

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.

Questions No. 1 and 5 are compulsory and out of the remaining, 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.

Diagrams/Figures, wherever required, shall be drawn in the space provided for answering the question itself.

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly.

Any page or portion of the page left blank in the Question-cum-Answer (QCA) Booklet must be clearly struck off.

Answers must be written in ENGLISH only.

SECTION A

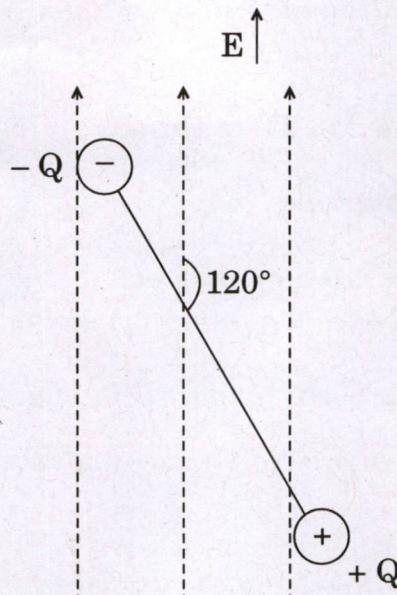
- Q1.** (a) The average number of mistakes committed by a typist is 3 per page. Find the probability that the typist commits

- (i) no mistake
- (ii) at least two mistakes per page.

12

- (b) An electric dipole is placed in a uniform electric field of strength 7×10^6 V/m as shown in the figure. The charge on each dipole is opposite in nature and each equal to the charge of an electron. Both charges are separated by a distance of 2 angstrom. Both, field and dipoles are in same plane. Calculate the magnitude and direction of the dipole moment and torque.

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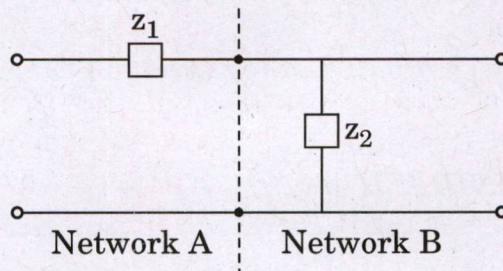


- (c) Define magnetostriction. Explain different types of magnetostriction.

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- (d) The equivalent ABCD constants of a network are obtained by cascade connection of two networks as shown in the figure. The value of constant B of equivalent network is $5 + j40$. Calculate the value of z_1 .

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- (e) Write a C-program to check whether a number is a perfect number or not.

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Q2. (a) (i) Expand $f(x) = e^{-x}$, $-\pi < x < \pi$ in a complex Fourier series. 10

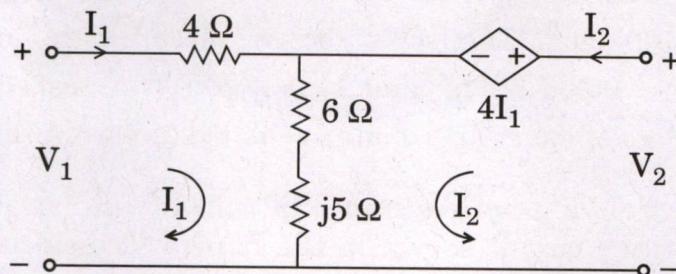
(ii) Find the frequency spectrum of the periodic square wave given by the extension of the function

$$f(x) = \begin{cases} 0, & -\frac{1}{2} < x < -\frac{1}{4} \\ 1, & -\frac{1}{4} < x < \frac{1}{4} \\ 0, & \frac{1}{4} < x < \frac{1}{2} \end{cases}. \quad \text{10}$$

(b) (i) What is piezoelectricity? Explain the construction and working of a piezoelectric device. State any two applications of piezoelectric devices. 10

(ii) A pn junction is doped with an acceptor ion concentration $N_A = 2 \times 10^{16} \text{ cm}^{-3}$ and a donor ion concentration $N_D = 9 \times 10^{15} \text{ cm}^{-3}$. Determine the capacitance of the device with $V_R = 2 \text{ V}$. Dielectric constant of silicon $\epsilon_{Si} = 11.7 \times 8.85 \times 10^{-14} \text{ F/cm}$. 10

(c) Draw the equivalent z parameter circuit of a network as shown in the figure and determine whether the circuit is (i) reciprocal, and (ii) symmetrical. 20



