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.

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*) 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

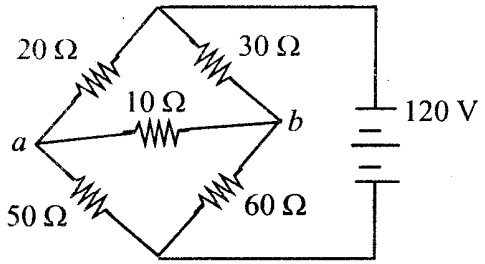


Fig. 1

(*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

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

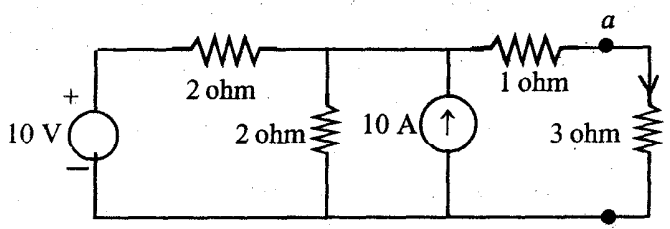


Fig. 1

(*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?

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*) 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. 8

(*b*) What do you understand by the term 'electric potential'? 6

(*c*) State and explain Thevenin's theorem. 6

2. (*a*) An arc lamp (which may be regarded as non-inductive) takes 10 A at 50 V. Find the impedance of a choke of 1 ohm resistance to be connected in series with the arc lamp so that the lamp may be used at 200 V 50 Hz supply. Also, find the total active power and power factor. 8

(*b*) Explain the term 'series resonance'. 4

(*c*) Define the terms 'impedance' and 'admittance'. 4

(*d*) What is the use of phasor diagram ? 4

3. (*a*) An air cored toroidal coil has 3000 turns and carries 0.1 A current. The length of magnetic circuit is 15 cm and cross-sectional area of coil is 4 cm^2. Find H, B and flux. 6

(*b*) What is meant by the term 'reluctance' ? 4

(*c*) Explain eddy current loss and hysteresis loss in a magnetic circuit. 6

(*d*) What is meant by 'saturation' of a magnetic circuit ? 4

4. (*a*) What is the difference between balanced and unbalanced load ? 4

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

(*c*) A star-connected three-phase load has a resistance of 6 ohms and an inductive reactance of 8 ohms in each branch. The line voltage is 220 V. Find line current, total active power, and phase voltage. 8

(*d*) What is the use of symmetrical components ? 4

Group B

5. (*a*) Distinguish between radial, ring and parallel feeders. 6

(*b*) Why are conductors of overhead lines stranded ? 3

(*c*) What is ACSR conductor ? 3

(*d*) A 400 m long distributor has the following unity power factor loads tapped off R phase :
100 A load at 100 m from feeding point
120 A load at 250 m from feeding point
80 A load at 400 m from feeding point.
The resistance of conductor is 0.25 ohm/km length. Voltage at feeding point is 240 V. Find the voltage at the far end. Neglect voltage drop in neutral conductor. 8

6. (*a*) What are various losses in a transformer ? 4

(*b*) What is meant by voltage regulation of a transformer ? Derive a formula for calculating voltage regulation. 8

(*c*) Write the names of different parts of a d.c. machine. 4

(*d*) Name different types of d.c. motors. 4

7. (*a*) An 8 pole lap wound d.c. generator has 960 conductors, a flux of 40 mWb per pole and is driven at 400 rpm. Find open circuit voltage. Derive the expression used. 10

(*b*) Name some applications of single-phase motor. 4

(*c*) Explain the process of self-excitation in d.c. generators. 6

8. (*a*) Explain the principle of operation of three-phase induction motor. 6

(*b*) The input to a three-phase 50 Hz 4-pole induction motor is 150 kW. Stator losses are 5 kW, mechanical losses are 3 kW and full load slip is 0.05. Find frequency of rotor e.m.f. at standstill, frequency of rotor e.m.f. at full load, and rotor copper losses. 9

(*c*) Briefly describe the principle of operation of synchronous generator. 5

Group C

9. Answer the following in brief: 10 × 2

(*i*) Name some applications of capacitors.

(*ii*) How are electric field intensity and potential related ?

(*iii*) Name some applications of principle of superposition.

(*iv*) How are magnetic materials classified ?

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

(*vi*) How are induced e.m.f.s classified ?

(*vii*) What are the factors on which inductance of a coil depend ?

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

(*ix*) What is back e.m.f. ?

(*x*) Why is rotor core loss negligible in three-phase induction motor ?

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 electric field intensity. 6

(*b*) A metallic sphere carries a charge. How does electric field and potential vary (*i*) inside the sphere, (*ii*) on the surface of sphere, and (*iii*) outside the sphere ? 6

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

2. (*a*) Differentiate between voltage source and current source. 6

(*b*) Use superposition theorem to find currents in different branches of the circuit shown in Fig. 1 : 8

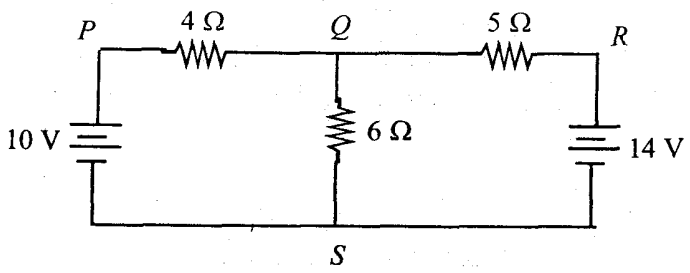


Fig. 1

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

3. (*a*) How can sinusoidal quantities be represented by phasors ? 6

(*b*) What is meant by the term 'power factor' ? Discuss its significance. 6

(*c*) An inductive coil takes 10 A and dissipates 1000 W when connected to 250 V, 25 Hz supply. Find impedance, resistance, reactance, inductance, power factor. 8

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

(*b*) Distinguish between balanced and unbalanced load. 6

(*c*) Three loads $31 + j\,59$ ohm, $30 - j\,40$ ohm and $80 + j\,60$ ohm are connected in delta across a 200 V, 3-phase system. Find phase currents and line currents. Also, find total power. 10

Group B

5. (*a*) Draw and explain equivalent circuit of a single-phase transformer. 10

(*b*) The primary and secondary winding resistance of a 40 kVA, 6600/250 V, single-phase transformer are 10 ohm and 0.02 ohm, respectively. The equivalent leakage reactance, as referred to primary, is 35 ohm. Find full load regulation at load power factors of unity and 0.8 lagging. 10

6. (*a*) Differentiate between series and shunt d.c. motors as regards their construction and characteristics. 10

(*b*) Name different parts of a d.c.generator. 5

(*c*) What is the function of commutator in a d.c. generator ? 5

7. (*a*) What is meant by the term 'rotating field' ? 6

(*b*) How are induction motors started ? 6

(*c*) The power input to rotor of a 3-phase 4-pole 50 Hz induction motor is 100 kW. The full load slip is 0.04. Find rotor speed and rotor copper loss. 8

8. Write short notes on the following : 7 + 7 + 6

(*a*) A.C. 3-phase 4-wire distribution

(*b*) Starting of single-phase induction motor

(*c*) Voltage regulation.

Group C

9. Choose the best alternative for the following : 20×1

(*i*) The electric field intensity at a point situated 4 m from a point charge is 500 N C^{-1}. If the distance is reduced to 2 m, the electric field intensity will be

(*a*) 1000 N C^{-1}
(*b*) 2000 N C^{-1}
(*c*) 250 N C^{-1}
(*d*) 125 N C^{-1}

(*ii*) An ideal voltage source should have

(*a*) zero internal resistance.
(*b*) infinite internal resistance.
(*c*) large value of e.m.f.
(*d*) low value of e.m.f

(*iii*) Tesla is the unit of

(*a*) flux
(*b*) field strength
(*c*) flux density
(*d*) mmf

(*iv*) An air gap is usually inserted in magnetic circuits to

(*a*) increase flux.
(*b*) prevent saturation.
(*c*) increase mmf.
(*d*) decrease flux.

(*v*) If the area of hysteresis loop of a material is large, the hysteresis loss in this material will be

(*a*) small.
(*b*) large.
(*c*) zero.
(*d*) small or zero.

(*vi*) The magnitude of statically induces e.m.f. depends on

(*a*) magnitude of flux.
(*b*) rate of change of flux.
(*c*) resistance of coil.
(*d*) None of the above.

(*vii*) If a capacitor is connected to a.c.source, the current — the source voltage by —.

