GATE CLOUD

NETWORK ANALYSIS

Vol 1

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Preface to First Edition

GATE CLOUD caters a versatile collection of Multiple Choice Questions to the students who are preparing for GATE (Gratitude Aptitude Test in Engineering) examination. This book contains over 1500 multiple choice solved problems for the subject of Network Analysis, which has a significant weightage in the GATE examination of Electronics and Communication Engineering. The GATE examination is based on multiple choice problems which are tricky, conceptual and tests the basic understanding of the subject. So, the problems included in the book are designed to be as exam-like as possible. The solutions are presented using step by step methodology which enhance your problem solving skills.

The book is categorized into fifteen chapters covering all the topics of syllabus of the examination. Each chapter contains :

- Exercise 1 : **Level 1**
- Exercise 2 : **Level 2**
- Exercise 3 : **Mixed Questions Taken form Previous Examinations of GATE.**
- Detailed Solutions to Exercise 1, 2 and 3.

Although we have put a vigorous effort in preparing this book, some errors may have crept in. We shall appreciate and greatly acknowledge the comments, criticism and suggestion from the users of this book which leads to some improvement.

You may write to us at rajkumar.kanodia@gmail.com and ashish.murolia@gmail.com.
Wish you all the success in conquering GATE.

Authors

SYLLABUS

GATE ELECTRONICS & COMMUNICATION ENGINEERING

Networks:

Network graphs: matrices associated with graphs; incidence, fundamental cut set and fundamental circuit matrices. Solution methods: nodal and mesh analysis. Network theorems: superposition, Thevenin and Norton's maximum power transfer, Wye-Delta transformation. Steady state sinusoidal analysis using phasors. Linear constant coefficient differential equations; time domain analysis of simple RLC circuits, Solution of network equations using Laplace transform: frequency domain analysis of RLC circuits. 2-port network parameters: driving point and transfer functions. State equations for networks.

IES ELECTRONICS & TELECOMMUNICATION ENGINEERING

Networks Theory:

Network analysis techniques; Network theorems, transient response, steady state sinusoidal response; Network graphs and their applications in network analysis; Tellegen's theorem. Two port networks; Z, Y, h and transmission parameters. Combination of two ports, analysis of common two ports. Network functions : parts of network functions, obtaining a network function from a given part. Transmission criteria : delay and rise time, Elmore's and other definitions effect of cascading. Elements of network synthesis.

CONTENTS

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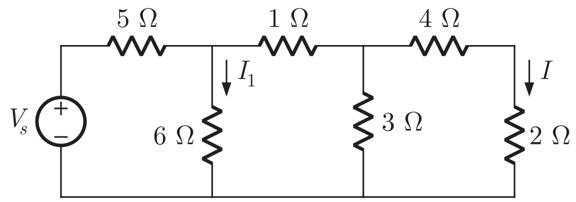
CHAPTER 5

CIRCUIT THEOREMS

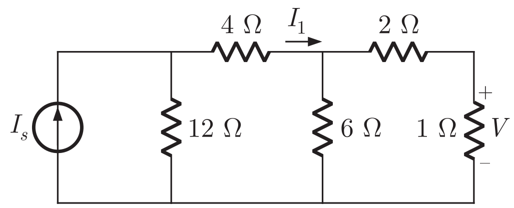
EXERCISE 5.1

MCQ 5.1.1 In the network of figure for $V_s = V_0$, $I = 1$ A then what is the value of I_1, if $V_s = 2V_0$?



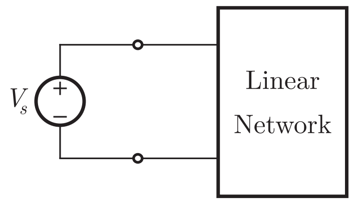
(A) 2 A
(B) 1.5 A
(C) 3 A
(D) 2.5 A

MCQ 5.1.2 In the network of figure, If $I_s = I_0$ then $V = 1$ volt. What is the value of I_1 if $I_s = 2I_0$?



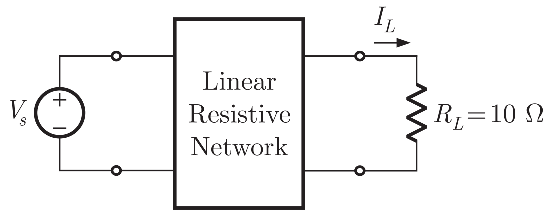
(A) 1.5 A
(B) 2 A
(C) 4.5 A
(D) 3 A

MCQ 5.1.3 The linear network in the figure contains resistors and dependent sources only. When $V_s = 10$ V, the power supplied by the voltage source is 40 W. What will be the power supplied by the source if $V_s = 5$ V ?



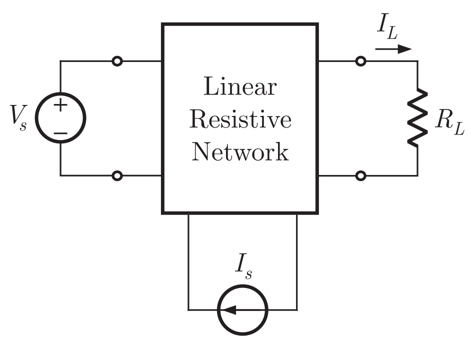
(A) 20 W
(B) 10 W
(C) 40 W
(D) can not be determined

MCQ 5.1.4 In the circuit below, it is given that when $V_s = 20\text{ V}$, $I_L = 200\text{ mA}$. What values of I_L and V_s will be required such that power absorbed by R_L is 2.5 W ?



(A) 1 A, 2.5 V
(B) 0.5 A, 2 V
(C) 0.5 A, 50 V
(D) 2 A, 1.25 V

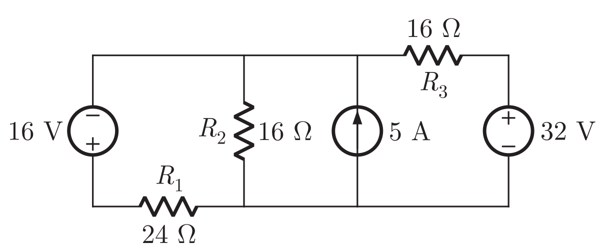
MCQ 5.1.5 For the circuit shown in figure below, some measurements are made and listed in the table.



	V_s	I_s	I_L
1.	14 V	6 A	2 A
2.	18 V	2 A	6 A

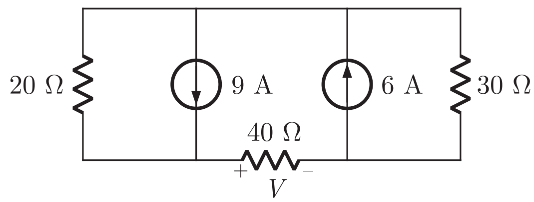
Which of the following equation is true for I_L ?
(A) $I_L = 0.6V_s + 0.4I_s$
(B) $I_L = 0.2V_s - 0.3I_s$
(C) $I_L = 0.2V_s + 0.3I_s$
(D) $I_L = 0.4V_s - 0.6I_s$

MCQ 5.1.6 In the circuit below, the voltage drop across the resistance R_2 will be equal to



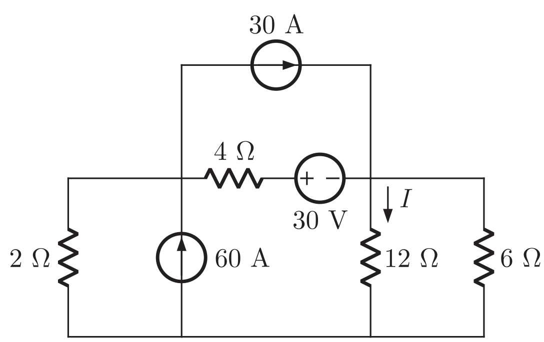
(A) 46 volt
(B) 38 volt
(C) 22 volt
(D) 14 volt

MCQ 5.1.7 In the circuit below, the voltage V across the $40\,\Omega$ resistor would be equal to



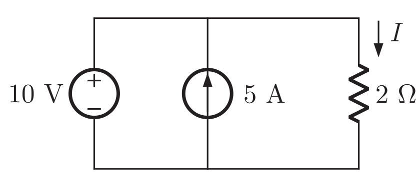
(A) 80 volt (B) 40 volt
(C) 160 volt (D) zero

MCQ 5.1.8 In the circuit below, current $I = I_1 + I_2 + I_3$, where I_1, I_2 and I_3 are currents due to 60 A, 30 A and 30 V sources acting alone. The values of I_1, I_2 and I_3 are respectively



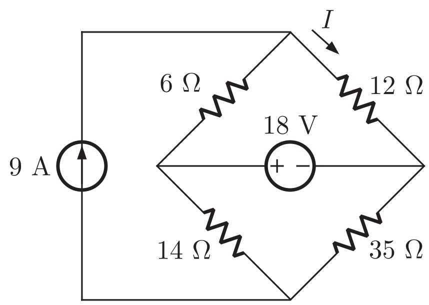
(A) 8 A, 8 A, −4 A
(B) 12 A, 12 A, −5 A
(C) 4 A, 4 A, −1 A
(D) 2 A, 2 A, −4 A

MCQ 5.1.9 The value of current I flowing through $2\,\Omega$ resistance in the circuit below, equals to



(A) 10 A (B) 5 A
(C) 4 A (D) zero

MCQ 5.1.10 In the circuit below, current I is equal to sum of two currents I_1 and I_2. What are the values of I_1 and I_2 ?

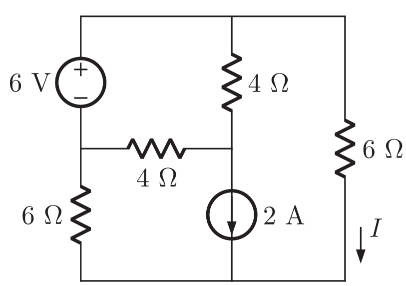


(A) 6 A, 1 A (B) 9 A, 6 A
(C) 3 A, 1 A (D) 3 A, 4 A

MCQ 5.1.11 A network consists only of independent current sources and resistors. If the values of all the current sources are doubled, then values of node voltages
(A) remains same (B) will be doubled
(C) will be halved (D) changes in some other way.

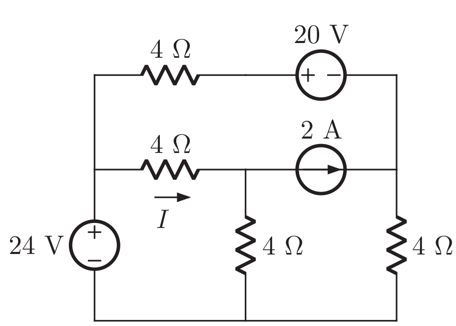
MCQ 5.1.12 Consider a network which consists of resistors and voltage sources only. If the values of all the voltage sources are doubled, then the values of mesh current will be
(A) doubled (B) same
(C) halved (D) none of these

MCQ 5.1.13 In the circuit shown in the figure below, the value of current I will be be given by



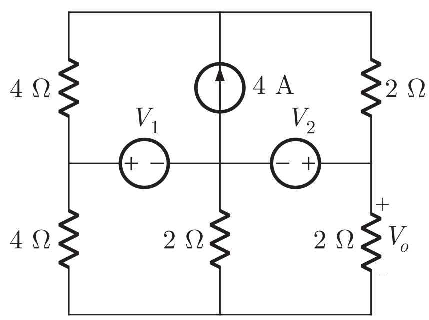
(A) 1.5 A (B) -0.3 A
(C) 0.05 A (D) -0.5 A

MCQ 5.1.14 What is the value of current I in the following network ?



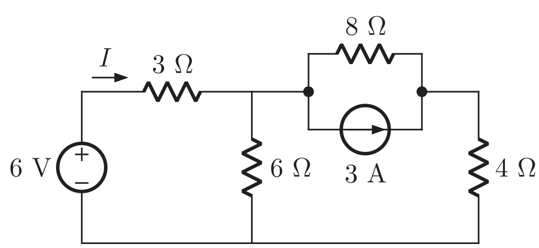
(A) 4 A (B) 6 A
(C) 2 A (D) 1 A

MCQ 5.1.15 In the given network if $V_1 = V_2 = 0$, then what is the value of V_o ?



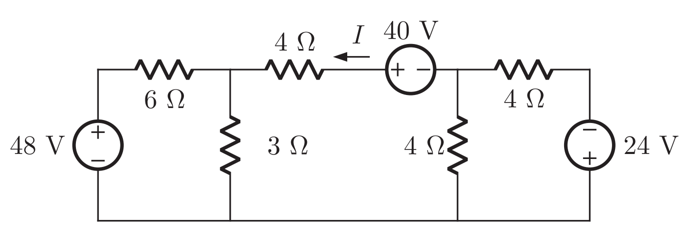
(A) 3.2 V
(B) 8 V
(C) 5.33 V
(D) zero

MCQ 5.1.16 The value of current I in the circuit below is equal to



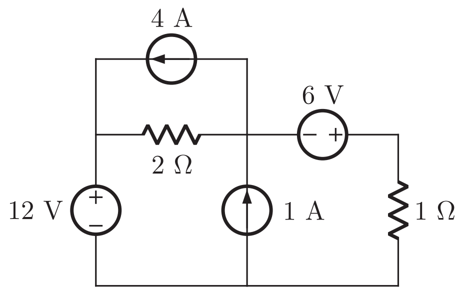
(A) $\frac{2}{7}$ A
(B) 1 A
(C) 2 A
(D) 4 A

MCQ 5.1.17 What is the value of current I in the circuit shown below ?



(A) 8.5 A (B) 4.5 A
(C) 1.5 A (D) 5.5 A

MCQ 5.1.18 In the circuit below, the 12 V source



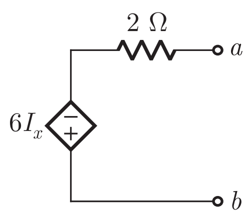
(A) absorbs 36 W

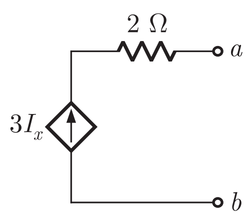
(B) delivers 4 W

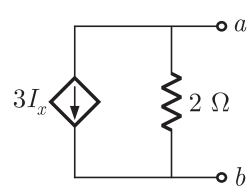
(C) absorbs 100 W

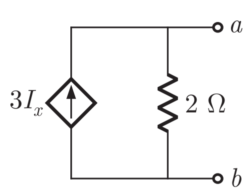
(D) delivers 36 W

MCQ 5.1.19 Which of the following circuits is equivalent to the circuit shown below ?



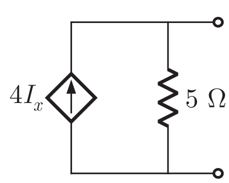
(A) 

(B) 

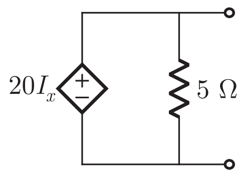
(C) 

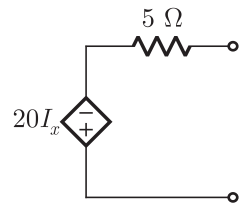
(D) None of these

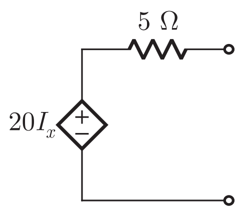
MCQ 5.1.20 Consider a dependent current source shown in figure below.



The source transformation of above is given by

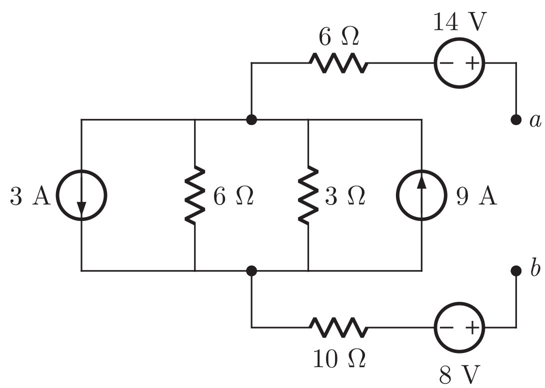
(A) 

(B) 

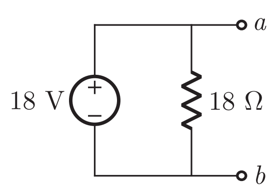
(C) 

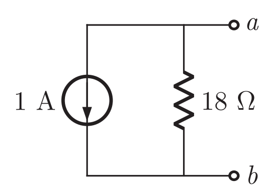
(D) Source transformation does not applicable to dependent sources

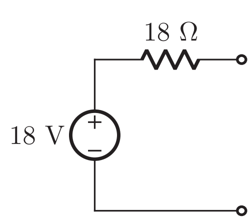
MCQ 5.1.21 Consider a circuit shown in the figure

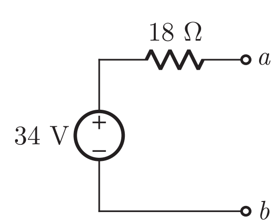


Which of the following circuit is equivalent to the above circuit ?

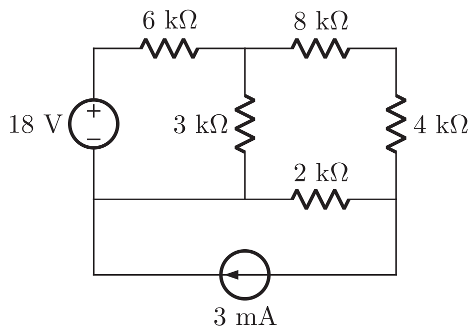
(A) 

(B) 

(C) 

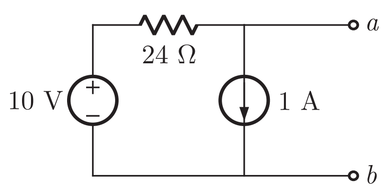
(D) 

MCQ 5.1.22 How much power is being dissipated by the $4\,\text{k}\Omega$ resistor in the network ?



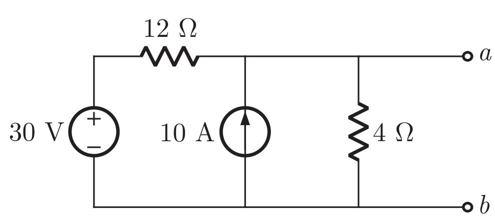
(A) 0 W
(B) 2.25 mW
(C) 9 mW
(D) 4 mW

MCQ 5.1.23 For the circuit shown in the figure the Thevenin voltage and resistance seen from the terminal a-b are respectively



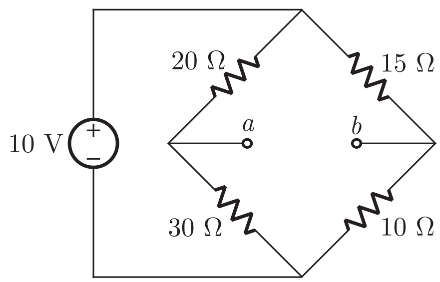
(A) $34\,\text{V},\ 0\,\Omega$
(B) $20\,\text{V},\ 24\,\Omega$
(C) $14\,\text{V},\ 0\,\Omega$
(D) $-14\,\text{V},\ 24\,\Omega$

MCQ 5.1.24 The Thevenin equivalent resistance R_{Th} between the nodes a and b in the following circuit is



(A) $3\,\Omega$
(B) $16\,\Omega$
(C) $12\,\Omega$
(D) $4\,\Omega$

MCQ 5.1.25 In the following circuit, Thevenin voltage and resistance across terminal a and b respectively are



(A) 10 V, 18 Ω (B) 2 V, 18 Ω

(C) 10 V, 18.67 Ω (D) 2 V, 18.67 Ω

MCQ 5.1.26 The value of R_{Th} and V_{Th} such that the circuit of figure (B) is the Thevenin equivalent circuit of the circuit shown in figure (A), will be equal to

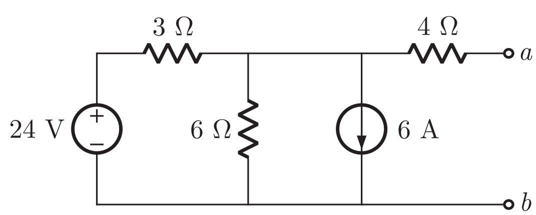


Fig.(A)

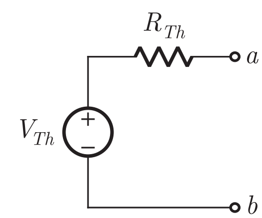


Fig.(B)

(A) $R_{Th} = 6\,\Omega$, $V_{Th} = 4$ V (B) $R_{Th} = 6\,\Omega$, $V_{Th} = 28$ V

(C) $R_{Th} = 2\,\Omega$, $V_{Th} = 24$ V (D) $R_{Th} = 10\,\Omega$, $V_{Th} = 14$ V

MCQ 5.1.27 What values of R_{Th} and V_{Th} will cause the circuit of figure (B) to be the equivalent circuit of figure (A) ?

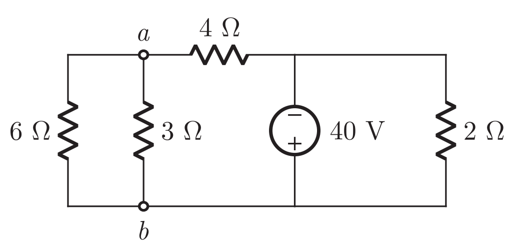


Fig.(A)

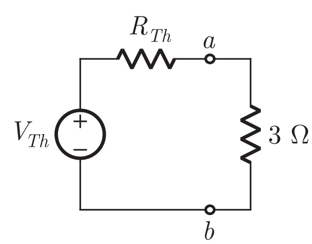


Fig.(B)

(A) 2.4 Ω, −24 V (B) 3 Ω, 16 V

(C) 10 Ω, 24 V (D) 10 Ω, −24 V

Common Data for Q. 28 to 29 :

Consider the two circuits shown in figure (A) and figure (B) below

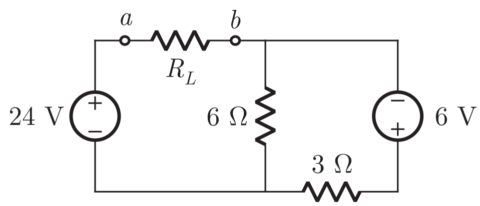


Fig.(A)

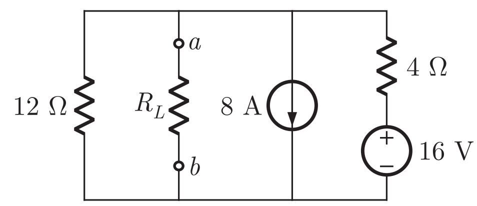


Fig.(B)

MCQ 5.1.28 The value of Thevenin voltage across terminals a-b of figure (A) and figure (B) respectively are

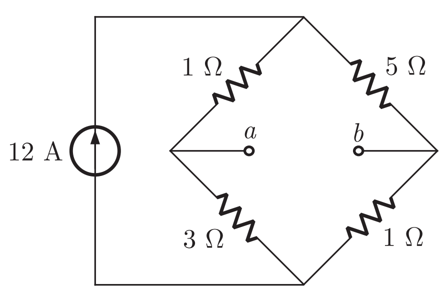
(A) 30 V, 36 V
(B) 28 V, −12 V
(C) 18 V, 12 V
(D) 30 V, −12 V

MCQ 5.1.29 The value of Thevenin resistance across terminals a-b of figure (A) and figure (B) respectively are

(A) zero, 3 Ω
(B) 9 Ω, 16 Ω
(C) 2 Ω, 3 Ω
(D) zero, 16 Ω

Statement for linked Questions 30 and 31 :

Consider the circuit shown in the figure.



MCQ 5.1.30 The equivalent Thevenin voltage across terminal a-b is

(A) 31.2 V
(B) 19.2 V
(C) 16.8 V
(D) 24 V

MCQ 5.1.31 The Norton equivalent current with respect to terminal a-b is

(A) 13 A
(B) 7 A
(C) 8 A
(D) 10 A

MCQ 5.1.32 For a network having resistors and independent sources, it is desired to obtain Thevenin equivalent across the load which is in parallel with an ideal current source. Then which of the following statement is true ?

(A) The Thevenin equivalent circuit is simply that of a voltage source.

(B) The Thevenin equivalent circuit consists of a voltage source and a series resistor.

(C) The Thevenin equivalent circuit does not exist but the Norton equivalent does exist.

(D) None of these

MCQ 5.1.33 The Thevenin equivalent circuit of a network consists only of a resistor (Thevenin voltage is zero). Then which of the following elements might be contained in the network ?

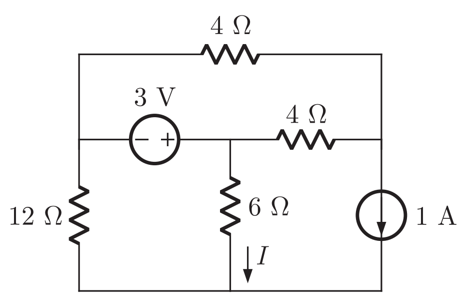
(A) resistor and independent sources

(B) resistor only

(C) resistor and dependent sources

(D) resistor, independent sources and dependent sources.

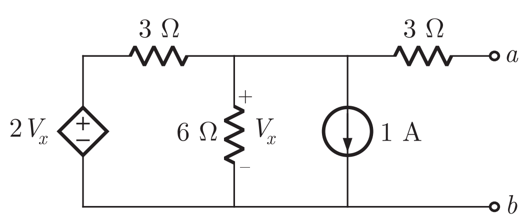
MCQ 5.1.34 In the following network, value of current I through $6\,\Omega$ resistor is given by



(A) 0.83 A (B) 2 A

(C) 1 A (D) -0.5 A

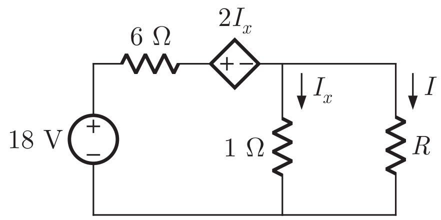
MCQ 5.1.35 For the circuit shown in the figure, the Thevenin's voltage and resistance looking into a-b are



(A) $2\,V$, $3\,\Omega$ (B) $2\,V$, $2\,\Omega$

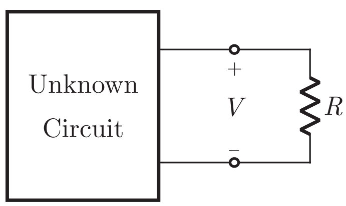
(C) $6\,V$, $-9\,\Omega$ (D) $6\,V$, $-3\,\Omega$

MCQ 5.1.36 For the circuit below, what value of R will cause $I = 3\text{ A}$?



(A) $2/3\,\Omega$ (B) $4\,\Omega$
(C) zero (D) none of these

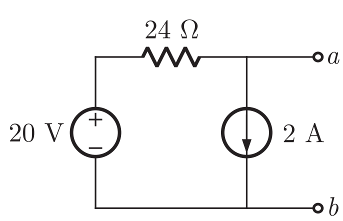
MCQ 5.1.37 For the following circuit, values of voltage V for different values of R are given in the table.



R	V
3 Ω	6 V
8 Ω	8 V

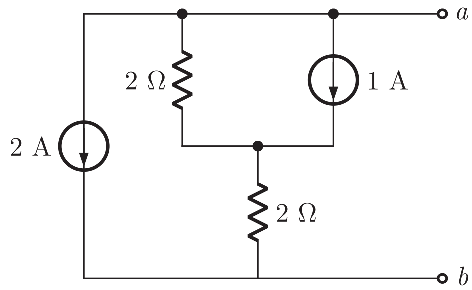
The Thevenin voltage and resistance of the unknown circuit are respectively.
(A) $14\text{ V}, 4\,\Omega$
(B) $4\text{ V}, 1\,\Omega$
(C) $14\text{ V}, 6\,\Omega$
(D) $10\text{ V}, 2\,\Omega$

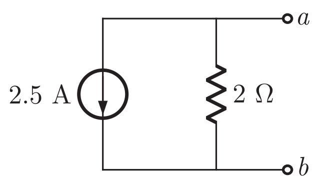
MCQ 5.1.38 In the circuit shown below, the Norton equivalent current and resistance with respect to terminal a-b is

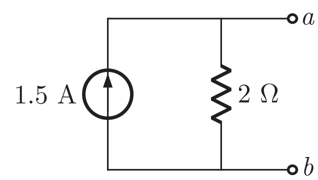


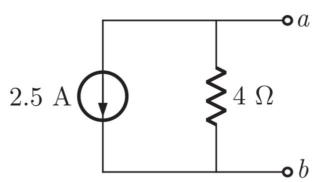
(A) $\frac{17}{6}\text{ A}, 0\,\Omega$
(B) $2\text{ A}, 24\,\Omega$
(C) $-\frac{7}{6}\text{ A}, 24\,\Omega$
(D) $-2\text{ A}, 24\,\Omega$

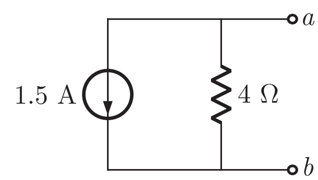
MCQ 5.1.39 The Norton equivalent circuit for the circuit shown in figure is given by



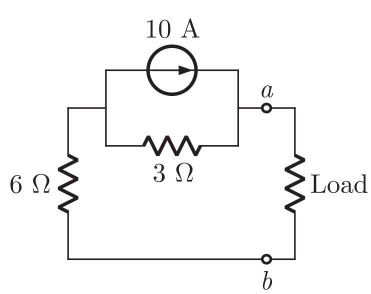
(A) 

(B) 

(C) 

(D) 

MCQ 5.1.40 What are the values of equivalent Norton current source (I_N) and equivalent resistance (R_N) across the load terminal of the circuit shown in figure ?



	I_N	R_N
(A)	10 A	2 Ω
(B)	10 A	9 Ω
(C)	3.33 A	9 Ω
(D)	6.66 A	2 Ω

MCQ 5.1.41 For a network consisting of resistors and independent sources only, it is desired to obtain Thevenin's or Norton's equivalent across a load which is in parallel with an ideal voltage sources.

Consider the following statements :

1. Thevenin equivalent circuit across this terminal does not exist.
2. The Thevenin equivalent circuit exists and it is simply that of a voltage source.
3. The Norton equivalent circuit for this terminal does not exist.

Which of the above statements is/are true ?

