

ELECTRICAL ENGINEERING (Paper I)

Time Allowed : Three Hours

Maximum Marks : 300

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.

Candidate has to attempt FIVE questions in all.

Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. Answer any three of the following:
 - (a) There are three concentric conducting spherical surfaces of radii a , b and c ($a < b < c$). The sphere of radius b carries a charge Q and the surfaces of spheres of radii a and c are grounded. Find the potential of the sphere of radius b . 20
 - (b) Find the output voltage in steady state condition for the operational amplifier shown in the figure below when (i) switch S is open, (ii) switch S is closed.
 [Figure: Inverting op-amp circuit: input V_i through a resistor R to the inverting ($-$) input; non-inverting ($+$) input grounded; feedback network from the inverting input: a resistor R to an intermediate node, and from that node to the output V_o two parallel paths – a resistor R , and a switch S in series with a capacitor C] 20
 - (c) Fig. (a) below shows a singly excited electromagnetic system consisting of a winding of N turns on a core carrying a flux ϕ . ($N=1000$). For the flux waveform of Fig. (b) below draw the waveform of induced e.m.f. $\omega=314$ rad/s.
 [Figure: Fig. (a): rectangular magnetic core with a winding of N turns on the left limb (two terminals); flux ϕ shown by a dashed path around the core]
 [Figure: Fig. (b): flux ϕ against ωt (one cycle): rises linearly from 0 at $\omega t=0$ to 1 mWb at $\pi/6$; stays at 1 mWb up to $2\pi/3$; falls linearly to 0 at $5\pi/6$; remains 0 up to π ; falls linearly to the negative maximum (-1 mWb, value not separately labelled) at $7\pi/6$; stays there up to $10\pi/6$; rises linearly to 0 at $11\pi/6$; remains 0 up to 2π] 20
 - (d) Draw a simple experimental set up to measure the Hall effect and show that the Hall field can be written as $E_y = V_x B_z$ where V_x and B_z are the applied voltage and magnetic fields respectively. What are the typical applications of Hall effect? 20
2. (a) Briefly explain the following statements on 3-phase induction motors: (i) Crawling is observed in squirrel cage motors. (ii) Rotor resistance method of speed control is employed only in wound rotor (slip ring) motors. (iii) Pole changing method is used in squirrel cage motors. (iv) Variable frequency method of speed control is used below base speed keeping the ratio of supply voltage to frequency constant. 20
 - (b) A half wave rectifier which prevents current flowing in one direction is connected in series with A.C. ammeter and a permanent magnet moving coil ammeter. The supply is sinusoidal. The reading on the A.C. ammeter is 10 A. Find the reading of the other ammeter. What would be the reading on the ammeters if the other half wave were rectified instead of being cut off? 20
 - (c) Reduce the following four variable function using Karnaugh map and implement it in NAND logic, $F = \sum m(0, 4, 12, 8, 13, 7, 15)$ 20
3. (a) Two coils A ($R_1=100$ ohm, $L_1=0.2$ H) and B ($R_2=100$ ohm, $L_2=0.4$ H) are coupled by an inductance of 0.2 H. Find the voltage V at a frequency of 1000 rad/s to be applied across 20

coil A to cause a current of 10 milliamperes through coil B across whose terminals a resistance of 100 ohms is connected.

[Figure: Coupled coils: source V in series with R_1 and coil L_1 (coil A, terminal marked A); coil L_2 (coil B, terminal marked B) in series with R_2 and a 100 Ω load resistor; mutual inductance M between L_1 and L_2 , dots at the upper ends of both coils]

- (b) Two identical 7.5 KW, 230 V 36 A d.c. shunt wound machines are used for speed control using Ward Leonard arrangement. One of them used as a generator is driven by a 6-pole, 50 Hz synchronous motor. Armature resistance of each d.c. machine is 0.22 ohm. Data for magnetisation curve of each machine is given below at 1000 r.p.m.:

Field current (A)	0.3	0.6	0.9	1.2	1.5	1.8
Armature voltage (V)	108	183	230	254	267	276

Compute the maximum and minimum values of generator field current to give the motor a speed range from 250 to 1500 r.p.m. at full load armature current (36 A) with the field current held at 0.80 A.

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- (c) State Faraday's Law of induction. A rectangular loop of sides a, b has its plane normal to a magnetic flux density of strength $B_0 \sin \omega t$. What is the voltage induced in the loop?

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4. (a) Explain the concept of Fermi-level. Sketch the Fermi-energy level for an n-type semiconductor as a function of temperature beginning at $T=0$ K and going to a very "high" temp. Qualitatively discuss the nature of the characteristic.

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- (b) The figure below shows a full wave rectifier circuit. For a sinusoidal input voltage, plot the voltage wave forms across R and D_1 .

