ELECTRICAL MACHINES
(MECH 3133)

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

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one 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) For speed control of a DC motor, which technique provides speed above base speed?
(a) Field control method
(b) Supply current control method
(c) Supply voltage control method
(d) Armature resistance control method.

(ii) The current drawn by a 120V d.c. motor of armature resistance 0.5Ω and back emf 110V is
(a) 20A (b) 220A (c) 240A (d) 5A.

(iii) A shunt generator running at 1000 rpm has generated an emf of 200 V. If the speed increases to 1200 rpm then the generated emf will be
(a) 150 V (b) 175 V (c) 290 V (d) 240 V.

(iv) The core flux in transformer depends mainly on
(a) supply voltage
(b) supply voltage and frequency
(c) supply voltage, frequency and load
(d) supply voltage and load but independent of frequency.

(v) For an ideal transformer the windings should have
(a) maximum resistance on primary side and least resistance on secondary side
(b) no ohmic resistance on either side
(c) least resistance on primary side and maximum resistance on secondary side
(d) equal resistance on primary and secondary side.

(vi) The basic function of a transformer is to change
(a) the level of the voltage (b) the power level
(c) the power factor (d) the frequency.

(vii) 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

(viii) The relationship between rotor frequency f_r, slip s and stator supply frequency f_s is given by
(a) $f_s = sf_r$ (b) $f_r = sf_s$
(c) $f_r = (1-s)f_s$ (d) $f_r = s^2 f_s$

(ix) A 3 phase synchronous motor has
(a) high starting torque (b) no starting torque
(c) low starting current (d) low starting torque.

(x) In synchronous motor, 'V' curves represent the variation of
(a) armature current with maximum power developed
(b) armature current with field current
(c) field excitation with stalling torque
(d) field excitation with minimum power developed.

Fill in the blanks with the correct word

(xi) The number of parallel paths in a 4 pole lap connected dc machine is _____.

(xii) The emf equation of a dc generator is given by _____.

(xiii) A 40kVA single phase transformer has a full load copper loss of 160W. The copper loss at 75% of full load is _____.

(xiv) The no load current of a transformer is approximately _____ % of full load current.

(xv) The full load secondary current of a single phase 10kVA, 100/200 V, 50 Hz transformer is _____.

Group - B

2. (a) Classify dc generator according to its type of excitation. Draw relevant diagrams. *[(CO1)(Analyse/HOCQ)]*

(b) Draw the equivalent circuit of a dc motor and write the emf equation obtained from it. *[(CO2)(Remember/LOCQ)]*

(c) A 8 pole generator has 500 armature conductors and has a useful flux per pole of 0.065 Wb. What will be the emf generated if it is lap connected and runs at 1000 r.p.m.? What must be the speed at which it is to be driven to produce the same emf if it is wave wound? *[(CO1)(Analyse/HOCQ)]*

4 + 2 + 6 = 12

3. (a) Obtain the emf equation of a dc machine. *[(CO1)(Analyse/HOCQ)]*

(b) Draw and explain the torque vs armature current characteristics of a dc series and shunt motor. *[(CO2)(Remember/LOCQ)]*

(c) A 250 V DC shunt motor has an armature resistance of 0.25 Ω and carries an armature current of 50 A and runs at 750 rpm. Calculate the speed if the flux is reduced by 15%. Assume that the load torque remains same. *[(CO2)(Apply/IOCQ)]*

4 + 3 + 5 = 12

Group - C

4. (a) Derive an expression for voltage regulation of a single phase transformer operating under lagging power factor load. *[(CO3)(Remember/LOCQ)]*

(b) A transformer is rated at 100 kVA. At full load its copper loss is 1200 W and its iron loss is 960 W. Calculate
(i) the efficiency at full load, unity power factor,
(ii) the efficiency at half load, 0.8 power factor,
(iii) the efficiency at 75% full load, 0.7 power factor
(iv) the kVA delivered by the transformer at which maximum efficiency occurs,
(v) the maximum efficiency at 0.85 power factor *[(CO3) (Apply/IOCQ)]*

(c) Evaluate the condition for zero voltage regulation of transformer. *[(CO3)(Evaluate/HOCQ)]*

4 + 5 + 3 = 12

5. (a) Derive the condition of maximum efficiency for a single phase transformer. *[(CO3)(Remember/LOCQ)]*

(b) A single phase transformer working at unity power factor has an efficiency of 90% at both half load and at the full load of 500 W. Determine the efficiency at 75% full load and the maximum efficiency. *[(CO3)(Apply/IOCQ)]*

(c) At 400 V and 50 Hz the total core loss of a transformer was found to be 2400 W. When the transformer is supplied at 200 V, and 25 Hz, the core loss is 800 W. Evaluate the hysteresis loss and eddy current loss at 400 V and 50 Hz. *[(CO3)(Evaluate/HOCQ)]*

4 + 5 + 3 = 12

Group - D

6. (a) Derive the torque equation of a 3 phase induction motor. *[(CO4)(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). *[(CO4)(Analyse/IOCQ)]*

(c) A 3 phase, 4 pole induction motor has a speed of 1440 rpm at a particular load when connected to 400 V, 50 Hz supply. Evaluate (i) slip of the motor, (ii) frequency of the rotor emf. *[(CO4)(Evaluate/HOCQ)]*

4 + 5 + 3 = 12

7. (a) Derive an expression for electromagnetic torque developed by a 3-ϕ induction motor. *[(CO4)(Remember/LOCQ)]*

(b) Find out the condition at which a 3-ϕ induction motor develops maximum torque and hence derive an expression for maximum torque developed. *[(CO4)(Analyse /IOCQ)]*

(c) A 16 pole, 50 Hz, 3-ϕ induction motor has a full load slip of 4%. The rotor has a resistance of 0.02 Ω per phase and standstill leakage reactance of 0.15 Ω per phase. Evaluate: (i) the slip at which maximum torque occurs, (ii) the speed at which maximum torque occurs, (iii) the ratio of full load torque to maximum torque. *[(CO4)(Evaluate/HOCQ)]*

4 + 5 + 3 = 12

Group - E

8. (a) Explain the phenomenon of armature reaction when the alternator is delivering load current at a purely lagging power factor. *[(CO5)(Analyse/HOCQ)]*

(b) Mention the main characteristic features of a synchronous motor. *[(CO6)(Remember/LOCQ)]*

(c) Explain the methods for starting of synchronous motors. *[(CO6)(Apply/IOCQ)]*

5 + 2 + 5 = 12

9. (a) Derive the emf equation of alternator. *[(CO5)(Analyse/HOCQ)]*

(b) A 6 pole alternator rotating at 1000 rpm has a single phase winding housed in 3 slots per pole, the slots of three being 20 degrees apart. If each slot contains 10 conductors and the flux per pole is 0.02 Wb calculate the voltage generated assuming the flux distribution to be sinusoidal. *[(CO5)(Remember/LOCQ)]*

(c) What is a synchronous condenser? Explain its operation. *[(CO6)(Apply/IOCQ)]*

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	28.12	35.42	36.46