09475

A-DMHH-N-FUA

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

Paper I

(CONVENTIONAL)

Time Allowed : Three Hours *Maximum Marks : 200*

INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions :

Candidates should attempt FIVE questions in all.

Question no. 1 is compulsory.

Out of the remaining SIX questions attempt any FOUR questions.

All questions carry equal marks. The number of marks carried by a part of a question is indicated against it.

Answers must be written in ENGLISH only.

Assume suitable data, if necessary, and indicate the same clearly.

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

Values of the following constants may be used as indicated, wherever necessary :

Electronic charge = $-1{\cdot}6 \times 10^{-19}$ coulomb

Free space permeability = $4\pi \times 10^{-7}$ Henry/m

Free space permittivity = $(1/36\pi) \times 10^{-9}$ Farad/m

Velocity of light in free space = 3×10^{8} m/s

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ J/K

Planck constant = $6{\cdot}626 \times 10^{-34}$ J-s

Neat sketches may be drawn, wherever required.

All parts and sub-parts of a question are to be attempted together in the answer book.

Attempts of questions shall be counted in chronological 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 answer book must be clearly struck off.

1. Answer ***all*** of the following :

(a) Clearly distinguish between the following : 5

(i) Conductivity and Mobility

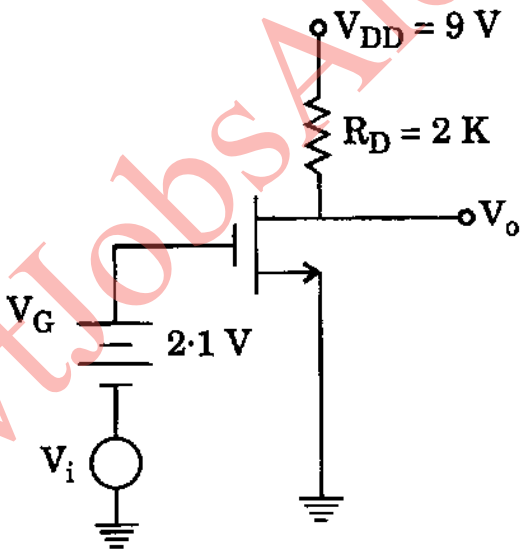
(ii) Zener breakdown and Avalanche breakdown

(iii) Piezoelectric and Ceramic

(iv) Direct band-gap and Indirect band-gap

(v) Polarizability and Permittivity

(b) The n-channel MOSFET in the circuit has $V_{TN} = 1$ V and $K = 0{\cdot}8$ mA/V^2.



(i) Assume that FET is operating in its saturation region. Show that $I_D \simeq 1$ mA.

(ii) Determine the transconductance g_m.

(iii) If $V_i = 10$ mV, what are drain current and voltages ? 5

(c) Prove that for an alloy p – n junction (with $N_A << N_D$), the width of the depletion layer is given by,

$$W = \left(\frac{2\varepsilon \mu_p V_j}{\sigma_p} \right)^{\frac{1}{2}}$$

where V_j is the junction potential under the condition of applied diode voltage. *5*

(d) What is a positive real function as applied to driving point immittance functions ?

Realize the following driving point impedance function using Foster-I form :

$$Z(s) = \frac{6(s+3)(s+9)}{s(s+6)}$$ *5*

(e) For an LTI system with unit impulse response $h(t) = e^{-2t}\, u(t)$, determine the output for an input of $x(t) = e^{-t}\, u(t)$. *5*

(f) Draw sample and hold circuit and explain its operation. *5*

(g) For a transmission line, the primary constants are :

$R = 0{\cdot}5\ \Omega/m$

$L = 0{\cdot}02\ \mu H/m$

$C = 100\ pF/m$

$G = 0{\cdot}01\ \mho/m$

Compute the values of complex propagation constant. *5*

(h) What is a strain gauge ? Where does it find applications ? How is temperature compensation done in such gauges ? *5*

2. (a) The following data is obtained for a nickel-iron alloy during the generation of steady-state ferromagnetic hysteresis loop :

H(A/m)	50	25	0	–10	–15	–20	–25	–50
B(Wb/m^2)	0·95	0·94	0·92	0·90	0·75	– 0·55	– 0·87	– 0·95

(i) What is remanent induction ?

(ii) What is coercive field ?

(iii) Determine the saturation induction.

(iv) Determine the saturation magnetization.

(v) Identify these parameters on the graph. *10*

(b) (i) Why do we classify Magnesium and Aluminium as good electrical conductors even though outer 3s energy bands are filled ?

