S'11 : 5 AN : AN 210 (1410)

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 answers 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 laws of electrostatics. 6

(*b*) Two parallel metal plates of large area are spaced at a distance of 10 mm from each other in air. A sheet of glass, 5 mm thick with a relative permittivity of 6, is introduced between the plates. A potential difference of 5000 V is applied between the plates. Determine the electric field intensities in air and in the glass sheet. 6

(*c*) Derive an expression for the energy stored in a capacitor of C farads when charged to a potential difference of V volt. 8

2. (*a*) What is eddy-current loss? How can it be minimized? Mention some applications of eddy currents. 8

(*b*) State and explain Norton's theorem. 6

(*c*) Draw and explain B-H curves for a magnetic material. 6

3. (*a*) Determine the current I in the network shown in Fig. 1 by Thevenin's theorem. 8

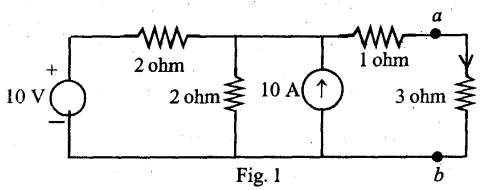

Fig. 1

(*b*) An alternating current is given by $i = 14.14 \sin 377t$. Find the time taken for the current to reach 10 A for the first time after passing through zero value. 6

(*c*) Define the terms 'period' and 'phase difference'. 6

4. (*a*) Explain, with the aid of a phasor diagram, the phenomenon of resonance in a circuit containing an inductor, a capacitor and a resistor in series. 6

(*b*) Obtain the relationship between the line and phase values of voltage in a three-phase star-connected system with the aid of a phasor diagram. 8

(*c*) Discuss the principle of symmetrical components. 6

Group B

5. (*a*) Define and explain the terms 'feeder', 'distributors' and 'service mains'. 3 × 3

(*b*) Why are conductors for overhead lines transposed? 5

(*c*) What is per unit system? Why is it used? 6

6. (*a*) Derive expressions for calculating the economic voltage and economic conductor cross-section of a line. 6

(*b*) An electric train runs between two sub-stations 6 km apart maintained at voltages 600 V and 590 V respectively and draws a constant current of 300 A while in motion. The track resistance of go and return path is 0.04 Ω/km. Calculate the (*i*) point along the track where minimum potential occurs, and (*ii*) current supplied by the two sub-stations when the train is at the point of minimum potential. 4+4

(*c*) Find the condition for maximum efficiency of a transformer. 6

7. (*a*) Derive the equivalent circuit of a transformer. How are the parameters obtained from no-load and short-circuit tests? 10

(*b*) Explain what is meant by back e.m.f. Explain the principle of torque production in a d.c. motor. 10

8. (*a*) For an induction motor, deduce the expression

$$\frac{T_{st}}{T_{fl}} = \frac{S^2 + S_M^2}{S(1 + S_M^2)}$$

where T_{fl} = full load torque, T_{st} = starting torque, S = full-load slip of the motor, and S_M = slip at maximum torque. 7

(*b*) The power input to a three-phase induction motor is 60 kW. The stator losses are 1 kW. Find the total mechanical power developed and the rotor copper loss per phase if the motor is running with a slip of 3%. 7

(*c*) How can you determine the regulation of synchronous generator by synchronous impedance method? 6

Group C

9. Answer the following in brief: 10 × 2

(*i*) Mention the colour band with tolerance of resistor.

(*ii*) Write the applications of eddy currents.

(*iii*) Find the relation between magnetic field intensity and magnetomotive force.

(*iv*) State Kirchhoff's laws.

(*v*) What are the functions of relays?

(*vi*) What are the advantages of a doubly fed distributor over single fed distributor?

(*vii*) What is breadth factor?

(*viii*) Why is open-circuit test of 1-ϕ transformer done on low-voltage side?

(*ix*) The frequency of the e.m.f. in the stator of a 4-pole induction motor is 50 Hz and that in the rotor is 1.5 Hz. What is the slip and what speed of the motor running?

(*x*) What are different methods of speed control of a d.c. motor?

W'11:5AN:AN 210(1410)

ELECTRICAL SCIENCE

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Group A

1. (*a*) Four point electric charges 1×10^{-8}C, -2×10^{-8}C, 3×10^{-8}C and 2×10^{-8}C are situated at corners of a square of 1m side. Find electric potential at centre of square. 10

(*b*) Define the terms 'electric flux', 'electric flux density' and 'electric charge density'. 3 × 2

(*c*) Define electric field intensity. 4

2. (*a*) Find current through 10 ohm resistance in Fig.1 using Thevenin's theorem. 10

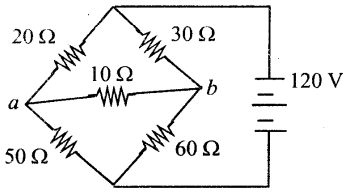

Fig. 1

(*b*) State and explain superposition theorem. 6

(*c*) Explain the phenomenon of hysteresis. 4

3. (*a*) A leaky capacitor has Z_C = 74.5 ohm. It is connected in series with a coil of Z_L = 40 ohm and another resistance R of 56 ohm. Applied voltage is 200 V and circuit current is 2.5 A. Voltage across R and Z_L combination is 194 V. Find loss in capacitor. 12

(*b*) Explain phasor representation of sinusoids. 4

(*c*) What is meant by reactive power ? 4

4. (*a*) A star-connected three-phase load has 6 ohm resistance and 8 ohm inductive reactance in each branch. Line voltage is 220 V. Write phasor expressions for voltage across each branch, line voltages and line currents. Find total power. 10

(*b*) Explain the phenomenon of series resonance. 6

(*c*) What is a B-H curve ? 4

Group B

5. (*a*) A 230 V source feeds three loads A, B and C each taking 50 A. Loads A, B, C are connected to source through 0.05 ohm, 0.1 ohm, and 0.02 ohm resistance. Cables A is joined to B through 0.1 ohm resistance cable and B is joined to C through 0.15 ohm cable. Find voltages at loads A, B, and C. 12