(A) 1 and 3 (B) 1 only
(C) 2 and 3 (D) 3 only

MCQ 5.1.42 For a network consisting of resistors and independent sources only, it is desired to obtain Thevenin's or Norton's equivalent across a load which is in series with an ideal current sources.

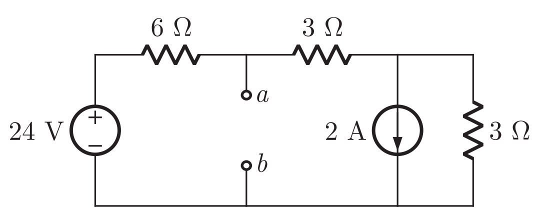
Consider the following statements

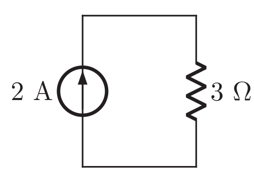
1. Norton equivalent across this terminal is not feasible.
2. Norton equivalent circuit exists and it is simply that of a current source only.
3. Thevenin's equivalent circuit across this terminal is not feasible.

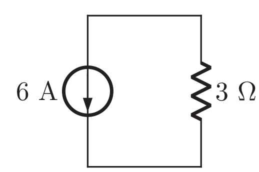
Which of the above statements is/are correct ?

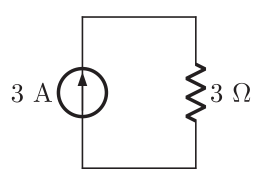
(A) 1 and 3
(B) 2 and 3
(C) 1 only
(D) 3 only

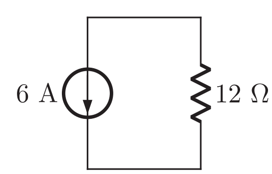
MCQ 5.1.43 The Norton equivalent circuit of the given network with respect to the terminal a-b, is



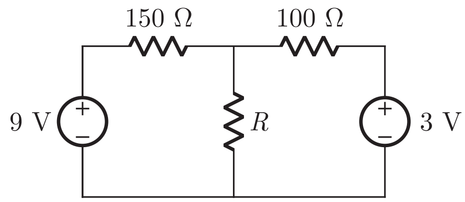
(A) 

(B) 

(C) 

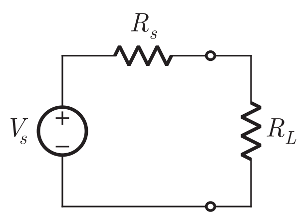
(D) 

MCQ 5.1.44 The maximum power that can be transferred to the resistance R in the circuit is



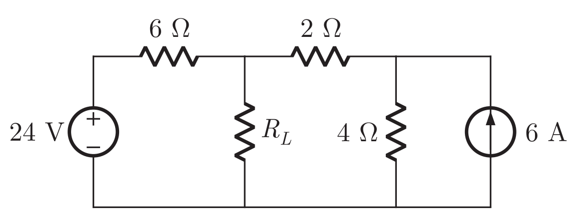
(A) 486 mW
(B) 243 mW
(C) 121.5 mW
(D) 225 mW

MCQ 5.1.45 In the circuit below, if R_L is fixed and R_s is variable then for what value of R_s power dissipated in R_L will be maximum ?



(A) $R_S = R_L$
(B) $R_S = 0$
(C) $R_S = R_L/2$
(D) $R_S = 2R_L$

MCQ 5.1.46 In the circuit shown below the maximum power transferred to R_L is $P_{\max}$, then



(A) $R_L = 12\,\Omega,\ P_{\max} = 12$ W
(B) $R_L = 3\,\Omega,\ P_{\max} = 96$ W
(C) $R_L = 3\,\Omega,\ P_{\max} = 48$ W
(D) $R_L = 12\,\Omega,\ P_{\max} = 24$ W

MCQ 5.1.47 In the circuit shown in figure (A) if current $I_1 = 2$ A, then current I_2 and I_3 in figure (B) and figure (C) respectively are

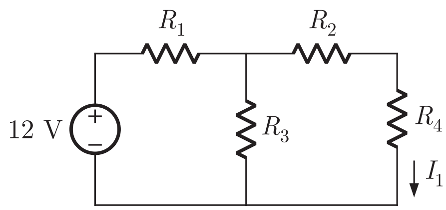


Fig.(A)

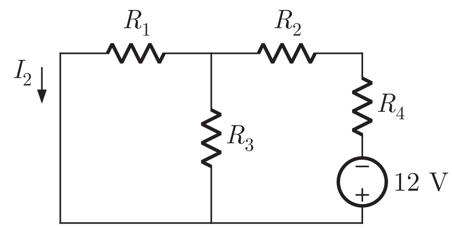


Fig.(B)

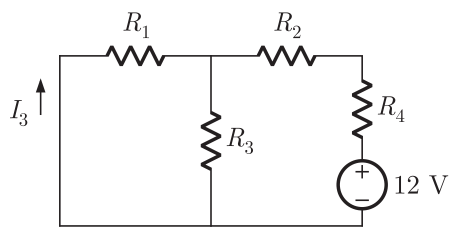


Fig.(C)

(A) 2 A, 2 A
(B) −2 A, 2 A
(C) 2 A, −2 A
(D) −2 A, −2 A

MCQ 5.1.48 In the circuit of figure (A), if $I_1 = 20\,\text{mA}$, then what is the value of current I_2 in the circuit of figure (B) ?

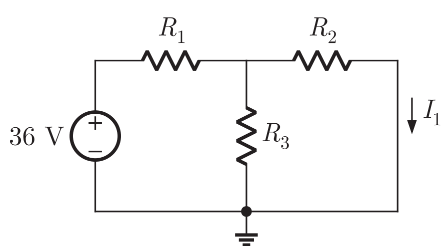


Fig.(A)

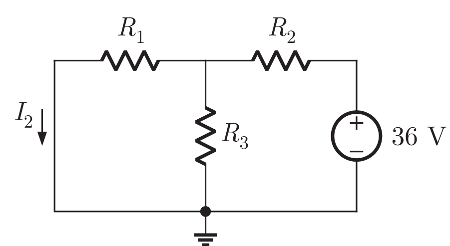


Fig.(B)

(A) 40 mA
(B) −20 mA
(C) 20 mA
(D) R_1, R_2 and R_3 must be known

MCQ 5.1.49 If $V_1 = 2\,\text{V}$ in the circuit of figure (A), then what is the value of V_2 in the circuit of figure (B) ?

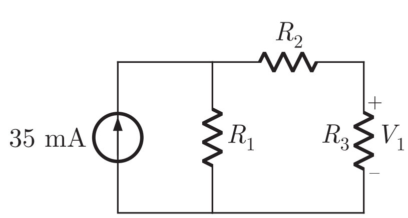


Fig.(A)

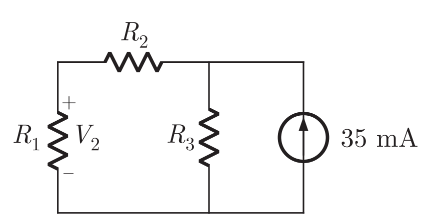
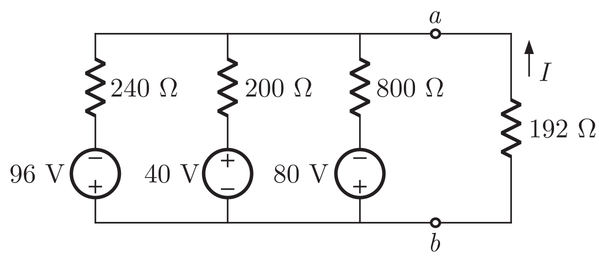


Fig.(B)

(A) 2 V (B) -2 V

(C) 4 V (D) R_1, R_2 and R_3 must be known

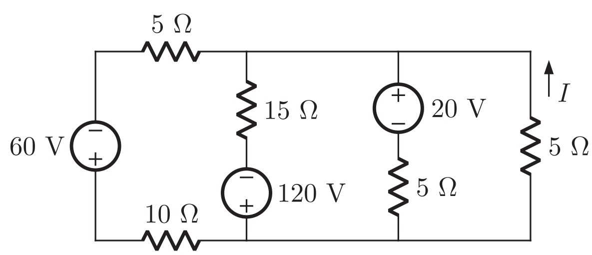
MCQ 5.1.50 The value of current I in the circuit below is equal to



(A) 100 mA (B) 10 mA

(C) 233.34 mA (D) none of these

MCQ 5.1.51 The value of current I in the following circuit is equal to



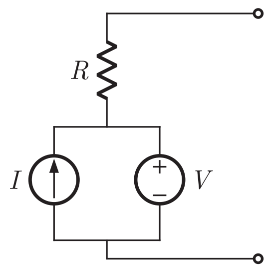
(A) 1 A (B) 6 A

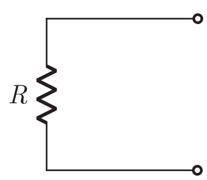
(C) 3 A (D) 2 A

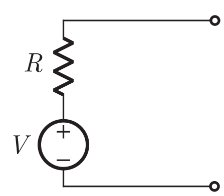
****

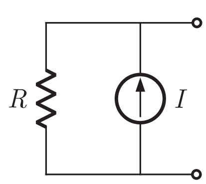
EXERCISE 5.2

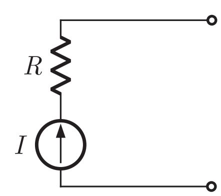
MCQ 5.2.1 A simple equivalent circuit of the two-terminal network shown in figure is



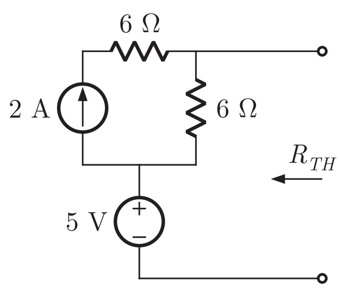
(A) 

(B) 

(C) 

(D) 

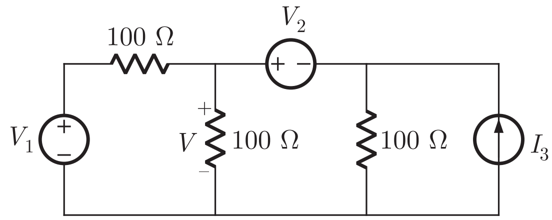
MCQ 5.2.2 For the following circuit the value of R_{Th} is



(A) 3 Ω (B) 12 Ω

(C) 6 Ω (D) ∞

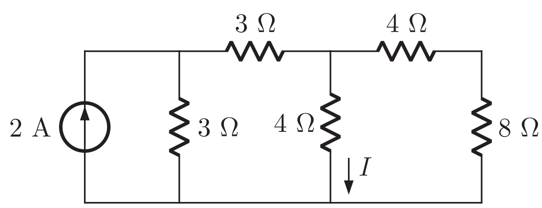
MCQ 5.2.3 If $V = AV_1 + BV_2 + CI_3$ in the following circuit, then values of A, B and C respectively are



(A) $\frac{2}{3}, \frac{2}{3}, \frac{1}{3}$ (B) $\frac{1}{3}, \frac{1}{3}, \frac{100}{3}$

(C) $\frac{1}{2}, \frac{1}{2}, \frac{1}{3}$ (D) $\frac{1}{3}, \frac{2}{3}, \frac{100}{3}$

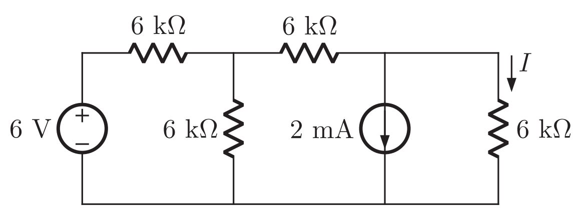
MCQ 5.2.4 What is the value of current I in the network of figure ?



(A) 0.67 A (B) 2 A

(C) 1.34 A (D) 0.5 A

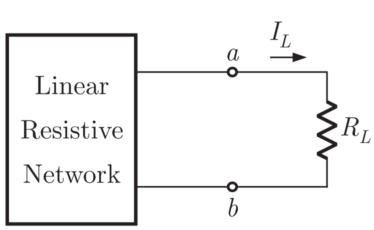
MCQ 5.2.5 The value of current I in the figure is



(A) -1 mA (B) 1.4 mA

(C) 1.8 mA (D) -1.2 mA

MCQ 5.2.6 For the circuit of figure, some measurements were made at the terminals a-b and given in the table below.



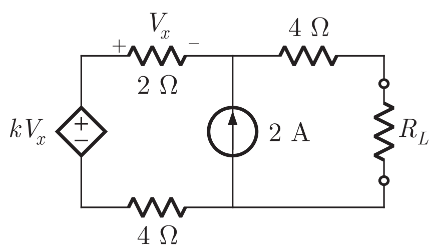
R_L	I_L
2 Ω	10 A
10 Ω	6 A

What is the value of I_L for $R_L = 20\,\Omega$?

(A) 3 A (B) 12 A

(C) 2 A (D) 4 A

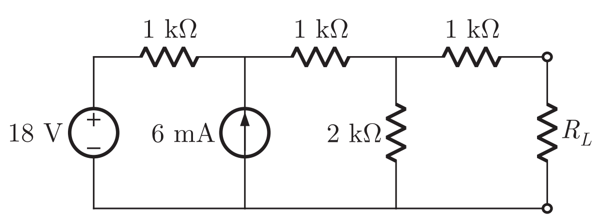
MCQ 5.2.7 In the circuit below, for what value of k, load $R_L = 2\,\Omega$ absorbs maximum power ?



(A) 4 (B) 7

(C) 2 (D) 6

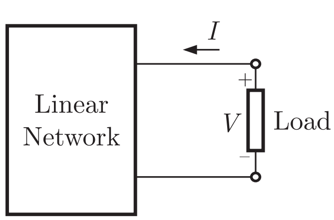
MCQ 5.2.8 In the circuit shown below, the maximum power that can be delivered to the load R_L is equal to

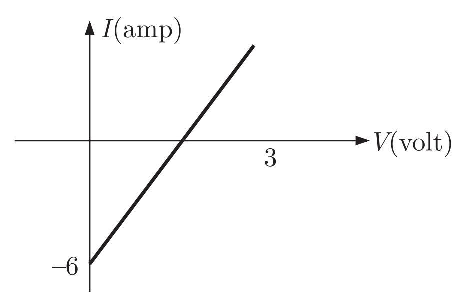


(A) 72 mW (B) 36 mW

(C) 24 mW (D) 18 mW

MCQ 5.2.9 For the linear network shown below, V-I characteristic is also given in the figure. The value of Norton equivalent current and resistance respectively are

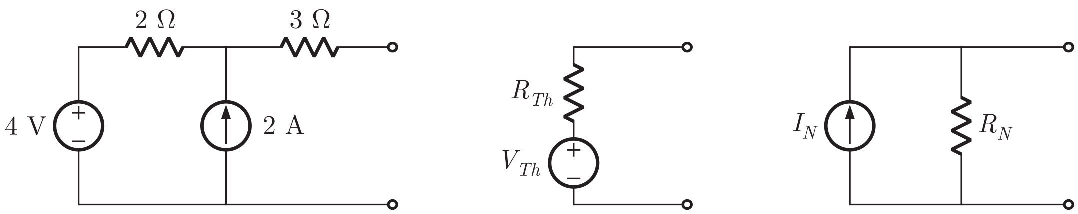




(A) 3 A, 2 Ω (B) 6 Ω, 2 Ω

(C) 6 A, 0.5 Ω (D) 3 A, 0.5 Ω

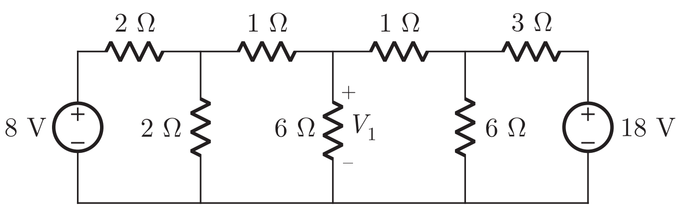
MCQ 5.2.10 In the following circuit a network and its Thevenin and Norton equivalent are given.



The value of the parameter are

	V_{Th}	R_{Th}	I_N	R_N
(A)	4 V	2 Ω	2 A	2 Ω
(B)	4 V	2 Ω	2 A	3 Ω
(C)	8 V	1.2 Ω	$\frac{30}{3}$ A	1.2 Ω
(D)	8 V	5 Ω	$\frac{8}{5}$ A	5 Ω

MCQ 5.2.11 In the following circuit the value of voltage V_1 is



(A) 6 V (B) 7 V

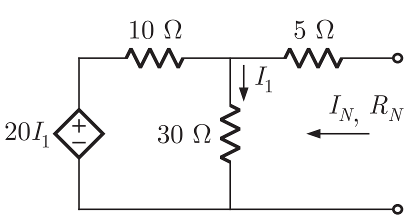
(C) 8 V (D) 10 V

MCQ 5.2.12 A practical DC current source provide 20 kW to a 50 Ω load and 20 kW to a 200 Ω load. The maximum power, that can drawn from it, is

(A) 22.5 kW (B) 45 kW

(C) 30.3 kW (D) 40 kW

MCQ 5.2.13 For the following circuit the value of equivalent Norton current I_N and resistance R_N are



(A) 2 A, 20 Ω (B) 2 A, −20 Ω

(C) 0 A, 20 Ω (D) 0 A, −20 Ω

MCQ 5.2.14 Consider the following circuits shown below

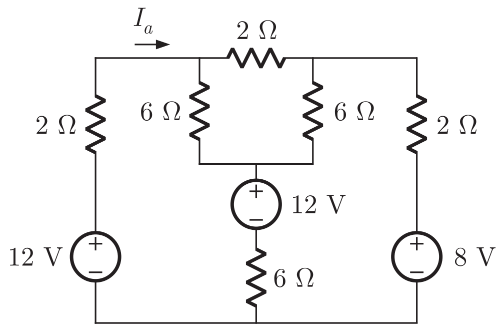


Fig (A)

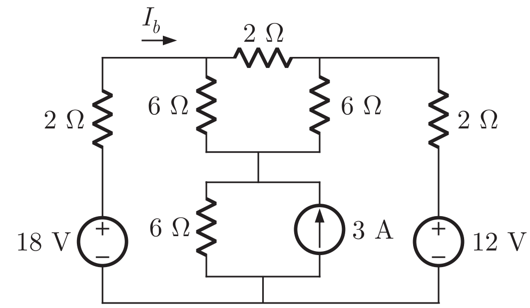


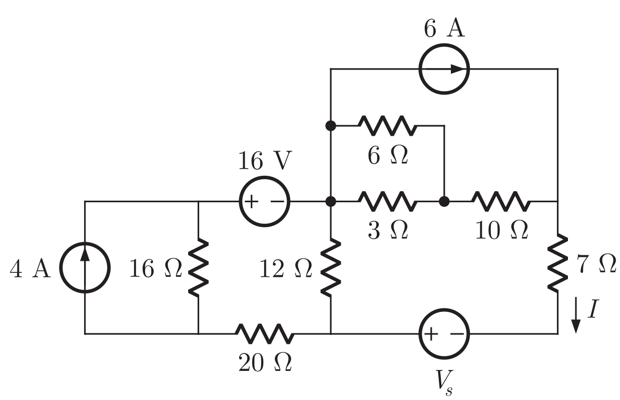
Fig (B)

The relation between I_a and I_b is

(A) $I_b = I_a + 6$ (B) $I_b = I_a + 2$

(C) $I_b = 1.5I_a$ (D) $I_b = I_a$

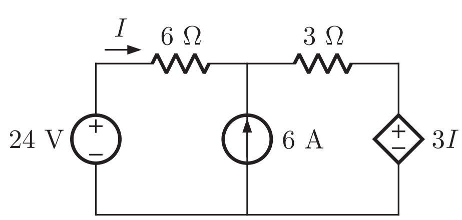
MCQ 5.2.15 If $I = 5$ A in the circuit below, then what is the value of voltage source V_s ?



(A) 28 V (B) 56 V

(C) 200 V (D) 224 V

MCQ 5.2.16 For the following circuit, value of current I is given by

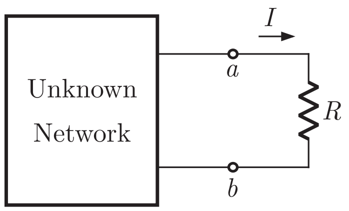


(A) 0.5 A (B) 3.5 A

(C) 1 A (D) 2 A

Statement for Linked Questions

In the following circuit, some measurements were made at the terminals a, b and given in the table below.



R	I
3 Ω	2 A
5 Ω	1.6 A

MCQ 5.2.17 The Thevenin equivalent of the unknown network across terminal a-b is

(A) 3 Ω, 14 V (B) 5 Ω, 16 V

(C) 16 Ω, 38 V (D) 10 Ω, 26 V

MCQ 5.2.18 The value of R that will cause I to be 1 A, is

(A) 22 Ω (B) 16 Ω

(C) 8 Ω (D) 11 Ω

MCQ 5.2.19 In the circuit shown in fig (a) if current $I_1 = 2.5$ A then current I_2 and I_3 in fig (B) and (C) respectively are

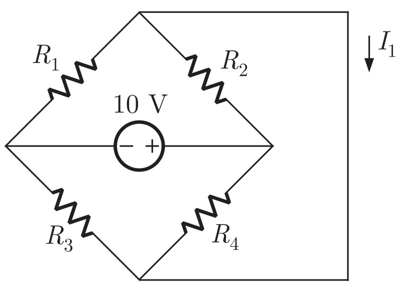


Fig.(A)

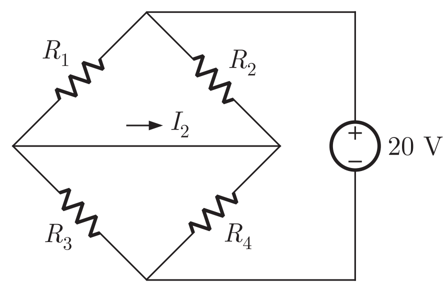


Fig.(B)

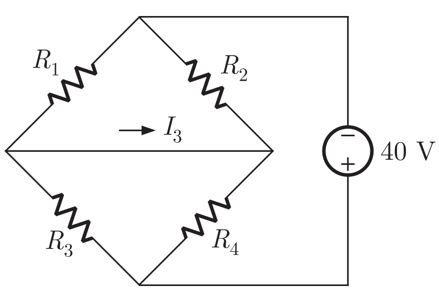
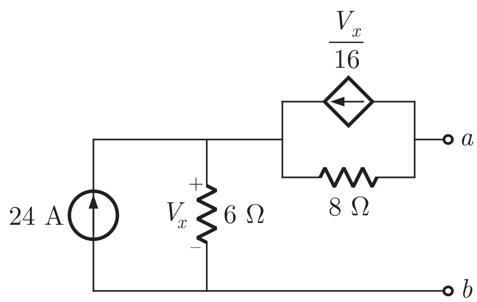


Fig.(C)

(A) 5 A, 10 A (B) −5 A, 10 A

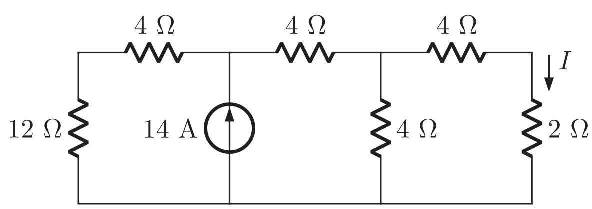
(C) 5 A, −10 A (D) −5 A, −10 A

MCQ 5.2.20 The Thevenin equivalent resistance between terminal a and b in the following circuit is



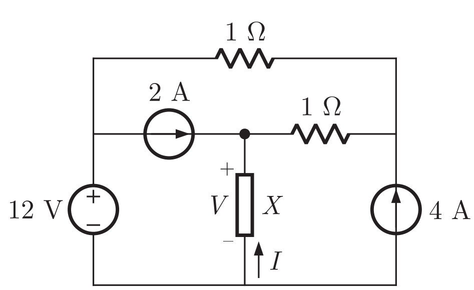
(A) $22\,\Omega$
(B) $11\,\Omega$
(C) $17\,\Omega$
(D) $1\,\Omega$

MCQ 5.2.21 In the circuit shown below, the value of current I will be given by



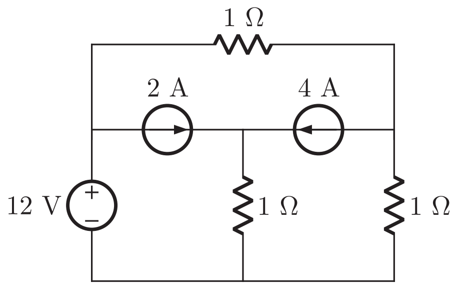
(A) 2.5 A
(B) 1.5 A
(C) 4 A
(D) 2 A

MCQ 5.2.22 The V-I relation of the unknown element X in the given network is $V = AI + B$. The value of A (in ohm) and B (in volt) respectively are



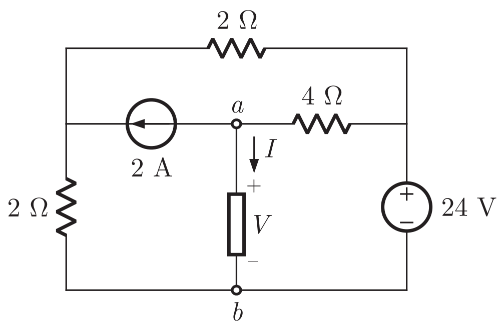
(A) $2, 20$
(B) $2, 8$
(C) $0.5, 4$
(D) $0.5, 16$

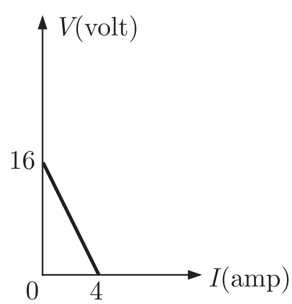
MCQ 5.2.23 The power delivered by 12 V source in the following network is

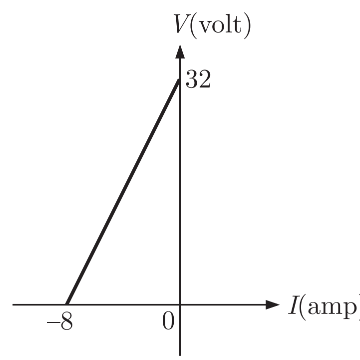


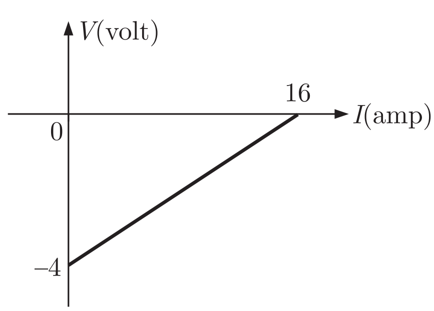
(A) 24 W (B) 96 W
(C) 120 W (D) 48 W

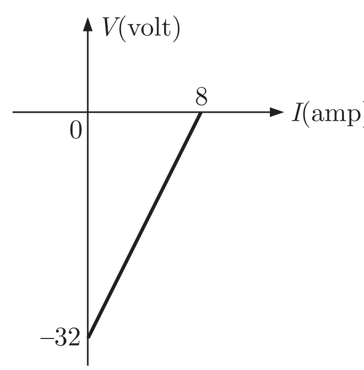
MCQ 5.2.24 For the following network the V-I curve with respect to terminals a-b, is given by



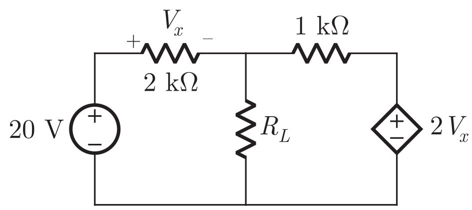
(A)


(B)


(C)


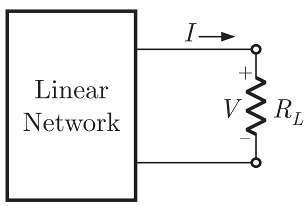
(D)


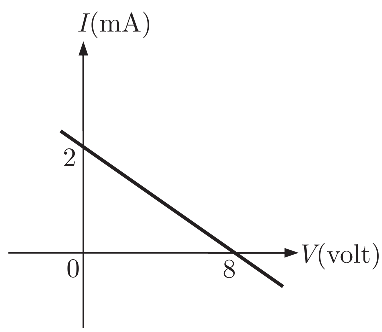
MCQ 5.2.25 In the circuit shown, what value of R_L maximizes the power delivered to R_L ?



