ELECTRICAL MACHINE - 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) In Swinburn's test of a dc machine
(a) no load losses are calculated and copper losses are measured
(b) no load losses are measured and copper losses are calculated
(c) both the no-load losses and the copper losses are calculated
(d) both the no-load losses and the copper losses are measured.

(ii) The waveform of armature mmf in dc machine is
(a) square (b) rectangular
(c) triangular (d) sinusoidal.

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

(iv) Wave winding is employed in a dc machine of
(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.

(v) For a P-pole machine, the relation between electrical and mechanical angles is given by
(a) $\theta_e = \frac{2}{P}\theta_m$ (b) $\theta_e = P\theta_m$ (c) $\theta_e = \frac{4}{p}\theta_m$ (d) $\theta_e = \frac{P}{2}\theta_m$.

(vi) For sinusoidal applied voltage in a single phase transformer, the flux wave and the magnetizing-current are respectively
(a) sinusoidal, sinusoidal (b) peaky, flat-topped
(c) flat-topped, peaky (d) sinusoidal, peaky.

(vii) The main advantage of using fractional pitch winding is to reduce the
(a) harmonics in generated emf
(b) amount of copper in the winding
(c) size of the machine
(d) cost of the machine.

(viii) 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.

(ix) Open circuit test in a transformer is performed with
(a) rated transformer voltage (b) rated transformer current
(c) direct current (d) high frequency current.

(x) Full load core loss in a transformer is 1000W. At half load the loss will be
(a) 400 W (b) 1600 W (c) 250 W (d) 1000 W.

Group – B

2. Determine an expression for the force per unit area between the plates of a parallel plate air capacitor using both the energy and co-energy methods. **(6 + 6) = 12**

3. An 8 pole, 3-phase, 60^0 spread, double layer winding has 72 coils in 72 slots. The coils are short-pitched by two slots. Calculate the winding factor for the fundamental and third harmonic. **(6 + 6) = 12**

Group – C

4. A 10 kW , 230 V 1000 rpm lap connected shunt motor has 4 poles, 4 parallel armature paths, and 900 armature conductors, R_a = 0.2 Ω. At rated speed and rated output the armature current is 70 A and field current is 1.5 A. Calculate (i) flux/pole (ii) the torque developed (iii) rotational losses (iv) efficiency (v) the shaft torque (vi) the shaft torque remains fixed, but the field is reduced by 10% of its value by field control, determine new operating speed. **(2 + 2 + 2 + 2 + 2 + 2) = 12**

5. A 230 V shunt motor has an armature resistance of 0.1 Ω and field resistance of 230 Ω and rotational loss 230 W. On full-load, the line current is 9.5 A with the motor running at 1500 rpm. Determine (i) the mechanical power

developed (ii) the power output (iii) the load torque (iv) the full-load efficiency.

(3 + 3 + 3 + 3) = 12

Group – D

6. (a) A 30 kVA, single phase transformer has an iron loss of 450 W and copper loss of 100 W when delivering half full load. At what percent of the full load will the transformer have maximum efficiency?

   (b) Determine the secondary terminal voltage of a 6000/440 transformer whose ohmic drop is 2% and leakage reactance drop is 6% at full load 0.8 pf lagging.

   (c) Discuss the condition of parallel operation of a two single phase transformer.

4 + 4 + 4 = 12

7. (a) A 2000/200 V, 1-phase transformer has maximum possible voltage regulation of 7% and it occurs at a pf of 0.4 (lagging). Find the full load voltage regulation at 0.8 pf (leading).

   (b) Two single phase transformers rated at 500 kVA and 400 kVA respectively are connected in parallel to supply a load of 2000 kVA at 0.8 lagging power factor. The resistance and reactance of the first transformer are 2.5% and 6% respectively, and that of the second transformer 1.6% and 7% respectively. Calculate the kVA loading and the power factor at which each transformer operates.

   (c) Discuss the advantage of using CRGO lamination in transformers.

4 + 6 + 2 = 12

Group – E

8. (a) Explain how the exciting current of a single-phase transformer contains harmonics even when supply voltage is a sine wave.

   (b) A bank of three transformers, connected in Y-Y, is fed from 3-phase 3-wire supply. If a single phase load is applied between one line and neutral, then the voltage of loaded phase collapses, but this does not happen in 3-phase core type transformer. Explain.

   (c) Explain how the Scott-connection are used to obtain 2-phase from 3-phase.

4 + 4 + 4 = 12

9. (a) Draw the phasor diagram and connection diagram of the following three-phase transformer group. (i) Dy1 (ii) Yd1.

   (b) A 50 kW, 400 V 3-phase load operates at 0.8 p.f. lagging is to be supplied by transformers connected in open-delta from an 6.6 kV line.
   (i) Determine kVA rating of each of the two transformers.
   (ii) Determine the line currents on the l.v. and h.v. sides.
   (iii) At what p.f. is each transformer operating?
   (iv) What is the real power supplied by each transformer?
   (v) What would be the available capacity, if third transformer of the same rating is used to form the closed delta?

   (c) Write the methods to suppress the harmonics in a transformer.

4 + (2 + 1 + 1 + 1 + 1) + 2 = 12