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- (c) The circuit arrangement of an Owen Bridge for the measurement of the effective self inductance and resistance of an iron cored coil is shown in the figure below. Determine the balance conditions for the bridge and calculate the effective inductance and resistance of the coil if, for a frequency of 1000 Hz, the values of the circuit elements at balance are as follows: $R_1=10 \Omega$, $R_2=842 \Omega$, $C_1=1 \mu F$, $C_2=0.135 \mu F$

[Figure: Owen bridge drawn as a diamond: upper-left arm capacitor C_1 ; upper-right arm capacitor C_2 in series with resistor R_2 ; lower-left arm resistor R_1 ; lower-right arm the iron-cored coil (L, R); detector D between the top and bottom corners; a.c. source connected between the left and right corners]

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SECTION 'B'

5. Answer any three of the following:

- (a) a single element rectifying device is connected in series with a moving coil ammeter and a thermal ammeter and it is found that the circuit has a resistance of 100 Ω to current in one direction and infinitely large resistance to current in the opposite direction. If a sinusoidal e.m.f. of 10 V (r.m.s.) is applied to this circuit, what will be the reading of each instrument and what will be the power taken from the supply?

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- (b) Find X and; [?] in terms of R and R2 to give maximum power dissipation in R2 shown in the figure.

[Figure: a.c. source in series with resistor R_1 ; then a shunt reactance X_1 (inductor) across the line; then a series reactance X_2 followed by the load resistor R_2 across the line]

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- (c) A 3-phase delta connected squirrel cage induction motor has certain equivalent circuit parameters. With the same stator core, the motor is rewound with star connected windings of same poles for operation at the same supply voltage and frequency to give same rated power output at the same rated slip. By what factors each of the equivalent circuit parameters would be changed?

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- (d) An infinitesimal dipole (Hertzian) antenna of 1 cm length radiates a power of 1 mW at 100 MHz. Calculate (i) the current in the dipole, (ii) E and H fields at 100 meters. $\phi=90^\circ$, $\phi=0^\circ$

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6. (a) 415 V star connected 3-phase, 4-pole synchronous generator has 36 stator slots carrying double layer 3-phase windings formed through uniformly distributed coils each short chorded by one slot. The diameter at the airgap is 20 cm and the effective axial length is 60 cm. The rotor driven at 1500 r.p.m is excited to result in a sinusoidally varying airgap flux density distribution in space with a peak value of 0.5 T. Calculate the number of series turns per phase to generate rated no load voltage. 20
- (b) What are the starting methods used for 1-phase induction motors. Draw typical torque-speed characteristics in each case both under starting and running conditions. 20
- (c) Two perfectly insulated condensers are connected in series. One is an air condenser with a plate area of 100 cm^2 and the plates being 1 mm apart; the other has a plate area of 10 cm^2 , the plates being separated by dielectric of 0.1 mm thick with a permittivity of 5. Find the voltage across the combination if the potential gradient in the air condenser is 20 KV per cm. 20
7. (a) 11 MV [?], 415 V, 3-phase 50 Hz distribution transformer has its HV and LV windings connected in delta and star respectively. It is delivering 100 KVA load at 0.8 PF (lag). Calculate all HV and LV currents. Draw a phasor diagram showing all voltages and currents. 20
- (b) For the circuit shown in the figure below, draw the ac. equivalent circuit and find the voltage gain of the amplifier.
[Figure: JFET common-source amplifier: a.c. source (grounded) coupled through capacitor C_c to the gate; gate bias divider R_1 from V_{DD} to the gate and R_2 from the gate to ground; drain connected through 100 K to V_{DD} , output V_o taken at the drain; source grounded; device data $r_d = 50 \text{ K}\Omega$, $\mu = 300$ [?]] 20
- (c) Draw the circuit diagram of an R-C phase shift oscillator using a transistor with CE configuration and derive an expression for its frequency of oscillation. Prove that $H_{fe} = 23 + 29R/R_L + 4R_L/R_1$ 20
8. (a) Consider the set up shown in the figure below for measuring Hall effect. Assume that $L = 10^{-1} \text{ cm}$, $W = 10^{-2} \text{ cm}$. The following parameters are measured: $I_x = 1.0 \text{ mA}$, $V_x = 12.5 \text{ V}$, $B_z = 5 \times 10^{-2} \text{ T}$, $V_H = -6.2 \text{ mV}$ Find the type of the semiconductor, majority carrier concentration and the mobility.
[Figure: Hall-effect set-up: rectangular semiconductor bar of length L (along x, between the current contacts), width W and thickness d, lying in the x-y plane; voltage V_x (battery, + and - marked) drives current I_x along the length; magnetic field B_z perpendicular to the bar; Hall voltage V_H (+ and - marked) measured across the width; fields E_x and E_H and the carrier drift marked inside the bar] 20
- (b) Determine the condition under which the input impedance of the network shown in the figure below will be equal to R.
[Figure: Two-port: in the upper line a resistor R in series, bridged by an impedance Z_2 connected in parallel with it; after it a shunt impedance Z_1 from the upper line to the lower line, followed by a shunt resistor R across the output terminals] 20
- (c) A 250 V, d.c. shunt motor has $R_f = 150 \Omega$ and $R_a = 0.6 \Omega$. The motor operates on no load with a full field flux at its base speed of 1000 r.p.m. with $I_a = 5 \text{ A}$. If the machine drives a load requiring a torque of 100 Nm. Calculate the armature Current and speed of the motor if the motor is required to develop 10KW at 1200 r.p.m. What is the required value of the external series resistance in the field circuit? Neglect saturation and armature reaction. 20