(*a*) lags, 90°
(*b*) lags, 45°
(*c*) leads, 90°
(*d*) leads, 45°

(*viii*) A series RLC circuit has a resonance frequency of 1000 Hz. If the inductance is made 4 times, the resonance frequency will be

(*a*) 1000 Hz
(*b*) 500 Hz
(*c*) 707 Hz
(*d*) 4000 Hz

(*ix*) At a half power point of a series RLC circuit,

(*a*) $X_L - X_C = R$
(*b*) $X_L = R$
(*c*) $X_L - X_C = 2R$
(*d*) $X_L - X_C = 0$

(*x*) A 3-phase 4-wire system supplies a balanced star load. The current in each phase wire is 5 A. The current in neutral wire is

(*a*) 5 A
(*b*) $5\sqrt{3}$ A
(*c*) 0
(*d*) 15 A

(*xi*) In a 10 kVA, 230/1000 V single-phase transformer, the no-load current is about

(*a*) 1 A
(*b*) 3 A
(*c*) 0.5 A
(*d*) 10 A

(*xii*) Under no-load conditions, the power factor of a transformer is

(*a*) zero.
(*b*) about 0.4 lagging.
(*c*) unity.
(*d*) about 0.8 lagging.

(*xiii*) The voltage regulation of a well designed transformer is of the order of

(*a*) 10%
(*b*) 50%
(*c*) 2%
(*d*) 0.1%

(*xiv*) The change in speed from no load to full-load in a 3-phase induction motor is about

(*a*) 2%
(*b*) 8%
(*c*) 15%
(*d*) 50%

(*xv*) In a 50 Hz 3-phase induction motor, the frequency of rotor current is about

(*a*) 50 Hz
(*b*) 2 Hz
(*c*) 10 Hz
(*d*) zero

(*xvi*) At s = zero, the torque of a 3-phase induction motor is

(*a*) 0
(*b*) small
(*c*) very high
(*d*) high

(*xvii*) In India, the rated voltage of alternators used in power stations is usually

(*a*) 11 kV
(*b*) 66 kV
(*c*) 132 kV
(*d*) 400 kV

(*xviii*) The motor used in household in mixers is generally

(*a*) shaded pole motor.
(*b*) universal motor.
(*c*) capacitor start motor.
(*d*) split capacitor motor.

(*xix*) In a capacitor start motor, the capacitor is connected in

(*a*) series with main winding.

(*b*) series with auxiliary winding.

(*c*) parallel with main winding.

(*d*) parallel with auxiliary winding.

(*xx*) A series circuit has $R = 10\ \Omega$, $L = 0.1$ H, $C = 10\ \mu$F. The Q-factor is

(*a*) 100

(*b*) 10

(*c*) 115

(*d*) 10.1

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 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. 4+6

(*b*) An iron ring, having a mean diameter 20 cm and cross-section 4 cm^2, is uniformly wound with a coil of 2000 turns. A current of 0.25 A through the coil produces 0.1 mWb flux inside the core. Determine the relative permeability of the core material. 6

(*c*) A radial air gap, 1 mm in length, is cut into the above ring. Find the current that would now produce the same flux in the core as above. Ignore fringing. 4

2. (*a*) The emf of a 240 V alternator passes through an instantaneous value of 280 V and changes at the rate of 60000 V/sec at $t = 0$. Derive a mathematical equation for the waveform. 6

(*b*) Derive an expression for the energy stored in the electric field when a capacitor C is charged to a potential difference of V. 6

(*c*) For the arrangement shown in Fig. 1, find the equivalent capacitance of the combination between terminals *a* and *b*. Also, calculate the energy stored in the 4 μF capacitor, if the combination is connected across a 250 V d.c. supply. 4+4

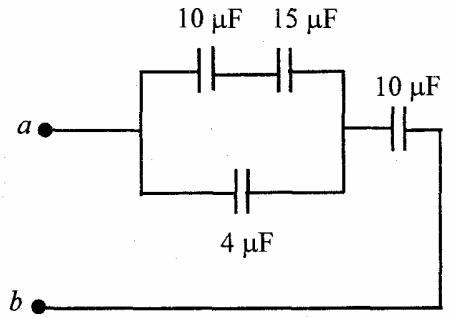


Fig. 1

3. (*a*) State and explain the principle of superposition. 4

(*b*) A linear network is energised with two ideal voltage sources having emfs E_1 and E_2. The currents in a particular branch of the network are found to be 4 A when $E_2 = 0$ and 2 A when $E_1 = 0$. Determine the current that would flow through this branch due to simultaneous action of the sources assuming that the emf values have been changed respectively to $3E_1$ and $-2E_2$. 4

(*c*) Load resistances 5 Ω and 15 Ω, when connected across the terminals *a* and *b* of an energised network, draw currents 4 A and 2 A, respectively. Find the (*i*) current that would flow when a 35 Ω resistance is connected across these terminals, and (*ii*) maximum power deliverable by the network to a load that may be connected across these terminals. 8+4

4. (*a*) A 0.5 H choke coil having a resistance of 100 Ω is connected in series with a variable capacitor across a 100 V, 50 Hz supply. Determine the value of the capacitance so that the current through the combination is the maximum. Draw a phasor diagram and find the voltage drop across the (*i*) coil, and (*ii*) capacitor under this condition. 4+2+2+2

(*b*) With a neat connection diagram, show how two wattmeters may be connected to measure the active power in a three-phase three-wire circuit. 6

(*c*) Two wattmeters are connected to measure power in a balanced three-phase 4 kVA, 0.75 lagging power factor load. Determine their individual readings. 4

Group B

5. (*a*) Define regulation as applicable to a transformer and derive an expression for the same in terms of the parameters of the equivalent circuit in case of a single-phase transformer. 8

(*b*) On short-circuiting the high voltage terminals of a 25 kVA, 250 V : 2500 V, 50 Hz transformer, a potential difference of 20 V at the low voltage terminals circulates full load current in the transformer, resulting in 400 W copper loss. Calculate the (*i*) regulation of the transformer for full-load, unity power factor condition, and (*ii*) potential difference at the high voltage terminals for half load at 0.8 lagging power factor, assuming that source voltage at low voltage terminals is maintained at 250 V. 4+4

(*c*) Discuss why all day efficiency is important in case of a distribution transformer. 4

6. (*a*) An induction motor runs at 1440 rpm at full load from a three-phase, 415 V, 50 Hz supply. Calculate the (*i*) number of poles, (*ii*) speed of the rotor field with respect to the rotor, and (*iii*) speed of the rotor field with respect to the stator frame. 6

(*b*) Derive an expression for the torque developed in an induction motor. Draw the nature of torque-slip curve with justification. Also, determine the slip at which maximum torque occurs. 8

(*c*) Discuss the functions of a rotor-resistance starter for an induction motor. 6

7. (*a*) Explain clearly the significance of the (*i*) pitch factor, and (*ii*) distribution factor of the armature winding of an alternator. Derive an expression for emf induced in each phase of an alternator. 8

(*b*) Calculate the frequency and no-load terminal voltage of a three-phase star-connected alternator with 4 poles, producing sinusoidally distributed flux of 50 mWb per pole and having 180 armature slots with 12 conductor per slot and running at 1500 rpm. Assume armature coils are full pitched. 8

(*c*) What type of motor would you prefer for driving the line-shaft in a workshop ? Justify your answer. 4

8. (*a*) Derive an expression for the torque developed in a d.c. machine. 6

(*b*) A belt driven shunt generator delivers 110 kW to a 220 V bus bar while running at 500 rpm. The belt breaks suddenly, but the machine continues to run as a motor, drawing 11 kW from the bus bar. Assuming armature and field resistances to be 0.025 Ω and 55 Ω, respectively and total brush voltage drop to be 1 V, determine the speed at which the machine shall run under this changed situation. Ignore armature reaction. 8

(*c*) Compare the advantages and disadvantages of a.c. 3-wire and 4-wire distribution system. 6

Group C

9. Choose the *correct* answer for the following: 20×1

(*i*) Two point charges, each equal to 1.0 μC are spaced at a distance of 1 cm in a liquid having permittivity of 3. The electrostatic force between them is nearly

(*a*) 10 kg

(*b*) 30 N

(*c*) 90 N

(*d*) None of the above.

