ELECTRICAL MACHINES
(MEC3132)

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) No load saturation characteristics are plotted between
(a) No load voltage and field current
(b) No load voltage and armature current
(c) Short circuit current and field current
(d) Short circuit current and armature current

(ii) The emf induced in the armature of the shunt generator is 600 V. the armature resistance is 0.1 Ω. If the armature current is 200 A then the terminal voltage will be
(a) 640 V (b) 620 V (c) 600 V (d) 580 V

(iii) What will happen if DC shunt motor is connected across AC supply?
(a) Will run at normal speed (b) Will not run
(c) Will Run at lower speed (d) Burn due to heat produced in the field winding

(iv) If P_{core} and P_{cu} represents core loss and full load copper loss respectively, the maximum kVA delivered to the load corresponding to maximum efficiency is equal to rated kVA multiplied by
(a) $\frac{P_{core}}{P_{cu}}$ (b) $\sqrt{\frac{P_{core}}{P_{cu}}}$ (c) $\left(\frac{P_{core}}{P_{cu}}\right)^2$ (d) $\frac{P_{cu}}{P_{core}}$

(v) A 5 kVA, 200 V/400 V single-phase transformer has an efficiency of 95% at full load and unity power factor. What will be the output power of the transformer at full load?
(a) 4.75 kW (b) 5 kW (c) 4.50 kW (d) 5.26 kW

(vi) In an induction motor, maximum torque varies as
(a) $\frac{V}{X_{20}}$ (b) $\frac{V^2}{X_{20}}$ (c) $\frac{V}{R_2}$ (d) $\frac{V}{X_{20}{}^2}$

(vii) The rotor power output of a 3 phase induction motor is 15 kW. The rotor copper loss at a slip of 4% is
(a) 600 W (b) 625 W (c) 550 W (d) 587 W

(viii) How much load current will a 900 MW star-connected three phase alternator with a voltage of 5 kV per phase deliver when full load is supplied at 0.6 lagging power factor?
(a) 1 kA (b) 1000 kA (c) 100 kA (d) 10 kA

(ix) Determine the pitch factor for winding: 36 stator slots, 4-poles, coil spans 1 to 8.
(a) cos 20° (b) cos 40° (c) cos 30° (d) cos 80°

(x) In a 3-phase synchronous motor, the effect of armature reaction depends mainly on the excitation level. Which of the following statements is correct?
(a) At under-excitation, armature reaction is demagnetizing.
(b) At normal excitation, armature reaction is magnetizing.
(c) At over-excitation, armature reaction is demagnetizing.
(d) Armature reaction is always cross-magnetizing regardless of excitation.

Fill in the blanks with the correct word

(xi) The nature of speed vs armature current for a dc shunt motor is _____.

(xii) The no load current of a transformer is approximately _____ % of full load current.

(xiii) The slip speed of a 3 phase, 6 pole induction motor operating at 3% slip is _____.

(xiv) The coil span of a short pitch coil is _____.

(xv) The maximum value of torque which a synchronous motor can develop at rated voltage and frequency without losing synchronism is called as _____.

Group - B

2. (a) What is armature reaction. Explain the effect of armature reaction on the operation of dc machines. *[(CO1)(Analyse/IOCQ)]*

(b) A 400 V series motor runs at 500 rpm with armature current of 50 A. Calculate the speed and % change in torque if load is reduced so that the armature current becomes 40 A. The total resistance of the armature and field current is 0.8 Ω. *[(CO2)(Evaluate/HOCQ)]*

6 + 6 = 12

3. (a) Explain the need for starter in a dc motor. *[(CO2)(Understand/LOCQ)]*

(b) Draw and explain the power flow diagram of a dc generator. *[(CO1)(Apply/IOCQ)]*

(c) The armature resistance of a 220 V dc shunt motor is 0.4 Ω and no load current armature current through it is 2 A. When loaded the armature current is 50 A and the speed is 1200 rpm. Calculate the no load speed. *[(CO2)(Evaluate/HOCQ)]*

3 + 4 + 5 = 12

Group - C

4. (a) Derive the e.m.f equation of a single phase transformer and show that the voltage ratio of the primary and secondary windings is the same as their turns ratio. *[(CO3)(Remember/LOCQ)]*

