Sl. No. **19451**

A-DMHH-N-FFA

ELECTRICAL 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.*

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

Answers must be written in ENGLISH only.

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

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

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. (a) A parallel combination of $R = 16\ K\Omega$ and $L = 1\ H$ is excited by a constant voltage source of 8 volts, having internal resistance of $4\ K\Omega$. Obtain the current through inductance in steady state and the time constant of the circuit.   8

(b) Obtain the unit step response of a system whose impulse response $h(t) = u(t)$, where $u(t) = $ unit step input.   8

(c)
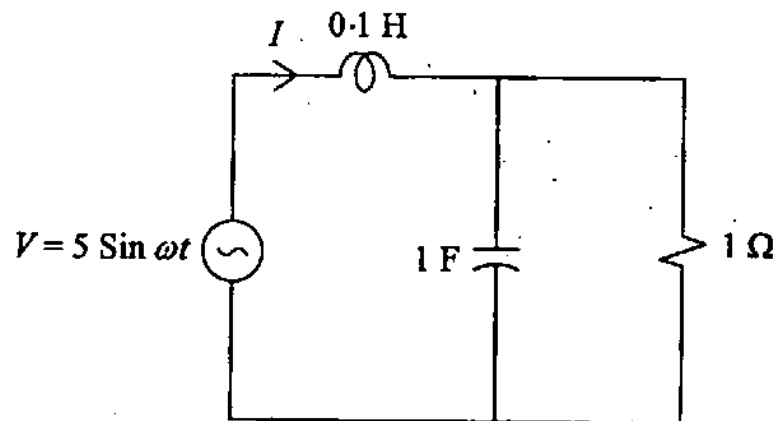
For the network shown above, obtain the source frequency ω so that applied voltage V and current I shall be in phase.   8

(d) In a certain region

$$(\mu = 4 \cdot 6 \, \mu_0), \; \vec{B} = 10 e^{-y} \vec{a}_z \; \text{mWb/m}^2.$$

Find

    (i) χ_m,

    (ii) $\vec{H}$,

    (iii) $\vec{M}$.   8

(e) Derive Coulomb's law, starting from Gauss theorem. State any reasonable assumptions which you think are necessary for the derivation.   8

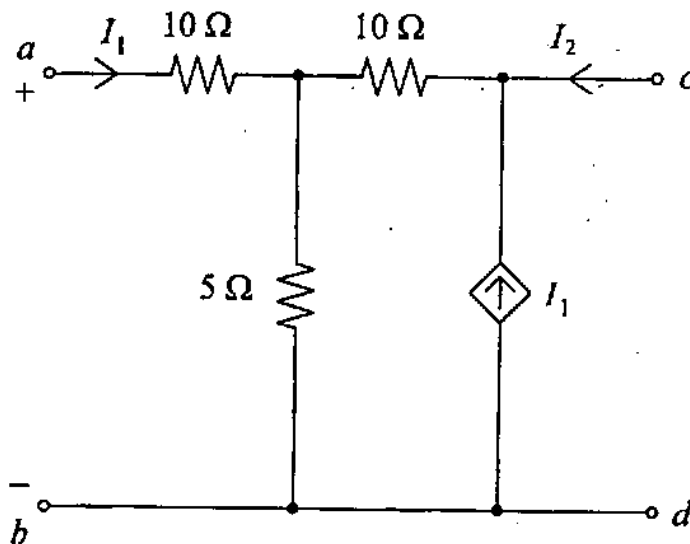(f) For a uniform plane wave in air, the magnetic field is given by

$$H = i_x 2 \exp \left\{ j \left(wt - \frac{\pi}{20} z \right) \right\}$$

Calculate :