(*ii*) Three conductors A, B and C meet at a junction. The current in conductor A is $10 \angle 45°$ A towards the junction and that in B is $10 \angle -45°$ A, away from the junction. The current in C towards the junction is

(*a*) $10.00 \angle 90°$ A

(*b*) $14.14 \angle -90°$ A

(*c*) $20.00 \angle 45°$ A

(*d*) $14.14 \angle 0°$ A

(*iii*) A 2 A d.c. current source, having internal resistance of 50 ohm in parallel, is connected across a load resistance. The maximum value of power that may be supplied to the load is

(*a*) 50 W

(*b*) 100 W

(*c*) 25 W

(*d*) None of the above.

(*iv*) A 10 μF capacitor, initially having no charge, is supplied with a constant current of 10 mA for 10 sec. The final energy stored in it is

(*a*) 150 J

(*b*) 250 J

(*c*) 500 J

(*d*) None of the above.

(*v*) Two coils with self-inductance of 1 H and 4 H are mutually coupled, the coefficient of coupling being 0.5. The coils are connected in series. The possible values of the equivalent inductance of the combination are

(*a*) 3 H and 5 H

(*b*) 3 H and 7 H

(*c*) 5 H and 7 H

(*d*) 1 H and 9 H

(*vi*) Three capacitors, each of 100 μF capacitance, are star-connected to form a capacitor bank. The reactive power drawn by the combination when connected across a 415 V, 3-phase, 50 Hz supply is

(*a*) 1.803 kVAR

(*b*) 5.408 kVAR

(*c*) 9.368 kVAR

(*d*) 16.225 kVAR

(*vii*) A tank circuit, consisting of a 10 mH choke coil having a resistance of 1 Ω, and a 1 μF capacitance, is tuned for parallel resonance. The equivalent resistance of the combination is

(*a*) 0.001 ohm

(*b*) 1.000 ohm

(*c*) 1000 ohm

(*d*) 10000 ohm

(*viii*) The total power delivered in a balanced three-phase 50 Hz a.c. circuit is

(*a*) constant at every instant of time.

(*b*) pulsating at 25 Hz.

(*c*) pulsating at supply frequency.

(*d*) pulsating at 100 Hz.

(*ix*) Two wattmeters, connected to measure power in a three-phase balanced circuit, read 100 W each. The reactive power absorbed by the circuit is

(*a*) 0 Var

(*b*) 100 Var

(*c*) 200 Var

(*d*) None of the above.

(*x*) The insulation resistance of 1 km length of a piece of cable is known to be 100 MΩ. The insulation resistance of 100 m length of the same cable will be

(*a*) 10 MΩ

(*b*) 100 MΩ

(*c*) 1000 MΩ

(*d*) 100000 MΩ

(*xi*) For a uniformly loaded d.c. distributor, when fed at one end, the maximum voltage drop is found to be 10 V. The maximum voltage drop in the distributor for the same load when it is fed at both ends at the same voltage would be

(*a*) 2.5 V

(*b*) 5.0 V

(*c*) 10 V

(*d*) 20 V

(*xii*) For a 150 kVA transformer, the iron loss and full load copper loss are 2.25 kW and 4 kW, respectively. The maximum efficiency of the transformer is nearly

(*a*) 0.962

(*b*) 0.974

(*c*) 0.980

(*d*) 0.985

(*xiii*) The core of a transformer is laminated to reduce the

(*a*) eddy current loss

(*b*) hysteresis loss

(*c*) copper loss

(*d*) All of the above.

(*xiv*) A 4-pole, wave-wound d.c. machine having 480 armature conductors, runs at 600 rpm in a field flux of 50 mWb per pole. The induced emf in the machine is

(*a*) 60 V

(*b*) 120 V

(*c*) 240 V

(*d*) 480 V

(*xv*) During regenerative breaking of a d.c. motor, the induced emf in the machine shall be

(*a*) less than the supply voltage.

(*b*) equal to the supply voltage.

(*c*) larger than the supply voltage.

(*d*) None of the above.

(*xvi*) A 3-phase, 8-pole slip ring induction motor connected across a 415 V, 50 Hz supply is running at 720 rpm. Determine the frequency of the rotor current.

(*a*) 2 Hz

(*b*) 4 Hz

(*c*) 5 Hz

(*d*) 30 Hz

(*xvii*) No starting torque will develop in a split phase induction motor, if the phase difference between the currents of main and auxiliary winding is

(*a*) 90°

(*b*) more than 90°

(*c*) less than 90°

(*d*) zero

(*xviii*) A star-delta starter reduces the line current of a three-phase induction motor at starting by a factor of

(*a*) $\sqrt{3}$

(*b*) 3

(*c*) $3\sqrt{3}$

(*d*) None of the above.

(*xix*) For an alternator connected directly to an infinite bus, when the field current is increased, the

(*a*) active power output increases.

(*b*) terminal voltage increases.

(*c*) frequency increases.

(*d*) reactive power output increases.

(*xx*) A synchronous motor with an under-excited field

(*a*) draws leading power factor current.

(*b*) draws lagging power factor current.

(*c*) runs at more than synchronous speed.

(*d*) runs at sub-synchronous speed.

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 Thevenin's theorem and mention its applications. 10

(*b*) Find the Thevenin's equivalent for the circuit shown in Fig. 1. 10

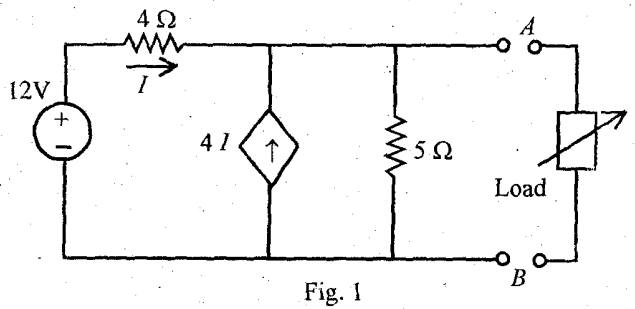


Fig. 1

2. (*a*) Explain magnetization characteristics of ferro-magnetic materials and draw the characteristics. 8

(*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. 12

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

(*b*) A symmetrical 440 V, 3-phase system supplies a star-connected load with the following impedances: $Z_A = 50$ ohms; $Z_B = j15$ ohms; and $Z_C = -j15$ ohms. Calculate the voltage drop across each branch and the potential of the star point with reference to earth. Also, sketch the phasor diagram of voltages, the phase sequence being *A*–*B*–*C*. 12

4. (*a*) Define symmetrical components and mention their applications. 8

(*b*) The power input to a 2200 V, 50 Hz, 3-phase motor, running on full-load at an efficiency of 90%, is measured by two watt-meters, which indicate 500 kW and 200 kW, respectively. Calculate the (*i*) total input power, (*ii*) power factor, (*iii*) line current, and (*iv*) horse power output. 12

Group B

5. (*a*) Describe various losses in single-phase transformer and derive condition for maximum efficiency. 8

(*b*) A small sub-station has a single-phase 6600/240 V transformer supplying four feeders which take the following loads:
(*i*) 10 kW at 0·8 p.f. lag
(*ii*) 50 A at 0·7 p.f. lag
(*iii*) 5 kW at unity p.f.
(*iv*) 8 kVA at 0·6 p.f. lead.
Determine the primary current and power factor which the transformer takes from the 6600 V system. Neglect losses in the transformer and magnetising current. 12

6. (*a*) Explain principle of operation of 3-ϕ induction motor and distinguish between squirrel cage induction motor and slip ring induction motor. Mention their applications. 8

(*b*) 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. 12

7. (*a*) Draw the load characteristics of various types of d.c. generators in one figure, assuming same no-load terminal voltage. Compare these characteristics. Give one application of each generator. 8

(*b*) The induced emf in a d.c. machine while running at 750 rpm is 220 V. Calculate the

(*i*) speed at which the induced emf will be 250 V, assuming constant flux, and 6

(*ii*) percentage increase in the field flux for an induced emf of 250 V and speed of 700 rpm. 6

8. (*a*) Explain operation of single-phase induction motor of shaded pole type with a neat sketch. Mention its applications. 10

(*b*) Compare copper efficiencies of different disribution systems. 10

Group C

9. Choose the *correct* answer for the following: 20×1

(*i*) Which one of the following would represent the shunt field resistance of a d.c. compound generator ?

(*a*) 1·0 Ω

(*b*) 100 Ω

(*c*) 1·5 Ω

(*d*) None of the above.

(*ii*) When the induction motor is supplying a load, the relative speed between the rotor and the rotating magnetic field is

(*a*) zero.

(*b*) equal to the synchronous speed.

(*c*) more than the synchronous speed.

(*d*) less than the synchronous speed.

(*iii*) When a transformer, having a turns ratio of a (N_1 / N_2) supplies a secondary load current of I_2, the primary current consists of the

(*a*) phasor sum of I_0 and I_2.