(*b*) Compare a.c. 3 wire and a.c. 4 wire distribution systems. 4

(*c*) What is a ring main distribution system ? 4

6. (*a*) Draw and explain phasor diagram of a two winding transformer. 10

(*b*) Define regulation of a transformer. 4

(*c*) How are d.c. motors classified ? 6

7. (*a*) Derive emf equation of an alternator. Explain the terms 'breadth factor' and 'pitch factor'. 12

(*b*) How are single phase induction motors classified ? 4

(*c*) Draw characteristics of d.c. shunt generator. 4

8. (*a*) Explain the principle of operation of three-phase induction motor. 8

(*b*) Explain the term 'slip' in an induction motor. 2

(*c*) A three-phase induction motor is fed from 50 Hz supply. The number of poles is 6. Find full load slip and speed, if frequency of rotor emf at full load is 2 Hz. 10

Group C

9. Answer the following in brief: 10×2

(*i*) What is the difference between potential and potential difference?

(*ii*) What is Faraday's laws of electromagnetic induction?

(*iii*) State Norton's theorem.

(*iv*) What is the significance of power factor?

(*v*) What is the need of power factor improvement?

(*vi*) What is an a.c. 4-wire system?

(*vii*) What is an a.c. commutator machine?

(*viii*) What are the different losses in a transformer?

(*ix*) What is meant by torque?

(*x*) Name the methods of starting of three-phase induction motor.

S'12:7AN:AN210 (1410)

ELECTRICAL SCIENCE

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Group A

1. (*a*) State and explain Coulomb's laws of electrostatics. 6

(*b*) Point charges in air are located as follows :

$+5 \times 10^{-8}$ C at (0, 0) metres, $+4 \times 10^{-8}$ C at (3, 0) metres and -6×10^{-8} C at (0, 4) metres. Find the electric field intensity at (3, 4) metres. 8

(*c*) Derive an expression for the total capacitance of a group of capacitors when they are all connected in (*i*) parallel, and (*ii*) series. 2 × 3

2. (*a*) Define self and mutual inductances. 6

(*b*) State and explain Norton's theorem. 6

(Turn Over)

(*c*) Determine the current I in the network as shown in Fig. 1 by Thevenin's theorem. 8

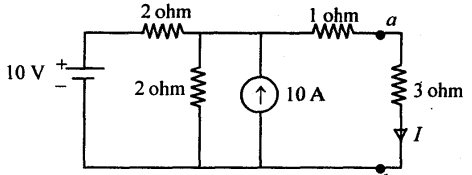

Fig. 1

3. (*a*) Explain, with the aid of a typical B–H curve, the meaning of the following terms : (*i*) Magnetic hysteresis, and (*ii*) B–H loop ? 2 × 5

(*b*) What is eddy-current loss ? What are the undesirable effects of eddy currents ? How can they be minimized ? Mention some applications of eddy currents. 10

4. (*a*) With the aid of a phasor diagram, obtain the relationship between the line and phase values of voltage in a three-phase, star-connected system. 10

(*b*) A delta-connected load draws a current of 15A at a lagging power factor of 0·85 from a 400 V, 3-phase, 50 Hz supply. Find the resistance and inductance of each phase. 10

Group B

5. (*a*) A distributor AB is fed from both ends. At feeding point A, the voltage is maintained at 236 V, and at B at 237 V. The total length of the distributor is 200 m and loads are tapped off under :
(*i*) 20 A at 50 m from A, (*ii*) 40 A at 75 m from A, (*iii*) 25 A at 100 m from A, and (*iv*) 30 A at 150 m from A. The resistance per kilometer of one conductor is 0·4 ohm. Calculate the currents in the various sections of the distributor, the minimum voltage, and the point at which it occurs. 10

(*b*) What is grid distribution system ? 5

(*c*) Explain three-phase 4-wire system of distribution of electrical power. 5

6. (*a*) Draw no-load phasor diagram of a transformer and derive expressions for magnetising and core loss components of no-load current. 10

(*b*) Define the efficiency of a transformer. 4

(*c*) Derive the torque equation of d.c. motor. 6

7. (*a*) Explain the principle of operation of a three-phase synchronous motor. 6

(*b*) Draw the circuit diagram of a capacitor-start, capacitor-run single-phase induction motor and explain its working. 6

(*c*) Discuss different types of excitation system used for d.c. generators. Draw their connection diagrams and explain them for each type of excitation system. 8

8. (*a*) Compare cage and wound rotors-type three-phase induction motor. 6

(*b*) Why are starters necessary for starting three-phase induction motors ? Name different kinds of starters. 6

(*c*) How e.m.f's produce by pulsating field in a single-phase commutator machines ? Deduce the e.m.f. equation. 8

Group C

9. Answer the following in brief : 10×2

(*i*) Energy stored in a charged capacitor.

(*ii*) Coefficient of mutual inductance between two magnetically coupled coils.

(*iii*) Kirchhoff's laws for an electric circuit.

(*iv*) Different methods for the improvement of power factor.

(*v*) 3-wire d.c. distribution system.

(*vi*) On what factor does the direction of rotation of a 3-phase induction motor depend ?

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

(*viii*) Why is transformer core laminated ?

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

(*x*) Importance of phase-sequence.

