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) Electromagnetic torque in rotating machine is present when
(a) air gap is present
(b) stator winding alone carries current
(c) rotor winding alone carries current
(d) both stator and rotor winding carries current.

(ii) The current drawn by the a 220 V DC motor of armature resistance 0.4 A and back emf 200 V is
(a) 50 A (b) 550 A (c) 500 A (d) 0 A.

(iii) A DC shunt motor runs at rated speed. If its field circuit gets open circuited, then soon after this the motor speed would tends to
(a) decrease (b) remain unchanged
(c) increase (d) fluctuate around its previous speed.

(iv) If the back emf in DC motor vanishes suddenly the motor will
(a) Burn (b) Run at very high speed
(c) Run at very low speed (d) Start haunting.

(v) The possible resistance of the 230V DC shunt machine field winding is
(a) 1 Ω (b) 2 Ω (c) 200 Ω (d) 20 Ω.

(vi) In a d.c. series generator, the terminal voltage with increase in load
(a) decrease (b) increase
(c) remains unchanged (d) varies with drooping characteristics.

(vii) The short circuit test on a transformer gives
(a) equivalent resistance and leakage reactance
(b) equivalent resistance and core loss
(c) equivalent leakage reactance and magnetizing current
(d) magnetizing current and core loss.

(viii) A 4 kVA 400/200 V single phase transformer has resistance of 0.02 p.u. and reactance of 0.06 p.u. What are its resistance and reactance referred to h.v. side?
(a) 0.2 ohm and 0.6 ohm (b) 0.8 ohm and 2.4 ohm
(c) 0.08 ohm and 0.24 ohm (d) 1 ohm and 3 ohm.

(ix) A star-zigzag three phase transformer can have the following symbol:
(a) Yz0 and Yz6 (b) Yz1 and Yz11
(c) Yz1 only (d) Yz11 only.

(x) The utilization factor for Scott connected transformers is
(a) 0.866 (b) 0.9625 (c) 0.928 (d) 1.

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) For the mechanical configuration shown in Fig.1, assume that all the field energy is present in the overlapping regions. The radius r is much greater than air-gap length g. Evaluate the magnitude of torque, when the maximum flux density in the air-gap is limited to 3.2 Wb/m^2. The other data are as follows:
Radius, $r = 40\ mm$
Gap Length, $g = 1.5\ mm$
Length normal to radius r is $l = 8\ mm$ *[(CO1)(Evaluate/HOCQ)]*

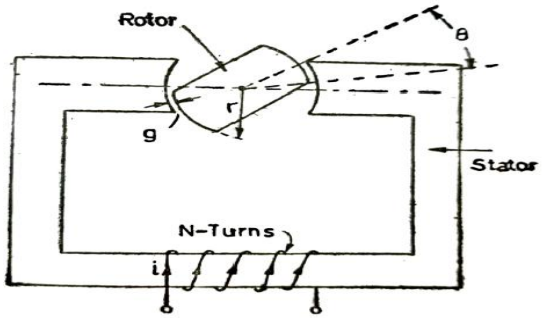

Fig.1

(c) In a 200 V compound generator, the resistances of armature, series and shunt field windings are 0.08 Ω, 0.04 Ω, and 50 Ω respectively. The load current is 90 A. Find the induced EMF and armature current of the machine when it is connected as (i) short-shunt (ii) long shunt. *[(CO2)(Remember/LOCQ)]*

4 + 4 + 4 = 12

3. (a) For electromagnetic system shown in Fig.2 each limb of core has cross-sectional area of 15 cm^2. The coil has 1000 turns. Assume that the iron part of the magnetic circuit has $\mu_r = \propto$. For a coil current of 2.5 A and air-gap length $x = 1\ cm$, calculate the force on the movable component. *[(CO1)(Apply/IOCQ)]*

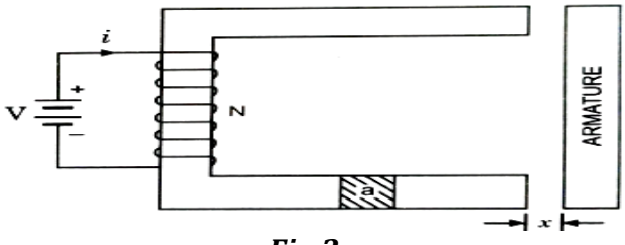

Fig.2

(b) A 4-pole lap connected DC machine has an armature resistance of 0.1 Ω. Find the armature resistance of the machine when rewound for wave connection. *[(CO2)(Evaluate/HOCQ)]*