(*b*) phasor sum of I_0 and aI_2.

(*c*) phasor sum of I_0 and $a^2 I_2$.

(*d*) phasor sum of (I_2 / a) and I_0.

(*iv*) When a 400 V, 50 Hz, 6-pole induction motor is rotating at 960 rpm on no-load, its slip is

(*a*) 1%

(*b*) 2%

(*c*) 3%

(*d*) 4%

(*v*) When a single-phase supply is connected across a single-phase winding, the nature of the magnetic field produced is

(*a*) pulsating in nature.

(*b*) rotating in nature.

(*c*) constant in magnitude but rotating at synchonous speed.

(*d*) constant in magnitude and direction.

(*vi*) The copper-loss and core loss of a transformer at various loads are as shown below. At what load will the efficiency of the transformer be maximum ?

	Load	Core Loss	Copper Loss
(*a*)	50 kVA	320 W	500 W
(*b*)	40 kVA	320 W	320 W
(*c*)	30 kVA	320 W	180 W
(*d*)	20 kVA	320 W	80 W

(*vii*) A transformer, when supplying a load, maintained 11 kV across load terminals. When the load was switched-off, the terminal voltage became 11,550 V. What is the voltage regulation at this load?

(*a*) 11·55%

(*b*) 5·5%

(*c*) 5%

(*d*) 55%

(*viii*) In a d.c. machine, interpoles are used to

(*a*) neutralize the effect of armature reaction in the interpolar region.

(*b*) generate more induced emf in the armature.

(*c*) avoid interference of the armature flux with the main field flux.

(*d*) reduce the demagnetising effect of armature reaction.

(*ix*) A d.c. series motor should always be started with load because

(*a*) at no-load it will rotate at a dangerously high speed.

(*b*) at no-load it will not develop high starting torque.

(*c*) it cannot start without load.

(*d*) it draws a small amount of current at no-load.

(*x*) The number of parallel paths in the armature winding of a four-pole wave connected d.c machine having 22 coil-sides is

(*a*) 4

(*b*) 2

(*c*) 22

(*d*) 1

(*xi*) In a circuit, having a resistance, reactance and a power factor angle ϕ, the power absorbed by the circuit is maximum when ϕ is equal to

(*a*) 90°

(*b*) 45°

(*c*) 0°

(*d*) None of the above.

(*xii*) Reactive power in a circuit signifies

(*a*) energy exchanged between magnetic/electric field and source.

(*b*) energy consumed by the magnetic/electric field.

(*c*) energy consumed by the resistance of the inductance/capacitance.

(*d*) energy consumed by the resistance in the circuit.

(*xx*) At $S = 0$, the torque of an induction...

(*a*) zero

(*b*) equal to full-load

(*c*) very high

(*d*) nearly zero.

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 Kirchhoff's laws for an electrical circuit. 6

(*b*) Explain the Faraday's laws of electromagnetic induction. 4

(*c*) Determine the current through a 2 ohm resistor connected between *A* and *B* in the circuit, shown in Fig. 1, using Thevenin theorem. 10

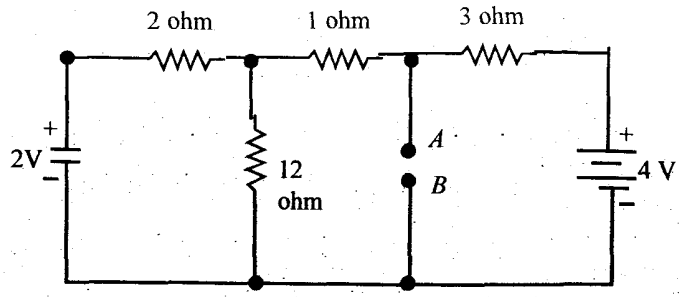


Fig. 1

2. (*a*) State and explain Coulomb's laws. Calculate the distance of separation between two electrons (in vacuum) for which the electric force between them is equal to the gravitational force on one of them at the earth surface. Mass of electron $= 9{\cdot}1 \times 10^{-31}$ kg, charge of electron $= 1{\cdot}6 \times 10^{-19}$ C. 5+5

(*b*) Two identical 750 turns coils *A* and *B* lie in parallel planes. A current changing at the rate of 1500 A/S in *A* induces an e.m.f. of 11·25 V in *B*. Calculate the mutual inductance of the arrangement. If the self-inductance of each coil is 15 mH, calculate the flux produced in coil *A* per ampere and the percentage of this flux which links the turns of *B*. 10

3. (*a*) Three similar coils, having a resistance of 20 ohms each, and an inductance of 0·05 H are connected in (*i*) star, (*ii*) mesh to a 3-phase, 50 Hz supply with 400 V between lines. Calculate the total power absorbed and the line current in each case. Draw the phasor diagram of current and voltage in each case. 12

(*b*) In the circuit of Fig. 2, calculate the voltage across the capacitor. Given that the applied voltage is 5 V, drops across the resistance and the inductance are 3 V and 1 V, respectively. Draw the voltage phasors. Assume that the inductance has negligible resistance. 8

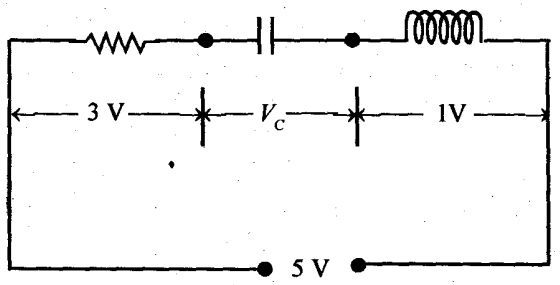


Fig. 2

4. (*a*) Explain the magnetic hysteresis and find out the expression for network done per cycle per metre cube, when the magnetic material of area *A* is subjected to an a.c. supply having frequency *f*. 10

(*b*) Show that in two wattmeters method of 3-phase power measurement, the sum of readings of two wattmeters gives the total power consumed in a 3-phase circuit. Hence, prove that

$$\tan\Phi = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$$

where Φ is the phase angle of the load; and W_1 and W_2, the readings of wattmeters. 10

Group B

5. (*a*) Describe the operation of a single-phase transformer, explaining clearly the functions of different parts. Why are the cores laminated? 10

   (*b*) A single-phase, 100 kVA, 2000/200 V, 50-Hz transformer has an impedance drop of 10% and resistance drop of 5%. Calculate the (*i*) regulation at full load 0·8 power factor lagging; (*ii*) value of the power factor at which the regulation is zero. 5+5

6. (*a*) Explain the principle of operation of a 3-phase induction motor. What is meant by slip of an induction motor? 10

   (*b*) A three-phase delta-connected cage-type induction motor when connected directly to 400 V, 50 Hz supply takes a starting current of 100 A in each stator phase. Calculate the

   (*i*) line current for direct on-line starting, 3

   (*ii*) line and phase starting currents for star-delta starting, and 3

   (*iii*) line and phase starting currents for a 70 percent tapping on auto-transformer starting. 4

7. (*a*) Explain what is meant by back e.m.f. Explain the principle of torque production in a d.c. motor. 3+7

   (*b*) (*i*) Explain the essential difference between cylindrical (smooth) and salient-pole rotors used in large alternators. 4

   (*ii*) What types of rotor would you expect to find in a 2-pole machine and a 12-pole machine? 4

   (*iii*) At what speed would each of the machines be driven in order to produce a frequency of 50 Hz. 2

8. (*a*) Discuss where ring main and radial distribution systems are used. 6

   (*b*) A 2-wire distributor, 500 m long, is fed at P at 250 V and loads of 40 A, 20 A, 60 A, 30 A and are tapped off from points A, B, C and D which are at distances of 100 m, 150 m, 300 m and 400 m from P, respectively. The distributor is also uniformly loaded at the rate of 0·1 A/m. If the resistance of the distributor per metre (go and return) is 0·0005 ohm, calculate the voltage at (*i*) point Q, and (*ii*) B. 14

Group C

9. Choose the *correct* answer for the following: 1 × 20

   (*i*) In a circuit, the voltage and the current are given by

   $$V = 10 \sin(\omega t + 30^\circ)$$

   and $$i = 10 \sin(\omega t - 30^\circ)$$

   The power consumed in the circuit is

   (*a*) 100 W

   (*b*) 50 W

   (*c*) 25 W

   (*d*) 12·5 W

   (*ii*) In a series RLC circuit excited by a voltage $e = E \sin \omega t$, where $LC < 1/\omega^2$,

   (*a*) current lags the applied voltage.

