CIRCUIT THEORY
(ELEC 2101)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

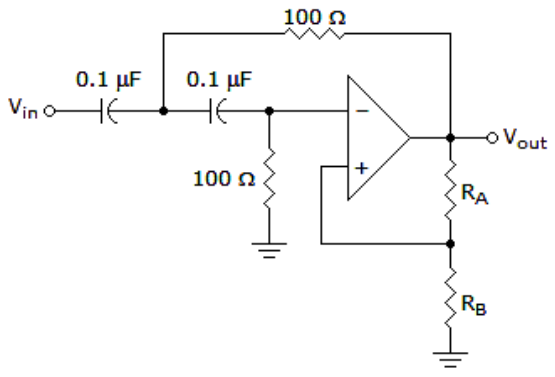
Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) As order of a filter increases cut-off rate of a low pass filter circuit
(a) increases (b) decreases
(c) remains same (d) none of these.

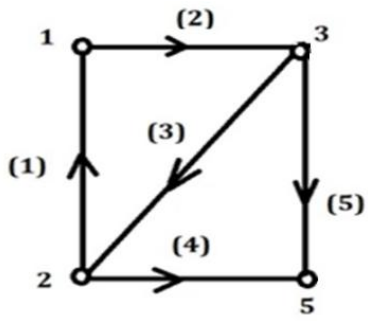
(ii) Refer to the given figure. This circuit is known as a _____ filter, and the fc is _____.

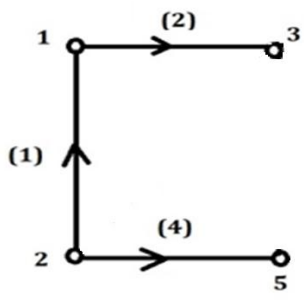


(a) high-pass, 1.59 kHz
(b) high-pass, 15.9 kHz
(c) low-pass, 15.9 kHz
(d) band-pass, 15.9 kHz

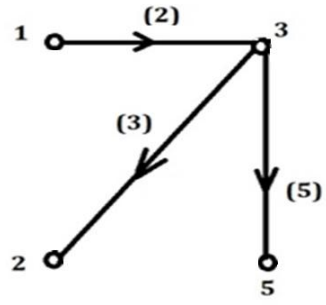
(iii) In a certain low-pass filter, fc = 4.5 kHz. Its pass band is
(a) 0 Hz (b) 0 Hz to 4.5 kHz (c) 9 kHz (d) 4.5 kHz.

(iv) Which of the given options is not a tree of the following graph?

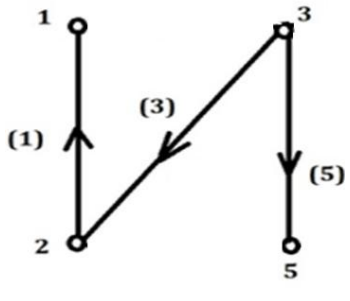




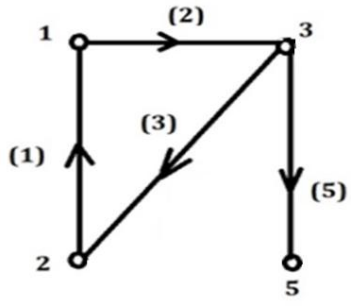
(a)



(b)



(c)



(d)

(v) Short circuit reverse transfer admittance is
(a) Y_{11} (b) Y_{12} (c) Y_{21} (d) Y_{22}.

(vi) If the number of branches in a network is B, the number of nodes is N then the number of mesh equations will be
(a) $B - N - 1$ (b) $B - N + 1$ (c) $N - 1$ (d) $N + 1$.

(vii) Two coils having self-inductance 2 H and 8 H and with mutual inductance of 2 H between them, the coupling coefficient is
(a) 0.5 (b) 20 (c) 2 (d) 8.

