CIRCUIT THEORY AND NETWORK ANALYSIS
(AEIE 2103)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) In a parallel RLC circuit, the currents through the capacitor and inductor are equal. What is the power factor of the circuit?
(a) Lagging (b) Leading (c) Unity (d) 0.5.

(ii) The impedance of an element is given by (2 - j 3)Ω. The element comprises of
(a) resistor and inductor (b) resistor and capacitor
(c) capacitor and inductor (d) all of the above.

(iii) The most elementary form of a loop which cannot be further divided into other loops is called
(a) node (b) branch (c) loop (d) mesh.

(iv) In a series RLC circuit, voltages across the resistor, inductor and capacitor are 3 V, 4 V and 4 V respectively, then the applied voltage is
(a) 3 V (b) 4 V (c) 5 V (d) 7 V .

(v) Superposition theorem is not applicable for
(a) voltage calculations (b) current calculations
(c) power calculations (d) none of the above.

(vi) The function of an inductor is to oppose any change in_____.
(a) current (b) voltage
(c) voltage and current (d) neither voltage nor current.

(vii) Current division rule is valid for
(a) series circuit (b) parallel Circuit (c) resonant circuit (d) all of these.

(viii) The property of an electrical circuit that dissipates electric energy is called
(a) resistance (b) reactance (c) conductance (d) inductance.

(ix) Under maximum power transfer condition in a DC circuit, the load voltage is _____ the source voltage.
(a) equal to (b) half (c) one third (d) double

(x) The gain of the second order low pass filter
(a) increases at the rate 20 dB/decade (b) increases at the rate 40 dB/decade
(c) decreases at the rate 20 dB/decade (d) decreases at the rate 40 dB/decade.

Group- B

2. (a) State Norton's theorem. List its applications. Indicate its limitations. [(CO3)(Remember/LOCQ)]

(b) Determine the current i_0 in the circuit shown in Fig. 1 using
(i) Nodal analysis, (ii) Mesh analysis.

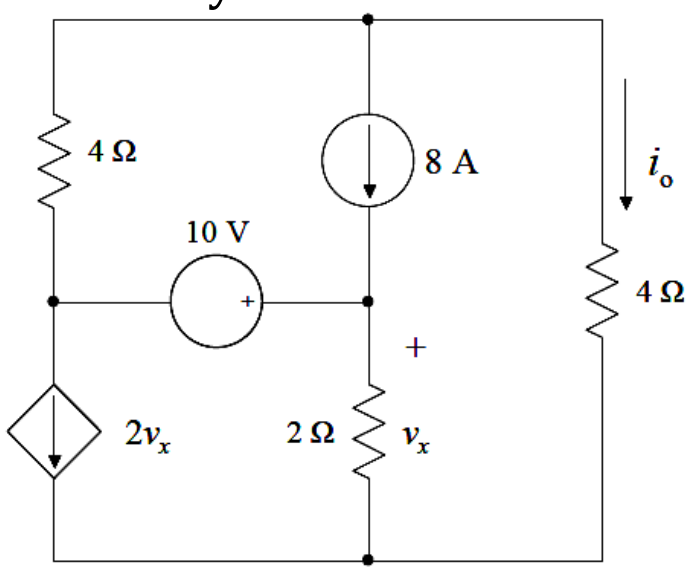

Fig. 1

[(CO2)(Analyze/IOCQ)]
(2 + 2 + 2) + (3 + 3) = 12

3. (a) Calculate i_b for the circuit shown in Fig.2 using the superposition principle.

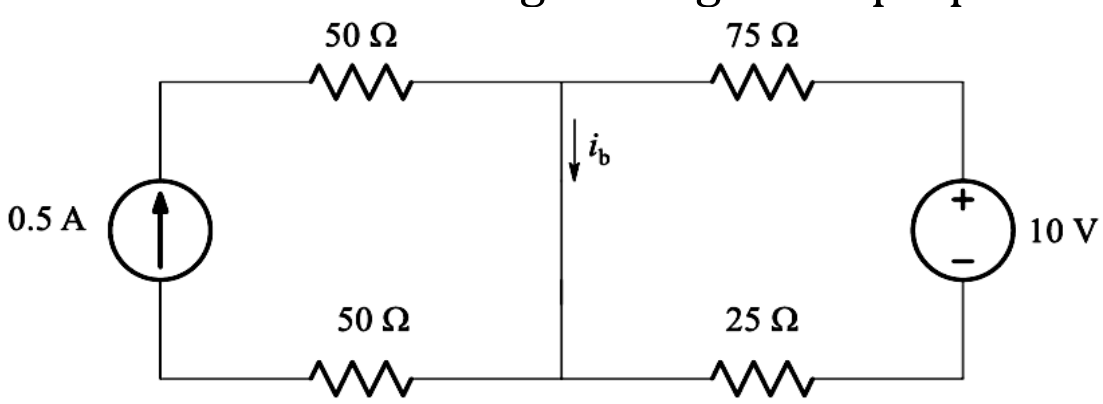

Fig. 2

[(CO3)(Apply/IOCQ)]

