CIRCUIT THEORY
(ELEC 2101)

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) For super node analysis technique we apply
(a) KVL only (b) KCL only
(c) both KVL and KCL (d) source transformation only.

(ii) The final value of f(t) whose Laplace transform $F(s) = \frac{3s^2+2s+8}{s(s^2+s+4)}$ is
(a) 2 (b) ∞ (c) 0 (d) 1.

(iii) For perfect magnetic coupling the value of coefficient of coupling is
(a) 1 (b) 0 (c) ∞ (d) 0.5.

(iv) Two 'two-port' networks are connected in cascade. The combination is to be represented as a single two -port network
(a) by multiplying individual ABCD parameter matrices
(b) by dividing individual ABCD parameter matrices
(c) by adding individual ABCD parameter matrices
(d) by subtracting individual ABCD parameter matrices.

(v) Transient current in series RLC circuit when excited by a constant voltage source is oscillatory when
(a) $R = 2\sqrt{\frac{L}{C}}$ (b) $R = \infty$ (c) $R < 2\sqrt{\frac{L}{C}}$ (d) $R = 0$.

(vi) The transfer function $T(s) = \frac{s^2}{s^2 + as + b}$ belongs to an active
(a) low pass filter (b) high pass filter
(c) band pass filter (d) band reject filter.

(vii) The condition of reciprocity for h-parameters is
(a) $h_{11}=h_{22}$ (b) $h_{12}= -h_{21}$
(c) $h_{11}\, h_{22}- h_{12}\, h_{21} =1$ (d) $h_{12}= h_{21}$.

(viii) At certain current, the energy stored in an iron –cored coil is 1000J and its copper loss is 2000W. The time constant (in second) of the coil is
(a) 0.25 (b) 0.5 (c) 1.0 (d) 2.0.

(ix) The output y and the input x of a system is related by the relation y = mx + c, where m and c are constants. The system is
(a) linear (b) non-linear (c) bilateral (d) unilateral.

(x) The cut-set matrix gives the relation between
(a) branch voltages and branch currents
(b) branch voltages and twig branch voltages
(c) branch voltages and link currents
(d) link voltages and link currents.

Group – B

2. (a) Find mesh currents for the circuit of Fig.2(a).

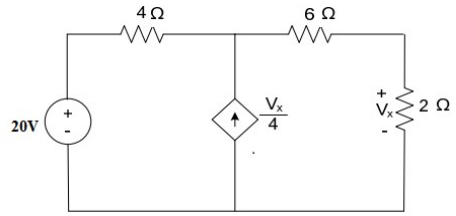

Fig. 2(a)

(b) In the circuit of Fig. 2(b), find Thevenin's equivalent circuit looking from the terminals A-B.

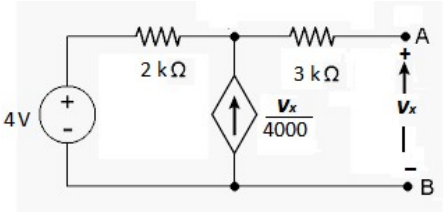

Fig. 2(b)

Group – D

6. (a) State the properties of Complete Incidence matrix.

(b) Compute Complete Incidence matrix of the directed graph shown in Fig. 6(b). Assume the sub-graph shown in figure below as a tree, find fundamental cut-set matrix and tie-set matrix.

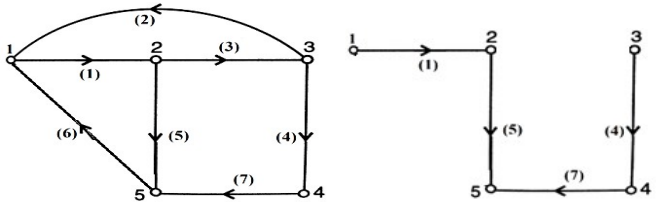

Fig. 6(b)

3+ (3 + 3 + 3)=12

7. (a) Define Y-parameters. Express Y-parameters in terms of hybrid parameters and transmission parameters.

(b) Determine Z parameters and ABCD- parameters of the circuit shown in Fig. (7b).