W'13: 7AN: AN 210 (1410)

ELECTRICAL SCIENCE

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Group A

1. (*a*) State and explain Coulomb's law. Define permittivity, absolute permittivity and relative permittivity. 3 + 3 + 2

(*b*) Three charges each of 2×10^{-5} C are placed at the three corners of an equilateral triangle each of side 2 m. Find the force on any one charge due to the presence of other two charges. 8

(*c*) What is meant by electric flux density ? 4

2. (*a*) What is a B-H curve ? What is its use ? 8

(*b*) An air cored coil has 400 turns. The mean length of magnetic flux path is 60 cm and area of cross-section is 5 cm^2. The exciting current is 5 A. Find H, B and flux near the axis of the coil 8

(*c*) Write some applications of relays. 4

3. (*a*) In the circuit, shown in Fig. 1, find voltage *V* and show that power consumed by resistances is equal to power supplied by batteries. 8

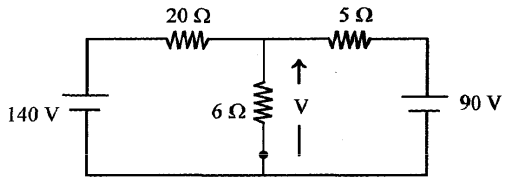

Fig. 1

(*b*) Define the terms mesh and node. 2 + 2

(*c*) State and explain Kirchhoff's laws. 8

4. (*a*) An inductor coil takes 10 A and dissipates 1000 W when fed from 250 V 25 Hz supply. Find the impedance, resistance, inductance, and power factor of the coil. 8

(*b*) Differentiate between balanced and unbalanced three-phase loads. 4

(*c*) How is the power consumed in a three-phase circuit measured ? Show the wattmeter connection and the power relation. 8

Group B

5. (*a*) What is an ideal transformer ? 4

(*b*) A 230/110 V single phase transformer takes 350 VA at no load and rated voltage. Core loss is 110 W. Find magnetising current and no load power factor. 4

(*c*) Draw and explain the phasor diagram of a two winding transformer. 8

(*d*) Define voltage regulation of transformer. 4

6. (*a*) Differentiate between series and shunt d.c. generators. 4

(*b*) A 60 hp 230 V d.c. shunt motor has an armature resistance of 0·05 ohm and field circuit resistance of 46 ohm. The no load speed is 1000 rpm. Find the speed when the line current is 75 A. Assume that the motor has compensating winding. 8

(*c*) Derive an expression for emf induced in d.c. machine. 8

7. (*a*) What is meant by slip of induction motor ? 4

(*b*) Explain the methods of starting of three phase induction motor. 8

(*c*) How can synchronous impedance of an alternator be found ? 8

8. (*a*) A 230 V source feeds three loads *A*, *B*, *C* each taking 50 A. Loads *A*, *B*, *C* are connected to source through 0·05 Ω, 0·1 Ω and 0·02 resistance cables. *A* is joined to *B* through 0·1 Ω cable and *B* to *C* through 0·15 Ω cable. Find voltages at loads *A*, *B* and *C*. 8

(*b*) Discuss advantages and disadvantages of radial and ring main distributors. 6

(*c*) Compare single phase and three phase system of distribution. 6

Group C

9. Give very brief answer of the following : 10×2

(*i*) What is Faraday's law ?

(*ii*) What is the use of Thevenin's theorem ?

(*iii*) What is a phasor ?

(*iv*) What is eddy current loss ?

(*v*) What is resonance ?

(*vi*) What is meant by voltage profile ?

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

(*viii*) What is an a.c. commutator motor ?

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

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

S'14:7AN : AN 210 (1410)

ELECTRICAL SCIENCE

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Group A

1. (*a*) State similarities and dissimilarities between electric circuit and magnetic circuit. **2 + 2**

(*b*) Explain leakage fuse and fringing with respect to a magnetic circuit. **4**

(*c*) An iron ring of 100 cm mean circumference and cross-section of 10 cm^2 has a saw cut 2 mm wide made in it. Find the number of turns to be wound to produce a flux of 1 mWb in the air gap, if the current is 5A. Given relative permeability of iron as 300. **8**

(*d*) State Lenz's law and illustrate it with an example. **4**

2. (*a*) State and explain maximum power transfer theorem. Also, discuss its importance. **4**

(*b*) State and explain Kirchhof's voltage and current laws as applied to d.c. circuit. 4

(*c*) State Thevenin's theorem as applied to a d.c.circuit. How will you determine the value of R^{th} in a practical system. 2 + 2

(*d*) In applying Kirchhof's voltage law to a network path (*i*) when is an emf labelled positive, (*ii*) when is emf labelled negative, (*iii*) when is an IR drop across a resistor labelled negative. 8

3. (*a*) State and explain superposition theorem. How is it applied for solution of networks ? 6

(*b*) Using superposition theorem, find the current in different tranches of the network shown in Fig.1. All resistances are in ohm. 8

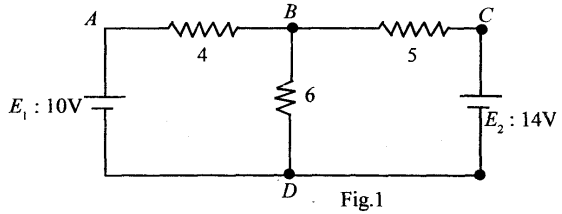

Fig.1

(*c*) State Norton's theorem. List the steps for obtaining Norton equivalent circuit. Compare Norton and Thevenin equivalent circuits. 6

4. (*a*) Distinguish between 'resistance' and 'resistivity'. Also, state the factors on which they depend. 4

(*b*) State the effect of temperature on resistance of pure metals, metal alloys, insulating materials and semi-conductors. Give one example of each material. Define resistance temperature coefficient. 6 + 2

(*c*) Two coils in series have resistances of 600 ohm and 400 ohm with temperature coefficient of 0·1% and 0·4%, respectively. Find effective temperature coefficient of series combination at 20°C and when the (series) combination is heated to 50°C. 8

Group B

5. (*a*) Explain the concept of phase and phase difference in alternating quantities. 4

(*b*) Define Root Mean Square (RMS) value of alternating quantity and derive its expression for sinusoidal current. 8

