, has an air-gap of 1 mm. The ring is uniformly wound with 500 turns of copper wire carrying a current of 3 A. Calculate (a) magneto-motive force, {b) magnetic flux, (c) flux density, and {d) reluctance. Neglect magnetic leakage and fringing. Assume that the steel ring takes 30% of the total magneto-motive force. 8

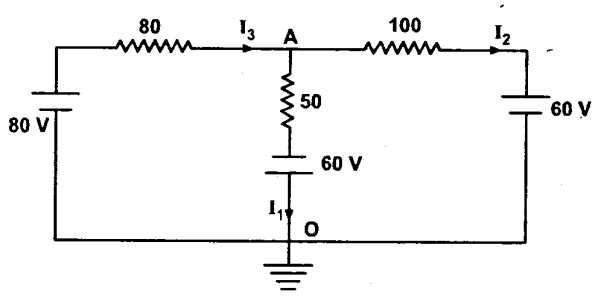
   (c) State and explain Biot-Savart's law of electromagnetism. A conductor, in the form of a circular loop of radius r, is carrying a current I. Obtain an expression for the magnetic field intensity at the centre of the loop. 6

3. (a) State and explain Thevenin theorem and mention its applications. 8

(b) Following figure shows a d.c. circuit. Apply Thevenin's theorem to find current through 3 ohm resistance if connected between A and B. Draw Thevenin's equivalent circuit. 6



(c) For the circuit shown in figure, applying superposition theorem or mesh analysis or any other method, find the current in the branches shown. All resistances are in ohm. 6



4. (a) Explain the resonance phenomenon in a.c. circuits containing inductor, capacitor and resistor. 8

(b) A 100 ohm resistance and 0.6 H inductance are connected in parallel across a 230 V 50 Hz source. Find line current, circuit phase angle, circuit impedance and power dissipated. 6

(c) Compare copper efficiencies in DC 2-wire, AC 3-phase, 3-wire and AC 3-phase 4 wire distribution system. 6

Group B

5. (a) Draw a 4-pole d.c. machine/generator construction diagram labelling its main parts. describe briefly its (i) Field system (ii) Armature (iii) Commutator (iv) Brushes. 8

(b) A 6 pole lap wound d.c. generator has an armature with 90 slots and 6 6

conductors per slot and rotates at speed of 6000 rpm. The flux per pole is 100 mWb. calculate the emf produced.

(c) A shunt d.c. generator has an open circuit no load voltage of 127 V and a voltage of 120 V on full load. The armature resistance is 0.02 ohm. Find armature current, field current and load current. Field resistance is 15 ohm. 6

6. (a) What are different types of three phase induction motors? What are different methods of starting induction motors? Compare them. 8

(b) Find the voltage regulation for a 100MVA 11 kV star-connected alternator having a resistance of 0.02 ohm and synchronous reactance of 0.2 ohm per phase. The load power factor is 0.8 lagging. 6

(c) A 2000 kVA, 6600 V, three-phase star-connected synchronous generator has a resistance of 0.4 ohms per phase and a synchronous reactance of 4.5 ohms per phase. Calculate the percentage change in terminal voltage when the rated output of 2000 kVA at a power factor of 0.8 lagging is switched-off. The speed and exciting current remain unchanged. 6

7. (a) Draw and explain exact equivalent circuit of a single phase transformer. 6

(b) What are hysteresis and eddy current losses ? Obtain their expressions. How do you reduce them? 6

(c) A single-phase transformer has 1000 turns on the primary and 200 turns on the secondary. The no -load current is 3A at a p.f. of 0.2 lagging. Calculate the primary current and p.f. when the secondary current is 280 A at a p.f. of 0.8 lagging. Assume the voltage drop in the windings to be negligible. 8

8. (a) Explain the term phase sequence. What is the use of symmetrical components? 6

(b) Obtain the relationship between line voltage and phase voltage for a 3 - phase star connected balanced load with the help of phasor diagram. 8

(c) Three star connected impedances $z_a = 50\angle 30^0\ \Omega$, $z_b = 40\angle 60^0\Omega$ and $z_c = 40\angle 60^0\ \Omega$ are connected to a 400 volts, 3-phase supply. Determine the line currents and the two wattmeter readings when power is measured by two wattmeter method. a, b, c is the phase sequences. 6

Group C

9. Answer the following in brief: 20

(i) What is meant by voltage profile?

(ii) How is a torque produced in three-phase induction motor ?

(iii) What is meant by phase sequence of a supply ?

(iv) How does the "improvement in power factor' help the customer and the power supply agency?

(v) State Norton's theorem.

(vi) What is meant by step up and step down transformers ?

(vii) Kirchhoff's laws for an electric circuit.

(viii) What is meant by the term voltage regulation of an alternator ?

(ix) The main flux in a transformer remains practically constant from no-load to full-load condition, why ?

(x) What are the functions of relays ?

(Refer our course material for answers)