(i) the wavelength

(ii) the frequency

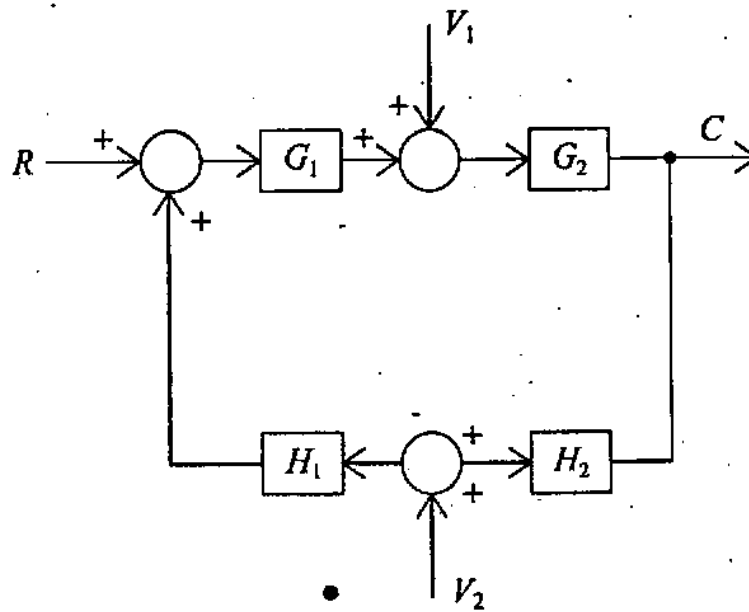(iii) the value of E at $t = \frac{1}{15}$ μ sec, $z = 5$ m.

8

(g)

Determine the Z-parameters of the network shown in the above figure. 8

(h) Explain the principle operation of the thermo-couple. List the types of the thermocouple and discuss how the temperature i.e. 0°C to 256°C and –256°C to 0°C can be sensed using thermocouple. 8

(i)

Determine the output C for the above system using block reduction technique and signal flow graph technique. 8

(j) Construct the dB magnitude phase angle plot of the locus defined by the closed loop frequency response function of a unity feedback system.

$$\left| G(jw) \right| + \cos\phi_G - \frac{1}{N}\sin\phi_G = 0$$

Where

$$\phi_G = arg\,G(jw) \text{ and } N = \tan\left[arg\frac{C}{R}(jw)\right]$$
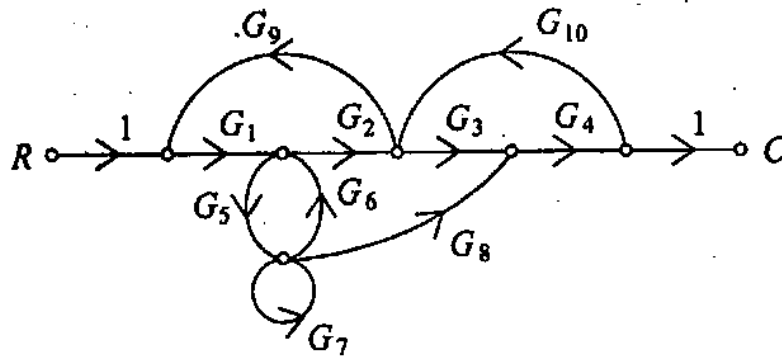
For dB magnitude of $\frac{C}{R}(jw)$ equal to 6 dB.

8

2. (a) Differentiate between linear, homogeneous and isotropic dielectric material.

At the centre of a hollow dielectric sphere ($\varepsilon = \varepsilon_0\varepsilon_v$) is placed a point charge Q. If the sphere has inner radius a and outer radius b, calculate $\vec{D}$, $\vec{E}$ and $\vec{P}$. 12

(b)

Using Mason's Gain formula, find $\dfrac{C}{R}$ of the *SFG* shown in the above figure.   10

(c) In Hay's bridge, the four arms, namely, $R_1 - L_1$, R_2, $R_3 - C_3$ and R_4 are connected in clockwise order. Show that under balanced condition, the quality factor Q of the coil is given by,

$$Q = \frac{\text{Voltage across } C_3}{\text{Voltage across } R_3}$$ 8

3. (a) Two equal charges (Q_0) are placed on a line, at a distance a apart. This line joining the charges is parallel to the surface of an infinite conducting regoin which is at zero potential. The specified line is at a distance $\frac{a}{2}$ from the surface of the conducting regoin.

(i) Show that the force between the charges is $\dfrac{3Q_0^2}{8\pi\varepsilon_0 a^2}$.

(ii) What happens to the force when the sign of one of the charge is reversed.

12

(b) A single phase load of $100\angle-36.9°$ ohms is connected across terminals RY of a balanced 3-phase supply, 415 volts, having phase sequence RYB. The current coil of a wattmeter is connected in series with the load, whereas its pressure coil is connected between terminals B & N of the supply. Obtain the wattmeter reading. Assume V_{RN} as a reference phaser voltage.