   (*b*) current leads the applied voltage.

   (*c*) current is in phase with the applied voltage.

   (*d*) voltages across L and C are equal.

(*iii*) The circuit, shown in Fig. 3, is linear and time-invariant. The sources are ideal. The voltage across the one ohm resistor and the current through it will be

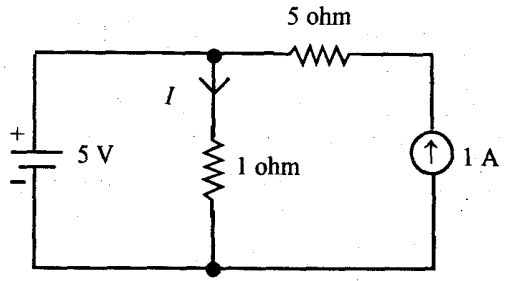


Fig. 3

(*a*) - 5 V and - 5 A.

(*b*) 1 V and 1 A.

(*c*) 1 V and 6 A.

(*d*) 5 V and 5 A.

(*iv*) When two coils, having self-inductances of L_1 and L_2, are coupled through a mutual inductance M, the coefficient of coupling, K, is

(*a*) $K = M/\sqrt{L_1 L_2}$

(*b*) $K = M/\sqrt{2L_1 L_2}$

(*c*) $K = 2M/\sqrt{L_1 L_2}$

(*d*) $K = L_1 L_2 / M$

(*v*) Three identical impedances are connected in delta to a 3-phase supply of 400 V. The line current is 34·65 A and the total power taken is 14·4 kW. The resistance of the load in each phase (in ohms) is

(*a*) 20

(*b*) 16

(*c*) 12

(*d*) 10

(*vi*) 'In any network of linear impedances, the current flowing through any branch is equal to the algebraic sum of the currents caused to flow through that branch by each of the sources of emf taking separately with all other emf's reduced to zero.' This statement represents

(*a*) Kirchhoff's current law

(*b*) Norton's theorem

(*c*) Thevenin's theorem

(*d*) Superposition theorem.

(*vii*) The power, in a 3-phase, 3-wire load circuit, is measured by two wattmeters. If the p.f. of the load circuit is approximately 0·2, then reading of

(*a*) one wattmeter will be negative.

(*b*) both wattmeters will be negative.

(*c*) both wattmeters will be positive.

(*d*) may be positive or negative depending upon the magnitude of load.

(*viii*) Dynamometer type wattmeter is more advantageous over induction type wattmeter because

(*a*) it can be used on both a.c. and d.c. systems.

(*b*) of comparatively low power consumption.

(*c*) of comparatively light moving system.

(*d*) All of the above.

(*ix*) The materials to be used in the manufacture of a standard resistor should be of

(*a*) low resistance.

(*b*) high resistivity and low temperature coefficient.

(*c*) high temperature coefficient.

(*d*) low resistivity and high temperature coefficient.

(*x*) The value of permittivity for free space, ε_0 in MKS system can be determined from the relation

(*a*) $C=\sqrt{\mu_0 \varepsilon_0}$

(*b*) $C=\mu_0 \varepsilon_0$

(*c*) $C=1/\mu_0 \varepsilon_0$

(*d*) $C=1/\sqrt{\mu_0 \varepsilon_0}$

(*xi*) Transmitting power remaining the same, if the supply voltage of a d.c. 2-wire distributor is doubled, saving in copper will be

(*a*) 25%

(*b*) 50%

(*c*) 75%

(*d*) 100%

(*xii*) If the excitation of a synchronous generator suddenly fails, then the

(*a*) machine will run as a generator supplying only positive reactive power.

(*b*) machine will run as a synchronous motor with lagging power factor.

(*c*) machine will run as a synchronous motor with unity power factor.

(*d*) machine will run as an induction generator.

(*xiii*) Which one of the following distribution system is the most economical?

(*a*) d.c. system

(*b*) single-phase a.c. system

(*c*) three-phase, 3-wire a.c. system

(*d*) three-phase, 4-wire a.c. system

(*xiv*) The basic function of the transformer is to change the

(*a*) level of the voltage.

(*b*) power level.

(*c*) power factor.

(*d*) frequency.

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 Faraday's law of electromagnetic induction. 5

(*b*) The capacitance of two parallel metal sheets, each 100 cm^2 in area, separated by a dielectric 2 mm thick, is 2×10^{-4} μF. A potential difference of 20 kV is applied. Find the (*i*) total electric flux in coulombs, (*ii*) potential gradient in kV/cm, (*iii*) relative permittivity of the material, and (*iv*) electric flux density. 15

2. (*a*) State and explain Thevenin's theorem. 5

(*b*) The Thevenin equivalent for a certain circuit is $E_{thev} = 20\angle 30°$ V, $Z_{thev} = 5\angle 20°\ \Omega$. A load impedance of $6\angle 40°\ \Omega$ is connected across the output terminals. Determine the load current and the voltage across the load using the (*i*) Thevenin equivalent, (*ii*) Norton equivalent, and (*iii*) determine the active and reactive power delivered to the load. 15

3. (*a*) Explain how the energy losses in a sample of ferromagnetic material subjected to an alternating magnetic field depend on the frequency and flux density. What particular property of the material can be used as a measure of the magnitude of each type of loss? 10

(*b*) A coil of 200 turns is wound uniformly over a wooden ring having a mean circumference of 600 mm and a uniform cross-sectional area of 500 mm^2. If the current through the coil is 4A, calculate the (*i*) magnetic field strength, (*ii*) average flux density, and (*iii*) total flux. 10

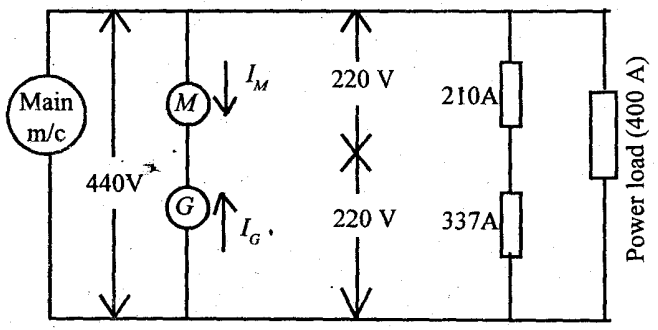
4. (*a*) Two wattmeters are used to measure power in a three-phase three wire network. Show, by means of connection and complexor (phasor) diagrams, that the sum of the wattmeter readings will measure the total active power. 10

(*b*) In a three-phase four wire system, the line voltage is 415 V and non-inductive loads of 10 kW, 8 kW and 5 kW are connected between the three line conductors and the neutral. Calculate (*i*) current in each line, and (*ii*) current in neutral conductor. 10

Group B

5. (*a*) Distinguish between a feeder, distributor and service main in a distribution scheme. Show that the cross-sections of a feeder and a distributor would be reduced to $1/n$ and $1/n^2$ of their respective values, with an increase in working voltage be n times. 10

(*b*) The load on a d.c. 3-wire system employing a rotary balance set with 440 V between outers consists of lighting loads of 210 A on the positive side and 337 A on the negative side. Power loads taking 400 A are connected across the outers. Calculate the load (in kW) on the main generators and on each of the balancer machines. Assume a loss of 1·5 kW in each balancer machine. 10



6. (*a*) Explain why the ferromagnetic circuits, subject to alternating magnetic field, are usually laminated and give examples of typical core construction. 6

(*b*) 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. 14

7. (*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 emf are related to slip. 10

(*b*) A three-phase, 600 MVA generator has a rated terminal voltage of 22 kV (line). The stator winding is star connected and has a resistance of 0·014 Ω/phase and a synchronous impedance of 0·16 Ω/phase. Calculate the voltage regulation for a load having a power factor of (*i*) unity, and (*ii*) 0·8 lagging. 10

8. (*a*) Derive an expression for the terminal voltage of a synchronous generator in terms of the frequency, flux per pole and the number of conductors, discussing the assumptions that are made. 10

(*b*) A three-phase star-connected synchronous generator on open circuit is required to generate a line voltage of 3600 V, 50 Hz, when driven at 500 rev./min. The stator has 3 slots/p/ph and 10 conductors per slot. Calculate the (*i*) number of poles, and (*ii*) useful flux/pole. Assume all the conductors per phase to be connected in series and the coils to be full pitch. 10

Group C

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

(*i*) If a discharged capacitor is connected across a battery, its instantaneous action is equivalent to that of a

(*a*) open circuit.

(*b*) short circuit.

(*c*) resistive circuit.