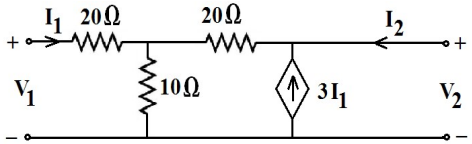

Fig. (7b)

(1+ 2 +2) + 7=12

Group – E

8. (a) Draw the circuit diagram of a 2nd order Sallen Key type low pass filter. Derive the expression transfer function and cut-off frequency of this filter. Sketch its frequency response curve for different Q-factor.

(b) Design a Band pass filter whose lower and upper cut-off frequencies are 1kHz and 4kHz respectively and pass-band gain unity.

(1+ 5+ 1 + 1)+4=12

9.(a) If $B_n(s)$ is nth order Butterworth polynomial then show that $B_2(s)B_2(-s) = 1 + \omega^4$, where $s = j\omega$.

(b) Determine the poles of 3rd order Butterworth filter. Sketch the location of poles on s-plane and hence determine the normalized transfer function of the low pass filter.

5 + (3 +1 + 3) =12

(c) In Fig. 2(c), a resistance 'r' is shown to be connected across an active network. It is given that when

(i) r = ∞, V= 5V

(ii) r = 0, I = 2.5 A

What would be the current through 'r' when the value of r is 5 Ω.

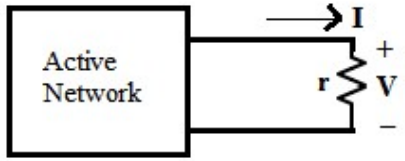

Fig. 2(c)

5 + 5 + 2 =12

3. (a) In the circuit of Fig. (3a), the load consists of a pure resistor R_L. Find the value of R_L for which the source delivers maximum power to the load. Also determine maximum power.

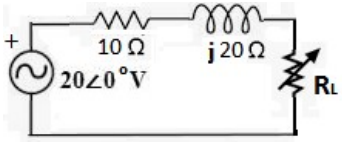

Fig. (3a)

(b) Find the conductively coupled equivalent circuit for the magnetically coupled circuit of Fig. (3b).

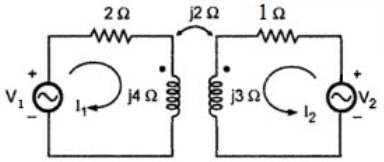

Fig. (3b)

(c) For the three series connected coupled coils as shown in Fig. (3c) calculate the total inductance.

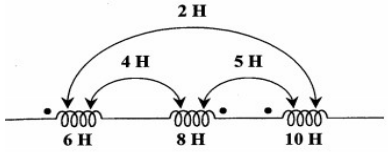

Fig. (3c)

(2 + 2)+6+2=12

Group – C

4. (a) Determine the signal *x(t)*, whose first derivative is as shown by the waveform in Fig. 4(a). Also sketch the signal.

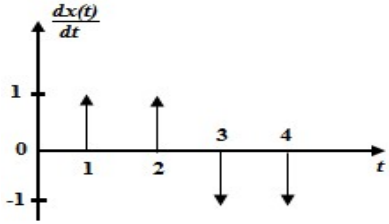

Fig. 4(a)

(b) In the network shown in Fig. (4b), the switch K is closed and a steady-state condition is attained. At t= 0, the switch is opened. Determine the current through inductor for t>0.

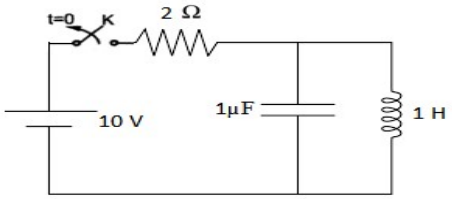

Fig. (4b)

(3 + 2) + 7 =12

5. (a) A unit impulse voltage δ(t-2) is applied in a series R-L circuit where L=1 H and R= 3Ω by closing a switch at t=0. Assuming zero initial condition, find i(t). Also draw the response of i(t).

(b) For the circuit of Fig. 5(b) the switch 'S' is closed at t= 0. Find the expression of i(t) for t > 0. Assume the inductor is initially de-energised.

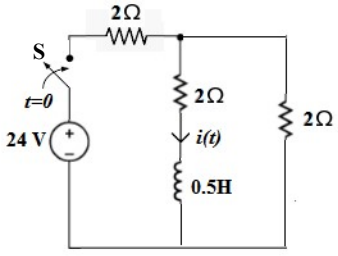

Fig. 5(b)

(4 +1)+7=12