

**PRINCIPLES OF ELECTRICAL MACHINES  
(ELEC 4126)**

**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) In a single phase transformer electrical power is transferred from the primary to the secondary side without change in  
(a) voltage (b) current  
(c) number of turns (d) frequency.
- (ii) Which of the following rule is used to determine the direction of rotation of a D.C motor?  
(a) Coloumb's Law (b) Lenz's Law  
(c) Fleming's Right-hand Rule (d) Fleming's Left-hand Rule.
- (iii) A shunt generator running at 1000 rpm has a generated emf of 100 V. If the speed increases to 1500 rpm then the emf generated will be nearly  
(a) 150 V (b) 140 V  
(c) 175 V (d) 240 V.
- (iv) A 10 kW, 4 pole, star connected 50 Hz induction motor has a synchronous speed of  
(a) 1200 rpm (b) 1500 rpm  
(c) 1000 rpm (d) 3000 rpm.
- (v) The flux created by the current flowing through the primary winding of a transformer induces emf in  
(a) primary winding only (b) both primary and secondary winding  
(c) secondary winding only (d) transformer core only.
- (vi) Hysteresis loss in a transformer can be reduced by using  
(a) laminated core (b) silicon steel  
(c) oil (d) solid steel.
- (vii) For a slip ring induction motor, if the rotor resistance is increased, then  
(a) starting torque decreases (b) starting torque increases  
(c) starting torque remain unchanged (d) none of these.

- (viii) A balanced 3 phase induction motor runs at slips. 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)  $(1-s)/N_s$ .
- (ix) 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.
- (x) In a DC shunt motor speed is
- (a) independent of field current  
(b) directly proportional to field current  
(c) proportional to square of the field current  
(d) inversely proportional to field current.

*Fill in the blanks with the correct word*

- (xi) The no load current of a transformer is approximately \_\_\_\_\_ % of full load current.
- (xii) The number of parallel path in case of lap winding is \_\_\_\_\_.
- (xiii) If the coil pitch is less than one pole pitch, then the coil is called \_\_\_\_\_.
- (xiv) A 40 kVA single phase transformer has a full load copper loss of 160 W. The copper loss at 50% of full load is \_\_\_\_\_.
- (xv) The open circuit test of a single phase transformer is performed on \_\_\_\_\_ side.

### Group - B

2. (a) Derive the torque equation of a DC motor. [[CO2](Apply/IOCQ)]  
(b) A DC shunt generator is used to supply 10 A current to a load at a terminal voltage of 220 V. It has armature resistance and field resistance  $0.2 \Omega$  and  $220 \Omega$  respectively. Find (i) the field current, (ii) Armature current, (iii) generated emf. [[CO1](Evaluate/HOCQ)]  
**6 + 6 = 12**
3. (a) Discuss the principle of operation of a three point starter with the help of a neat diagram. [[CO2](Understand/LOCQ)]  
(b) What is critical resistance? [[CO1](Remember/LOCQ)]  
(c) A 400 V, 6 pole series generator has wave wound armature with 250 conductors. The armature resistance is  $0.3 \Omega$ , field resistance is  $0.2 \Omega$  and flux per pole is 0.04 Wb. Determine the generated emf and the speed if the generator supplies 10A to the load. Assume brush drop is 1V per brush. [[CO1](Apply/IOCQ)]  
**6 + 2 + 4 = 12**

## Group - C

4. (a) Explain with the help of a neat diagram the working principle of a single phase transformer. [[CO3](Understand/LOCQ)]
- (b) A single phase 240/20 V, 50 Hz transformer has the secondary full load current of 180 A. It has 45 turns on its secondary. Calculate the voltage per turn, the number of primary turns, full load primary current and kVA output of the transformer. [[CO3](Apply/IOCQ)]
- (c) Compare between core type and shell type transformer. Why laminated core is used in a transformer? [[CO3](Remember/LOCQ)]
- 4 + 4 + 4 = 12**
5. (a) What are the major sources of losses in a single phase transformer? Which loss is called variable loss and why? [[CO3](Understand/LOCQ)]
- (b) Draw and explain the approximate equivalent circuit of a single phase transformer referred to secondary side. [[CO3](Analyze/IOCQ)]
- (c) The following results were obtained on a 50 kVA, 2400/120V transformer:  
Open circuit test: 120V 9.65A 396W (instruments on l.v. side)  
Short circuit test: 92V 20.8A 810W (instruments on h.v. side)  
Determine the circuit constants and the efficiency at full load, 0.8 power factor lagging. [[CO3](Evaluate/HOCQ)]
- 3 + 4 + 5 = 12**

## Group - D

6. (a) Derive the condition of maximum torque in 3-phase induction motor. [[CO4](Analyse/IOCQ)]
- (b) A 5 kW, 4 pole three phase star connected induction motor has rotor resistance of  $0.05 \Omega$  and standstill reactance of  $0.5 \Omega$  per phase. The full load speed is 1450 rpm. Determine the ratio of maximum torque to full load torque and ratio of starting torque to full load torque. [[CO4](Evaluate/HOCQ)]
- 6 + 6 = 12**
7. (a) Explain the principle of operation of a 3-phase induction motor. [[CO3](Understand/LOCQ)]
- (b) A 500 V, 50 Hz 3-phase induction motor develops an output of 15 kW at 950 rpm. If the input p.f. is 0.86 lagging, mechanical losses are 730W and stator losses are 150 W, find the synchronous speed, slip, rotor Cu loss, motor input power, line current and air-gap power. [[CO4](Evaluate/HOCQ)]
- 6 + 6 = 12**

## Group - E

8. (a) Draw the equivalent circuit of a synchronous generator. Also derive the necessary e.m.f. equation for the synchronous generator at a leading power factor of  $\cos\theta$ . [[CO5](Understand/LOCQ)]

- (b) Sketch the equivalent circuit of a 3 phase synchronous motor and hence analyze the phasor diagram of the same under (i) lagging power factor load, (ii) leading power factor load, and (iii) unity power factor load. [[CO6](Apply/IOCQ)]  
**(2 + 4) + 6 = 12**
9. (a) Why is synchronous motor not self-starting? What methods are generally used to start the synchronous motors? [[CO6](Remember/LOCQ)]
- (b) A 3-phase, star connected wound rotor synchronous generator rated at 10 kVA, 230 V has a synchronous reactance of 1.2 Ω per phase and an armature resistance of 0.5 Ω per phase. Calculate the percent voltage regulation at full-load with 0.8 lagging power factor. [[CO5](Apply/IOCQ)]  
**6 + 6 = 12**
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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	38.54	37.50	23.96

**Course Outcome (CO):**

After the completion of the course students will be able to

1. Acquire knowledge of the constructional details and operating principle of DC generator and analyze the performance under various operating conditions.
2. Understand the operating principle of DC motor and analyze the performance.
3. Acquire knowledge about the constructional details, principle of operation, performance analysis and testing of single phase transformers.
4. Understand operating principle and analyze the performance of Three Phase Induction Motors.
5. Understand working of Alternators and its applications.
6. Understand working of synchronous motor and its applications.

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