

# ELECTRICAL ENGINEERING

## Paper - I

HJI-F-ELEC

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 Booklet must be clearly struck off.*

*Answers must be written in **ENGLISH** only.*

Q1. (a) (i)

SECTION A

Obtain the partial differential equation governing the equations

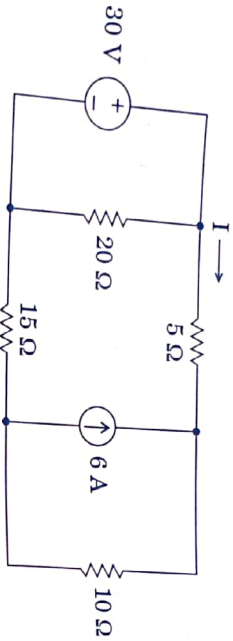
(ii)  $Ru, v = 0, u = x + yz, v = x + y + z$

Construct a partial differential equation of all surfaces of revolution having z-axis as the axis of rotation.

(b) Discuss the phenomena of Hysteresis in ferromagnetic materials. On the B-H curve show the retentivity, coercivity and saturation points. What is coercive force and the energy dissipated per unit volume of the ferromagnetic substance during the hysteresis cycle?

(c) Explain and derive continuity of current equation using the principle of conservation of charge.

(d) Using the principle of superposition, determine the current I in the 5 Ω resistor in the circuit shown in the figure.



(e) State Ampere's circuital law. A hollow conducting cylinder has inner radius a and outer radius b and carries current I along the positive z-direction. Find H everywhere.

(i) If a square matrix A of order n with entries in field F has n distinct eigenvalues, then prove that matrix A is similar to a diagonal matrix.

(ii) Find the matrix P which diagonalizes the matrix associated with the quadratic form

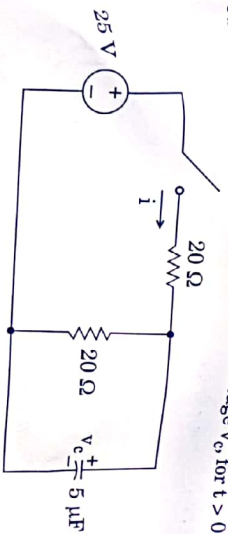
$$3x^2 + 5y^2 + 3z^2 - 2yz + 2zx - 2xy.$$

(i) On the basis of specific resistance ρ, discuss the difference between conductors, semi-conductors and insulators.

(ii) Prove that insulation resistance of a cable is inversely proportional to its length. Define insulation resistance.



(c) In the circuit shown in the figure given below, the switch is closed at  $t = 0$ . Obtain the current i and capacitor voltage  $V_c$  for  $t > 0$ .



Q3. (a) (i) If the density function of a continuous random variable is given by

$$f(x) = \begin{cases} 0, & x < 0 \\ ax, & 0 \leq x \leq 2 \\ (4-x)a, & 2 \leq x \leq 4 \\ 0, & x > 4 \end{cases}$$

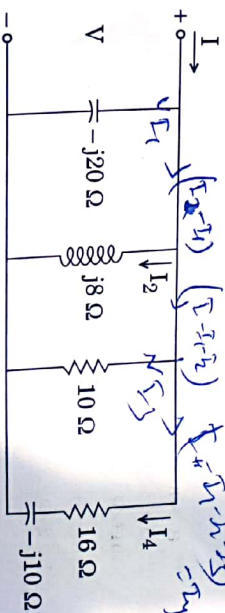
(p) Find value of a.

(q) Find the cumulative distribution function (cdf).

(r) Find  $P(X > 2.5)$ .

(ii) Compute  $\int_c \frac{\cos z dz}{z^2(z-\pi)^3}$ , where  $c: |z| = 4$ .

(b) For the circuit shown in the figure given below, the total current I entering the circuit is  $30 \angle -21^\circ$  A. Determine the voltage V and the branch currents  $I_2$  and  $I_4$ .



(c) (i) Discuss the factors affecting electrical resistance of conductors.

(ii) Find the diffusion co-efficients of electrons and holes of a single silicon crystal at 27°C, if the mobilities of electrons and holes are 0.17 and 0.025 m<sup>2</sup>/volt-sec respectively at 27°C. (Boltzmann's constant  $k = 1.38 \times 10^{-23}$  Joule/degree)



Q4. (a) (i) State Dirichlet's conditions for existence of Fourier series of a function. Determine the half range Fourier cosine series of

$$f(x) = \begin{cases} x, & 0 < x < \frac{\pi}{2} \\ \pi - x, & \frac{\pi}{2} \leq x < \pi \end{cases}$$

(ii) By converting into a line integral, evaluate  $\iint_S (\nabla \times \vec{F}) \cdot \hat{n} \, dS$ ,

where  $\vec{F} = (x^2 + y - 4)\hat{i} + 3xy\hat{j} + (2xy + z^2)\hat{k}$  and S is the surface of paraboloid  $x^2 + y^2 + z = 4$  above xy-plane.