(*d*) inductive circuit.

(*ii*) Independent sources in a circuit involves

(*a*) ideal voltages and ideal current.

(*b*) non-ideal voltages and ideal current

(*c*) ideal voltages and non-ideal current.

(*d*) Non-ideal voltages and non-ideal current.

(*iii*) Thevenin's theorem provides a mathematical method for replacing a section of a network containing one or more voltage sources and impedances with an equivalent circuit model that contains

(*a*) only one voltage source and one series connected impedance.

(*b*) only two voltage sources and no impedance.

(*c*) only one voltage source and two impedances.

(*d*) only two voltage sources and two impedances.

(*iv*) For a non-magnetic medium, the relative permeability is

(*a*) less than unity.

(*b*) more than unity.

(*c*) unity.

(*d*) zero.

(*v*) The input power to a three-phase motor was measured by the two wattmeter method, the readings were 5·2 kW and – 1·7 kW and the line voltage was 415 V. The total active power is

(*a*) 5 kW

(*b*) 3 kW

(*c*) 2·5 kW

(*d*) 3·5 kW

(*vi*) In case of a three-phase induction motor for torques varying between zero and full load values, the slip is

(*a*) independent of torque.

(*b*) equal to torque.

(*c*) practically proportional to the torque.

(*d*) twice the amount of torque.

(*vii*) If the current in a coil having a constant inductance of L henrys grows at a uniform rate from zero to I amps in t sec, the average value of current and the emf induced in the coil are respectively

(*a*) I and $L \times 1/t$

(*b*) $(1/4)\ I$ and $-L/2t$

(*c*) $(1/2)\ I$ and $-(L \times I/t)$

(*d*) $2I$ and $L/4t$

 (*Continued*)

(*viii*) If a circuit, having a resistance of 4Ω, an inductance of 0·5 H and a variable capacitance in series, is connected across a 100 V, 50 Hz supply, the capacitance to give resonance is

(*a*) 11·5 μF

(*b*) 16·2 μF

(*c*) 18·5 μF

(*d*) 20·3 μF

(*ix*) When a three-phase induction motor is wound for 4 poles and is supplied from a 50 Hz system, the speed of rotor, when the slip is 4%, will be

(*a*) 1440 rpm.

(*b*) 1210 rpm.

(*c*) 1480 rpm.

(*d*) 1360 rpm.

(*x*) If a three-phase motor, operating on a 415 V system, is developing 20 kW at an efficiency of 0·87 p.u. and a p.f. of 0·82, the line current is

(*a*) 21 A

(*b*) 39 A

(*c*) 15 A

(*d*) 26 A

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.

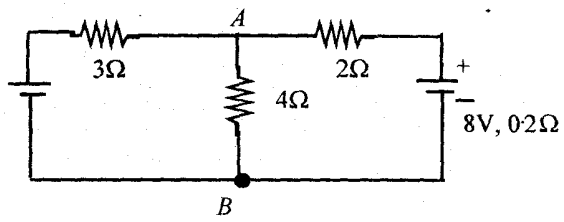
Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) State and explain superposition theorem. Mention its limitations. 5

(*b*) State and explain Norton's theorem. 5

(*c*) If the batteries, having emfs of 12 V and 8 V and internal resistances of 0·4 ohm and 0·2 ohm, are connected, as shown in Fig. 1, determine the currents and voltage across *AB*. 10



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. 8

(*b*) A magnetic ring has a mean circumference of 1·5 m, and is of 0·01 m^2 in cross-section, and is wound with 175 turns. A saw cut of 4 mm wide is made in the ring. Calculate the magnetising current required to produce a flux of 0·8 mWb in the air gap. Assume permeability of iron as 400 and leakage factor as 1·25. 12

3. (*a*) A three-phase delta connected load having resistances R_{12}, R_{23} and R_{31} across the supply terminals 1,2,3 is replaced by an equivalent star connected load R_{10}, R_{20} and R_{30}. (*i*) Obtain the values of R_{10}, R_{20} and R_{30} in terms of delta connected load values; (*ii*) In each case, draw the phasor diagram showing line and phase values of voltage and current. 8

(*b*) A balanced delta-connected load $8 + j6\ \Omega$ per phase is connected to a three phase, 230 V supply. Find the line current, power factor, power, reactive volt-amperes, and total volt amperes. 12

4. (*a*) What are hysteresis and eddy current losses ? Obtain their expressions. How do you reduce them ? 10

(*b*) How can you measure three-phase active power using two wattmeters ? 10

Group B

5. (*a*) Derive the equation for induced emf of a d.c. machine. Which are the quantities in the expression constant ? 5

(*b*) What are different types of d.c. generators and d.c. motors ? Discuss with schematic diagrams. 5

(*c*) A 4 pole, 220 V, d.c. shunt generator has an armature resistance of 1 ohm, shunt field resistance of 220 ohms. The generator supplies power to a 10 ohm resistor. Calculate the generated emf of the generator, if the load voltage is to be maintained at 220 V. Assume brush contact drop to be 2 V. 10

6. (*a*) (*i*) What is an equivalent circuit of a transformer ? (*ii*) What is its utility ? (*iii*) What are the tests conducted to obtain the parameters of the equivalent circuit ? (*iv*) Develop the equivalent circuit of a single phase transformer stating the assumptions made; (*v*) How is the equivalent circuit of a 3-ϕ transformer obtained ? 5×2

(*b*) A 100 kVA 6600/250 V single phase, 50 Hz transformer has 650 primary turns. The cross-sectional area of the core is 0·0425 m^2 of which 90% is iron, the mean length of the core is 2·5 m. Find the maximum flux density, assuming a permeability of 1200. 10

7. (*a*) Explain the operation of a synchronous motor. Why is it not self-starting ? How does it maintain constant speed at load ? How does it improve power factor of the power supply ? 12

(*b*) What are different types of three-phase induction motors ? What are different methods of starting induction motors ? Compare them. 8

8. (*a*) Compare the copper efficiencies in different systems of power distribution. 8

(*b*) Discuss the merits and demerits of (*i*) d.c. 2-wire and 3-wire distribution systems, and (*ii*) a.c. 3-wire and 4-wire distribution systems. 8

(*c*) What are different types of single-phase induction motors? 4

Group C

9. Choose the *correct* answer for the following: 1×20

(*i*) Superposition theorem cannot be applied to

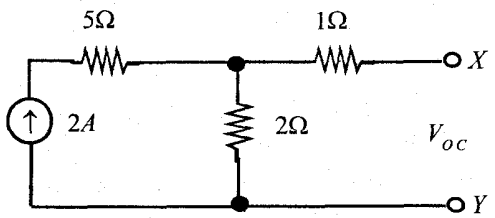
(*a*) an a.c. circuit.

(*b*) a circuit containing more than one emf source.

(*c*) a circuit containing non-linear elements.

(*d*) a circuit with internal resistances in its emf sources.

(*ii*) For the circuit shown below, V_{oc} and R_{eq} at *X*, *Y* are



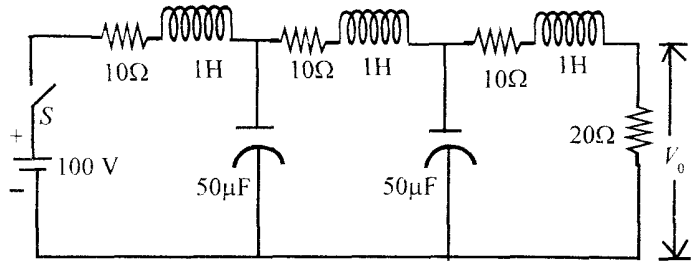
(*a*) 4 V, 3 Ω

(*b*) 2 V, 3 Ω

(*c*) 2 V, 17/7 Ω

(*d*) 2 V, 7 Ω

(*iii*) The steady state voltage V_0, after the switch *S* is closed (Figure below), is



(*a*) $20 \sin \omega t$

(*b*) 25 V

(*c*) 40 V

(*d*) 100 V

(*iv*) Kirchhoff's current law is related to

(*a*) meshes

(*b*) loops

(*c*) branches

(*d*) nodes

(*v*) If each of the three resistances connected in delta is equal to *R*, the equivalent star connected circuit will have its resistances in each leg equal to

(*a*) 3 *R*

(*b*) *R*

(*c*) *R*/3

(*d*) *R*/9

(*vi*) Carbon has negative resistance-temperature coefficient. Three carbon resistances connected in series have an a.c. emf source. The circuit is

(*a*) linear but not bilateral.

(*b*) bilateral but not linear.

