

ELECTRICAL MACHINES - I
(ELEC 2201)

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) Tesla is a unit of
 - (a) magnetic field strength
 - (b) self inductance
 - (c) magnetic flux density
 - (d) magnetic flux.
 - (ii) The waveform of armature mmf in dc machine is
 - (a) square
 - (b) rectangular
 - (c) triangular
 - (d) sinusoidal.
 - (iii) Wave winding is employed in a DC machine with
 - (a) high current and low voltage rating
 - (b) low current and high voltage rating
 - (c) high current and high voltage rating
 - (d) low current and low voltage rating.
 - (iv) The most suitable generator for welding purpose is
 - (a) shunt
 - (b) cumulative compound
 - (c) differential compound
 - (d) separately excited.
 - (v) For a d.c. generator if the brushes are given a small amount of forward shift the effect of armature reaction is
 - (a) totally demagnetizing
 - (b) totally magnetizing
 - (c) partially demagnetizing and partially cross- magnetizing
 - (d) totally cross- magnetizing.
 - (vi) For a transformer given of 1 kVA, 200/50 V transformer, short circuit test is performed. What current rating is needed?
 - (a) 20A
 - (b) 5A
 - (c) 10A
 - (d) 2A.

- (vii) Which of the following is the main advantage of an auto-transformer over a two winding transformer?
 (a) Hysteresis losses are reduced
 (b) Saving in winding material
 (c) Copper losses are negligible
 (d) Eddy current losses are totally eliminated.
- (viii) For the parallel operation of single-phase transformers it is necessary that they should have
 (a) same efficiency (b) same polarity
 (c) same kVA rating (d) same number of turns on the secondary side.
- (ix) The utilization factor for Scott connection is
 (a) 0.9625 (b) 0.866 (c) 0.928 (d) 1.
- (x) The full-load copper loss of a transformer is 1600 W. At half-load, the copper loss will be _____
 (a) 1600 W (b) 6400 W (c) 400 W (d) 800 W.

Group - B

2. (a) Show that the magnetic force f_e is given by the expression $f_e = \frac{\partial W_{fld}}{\partial x}(\Psi, x)$.
 Where w_{fld} is the energy stored in the magnetic field and Ψ is the flux linkages.
 [(CO1)(Remember/LOCQ)]
- (b) A 8kW, 1400 rpm d.c. shunt generator has time constant of 0.3 sec for its field winding. Under normal operating conditions, the field winding lossless is 300 watts. Compute the energy store in the magnetic field under normal operating condition.
 [(CO2)(Apply/IOCQ)]
- (c) In a 150 V computed generator, the resistances of armature, series and shunt field windings are 0.07Ω , 0.03Ω and 30Ω respectively. The load current is 90A. Find the induced EMF and armature current of the machine when it is connected as (i) short-shunt (ii) long shunt.
 [(CO2)(Evaluate/HOCQ)]
- 4 + 3 + 5 = 12**
3. (a) For the electromagnet shown in Fig.1, obtain an expression for the magnetic force f_e . The reluctance is assumed to be offered by the air gap alone. Magnetic leakage and fringing is neglected.
 [(CO1)(Apply/IOCQ)]

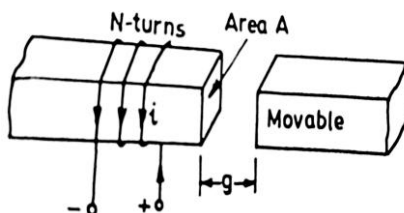


Fig.1

- (b) Calculate the torque developed when a current of 5A flows through the armature of a 4-pole, lap-wound motor with 300 conductors. The pole shoe has 20 cm lateral length and subtends an angle of 70° at the shaft centre as shown in Fig.2. The bore diameter is 30 cm. Air gap flux density is 0.7 Wb/m^2 .

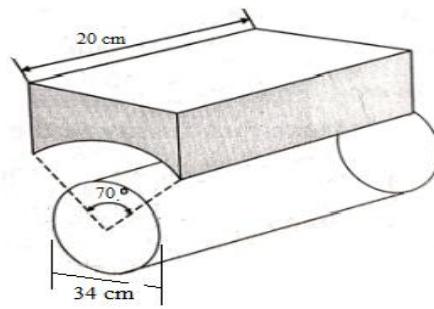


Fig. 2

[[CO2](Evaluate/HOCQ)]

- (c) What is reluctance torque? Explain whether a DC motor can develop reluctance torque.