(b) A 600 kVA, single phase transformer has efficiency of 92% at both full load and at half load under unity p.f. Determine its efficiency at 75% of the full load and 0.9 p.f.
[(CO3) (Apply/IOCQ)]

(c) The e.m.f per turn of a single phase 10 kVA, 2200/220 V, 50 Hz transformer is 10 V. Evaluate: (i) the number of primary and secondary turns, (ii) maximum value of flux, and (iii) net cross sectional area of the core for a maximum flux density of 1.5 Wb/m^2.
[(CO3)(Evaluate/HOCQ)]

4 + 5 + 3 = 12

5. (a) Sketch the equivalent circuit of a practical transformer. Hence draw the phasor diagram of the transformer operating at lagging power factor load.
[(CO3)(Remember/LOCQ)]

(b) An 11 kV/220 V, 50 Hz, single phase transformer gave the following test results:

OC Test	220 V	45 A	2 kW
SC Test	500 V	9.09 A	3 kW

Determine the equivalent circuit parameters. *[(CO3)(Apply/IOCQ)]*

(c) A transformer is connected to a 1000 V, 50 Hz supply. The total core loss is 1000 W of which 700 W are hysteresis and 300 W are eddy current loss. If applied voltage is raised to 2000 V and the frequency to 100 Hz, evaluate the new core loss.
[(CO3)(Evaluate/HOCQ)]

4 + 5 + 3 = 12

Group - D

6. (a) Show that in a 3 phase induction motor

$$\frac{P_g}{P_m} = \frac{1}{1-s}$$

Where P_g = air gap power, P_m = mechanical power developed and s = operating slip of the motor. *[(CO4)(Remember/LOCQ)]*

(b) A 6 pole, 50 Hz, 3-ϕ induction motor has a slip of 1% at no load and 3% at full load. Estimate: (i) synchronous speed, (ii) no load speed, (iii) full load speed, (iv) frequency of rotor current at no load, (v) frequency of rotor current at full load.
[(CO4)(Apply/IOCQ)]

(c) A 3 phase, 4 pole induction motor has a rotor frequency of 2 Hz while connected to 400 V, 3 phase, 50 Hz supply. Evaluate (i) the slip, and (ii) the rotor speed of the motor. *[(CO4)(Evaluate/HOCQ)]*

4 + 5 + 3 = 12

7. (a) Explain with necessary diagram and calculations how rotating magnetic field is produced in a 3 phase induction motor. *[(CO4) (Remember/LOCQ)]*

(b) A 6 pole, 50 Hz, 3-ϕ induction motor has a slip of 1% at no load and 3% at full load. Evaluate: (i) synchronous speed, (ii) no load speed, (iii) full load speed, (iv) frequency of rotor current at standstill, (v) frequency of rotor current at full load.
[(CO4) (Evaluate/HOCQ)]

(c) Define slip of an induction motor. Hence explain why an induction motor cannot run at synchronous speed. *[(CO4) (Analyze/IOCQ)]*

4 + 5 + 3 = 12

Group - E

8. (a) A 4 pole, 3 phase, 50 Hz star connected alternator has 60 slots, with 2 conductors per slot and having armature winding of the two-layer type. Coils are short pitched in such a way that if one coil side lies in slot number 1, the other lies in slot number 13. Determine the useful flux per pole required to generate a line voltage of 6000 V. *[(CO5)(Analyse/HOCQ)]*

   (b) Describe briefly the effect of varying excitation upon armature current and power factor of a synchronous motor when input power to the motor is maintained constant. *[(CO6)(Remember/LOCQ)]*

6 + 6 = 12

9. (a) What are the different tests performed on an alternator to measure its performance. Explain any one of them. *[(CO5)(Analyse/HOCQ)]*

   (b) Draw and explain the equivalent circuit and phasor diagram of a cylindrical rotor synchronous motor at lagging power factor. *[(CO6)(Remember/LOCQ)]*

   (c) Draw the V curves of a synchronous motor. *[(CO6)(Apply/IOCQ)]*

5 + 4 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	30.21	32.29	37.5