(ii) How do you explain for poor conductivity of pure diamond with the help of energy band model ? *10*

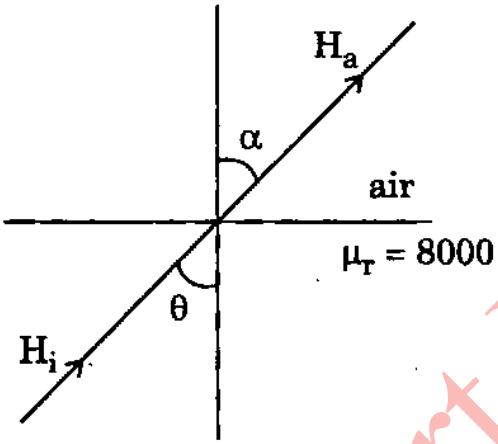
(c) In an electronic watch, the quartz crystals are 1 mm thick. They are excited piezoelectrically in their fundamental mode.

(i) Estimate the frequency at which they oscillate.

(ii) Estimate its daily drift (sec/day) in winter if there is no compensation for changes in the quartz. Do you think that the watch does have such compensation ?

$B = 10^{12}$ erg/cm^3 and $\rho = 2{\cdot}7$ g/cm^3. *10*

(d) A steady-state magnetic field of 10 A/m is incident on an iron air boundary as shown in figure. ($\mu_r = 8000$)



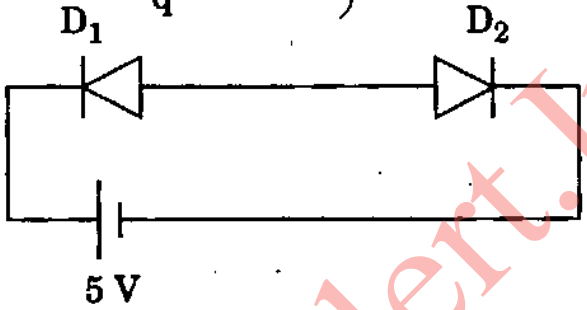
(i) Write the boundary conditions for the magnetic field in terms of the indicated variables and parameters assuming surface currents to be absent.

(ii) Plot α vs θ for the range $0 < \theta < \frac{\pi}{2}$.

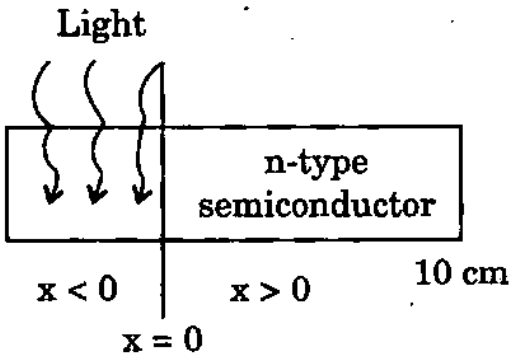
(iii) For $\theta = \frac{\pi}{4}$, find the magnetic flux density in magnitude and direction at the interface. *10*

3. (a) A small number of readily ionized donors N_D are added to an intrinsic semiconductor, such that $N_D << n_i$, where 'n_i' is the intrinsic carrier concentration. Find the free electron and hole concentration in a semiconductor, accurate to the first order N_D/n_i. *8*

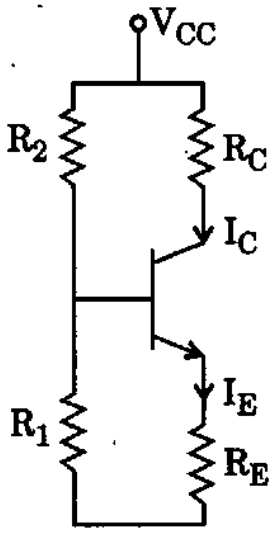
(b) Two identical silicon junction diodes D_1 and D_2 are connected back to back as shown below. The reverse current I_s of each diode is 10^{-8} A and the breakdown voltage V_B is 50 V. Find the V_{D_1} and V_{D_2} voltages dropped across diodes D_1 and D_2. $\left(\text{Assume } \frac{KT}{q} = 25 \text{ mV}\right)$ *8*



(c) An n-type silicon bar is doped uniformly by phosphorus atoms to a concentration of $4{\cdot}5 \times 10^{15}$/cc. The bar has a cross-section of 1 mm^2 and a length of 10 cm. It is illuminated uniformly for region $x < 0$ as shown in the figure. Assume optical generation rate 10^{21} electron-hole pairs per cm^3/sec. The hole lifetime and electron lifetime are equal and are 1 μsec. Find the hole and electron diffusion current at x = 34·6 μm. *8*



(d) Design a self biasing circuit such that $I_C = 5$ mA, $V_{CC} = 8$ V, $V_E = 6$ V, S = 10, $h_{fe} = 200$ and $V_{CC} = 20$ V. *8*



