ELECTRICAL MACHINES – I
(ELE2201)

Time Allotted : 2½ hrs   **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and
<u>any 4 (four)</u> from Group B to E, taking <u>one</u> 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)   The principle of operation of a DC generator is based on:
           (a) Electrostatic Induction   (b) Faraday's Law of Electromagnetic Induction
           (c) Coulomb's Law   (d) Ampere's Circuital Law

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

    (iii) In a DC machine, lap winding is preferred when:
           (a) High voltage and low current are required
           (b) High current and low voltage are required
           (c) Both high current and high voltage are required
           (d) None of the above

    (iv)   What condition must be satisfied for a self-excited DC shunt generator to build up voltage?
           (a) Residual magnetism must be present in the poles
           (b) The generator must be under full load
           (c) The brushes must be short-circuited
           (d) The interpoles must be absent

    (v)   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

    (vi)   Why is the core of a transformer laminated?
           (a) To reduce copper loss   (b) To increase mechanical strength
           (c) To reduce eddy current loss   (d) To improve efficiency of winding

    (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) If a single-phase transformer is operating under no-load conditions, the input current is primarily used to compensate for
(a) Copper loss   (b) Eddy current loss and hysteresis loss
(c) Load current   (d) Power factor improvement

(ix) 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

(x) Scott connections are used in _____
(a) three-phase to single phase transformation
(b) three-phase to two-phase transformation
(c) single phase to three-phase transformation
(d) all phase transformations

Fill in the blanks with the correct word

(xi) Interpoles in a DC machine are placed between the _____ to improve commutation.

(xii) In _____ test, two identical DC machines are coupled together to test their efficiency under full-load conditions.

(xiii) The force in an electromechanical system is generated due to the interaction between the magnetic field and _____.

(xiv) The all-day efficiency of a transformer is defined as the ratio of _____, over a 24-hour period.

(xv) When a V-V system is converted into a Δ-Δ system, the capacity of the system increases by _____.

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)(Understand/LOCQ)]

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

(c) A simple DC generator has 4 poles, 200 turns in the armature winding, and operates at 1500 RPM. The flux per pole is 0.02 Wb. Calculate the generated EMF.
[(CO2)(Understand/LOCQ)]
5 + 5 + 2 = 12

3. (a) What is reluctance torque? Explain whether a DC motor can develop reluctance torque. *[(CO1)(Understand/LOCQ)]*

(b) Compare the lap and wave winding used in DC machine. *[(CO2)(Understand/LOCQ)]*

(c) What is the function of commutator in DC motor? *[(CO2)(Understand/LOCQ)]*

(d) A DC motor has an armature current of 30A and a field flux of 0.03 Wb per pole. The machine has 4 poles and 500 conductors in the armature. The armature is lap-wound. Determine the torque developed. *[(CO2)(Understand/LOCQ)]*

4 + 3 + 3 + 2 = 12

Group - C

4. (a) A 250V DC shunt motor has the following test data:
No-load power: P0=500W
Field current: If=2A
Armature resistance: Ra=0.25Ω
Full-load current: I_L=25A
Determine the efficiency of the motor at full load. *[(CO3)(Understand/LOCQ)]*

(b) A DC shunt machine has total armature circuit resistance of 0.5Ωand the field circuit resistance of 100Ω. Its open circuit voltage at 1500r.p.m is 230V for field current of 1.2A and 210V for a field current of 0.8A. If this machine is made to run as a DC shunt motor from 230V supply mains at its full load armature current of 20A and at 1500 r.p.m., find the external resistance that must be inserted in the field circuit. Neglect armature reaction and assume the magnetic circuit is linear. *[(CO3)(Analyse/HOCQ)]*

5 + 7 = 12

5. (a) A 4-pole generator supplies a current of 143 A. It has 492 armature conductors and wave wound. When delivering full load, the brushes are given an actual lead of 15^0. Calculate the demagnetising ampere-turn per pole. This field winding is shunt connected and takes 10A. Find the number of extra field turns to neutralize the demagnetization. *[(CO3)(Analyse/HOCQ)]*

(b) Had there been no saturation in self excited shunt generator, what would be the terminal voltage at no load? Explain. *[(CO3)(Understand/LOCQ)]*

(c) What is the residual voltage of a DC generator. *[(CO3)(Understand/LOCQ)]*

7 + 3 + 2 = 12

Group - D

6. (a) Draw the phasor diagram and equivalent circuit of an auto transformer. *[(CO4)(Understand/LOCQ)]*

(b) Analyze the following statement "Open circuit should be performed on low voltage side and short circuit test to be performed on high voltage side". *[(CO4)(Analyze/IOCQ)]*

(c) A 3000/1500/750 V, single phase 3 winding transformer is used as an autotransformer with supply voltage 5000 V. Two loads one 1050 kVA at 3500 V and the other of 150 kVA at 1000 V are to be energized from this auto-transformer output. Draw suitable diagram of connection and determine the currents in various parts of the circuit. Assume the loads to have same power factor. *[(CO4)(Evaluate/HOCQ)]*

4 + 4 + (2 + 2) = 12

7. (a) Draw the approximate equivalent circuit of the transformer referred to secondary. *[(CO4)(Remember/HOCQ)]*
   (b) A 10 kVA, single-phase transformer for 2500/500 V at no load, has $R_1=6.5\Omega$, $R_2=0.4\Omega$, $X_1=10\Omega$, $X_2=0.55\Omega$. Determine the approximate value of the secondary voltage at full load, 0.8 power factor (lagging) and 0.8 power factor (leading), when the primary applied voltage is 2000V. *[(CO4)(Evaluate/HOCQ)]*
   (c) A 230/110 V single-phase transformer takes an input of 350 VA at no load and rated voltage. The core loss is 110 W. Find (i) the magnetizing component of no load current (ii)the working component of no load current and (iii) no-load power factor. *[(CO4)(Apply/IOCQ)]*

3 + 6 + 3 = 12

Group - E

8. (a) Draw the phasor diagram and connection diagram of the following three phase transformer connections:
   (i) Dd0   (ii) Yy6   (iii) Yz1 *[(CO5)(Analyze/IOCQ)]*
   (b) A 1000 kVA, 3 phase transformer having per phase leakage impedance of 0.025 + j0.1 Ω is connected in parallel with another transformer of same voltage having a rating 800 kVA and per phase leakage impedance of 0.008 + j0.035 Ω. Determine the load shared by each transformer and their operating power factors for a total load of 1200 kVA at 0.8 p.f. lagging. *[(CO5)(Evaluate/HOCQ)]*
   (c) What are the functions of tertiary windings in a star-star connected transformer? *[(CO6)(Remember/LOCQ)]*

6 + 3 + 3 = 12

9. (a) Analyse the operation of an open delta transformer supplying power to a delta connected load. *[(CO5)(Analyze/IOCQ)]*
   (b) Discuss the disadvantages of autotransformers. *[(CO5)(Remember/LOCQ)]*
   (c) A bank of three 1-phase transformers 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. *[(CO6)(Apply/IOCQ)]*

6 + 2 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	40	24	36