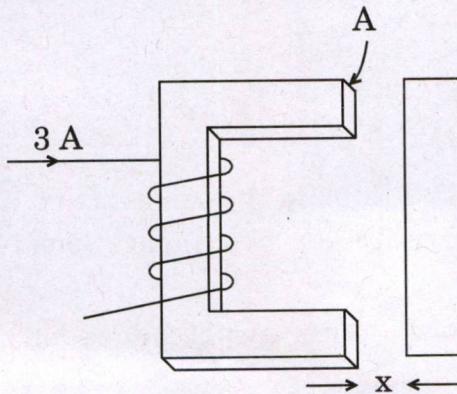
Q3. (a) (i) An elastic membrane in the x_1x_2 -plane with boundary circle $x_1^2 + x_2^2 = 1$ is stretched so that a point P (x_1, x_2) goes over into the point Q (y_1, y_2) given by

$$\mathbf{y} = \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \mathbf{AX} = \begin{bmatrix} 5 & 3 \\ 3 & 5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}.$$

Find the principal directions, i.e., the directions of the position vector X of P for which the direction of the position vector Y of Q is same or exactly opposite. What shape does the boundary circle take under this deformation? 10

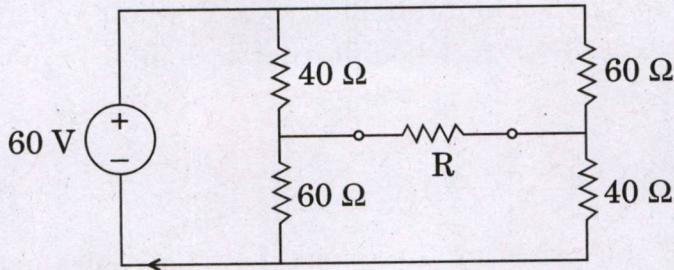
(ii) Using the contour integration, evaluate the integral $\int_{-\infty}^{\infty} \frac{dx}{1+x^4}$. 10

- (b) The magnetic circuit of a relay is shown in the figure. Calculate the energy that coil carries and the force on the armature of the relay when 3 Amp current flows in the coil. The air gap x is 2 cm, cross-section area of core is 50 cm^2 and the number of turns in the coil is 2000. Neglect the fringing effect and the reluctance of magnetic circuit in the core. 20



- (c) (i) A capacitor of $0.025 \mu\text{F}$ has the loss angle, $\delta = 0.0286^\circ$. Calculate the dielectric loss of the capacitor when it carries a current of 100 A at a frequency of 25 kHz. 10
- (ii) An iron piece of 50 kg mass, 7500 kg/m^3 density is subjected to an AC supply of 50 Hz frequency; its hysteresis loop area is found to be 160 cm^2 . The scale factors on ordinate and abscissa are $1 \text{ cm} = 0.008 \text{ Wb/m}^2$ and $1 \text{ cm} = 20 \text{ AT/m}$, respectively. Calculate the loss of energy per hour due to hysteresis in the specimen. 10

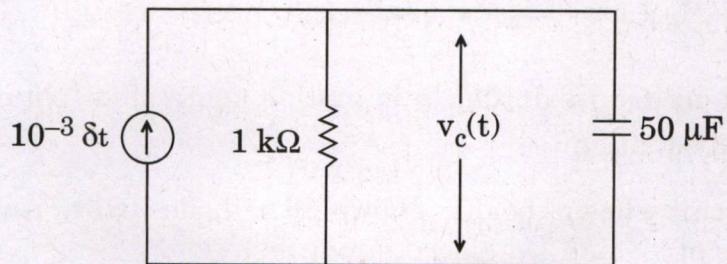
- Q4.** (a) Determine the value of resistance 'R' which will extract the maximum power from the circuit shown in the figure. Also calculate the value of maximum power. 20



- (b) (i) Define Hall effect. With a sketch, explain the concept of Hall effect and arrive at an equation for Hall voltage V_H . 10
- (ii) The superconducting state of a lead specimen has critical temperature of 7.26 K at zero magnetic field and the critical field is $8 \times 10^5 \text{ A/m}$ at 0 K. Estimate the critical field at 5 K for this specimen. 10

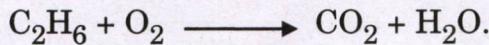
- (c) A circuit shown in the figure is initially being quiescent and excited by a current impulse. Find the expression for $v_c(t)$ for $t > 0$ and draw the voltage response. Calculate the value of voltage across the capacitor at $t = 50 \text{ ms}$.

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SECTION B

- Q5.** (a) Form the homogeneous system of equations to balance the chemical equation

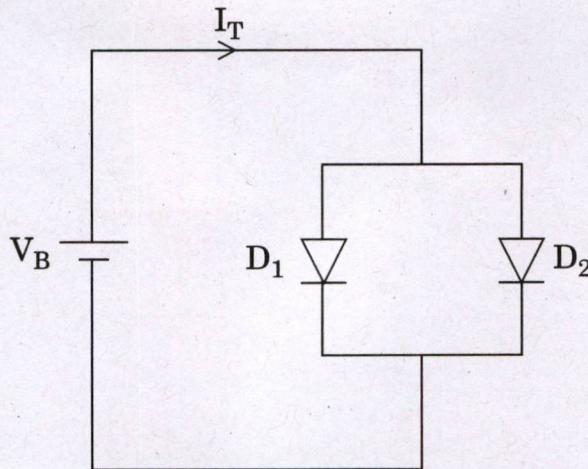


Solve it by Gauss-Jordan elimination method to obtain the balanced chemical equation. 12

- (b) The circuit shown below, shows two diodes with reverse saturation currents of I_{S1} and I_{S2} placed in parallel.