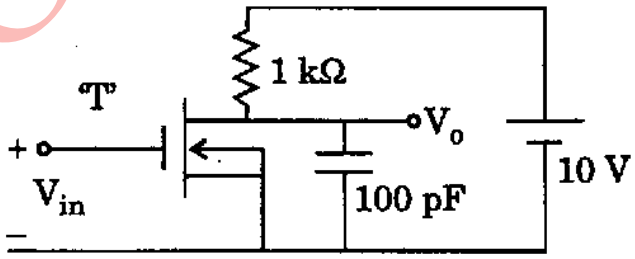
(e) An n-channel MOSFET-'T' having a V_T of 2 V (Threshold voltage) is used in the circuit as shown. Initially 'T' is OFF and is in steady-state. At time t = 0, a step voltage of magnitude 4 V is applied to the input so that MOSFET turns 'ON' instantaneously. The device parameters are

$K = 5$ mA/V^2

$R_{DS} = \infty$

$C_{DS} = 0$

$C_{DG} = 0$



Draw the equivalent circuit and calculate the time taken for the output to fall to 5 V. *8*

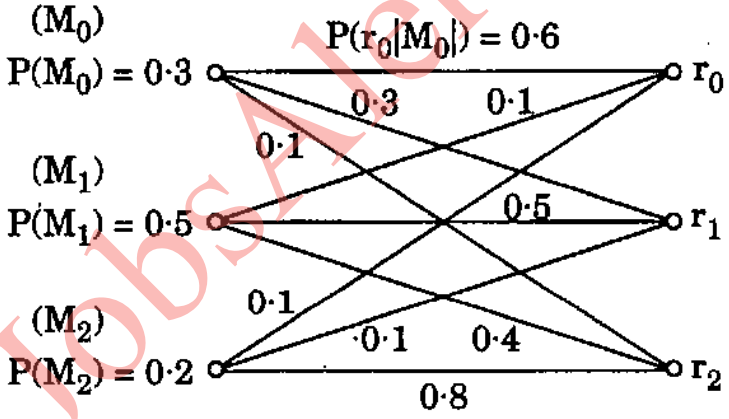
4. (a) What is a Z-transform ? Give its utility. *4*

(b) Obtain the Inverse – Laplace transform of the following :

$$Y(s) = \frac{s}{s(s^2 + 3s + 2)}$$ *10*

(c) (i) For the channel and message probabilities given in the figure below, determine the best decisions about the transmitted message for each possible received response.

(ii) With decisions made as in part (a), calculate the probability of error.



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(d) 40% of the population of a town are voters, 50% are educated and 20% are educated-voters. A person is chosen at random.

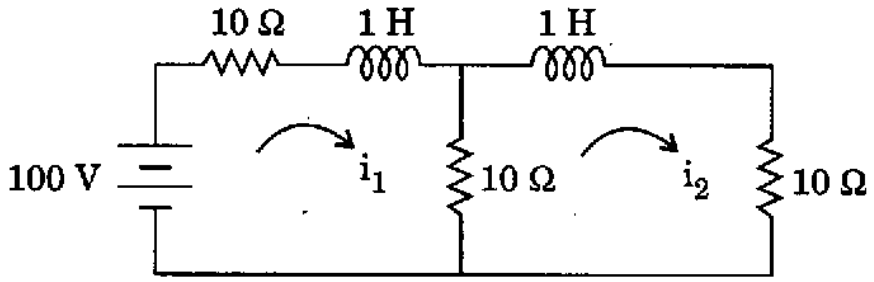
(i) If he is educated, what is the probability that he is a voter ?

(ii) If he is a voter, what is the probability that he is not educated ?

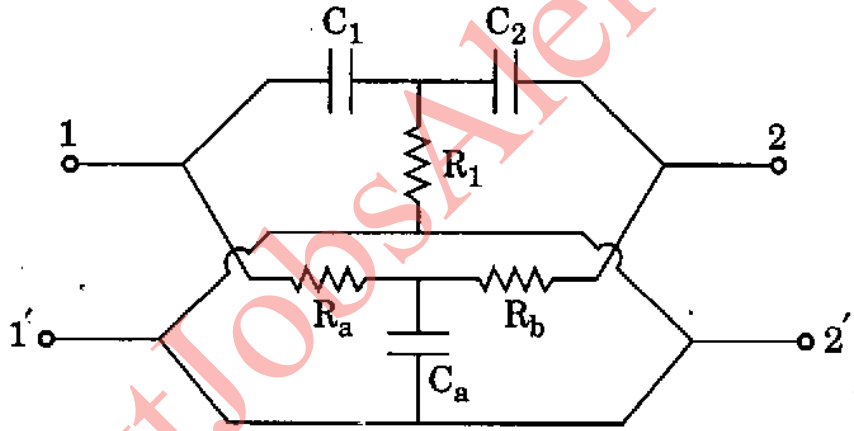
(iii) What is the probability that he is neither a voter nor educated ? *10*

