ELECTRICAL MACHINES
(MECH 3133)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) 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.

(ii) A separately excited dc generator is operating at 220V. The core loss in the machine is 200W when supplying a current of 30A to the loads. Find the armature resistance (in Ω) given that the machine is working on maximum efficiency.
(a) 0.22Ω (b) 0.25Ω (c) 0.3Ω (d) 0.35Ω.

(iii) The essential condition for parallel operation of two single phase transformers is that they should have same
(a) polarity (b) KVA rating
(c) voltage ratio (d) percentage impedance.

(iv) A transformer will have maximum voltage regulation at
(a) zero pf (b) leading pf (c) lagging pf (d) unity pf.

(v) A transformer will have maximum efficiency when
(a) Iron loss=Copper loss (b) Iron loss>Copper loss
(c) Iron loss<Copper loss (d) None of these.

(vi) A three phase, 50Hz induction motor has a full load speed of 1440rpm. The full load slip will be
(a) 3% (b) 5% (c) 4% (d) 2%.

(vii) The rotor power output of a 3 phase induction motor is 15kW and corresponding slip is 4%. The rotor copper loss is
(a) 700W (b) 625W (c) 600W (d) 650W.

(viii) The friction and windage losses in a three phase induction motor are 400W, the output power is 1000W and the air-gap power is 1443W. Find the slip of the machine.
(a) 0.05 (b) 0.03 (c) 0.04 (d) 0.06.

(ix) The maximum power developed in a synchronous motor occurs at a coupling angle of
(a) 30^0 (b) 60^0 (c) 90^0 (d) 180^0.

(x) A synchronous motor can be used as synchronous capacitor when it is
(a) overloaded (b) underloaded (c) overexcited (d) underexcited.

Group- B

2. (a) Mention the conditions required for voltage build up in self-excited generators. [(CO1)(Analyze/IOCQ)]

(b) A 250V shunt motor on no load runs at 1000rpm and takes 5A. The total armature and shunt field resistance are respectively 0.2Ω and 250Ω. Calculate the speed when loaded and taking current of 50A, if the armature reaction weakens the field by 3%. [(CO2)(Evaluate/HOCQ)]

(c) What are the different types of excitations in DC machine? [(CO1)(Remember/LOCQ)]

4 + 5 + 3 = 12

3. (a) Derive the emf equation of a dc generator. [(CO1)(Analyze/IOCQ)]

(b) A 250V dc shunt motor having an armature resistance of 0.25Ω carries an armature current of 50A and runs at 750r.p.m. If the flux is reduced by 10%, find the speed. Assume that the load torque remains same. [(CO2)(Evaluate/HOCQ)]

(c) Define armature reaction? What is the effect on generated voltage due to armature reaction? [(CO1)(Remember/LOCQ)]

4 + 5 + (2 + 1) = 12

Group - C

4. (a) Describe the phasor diagram of transformer working under lagging power factor load. [(CO3)(Understanding/LOCQ)]

(b) Derive the condition of maximum voltage regulation for a single phase transformer. [(CO3)(Apply/IOCQ)]

(c) A 150kVA transformer has an iron loss of 700W and full load copper loss of 1600W. Estimate the efficiency of the transformer delivering 75% of rated load at a power factor of 0.7 lagging. [(CO3)(Evaluate/HOCQ)]

4 + 5 + 3 = 12

5. (a) Describe briefly the derivation of EMF equation of a transformer. [(CO3)(Understand/LOCQ)]

(b) The open circuit and short circuit test on a 5KVA, 200/400V, 50Hz single phase transformer gave the following results:
O.C.Test: 200V, 1.25A, 150W (l.v. side)
S.C.Test: 20V, 12.5A, 175W (h.v. side)
Calculate the equivalent circuit parameters of the transformer. [(CO3)(Analyze/IOCQ)]

(c) A 415/220V single phase transformer takes a no load current of 1A at a power factor of 0.19 lagging. Estimate the primary current when the secondary supplies a current of 100A at a power factor of 0.8 lagging. [(CO3)(Evaluate/HOCQ)]

4 + 5 + 3 = 12

Group – D

6. (a) Explain how rotating magnetic field is produced in a three phase induction motor. [(CO4)(Understand/LOCQ)]

(b) Sketch and analyze the torque-slip characteristics of 3 phase induction motor. How do starting and maximum torque vary with rotor resistance? [(CO4)(Analyze/IOCQ)]

(c) A 4 pole induction motor is fed from a 50Hz ac supply and has a rotor speed of 1425r.p.m. Find (i) slip speed (ii) % slip (iii) rotor frequency. [(CO4)(Evaluate/HOCQ)]

4 + 5 + 3 = 12

7. (a) Explain how plugging is carried out in an induction motor. [(CO4)(Understand/LOCQ)]

(b) Examine the method of speed control for an induction motor by rotor resistance control. [(CO4)(Analyze/IOCQ)]

(c) A 500V, 6P, 3 phase, 50Hz IM develops 20kW inclusive of mechanical losses when running at 995rpm at a power factor of 0.87. Calculate (i) slip (ii) rotor copper loss (iii) total input if the stator losses are 1500W. [(CO4)(Evaluate/HOCQ)]

4 + 5 + 3 = 12

Group - E

8. (a) Define the following terms:
(i) Coil span (ii) Pole pitch (iii) Full-pitch coil (iv) Chorded coil (v) Pitch factor (vi) Distribution factor. [(CO5)(Remember/LOCQ)]

(b) A 3 phase, 400V synchronous motor takes 52.5A at a power factor of 0.8 leading. Determine the induced emf and the power supplied, the motor impedance per phase is (0.25 + j3.2) Ω. [(CO6)(Analyze/IOCQ)]

6 + 6 = 12

9. (a) Derive an expression for the power developed in a 3 phase synchronous motor. [(CO6)(Remember/LOCQ)]

(b) A 3-phase star connected alternator is rated at 1600kVA, 13500V. The armature effective resistance and synchronous reactance are 1.5Ω and 30Ω respectively per phase. Calculate the percentage regulation for a load of 1280kW at power factors of (i) 0.8 leading (ii) unity. [(CO5)(Evaluate/HOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	35.42	35.42	29.16

Course Outcome (CO):

After the completion of the course students will be able to

CO1: Acquire the knowledge of the constructional details and operating principle of DC generator and analyze the performance under various operating conditions to solve complex electrical engineering problems.

CO2: Acquire the knowledge of the operating principle of DC motor and analyze the performance under various operating conditions to solve complex electrical engineering problems.

CO3: Identify and analyze the problems related to performance analysis of single phase transformer reaching substantiated conclusion.

CO4: Identify, formulate and solve the numerical problems related to three phase induction motor.

CO5: Acquire the knowledge of synchronous generator to identify and analyze the problems related to performance analysis.

CO6: Understand the knowledge of synchronous motor to solve complex engineering problems related to various applications.

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