(b) Discuss photoelectricity and photoemissive effect along with laws of photoemissive effect. 10

(c) Show that the ratio of the amplitudes of conduction current density and displacement current density is  $\frac{\sigma}{\omega \epsilon_0}$  for the applied field 20

$$E = E_m \sin \omega t. \text{ Assume } \mu = \mu_0.$$

What is the amplitude ratio if the applied field is  $E = E_m e^{-t/\tau}$ , where  $\tau$  is real? 10

SECTION B

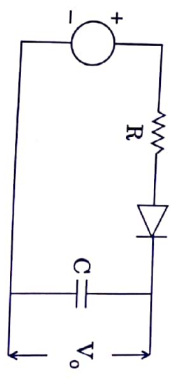
Q5. (a) (i) Using an iterative method, write C program segment to generate first n ( $n \geq 8$ ) Fibonacci numbers. 6

(ii) Find minimal disjunctive normal form (DNF) for the expressions  $\bar{x}yz + xyz + xy\bar{z}$  and  $x + yz + z\bar{x}y + \bar{y}xz$ . 6

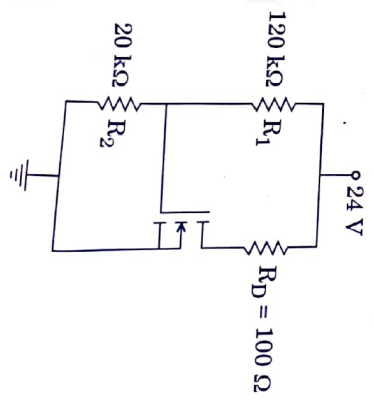
(b) Why and how are volt-ratio boxes utilized along with d.c. potentiometers? How should the value of the volt-ratio box resistance be chosen? 6

(c) The self-capacitance or distributed capacitance of a coil is measured using Q meter. The first measurement is carried out at 2.5 MHz, when the tuning capacitor is set at 425 pF. The second measurement is carried out by increasing the frequency to 6 MHz, when the tuning capacitor is set at 60 pF. Determine the distributed capacitance of the coil. 12

(d) Calculate the output voltage  $V_o$  at 7 ms in the figure shown below if a  $\pm 10$  V square wave of 250 Hz source is applied to R = 10  $\Omega$ , C = 20  $\mu$ F. The diode is ideal and capacitor is initially uncharged. 12



(e) Determine  $V_{GS}$  and  $V_{DS}$  for the E-MOSFET circuit shown in the figure below. The minimum values of  $I_{D(ON)} = 200$  mA at  $V_{GS} = 4$  V and Gate to Source threshold voltage  $V_{GS(Th)} = 2$  V. 12



Q6. (a) (i)

- Explain in brief the following and differentiate between them :
- I. Stack and Queue
  - II. Sort and Search

12

(ii)

- Write a pseudo code or in any standard programming language for interchanging the values of two variables :
- I. Using a third variable.
  - II. Not using any extra variable.

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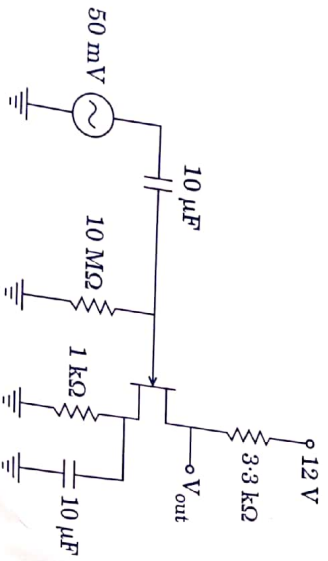
(b)

A 230 V, single phase, watt hour meter has a constant load of 5 A passing through it for 8 hours at unity power factor. If the meter constant is 460 revolutions per kWh, how many revolutions does the meter disc make during this period ? If the same meter makes 1638 revolutions when operating at 230 V and a constant load of 6 A passing through it for a certain duration at a power factor of 0.86, determine the duration of operation of the meter in hours.