(i) Prove that the parallel combination operates as a diode. 6

(ii) If the total current is I_T , then determine the current carried by each diode. 6



- (c) (i) What are trigraph characters ? How are they useful ? Translate the following trigraph sequences into their equivalent symbols : 6

(I) ??= (II) ??) (III) ??< (IV) ??/ (V) ??- (VI) ??!

- (ii) From the keywords and identifiers given below, segregate the keywords and identifiers in two separate groups : 6

(I) break (II) ifloat (III) unsigned (IV) size (V) vshort (VI) goto
 (VII) sizeof (VIII) reverse (IX) enum (X) register (XI) iff
 (XII) continue

(d) Draw the schematic diagram of a series-series feedback amplifier and obtain expression for

- (i) closed loop gain
- (ii) input impedance
- (iii) output impedance.

The forward amplifier is characterised by finite input impedance R_i and finite output impedance R_o .

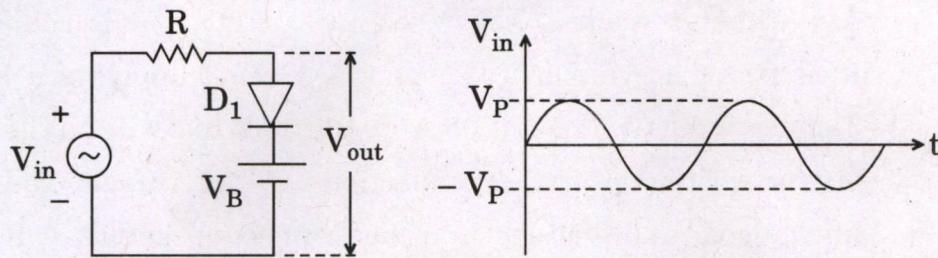
$3+3 \times 3 = 12$

(e) With a block schematic, explain the essential functional operations of a generalised data acquisition system.

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Q6. (a) For the diode-resistor-battery circuit shown below, the diode D_1 is assumed to be ideal. Sketch the time-average of V_{out} , as the battery voltage V_B is varied from $-\infty$ to $+\infty$, if the input voltage is a sinusoidal voltage with an amplitude equal to V_p .

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(b) A dynamometer ammeter is arranged so that 1% of total current passes through the moving coil and rest through the fixed coil. The mutual inductance between the two coils varies with the angle of displacement of the moving coil from its zero position as follows :

Angle (degree)	0	15	30	60	90	105	120
Mutual inductance (μH)	-336	-275	-192	0	192	275	336

If a torque of 10.5×10^{-6} Nm is required to give the full scale deflection of 120° , calculate the current at half and full scale deflection. (Graph sheet attached)

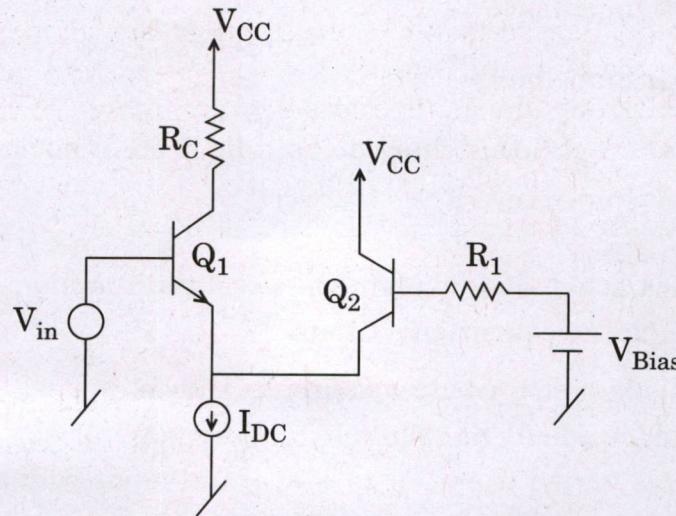
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(c) Using any high level language, write a computer program to compute the area enclosed by a curve $f(x) = x^2 + 1$, between $x = A$ and $x = B$, by using trapezoidal approximation.

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- Q7.** (a) Assuming the Early Voltage $V_A = \infty$, compute the voltage gain and input impedance of the circuit shown below. I_{DC} is an ideal current source while V_{Bias} is an ideal voltage source used to bias Q_1 and Q_2 in the active mode.