(*c*) A 50 Hz alternating current has an instantaneous value of 7·07 A at $t = 0$ and RMS value of $10\sqrt{2}$ A. Assuming the current wave to enter positive half at $t = 0$, determine (*i*) expression for instantaneous current, (*ii*) magnitude of current at $t = 0{\cdot}0125$ sec, (*iii*) magnitude of current at $t = 0{\cdot}0225$ sec and (*iv*) draw waveform and show all parameters on it. 8

6. (*a*) Explain, with a neat sketch, construction details of core-type and shut-type transformer. Derive this emf equation of a single phase transformer. 6

(*b*) Explain why (*i*) the open circuit test on a transformer is conducted at rated voltage, (*ii*) only a small voltage is applied to the transformer during short circuit test, (*iii*) usually low voltage winding is excited and the high voltage winding is open-circuited for the open circuit test, and (*iv*) usually low voltage winding is short-circuited and the high voltage winding is excited for short-circuit test. 4 × 2

(*c*) A 10 kVA, 4000/400 V transformer has primary and secondary winding resistance of 13 ohm and 0·15 ohm and leakage reactances of 20 ohm and 0·25 ohm, respectively. The magnetizing reactances is 6000 ohm

and the resistance representing core loss is 12000 ohm. Determine (*i*) equivalent resistance and reactance as referred to primary side, (*ii*) input current with secondary terminals open-circuited, and (*iii*) input current when the secondary load current is 25 A at 0·8 p.f. lagging. 6

7. (*a*) Describe the basic principle of operation of 3-phase induction motor. Also, compare squirrel-cage induction motor with slip-ring induction motor. 6

(*b*) Derive an expression for torque in a three-phase induction motor and explain, with the help of neat curves, the torque-slip characteristics of a 3-phase induction motor. 6

(*c*) A 3000 V, 24 pole, 50 Hz, 3-phase star (λ) connected induction motor has a slip ring rotor of resistance 0·016 Ω and stands till reactance of 0·256 Ω/phase. Full load torque is obtained at a speed of 247 rpm. Calculate (*i*) ratio of maximum-to-full load torque and (*ii*) speed at maximum torque. Neglect stator impedance. 8

8. (*a*) Explain the principle of a d.c. motor. What is meant by back emf and its relation with the applied voltage. Also, derive the voltage equation of a d.c. motor. 6

(*b*) What are the different methods of controlling the speed of a d.c. series motor. 6

(*c*) A shunt d.c. motor running at 440 V takes a current of 3·0 A. The field resistance is 600 Ω and armature resistance of 0.40 Ω and speed of 1000 r.p.m. Calculate its speed when taking a current of 30 A from the line, neglecting armature reaction. 8

Group C

9. Answer the following in brief : 10×2

(*i*) Define mutual and self-inductances of a coupled coil.

(*ii*) Why are electrical machines made from magnetic materials ?

(*iii*) In a series circuit the current is same in all the resistances. Why ?

(*iv*) The pole face of a d.c. machine is laminated even though a constant flux flows through the yoke. Justify.

(*v*) During a short-circuit test on a transformer, the iron losses are negligible. Justify.

(*vi*) The speed of an induction motor is always less than the synchronous speed, why ?

(*vii*) The core of the rotor of a three-phase induction motor is always laminated. Why ?

(*viii*) The conductors of the compensating winding are housed in the slots in the pole faces. Justify.

(*ix*) The resistance of earth continuity conductor is about 2Ω. Why ?

(*x*) If the power of a circuit is unity, its reactive power is zero. Justify.

W'14: 7 AN : AN 210 (1410)

ELECTRICAL SCIENCE

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Group A

1. (*a*) Explain the terms 'magnetic flux density' and 'magnetomotive force (MMF)'. 5

   (*b*) What do you understand by the terms 'retentivity' and 'coercive force' ? 5

   (*c*) State and explain Coulomb's law. A negative point charge of 0·2 C is situated at $x = 0$ in free space. Find the electric field intensity at a point having co-ordinates (3, 4) m. 5 + 5

2. (*a*) State and explain superposition theorem and mention its limitations. 5

   (*b*) For the circuit shown in Fig. 1, determine the

currents in all the branches and the voltage across AB by any method. 12

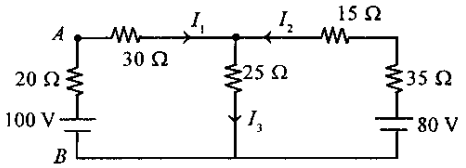

Fig. 1

(*c*) Calculate the power supplied by two batteries in part (b) above. 3

3. (*a*) How do you represent sinusoidal quantities of same frequency by phasors ? 5

(*b*) For the circuit shown in Fig. 2, determine the circuit impedance and the currents I_1, I_2 and I_3. Determine the power supplied and the power factor of the circuit. 10

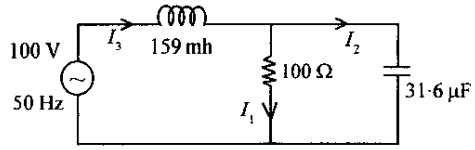

Fig. 2

(*c*) Show the phasor diagram indicating the voltage and currents. What is the need of power factor improvement in a circuit and how is it done ? 5

4. (*a*) What do you understand by balanced and unbalanced three-phase supply system and balanced and unbalanced three-phase loads ? 6

(*b*) A three-phase (unbalanced) load, shown in Fig. 3, is connected to a balanced three-phase 400 V 50 Hz supply.