(c) What is reluctance torque? Explain whether a DC motor can develop reluctance torque. *[(CO2)(Understand/LOCQ)]*

4 + 4 + 4 = 12

Group – C

4. (a) Why does the terminal voltage fall more rapidly in a self-excited shunt generator than in a separately excited DC generators? Explain. *[(CO3)(Understand/LOCQ)]*

(b) A 6-pole, 10 kW, 240 V, DC machine is wave-connected. If the same machine is lap-connected, all other things remaining same, evaluate its voltage, current and power ratings. *[(CO3)(Evaluate/HOCQ)]*

(c) Analyze the effect of brush shifting in the direction of rotation (forward shift) on the main field flux for DC generator. *[(CO3)(Analyze/IOCQ)]*

4 + 4 + 4 = 12

5. (a) A 400 V, 20 HP DC shunt motor takes 2 A while running at no load. The field and armature resistance are 600 Ω and 0.5 Ω, respectively. Calculate the full load efficiency, assuming brush drop of 2 V. *[(CO3)(Remember/LOCQ)]*

(b) Two shunt generator with straight line characteristics are operated in parallel, their no load voltages being 230 V and 240 V respectively. The rating of the above generators are 450 kW at 220 V and 250 kW at 230 V. If the total load supplied is 650 kW calculate (i) the terminal voltage and (ii) power supplied by each machine in kW. *[(CO3)(Understand/LOCQ)]*

(c) Why the starter is needed to start the DC motor? *[(CO3)(Understand/LOCQ)]*

5 + (2 + 3) + 2 = 12

Group – D

6. (a) What are the various methods of cooling of a transformer? *[(CO4)(Remember/LOCQ)]*

(b) The efficiency of a 500 kVA transformer is 98% hen delivering full load at 0.8 power factor and 98.5% at half load and 0.9 power factor. Calculate the iron loss and full load copper loss. *[(CO4)(Analyze/IOCQ)]*

(c) The maximum efficiency of a 100 kVA single phase transformer is 97% and occurs at 85% of full load at a power factor of 0.8 lagging. If the leakage impedance of the transformer is 3%. Find the voltage regulation at rated load 0.8 power factor lag. *[(CO4)(Evaluate/HOCQ)]*

3 + 4 + 5 = 12

7. (a) Briefly describe the operation of an on load tap changer with proper diagram. *[(CO4)(Understand/LOCQ)]*

(b) With proper equations show the relationship between transformed power and conducted power with input power. *[(CO4)(Analyze/IOCQ)]*

(c) A 33 kVA, 2200/200 V single phase transformer has the following parameters:
r_1 = 3 ohm x_1 = 5 ohm
r_2 = 0.04 ohm x_2 = 0.06 ohm
(i) Find the equivalent resistance and reactance when referred to secondary side.
(ii) Find the total ohmic loss on full load. *[(CO4)(Evaluate/HOCQ)]*

5 + 4 + 3 = 12

Group – E

8. (a) State the conditions for parallel operation of three phase transformers. *[(CO5)(Understand/LOCQ)]*

(b) Draw the phasor diagram and connection diagram of the following three phase transformer connections:
(i) Dz0, (ii) Dy1, (iii) Yd11. *[(CO5)(Analyze/IOCQ)]*

(c) Examine why in star connection arrangement line voltages are free from triplen harmonics. *[(CO6)(Analyze/IOCQ)]*

3 + 6 + 3 = 12

9. (a) What are the disadvantages of harmonics in transformers? *[(CO6)(Understand/LOCQ)]*

(b) Analyse the operation of an open delta transformer supplying power to a star connected load. *[(CO5)(Analyze/IOCQ)]*

(c) A 300 kVA, 3 phase transformer having per phase leakage impedance of 0.016 + j0.07 Ω is connected in parallel with another transformer of same voltage having a rating 500 kVA and per phase leakage impedance of 0.006 + j0.036 Ω. Determine the load shared by each transformer and their operating power factors for a total load of 800 kVA at 0.8 p.f. lagging. *[(CO5) Evaluate/HOCQ)]*

2 + 6 + 4 = 12

Cognition Level	*LOCQ*	*IOCQ*	*HOCQ*
Percentage distribution	*42.71*	*32.29*	*25*

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. cquire 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*