(*c*) neither linear nor bilateral.

(*d*) linear and bilateral

(*vii*) Self-inductance of a magnetic coil of N turns is proportional to

(*a*) N^2

(*b*) N

(*c*) $1/N$

(*d*) $1/N^2$

(*viii*) The power factor of a purely capacitive circuit is

(*a*) ∞

(*b*) unity leading

(*c*) unity lagging

(*d*) zero

(*ix*) At resonance the frequency is given by

(*a*) $\omega_0 = 1/2\pi\sqrt{LC}$

(*b*) $\omega_0 = 1/\sqrt{LC}$

(*c*) $\omega_0 = \sqrt{L/C}$

(*d*) $\omega_0 = \sqrt{C/L}$

(*x*) If R, X and Z are the resistance, reactance and impedance of a load, its power factor can be expressed as

(*a*) Z/R

(*b*) Z/X

(*c*) X/Z

(*d*) R/Z

(*xi*) For the measurement of three-phase power using two-wattmeter method, the three-phase load should be

(*a*) balanced only

(*b*) unbalanced only

(*c*) balanced or unbalanced

(*d*) delta connected only

(*xii*) Which one of the following is used for power factor improvement of a power supply ?

(*a*) Synchronous motor excited at lagging p.f.

(*b*) Induction motor

(*c*) Capacitor bank

(*d*) Pure resistive load

(*xiii*) A three-phase induction motor fed from 50 Hz supply is running at a slip of 5%. Its frequency of rotor current is

(*a*) 55 Hz

(*b*) 45 Hz

(*c*) 25 Hz

(*d*) 2·5 Hz

(*xiv*) The emf generated in the armature of a d.c. machine is proportional to

(*a*) P/N

(*b*) P/ϕ

(*c*) $P\phi$

(*d*) ϕ/N

(*xv*) Which of the following is *not* true for yoke of a d.c. machine?

(*a*) It gives mechanical support to the machine.

(*b*) It helps in supplying current to armature.

(*c*) It provides path for magnetic flux.

(*d*) It is made of cast iron.

(*xvi*) Which of the following motors is *not* self-starting?

(*a*) Synchronous motor

(*b*) d.c. shunt motor

(*c*) d.c. series motor

(*d*) 3-phase squirrel cage induction motor

(*xvii*) Which of the following is *not* true for a phasor diagram?

(*a*) It depends on phase sequence.

(*b*) The magnitudes are rms values.

(*c*) All the phasors have same frequency.

(*d*) The phase angles shown are in radians only.

(*xviii*) The maximum speed of a 50 Hz motor is

(*a*) 6000 rpm

(*b*) 3600 rpm

(*c*) 3000 rpm

(*d*) dependent on mechanical strength of motor

(*xix*) Star-Delta starter is used

(*a*) to start a synchronous motor.

(*b*) for speed control of a three phase induction motor.

(*c*) to start a three phase induction motor.

(*d*) to start a single phase induction motor.

(*xx*) To reduce eddy current loss in an iron cored solenoid, the core should be

(*a*) replaced by brass.

(*b*) solid.

(*c*) made of high permeability material.

(*d*) laminated.

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. 5

   (*b*) Find the force on a charge Q_1 due to another charge Q_2 if $Q_1 = 10\,C$, $Q_2 = -100\,\mu C$ and the distance between them is 0·1 m. 8

   (*c*) A negative point charge 0·1 C is situated at $x = 0$ in free space. Find electric field intensity at a point having coordinates (4, 0) m. 7

2. (*a*) 'How can sinusoidal quantities be represented as phasors'—Explain. 5

(*Turn Over*)

(*b*) A current of 10 A flows in a circuit with 30° angle of lag when a.c. voltage of rms value 100 V is applied. Find resistance, inductance, impedance, power and power factor. Take $f = 50$ Hz. 10

(*c*) Explain the resonance phenomenon in a.c. circuits. 5

3. (*a*) Explain the terms voltage source and current source. 5

(*b*) Find the current through 20 ohm resistance in the circuit of *Fig. 1*. Use Thevenin's theorem. 10

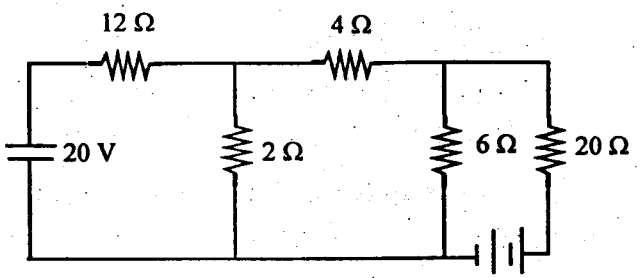


Fig. 1

(*c*) State and explain Kirchhoff's laws. 5

4. (*a*) Differentiate between balanced and unbalanced 3 phase systems. 5

(*b*) A load consisting of 3 identical impedances $10 \angle -45°$ connected in delta is fed from 220 V 3 phase source. Find magnitude of phase and line currents and total power. 8

(*c*) Explain the two wattmeter method of power measurements in 3-phase circuits. 7

Group B

5. (*a*) Differentiate between step-up and step-down transformes. 4

(*b*) Enumerate the losses in a transformer show the variation of efficiency with load current. Derive the condition for maximum efficiency. 8

(*c*) Define voltage regulation of a transformer. Derive equation for calculating voltage regulation. 8

6. (*a*) What is a synchronous machine? 3

(*b*) Find the voltage regulation for a 100 MVA 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. 10

(*c*) Explain the methods for starting of 3-phase induction motor. 7

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

(*b*) Explain the difference in the principles of working of series, shunt and compound d.c. generators. 9

(*c*) A 6-pole lap-wound d.c. shunt motor is fed from 400 V d.c. supply. The armature current is 50 A and armature resistance is 0·2 ohm. If flux per pole is 0·05 Wh and the motor has 540 conductors find the speed. 6

8. (*a*) Differentiate between radial and ring main distribution systems. Draw diagrams to illustrate your answer. 8

(*b*) Compare d.c. two-wire, d.c. three-wire single-phase a.c. and 3-phase a.c. as regards volume of conductor material. 8

(*c*) Explain the term voltage profile and its importance. 4

Group C

9. Select the best alternative : 1×20

(*i*) The electric field intensity at a point situates at a distance r from a point charge is proportional to

(*a*) r

(*b*) r^2

(*c*) $\frac{1}{r}$

(*d*) $\frac{1}{r^2}$

(*ii*) A capacitor having capacitance C is raised to voltage V. The energy stored will be

(*a*) CV^2

(*b*) V^2/C

(*c*) $0{\cdot}5CV^2$

(*d*) $0{\cdot}5C^2V$

(*iii*) The inductance of an air cored coil is 2 H. The number of turns is made 3 times all other quantities remaining the same. The new value of inductance will be

(*a*) $\frac{2}{9}$H

(*b*) $\frac{2}{3}$H

(*c*) 6 H

(*d*) 18 H

(*iv*) An ideal current source has

(*a*) infinite source resistance

(*b*) zero source resistance

(*c*) low value of source resistance

(*d*) finite value of source resistance

(*v*) Kirchhoff's laws are applicable to

(*a*) d.c. only

(*b*) a.c. sinusoidal wave only

(*c*) both d.c. and a.c. sinusoidal wave

(*d*) all wave shapes

(*vi*) When determining R_{TH} of a network

(*a*) all sources must be open circuited

(*b*) all sources must be short circuited

(*c*) all voltage sources must be open circuited and all current sources must be short circuited

(*d*) all sources must be replaced by their internal resistances.