(A) 286 Ω (B) 350 Ω
(C) zero (D) 500 Ω

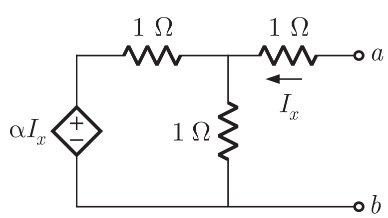
MCQ 5.2.26 The V-I relation for the circuit below is plotted in the figure. The maximum power that can be transferred to the load R_L will be





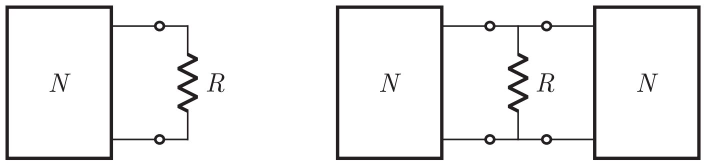
(A) 4 mW (B) 8 mW
(C) 2 mW (D) 16 mW

MCQ 5.2.27 In the following circuit equivalent Thevenin resistance between nodes a and b is $R_{Th} = 3\,\Omega$. The value of α is



(A) 2 (B) 1
(C) 3 (D) 4

MCQ 5.2.28 A network N feeds a resistance R as shown in circuit below. Let the power consumed by R be P. If an identical network is added as shown in figure, the power consumed by R will be



(A) equal to P
(B) less than P
(C) between P and $4P$
(D) more than $4P$

MCQ 5.2.29 A certain network consists of a large number of ideal linear resistors, one of which is R and two constant ideal source. The power consumed by R is P_1 when only the first source is active, and P_2 when only the second source is active. If both sources are active simultaneously, then the power consumed by R is

(A) $P_1 \pm P_2$
(B) $\sqrt{P_1} \pm \sqrt{P_2}$
(C) $(\sqrt{P_1} \pm \sqrt{P_2})^2$
(D) $(P_1 \pm P_2)^2$

MCQ 5.2.30 If the $60\,\Omega$ resistance in the circuit of figure (A) is to be replaced with a current source I_s and $240\,\Omega$ shunt resistor as shown in figure (B), then magnitude and direction of required current source would be

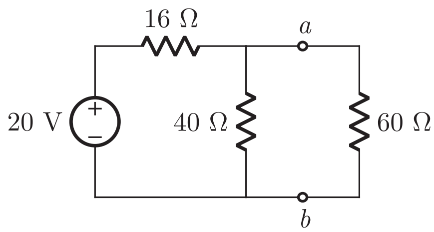


Fig.(A)

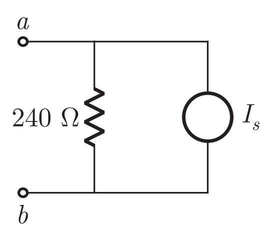
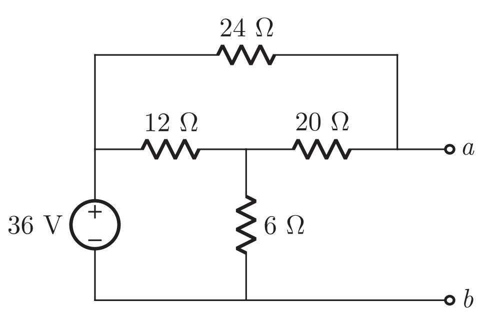


Fig.(B)

(A) $200\,\text{mA}$, upward
(B) $150\,\text{mA}$, downward
(C) $50\,\text{mA}$, downward
(D) $150\,\text{mA}$, upward

MCQ 5.2.31 The Thevenin's equivalent of the circuit shown in the figure is

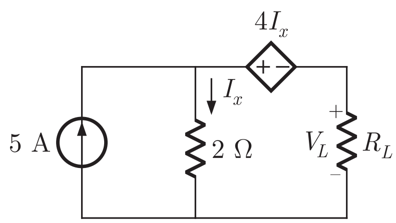


(A) $4\,\text{V}$, $48\,\Omega$
(B) $24\,\text{V}$, $12\,\Omega$
(C) $24\,\text{V}$, $24\,\Omega$
(D) $12\,\text{V}$, $12\,\Omega$

MCQ 5.2.32 The voltage V_L across the load resistance in the figure is given by

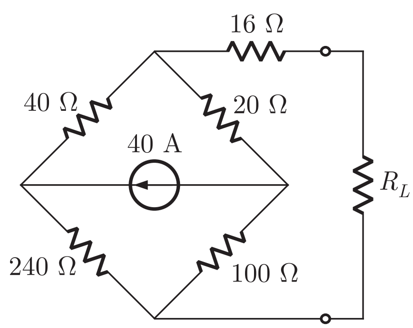
$$V_L = V\left(\frac{R_L}{R + R_L}\right)$$

V and R will be equal to



(A) -10 V, 2 Ω (B) 10 V, 2 Ω
(C) -10 V, -2 Ω (D) none of these

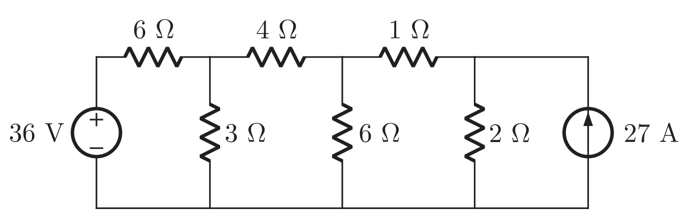
MCQ 5.2.33 The maximum power that can be transferred to the load resistor R_L from the current source in the figure is



(A) 4 W (B) 8 W
(C) 16 W (D) 2 W

Common data for Q. 34 to Q. 35

An electric circuit is fed by two independent sources as shown in figure.



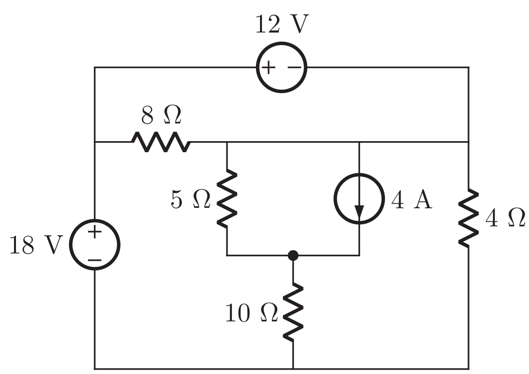
MCQ 5.2.34 The power supplied by 36 V source will be
(A) 108 W (B) 162 W
(C) 129.6 W (D) 216 W

MCQ 5.2.35 The power supplied by 27 A source will be

(A) 972 W (B) 1083 W

(C) 1458 W (D) 1026 W

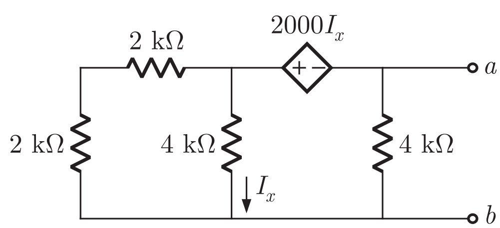
MCQ 5.2.36 In the circuit shown in the figure, power dissipated in $4\,\Omega$ resistor is



(A) 225 W (B) 121 W

(C) 9 W (D) none of these

MCQ 5.2.37 In the circuit given below, viewed from a-b, the circuit can be reduced to an equivalent circuit as



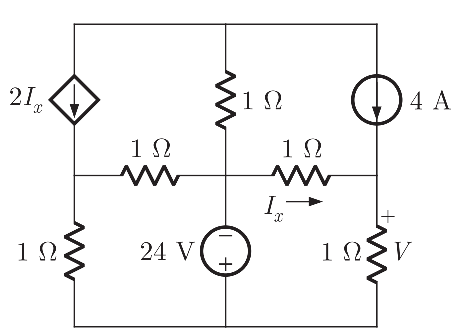
(A) 10 volt source in series with $2\,k\Omega$ resistor

(B) $1250\,\Omega$ resistor only

(C) 20 V source in series with $1333.34\,\Omega$ resistor

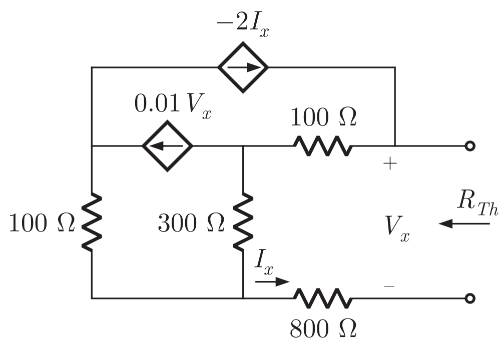
(D) $800\,\Omega$ resistor only

MCQ 5.2.38 What is the value of voltage V in the following network ?



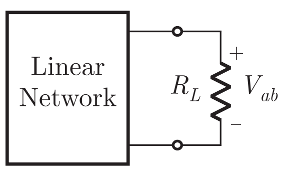
(A) 14 V
(B) 28 V
(C) -10 V
(D) none of these

MCQ 5.2.39 For the circuit shown in figure below the value of R_{Th} is



(A) 100 Ω
(B) 136.4 Ω
(C) 200 Ω
(D) 272.8 Ω

MCQ 5.2.40 Consider the network shown below :

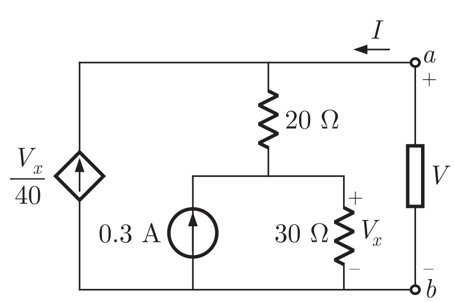


The power absorbed by load resistance R_L is shown in table :

R_L	10 kΩ	30 kΩ
P	3.6 mW	4.8 mW

The value of R_L, that would absorb maximum power, is
(A) 60 kΩ
(B) 100 Ω
(C) 300 Ω
(D) 30 kΩ

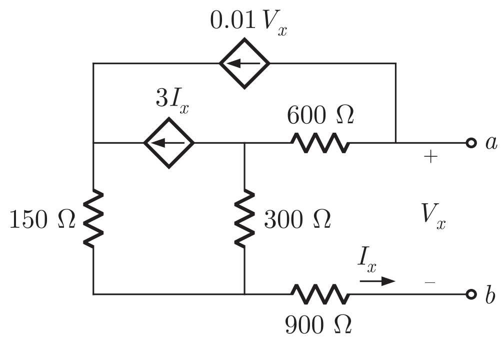
MCQ 5.2.41 The V-I equation for the network shown in figure, is given by



(A) $7V = 200I + 54$ (B) $V = 100I + 36$

(C) $V = 200I + 54$ (D) $V = 50I + 54$

MCQ 5.2.42 In the following circuit the value of open circuit voltage and Thevenin resistance at terminals a, b are



(A) $V_{oc} = 100\text{ V},\ R_{Th} = 1800\,\Omega$

(B) $V_{oc} = 0\text{ V},\ R_{Th} = 270\,\Omega$

(C) $V_{oc} = 100\text{ V},\ R_{Th} = 90\,\Omega$

(D) $V_{oc} = 0\text{ V},\ R_{Th} = 90\,\Omega$

****

EXERCISE 5.3

Common Data for Questions 1 and 2 :

GATE EC 2012

With 10 V dc connected at port A in the linear nonreciprocal two-port network shown below, the following were observed :

(i) $1\,\Omega$ connected at port B draws a current of 3 A

GATE EE 2012

(ii) $2.5\,\Omega$ connected at port B draws a current of 2 A

MCQ 5.3.1 With 10 V dc connected at port A, the current drawn by $7\,\Omega$ connected at port B is

(A) 3/7 A (B) 5/7 A

(C) 1 A (D) 9/7 A

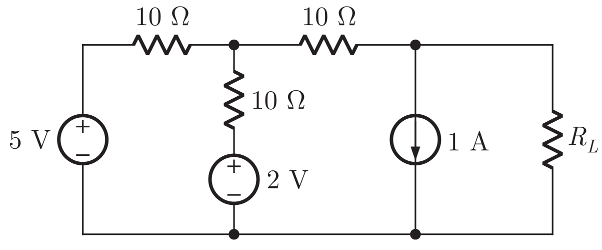
MCQ 5.3.2 For the same network, with 6 V dc connected at port A, $1\,\Omega$ connected at port B draws 7/3 A. If 8 V dc is connected to port A, the open circuit voltage at port B is

(A) 6 V (B) 7 V

(C) 8 V (D) 9 V

MCQ 5.3.3 In the circuit shown below, the value of R_L such that the power transferred to R_L is maximum is

GATE EC 2011

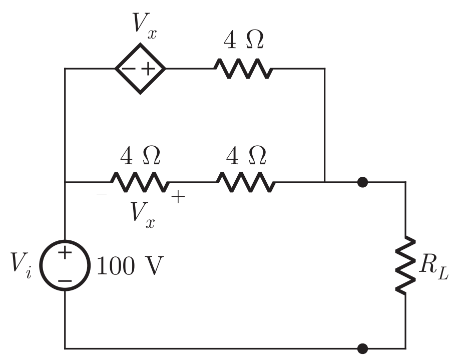


(A) $5\,\Omega$ (B) $10\,\Omega$

(C) $15\,\Omega$ (D) $20\,\Omega$

MCQ 5.3.4
GATE EC 2009

In the circuit shown, what value of R_L maximizes the power delivered to R_L?

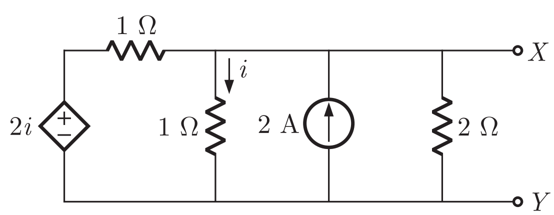


(A) $2.4\,\Omega$ (B) $\frac{8}{3}\,\Omega$

(C) $4\,\Omega$ (D) $6\,\Omega$

MCQ 5.3.5
GATE EC 2007

For the circuit shown in the figure, the Thevenin voltage and resistance looking into X-Y are

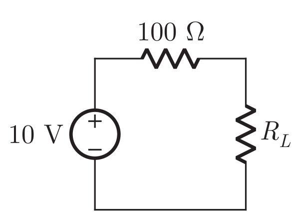


(A) $\frac{4}{3}\,\text{V}, 2\,\Omega$ (B) $4\,\text{V}, \frac{2}{3}\,\Omega$

(C) $\frac{4}{3}\,\text{V}, \frac{2}{3}\,\Omega$ (D) $4\,\text{V}, 2\,\Omega$

MCQ 5.3.6
GATE EC 2005

The maximum power that can be transferred to the load resistor R_L from the voltage source in the figure is

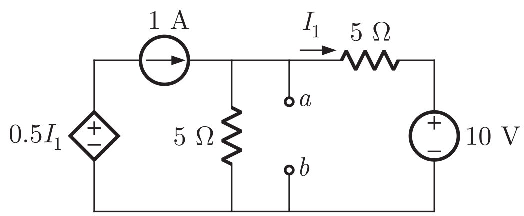


(A) 1 W (B) 10 W

(C) 0.25 W (D) 0.5 W

MCQ 5.3.7
GATE EC 2005

For the circuit shown in the figure, Thevenin's voltage and Thevenin's equivalent resistance at terminals a-b is

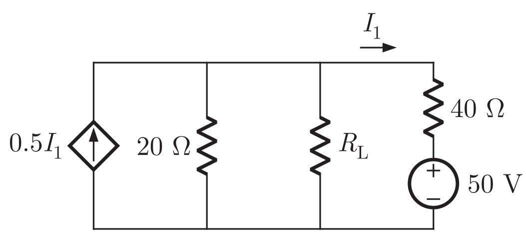


(A) 5 V and 2 Ω (B) 7.5 V and 2.5 Ω

(C) 4 V and 2 Ω (D) 3 V and 2.5 Ω

MCQ 5.3.8 GATE EC 2002

In the network of the figure, the maximum power is delivered to R_L if its value is

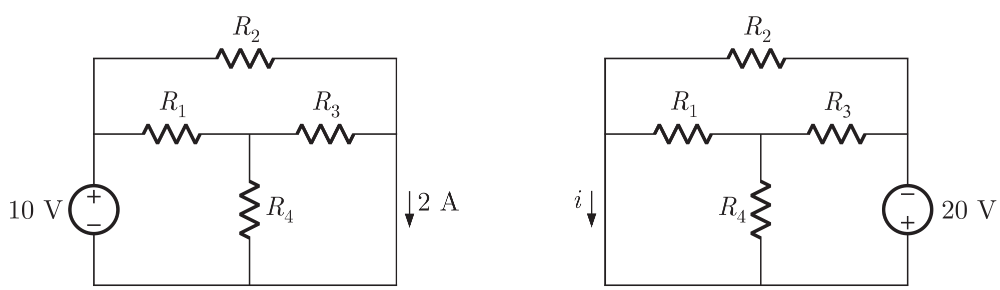


(A) 16 Ω (B) $\frac{40}{3}$ Ω

(C) 60 Ω (D) 20 Ω

MCQ 5.3.9 GATE EC 2000

Use the data of the figure (a). The current i in the circuit of the figure (b)



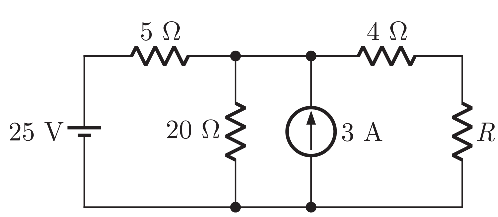
(a) (b)

(A) −2 A (B) 2 A

(C) −4 A (D) 4 A

MCQ 5.3.10 GATE EC 1999

The value of R (in ohms) required for maximum power transfer in the network shown in the given figure is



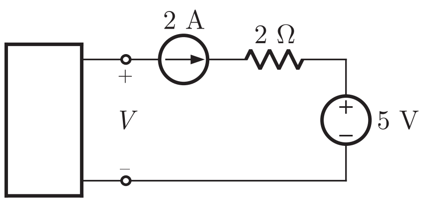
(A) 2 (B) 4
(C) 8 (D) 16

MCQ 5.3.11 GATE EC 1998

Superposition theorem is NOT applicable to networks containing
(A) nonlinear elements (B) dependent voltage sources
(C) dependent current sources (D) transformers

MCQ 5.3.12 GATE EC 1997

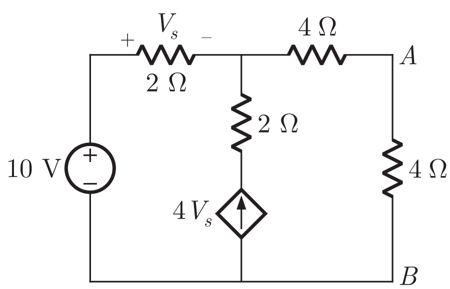
The voltage V in the figure is always equal to



(A) 9 V (B) 5 V
(C) 1 V (D) None of the above

MCQ 5.3.13 GATE EE 1997

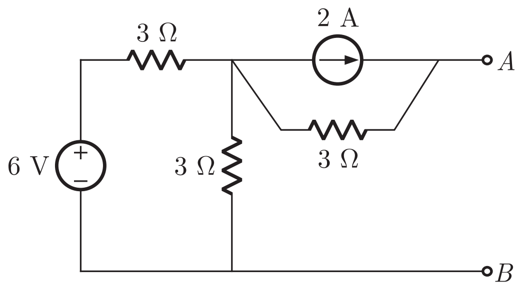
The Thevenin voltage and resistance about AB for the circuit shown in figure respectively are



(A) $10\text{ V}, -\frac{2}{9}\,\Omega$ (B) $0\text{ V}, -\frac{2}{9}\,\Omega$
(C) $10\text{ V}, \frac{12}{5}\,\Omega$ (D) $0\text{ V}, \frac{12}{5}\,\Omega$

MCQ 5.3.14 GATE EE 1997

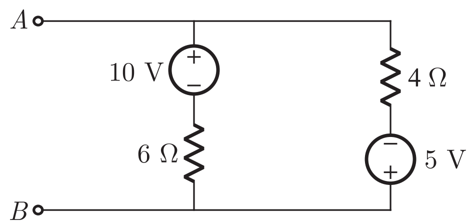
For the circuit shown in figure, the Norton equivalent source current value and and its resistance is



(A) $(2\text{ A}, \frac{3}{2}\,\Omega)$ (B) $(2\text{ A}, \frac{9}{2}\,\Omega)$
(C) $(4\text{ A}, \frac{3}{2}\,\Omega)$ (D) $(4\text{ A}, \frac{3}{4}\,\Omega)$

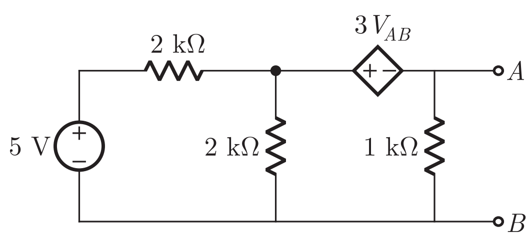
MCQ 5.3.15
GATE EE 1998

Viewed from the terminals A-B, the following circuit shown in figure can be reduced to an equivalent circuit of a single voltage source in series with a single resistor with the following parameters



(A) 5 volt source in series with $10\,\Omega$ resistor
(B) 1 volt source in series with $2.4\,\Omega$ resistor
(C) 15 volt source in series with $2.4\,\Omega$ resistor
(D) 1 volt source in series with $10\,\Omega$ resistor

Statement for Linked Answer Question 16 and 17 :



MCQ 5.3.16
GATE EE 2009

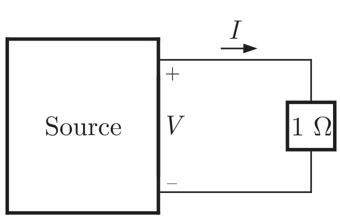
For the circuit given above, the Thevenin's resistance across the terminals A and B is
(A) $0.5\,\text{k}\Omega$
(B) $0.2\,\text{k}\Omega$
(C) $1\,\text{k}\Omega$
(D) $0.11\,\text{k}\Omega$

MCQ 5.3.17
GATE EE 2009

For the circuit given above, the Thevenin's voltage across the terminals A and B is
(A) 1.25 V
(B) 0.25 V
(C) 1 V
(D) 0.5 V

MCQ 5.3.18
GATE EE 2010

As shown in the figure, a $1\,\Omega$ resistance is connected across a source that has a load line $V + I = 100$. The current through the resistance is

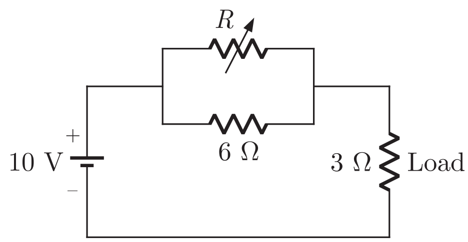


(A) 25 A (B) 50 A

(C) 100 A (C) 200 A

MCQ 5.3.19
GATE EE 2011

In the circuit given below, the value of R required for the transfer of maximum power to the load having a resistance of $3\,\Omega$ is

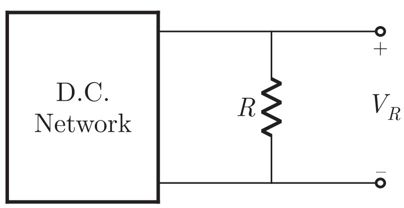


(A) zero (B) $3\,\Omega$

(C) $6\,\Omega$ (D) infinity

MCQ 5.3.20
GATE IN 2000

For the circuit shown in figure $V_R = 20$ V when $R = 10\,\Omega$ and $V_R = 30$ V when $R = 20\,\Omega$. For $R = 80\,\Omega, V_R$ will read as

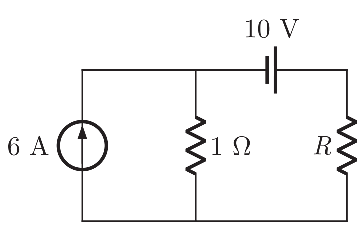


(A) 48 V (B) 60 V

(C) 120 V (D) 160 V

MCQ 5.3.21
GATE IN 2000

For the circuit shown in figure R is adjusted to have maximum power transferred to it. The maximum power transferred is

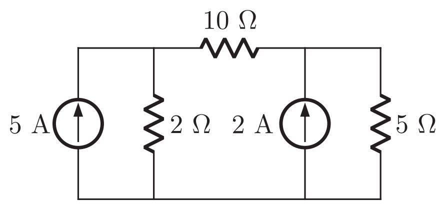


(A) 16 W (B) 32 W

(C) 64 W (D) 100 W

MCQ 5.3.22
GATE IN 2001

In the circuit shown in figure, current through the $5\,\Omega$ resistor is



(A) zero (B) 2 A

(C) 3 A (D) 7 A

MCQ 5.3.23 GATE IN 2007

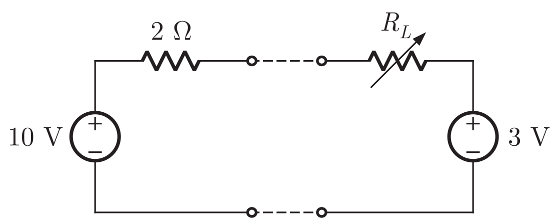
In full sunlight, a solar cell has a short circuit current of 75 mA and a current of 70 mA for a terminal voltage of 0.6 with a given load. The Thevenin resistance of the solar cell is

(A) 8 Ω (B) 8.6 Ω

(C) 120 Ω (D) 240 Ω

MCQ 5.3.24 GATE IN 2009

The source network S is connected to the load network L as shown by dashed lines. The power transferred from S to L would be maximum when R_L is

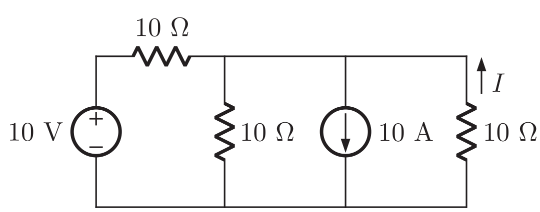


(A) 0 Ω (B) 0.6 Ω

(C) 0.8 Ω (D) 2 Ω

MCQ 5.3.25 GATE IN 2011

The current I shown in the circuit given below is equal to



(A) 3 A (B) 3.67 A

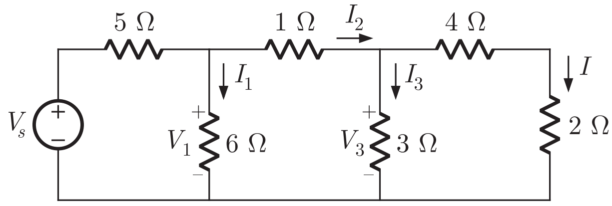
(C) 6 A (D) 9 A

****

SOLUTIONS 5.1

SOL 5.1.1 Option (C) is correct.

We solve this problem using principal of linearity.



In the left, $4\,\Omega$ and $2\,\Omega$ are in series and has same current $I = 1$ A.

$$V_3 = 4I + 2I \qquad \text{(using KVL)}$$
$$= 6I = 6 \text{ V}$$
$$I_3 = \frac{V_3}{3} = \frac{6}{3} = 2 \text{ A} \qquad \text{(using ohm's law)}$$
$$I_2 = I_3 + I \qquad \text{(using KCL)}$$
$$= 2 + 1 = 3 \text{ A}$$
$$V_1 = (1)\, I_2 + V_3 \qquad \text{(using KVL)}$$
$$= 3 + 6 = 9 \text{ V}$$
$$I_1 = \frac{V_1}{6} = \frac{9}{6} = \frac{3}{2} \text{ A} \qquad \text{(using ohm's law)}$$

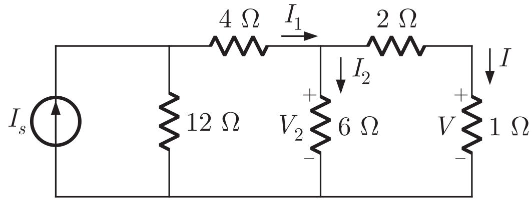
Applying principal of linearity

For $V_s = V_0$, $\quad I_1 = \frac{3}{2}$ A

So for $V_s = 2V_0$, $\quad I_1 = \frac{3}{2} \times 2 = 3$ A

SOL 5.1.2 Option (D) is correct.

We solve this problem using principal of linearity.



$$I = \frac{V}{1} = \frac{1}{1} = 1\text{ A} \qquad \text{(using ohm's law)}$$

$$V_2 = 2I + (1)I \qquad \text{(using KVL)}$$
$$= 3\text{ V}$$

$$I_2 = \frac{V_2}{6} = \frac{3}{6} = \frac{1}{2}\text{ A} \qquad \text{(using ohm's law)}$$

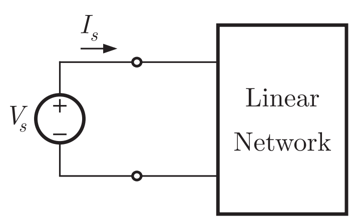
$$I_1 = I_2 + I \qquad \text{(using KCL)}$$
$$= \frac{1}{2} + 1 = \frac{3}{2}\text{ A}$$

Applying principal of superposition

When $I_s = I_0$, and $V = 1\text{ V}$, $\quad I_1 = \frac{3}{2}\text{ A}$

So, if $I_s = 2I_0$, $\quad I_1 = \frac{3}{2} \times 2 = 3\text{ A}$

SOL 5.1.3 Option (B) is correct.



For, $\quad V_s = 10\text{ V},\ P = 40\text{ W}$

So, $\quad I_s = \frac{P}{V_s} = \frac{40}{10} = 4\text{ A}$

Now, $\quad V_s' = 5\text{ V}$, so $I_s' = 2\text{ A}$ (From linearity)

New value of the power supplied by source is

$$P_s' = V_s' I_s' = 5 \times 2 = 10\text{ W}$$

Note: Linearity does not apply to power calculations.

SOL 5.1.4 Option (C) is correct.

From linearity, we know that in the circuit $\frac{V_s}{I_L}$ ratio remains constant

$$\frac{V_s}{I_L} = \frac{20}{200 \times 10^{-3}} = 100$$

Let current through load is I_L' when the power absorbed is 2.5 W, so

$$P_L = (I_L')^2 R_L$$
$$2.5 = (I_L')^2 \times 10$$
$$I_L' = 0.5\text{ A}$$
$$\frac{V_s}{I_L} = \frac{V_s'}{I_L'} = 100$$

So, $\quad V_s' = 100 I_L' = 100 \times 0.5 = 50\text{ V}$

Thus required values are

$$I_L' = 0.5\text{ A},\ V_s' = 50\text{ V}$$

SOL 5.1.5 Option (D) is correct.

From linearity,

$$I_L = AV_s + BI_s, \quad A \text{ and } B \text{ are constants}$$

From the table

$$2 = 14A + 6B \quad ...(i)$$

$$6 = 18A + 2B \quad ...(ii)$$

Solving equation (i) & (ii)

$$A = 0.4,\ B = -0.6$$

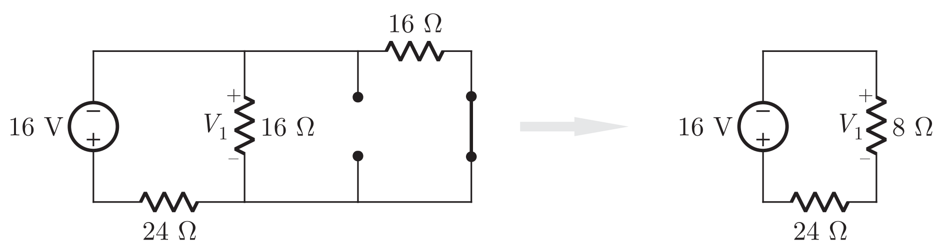
So, $$I_L = 0.4V_s - 0.6I_s$$

SOL 5.1.6 Option (B) is correct.

The circuit has 3 independent sources, so we apply superposition theorem to obtain the voltage drop.

Due to 16 V source only : (Open circuit 5 A source and Short circuit 32 V source)

Let voltage across R_2 due to 16 V source only is V_1.



