ELECTRICAL MACHINES - I
(ELEC 2201)

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) Which of the following DC generator will have a negligible terminal voltage while running on no load?
(a) Series generator (b) Shunt generator
(c) Compound generator (d) Separately excited generator.

(ii) If the resistance of the shunt field of a motor is increased then the speed will
(a) increase (b) decrease
(c) remain same (d) be zero

(iii) The direction of rotation of a dc shunt motor can be reversed by increasing
(a) the supply terminals (b) the field terminal only
(c) the armature terminal only (d) either field or the armature terminals.

(iv) No-load speed of which of the following motor will be highest?
(a) Shunt motor (b) Series motor
(c) Cumulative compound motor (d) Differentially compound motor.

(v) Starter is used in DC motor to
(a) reduce the starting current (b) increase the starting current
(c) increase the starting voltage (d) reduce the starting torque

(vi) A generator has a no load voltage of 230 V and full load voltage of 250 V. The generator is
(a) series generator (b) over compound generator
(c) differential compound generator (d) level compound generator.

(vii) A delta-zigzag three phase transformer can have the following symbol:
(a) Dz0 and Dz6 (b) Dz1 and Dz11
(c) Dz0 only (d) Dz6 only.

(viii) Which generator can be used as a voltage booster in DC transmission line?
(a) Series generator (b) Shunt generator
(c) Separately excited generator (d) Compound generator.

(ix) Generally the no-load losses of a transformer is represented in its equivalent circuit by a
(a) Parallel resistance with a low value (b) Series resistance with a low value
(c) Parallel resistance with a high value (d) Series resistance with a high value.

(x) A three phase transformer has 420 and 36 turns on the primary and secondary windings respectively. The supply voltage is 3300 V. The secondary line voltage on no-load when the windings are connected in star-delta is nearly:
(a) 1908 V (b) 22260 V (c) 490 V (d) 160 V.

Fill in the blanks with the correct word

(xi) In a DC series motor if the current is increased by 2 times the torque will increase by _____ times.

(xii) Which motor should not be started at no load? _____.

(xiii) Which DC machine can be used as a constant speed machine? _____

(xiv) The power factor at which maximum regulation occurs in a transformer is _____

(xv) The condition for maximum efficiency in a transformer is _____.

Group - B

2. (a) Two air-cored coils have their magnetic axes coincident. Their parameters are: $L_1 = 0.5$ H, $L_2 = 0.3$ H, $M_{12} = M_{21} = 0.1e^{-5x}$ where 'x' is the distance between the two coils. For steady current of $I_1 = 8$A and $I_2 = 6$A,find the expression of forced developed. *[(CO1)(Analyze/IOCQ)]*

(b) A 6Pole, 12kW, 240V, dc machine is wave connected. If the same machine is lap-connected, all other things remain same, calculate its voltage, current and power rating. *[(CO2)(Evaluate/HOCQ)]*

(c) Derive the emf equation of DC machine. *[(CO2)(Understand/LOCQ)]*

4 + (2 + 2 + 2) + 2 = 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.

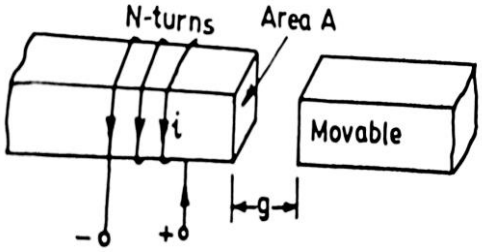

Fig. 1 *[(CO1)(Evaluate/HOCQ)]*

(b) A 25kW, 220V dc shunt generator has armature and field resistance of 0.04 ohm and 100 ohm respectively. Calculate the total armature power developed when working:
(i) as a generator delivering 25kW output
(ii) as a motor taking 25kW input. *[(CO2)(Remember/LOCQ)]*

