BASIC ELECTRICAL ENGINEERING
(ELE 1001)

Time Allotted : 2½ hrs   **Full Marks : 60**

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
<u>any 4 (four)</u> from Group B to E, taking <u>one</u> from each group.*

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) If the reading of the two wattmeter's is equal while measuring power in a 3 phase induction motor then the power factor of the load will be?
(a) 0.8 leading   (b) 0.8 lagging   (c) zero   (d) unity

(ii) The efficiency of a circuit under Maximum Power Transfer condition is?
(a) 40%   (b) 80%   (c) 75%   (d) 50%

(iii) For additive flux of two coils connected in series the equivalent inductance can be expressed as
(a) $L_1 + L_2 - M$ (b) $L_1 + L_2 + M$
(c) $L_1 + L_2 - 2M$ (d) $L_1 + L_2 + 2M$

(iv) The impedance of an a.c. circuit is $100\angle-30°$ Ω. The circuit is
(a) Resistive   (b) Capacitive   (c) Inductive   (d) None of these

(v) In an RC series circuit if $X_C = R$, then the phase angle between the applied voltage and current is
(a) 30°   (b) 45°   (c) 60°   (d) 90°

(vi) For Lap wound dc machine no of parallel path is equal to
(a) 4   (b) 2   (c) 2P   (d) P

(vii) With field flux control method of dc shunt motor speed of the machine?
(a) Cannot be kept constant   (b) Cannot be controlled at all
(c) Cannot be increased below rated speed   (d) Cannot be decreased below rated speed

(viii) The maximum efficiency of transformer occurs when
(a) Iron loss > Copper loss   (b) Iron loss = Copper loss
(c) Iron loss < Copper loss   (d) None of these

(ix) A balanced 3 phase induction motor runs at slip s. If N_s is its synchronous speed, the actual speed of the rotor is
(a) sN_s (b) $(1-s)N_s$ (c) N_s (d) Zero

(x)   The frequency of the a.c. voltage, $v = 215 \sin 408.2t$ is
        (a) 50 Hz   (b) 65 Hz   (c) 70 Hz   (d) 75 Hz

Fill in the blanks with the correct word

(xi)   If V is the line voltage, I is the line current and φ is the angle between them, then the total power measured in a delta three-phase load is equal to: _____

(xii)   When a pure inductance is connected to an a.c. source, the current lags the voltage by _____ .

(xiii) The r.m.s. value of an a.c. voltage, $v = 100 \sin(314t + 30°)$ is _____ .

(xiv)   For any medium, the relation between the electric flux density D and electric field intensity E is _____ .

(xv)   The short circuit test in a transformer is performed to determine _____ loss.

Group - B

2. (a)   Derive the expression of coefficient of coupling (K) in terms of self-inductances (L1, L2) and mutual- inductance (M) in between the two inductances.   *[(CO3)(Apply/IOCQ)]*

    (b)   Find value of R_L when maximum power will be transferred through the circuit. What will be the maximum power?   *[(CO1)(Analyse/HOCQ)]*
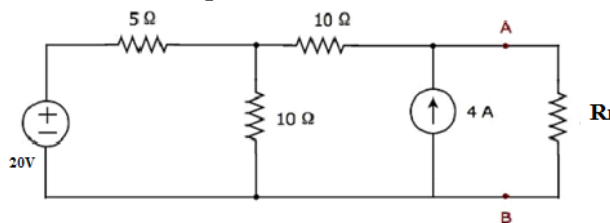

Fig. 1

4 + (3 + 5) = 12

3. (a)   An electromagnet has a cross-sectional area of 14 cm². Mean length of iron path is 60 cm. It is excited by current through a coil, having 400 turns. When the current in the coils is 1 A, the resulting flux density gives a relative permeability of 1000 and $\mu_0 = 4\pi \times 10^{-7} \, H/m$. Evaluate (i) reluctance of iron part of the magnetic circuit; (ii) reluctance of the air-gap; (iii) total reluctance; (iv) total flux. Neglect leakage and fringing.   *[(CO3)(Evaluate/HOCQ)]*
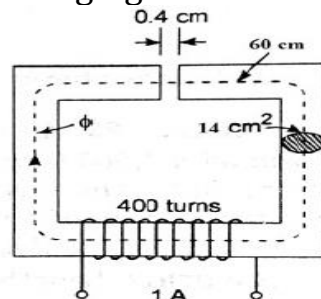

Fig. 2

    (b)   Using star delta conversion find the equivalent resistance between the terminal A and B.   *[(CO1)(Analyse/IOCQ)]*
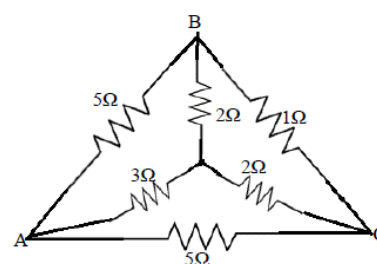

Fig. 3   **(4 × 2) + 4 = 12**

2

Group - C

4. (a) Prove that the average power consumption in pure capacitor is zero when ac voltage is applied. *[(CO4)(Remember/LOCQ)]*