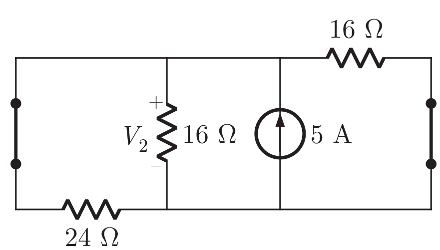
Using voltage division

$$V_1 = -\frac{8}{24+8}(16)$$

$$= -4 \text{ V}$$

Due to 5 A source only : (Short circuit both the 16 V and 32 V sources)

Let voltage across R_2 due to 5 A source only is V_2.

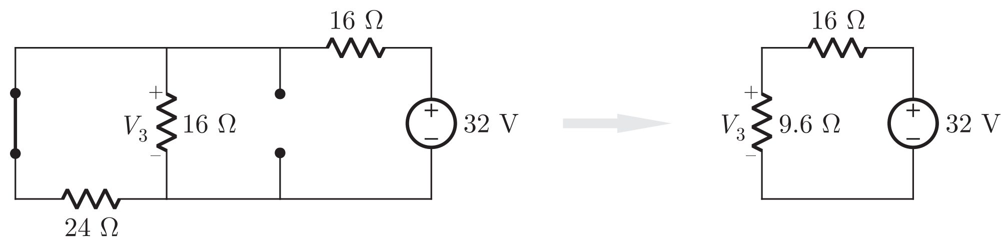


$$V_2 = (24\,\Omega \,||\, 16\,\Omega \,||\, 16\,\Omega) \times 5$$

$$= 6 \times 5 = 30 \text{ volt}$$

Due to 32 V source only : (Short circuit 16 V source and open circuit 5 A source)

Let voltage across R_2 due to 32 V source only is V_3



Using voltage division

$$V_3 = \frac{9.6}{16+9.6}(32) = 12 \text{ V}$$

By superposition, the net voltage across R_2 is

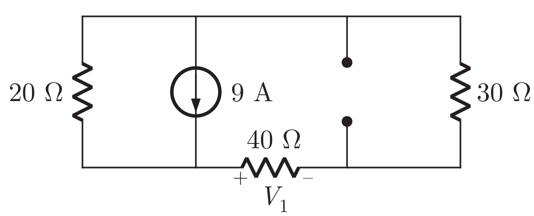
$$V = V_1 + V_2 + V_3 = -4 + 30 + 12 = 38 \text{ volt}$$

Alternate Method: The problem may be solved by applying a node equation at the top node.

SOL 5.1.7 Option (C) is correct.

We solve this problem using superposition.

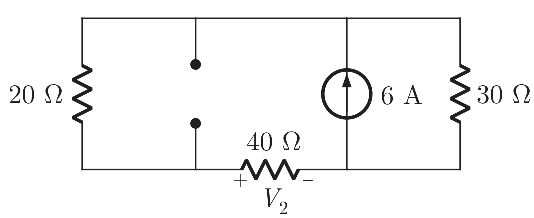
Due to 9 A source only : (Open circuit 6 A source)



Using current division

$$\frac{V_1}{40} = \frac{20}{20+(40+30)}(9) \Rightarrow V_1 = 80 \text{ volt}$$

Due to 6 A source only : (Open circuit 9 A source)



Using current division,

$$\frac{V_2}{40} = \frac{30}{30+(40+20)}(6) \Rightarrow V_2 = 80 \text{ volt}$$

From superposition,

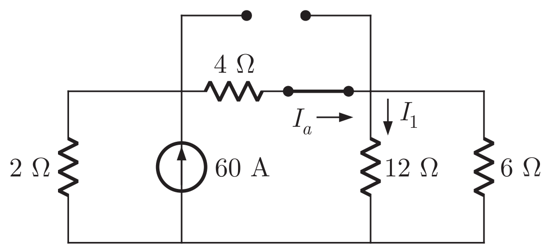
$$V = V_1 + V_2 = 80 + 80 = 160 \text{ volt}$$

Alternate Method: The problem may be solved by transforming both the current sources into equivalent voltage sources and then applying voltage division.

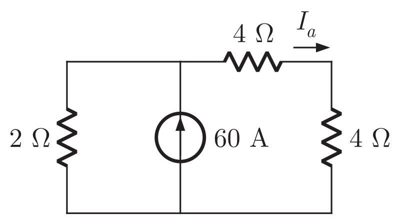
CONCEPT: Superposition

SOL 5.1.8 Option (C) is correct

Due to 60 A source only : (Open circuit 30 A and short circuit 30 V sources)



$$12\,\Omega\,||\,6\,\Omega = 4\,\Omega$$



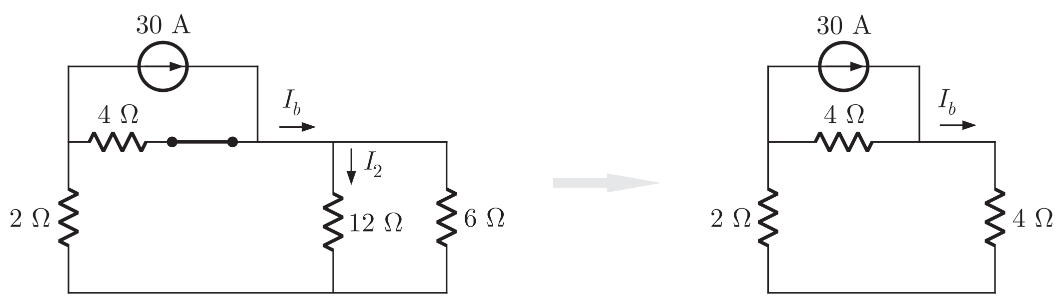
Using current division

$$I_a = \frac{2}{2+8}(60) = 12\text{ A}$$

Again, I_a will be distributed between parallel combination of $12\,\Omega$ and $6\,\Omega$

$$I_1 = \frac{6}{12+6}(12) = 4\text{ A}$$

Due to 30 A source only : (Open circuit 60 A and short circuit 30 V sources)



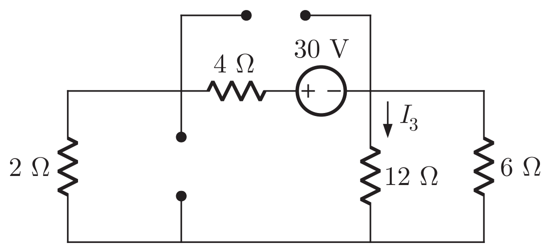
Using current division

$$I_b = \frac{4}{4+6}(30) = 12\text{ A}$$

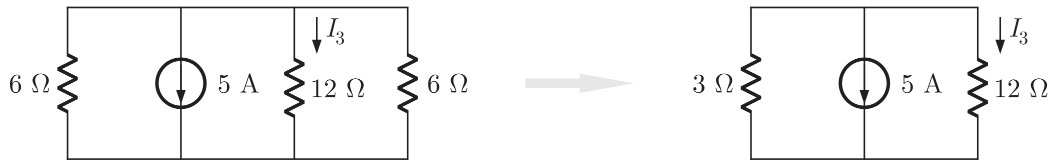
I_b will be distributed between parallel combination of $12\,\Omega$ and $6\,\Omega$

$$I_2 = \frac{6}{12+6}(12) = 4\text{ A}$$

Due to 30 V source only : (Open circuit 60 A and 30 A sources)



Using source transformation



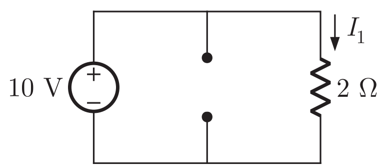
Using current division

$$I_3 = -\frac{3}{12+3}(5) = -1\text{ A}$$

SOL 5.1.9 Option (B) is correct.

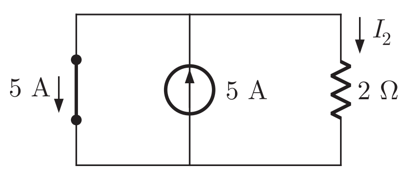
Using super position, we obtain I.

Due to 10 V source only : (Open circuit 5 A source)



$$I_1 = \frac{10}{2} = 5\text{ A}$$

Due to 5 A source only : (Short circuit 10 V source)



$$I_2 = 0$$
$$I = I_1 + I_2 = 5 + 0 = 5\text{ A}$$

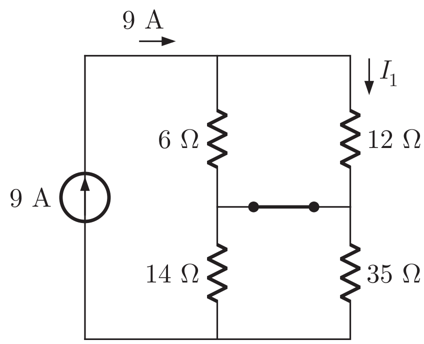
Alternatively :

We can see that voltage source is in parallel with resistor and current source so voltage across parallel branches will be 10 V and $I = 10/2 = 5$ A

SOL 5.1.10 Option (C) is correct.

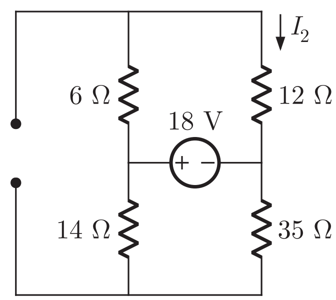
Using superposition, $I = I_1 + I_2$

Let I_1 is the current due to 9 A source only. (i.e. short 18 V source)



$$I_1 = \frac{6}{6+12}(9) = 3\text{ A} \qquad \text{(current division)}$$

Let I_2 is the current due to 18 V source only (i.e. open 9 A source)



$$I_2 = \frac{18}{6+12} = 1\text{ A}$$

So, $I_1 = 3\text{ A},\ I_2 = 1\text{ A}$

SOL 5.1.11 Option (B) is correct.

From superposition theorem, it is known that if all source values are doubled, then node voltages also be doubled.

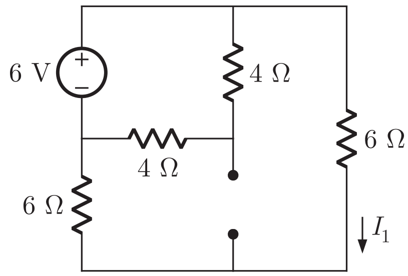
SOL 5.1.12 Option (A) is correct.

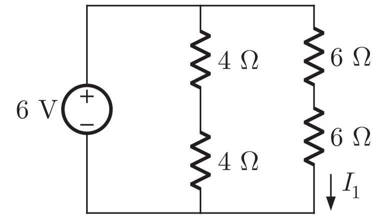
From the principal of superposition, doubling the values of voltage source doubles the mesh currents.

SOL 5.1.13 Option (D) is correct.

Applying superposition,

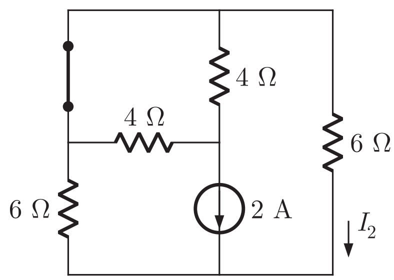
Due to 6 V source only : (Open circuit 2 A current source)

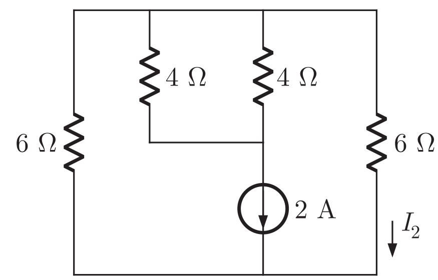




$$I_1 = \frac{6}{6+6} = 0.5 \text{ A}$$

Due to 2 A source only : (Short circuit 6 V source)





$$I_2 = \frac{6}{6+6}(-2) \quad \text{(using current division)}$$

$$= -1 \text{ A}$$

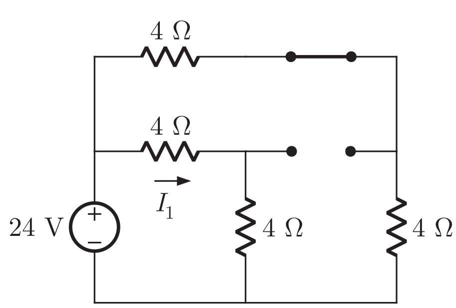
$$I = I_1 + I_2 = 0.5 - 1 = -0.5 \text{ A}$$

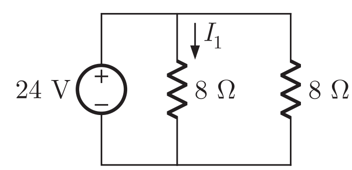
Alternate Method: This problem may be solved by using a single KVL equation around the outer loop.

SOL 5.1.14 Option (A) is correct.

Applying superposition,

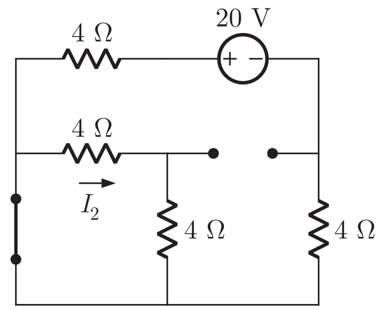
Due to 24 V source only : (Open circuit 2 A and short circuit 20 V source)





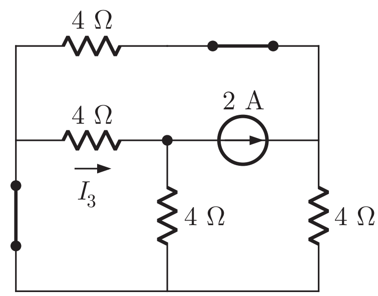
$$I_1 = \frac{24}{8} = 3 \text{ A}$$

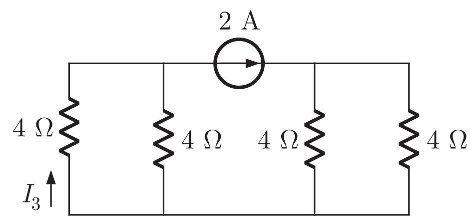
Due to 20 V source only : (Short circuit 24 V and open circuit 2 A source)



So $I_2 = 0$ (Due to short circuit)

Due to 2 A source only : (Short circuit 24 V and 20 V sources)





$$I_3 = \frac{4}{4+4}(2) \quad \text{(using current division)}$$

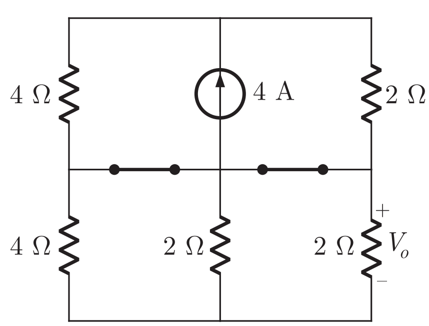
$$= 1\ \text{A}$$

So $I = I_1 + I_2 + I_3 = 3 + 0 + 1 = 4\ \text{A}$

Alternate Method: We can see that current in the middle $4\,\Omega$ resistor is $I - 2$, therefore I can be obtained by applying KVL in the bottom left mesh.

SOL 5.1.15 Option (D) is correct.

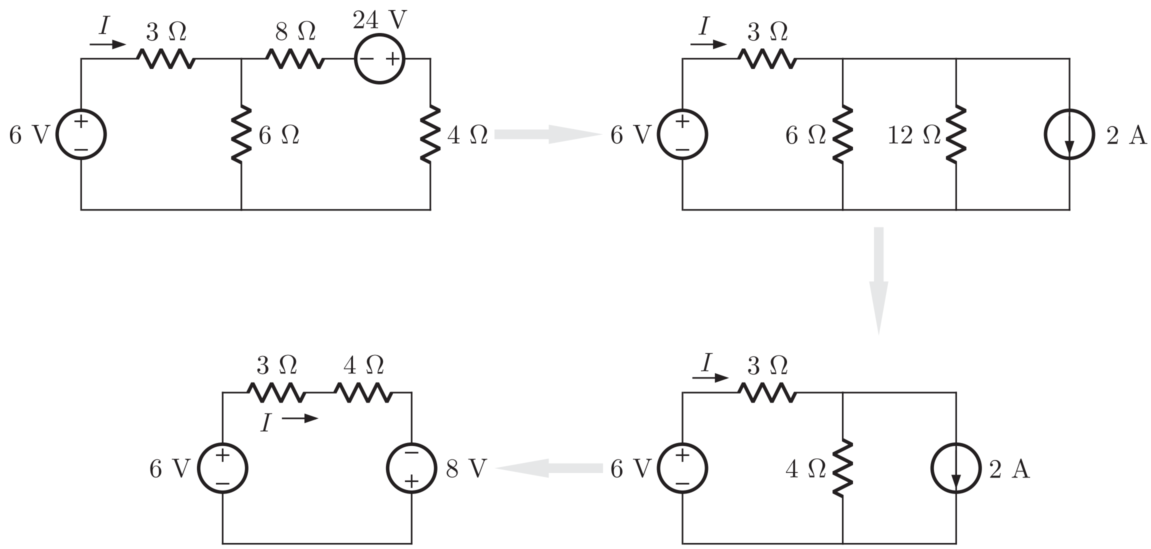
$V_1 = V_2 = 0$ (short circuit both sources)



$$V_o = 0$$

SOL 5.1.16 Option (C) is correct.

Using source transformation, we can obtain I in following steps.

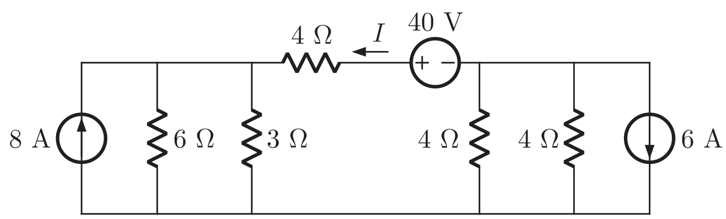


$$I = \frac{6+8}{3+4} = \frac{14}{7} = 2\text{ A}$$

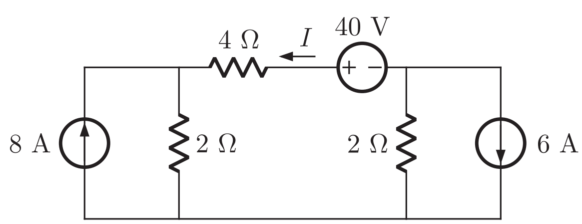
Alternate Method: Try to solve the problem by obtaining Thevenin equivalent for right half of the circuit.

SOL 5.1.17 Option (C) is correct.

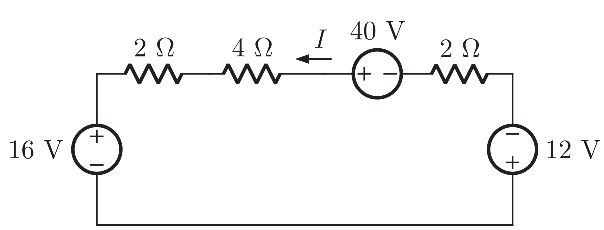
Using source transformation of 48 V source and the 24 V source



using parallel resistances combination



Source transformation of 8 A and 6 A sources

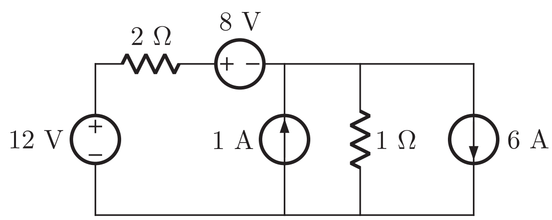


Writing KVL around anticlock wise direction

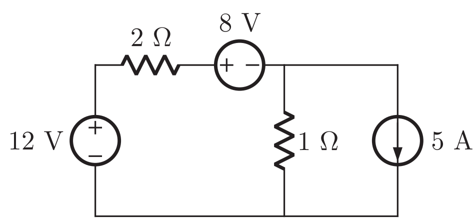
$$-12 - 2I + 40 - 4I - 2I - 16 = 0$$
$$12 - 8I = 0$$
$$I = \frac{12}{8} = 1.5\text{ A}$$

SOL 5.1.18 Option (D) is correct.

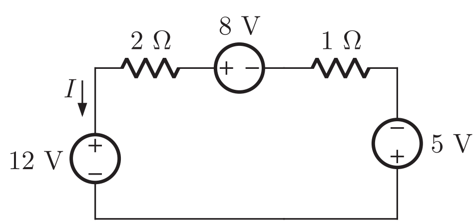
Using source transformation of 4 A and 6 V source.



Adding parallel current sources



Source transformation of 5 A source



Applying KVL around the anticlock wise direction

$$-5 - I + 8 - 2I - 12 = 0$$
$$-9 - 3I = 0$$
$$I = -3\text{ A}$$

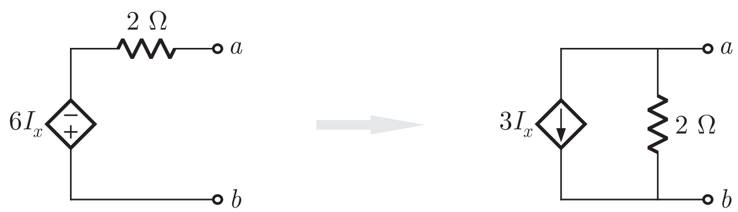
Power absorbed by 12 V source

$$P_{12\text{ V}} = 12 \times I \qquad \text{(Passive sign convention)}$$
$$= 12 \times -3$$
$$= -36\text{ W}$$

or, 12 V source supplies 36 W power.

SOL 5.1.19 Option (B) is correct.

We know that source transformation also exists for dependent source, so



Current source values

$$I_s = \frac{6I_x}{2} = 3I_x \text{ (downward)}$$

$$R_s = 2\,\Omega$$

SOL 5.1.20 Option (C) is correct.

We know that source transformation is applicable to dependent source also.

Values of equivalent voltage source

$$V_s = (4I_x)(5) = 20I_x$$

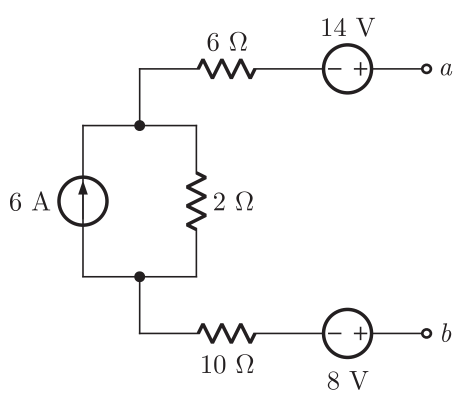
$$R_s = 5\,\Omega$$

SOL 5.1.21 Option (C) is correct.

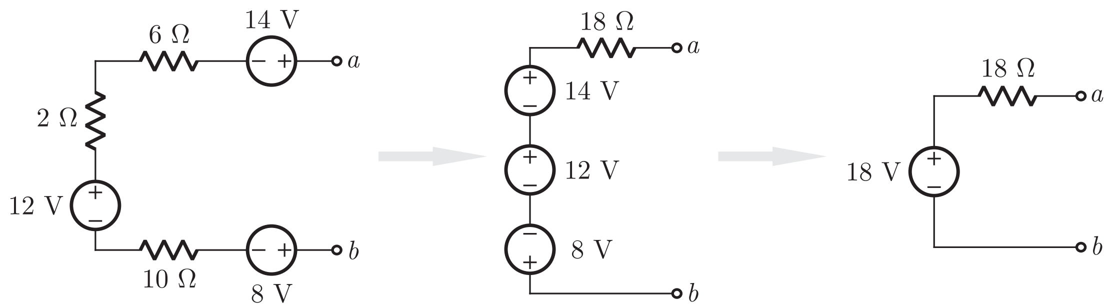
Combining the parallel resistance and adding the parallel connected current sources.

$$9\text{ A} - 3\text{ A} = 6\text{ A (upward)}$$

$$3\,\Omega\,||\,6\,\Omega = 2\,\Omega$$



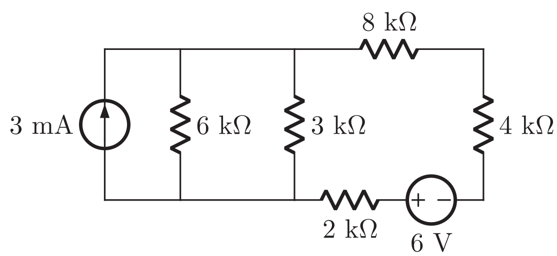
Source transformation of 6 A source



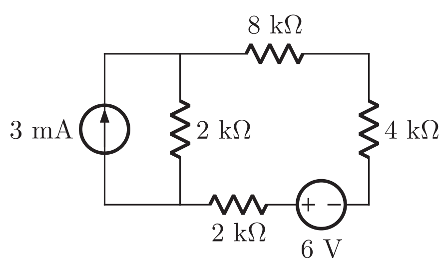
SOL 5.1.22 Option (B) is correct.

We apply source transformation as follows.

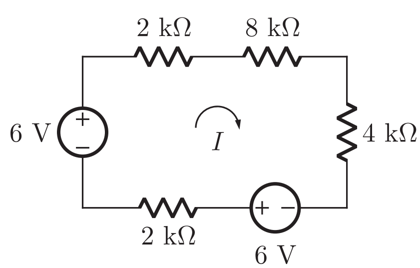
Transforming $3\,\text{mA}$ source into equivalent voltage source and $18\,\text{V}$ source into equivalent current source.



$6\,\text{k}\Omega$ and $3\,\text{k}\Omega$ resistors are in parallel and equivalent to $2\,\Omega$.



Again transforming $3\,\text{mA}$ source



$$I = \frac{6+6}{2+8+4+2} = \frac{3}{4}\,\text{mA}$$

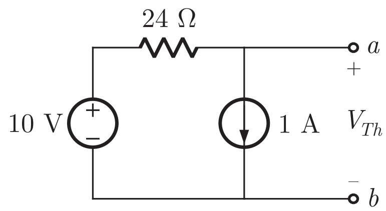
$$P_{4\,\text{k}\Omega} = I^2(4\times 10^3)$$

$$= \left(\frac{3}{4}\right)^2 \times 4 = 2.25\,\text{mW}$$

SOL 5.1.23 Option (D) is correct.

Thevenin voltage : (Open circuit voltage)

The open circuit voltage between a-b can be obtained as



Writing KCL at node a

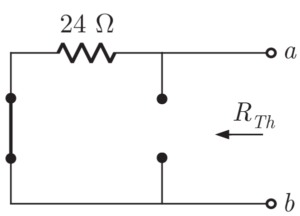
$$\frac{V_{Th} - 10}{24} + 1 = 0$$

$$V_{Th} - 10 + 24 = 0$$

$$V_{Th} = -14\text{ volt}$$

Thevenin Resistance :

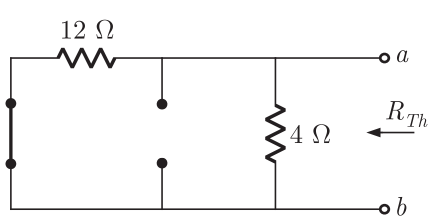
To obtain Thevenin's resistance, we set all independent sources to zero i.e., short circuit all the voltage sources and open circuit all the current sources.



$$R_{Th} = 24\,\Omega$$

SOL 5.1.24 Option (A) is correct.

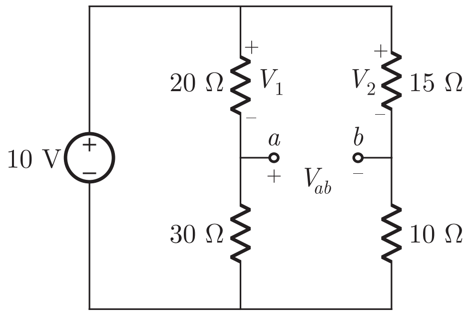
Set all independent sources to zero (i.e. open circuit current sources and short circuit voltage sources) to obtain R_{Th}



$$R_{Th} = 12\,\Omega\,||\,4\,\Omega = 3\,\Omega$$

SOL 5.1.25 Option (B) is correct.

Thevenin voltage :



Using voltage division

$$V_1 = \frac{20}{20+30}(10) = 4 \text{ volt}$$

and, $$V_2 = \frac{15}{15+10}(10) = 6 \text{ volt}$$

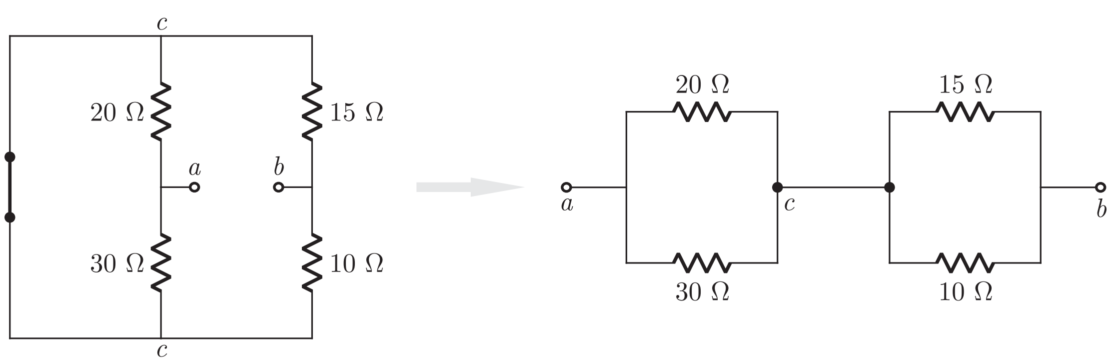
Applying KVL

$$V_1 - V_2 + V_{ab} = 0$$

$$4 - 6 + V_{ab} = 0$$

$$V_{Th} = V_{ab} = -2 \text{ volt}$$

Thevenin Resistance :



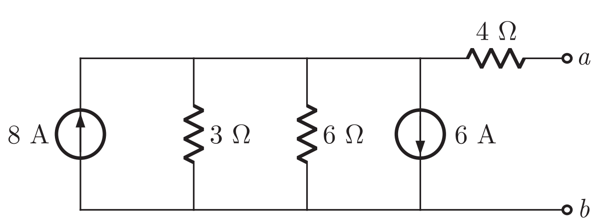
$$R_{ab} = [20\,\Omega\,||\,30\,\Omega] + [15\,\Omega\,||\,10\,\Omega]$$

$$= 12\,\Omega + 6\,\Omega = 18\,\Omega$$

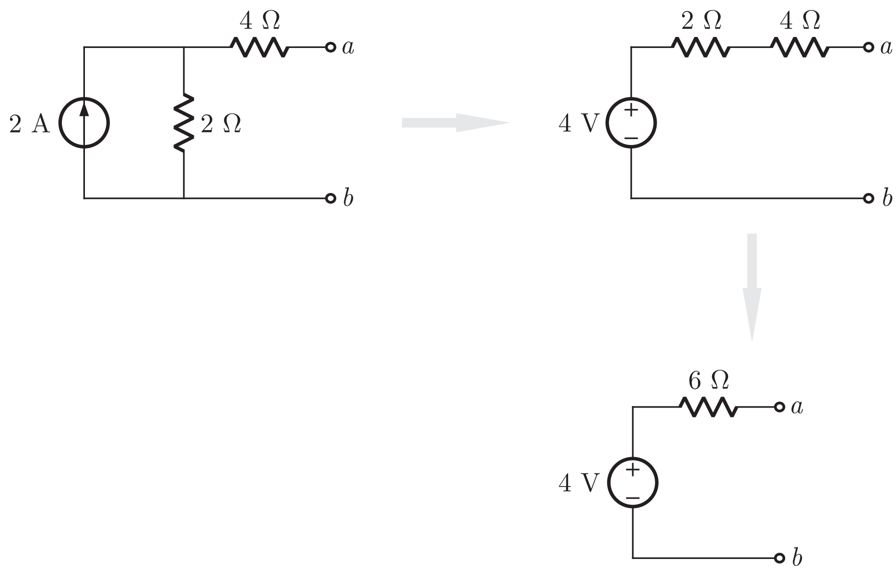
$$R_{Th} = R_{ab} = 18\,\Omega$$

SOL 5.1.26 Option (A) is a correct.