(viii) The Laplace transform of a function is $F(s) = \frac{s+2}{s(s+1)}$. Its final value is
(a) 1 (b) 2 (c) 0 (d) -1

(ix) A 10 Ω resistor, a 1 H inductor and 1 F capacitor are connected in parallel. The combination is driven by a unit step current. Under steady state condition, the source current flow through
(a) Resistor only (b) Inductor only (c) Capacitor only (d) all of the three elements.

(x) For super mesh analysis we apply
(a) KVL only (b) KCL only (c) both KVL and KCL (d) Lenz's Law

Fill in the blanks with the correct word

(xi) The number of poles in a 2nd order low pass filter is _____.

(xii) The cut-off rate in a 2nd order filter is _____.

(xiii) The relation between branch current matrix and loop current matrix is _____.

(xiv) Derivative of a unit ramp function will lead to _____ function.

(xv) A 10 Ω resistor, a 2 H inductor and 3 F capacitor are connected in series. The combination is driven by a unit step voltage. The current flowing through the circuit under steady state condition is_____ A.

Group – B

2. (a) Calculate v_0 and i_0 for the circuit of Fig.1.

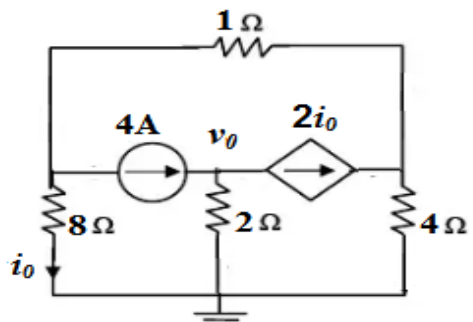


Fig. 1

[(CO1)(Apply/IOCQ)]

(b) Calculate current through 5Ω resistance of Fig.2 using Thevenin's theorem.

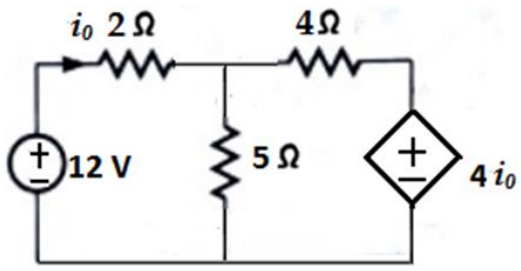


Fig. 2

[(CO1) (Apply/IOCQ)]

6 + 6 = 12

3. (a) Select the value of R_L to be connected across AB in Fig.3 for maximum power transfer. Also calculate the amount of maximum power absorbed by the R_L.

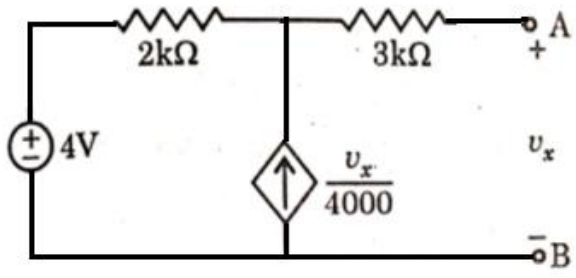


Fig. 3

[(CO1)(Apply/IOCQ)]

(b) Evaluate the value of I_1 and I_2 in the magnetically coupled circuit of Fig. 4.

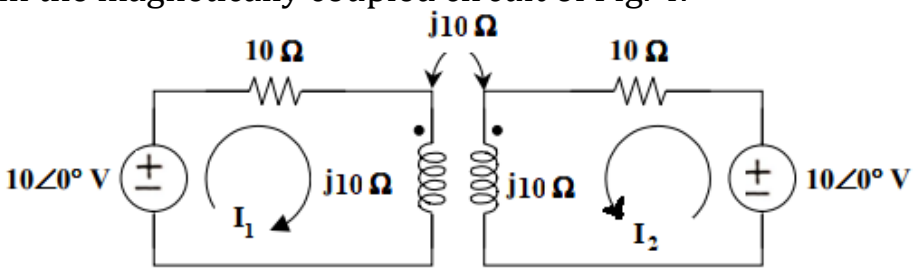


Fig. 4

[(CO2)(Evaluate/HOCQ)]

6 + 6 = 12

Group - C

4. (a) Find the Laplace transform for the saw-tooth waveform shown in Fig. 5.