6 + 6 = 12

Group - C

4. (a) Two shunt generator operating is parallel have each an armature resistance of 0.05 ohm. The combined external load current is 2000A. If the generated emf of the machines are 540V and 550 V respectively, calculate the bus-bar voltage and output in kW of each machine. *[(CO3)(Analyse/IOCQ)]*

   (b) A 400V, 100A dc shunt motor is braked by plugging. Calculate (i) the value of resistance that must be connected in series with the armature circuit to limit the breaking current to 150A (ii) the breaking torque. Armature resistance R_a=0.1Ω and full-load speed =600 r.p.m. *[(CO3)(Evaluate/HOCQ)]*

   (c) Why the DC series motor is not advisable to start without load? *[(CO3)(Understand/LOCQ)]*

(3 + 3) + (2 + 2) + 2 = 12

5. (a) A 200V dc series motor runs at 700rpm when operating at its full load current of 20A. The resistance is 0.5 ohm and the magnetic circuit can be assumed un saturated. What will be the speed if (i) the load current is increased by 44% (ii) the motor current is 10A? *[(CO3)(Analyse/IOCQ)]*

   (b) A DC shunt generator is working at rated condition; suddenly the load terminals are being short circuited. What will happen to the machine? Explain. *[(CO3)(Remember/LOCQ)]*

   (c) Why the inter pole and compensated winding is used to the DC machine? *[(CO3)(Understand/LOCQ)]*

4 + 6 + 2 = 12

Group - D

6. (a) What are the differences between a core type and shell type transformer? *[(CO4)(Remember/LOCQ)]*

   (b) A 10 kVA, single phase transformer for 2000/400 V at no load has R_1 = 5.5 Ω, R_2 = 0.2 Ω, X_1 = 12 Ω, X_2 = 0.45 Ω. Determine the approximate value of the secondary voltage at full load, 0.8 pf (lag), when the primary applied voltage is 2000 V. *[(CO4)(Analyze/IOCQ)]*

   (c) The maximum efficiency of a 500 kVA, 3300/500 V, 50 Hz single phase transformer is 96% and occurs at 80% full load and 0.8 power factor lag. Determine the copper loss at full load. *[(CO4)(Evaluate/HOCQ)]*

4 + 4 + 4 = 12

7. (a) Briefly describe the operation of a no load (or off load) tap changer with proper diagram. *[(CO4)(Understand/LOCQ)]*

   (b) Draw and explain the equivalent circuit and phasor diagram of an auto transformer. *[(CO4)(Analyze/IOCQ)]*

   (c) A 10 kVA, 2000/200 V single phase transformer has the following parameters:
   r1 = 3 ohm x1 = 5 ohm
   r2 = 0.04 ohm x2 = 0.06 ohm
   Show that the per unit parameters referred to high voltage and low voltage sides are same. *[(CO4)(Evaluate/HOCQ)]*

5 + 4 + 3 = 12

Group - E

8. (a) Explain the effect of change in polarity markings on the line voltages of the transformer. *[(CO5)(Understand/LOCQ)]*

   (b) Draw the phasor diagram and connection diagram of the following three phase transformer connections:
   (i) Dd0 (ii) Yy6 (iii) Yz1 . *[(CO5)(Analyze/IOCQ)]*

   (c) Examine the phenomenon of oscillation of neutral. *[(CO6)(Analyze/IOCQ)]*

   3 + 6 + 3 =12

9. (a) What are the functions of tertiary windings in a star-star connected transformer? *[(CO6)(Understand/LOCQ)]*

   (b) Show that 2-phase voltage is generated from 3 phase supply in a Scott connection. *[(CO5)(Analyze/IOCQ)]*

   (c) A bank of three 1-phase transfomers is connected to 11000 V supply and takes 15 A. If the ratio of turns per phase is 10, calculate secondary line voltage and current, primary and secondary phase currents and output for the following connections (i) star-star (ii) delta-star. *[(CO5)(Evaluate/HOCQ)]*

   2 + 6 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	33.33	38.54	28.13

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.*