Using source transformation of 24 V source



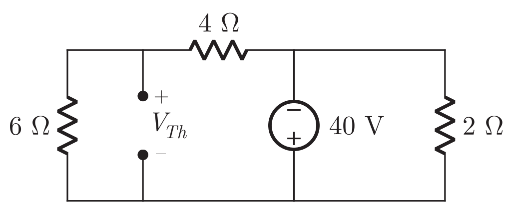
Adding parallel connected sources



So, $V_{Th} = 4\,\text{V},\ R_{Th} = 6\,\Omega$

SOL 5.1.27 Option (A) is correct.

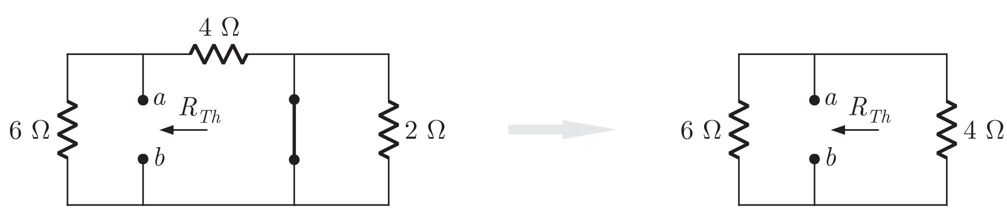
Thevenin voltage: (Open circuit voltage)



$$V_{Th} = \frac{6}{6+4}(-40) \qquad \text{(using voltage division)}$$

$$= -24 \text{ volt}$$

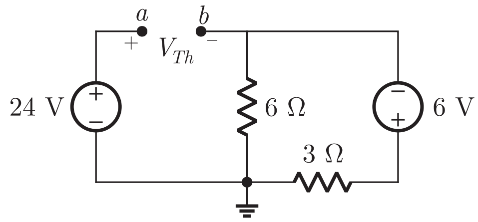
Thevenin resistance :



$$R_{Th} = 6\,\Omega\,||\,4\,\Omega = \frac{6\times 4}{6+4} = 2.4\,\Omega$$

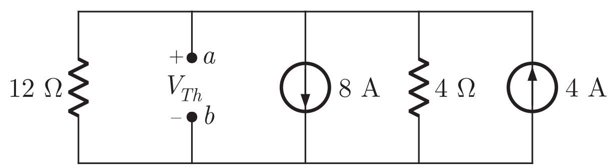
SOL 5.1.28 Option (B) is correct.

For the circuit of figure (A)



$$V_{Th} = V_a - V_b$$
$$V_a = 24 \text{ V}$$
$$V_b = \frac{6}{6+3}(-6) = -4 \text{ V} \qquad \text{(Voltage division)}$$
$$V_{Th} = 24 - (-4) = 28 \text{ V}$$

For the circuit of figure (B), using source transformation

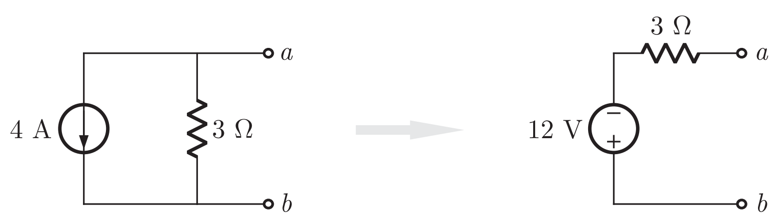


Combining parallel resistances,

$$12\,\Omega\,||\,4\,\Omega = 3\,\Omega$$

Adding parallel current sources,

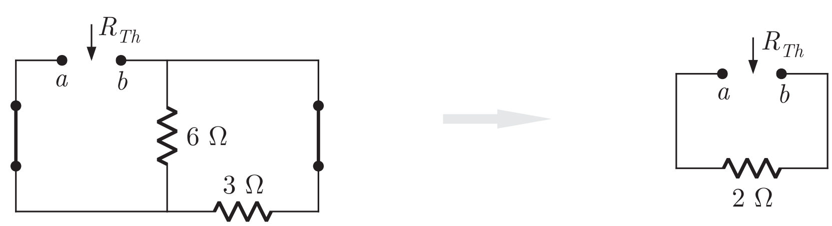
$$8 - 4 = 4 \text{ A (downward)}$$



$$V_{Th} = -12 \text{ V}$$

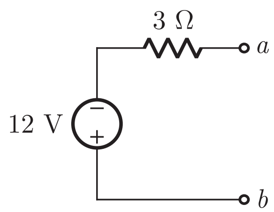
SOL 5.1.29 Option (C) is correct.

For the circuit for fig (A)



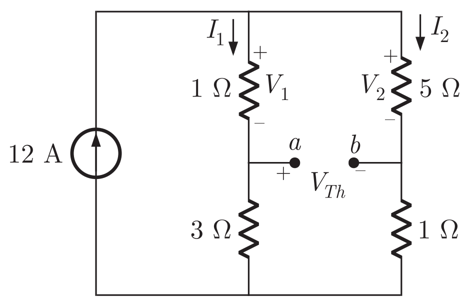
$$R_{Th} = R_{ab} = 6\,\Omega\,||\,3\,\Omega = 2\,\Omega$$

For the circuit of fig (B), as obtained in previous solution.



$$R_{Th} = 3\,\Omega$$

SOL 5.1.30 Option (C) is correct.



Using current division

$$I_1 = \frac{(5+1)}{(5+1)+(3+1)}(12) = \frac{6}{6+4}(12)$$

$$= 7.2\text{ A}$$

$$V_1 = I_1 \times 1 = 7.2\text{ V}$$

$$I_2 = \frac{(3+1)}{(3+1)+(5+1)}(12) = 4.8\text{ A}$$

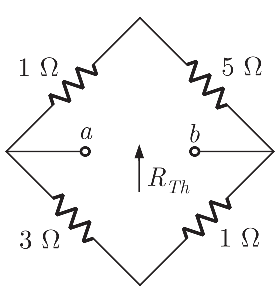
$$V_2 = 5I_2 = 5 \times 4.8 = 24\text{ V}$$

$$V_{Th} + V_1 - V_2 = 0 \qquad \text{(KVL)}$$

$$V_{Th} = V_2 - V_1 = 24 - 7.2 = 16.8\text{ V}$$

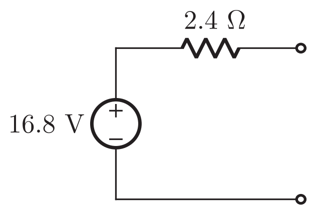
SOL 5.1.31 Option (B) is correct.

We obtain Thevenin's resistance across a-b and then use source transformation of Thevenin's circuit to obtain equivalent Norton circuit.

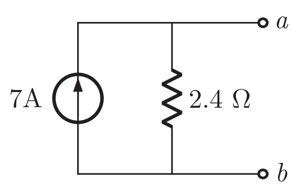


$$R_{Th} = (5+1)\,||\,(3+1) = 6\,||\,4 = 2.4\,\Omega$$

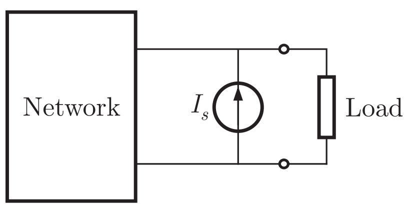
Thevenin's equivalent is



Norton equivalent



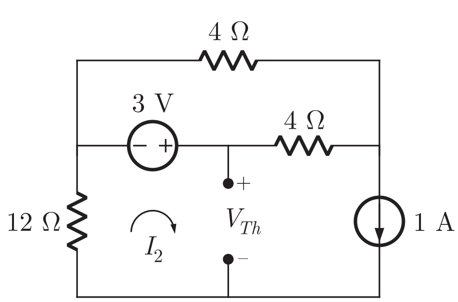
SOL 5.1.32 Option (B) is correct.



The current source connected in parallel with load does not affect Thevenin equivalent circuit. Thus, Thevenin equivalent circuit will contain its usual form of a voltage source in series with a resistor.

SOL 5.1.33 Option (C) is correct.
The network consists of resistor and dependent sources because if it has independent source then there will be an open circuit Thevenin voltage present.

SOL 5.1.34 Option (D) is correct.
Current I can be easily calculated by Thevenin's equivalent across $6\,\Omega$.
Thevenin voltage : (Open circuit voltage)



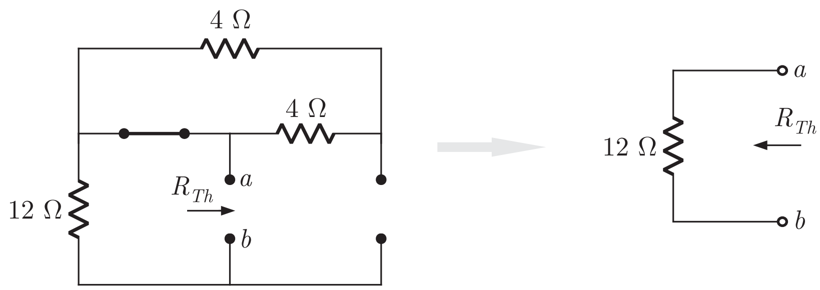
In the bottom mesh

$$I_2 = 1\,\text{A}$$

In the bottom left mesh

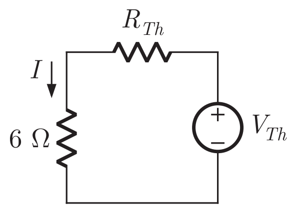
$$-V_{Th} - 12I_2 + 3 = 0$$
$$V_{Th} = 3 - (12)(1) = -9\text{ V}$$

Thevenin Resistance :



$$R_{Th} = 12\,\Omega \qquad \text{(both } 4\,\Omega \text{ resistors are short circuit)}$$

so, circuit becomes as

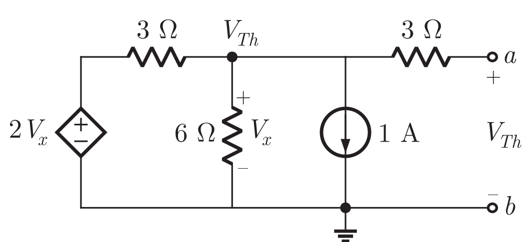


$$I = \frac{V_{Th}}{R_{Th}+6} = \frac{-9}{12+6} = -\frac{9}{18} = -0.5\text{ A}$$

Note: The problem can be solved easily by a single node equation. Take the nodes connecting the top $4\,\Omega$, 3 V and $4\,\Omega$ as supernode and apply KCL.

SOL 5.1.35 Option (D) is correct.

Thevenin voltage (Open circuit voltage) :



Applying KCL at top middle node

$$\frac{V_{Th} - 2V_x}{3} + \frac{V_{Th}}{6} + 1 = 0$$

$$\frac{V_{Th} - 2V_{Th}}{3} + \frac{V_{Th}}{6} + 1 = 0 \qquad (V_{Th} = V_x)$$

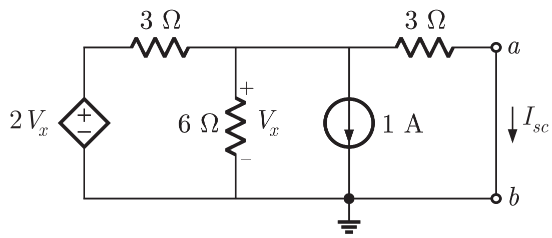
$$-2V_{Th} + V_{Th} + 6 = 0$$

$$V_{Th} = 6\text{ volt}$$

Thevenin Resistance :

$$R_{Th} = \frac{\text{Open circuit voltage}}{\text{Short circuit current}} = \frac{V_{Th}}{I_{sc}}$$

To obtain Thevenin resistance, first we find short circuit current through a-b



Writing KCL at top middle node

$$\frac{V_x - 2V_x}{3} + \frac{V_x}{6} + 1 + \frac{V_x - 0}{3} = 0$$

$$-2V_x + V_x + 6 + 2V_x = 0$$

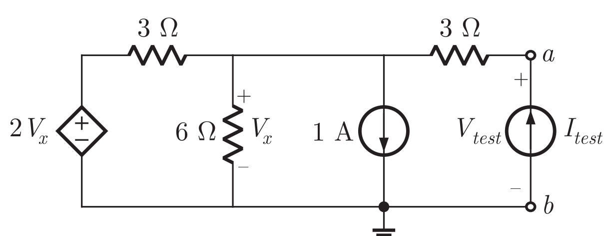
$$V_x = -6 \text{ volt}$$

$$I_{sc} = \frac{V_x - 0}{3} = -\frac{6}{3} = -2 \text{ A}$$

Thevenin's resistance, $R_{Th} = \frac{V_{Th}}{I_{sc}} = -\frac{6}{2} = -3\,\Omega$

Direct Method :

Since dependent source is present in the circuit, we put a test source across a-b to obtain Thevenin's equivalent.



By applying KCL at top middle node

$$\frac{V_x - 2V_x}{3} + \frac{V_x}{6} + 1 + \frac{V_x - V_{test}}{3} = 0$$

$$-2V_x + V_x + 6 + 2V_x - 2V_{test} = 0$$

$$2V_{test} - V_x = 6 \qquad \text{...(i)}$$

We have $I_{test} = \frac{V_{test} - V_x}{3}$

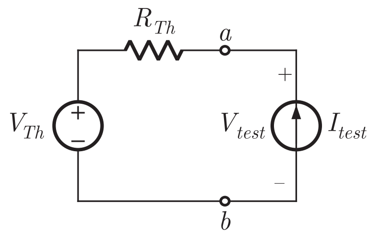
$$3I_{test} = V_{test} - V_x$$

$$V_x = V_{test} - 3I_{test}$$

Put V_x into equation (i)

$$2V_{test} - (V_{test} - 3I_{test}) = 6$$
$$2V_{test} - V_{test} + 3I_{test} = 6$$
$$V_{test} = 6 - 3I_{test} \quad ...(ii)$$

For Thevenin's equivalent circuit



$$\frac{V_{test} - V_{Th}}{R_{Th}} = I_{test}$$
$$V_{test} = V_{Th} + R_{Th} I_{test} \quad ...(iii)$$

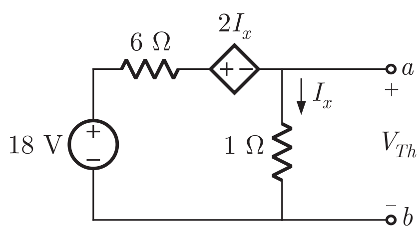
Comparing equation (ii) and (iii)

$$V_{Th} = 6\text{ V},\ R_{Th} = -3\,\Omega$$

SOL 5.1.36 Option (C) is correct.

We obtain Thevenin's equivalent across R.

Thevenin voltage : (Open circuit voltage)



Applying KVL

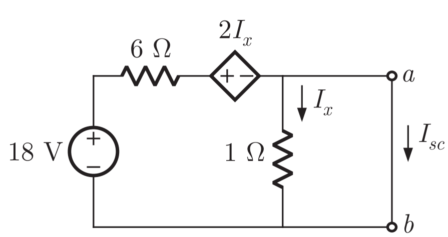
$18 - 6I_x - 2I_x - (1)I_x = 0$

$$I_x = \frac{18}{9} = 2\text{ A}$$
$$V_{Th} = (1)I_x = (1)(2) = 2\text{ V}$$

Thevenin Resistance :

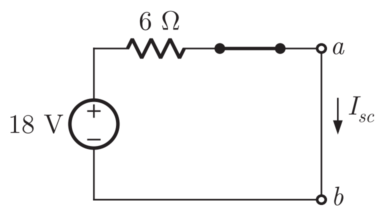
$$R_{Th} = \frac{V_{Th}}{I_{sc}}$$

$I_{sc} \rightarrow$ Short circuit current



$$I_x = 0 \qquad \text{(Due to short circuit)}$$

So dependent source also becomes zero.

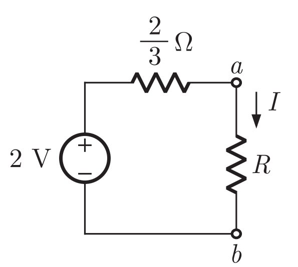


$$I_{sc} = \frac{18}{6} = 3\text{ A}$$

Thevenin resistance,

$$R_{Th} = \frac{V_{Th}}{I_{sc}} = \frac{2}{3}\,\Omega$$

Now, the circuit becomes as

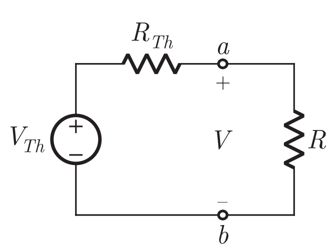


$$I = \frac{2}{\frac{2}{3} + R} = 3$$

$$2 = 2 + 3R$$

$$R = 0$$

SOL 5.1.37 Option (D) is correct.



Using voltage division

$$V = V_{Th}\left(\frac{R}{R + R_{Th}}\right)$$

From the table,

$$6 = V_{Th}\left(\frac{3}{3 + R_{Th}}\right) \qquad \text{...(i)}$$

$$8 = V_{Th}\left(\frac{8}{8 + R_{Th}}\right) \qquad \text{...(ii)}$$

Dividing equation (i) and (ii), we get

$$\frac{6}{8} = \frac{3(8+R_{Th})}{8(3+R_{Th})}$$

$$6+2R_{Th} = 8+R_{Th}$$

$$R_{Th} = 2\,\Omega$$

Substituting R_{Th} into equation (i)

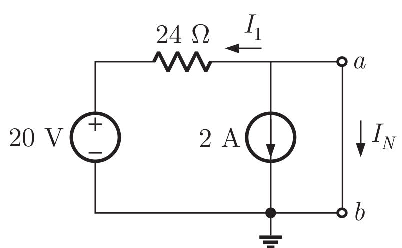
$$6 = V_{Th}\left(\frac{3}{3+2}\right)$$

$$V_{Th} = 10\text{ V}$$

SOL 5.1.38 Option (C) is correct.

Norton current : (Short circuit current)

The Norton equivalent current is equal to the short-circuit current that would flow when the load replaced by a short circuit as shown below



Applying KCL at node a

$$I_N + I_1 + 2 = 0$$

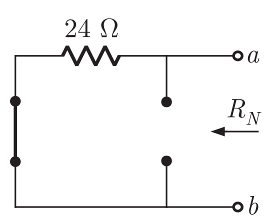
$\because$ $$I_1 = \frac{0-20}{24} = -\frac{5}{6}\text{ A}$$

So, $$I_N - \frac{5}{6} + 2 = 0$$

$$I_N = -\frac{7}{6}\text{ A}$$

Norton resistance :

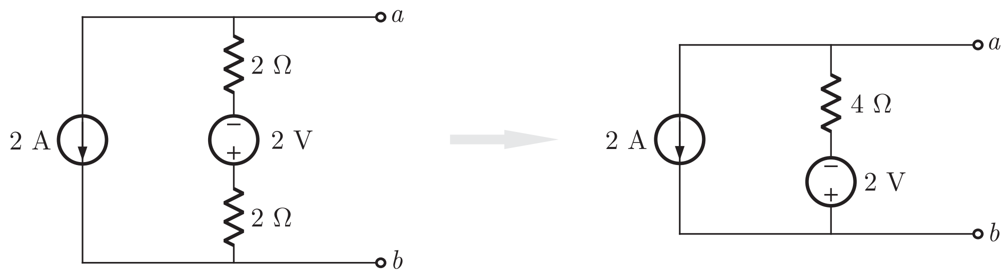
Set all independent sources to zero (i.e. open circuit current sources and short circuit voltage sources) to obtain Norton's equivalent resistance R_N.



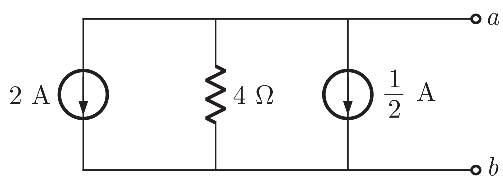
$$R_N = 24\,\Omega$$

SOL 5.1.39 Option (C) is correct.

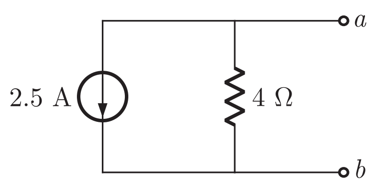
Using source transformation of 1 A source



Again, source transformation of 2 V source

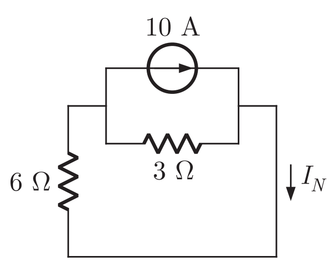


Adding parallel current sources

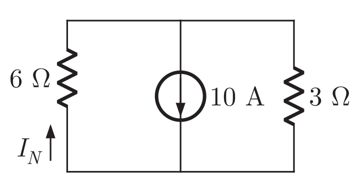


Alternate Method: Try to solve the problem using superposition method.

SOL 5.1.40 Option (C) is correct.
Short circuit current across terminal *a*-*b* is

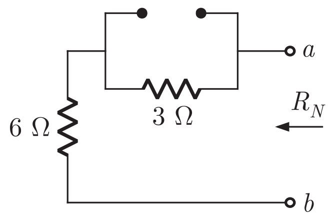


For simplicity circuit can be redrawn as



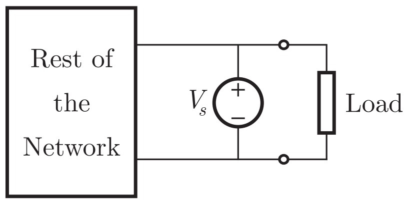
$$I_N = \frac{3}{3+6}(10) \qquad \text{(Current division)}$$
$$= 3.33 \text{ A}$$

Norton's equivalent resistance



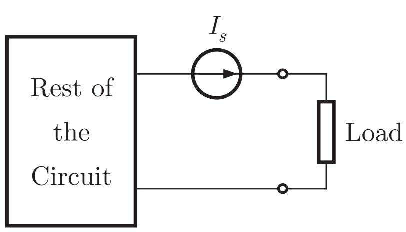
$$R_N = 6 + 3 = 9\,\Omega$$

SOL 5.1.41 Option (C) is correct.



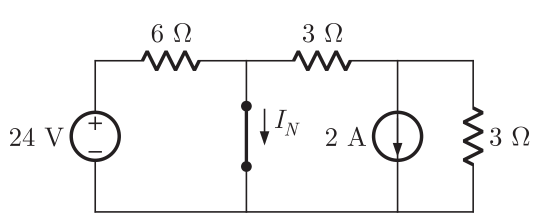
The voltage across load terminal is simply V_s and it is independent of any other current or voltage. So, Thevenin equivalent is $V_{Th} = V_s$ and $R_{Th} = 0$ (Voltage source is ideal).
The Norton equivalent does not exist because of parallel connected voltage source.

SOL 5.1.42 Option (B) is correct.

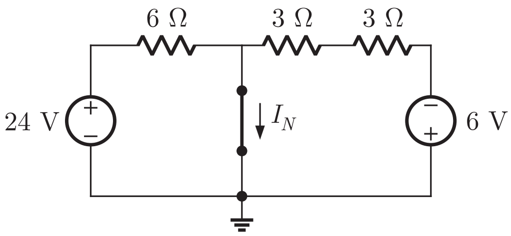


The output current from the network is equal to the series connected current source only, so $I_N = I_s$. Thus, effect of all other component in the network does not change I_N.
In this case Thevenin's equivalent is not feasible because of the series connected current source.

SOL 5.1.43 Option (C) is correct.
Norton current : (Short circuit current)



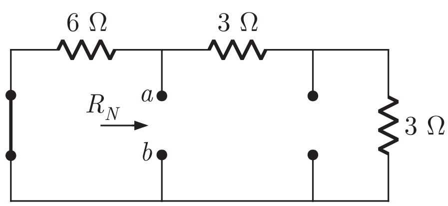
Using source transformation

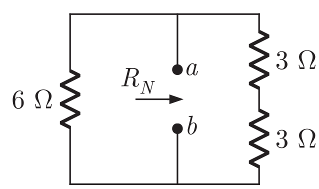


Nodal equation at top center node

$$\frac{0-24}{6}+\frac{0-(-6)}{3+3}+I_N=0$$
$$-4+1+I_N=0$$
$$I_N=3\text{ A}$$

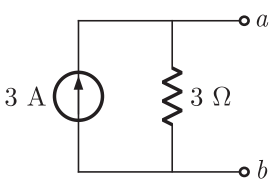
Norton Resistance :





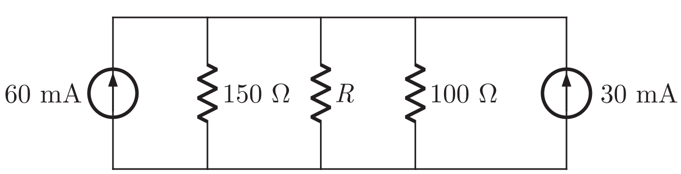
$$R_N=R_{ab}=6\,||\,(3+3)=6\,||\,6=3\,\Omega$$

So, Norton equivalent will be

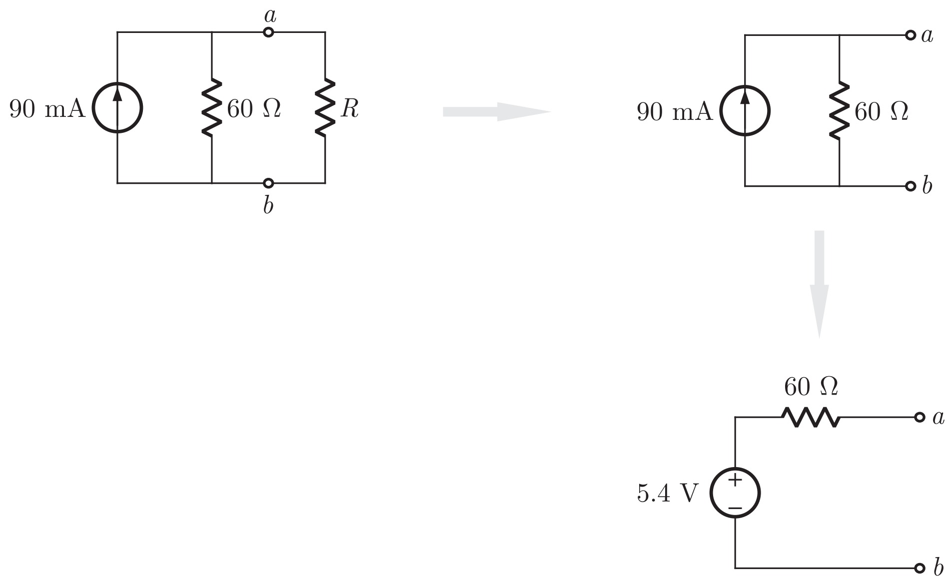


SOL 5.1.44 Option (C) is correct.

We obtain Thevenin's equivalent across R. By source transformation of both voltage sources



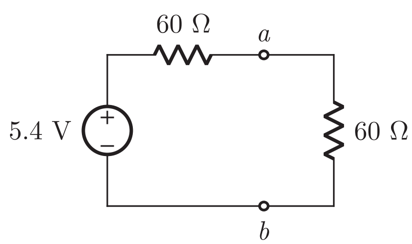
Adding parallel sources and combining parallel resistances



Here, $V_{Th} = 5.4\,\text{V}, \quad R_{Th} = 60\,\Omega$

For maximum power transfer

$$R = R_{Th} = 60\,\Omega$$

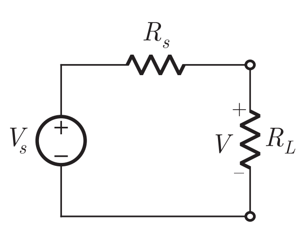


Maximum Power absorbed by R

$$P = \frac{(V_{Th})^2}{4R} = \frac{(5.4)^2}{4 \times 60} = 121.5\,\text{mW}$$

Alternate Method: Thevenin voltage (open circuit voltage) may be obtained using node voltage method also.

SOL 5.1.45 Option (B) is correct.



$$V = V_s\left(\frac{R_L}{R_s + R_L}\right)$$

Power absorbed by R_L

$$P_L = \frac{(V)^2}{R_L} = \frac{V_s^2 R_L}{(R_s + R_L)^2}$$

From above expression, it is known that power is maximum when $R_s = 0$

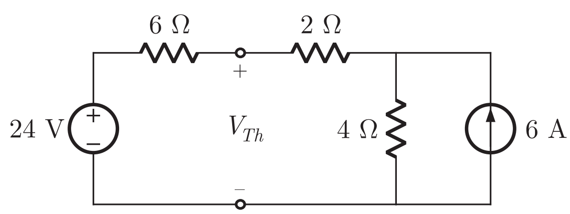
Note :

Do not get confused with maximum power transfer theorem. According to maximum power transfer theorem if R_L is variable and R_s is fixed then power dissipated by R_L is maximum when $R_L = R_s$.