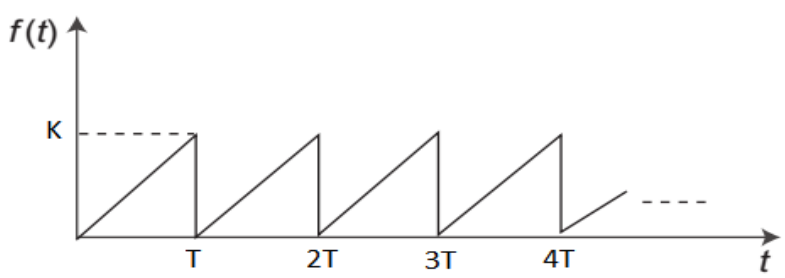


Fig. 5

[(CO3)(Understand/LOCQ)]

(b) In the network of Fig.6, switch 'S' is closed at $t = 0$. Determine the expression of current given by the source for $t > 0$. Assume zero initial condition.

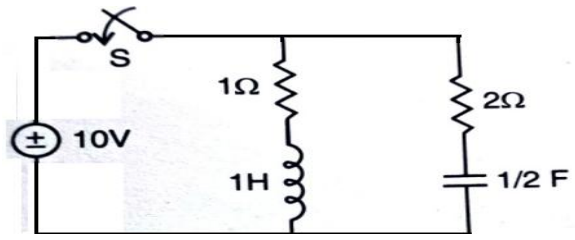


Fig. 6

[(CO4)(Apply/IOCQ)]

6 + 6 = 12

5. (a) Determine the Laplace transform for the staircase waveform as shown in Fig. 7.

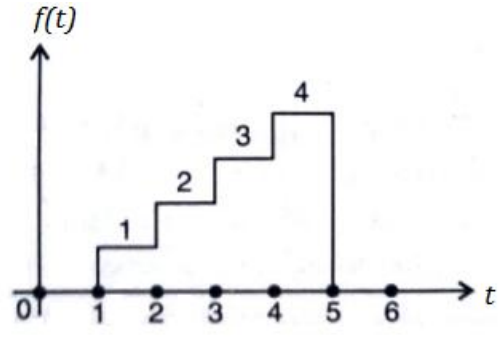


Fig.7

[(CO3)(Evaluate/HOCQ)]

(b) In the circuit shown in Fig. 8, the switch 'S' is closed at t=0. Develop the expression of voltage across the capacitor for $t > 0$ assuming zero initial voltage across the capacitor.

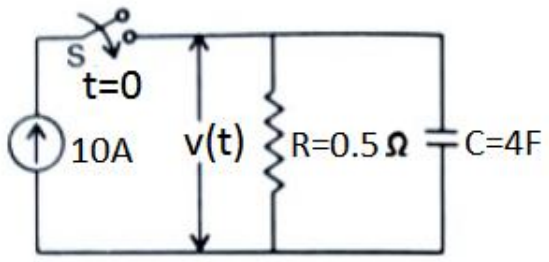


Fig. 8

[(CO3)(Apply/IOCQ)]

6 + 6 = 12

Group – D

6. (a) Develop Complete Incidence matrix of the directed graph shown in Fig. 9. *[(CO4) (Create/HOCQ)]*

(b) Assume the sub-graph shown in Fig. 10 as a tree and develop fundamental Cut-set matrix and Tie-set matrix. *[(CO4) (Apply/IOCQ)]*