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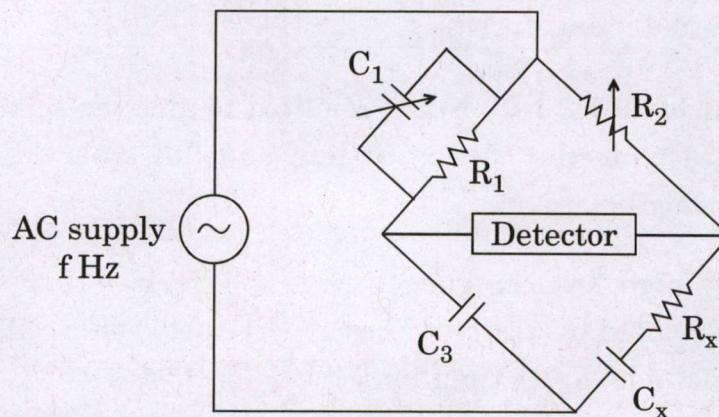


- (b) (i) A wattmeter reads 4 kW when its current coil is connected in R phase of a symmetrical 3-phase system supplying a balanced 3-phase inductive load of 25 A at 400 V. What will be the reading of the wattmeter if the connections of the current coil remain unchanged and voltage coil be connected between B and Y phases ? Draw the corresponding phasor diagram.

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- (ii) The following data is related to the Schering bridge shown in the figure. $R_1 = 2 \text{ k}\Omega$, $C_1 = 0.5 \mu\text{F}$, $R_2 = 4 \text{ k}\Omega$ and $C_3 = 0.5 \mu\text{F}$ at frequency 1 kHz. Determine the unknown resistance and capacitance of the bridge circuit and dissipation factor.

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- (c) (i) Construct a switching circuit for the Boolean function using logic gates. Simplify the function and draw the simplified circuit using logic gates

$$L = A \cdot B + A' \cdot B + A \cdot B'$$

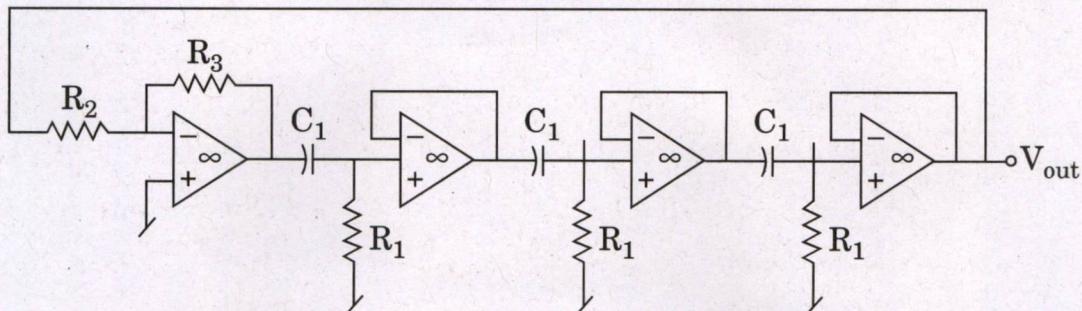
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- (ii) A 36-bit floating point binary number has eight bits plus sign for the exponent and twenty-six bits plus sign for mantissa. The mantissa is a normalized fraction. Numbers in the mantissa and exponent are in signed-magnitude form. Determine the largest and smallest positive quantities that can be represented, excluding zero.

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- Q8.** (a) For the RC phase shift oscillator circuit shown below, determine the condition of oscillation and the frequency of oscillation. What will be the frequency of oscillation (in Hz) if $R_1 = R_2 = 10 \text{ k}\Omega$ and $C_1 = 1.0 \text{ nF}$? Also calculate the minimum value of R_3 required to sustain sinusoidal oscillations.

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- (b) A parallel plate capacitive transducer uses plates of area 450 mm^2 which are separated by a distance 0.3 mm and having air as dielectric. Determine :

- (i) The change in capacitance if the transducer is subjected to a linear displacement which reduces distance between plates to 0.27 mm .
- (ii) The ratio of per unit change of capacitance to per unit change of displacement.
- (iii) If a mica sheet of 0.02 mm is inserted in the gap, determine the value of actual capacitance and the change in capacitance for the same displacement and the ratio of per unit change in capacitance to per unit change in displacement. Assume the dielectric constant of mica to be 8.

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(c) Show that :

(i) $\int_C (yz - 1) dx + (z + xz + z^2) dy + (y + xy + 2yz) dz$

is independent of path of integration from (1, 2, 3) to (4, 5, 6).

Hence, evaluate the integral.

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(ii) Let $\bar{F} = z \hat{j} + z \hat{k}$ represent the flow of a liquid. Find the flux of \bar{F} through the surface S given by that portion of the plane $z = 6 - 3x - 2y$ in the first octant oriented upward.

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