(b) State and prove Millman's theorem. [(CO3)(Remember/LOCQ)(Evaluate/HOCQ)]

6 + (2 + 4) = 12

Group - C

4. (a) In the circuit of Fig.3, R = 2Ω, L = 1mH, and C = 0.4μF.
(i) Calculate the resonant frequency ω_r and the half-power frequencies ω_1 and ω_2.
(ii) Calculate the quality factor and bandwidth.
(iii) Determine the amplitude of the current at ω_r, ω_1 and ω_2.

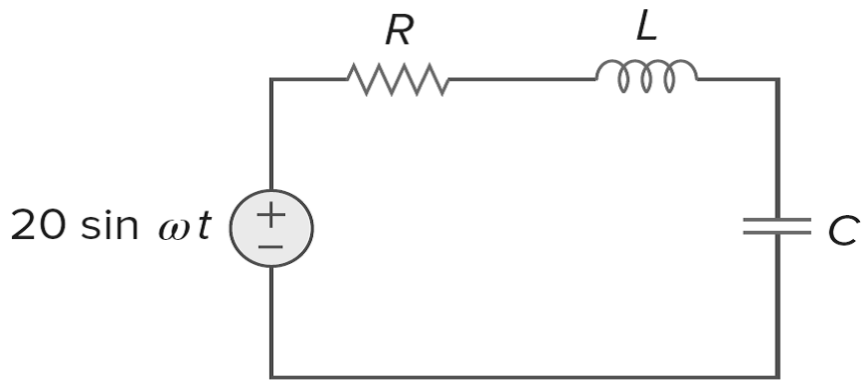

Fig. 3

[(CO1)(Analyze/IOCQ)]

(b) Determine the resonant frequency ω_r of the circuit shown in Fig.4.

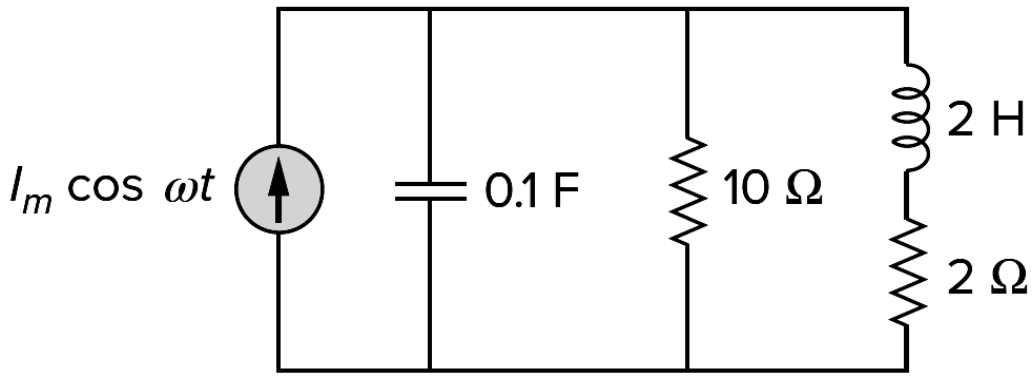

Fig. 4

[(CO1)(Analyze/IOCQ)]

(4 + 3 + 2) + 3 = 12

5. (a) A circuit, having a resistance of 4.0 Ω with an inductance of 0.5 H and a variable capacitance in series, is connected across a 100 V, 50 Hz supply. Calculate:
   (i) the capacitance required to attain resonance,
   (ii) voltages across the inductance and the capacitance at resonance,
   (iii) the *Q* factor of the circuit. [(CO1)(Analyze/IOCQ)]

   (b) Two coils connected in series-aiding fashion have a total inductance of 250 mH. When connected in a series-opposing configuration, the coils have a total inductance of 150 mH. If the inductance of one coil (L_1) is three times the other, determine L_1, L_2, and *M*. Also calculate the coupling coefficient. [(CO1)(Understand/LOCQ)]

(2 + 2 + 2) + 6 = 12

Group – D

6. (a) Derive Z-parameters of the network shown in the Fig.5.