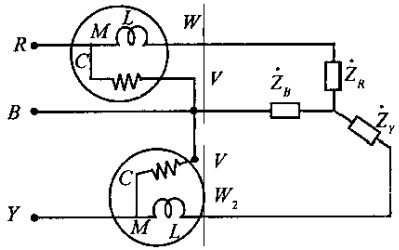

Fig. 3

Two wattmeters, W_1 and W_2, are connected as shown. Given :

$$\dot{Z}_R = 100\ \Omega,\ \dot{Z}_Y = (50 + j50)\ \Omega,\ \dot{Z}_B = (50 - j50)\Omega$$

Write the equations for currents. Determine the star point potential $\dot{V}_S$, the currents $\dot{I}_R$, $\dot{I}_Y$, $\dot{I}_B$ and the wattmeter readings W_1 and W_2. The phase sequence is *RYB*. 2 + 12

Group B

5. (*a*) A d.c. two wire distributor AB is long and is fed at both ends A and B at 400 V (Fig. 4). The loading is shown in the figure. The resistance of the lines is 0·05 Ω/km per line. Find the point of minimum potential along the line and the value of the potential. 10

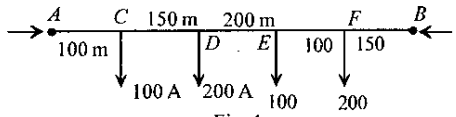

Fig. 4

(*b*) A sub-station *A* supplies a load of 16 MW at a power factor of 0.8 lagging to station *Q* through two overhead lines of impedances $(2 + j4)\,\Omega$ and $(4 + j4)\,\Omega$. Calculate the power supplied by each line. 10

6. (*a*) Derive the e.m.f. equation of a transformer. 5

(*b*) A single-phase transformer has 1000 turns on the primary and 200 turns on the secondary. The no-load current is 3A at 0.2 p.f. lagging. Calculate the primary current when the secondary is 280 A at 0.8 lagging. Assume the drop in the winding to be negligible. 10

(*c*) Derive the condition for maximum efficiency in a transformer. 5

7. (*a*) A d.c. shunt generator has 6 poles, 90 slots and six conductors per slot, with lap wound coils. It rotates at 750 rpm. The flux per pole is 100 mWb. Calculate the emf produced. 7

(*b*) Derive the torque equation of a d.c. shunt motor. 7

(*c*) A 6-pole lap wound d.c. shunt motor in fed from 400 V d.c. supply. The armature current is 50 A and the resistance of the armature is 0·2 Ω. The flux per pole is 0·05 Wb and the number of conductors is 540. Find the speed of the motor and the power developed. 6

8. (*a*) What is the basic difference between an induction motor and a synchronous motor ? 6

(*b*) An induction motor runs at 975 rpm when supplied from three-phase, 400 V 50 Hz mains. Determine the slip and frequency of the rotor current. 3 + 3

(*c*) What are the methods of starting of induction machines ? Discuss about their relative merits and demerits. 8

Group C

9. Choose the *correct* answer for the following : 10 × 2

(*i*) Two bulbs of ratings 60 W, 220 V and 400 W, 220 V are connected in series and the combination is supplied from a 220 V supply. The power taken by the combination (assuming linear resistances of the bulbs) will be

(*a*) 100 W

(*b*) 24 W

(*c*) 20 W

(*d*) 120 W

(*ii*) The current through the resistance $R = 10\,\Omega$ will be

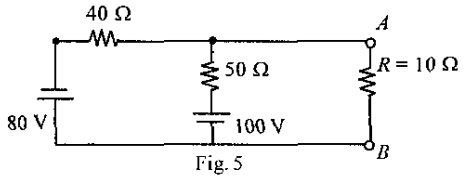

Fig. 5

(*a*) 4 A

(*b*) 0 A

(*c*) – 4 A

(*d*) – 3A

(*iii*) The wattmeter readings in a 2-wattmeter method of power measurement are 400 W and 200 W, respectively. The power factor of the load will be (for a balanced load)

(*a*) 0·866 lag

(*b*) 0·5 lag

(*c*) 0·5 lead

(*d*) 0·866 lead

(*iv*) In a circuit, the load terminals *A-B* show an open-circuit voltage of 100 V, and with the terminals *A-B* shorted, the short-circuit current is 10 A. When a load of $R_L = 40\ \Omega$ is connected across *A-B*, the current through the load will be

(*a*) 4 A

(*b*) 2 A

(*c*) 5 A

(*d*) 1 A

(*v*) If the frequency of the generated e.m.f. of a three-phase alternator is to be 60 Hz, the maximum possible speed at which a rotor can be run is

(*a*) 3000 r.p.m.

(*b*) 6000 r.p.m.

(*c*) 3600 r.p.m.

(*d*) 7200 r.p.m.

(*vi*) If in a transformer 220 V/440 V rated for a frequency of 60 Hz, the open circuit test is conducted at 220 V, 50 Hz. Then the total core loss will

(*a*) decrease due to decrease of a both hysteresis and eddy current losses.

(*b*) decrease due to decrease in hysteresis loss only.

(*c*) increase due to increase in both hysteresis and eddy current losses.

(*d*) increase due to increase in hysteresis loss only.

(*vii*) An electromagnet has an air gap of 4×10^{-3} m and a flux density of 1·3 *T*. The amp-turns for the gap will be

(*a*) 4000

(*b*) 4140

(*c*) 4350

(*d*) 4500

(*viii*) Two identical coils, with a coefficient of coupling $K = 0{\cdot}6$, placed adjacent to each other are connected in additive mode. The combination, when connected with a capacitor, shows resonance at 200 Hz. If the coils are connected in differential mode, resonance occurs at

(*a*) 400 Hz

(*b*) 100 Hz

(*c*) 50 Hz

(*d*) None of the three above.

(*ix*) A three-phase four-pole stator winding consists of 36 slots. Its distribution factor is approximately

(*a*) 1·0

(*b*) 0·96

(*c*) 0·85

(*d*) 0·75

(*x*) A voltage of $200 \sin(314t + 60^\circ)$ is supplied across an impedance of $(30 + j40)\ \Omega$. The power absorbed by the impedance is

(*a*) 240 W

(*b*) 480 W

(*c*) 120 W

(*d*) None of the three above.