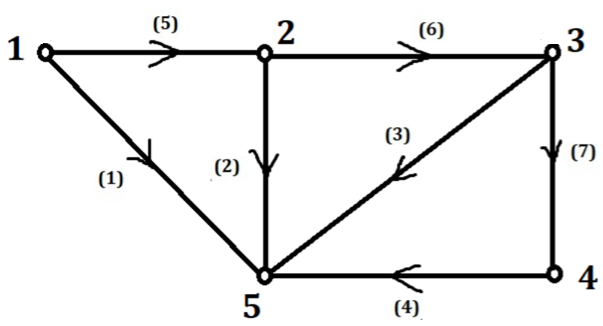


Fig. 9

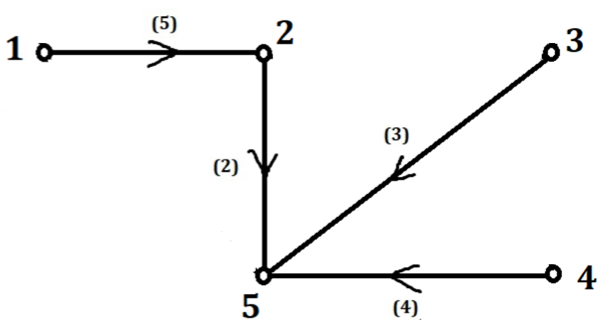


Fig. 10

4 + (4 + 4) = 12

7. (a) Define Z-parameters and transmission (ABCD) parameters. Express Z- Parameters in terms of hybrid parameters. *[(CO5)(Remember/LOCQ)]*

(b) For Y parameter, develop the condition of Symmetry. *[(CO5)(Create/HOCQ)]*

(c) Analyse the circuit shown in Fig. 11 and find its Z-parameters and Y-parameters.

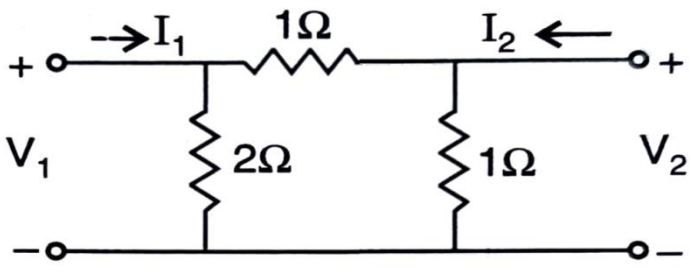


Fig. 11

[(CO5)(Analyze/IOCQ)]

(1 + 1 + 2) + 2 + 6 = 12

Group - E

8. (a) Sketch the circuit diagram of 2nd order high pass active filter. *[(CO6)(Apply/IOCQ)]*

(b) Show that the cut-off rate of a first order active high pass filter is +20dB/Decade. *[(CO6)(Understand/LOCQ)]*

(c)	Sketch the Gain (dB) vs. Frequency plot of First order active high pass filter.	*[(CO6)(Apply/IOCQ)]*
(d)	What is the nature of poles for different damping conditions?	*[(CO6)(Remember/LOCQ)]*
(e)	Show that the maximum gain reduces by 3dB at the cut-off frequency.	*[(CO6)(Apply/IOCQ)]*
		2 + 4 + 1 + 2 + 3 = 12

9.	(a)	Sketch the circuit diagram of a 2nd order active low pass Sallen-Key filter.	*[(CO6)(Apply/IOCQ)]*
	(b)	Design a Notch Filter with a centre frequency of 60 Hz.	*[(CO6)(Create/HOCQ)]*
	(c)	Sketch the Gain vs Frequency plot of Notch Filter.	*[(CO6)(Apply/IOCQ)]*
	(d)	Design a 2nd order Sallen-Key Filter whose cut-off frequency is 2 kHz with Quality Factor = 1.	*[(CO6)(Create/HOCQ)]*
	(e)	What is the nature of poles for different damping conditions?	*[(CO6)(Remember/LOCQ)]*
	(f)	Define cut-off or Roll-off Rate of a filter.	*[(CO6)(Remember/LOCQ)]*
			2 + 3 + 1 + 3 + 2 + 1 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	19.79	55.21	25

Course Outcome (CO):

After the completion of the course students will be able to

- apply network theorems to solve electrical circuits having both dependent and independent sources.
- analyze magnetically coupled circuits.
- apply Laplace transform technique in solving transient problems of electrical circuits.
- apply the concept of graph theory to electrical circuits.
- obtain the equivalent representation of electrical circuits using two- port parameter representation.
- analyze and synthesize filters.

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