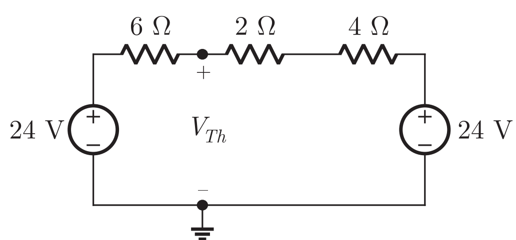
SOL 5.1.46 Option (C) is correct.

We solve this problem using maximum power transfer theorem. First, obtain Thevenin equivalent across R_L.

Thevenin Voltage : (Open circuit voltage)



Using source transformation

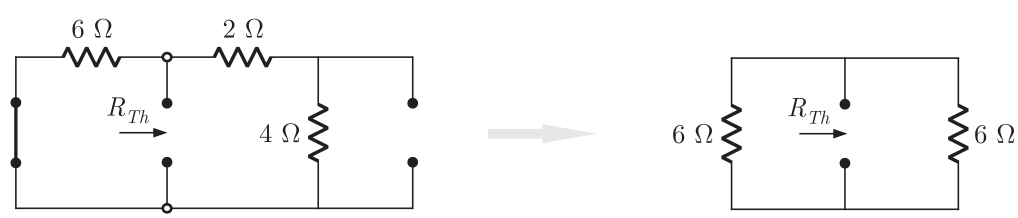


Using nodal analysis

$$\frac{V_{Th} - 24}{6} + \frac{V_{Th} - 24}{2 + 4} = 0$$

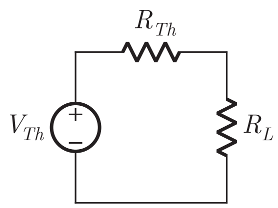
$$2V_{Th} - 48 = 0 \Rightarrow V_{Th} = 24 \text{ V}$$

Thevenin resistance :



$$R_{Th} = 6\,\Omega \,||\, 6\,\Omega = 3\,\Omega$$

Circuit becomes as



For maximum power transfer

$$R_L = R_{Th} = 3\,\Omega$$

Value of maximum power

$$P_{\max} = \frac{(V_{Th})^2}{4R_L} = \frac{(24)^2}{4 \times 3} = 48 \text{ W}$$

SOL 5.1.47 Option (D) is correct.

This can be solved by reciprocity theorem. But we have to take care that the polarity of voltage source have the same correspondence with branch current in each of the circuit.

In figure (B) and figure (C), polarity of voltage source is reversed with respect to direction of branch current so

$$\frac{V_1}{I_1} = -\frac{V_2}{I_2} = -\frac{V_3}{I_3}$$

$$I_2 = I_3 = -2 \text{ A}$$

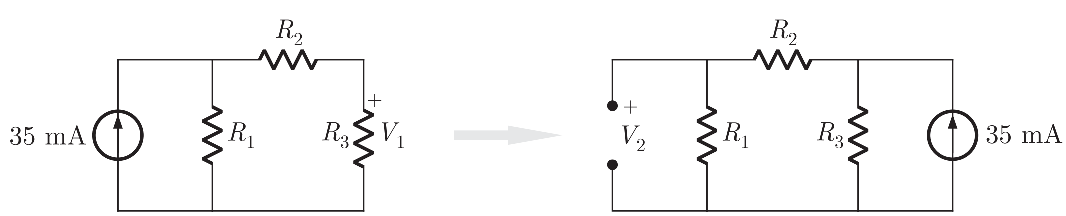
SOL 5.1.48 Option (C) is correct.

According to reciprocity theorem in any linear bilateral network when a single voltage source V_a in branch a produces a current I_b in branches b, then if the voltage source V_a is removed(i.e. branch a is short circuited) and inserted in branch b, then it will produce a current I_b in branch a.

So, $I_2 = I_1 = 20 \text{ mA}$

SOL 5.1.49 Option (A) is correct.

According to reciprocity theorem in any linear bilateral network when a single current source I_a in branch a produces a voltage V_b in branches b, then if the current source I_a is removed(i.e. branch a is open circuited) and inserted in branch b, then it will produce a voltage V_b in branch a.



So, $V_2 = 2 \text{ volt}$

SOL 5.1.50 Option (A) is correct.

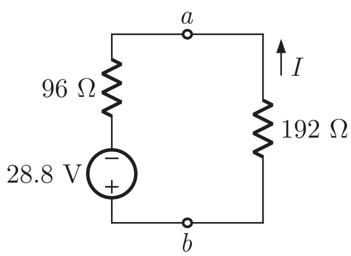
We use Millman's theorem to obtain equivalent resistance and voltage across a-b.

$$V_{ab} = \frac{-\frac{96}{240}+\frac{40}{200}+\frac{-80}{800}}{\frac{1}{240}+\frac{1}{200}+\frac{1}{800}} = -\frac{144}{5} = -28.8\text{ V}$$

The equivalent resistance

$$R_{ab} = \frac{1}{\frac{1}{240}+\frac{1}{200}+\frac{1}{800}} = 96\,\Omega$$

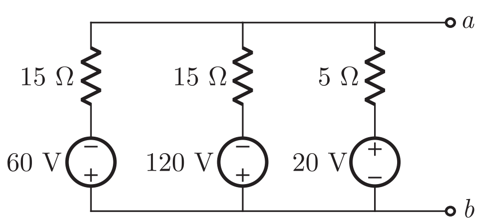
Now, the circuit is reduced as



$$I = \frac{28.8}{96+192} = 100\text{ mA}$$

SOL 5.1.51 Option (C) is correct.

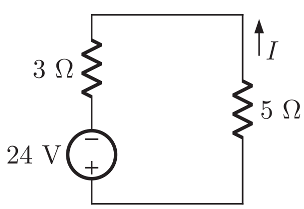
First we obtain equivalent voltage and resistance across terminal a-b using Millman's theorem.



$$V_{ab} = \frac{-\frac{60}{15}+\left(-\frac{120}{15}\right)+\frac{20}{5}}{\frac{1}{15}+\frac{1}{15}+\frac{1}{5}} = -24\text{ V}$$

$$R_{ab} = \frac{1}{\frac{1}{15}+\frac{1}{15}+\frac{1}{5}} = 3\,\Omega$$

So, the circuit is reduced as



$$I = \frac{24}{3+5} = 3\text{ A}$$

****

SOLUTIONS 5.2

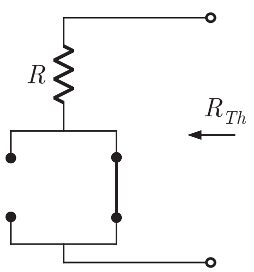
SOL 5.2.1 Option (B) is correct.

Thevenin Voltage: (Open circuit voltage):

The open circuit voltage will be equal to V, i.e. $V_{Th} = V$

Thevenin Resistance:

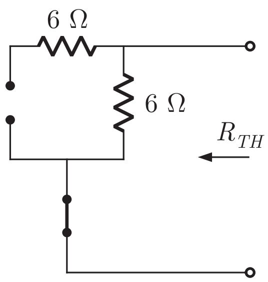
Set all independent sources to zero i.e. open circuit the current source and short circuit the voltage source as shown in figure



Open circuit voltage $= V_1$

SOL 5.2.2 Option (C) is correct.

Set all independent sources to zero as shown,

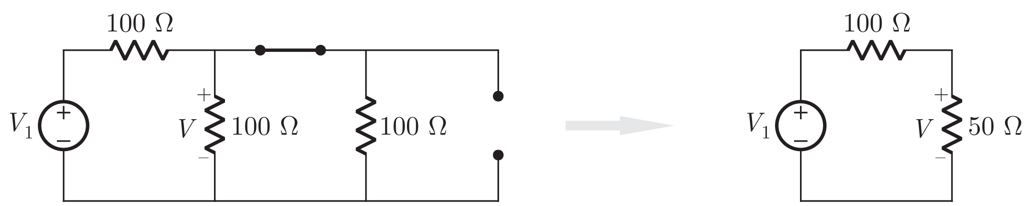


$R_{Th} = 6\,\Omega$

SOL 5.2.3 Option (B) is correct.

V is obtained using super position.

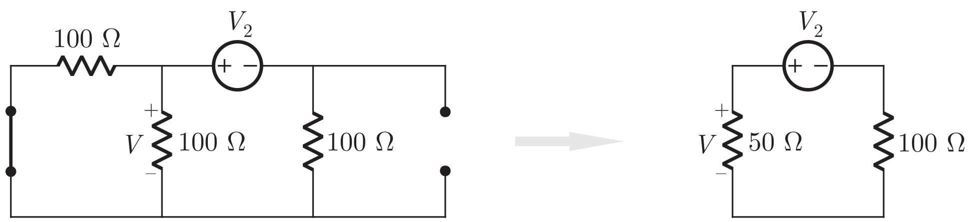
Due to source V_1 only : (Open circuit source I_3 and short circuit source V_2)



$$V = \frac{50}{100+50}(V_1) = \frac{1}{3}V_1 \qquad \text{(using voltage division)}$$

so, $A = \frac{1}{3}$

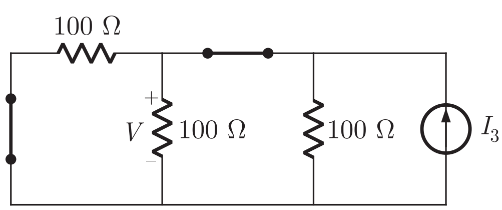
Due to source V_2 only : (Open circuit source I_3 and short circuit source V_1)



$$V = \frac{50}{100+50}(V_2) = \frac{1}{3}V_2 \qquad \text{(using voltage division)}$$

So, $B = \frac{1}{3}$

Due to source I_3 only : (short circuit sources V_1 and V_2)



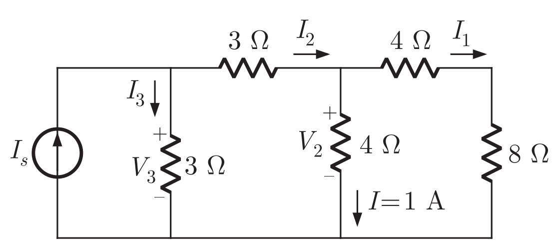
$$V = I_3[100\,||\,100\,||\,100] = I_3\left(\frac{100}{3}\right)$$

So, $C = \frac{100}{3}$

Alternate Method: Try to solve by nodal method, taking a supernode corresponding to voltage source V_2.

SOL 5.2.4 Option (D) is correct.

We solve this problem using linearity and taking assumption that $I = 1$ A.



In the circuit, $V_2 = 4I = 4$ V (Using Ohm's law)

$$I_2 = I + I_1 \qquad \text{(Using KCL)}$$

$$= 1 + \frac{V_2}{4+8} = 1 + \frac{4}{12} = \frac{4}{3}\text{ A}$$

$$V_3 = 3I_2 + V_2 \quad \text{(Using KVL)}$$
$$= 3 \times \frac{4}{3} + 4 = 8\text{ V}$$
$$I_s = I_3 + I_2 \quad \text{(Using KCL)}$$
$$= \frac{V_3}{3} + I_2 = \frac{8}{3} + \frac{4}{3} = 4\text{ A}$$

Applying superposition

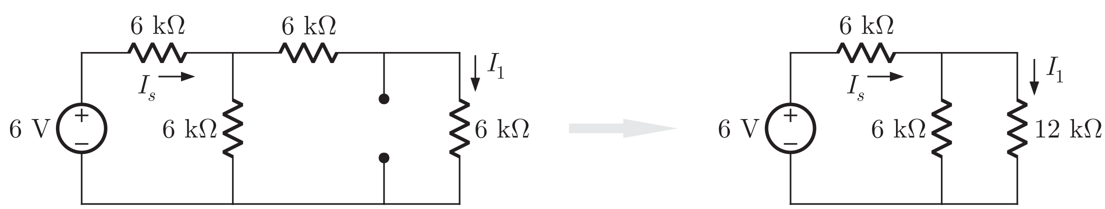
When $I_s = 4\text{ A}, \quad I = 1\text{ A}$

But actually $I_s = 2\text{ A}$, So $I = \frac{1}{4} \times 2 = 0.5\text{ A}$

SOL 5.2.5 Option (A) is correct.

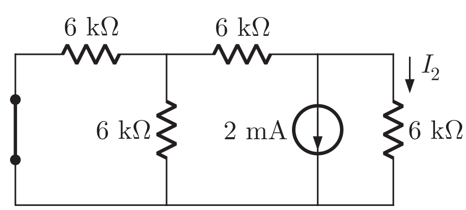
Solving with superposition,

Due to 6 V source only : (Open circuit 2 mA source)



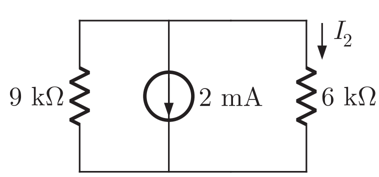
$$I_s = \frac{6}{6 + 6 \,||\, 12} = \frac{6}{6+4} = 0.6\text{ mA}$$
$$I_1 = \frac{6}{6+12}(I_s) = \frac{6}{18} \times 0.6 = 0.2\text{ mA} \quad \text{(Using current division)}$$

Due to 2 mA source only : (Short circuit 6 V source) :



Combining resistances,

$$6\text{ k}\Omega \,||\, 6\text{ k}\Omega = 3\text{ k}\Omega$$
$$3\text{ k}\Omega + 6\text{ k}\Omega = 9\text{ k}\Omega$$



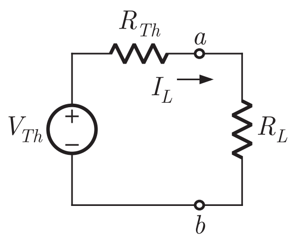
$$I_2 = \frac{9}{9+6}(-2) = -1.2\text{ mA} \quad \text{(Current division)}$$
$$I = I_1 + I_2 \quad \text{(Using superposition)}$$

$$= 0.2 - 1.2 = -1\,\text{mA}$$

Alternate Method: Try to solve the problem using source conversion.

SOL 5.2.6 Option (D) is correct.

We find Thevenin equivalent across a-b.



$$I_L = \frac{V_{Th}}{R_{Th} + R_L}$$

From the data given in table

$$10 = \frac{V_{Th}}{R_{Th} + 2} \qquad \text{...(i)}$$

$$6 = \frac{V_{Th}}{R_{Th} + 10} \qquad \text{...(ii)}$$

Dividing equation (i) and (ii), we get

$$\frac{10}{6} = \frac{R_{Th} + 10}{R_{Th} + 2}$$

$$10R_{Th} + 20 = 6R_{Th} + 60$$

$$4R_{Th} = 40 \Rightarrow R_{Th} = 10\,\Omega$$

Substituting R_{Th} into equation (i)

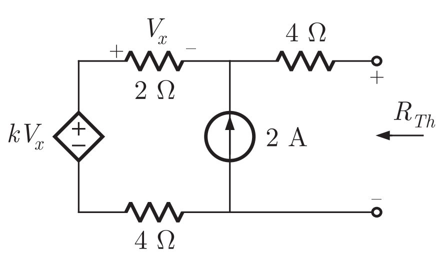
$$10 = \frac{V_{Th}}{10 + 2}$$

$$V_{Th} = 10(12) = 120\text{ V}$$

For $R_L = 20\,\Omega$,

$$I_L = \frac{V_{Th}}{R_{Th} + R_L} = \frac{120}{10 + 20} = 4\text{ A}$$

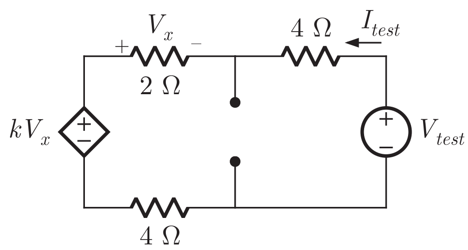
SOL 5.2.7 Option (A) is correct.



For maximum power transfer

$$R_{Th} = R_L = 2\,\Omega$$

To obtain R_{Th} set all independent sources to zero and put a test source across the load terminals.



$$R_{Th} = \frac{V_{test}}{I_{test}}$$

Using KVL,

$$V_{test} - 4I_{test} - 2I_{test} - kV_x - 4I_{test} = 0$$

$$V_{test} - 10I_{test} - k(-2I_{test}) = 0 \qquad (V_x = -2I_{test})$$

$$V_{test} = (10 - 2k)\,I_{test}$$

$$R_{Th} = \frac{V_{test}}{I_{test}} = 10 - 2k = 2$$

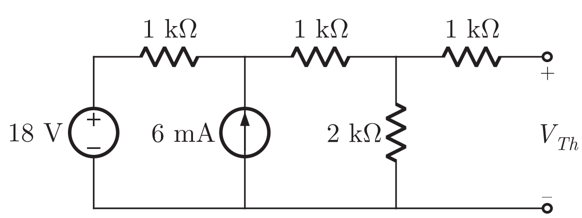
$$8 = 2k$$

$$k = 4$$

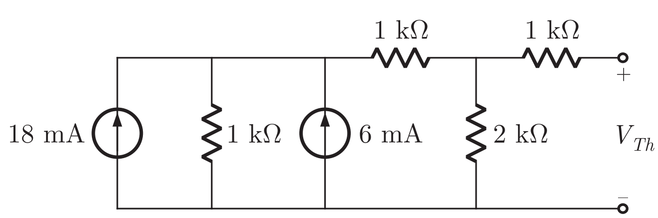
SOL 5.2.8 Option (D) is correct.

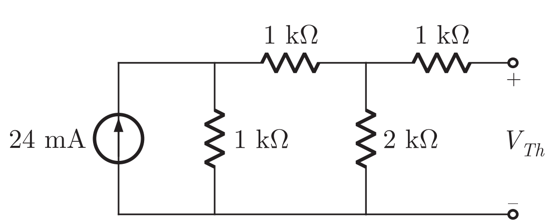
To calculate maximum power transfer, first we will find Thevenin equivalent across load terminals.

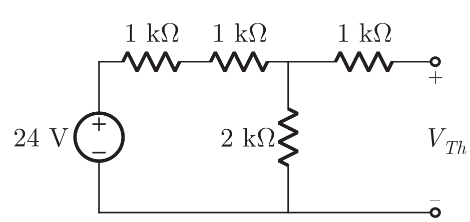
Thevenin voltage: (Open circuit voltage)



using source transformation

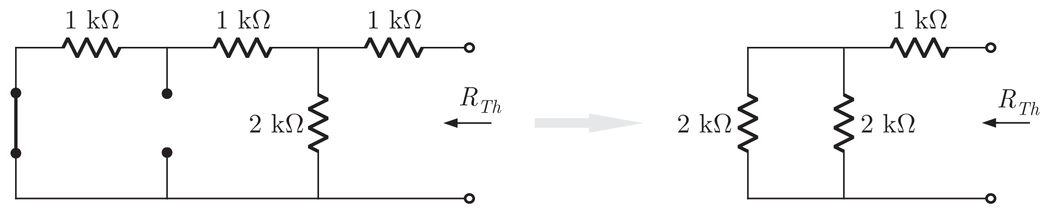






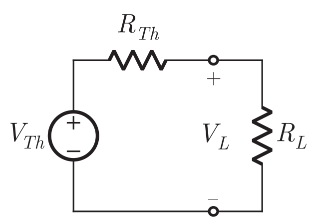
$$V_{Th} = \frac{2}{2+2}(24) \qquad \text{(using voltage division)}$$
$$= 12\text{ V}$$

Thevenin resistance :



$$R_{Th} = 1 + 2\,||\,2 = 1 + 1 = 2\text{ k}\Omega$$

circuit becomes as



$$V_L = \frac{R_L}{R_{Th} + R_L} V_{Th}$$

For maximum power transfer $R_L = R_{Th}$

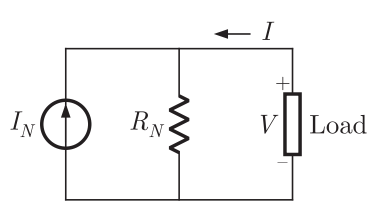
$$V_L = \frac{V_{Th}}{2R_{Th}} \times R_{Th} = \frac{V_{Th}}{2}$$

So maximum power absorbed by R_L

$$P_{\max} = \frac{V_L^2}{R_L} = \frac{V_{Th}^2}{4R_{Th}} = \frac{(12)^2}{4 \times 2} = 18\text{ mW}$$

SOL 5.2.9 Option (C) is correct.

The circuit with Norton equivalent



So,
$$I_N + I = \frac{V}{R_N}$$
$$I = \frac{V}{R_N} - I_N \qquad \text{(General form)}$$

From the given graph, the equation of line

$$I = 2V - 6$$

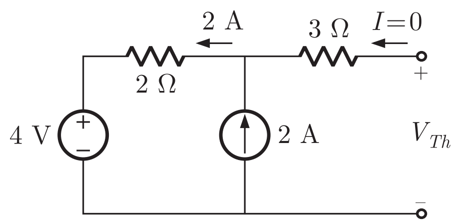
Comparing with general form

$$\frac{1}{R_N} = 2 \text{ or } R_N = 0.5\,\Omega$$

$$I_N = 6\text{ A}$$

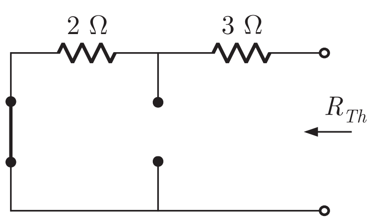
SOL 5.2.10 Option (D) is correct.

Thevenin voltage: (Open circuit voltage)



$$V_{Th} = 4 + (2 \times 2) = 4 + 4 = 8\text{ V}$$

Thevenin Resistance:



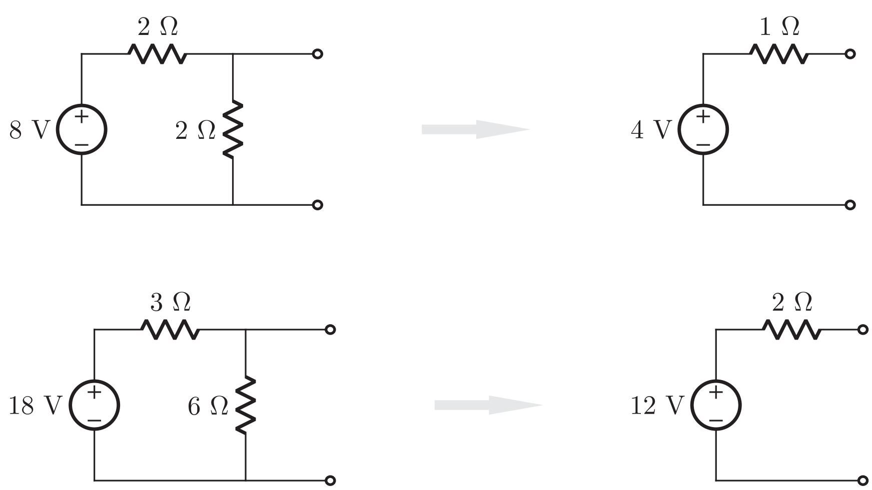
$$R_{Th} = 2 + 3 = 5\,\Omega = R_N$$

Norton current:

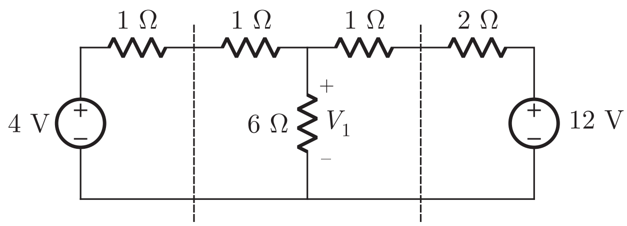
$$I_N = \frac{V_{Th}}{R_{Th}} = \frac{8}{5}\text{ A}$$

SOL 5.2.11 Option (A) is correct.

If we solve this circuit directly by nodal analysis, then we have to deal with three variables. We can replace the left most and write most circuit by their Thevenin equivalent as shown below.



Now the circuit becomes as shown



Writing node equation at the top center node

$$\frac{V_1 - 4}{1+1} + \frac{V_1}{6} + \frac{V_1 - 12}{1+2} = 0$$

$$\frac{V_1 + 4}{2} + \frac{V_1}{6} + \frac{V_1 - 12}{3} = 0$$

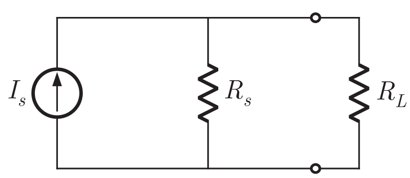
$$3V_1 - 12 + V_1 + 2V_1 - 24 = 0$$

$$6V_1 = 36$$

$$V_1 = 6 \text{ V}$$

SOL 5.2.12 Option (A) is correct.

The circuit is as shown below



When $R_L = 50\,\Omega$, power absorbed in load will be

$$\left(\frac{R_s}{R_s + 50} I_s\right)^2 50 = 20 \text{ kW} \qquad \text{...(i)}$$

When $R_L = 200\,\Omega$, power absorbed in load will be

$$\left(\frac{R_s}{R_s + 200} I_s\right)^2 200 = 20 \text{ kW} \qquad \text{...(ii)}$$

Dividing equation (i) and (ii), we have

$$(R_s + 200)^2 = 4(R_s + 50)^2$$

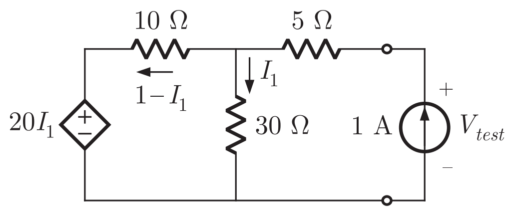
$$R_s = 100\,\Omega \text{ and } I_s = 30 \text{ A}$$

From maximum power transfer, the power supplied by source current I_s will be maximum when load resistance is equal to source resistance i.e. $R_L = R_s$. Maximum power is given as

$$P_{\max} = \frac{I_s^2 R_s}{4} = \frac{(30)^2 \times 100}{4} = 22.5 \text{ kW}$$

SOL 5.2.13 Option (C) is correct.

Norton current, $I_N = 0$ because there is no independent source present in the circuit. To obtain Norton resistance we put a 1 A test source across the load terminal as shown in figure.



Norton or Thevenin resistance

$$R_N = \frac{V_{test}}{1}$$

Writing KVL in the left mesh

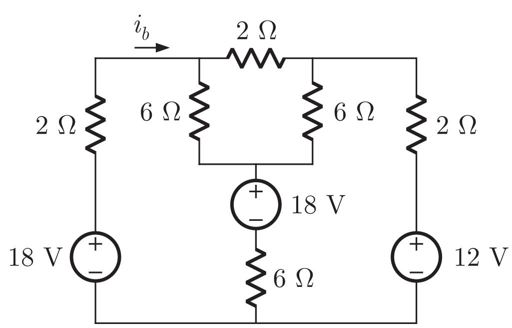
$$20I_1 + 10(1 - I_1) - 30I_1 = 0$$
$$20I_1 - 10I_1 - 30I_1 + 10 = 0$$
$$I_1 = 0.5\text{ A}$$

Writing KVL in the right mesh

$$V_{test} - 5(1) - 30I_1 = 0$$
$$V_{test} - 5 - 30(0.5) = 0$$
$$V_{test} - 5 - 15 = 0$$
$$R_N = \frac{V_{test}}{1} = 20\,\Omega$$

SOL 5.2.14 Option (C) is correct.

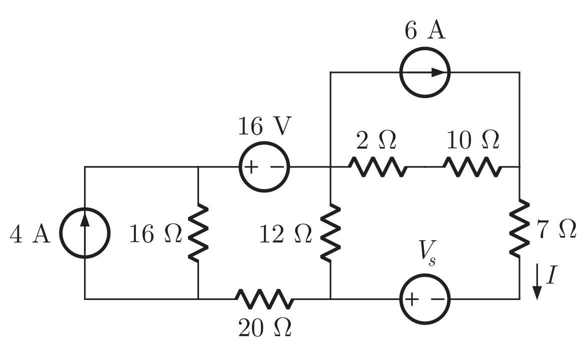
In circuit (b) transforming the 3 A source in to 18 V source all source are 1.5 times of that in circuit (a) as shown in figure.



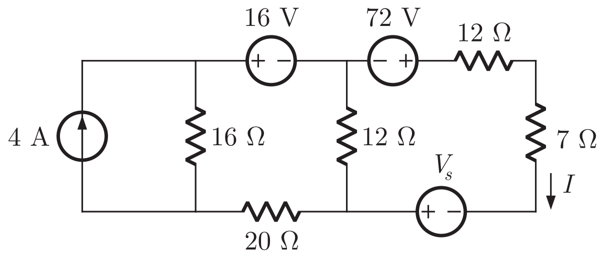
Using principal of linearity, $I_b = 1.5I_a$

SOL 5.2.15 Option (B) is correct.

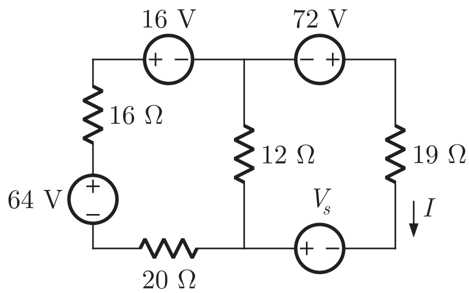
$6\,\Omega$ and $3\,\Omega$ resistors are in parallel, which is equivalent to $2\,\Omega$.