S'15:7AN:AN210 (1410)

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 answers 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*) Define the terms : Electric flux, electric flux density and electric charge density. 3 × 2

(*b*) Electric lines of force never cross – why ? 4

(*c*) Find currents in all branches of the circuit in Fig. 1 using mesh current analysis : 10

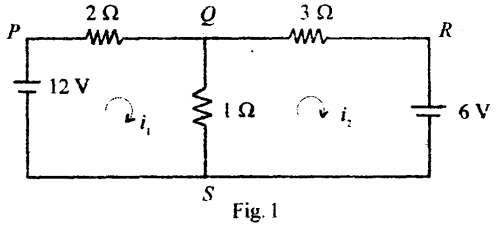

Fig. 1

2. (*a*) An a.c. voltage $160 + j\,120$ V is applied to a circuit. The current is $4 + j\,10$ A. Find impedance, active power, reactive power and power factor. 4 × 3

(*b*) What is series resonance ? 4

(*c*) What is the significance of power factor ? 4

3. (*a*) Explain the terms 'mutual inductance' and 'coefficient of coupling'. 4 + 4

(*b*) What is eddy current loss ? How can it be reduced ? 6

(*c*) An aeroplane, having a wing span of 52 m, is flying horizontally at 1100 km/h. If vertical component of earth's magnetic field is 38×10^{-6} T, find emf induced between the wing tips. 6

4. (*a*) Differentiate between balanced and unbalanced circuits. 5

(*b*) A star-connected three-phase load has a resistance of 6 Ω and inductive reactance of 8 Ω in each branch. Line voltage is 220 V. Write phasor expression of voltage across each branch, line voltages and line currents. Find total active power. 15

Group B

5. (*a*) Distinguish between radial and ring distributors. 6

(*b*) A 230 V d.c. source feeds three loads, each taking 50 A. Loads *A*, *B*, *C* are connected to source through 0·05 Ω, 0·1 Ω and 0·02 Ω resistance cables. *A* is joined to *B* through 0·1 Ω resistance cable and *B* to *C* through 0·15 ohm cable. Find voltages at loads *A*, *B* and *C*. 14

6. (*a*) Discuss the effect of core loss and magnetic leakage on the performance of transformer. 6

(*b*) What is turn ratio of transformer ? What is its significance ? 4

(*c*) Draw and explain phasor diagram of a two winding transformer. 10

7. (*a*) Derive torque equation of a d.c. machine. 5

(*b*) Differentiate between shunt, series and compound d.c. machines. 5

(*c*) Discuss the process of self-excitation in a d.c. shunt generator. 5

(*d*) What are the conditions to be met for parallel operation of d.c. machines ? 5

8. Write short notes on the following : 4 × 5

(*a*) Starting of induction motor

(*b*) Single-phase induction motor

(*c*) Types of alternators

(*d*) Use of commutator machines

Group C

9. Answer the following in brief : 10 × 2

(*i*) What is a dipole ?

(*ii*) What is the difference between loop analysis and node analysis ?

(*iii*) What is hysteresis loss ?

(*iv*) What is meant by relative permeability ?

(*v*) What is the importance of phase sequence ?

(*vi*) List applications of transformers.

(*vii*) What is meant by rotating field ?

(*viii*) What is synchronous impedance ?

(*ix*) Write some applications of single-phase induction motor.

(*x*) Why should speed of an alternator be kept constant ?

W'15: 7 AN: AN 210 (1410)

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 answers 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 clearly Faraday's laws of electromagnetic induction. 5

(*b*) A wire of 100 mm long is moved at a uniform speed of 4 m/s at right angles to its length and to a uniform magnetic field (i.e., if the conductor moves horizontally, the magnetic field is vertically directed). Calculate the density of the field, if the e.m.f. generated in the wire is 0·15 V. If the wire forms part of a closed circuit having a total resistance of 0·04 Ω, calculate the force on the wire (in newton). 8 + 2

(*c*) How do you define an inductance of a conductor or a coil and its unit ? How is it affected in a coil, if the number of turns is doubled ? 3 + 2

2. (*a*) Starting with Coulomb's law, define the terms 'permittivity' and 'relative permittivity'. 8

(*b*) Two point charges 6×10^{-4} C and 3×10^{-4} C are situated at two points A and B in air separated by 1 m. A charge of -8×10^{-6} C is located at a point P at a distance of 0·4 m from B along the line AB. Determine the force on the charge at P. Given : $\epsilon_0 = 8{\cdot}85 \times 10^{-12}$ F/m. Mention the assumptions made, if any. At what distance from the point B will there be zero force on the point P ? 6+6

3. (*a*) For the circuit shown in Fig. 1, determine the currents I_1 and I_2 by applying either superposition theorem or Mesh equation or Nodal analysis :

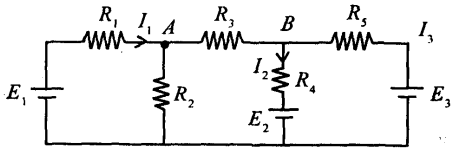

Fig. 1

$R_1 = R_3 = R_5 = 20\ \Omega$
$R_2 = R_4 = 10\ \Omega$
$E_1 = 100$ V, $E_2 = E_3 = 50$ V.