(e) Find the inverse 'Fourier transform' of signum function sgn. *6*

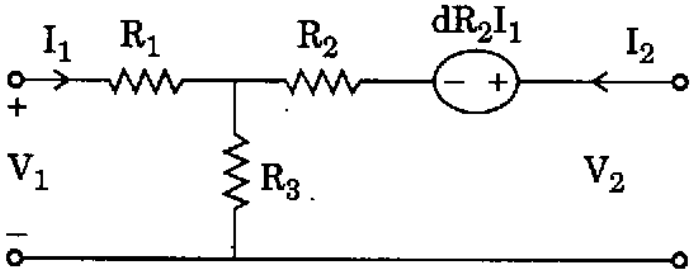
5. (a) In the network shown below, the switch is closed at t = 0. Obtain the current $i_2(t)$ in the network for $t \geq 0$. *10*



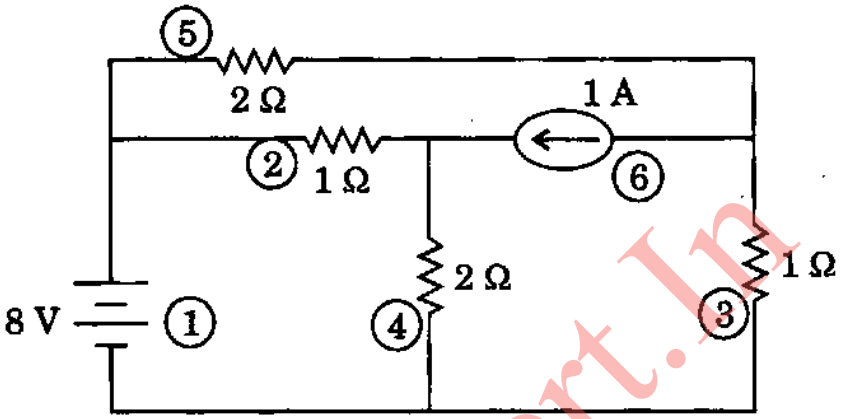
(b) Find the short circuit admittance parameters for two port networks as shown in figure with $R_1 = R_a = R_b = 1\ \Omega$ and $C_1 = C_2 = C_a = 1\ \Omega$. *14*



(c) For the network shown below, obtain the Z-parameters. Is the network reciprocal ? *6*



(d) Determine the voltages V_2 and V_3 in the following circuit using cut-set analysis. Choose the circuit elements marked 1, 2 and 3 in the tree for this purpose. *10*



6. (a) Find the force on a point charge of 50 μC at (0, 0, 5) m due to a charge of 500π μC that is uniformly distributed over the circular disk $r \leq 5$ m, $z = 0$ m. *8*

(b) 40 nC of charge is uniformly distributed around a circular ring of radius 2 m. Find the potential at a point on the axis at 5 m from the plane of the ring. What would be the voltage if all the charge is at the origin like a point charge ? *8*

(c) A 15 m length of 300 Ω line must be connected to a 3 m length of 150 Ω line that is terminated in a 150 Ω resistor. At f = 50 MHz, find the characteristic impedance and length of a quarter wave line to match the two lines. If no transformer is used, what is the VSWR on the main line ? *10*

(d) Determine the cut-off frequencies for the five modes in a rectangular waveguide of dimension 2·3 cm × 1·0 cm. Find the guide wavelength and phase velocity of those modes at a frequency of 1·5 f_c. *14*

7. (a) The expected value of current through a resistor is 20 mA. However, the measurement yields a current value of 18 mA. Calculate

(i) Absolute error

(ii) Percentage error

(iii) Relative accuracy

(iv) Percentage accuracy

(v) Precision for 6^{th} measurement if the set of 10 measurements are : 16, 19, 20, 17, 21, 18, 15, 16, 18 and 17 mA. *10*

(b) A CRT has an anode voltage of 2000 V and parallel deflecting plates are 2 cm long and 5 mm apart. The screen is 30 cm from the centre of the plates. Find the input voltage required to deflect the beam through 3 cm. If the input voltage is applied to the deflecting plates through amplifiers having an overall gain of 100, calculate the velocity of electron beam. *10*

(c) A thermistor has a resistance of 4 kΩ at 0°C and 800 Ω at 40°C. Determine the range of resistance to be measured if the temperature rises from 50°C to 100°C. *10*

(d) The diaphragms of pressure measuring transducer are 2·5 cm^2 in area and are 3 mm apart. A pressure of 10^4 N/m^2 produces a deflection of 0·3 mm of a diaphragm. Without any pressure, the capacitance is 300 pF. Determine the capacitance after a pressure of 10^4 N/m^2 is applied. *10*