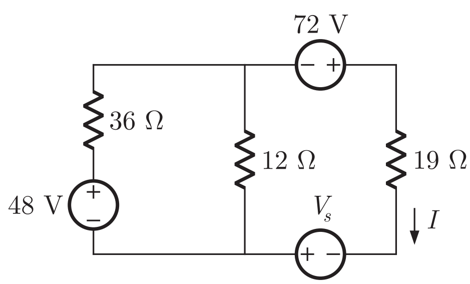
Using source transformation of 6 A source



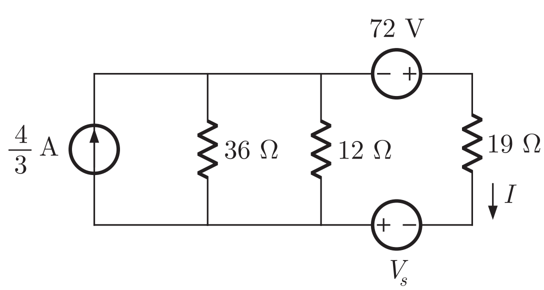
Source transform of 4 A source

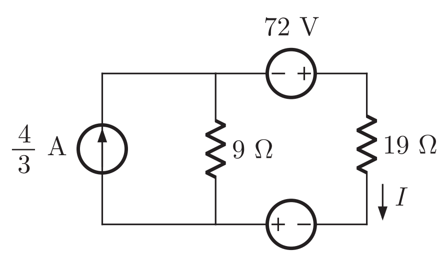


Adding series resistors and sources on the left

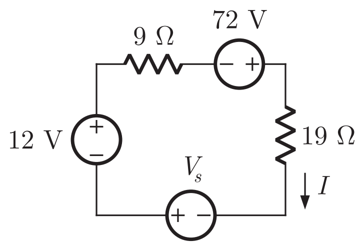


Source transformation of 48 V source





Source transformation of $\frac{4}{3}$ A source.



$$I = \frac{12 + 72 + V_s}{19 + 9}$$

$$V_s = (28 \times I) - 12 - 72$$

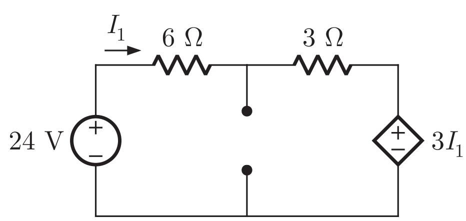
$$= (28 \times 5) - 12 - 72$$

$$= 56 \text{ V}$$

SOL 5.2.16 Option (A) is correct.

We obtain I using superposition.

Due to 24 V source only : (Open circuit 6 A)

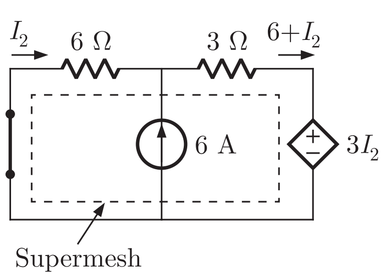


Applying KVL

$$24 - 6I_1 - 3I_1 - 3I_1 = 0$$

$$I_1 = \frac{24}{12} = 2 \text{ A}$$

Due to 6 A source only : (Short circuit 24 V source)



Applying KVL to supermesh

$$-6I_2 - 3(6 + I_2) - 3I_2 = 0$$

$$6I_2 + 18 + 3I_2 + 3I_2 = 0$$

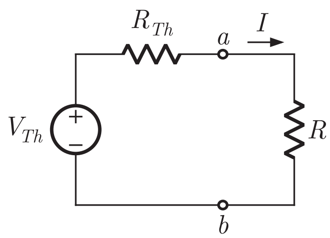
$$I_2 = -\frac{18}{12} = -\frac{3}{2} \text{ A}$$

From superposition, $I = I_1 + I_2$

$$= 2 - \frac{3}{2} = \frac{1}{2} \text{ A}$$

Alternate Method: Note that current in $3\,\Omega$ resistor is $(I+6)$ A, so by applying KVL around the outer loop, we can find current I.

SOL 5.2.17 Option (B) is correct.



$$I = \frac{V_{Th}}{R+R_{Th}}$$

From the table,

$$2 = \frac{V_{Th}}{3+R_{Th}} \qquad ...(i)$$

$$1.6 = \frac{V_{Th}}{5+R_{Th}} \qquad ...(ii)$$

Dividing equation (i) and (ii), we get

$$\frac{2}{1.6} = \frac{5+R_{Th}}{3+R_{Th}}$$

$$6+2R_{Th} = 8+1.6R_{Th}$$

$$0.4R_{Th} = 2$$

$$R_{Th} = 5\,\Omega$$

Substituting R_{Th} into equation (i)

$$2 = \frac{V_{Th}}{3+5}$$

$$V_{Th} = 2(8) = 16\text{ V}$$

SOL 5.2.18 Option (D) is correct.

We have, $$I = \frac{V_{Th}}{R_{Th}+R}$$

$$V_{Th} = 16\text{ V},\ R_{Th} = 5\,\Omega$$

$$I = \frac{16}{5+R} = 1$$

$$16 = 5+R$$

$$R = 11\,\Omega$$

SOL 5.2.19 Option (B) is correct.

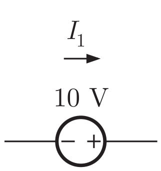


Fig.(A)

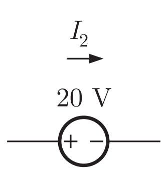


Fig.(B)

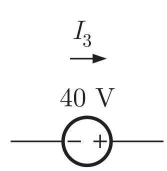


Fig.(C)

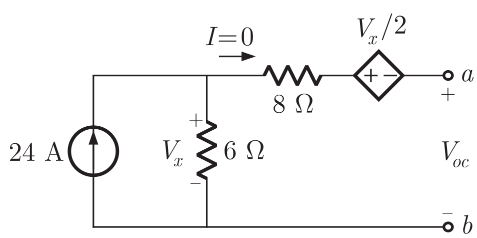
It can be solved by reciprocity theorem. Polarity of voltage source should have same correspondence with branch current in each of the circuit. Polarity of voltage source and current direction are shown below

So,
$$\frac{V_1}{I_1} = -\frac{V_2}{I_2} = \frac{V_3}{I_3}$$
$$\frac{10}{2.5} = -\frac{20}{I_2} = \frac{40}{I_3}$$
$$I_2 = -5\text{ A}$$
$$I_3 = 10\text{ A}$$

SOL 5.2.20 Option (B) is correct.
$$R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{\text{Open circuit voltage}}{\text{short circuit}}$$

Thevenin voltage: (Open circuit voltage V_{oc})

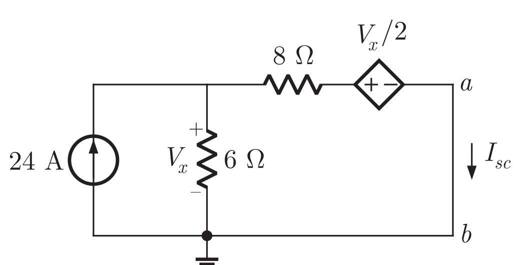
Using source transformation of the dependent source



Applying KCL at top left node
$$24 = \frac{V_x}{6} \Rightarrow V_x = 144\text{ V}$$

Using KVL,
$$V_x - 8I - \frac{V_x}{2} - V_{oc} = 0$$
$$144 - 0 - \frac{144}{2} = V_{oc}$$
$$V_{oc} = 72\text{ V}$$

Short circuit current (I_{sc}):



Applying KVL in the right mesh
$$V_x - 8I_{sc} - \frac{V_x}{2} = 0$$

$$\frac{V_x}{2} = 8I_{sc}$$

$$V_x = 16I_{sc}$$

KCL at the top left node

$$24 = \frac{V_x}{6} + \frac{V_x - V_x/2}{8}$$

$$24 = \frac{V_x}{6} + \frac{V_x}{16}$$

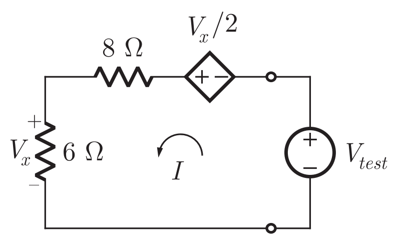
$$V_x = \frac{1152}{11}\ \text{V}$$

$$I_{sc} = \frac{V_x}{16} = \frac{1152}{11 \times 16} = \frac{72}{11}\ \text{A}$$

$$R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{72}{\left(\frac{72}{11}\right)} = 11\,\Omega$$

Alternate method :

We can obtain Thevenin equivalent resistance without calculating the Thevenin voltage (open circuit voltage). Set all independent sources to zero (i.e. open circuit current sources and short circuit voltage sources) and put a test source V_{test} between terminal a-b as shown



$$R_{Th} = \frac{V_{test}}{I_{test}}$$

$$6I + 8I - \frac{V_x}{2} - V_{test} = 0 \qquad \text{(KVL)}$$

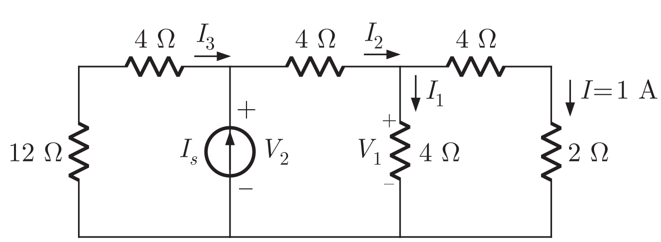
$$14I - \frac{6I}{2} - V_{test} = 0 \qquad V_x = 6I_{test} \text{ (Using Ohm's law)}$$

$$11I = V_{test}$$

So $$R_{Th} = \frac{V_{test}}{I_{test}} = 11\,\Omega$$

SOL 5.2.21 Option (C) is correct.

We solve this problem using linearity and assumption that $I = 1$ A.



$$V_1 = 4I + 2I \quad \text{(Using KVL)}$$
$$= 6\text{ V}$$
$$I_2 = I_1 + I \quad \text{(Using KCL)}$$
$$= \frac{V_1}{4} + I = \frac{6}{4} + 1 = 2.5\text{ A}$$
$$V_2 = 4I_2 + V_1 \quad \text{(Using KVL)}$$
$$= 4(2.5) + 6 = 16\text{ V}$$
$$I_s + I_3 = I_2 \quad \text{(Using KCL)}$$
$$I_s - \frac{V_2}{4+12} = I_2$$
$$I_s = \frac{16}{16} + 2.5 = 3.5\text{ A}$$

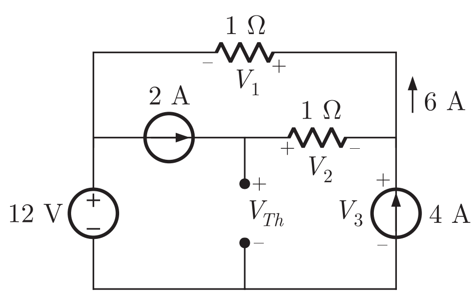
When $I_s = 3.5\text{ A}$, $I = 1\text{ A}$

But $I_s = 14\text{ A}$, so $I = \frac{.1}{3.5} \times 14 = 4\text{ A}$

SOL 5.2.22 Option (A) is correct.

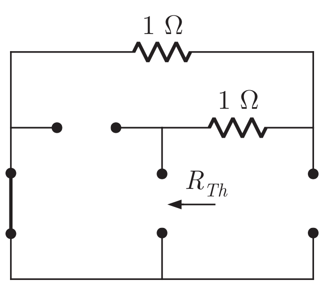
To obtain V-I equation we find the Thevenin equivalent across the terminal at which X is connected.

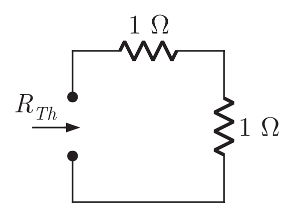
Thevenin voltage : (Open circuit voltage)



$$V_1 = 6 \times 1 = 6\text{ V}$$
$$12 + V_1 - V_3 = 0 \quad \text{(KVL in outer mesh)}$$
$$V_3 = 12 + 6 = 18\text{ V}$$
$$V_{Th} - V_2 - V_3 = 0 \quad \text{(KVL in Bottom right mesh)}$$
$$V_{Th} = V_2 + V_3 \quad (V_2 = 2 \times 1 = 2\text{ V})$$
$$V_{Th} = 2 + 18 = 20\text{ V}$$

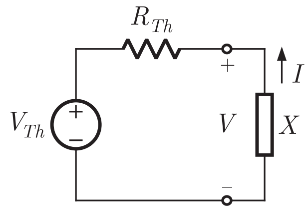
Thevenin Resistance :





$$R_{Th} = 1 + 1 = 2\,\Omega$$

Now, the circuit becomes as



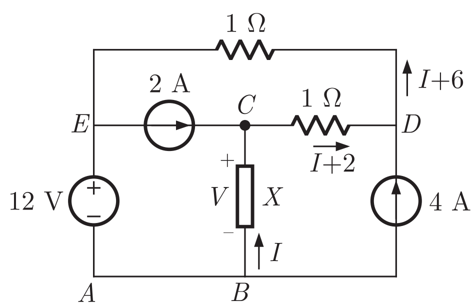
$$I = \frac{V - V_{Th}}{R_{Th}}$$

$$V = R_{Th} I + V_{Th}$$

so $$A = R_{Th} = 2\,\Omega$$

$$B = V_{Th} = 20\text{ V}$$

Alternate Method:



In the mesh $ABCDEA$, we have KVL equation as

$$V - 1(I+2) - 1(I+6) - 12 = 0$$

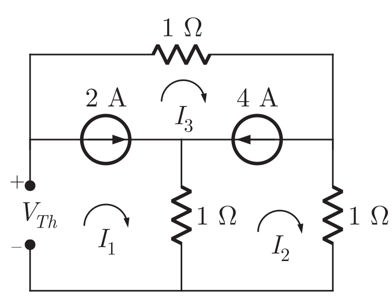
$$V = 2I + 20$$

So, $$A = 2, \quad B = 2$$

SOL 5.2.23 Option (C) is correct.

This problem will easy to solve if we obtain Thevenin equivalent across the 12 V source.

Thevenin voltage : (Open circuit voltage)



Mesh currents are

Mesh 1: $I_1 = 0$ (due to open circuit)

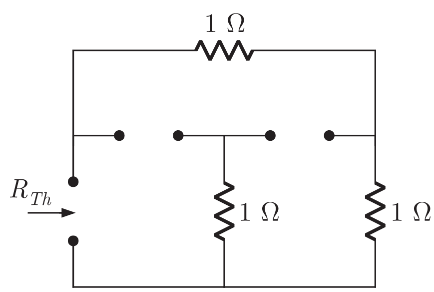
Mesh 2: $I_1 - I_3 = 2$ or $I_3 = -2$ A

Mesh 3: $I_3 - I_2 = 4$ or $I_2 = -6$ A

Mesh equation for outer loop

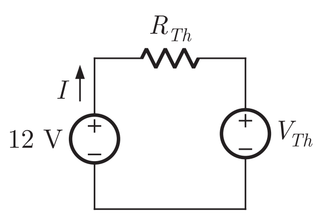
$$V_{Th} - 1 \times I_3 - 1 \times I_2 = 0$$
$$V_{Th} - (-2) - (-6) = 0$$
$$V_{Th} + 2 + 6 = 0$$
$$V_{Th} = -8 \text{ V}$$

Thevenin resistance :



$$R_{Th} = 1 + 1 = 2\,\Omega$$

circuit becomes as

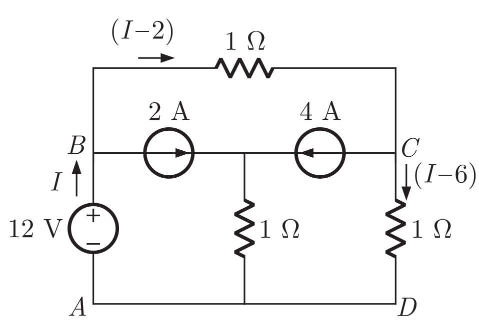


$$I = \frac{12 - V_{Th}}{R_{Th}} = \frac{12 - (-8)}{2} = 10 \text{ A}$$

Power supplied by 12 V source

$$P_{12\,\text{V}} = 10 \times 12 = 120 \text{ W}$$

Alternate Method:



KVL in the loop $ABCDA$

$$12 - 1(I - 2) - 1(I - 6) = 0$$

$$2I = 20$$

$$I = 10\text{ A}$$

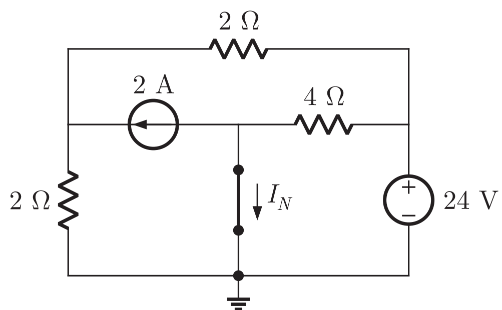
Power supplied by 12 V source

$$P_{12\text{ V}} = 10 \times 12 = 120\text{ W}$$

SOL 5.2.24 Option (A) is correct.

To obtain V-I relation, we obtain either Norton equivalent or Thevenin equivalent across terminal a-b.

Norton Current (short circuit current) **:**

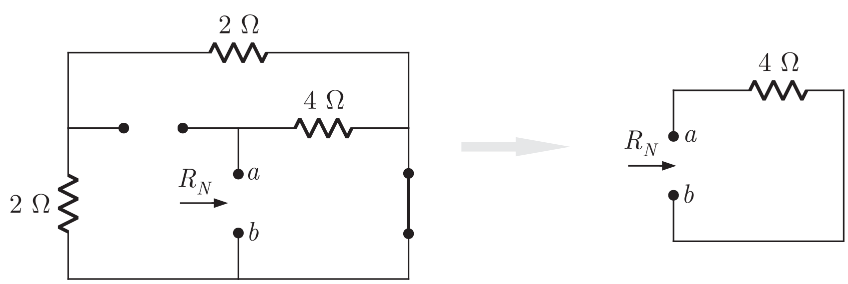


Applying nodal analysis at center node

$$I_N + 2 = \frac{24}{4}$$

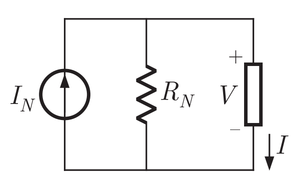
$$I_N = 6 - 2 = 4\text{ A}$$

Norton Resistance :



$$R_N = 4\,\Omega \qquad \text{(Both } 2\,\Omega \text{ resistor are short circuited)}$$

Now, the circuit becomes as

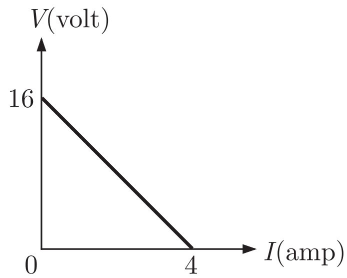


$$I_N = \frac{V}{R_N} + I$$

$$4 = \frac{V}{4} + I$$

$$16 = V + 4I$$

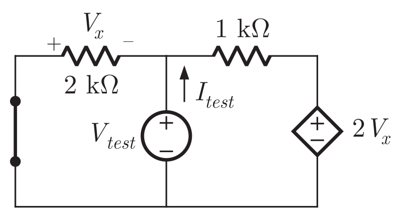
or $$V = -4I + 16$$



Alternate Method: Solve by writing nodal equation at the center node.

SOL 5.2.25 Option (A) is correct.

For maximum power transfer $R_L = R_{Th}$. To obtain Thevenin resistance set all independent sources to zero and put a test source across load terminals.



$$R_{Th} = \frac{V_{test}}{I_{test}}$$

Writing KCL at the top center node

$$\frac{V_{test}}{2\text{k}} + \frac{V_{test} - 2V_x}{1\text{k}} = I_{test} \qquad \text{...(i)}$$

Also, $$V_{test} + V_x = 0 \qquad \text{(KVL in left mesh)}$$

so $$V_x = -V_{test}$$

Substituting $V_x = -V_{test}$ into equation (i)

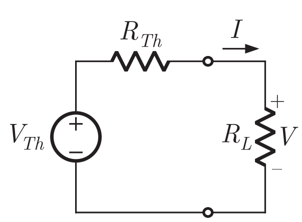
$$\frac{V_{test}}{2\text{k}} + \frac{V_{test} - 2(-V_{test})}{1\text{k}} = I_{test}$$

$$V_{test} + 6V_{test} = 2I_{test}$$

$$R_{Th} = \frac{V_{test}}{I_{test}} = \frac{2}{7}\text{ k}\Omega \simeq 286\,\Omega$$

SOL 5.2.26 Option (A) is correct.

Redrawing the circuit in Thevenin equivalent form



$$I = \frac{V_{Th} - V}{R_{Th}}$$

or, $$V = -R_{Th} I + V_{Th}$$ (General form)

From the given graph

$$V = -4I + 8$$

So, by comparing

$$R_{Th} = 4\,\text{k}\Omega, \quad V_{Th} = 8\,\text{V}$$

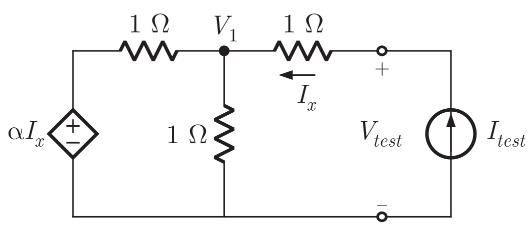
For maximum power transfer $R_L = R_{Th}$

Maximum power absorbed by R_L

$$P_{\max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{(8)^2}{4 \times 4} = 4\,\text{mW}$$

SOL 5.2.27 Option (C) is correct.

To fine out Thevenin equivalent of the circuit put a test source between node a and b,



$$R_{Th} = \frac{V_{test}}{I_{test}}$$

Writing node equation at V_1

$$\frac{V_1 - \alpha I_x}{1} + \frac{V_1}{1} = I_x$$

$$2V_1 = (1 + \alpha) I_x \quad \text{...(i)}$$

I_x is the branch current in $1\,\Omega$ resistor given as

$$I_x = \frac{V_{test} - V_1}{1}$$

$$V_1 = V_{test} - I_x$$

Substituting V_1 into equation (i)

$$2(V_{test} - I_x) = (1 + \alpha) I_x$$

$$2V_{test} = (3 + \alpha) I_x$$

$$2V_{test} = (3 + \alpha) I_{test} \quad (I_x = I_{test})$$

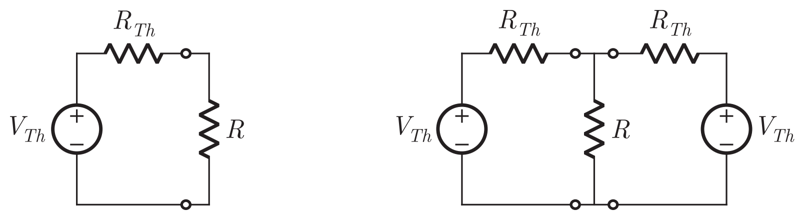
$$R_{Th} = \frac{V_{test}}{I_{test}} = \frac{3 + \alpha}{2} = 3$$

$$3 + \alpha = 6$$

$$\alpha = 3\,\Omega$$

SOL 5.2.28 Option (C) is correct.

Let Thevenin equivalent of both networks are as shown below.



$$P = \left(\frac{V_{Th}}{R_{Th}+R}\right)^2 R \qquad \text{(Single network } N\text{)}$$

$$P' = \left(\frac{V_{Th}}{R+\frac{R_{Th}}{2}}\right)^2 R \qquad \text{(Two } N \text{ are added)}$$

$$= 4\left(\frac{V_{Th}}{2R+R_{Th}}\right)^2 R$$

Thus $P < P' < 4P$

SOL 5.2.29 Option (C) is correct.

$$I_1 = \sqrt{\frac{P_1}{R}} \text{ and } I_2 = \sqrt{\frac{P_2}{R}}$$

Using superposition

$$I = I_1 \pm I_2$$

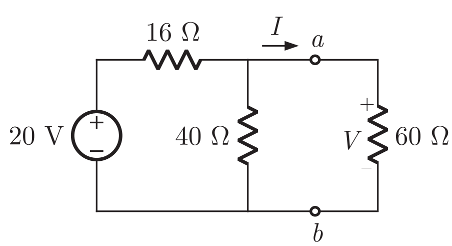
$$= \sqrt{\frac{P_1}{R}} \pm \sqrt{\frac{P_2}{R}}$$

$$I^2 R = (\sqrt{P_1} \pm \sqrt{P_2})^2$$

SOL 5.2.30 Option (B) is correct.

From the substitution theorem we know that any branch within a circuit can be replaced by an equivalent branch provided that replacement branch has the same current through it and voltage across it as the original branch.

The voltage across the branch in the original circuit



$$V = \frac{40\,||\,60}{(40\,||\,60)+16}(20) \qquad \text{(using voltage division)}$$

$$= \frac{24}{40} \times 20 = 12 \text{ V}$$

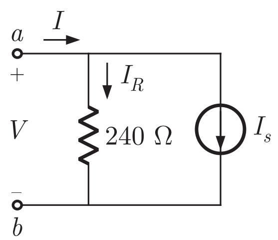
Current entering terminal a-b is

$$I = \frac{V}{R} = \frac{12}{60} = 200 \text{ mA}$$

In fig(B), to maintain same voltage $V = 12$ V current through $240\,\Omega$ resistor must be

$$I_R = \frac{12}{240} = 50\,\text{mA}$$

By using KCL at terminal a, as shown

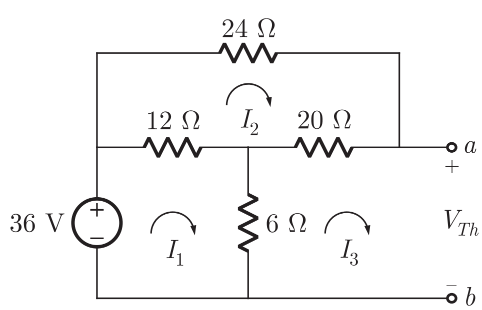


$$I = I_R + I_S$$
$$200 = 50 + I_s$$
$$I_s = 150\,\text{mA}, \quad \text{down wards}$$

SOL 5.2.31 Option (B) is correct.

Thevenin voltage : (Open circuit voltage)

In the given problem, we use mesh analysis method to obtain Thevenin voltage



$$I_3 = 0 \qquad (a\text{-}b \text{ is open circuit})$$

Writing mesh equations

Mesh 1:

$$36 - 12(I_1 - I_2) - 6(I_1 - I_3) = 0$$
$$36 - 12I_1 + 12I_2 - 6I_1 = 0 \qquad (I_3 = 0)$$
$$3I_1 - 2I_2 = 6 \qquad \text{...(i)}$$

Mesh 2:

$$-24I_2 - 20(I_2 - I_3) - 12(I_2 - I_1) = 0$$
$$-24I_2 - 20I_2 - 12I_2 + 12I_1 = 0 \qquad (I_3 = 0)$$
$$14I_2 = 3I_1 \qquad \text{...(ii)}$$

From equation (i) and (ii)

$$I_1 = \frac{7}{3}\,\text{A}, \quad I_2 = \frac{1}{2}\,\text{A}$$

Mesh 3:

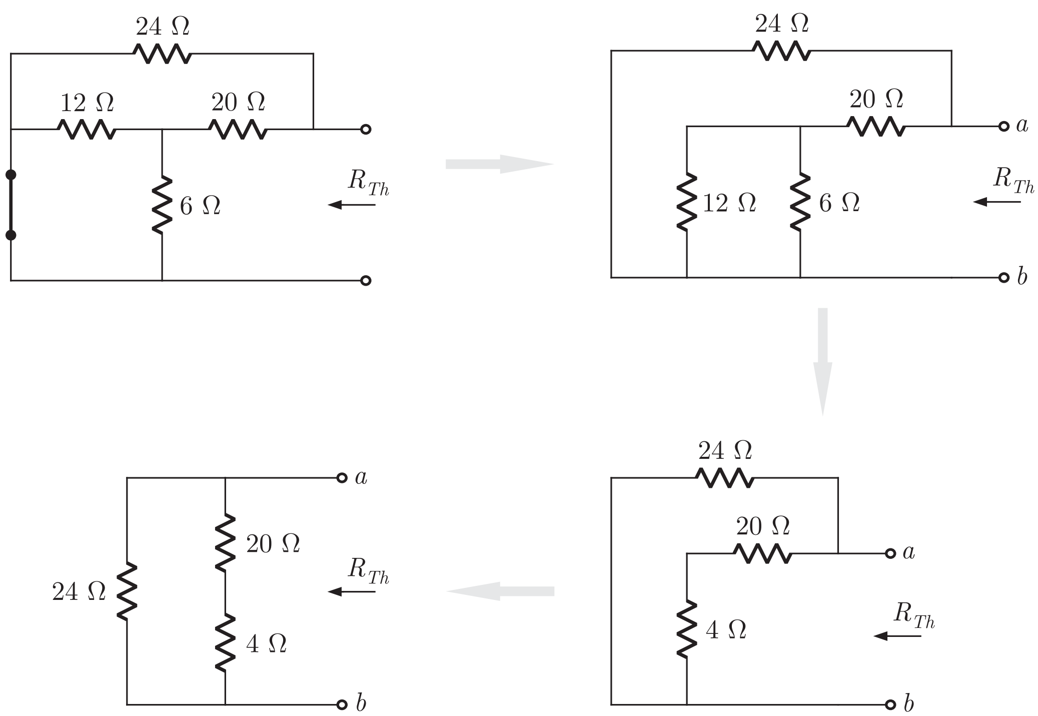
$$-6(I_3 - I_1) - 20(I_3 - I_2) - V_{Th} = 0$$

$$-6\left[0-\frac{7}{3}\right]-20\left[0-\frac{1}{2}\right]-V_{Th}=0$$

$$14+10=V_{Th}$$

$$V_{Th}=24 \text{ volt}$$

Thevenin Resistance :



$$R_{Th}=(20+4)\,||\,24\,\Omega$$

$$=24\,\Omega\,||\,24\,\Omega$$

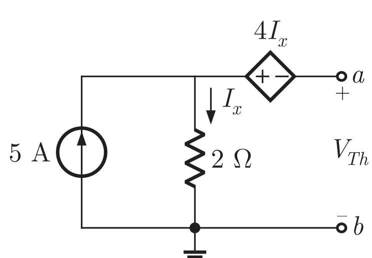
$$=12\,\Omega$$

Alternate Method: V_{Th} can be obtained by writing nodal equation at node a and at center node.

SOL 5.2.32 Option (C) is correct.

We obtain Thevenin's equivalent across load terminal.