(c)

(i) Find the voltage gain of JFET amplifier shown in the figure below for the drain to source current with gate shorted,  $I_{DSS} = 10 \text{ mA}$ , cut-off voltage  $V_{GS(OFF)} = -4 \text{ V}$  and  $I_D = 2 \text{ mA}$ . If a load resistance of  $4.7 \text{ k}\Omega$  is a.c. coupled to the output of this amplifier, calculate the percentage change in voltage gain.

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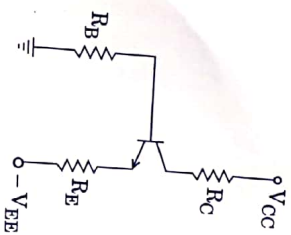
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(ii)

Find  $R_B$  in the figure shown below for silicon transistor with  $\beta = 100$  and negligible leakage current, if  $V_{CC} = 20 \text{ V}$ ,  $V_{BE} = 5 \text{ V}$ ,  $R_E = 100 \Omega$ ,  $R_C = 2 \text{ k}\Omega$  and  $I_C = 6 \text{ mA}$ .

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Q7. (a)

(i)

Execution of a sequence of instructions of a program involves 200 instruction fetch operations, 100 memory operand read operations, and 80 memory operand write operations. Find the average memory access time in executing this sequence of instructions if the memory access time is 2 ns for a read operation with a hit in cache, 5 ns for a read operation with a miss in cache, 3 ns for a write operation with a hit in cache and 10 ns for a write operation with a miss in cache. The cache hit ratio is 0.9. Consider the time taken for fetch operation to be equal to that of read operation.

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(ii)

Derive the expression for the number of comparisons required in the worst case for sorting an array of 'n' elements using Bubble sort. Calculate it for an array of 100 elements. When will such maximum number comparisons occur in Bubble sort ?

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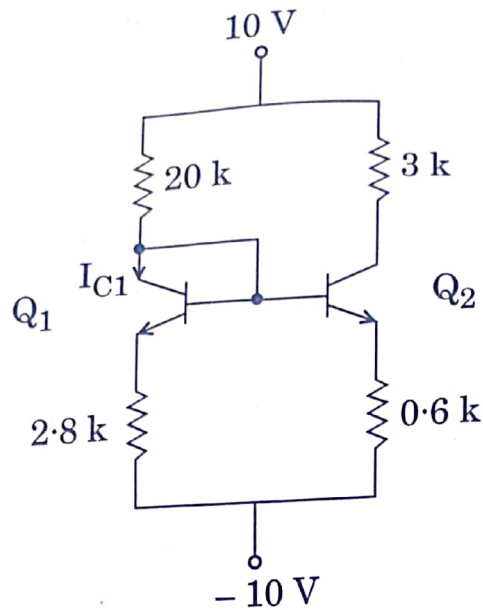
(b)

A spring controlled, electrodynamic voltmeter has a range of 100 V, has a square law scale response, and it takes  $0.08 \text{ A}$  on d.c. for full scale deflection of  $120^\circ$ . The control constant is  $1 \times 10^{-6} \text{ N-m/degree}$ . The true potential difference across the instrument is  $100.42 \text{ V}$ , when it reads  $100 \text{ V}$  at  $50 \text{ Hz}$ . Determine the initial mutual inductance of the instrument.

20



- (c) (i) Find  $I_{C1}$  in the circuit shown in the figure below. Assume that the two transistors are matched and  $V_{BE} = 0.7 \text{ V}$ ,  $\beta = 100$ . 12



- (ii) Find the feedback factor  $\beta$  of the negative feedback network required for an amplifier with open loop gain  $A_0 = 2000 \pm 200$  to reduce the variation to less than  $\pm 0.2\%$ . Find the overall gain of the system with feedback. 8

- Q8. (a) Name the layers of Open Systems Interconnection (OSI) model created by the International Organisation for Standardisation for different computer systems to communicate with each other using standard protocols. Mention the important functions of each of these layers in brief. 20
- (b) In an oscilloscope, the deflection factor of CRT is  $80 \text{ V/cm}$  and the accelerating voltage is  $2500 \text{ V}$ . What is the minimum distance required from center of deflection plates to screen that allows full deflection of  $4 \text{ cm}$  on the oscilloscope screen? 20
- (c) Derive the expression for the frequency and the condition for starting of sustained oscillation in a transistorised R-C phase shift oscillator. Neglect  $h_{oe}$  and  $h_{re}$ . Assume  $R \gg h_{ie}$  and a load resistance  $R_L$  is a.c. coupled to the oscillator. 20