10

(c) Synthesize the impedance function

$$z(s) = \frac{s(s^2 + 10)}{(s^2 + 4)(s^2 + 16)}$$ using any one of the

Foster forms of network realisation.   8

4. (a) A series combination of Resistance R and inductance L is connected across capacitance C. Determine values of R, L and C using following data :

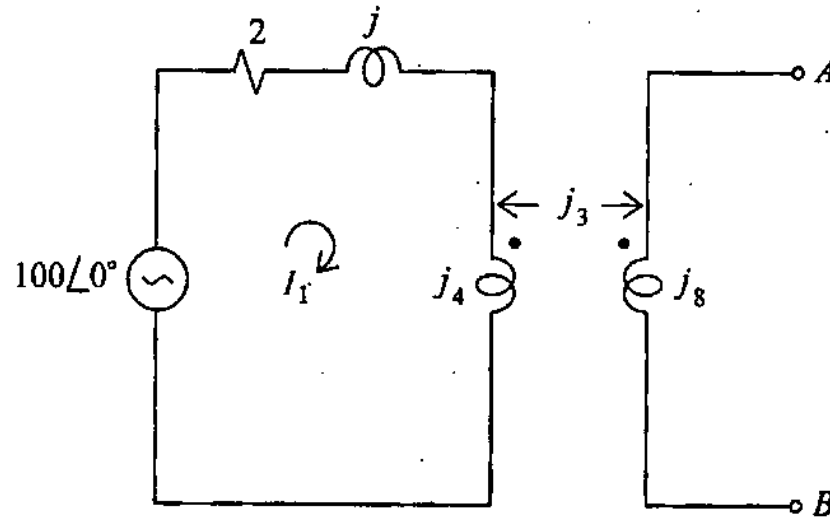   (i) poles of network function $z(s)$ are at

$$-0.5 \pm j\frac{\sqrt{3}}{2}.$$

     (ii) zeros of $z(s)$ are at $s = -1$.

     (iii) $z(j_0) = 1$.   12

(b)

Obtain Thevenin's Equivalent across termi-
nals AB and hence obtain Z_L to be connected
across AB to receive maximum power. 10

(c) The inductance of a certain moving iron ammeter is expressed as,

$L = 10 + 3\theta - \dfrac{\theta^2}{4}$ μH, where θ is deflection in radians from the zero position. The control spring torque is 25×10^{-6} N-m/rad. What would be the deflection of a pointer in radian when the meter carries a current of 5A ? 8

5. (a) Establish the continuity of current equation

$$\nabla \cdot \vec{J} = -\dfrac{\partial \rho_v}{\partial t}$$

If $\vec{J} = \dfrac{100}{\rho^2} \vec{a}_\rho$ A/m^2, find the rate of increase in the volume charge density. 12

(b) Mention various types of analog to digital converter in increasing order of speed of operation. Why is dual slope ADC preferred in digital voltmeter ?