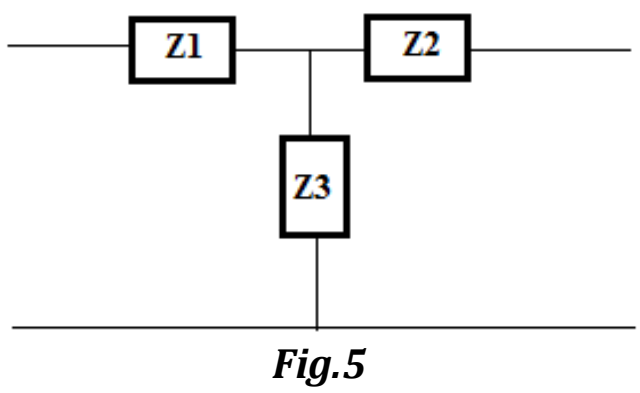

Fig.5

Where, Z1= (4+j5) Ω, Z2= 5 Ω and Z3= (4-j5) Ω.
Check the symmetry and Reciprocity of the network.
[(CO4)(Remember/LOCQ)(Understand/LOCQ)]

(b) Express Z-parameters in terms of h-parameters. [(CO4) (Remember/LOCQ)]

(4 + 2) + 6 = 12

7. (a) A current i(t) flows through the circuit shown in the Fig.6, when the switch is closed at t=0 sec. Derive the expressions of
   (i) current i (t),
   (ii) rate of change of current [di(t)/dt] for t>0.

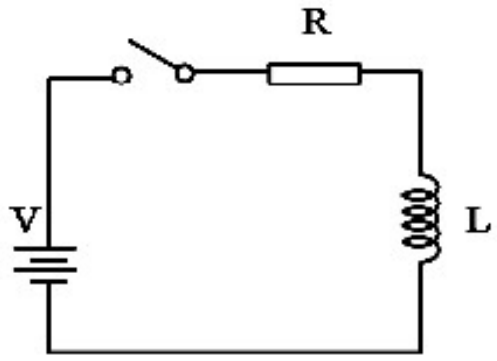

Fig.6

[(CO5)(Understand/LOCQ)]

(b) The capacitor, shown in Fig.7, is initially charged to +10 V. The switch closes at time t=0. Calculate the value of V_c (t) at time t=10 ms.

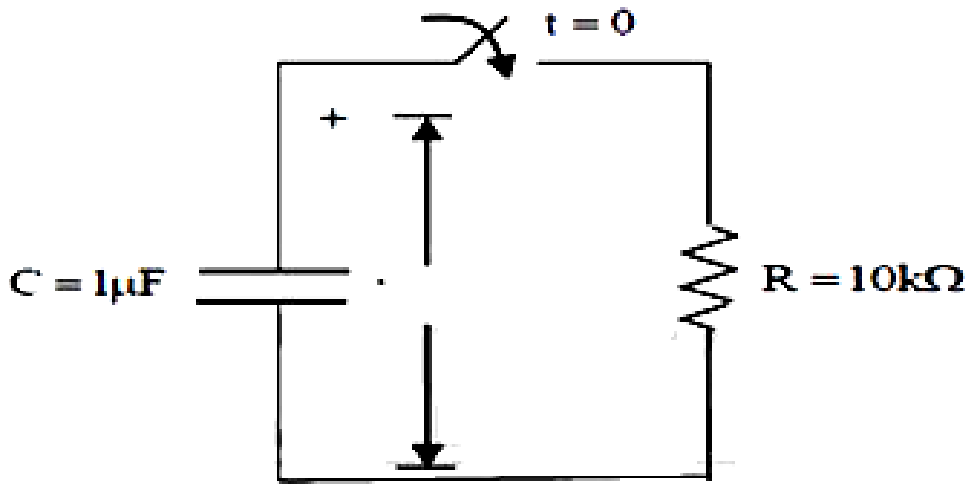

Fig.7

[(CO5)(Analyze/IOCQ)]

(4 + 2) + 6 = 12

Group - E

8. (a) Draw the frequency response of band pass and band reject filters.
[(CO6)(Understand/LOCQ)]

(b) Draw the circuit and explain the operation of 1st order HP Butterworth filter.
[(CO6)(Understand/LOCQ)]

(2 + 2) + 8 = 12

9. (a) Design a high-pass active filter at a cut-off frequency of 5 kHz with a pass band gain of 3. [(CO6)(Design/HOCQ)]

(b) Design a highly selective band-pass active filter having a center frequency of 100 kHz and a bandwidth of 2 kHz. [(CO6)(Design/HOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	43.75	36.5	18.75

Course Outcome (CO):

After the completion of the course students will be able to

1. Apply knowledge of mathematics, science, and engineering to the analysis and design of electrical circuits.
2. Choose appropriate circuit laws and analysis tools to analyze the dc and ac networks.
3. Create dc and ac circuit equations using network theorems.
4. Analyze the transient and steady state responses of dc circuits.
5. Analyze two-port networks with series, parallel, cascade connections and evaluate port parameters and conditions.
6. Design and analyze LP, HP, BP, BS passive and active filters.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question