Neglect the resistance of the sources. 8

(*b*) Determine the power supplied by the sources E_1, E_2 and E_3 and the power loss in R_5. 6

(*c*) When do you think Thevenin's theorem can be applied most effectively compared to other methods such as superposition theorem or mesh analysis ? 6

4. (*a*) A circuit consists of a lossy inductor which takes 5 A at 240 V and 50 Hz and the power dissipated is 600 W. What is the inductance of the coil ? Find the power factor. 4 + 4

(*b*) The above coil is now connected in series with a 100 μF capacitor. Determine the current in the new circuit, power factor, power dissipated and the voltages across the coil and the capacitor, when the same voltage is applied across it. 4+2+2+2+2

Group B

5. (*a*) Figure 2 shows the equivalent circuit for a single-phase transformer. The values given are in term of the primary side (in ohm). The ratio of secondary-to-primary turns is 10 and the load is inductive. Find the (*i*) secondary terminal voltage, (*ii*) primary current, (*iii*) regulation and (*iv*) efficiency. 4 × 4

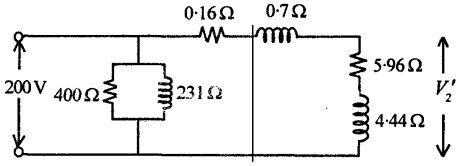

Fig. 2

(*b*) What is the power factor of the circuit ? 4

6. (*a*) Show the open circuit characteristics of a d.c. shunt generator and explain the building-up process. What do you understand by critical resistance and critical speed ? 6 + 6

(*b*) The emf generated by a 4-pole d.c. generator is 400 V when the armature is driven at 1000 r.p.m. Calculate the flux per pole, if the wave wound armature has 39 slots with 16 conductors per slot. 6

(*c*) What is the function of a commutator ? 2

7. (*a*) A d.c. motor takes an armature current of 110 A at 480 V. The resistance of the armature circuit is 0·2 Ω. The machine has six poles and the armature is lap wound with 864 conductors. The flux per pole is 0·05 Wb. Calculate the (*i*) speed and (*ii*) gross torque developed by the armature. 6 + 6

(*b*) A series motor runs at 600 rpm when taking 110 A from a 230 V supply. The resistance of the armature circuit is 0·12 Ω and that of the series winding is 0·03 Ω. Calculate the speed when the current has fallen to 50 A, given that the useful flux per pole for 110 A is 0·024 Wb and that for 50 A is 0·0155 Wb. 8

8. (*a*) Explain why an induction motor cannot develop torque when running at synchronous speed. Define the slip speed of an induction motor and deduce how the frequency of rotor currents and the magnitude of the rotor e.m.f. are related to slip. 8

(*b*) An induction motor has four poles and is energised from a three-phase 50 Hz supply. If the machine runs on full load at 2% slip, determine the running speed and frequency of the rotor current. 6

(*c*) Sketch the torque-speed characteristics of a three-phase induction motor. What is the torque maximum and how can it be obtained in a slip ring induction motor ? 6

Group C

9. Write short answers for *any five* of the following : 5 × 4

(*i*) Methods of starting a three-phase induction motor.

(*ii*) Determination of synchronous impedance of a synchronous generator (alternator).

(*iii*) Advantages of a ring main distribution system.

(*iv*) Measurement of three-phase power by 2-watt-meter method showing its connection diagram.

(*v*) Resonance in a series circuit and the variation of current with frequency.

(*vi*) Determination of Thevenin's equivalent circuit from a terminal pair A-B with the rest of the circuit elements unknown.

(*vii*) Measures to reduce eddy current and hysteresis losses in transformers.

S'16:7AN : AN 210 (1410)

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 answers 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 the term 'electric field intensity'. 5 + 3

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

   (*c*) What is meant by 'superposition of electric fields' ? Explain. 6

2. (*a*) A leaky capacitor has $Z_C = 74{\cdot}5\ \Omega$. It is connected in series with a coil having $Z_L = 40\ \Omega$ and a resistance, R, of 56 Ω. The applied voltage is 200 V and circuit current is 2·5 A. The voltage across R and Z_L combination is 194 V. Find the loss in capacitor. 10

(Turn Over)

(*b*) Explain the term 'power factor'. 5

(*c*) What is meant by series resonance in a.c. circuits ? 5

3. (*a*) What is eddy current loss ? How can it be reduced ? 8

(*b*) What is meant by power factor improvement ? Why is it necessary ? How can it be done ? 9

(*c*) What is a magnetization curve ? 3

4. (*a*) A star-connected load has a resistance of 6 Ω and reactance of 8 Ω in each branch. Line voltage is 220 V. Find line current and total power. 8

(*b*) Explain the term 'phase sequence'. 4

(*c*) How is power measured in a three-phase circuit ? Draw the connection diagram and explain. 8

Group B

5. (*a*) Derive the formula for calculating voltage regulation of a two winding transformer. 6

(*b*) Enumerate the losses in a transformer. 2

(*c*) A 230/110 V single-phase transformer takes an input of 350 VA at no load and at rated voltage. The core loss is 110 W. Find iron loss component of no load current and no load power factor. 6

(*d*) Draw equivalent circuit of a two winding transformer. 6

6. (*a*) Derive the emf equation of a d.c. generator. 6

(*b*) Explain the term 'commutation'. 6

(*c*) A d.c. shunt generator has an induced voltage of 127 V on open circuit. When the machine is supplying load, the terminal voltage is 120 V. Find load current, if armature resistance is 0·02 Ω and field resistance is 15 Ω . 6

(*d*) What is the function of brush in d.c. machines ? 2

7. (*a*) Derive an expression for voltage induced in an alternator. 7

(*b*) Explain the term 'synchronous impedance'. 6

(*c*) What is meant by slip of an induction motor ? 2

(*d*) Briefly explain the construction of an induction motor. 5

8. (*a*) Differentiate between ring main and radial distributor. 5

(*b*) Why is three-phase four-wire distribution so commonly used ? 5

(*c*) Compare two-wire d.c. and three wire d.c. distribution in terms of copper efficiency. 5

(*d*) Briefly explain the working of single-phase induction motor. 5

Group C

9. Answer the following in brief : 10 × 2

(*i*) What is meant by half power points ?

(*ii*) What is the utilility of Thevenin's theorem ?

(*iii*) What is the ratio I/E called ? What are its units ?

(*iv*) What is a dipole ?

(*v*) What is the difference between MMF and H ?

(*vi*) Why is transformer used in power system ?

(*vii*) What is meant by rotating field ?

(*viii*) Why should speed of an alternator be kept constant ?