(*vii*) Three resistances each of 15 ohm are in delta. The resistances of equivalent star will have a value

(*a*) 15 ohm

(*b*) 5 ohm

(*c*) $\frac{5}{3}$ ohm

(*d*) 45 ohm

(*viii*) Silver and Copper are

(*a*) Paramagnetic

(*b*) Nonmagnetic

(*c*) Ferromagnetic

(*d*) Diamagnetic

(*ix*) Two coils have self inductances of 16 H and 4 H respectively. If coefficient of coupling is 0·6, the mutual inductance is

(*a*) 38 H

(*b*) 4·8 H

(*c*) 2·4 H

(*d*) 12 H

(*x*) In an air cored coil a current of 2 A causes a flux density of 0·1 T. If the current is increased to 4 A, the flux density will be

(*a*) 0·2 T

(*b*) 0·1 T

(*c*) 0·05 T

(*d*) 0·4 T

(*xi*) An a.c. series RL circuit has an impedance of 20 ohms at 50 Hz. At a frequency of 100 Hz the impedance will be

(*a*) 20 ohm

(*b*) 40 ohm

(*c*) more than 20 ohm but less than 40 ohm

(*d*) more than 40 ohm

(*xii*) An a.c. parallel circuit has two branches. Each branch has only one element. The maximum phase difference between the currents in the two branches can be

(*a*) 0°

(*b*) 90°

(*c*) 270°

(*d*) 180°

(*xiii*) An RLC series circuit has a resonance frequency of 200 Hz. If inductance is increased to four times its initial value the resonant frequency will be

(*a*) 200 Hz

(*b*) 100 Hz

(*c*) 50 Hz

(*d*) 25 Hz

(*xiv*) In 3-phase power measurement by two wattmeter method, the readings of the two wattmeters were equal. The power factor of the load is

(*a*) 0

(*b*) 1

(*c*) less than 0·5

(*d*) between 0·5 and 1

(*xv*) A transformer has a turn ratio of 10 : 1. The secondary winding has a resistance of 0·01 ohm. The resistance of primary winding is about

(*a*) 0·01 ohm

(*b*) 0·1 ohm

(*c*) 1 ohm

(*d*) 10 ohm

(*xvi*) In a transformer the voltage regulation is 5% at unity power factor. The voltage regulation at 0·8 pf lagging is

(*a*) 5%

(*b*) less than 5%

(*c*) more than 5%

(*d*) any of above

RS

W'05 : 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 data 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 Norton's theorem. 5

(*b*) *Figure 1* shows a d.c. circuit. Apply Norton's theorem to find current through 11 ohm resistance. Draw Norton's equivalent circuit. 15

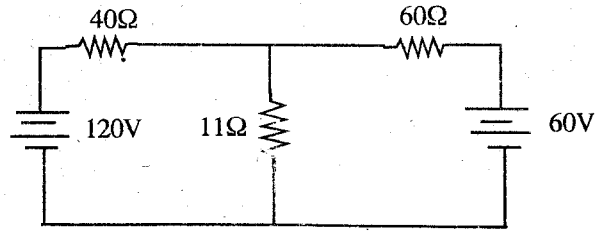


Fig. 1

2. (*a*) Explain the term 'power factor' in a.c. circuits. 6

(*b*) A resistance of 20 ohms, inductance of 0·2 H and capacitance of 150 μF are connected in series and fed by 230 V, 50 Hz a.c. supply. Find X_L, X_C, Z, Y, I, the power factor and the active power consumed. 2 × 7

3. (*a*) Explain the term 'phase sequence. 5

(*b*) A star connected three phase load has a resistance of 8 ohms and a capacitive reactance of 10 ohms connected in series in each phase. It is fed by 400 V 3-phase balanced supply. Find line current, active power, reactive power. 3 × 5

4. Write short notes on *any two* : 10 × 2

(*i*) Coulomb's law and ampere's law

(*ii*) Resonance and antiresonance

(*iii*) Hysteresis and eddy current losses

(*iv*) Superposition theorem.

Group B

5. (*a*) Draw and explain exact equivalent circuit of a single phase transformer. 10

(*b*) A 40 kVA, 6600/250 V single phase transformer has the following parameters:
Primary winding resistance = 8 ohms
Primary winding reactance = 15 ohms
Secondary winding resistance = 0·02 ohms
Secondary winding reactance = 0·05 ohms
Find full load regulation at 0·8 lagging power factor. 10

6. (*a*) Derive an equation for torque and emf of a d.c. machine. 8

(*b*) A d.c. motor has an armature current of 110 A at 480 V. The resistance of armature is 0·2 ohm. The motor has 6 poles and the armature has a lap winding with 864 conductors. The flux per pole is 0·05 Wb. Find (*i*) speed, (*ii*) torque. Assume a brush drop of 1 volt. 6 × 2

7. (*a*) Explain the synchronous impedance method for calculation of voltage regulation of a synchronous machine. 10

(*b*) Explain the principle of operation of a 3 phase induction motor. 10

Or

(*b*) Explain with a simple diagram the principle of operation of a star-delta starter. 10

8. Write short notes on *any two* : 10 × 2

(*a*) Comparison of d.c. 2 wire, d.c. 3-wire and a.c. 3-wire and a.c. 4 wire distribution systems

(*b*) Principle of operation of a single phase induction motor

(*c*) Methods of braking of 3-phase induction motor.

Group C

9. Select the best alternative: 1 × 20

(*i*) If the diameter of a wire is doubled, keeping the length constant, the resistance

(*a*) becomes twice

(*b*) remains the same

(*c*) becomes one fourth

(*d*) becomes four times

(*ii*) A coil has an inductance of 2H. Another coil has the wire of same weight and material but half the diameter. If core is the same, the inductance of second coil will be

(*a*) 1H
(*b*) 8H
(*c*) 16H
(*d*) 32H

(*iii*) To find the current through a resistance of 10 ohms connected in a circuit, Norton's theorem is used. I_N is found to be 10A. The current through the 10 ohm resistance

(*a*) will be 10A
(*b*) will always be less than 10A
(*c*) may be 10A or less
(*d*) may be 10A or more

(*iv*) As flux density is increased from zero to about 2 *T*, the relative permeability of a ferromagnetic material

(*a*) increases
(*b*) decreases
(*c*) first increases then decreases
(*d*) first decreases then increases

(*v*) Permeability is analogous to

(*a*) conductivity
(*b*) resistivity
(*c*) retentivity
(*d*) coercivity

(*vi*) In a specimen of cast iron, a field strength of 400AT/m causes a flux density of 0·7T. In a specimen of silicon steel, the same value of *H* would cause *B* to be

(*a*) 0·7T
(*b*) more than 0·7T
(*c*) slightly less than 0·7T
(*d*) 0T

(*vii*) If $A = 16\angle 64°$, $\sqrt{A}$ is

(*a*) $4\angle 64°$
(*b*) $4\angle 8°$
(*c*) $4\angle 128°$
(*d*) $4\angle 32°$

(*viii*) The peak to peak value of a sine wave is 100. The rms value is

(*a*) 70·7
(*b*) 50
(*c*) 35·35
(*d*) 100

(*ix*) An RLC series circuit has a variable inductance. The value of *L* for resonance at fundamental frequency is 0·18H. For resonance at third harmonic frequency, the value of inductance is

(*a*) 1·62H
(*b*) 0·54H
(*c*) 0·06H
(*d*) 0·02H

(*x*) The line currents in a 3-phase 4-wire system supplying a balanced star connected load are 5A each. The current in neutral wire is

(*a*) 15A

(*b*) -15A

(*c*) 5A

(*d*) zero

(*xi*) An emf induced in a coil due to change in current in a neighbouring coil is known as

(*a*) self induced emf

(*b*) speed emf

(*c*) mutually induced emf

(*d*) none of above

(*xii*) The pole shoes of a d.c. machine

(*a*) are always laminated

(*b*) are never laminated

(*c*) are sometimes laminated

(*d*) are partially laminated

(*xiii*) A 4-pole d.c. machine has a lap winding. The winding is removed and then a wave winding with the same number of turns is put. The induced emf will

(*a*) increase

(*b*) decrease

(*c*) remain the same

(*d*) may increase or decrease

(*xiv*) The purpose of using laminated core in a transformer is to reduce

(*a*) copper losses

(*b*) all losses

(*c*) hysteresis losses

(*d*) eddy current losses

(*xv*) The full load efficiency of a big transformer is about

(*a*) 0·75

(*b*) 0·85

(*c*) 0·9

(*d*) 0·98

(*xvi*) In a modern large size synchronous machine, the synchronous impedance is about

(*a*) 0·2 pu

(*b*) 0·5 pu

(*c*) 1 pu

(*d*) 0·05 pu

(*xvii*) At $s = 0$ the torque of a 3-phase induction motor is

(*a*) 0

(*b*) equal to full load torque

(*c*) very high

(*d*) nearly zero

(*xviii*) Under blocked rotor conditions the frequency of rotor currents in a 50 Hz, 3-phase induction motor is

(*a*) very low

(*b*) very high

(*c*) 50

(*d*) about 50

(*xix*) In a capacitor start motor, the capacitor is connected

(*a*) in series with both windings

(*b*) in series with auxiliary winding

(*c*) in series with main winding

(*d*) in parallel with auxiliary winding

(*xx*) The function of compensating winding in an a.c. series motor is

(*a*) to provide starting torque

(*b*) to reduce reactance of armature winding

(*c*) to improve efficiency of machine

(*d*) to convert it into a two phase motor.