   (b) Derive an expression for the (i) r.m.s value, (ii) average value, (iii) form factor and (iv) peak factor of the following full wave rectified current waveform.
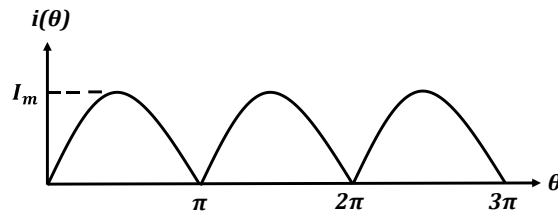

   Fig. 4

   [(CO4)(Apply/IOCQ)]

   (c) A coil of resistance 1000 Ω and inductive reactance of 200 Ω is connected in series across a supply voltage of 230 V. Evaluate (i) impedance, (ii) supply current. *[(CO4)(Evaluate/HOCQ)]*

   3 + 6 + 3 = 12

5. (a) Derive an expression of resonance frequency for the following parallel RLC circuit. *[(CO4)(Understand/LOCQ)]*
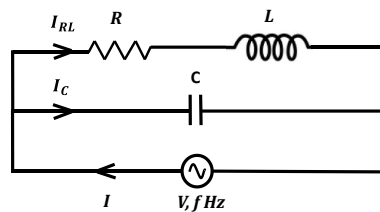

   Fig. 5

   (b) In the circuit shown in the following Fig. 6, evaluate (i) the current drawn by individual branches, (ii) the supply current, (iii) the power factor of the circuit, and (iv) the active power consumption of the circuit. *[(CO4)(Evaluate/HOCQ)]*
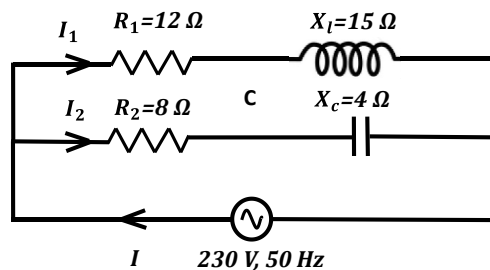

   Fig. 6

   4 + 8 = 12

Group - D

6. (a) Three coils each of resistance 40 Ω and inductance 0.3H are connected in star to a 3-phase 440V balanced supply. Calculate (i) phase current, (ii) line current, (iii) power factor and (iv) the active power (v) reactive power. *[(CO4)(Analyse/HOCQ)]*

   (b) Derive the emf equation of a DC machine. *[(CO2)(Remember/LOCQ)]*

   (c) Why series motor should not run at low load? *[(CO2)(Apply/IOCQ)]*

   5 + 4 + 3 = 12

3

7. (a) An 8 pole lap connected armature of a DC machine has 40 slots with 12 conductors per slot, and generates a voltage of 5000 Volts. Determine the speed at which it is running if the flux per pole is 50 mWb. Also calculate the terminal voltage at full load of 20 A if the armature resistance is 0.5 Ω and the machine is running as shunt generator having a shunt field resistance of 250 Ω.

[(CO2)(Analyse/IOCQ)]

(b) A balanced three-phase 220 V load has a power factor of 0.9. Two wattmeters are connected to measure the power which shows the input to be 10 kW. Find out the reading of each wattmeter.

[(CO4)(Apply/IOCQ)]

6 + 6 = 12

Group - E

8. (a) Sketch the equivalent circuit of a single phase transformer. Hence draw the phasor diagram of the transformer operating under lagging power factor load.

[(CO5)(Understand/LOCQ)]

(b) Analyse with the help of necessary diagrams, how a rotating magnetic field is produced in the air gap of a 3 phase induction motor.

[(CO6)(Analyse/IOCQ)]

(c) The e.m.f per turn of a single phase 10 kVA, 2200/220 V, 50 Hz transformer is 10 V. Evaluate: (i) the number of primary and secondary turns, (ii) maximum value of flux, and (iii) net cross sectional area of the core for a maximum flux density of 1.5 Wb/m^2.

[(CO5)(Evaluate/HOCQ)]

4 + 5 + 3 = 12

9. (a) Derive the condition for achieving maximum efficiency in a single-phase transformer.

[(CO5)(Understand/LOCQ)]

(b) What is slip in a 3 phase induction motor? Why is slip always positive in case of a 3 phase induction motor? Show that the frequency of the rotor induced e.m.f (f_r) in an induction motor is slip times its stator frequency (f).

[(CO6) (Analyse/IOCQ)]

(c) The short circuit test performed on a single phase, 5 kVA, 200/400 V, 50 Hz transformer gives the following test results:

V_{sc} = 20 V, I_{sc} = 12.5 A, W_{sc} = 175 W

Estimate: (i) equivalent winding resistance, (ii) equivalent winding leakage reactance.

[(CO5)(Evaluate/HOCQ)]

4 + 5 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	19.8	40.6	39.6

Course Outcome (CO):

After the completion of the course students will be able to

- Analyse DC electrical circuits using KCL, KVL and network theorems like Superposition Theorem, Thevenin's Theorem, Norton's Theorem and Maximum Power Transfer Theorem.
- Analyse DC Machines; Starters and speed control of DC motors.
- Analyse magnetic circuits.
- Analyse single and three phase AC circuits.
- Analyse the operation of single phase transformers.
- Analyse the operation of three phase induction motors.

LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.