(*ix*) Write applications of single-phase motor.

(*x*) What is meant by voltage profile of a distributor ?

W'16:7AN:AN 210 (1410)

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 answers 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 Ampere's law. 4

(*b*) State and explain Kirchhoff's Voltage and Current Laws. Discuss their applications. 6

(*c*) A battery of 10 V having no internal resistance is connected across between points *A* & *G*, which are diagonically opposite in a network shown here in Fig.1, where all the resistances (in the network) are of 12 ohm value. Calculate equivalent resistance of the network and currents along the various sides of the network. 10

(Turn Over)

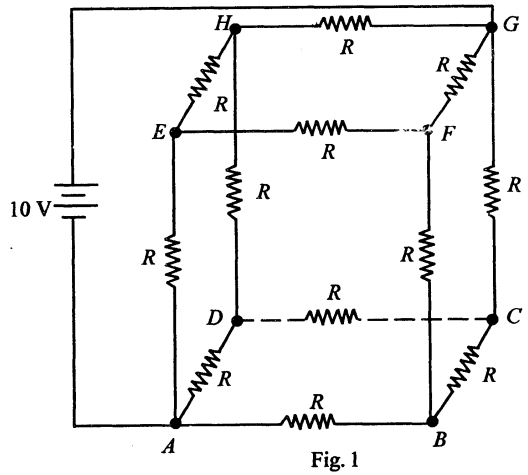

Fig. 1

2. (*a*) State and explain, Maximum power transfer theorem and show that efficiency under maximum power transfer is 50 percent lower. 6

(*b*) In the network shown in Fig.2, find value of load resistance R_L for maximum power transfer and also calculate maximum power (transfer). 8

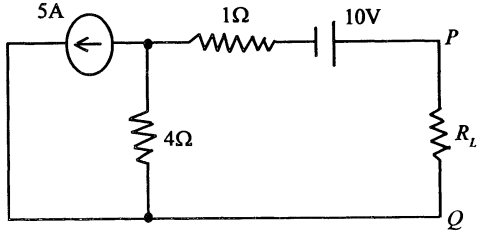

Fig.2

(*c*) What do you mean by "Source Conversion" in an electrical circuit, where does it find its application, explain. 6

3. (*a*) What does the term 'effective value' of an ac voltage mean ? Derive an expression for effective value of ac Sinusoidal voltage. Give a relationship between 'effective value' and 'average value, of ac sinusoidal voltage. 6

(*b*) Explain the terms 'Frequency' and 'Time period' of an ac wave. 4

(*c*) Explain an ac, R-L-C series circuit for (*a*) $X_L > X_C$, (*b*) $X_L < X_C$ and $X_L = X_C$ and draw the phasor diagram of each case, and discuss individual case (*a*, *b*, and *c*). 10

4. (*a*) Explain the terms ; (*i*) permeability, (*ii*) reluctance, (*iii*) permeance, and (*iv*) relative permeability. 4

(*b*) Bring out the analogy between electric circuit and magnetic circuit. What are the major points of difference between them ? 6

(*c*) Draw a B-H curve for a magnetic material and explain why this curve is non-linear. Explain the term saturation. 4

(*d*) Draw and explain the hysteresis loop of a ferromagnetic material. Explain the terms : hysteresis loss and how can it be reduced. 6

Group B

5. (*a*) Discuss principle of operation of a single phase transformer and derive an expression for the emf induced in the transformer winding. 7

(*b*) Explain working of a transformer On-Load (R-L- load) and draw a neat phasor diagram of the transformer (On-Load). 7

(*c*) A 1000 kVA transformer has primary and secondary turns of 400 and 100, respectively and induced voltage in this secondary winding is 1000 V. Find (*i*) the primary voltage, (*ii*) the primary and secondary full load current, and (*iii*) the secondary current when 1000 kW load at 0·8 p.f. is connected at the output. 6

6. (*a*) Distinguish between a feeder, distributor and service main in a distribution scheme. 6

(*b*) Compare a dc 2-wire system with ac, 3 phase 3 wire system for volume of copper in the two systems on the basis of equal maximum potential difference between conductors to earth. 8

2. (*c*) Prove that the voltage drop diagram for an uniformly loaded distributor fed at one end is a parabola. 6

7. (*a*) What are the types of three-phase induction motor as per their rotor construction ? Compare between them. 5

(*b*) Derive the expresson for maximum torque in a 3-phase induction motor in terms of rotor quantities. What is the expression for a starting torque ? 7

(*c*) Derive the torque-slip characteristics of a 3-phase induction motor. What is the effect of variation of rotor resistance (external) on this characteristic ? 8

8. (*a*) What are different types of dc generators according to the ways in which their respective fields are excited. Show the connection diagram of each type and discuss. 7

(*b*) Discuss the external characteristics of various types of dc generators. 7

(*c*) An 8-pole dc generator has 96 slots and 16 conductors per slot. The flux per pole is 40 mWb and the speed is 960 rpm. Find the emf produced if this machine is (*i*) wave wound and (*ii*) lap wound. 6

Group C

9. Answer the following, in brief : 10 × 2

(*i*) The superposition theorem is NOT valid for power responses, why ?

(*ii*) In electrical machines, the cores are laminated, why ?

(*iii*) A reactance relay is basically a directional restrained over-current relay, justify.

(*iv*) Power factor of a capacitive and inductive circuit will be zero, why ?

(*v*) A cummulatively compounded motor becomes a differentially compounded generator, why ?

(*vi*) Why dc shunt generator is used to charge the batteries ?

(*vii*) The rotor reactance of an induction motor slip ring type is more than squirrel type, why ?

(*viii*) In an alternator, the armature reaction influences the magnitude of terminal voltage per phase, why ?

(*ix*) A 3-phase induction motor should have small air gap length so as to have better power factor.

(*x*) Why a transformer can NOT work on dc supply ?