[[CO2](Understand/LOCQ)]

4 + 4 + (2 + 2) = 12

Group - C

4. (a) Why the DC series motor is not advisable to start without load?
[[CO3](Understand/LOCQ)]
- (b) A compensated DC machine has 19000 ampere turns per pole. The ratio of pole-arc to pole pitch is 0.7 interpolar air gap length and flux density are respectively 1 cm and 0.3 teslas. For rated armature current of 1000A, evaluate the compensating winding conductor per pole and number of turns on each interpole.
[[CO3](Evaluate/HOCQ)]
- (c) Why does the external characteristic of a DC shunt generator turn back as it is overloaded?
[[CO3](Analyze/IOCQ)]

3 + 5 + 4 = 12

5. (a) Why the interpoles are designed to provide m.m.f. more than the armature m.m.f. in the commutating zone?
[[CO3](Remember/LOCQ)]
- (b) The Hopkinson test on two identical shunt machines gave the following results:
Line voltage = 250V
Line current (including armature and field current of generator and motor) = 20A
Output current of generator (including armature and field current) = 80A
Field current of the generator = 5.5A
Field current of the motor = 4A
Armature resistance of each machine is 0.06Ω. Determine the efficiency of motor and generator.
[[CO3](Understand/LOCQ)]
- (c) Had there been no saturation in self excited shunt generator, what would be the terminal voltage at no load? Explain.
[[CO3](Analyze/IOCQ)]

4 + 6 + 2 = 12

Group - D

6. (a) With proper diagram explain the construction of a shell type transformer.
[[CO4](Understand/LOCQ)]
- (b) What current flows in the transformer primary when the secondary is open? What is its function?
[[CO4](Understand/LOCQ)]

- (c) A single phase transformer is designed to operate at rated primary voltage of 230 V and at rated frequency 50 Hz. If its primary voltage is increased by 10% on no load, discuss what would happen to transformer operation. [(C04)(Analyze/IOCQ)]
- (d) A transformer is rated at 150 kVA. At full load its copper loss is 1250 W and its iron loss is 950 W. Determine:
 (i) Load kVA at which maximum efficiency will occur.
 (ii) Maximum efficiency at 0.85 power factor. [(C04)(Evaluate/HOCQ)]
3 + 2 + 3 + (2 + 2) = 12
7. (a) Outline the steps involved in separation of core losses of a single phase transformer? [(C04)(Understand/LOCQ)]
- (b) In a single phase transformer if the load current is kept constant, find the power factor at which maximum efficiency occurs. [(C04)(Analyze/IOCQ)]
- (c) A single phase 300/250 V auto-transformer with secondary short circuited takes primary current 50 A at 15 V at a power factor of 0.24. The turns ratio (k) = 0.8. For an input voltage of 300 V determine the load voltage for a load current of 100 A at (i) unity power factor. (ii) 0.8 p.f. lag. [(C04)(Evaluate/HOCQ)]
4 + 4 + (2 + 2) = 12

Group – E

8. (a) Explain the effect of change in phase sequence on the line voltages of the transformer. [(C05)(Understand/LOCQ)]
- (b) Draw the phasor diagram and connection diagram of the following three phase transformer connections: (i) Yy0 (ii) Dd6 (iii) Yz11. [(C05) (Analyze/IOCQ)]
- (c) Identify the adverse effects of unbalanced operation in a three phase transformer. [(C06)(Apply/IOCQ)]
3 + 6 + 3 = 12
9. (a) What are the methods used to suppress harmonics in a transformer? [(C06)(Remember/LOCQ)]
- (b) Analyze the operation of an open delta transformer supplying power to a delta connected load. [(C05)(Analyze/IOCQ)]
- (c) A 500 kVA, 3 phase transformer having per phase leakage impedance of $0.016 + j0.07 \Omega$ is connected in parallel with another transformer of same voltage having a rating 700 kVA and per phase leakage impedance of $0.006 + j0.036 \Omega$. Determine the load shared by each transformer and their operating power factors for a total load of 1200 kVA at 0.6 p.f. lagging. [(C05)(Evaluate/HOCQ)]
2 + 6 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	36.46	36.46	27.08

Course Outcome (CO):

After the completion of the course students will be able to

- 1.** Understand the fundamental principle of electromechanical energy conversion.
- 2.** Acquire knowledge about the constructional details, principle of operation, excitation types in dc machines.
- 3.** Understand the working of dc machines and acquire knowledge about testing on dc machines.
- 4.** Acquire knowledge about the constructional details, principle of operation, performance analysis and testing of single phase transformers.
- 5.** Understand different types of connections of three phase transformers.
- 6.** Understand and analyze the performance of three phase transformers.

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