An 8 bit successive approximation type ADC uses a clock frequency of 1 MHz. Calculate the time of conversion. 10
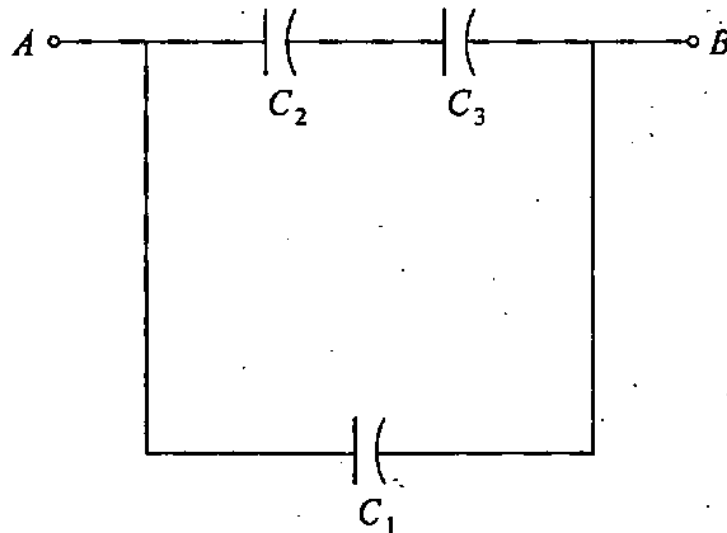
(c)
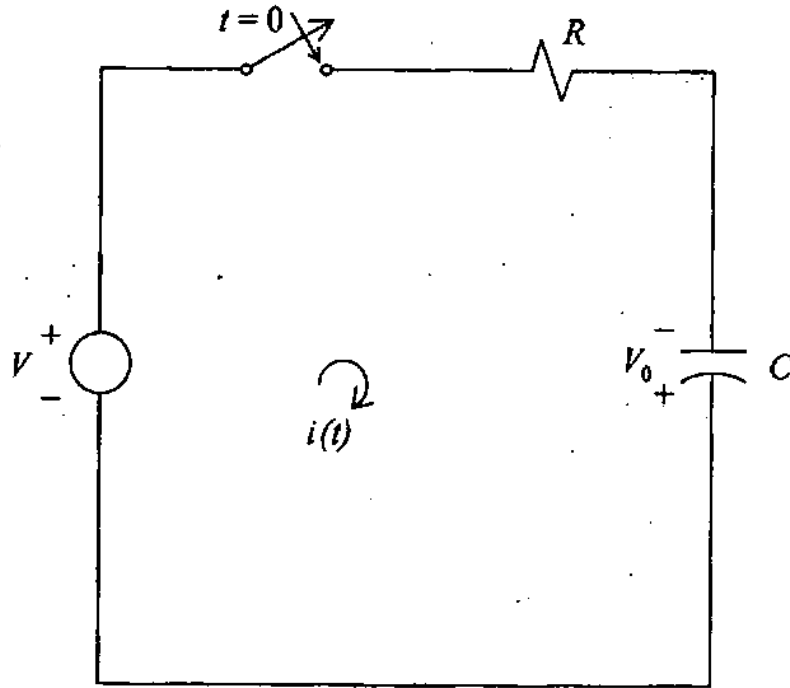
For the circuit shown above, the capacitor has initial voltage of V_0 volts as per polarity indicated. It is supplied by a constant voltage source of V volts. Draw s-domain equivalent circuit. Hence, obtain the expression for charging current $i(t)$ and the voltage across capacitance. Switch is closed at $t = 0$.   8

6. **(a)**

Three capacitors C_1, C_2 and C_3 whose values are 10 μF, 5 μF and 2 μF respectively, have breakdown voltages of 10 volts, 5 volts and 2 volts respectively. For their interconnection shown above, find the maximum safe voltage that can be applied across the combination and the corresponding total charge stored in the effective capacitance across the terminals AB.   12

(b) Give classification of magnetic materials and explain the significance of μ_r. Which of the material out of nickel, silver, tungsten and sodium chloride will require least value of magnetic strength to magnetize it. Explain briefly.   10

(c) A bridge circuit for measurement of parameters of an iron-core coil consists of,

Arm AB, iron-core coil with Resistance R_1 and inductance L_1

Arm BC, a pure resistance R_3

Arm CD, lossless capacitor C_4

Arm DA, capacitor C_2 in series with resistance R_2

At balance, $R_3 = 10\ \Omega$,

$$R_2 = 842\ \Omega,$$
$$C_2 = 0.135\ \mu F \text{ and}$$
$$C_4 = 1\ \mu F.$$

Calculate power factor of coil at supply frequency of 1000 Hz.

Draw the phasor diagram under balanced condition. 8

7. (a) Derive an equation to correlate the conductivity σ with number of charge carriers n and their mobility, μ. 12

(b) The magnetic field intensity is $H = 1200$ A/m in a material when $B = 2$ Wb/m^2. When $\vec{H}$ is reduced to 400 A/m, $B = 1.4$ Wb/m^2. Calculate the change in magnetization M. 10

(c) State the conditions that are to be satisfied for a network function to be $L-C$ impedance function. Test whether the following network function $z(s)$ represents $L-C$ impedance function :

$$z(s) = \frac{\left(s^2 + 4\right)\left(s^2 + 9\right)}{s\left(s^2 + 6\right)}.$$

8