Thevenin voltage : (Open circuit voltage)



Using KCL at top left node

$$5=I_x+0$$

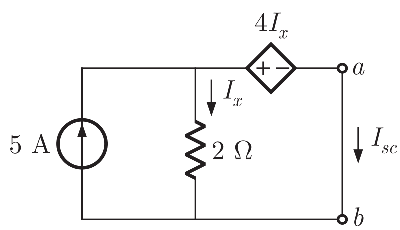
$$I_x = 5\text{ A}$$

Using KVL

$$2I_x - 4I_x - V_{Th} = 0$$
$$2(5) - 4(5) = V_{Th}$$
$$V_{Th} = -10\text{ volt}$$

Thevenin Resistance :

First we find short circuit current through a-b



Using KCL at top left node

$$5 = I_x + I_{sc}$$
$$I_x = 5 - I_{sc}$$

Applying KVL in the right mesh

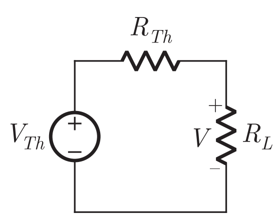
$$2I_x - 4I_x + 0 = 0$$
$$I_x = 0$$

So, $$5 - I_{sc} = 0 \text{ or } I_{sc} = 5\text{ A}$$

Thevenin resistance,

$$R_{Th} = \frac{V_{Th}}{I_{sc}} = -\frac{10}{5} = -2\,\Omega$$

Now, the circuit becomes as



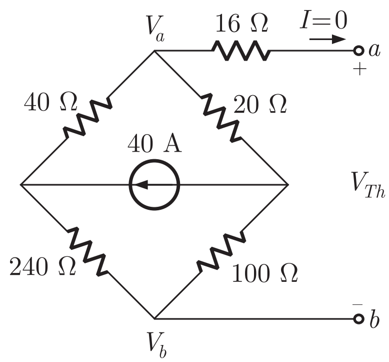
$$V = V_{Th}\left(\frac{R}{R + R_L}\right)$$ (Using voltage division)

So, $$V = V_{Th} = -10\text{ volt}$$
$$R = R_{Th} = -2\,\Omega$$

SOL 5.2.33 Option (C) is correct.

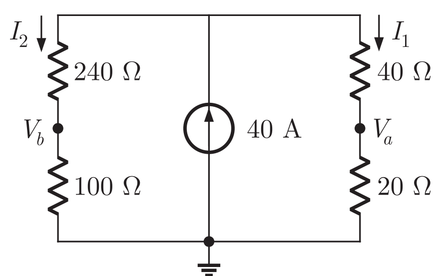
We obtain Thevenin equivalent across the load terminals

Thevenin Voltage : (Open circuit voltage)



$$V_{Th} = V_a - V_b$$

Rotating the circuit, makes it simple



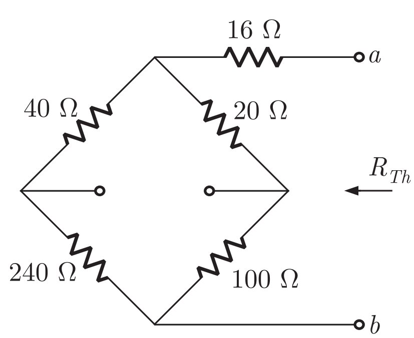
$$I_1 = \frac{340}{340+60}(40) \qquad \text{(Current division)}$$
$$= 34 \text{ A}$$
$$V_a = 20I_1 = 20 \times 34 = 680 \text{ V} \qquad \text{(Ohm's Law)}$$

Similarly,

$$I_2 = \frac{60}{60+340}(40) = 6 \text{ A} \qquad \text{(Current division)}$$
$$V_b = 100I_2 = 100 \times 6 = 600 \text{ V} \qquad \text{(Ohm's Law)}$$

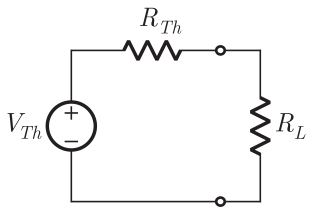
Thevenin voltage $V_{Th} = 680 - 600 = 80$ V

Thevenin Resistance :



$$R_{Th} = 16 + (240+40) \,||\, (20+100)$$
$$= 16 + (280 \,||\, 120) = 16 + 84$$
$$= 100 \,\Omega$$

Now, circuit reduced as



For maximum power transfer

$$R_L = R_{Th} = 100\,\Omega$$

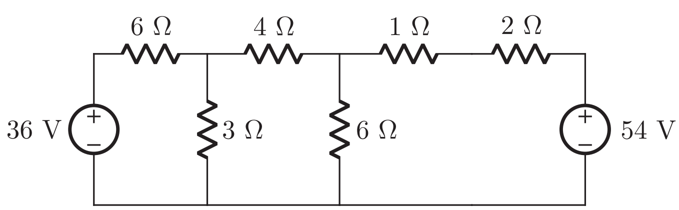
Maximum power transferred to R_L

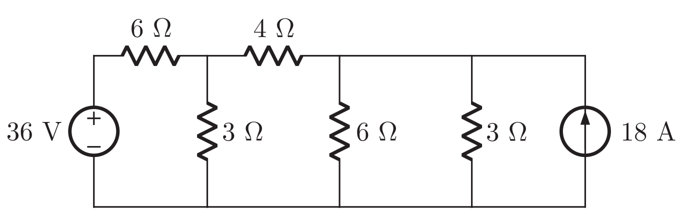
$$P_{\max} = \frac{(V_{Th})^2}{4R_L} = \frac{(80)^2}{4 \times 100}$$

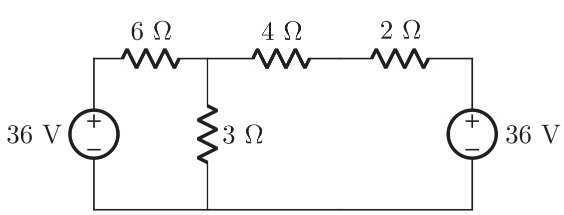
$$= 16\text{ W}$$

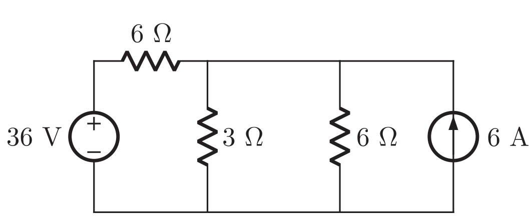
SOL 5.2.34 Option (A) is correct.

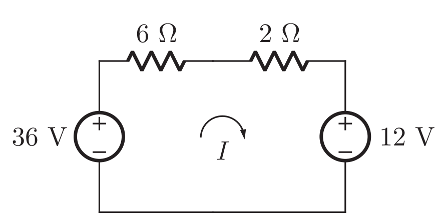
We use source transformation as follows











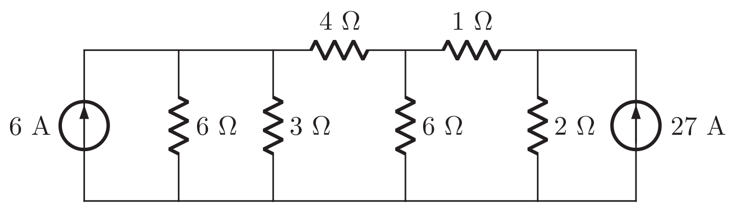
$$I = \frac{36 - 12}{6 + 2} = 3 \text{ A}$$

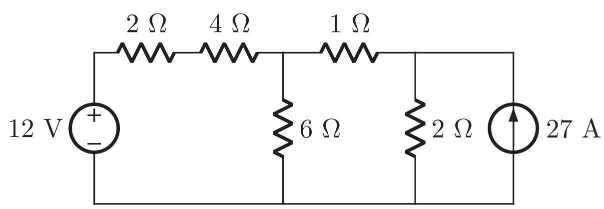
Power supplied by 36 V source

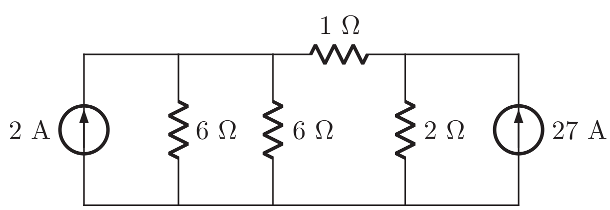
$$P_{36\text{ V}} = 3 \times 36 = 108 \text{ W}$$

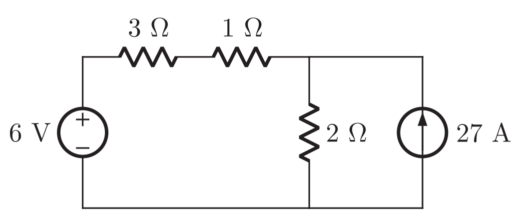
SOL 5.2.35 Option (D) is correct.

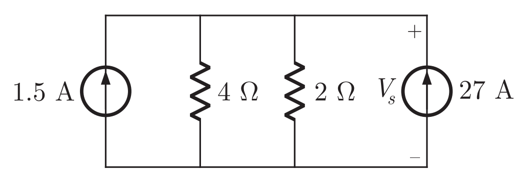
Now, we do source transformation from left to right as shown











$$\begin{aligned} V_s &= (27 + 1.5)(4\,\Omega \,||\, 2\,\Omega) \\ &= 28.5 \times \frac{4}{3} \\ &= 38 \text{ V} \end{aligned}$$

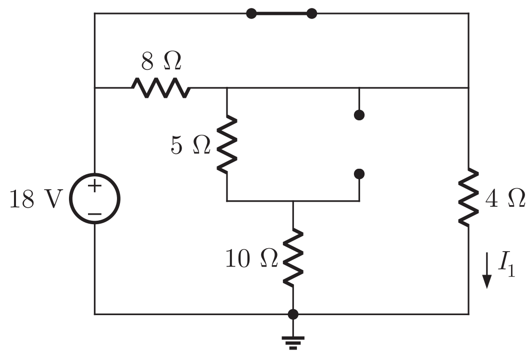
Power supplied by 27 A source

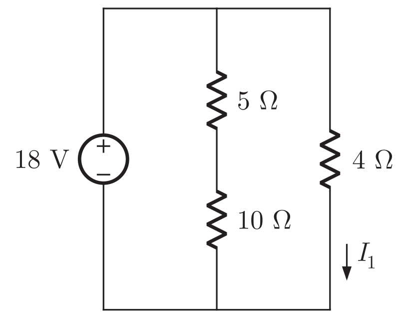
$$\begin{aligned} P_{27\text{ A}} &= V_s \times 27 = 38 \times 27 \\ &= 1026 \text{ W} \end{aligned}$$

SOL 5.2.36 Option (C) is correct.

First, we find current I in the $4\,\Omega$ resistors using superposition.

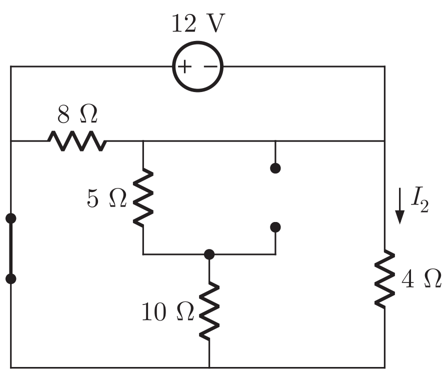
Due to 18 V source only : (Open circuit 4 A and short circuit 12 V source)

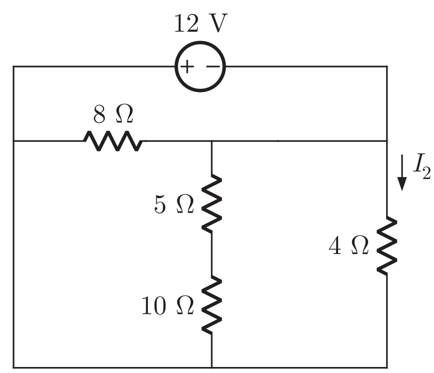




$$I_1 = \frac{18}{4} = 4.5 \text{ A}$$

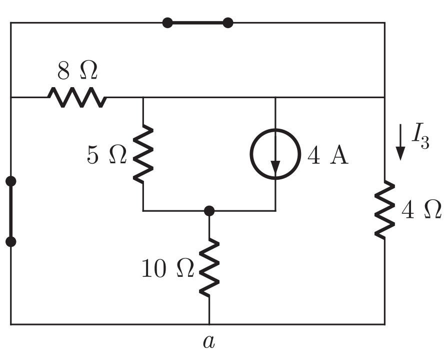
Due to 12 V source only : (Open circuit 4 A and short circuit 18 V source)

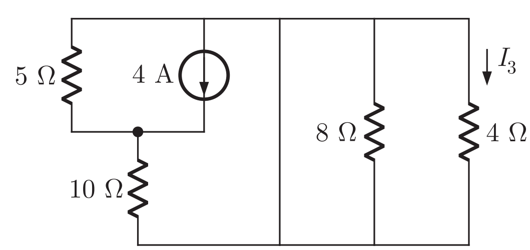




$$I_2 = -\frac{12}{4} = -3 \text{ A}$$

Due to 4 A source only : (Short circuit 12 V and 18 V sources)





$I_3 = 0$ (Due to short circuit)

So, $I = I_1 + I_2 + I_3 = 4.5 - 3 + 0 = 1.5 \text{ A}$

Power dissipated in $4\,\Omega$ resistor

$$P_{4\,\Omega} = I^2(4) = (1.5)^2 \times 4 = 9 \text{ W}$$

Alternate Method: Let current in $4\,\Omega$ resistor is I, then by applying KVL around the outer loop

$$18 - 12 - 4I = 0$$

$$I = \frac{6}{4} = 1.5\text{ A}$$

So, power dissipated in $4\,\Omega$ resistor

$$P_{4\,\Omega} = I^2(4) = (1.5)^2 \times 4 = 9\text{ W}$$

SOL 5.2.37 Option (D) is correct.

We obtain Thevenin equivalent across terminal a-b.

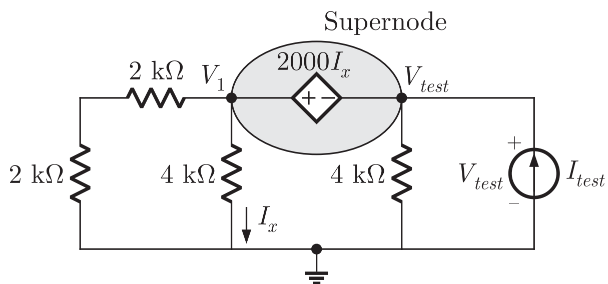
Thevenin Voltage :

Since there is no independent source present in the network, Thevenin voltage is simply zero.

$$V_{Th} = 0$$

Thevenin Resistance :

Put a test source across terminal a-b



$$R_{Th} = \frac{V_{test}}{I_{test}}$$

For the super node

$$V_1 - V_{test} = 2000 I_x$$

$$V_1 - V_{test} = 2000\left(\frac{V_1}{4000}\right) \qquad (I_x = V_1/4000)$$

$$\frac{V_1}{2} = V_{test} \text{ or } V_1 = 2V_{test}$$

Applying KCL to the super node

$$\frac{V_1 - 0}{4\text{k}} + \frac{V_1}{4\text{k}} + \frac{V_{test}}{4\text{k}} = I_{test}$$

$$2V_1 + V_{test} = 4 \times 10^3 I_{test}$$

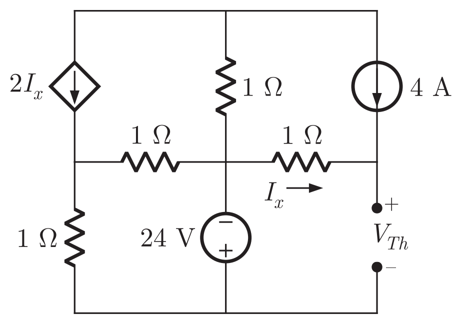
$$2(2V_{test}) + V_{test} = 4 \times 10^3 I_{test} \qquad (V_1 = 2V_{test})$$

$$\frac{V_{test}}{I_{test}} = \frac{4 \times 10^3}{5} = 800\,\Omega$$

SOL 5.2.38 Option (C) is correct.

Using, Thevenin equivalent circuit

Thevenin Voltage : (Open circuit voltage)



$$I_x = -4\text{ A} \qquad \text{(due to open circuit)}$$

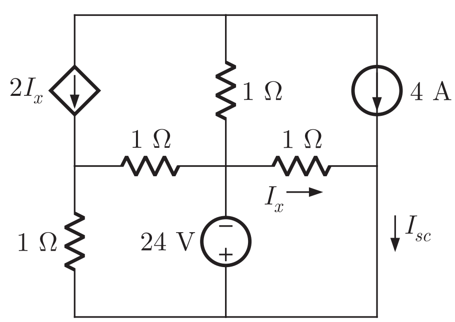
Writing KVL in bottom right mesh

$$-24 - (1)I_x - V_{Th} = 0$$
$$V_{Th} = -24 + 4 = -20\text{ V}$$

Thevenin resistance :

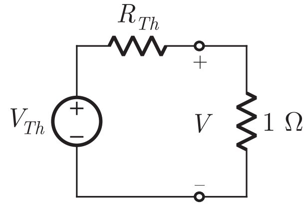
$$R_{Th} = \frac{\text{open circuit voltage}}{\text{short circuit current}} = \frac{V_{oc}}{I_{sc}}$$
$$V_{oc} = V_{Th} = -20\text{ V}$$

I_{sc} is obtained as follows



$$I_x = -\frac{24}{1} = -24\text{ A}$$
$$I_x + 4 = I_{sc} \qquad \text{(using KCL)}$$
$$-24 + 4 = I_{sc}$$
$$I_{sc} = -20\text{ A}$$
$$R_{Th} = \frac{-20}{-20} = 1\,\Omega$$

The circuit is as shown below



$$V = \frac{1}{1 + R_{Th}}(V_{Th}) = \frac{1}{1+1}(-20) = -10\text{ volt} \qquad \text{(Using voltage division)}$$

Alternate Method: Note that current in bottom right most $1\,\Omega$ resistor is $(I_x + 4)$, so applying KVL around the bottom right mesh,

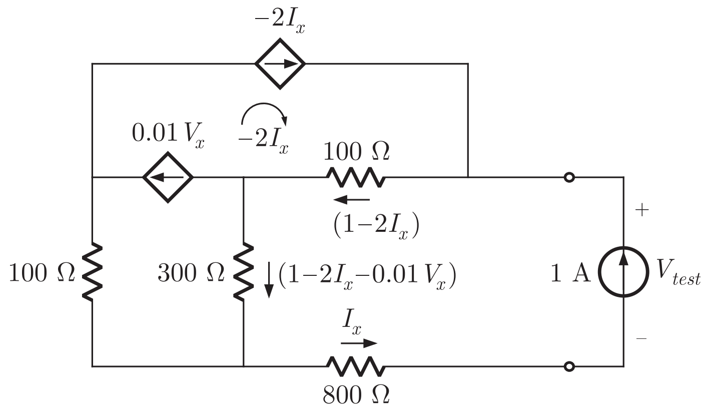
$$-24 - I_x - (I_x + 4) = 0$$

$$I_x = -14 \text{ A}$$

So, $V = 1 \times (I_x + 4) = -14 + 4 = -10 \text{ V}$

SOL 5.2.39 Option (A) is correct.

Writing currents into $100\,\Omega$ and $300\,\Omega$ resistors by using KCL as shown in figure.



$$I_x = 1 \text{ A}, \; V_x = V_{test}$$

Writing mesh equation for bottom right mesh.

$$V_{test} = 100(1 - 2I_x) + 300(1 - 2I_x - 0.01V_x) + 800 = 100 \text{ V}$$

$$R_{Th} = \frac{V_{test}}{1} = 100\,\Omega$$

SOL 5.2.40 Option (D) is correct.

For $R_L = 10\,\text{k}\Omega$, $V_{ab1} = \sqrt{10\text{k} \times 3.6\text{m}} = 6 \text{ V}$

For $R_L = 30\,\text{k}\Omega$, $V_{ab2} = \sqrt{30\text{k} \times 4.8\text{m}} = 12 \text{ V}$

$$V_{ab1} = \frac{10}{10 + R_{Th}} V_{Th} = 6 \qquad \text{...(i)}$$

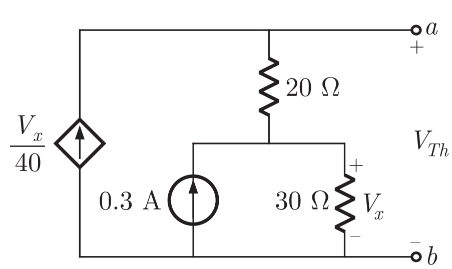
$$V_{ab2} = \frac{30}{30 + R_{Th}} V_{Th} = 12 \qquad \text{...(ii)}$$

Dividing equation (i) and (ii), we get $R_{Th} = 30\,\text{k}\Omega$. Maximum power will be transferred when $R_L = R_{Th} = 30\,\text{k}\Omega$.

SOL 5.2.41 Option (C) is correct.

Equation for V-I can be obtained with Thevenin equivalent across a-b terminals.

Thevenin Voltage: (Open circuit voltage)



Writing KCL at the top node

$$\frac{V_x}{40} = \frac{V_{Th} - V_x}{20}$$

$$V_x = 2V_{Th} - 2V_x$$

$$3V_x = 2V_{Th} \Rightarrow V_x = \frac{2}{3}V_{Th}$$

KCL at the center node

$$\frac{V_x - V_{Th}}{20} + \frac{V_x}{30} = 0.3$$

$$3V_x - 3V_{Th} + 2V_x = 18$$

$$5V_x - 3V_{Th} = 18$$

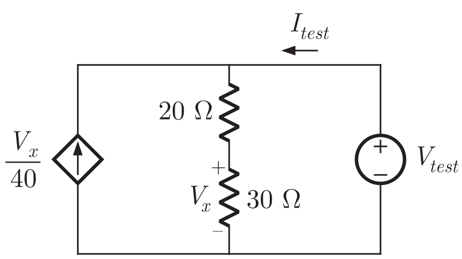
$$5\left(\frac{2}{3}\right)V_{Th} - 3V_{Th} = 18 \qquad \left(V_x = \frac{2}{3}V_{Th}\right)$$

$$10V_{Th} - 9V_{Th} = 54$$

$$V_{Th} = 54 \text{ volt}$$

Thevenin resistance :

When a dependent source is present in the circuit the best way to obtain Thevenin resistance is to remove all independent sources and put a test source across a-b terminals as shown in figure.



$$R_{Th} = \frac{V_{test}}{I_{test}}$$

KCL at the top node

$$\frac{V_x}{40} + I_{test} = \frac{V_{test}}{20 + 30}$$

$$\frac{V_x}{40} + I_{test} = \frac{V_{test}}{50} \qquad \text{...(i)}$$

$$V_x = \frac{30}{30 + 20}(V_{test}) \qquad \text{(using voltage division)}$$

$$= \frac{3}{5}V_{test}$$

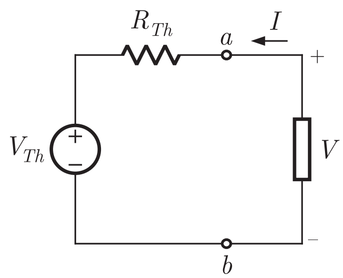
Substituting V_x into equation (i), we get

$$\frac{3V_{test}}{5(40)} + I_{test} = \frac{V_{test}}{50}$$

$$I_{test} = V_{test}\left(\frac{1}{50} - \frac{3}{200}\right) = \frac{V_{test}}{200}$$

$$R_{Th} = \frac{V_{test}}{I_{test}} = 200\,\Omega$$

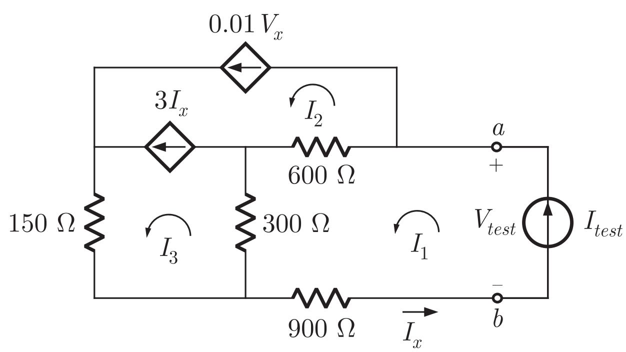
The circuit now reduced as



$$I = \frac{V - V_{Th}}{R_{Th}} = \frac{V - 54}{200}$$
$$V = 200I + 54$$

SOL 5.2.42 Option (D) is correct.

To obtain Thevenin resistance put a test source across the terminal a, b as shown.



$$V_{test} = V_x,\ I_{test} = I_x$$

By writing loop equation for the circuit

$$V_{test} = 600(I_1 - I_2) + 300(I_1 - I_3) + 900(I_1)$$
$$V_{test} = (600 + 300 + 900)I_1 - 600I_2 - 300I_3$$
$$V_{test} = 1800I_1 - 600I_2 - 300I_3 \qquad \text{...(i)}$$

The loop current are given as,

$$I_1 = I_{test},\quad I_2 = 0.3V_s,\quad \text{and}\quad I_3 = 3I_{test} + 0.2V_s$$

Substituing theses values into equation (i),

$$V_{test} = 1800I_{test} - 600(0.01V_s) - 300(3I_{test} + 0.01V_s)$$
$$V_{test} = 1800I_{test} - 6V_s - 900I_{test} - 3V_s$$
$$10V_{test} = 900I_{test},$$
$$V_{test} = 90I_{test}$$

Thevenin resistance

$$R_{Th} = \frac{V_{test}}{I_{test}} = 90\,\Omega$$

Thevenin voltage or open circuit voltage will be zero because there is no independent source present in the network, i.e. $V_{oc} = 0$ V

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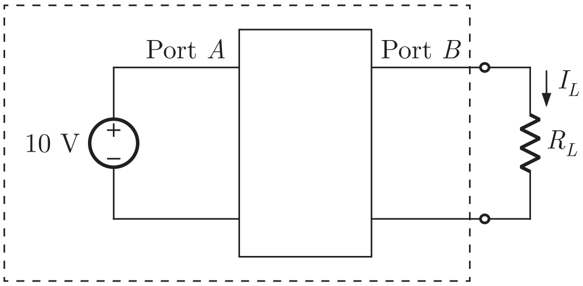
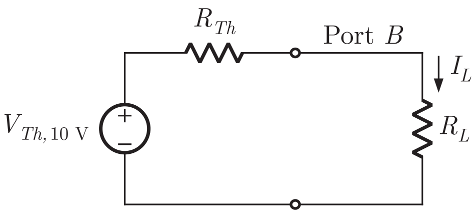
SOLUTIONS 5.3

SOL 5.3.1 Option (C) is correct.

When 10 V is connected at port A the network is



Now, we obtain Thevenin equivalent for the circuit seen at load terminal, let Thevenin voltage is $V_{Th,10\,\text{V}}$ with 10 V applied at port A and Thevenin resistance is R_{Th}.



$$I_L = \frac{V_{Th,10\,\text{V}}}{R_{Th} + R_L}$$

For $R_L = 1\,\Omega$, $I_L = 3$ A

$$3 = \frac{V_{Th,10\,\text{V}}}{R_{Th} + 1} \qquad \text{...(i)}$$

For $R_L = 2.5\,\Omega$, $I_L = 2$ A

$$2 = \frac{V_{Th,10\,\text{V}}}{R_{Th} + 2.5} \qquad \text{...(ii)}$$

Dividing above two

$$\frac{3}{2} = \frac{R_{Th} + 2.5}{R_{Th} + 1}$$

$$3R_{Th} + 3 = 2R_{Th} + 5$$

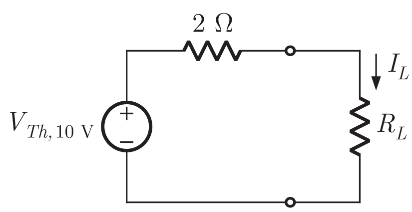
$$R_{Th} = 2\,\Omega$$

Substituting R_{Th} into equation (i)

$$V_{Th,10\,\text{V}} = 3(2+1) = 9\text{ V}$$

Note that it is a non reciprocal two port network. Thevenin voltage seen at port B depends on the voltage connected at port A. Therefore we took subscript $V_{Th,10\,\text{V}}$. This is Thevenin voltage only when 10 V source is connected at input port A. If the voltage connected to port A is different, then Thevenin voltage will be different. However, Thevenin's resistance remains same.

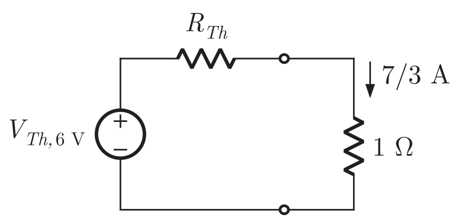
Now, the circuit is



For $R_L = 7\,\Omega$, $$I_L = \frac{V_{Th,10\,\text{V}}}{2+R_L} = \frac{9}{2+7} = 1\text{ A}$$

SOL 5.3.2 Option (B) is correct.

Now, when 6 V connected at port A let Thevenin voltage seen at port B is $V_{Th,6\,\text{V}}$. Here $R_L = 1\,\Omega$ and $I_L = \frac{7}{3}$ A



$$V_{Th,6\,\text{V}} = R_{Th}\times\frac{7}{3} + 1\times\frac{7}{3} = 2\times\frac{7}{3} + \frac{7}{3} = 7\text{ V}$$

This is a linear network, so V_{Th} at port B can be written as

$$V_{Th} = V_1\alpha + \beta$$

where V_1 is the input applied at port A.

We have $V_1 = 10\text{ V}$, $V_{Th,10\,\text{V}} = 9\text{ V}$

$\therefore$ $$9 = 10\alpha + \beta \qquad \text{...(i)}$$

When $V_1 = 6\text{ V}$, $V_{Th,6\,\text{V}} = 9\text{ V}$

$\therefore$ $$7 = 6\alpha + \beta \qquad \text{...(ii)}$$

Solving (i) and (ii)

$$\alpha = 0.5,\ \beta = 4$$

Thus, with any voltage V_1 applied at port A, Thevenin voltage or open circuit voltage at port B will be

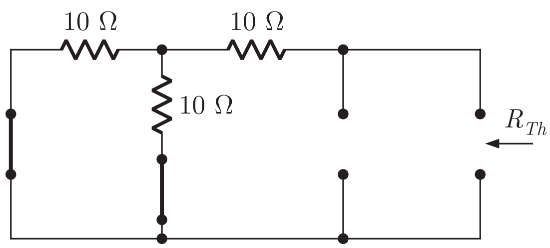
So, $$V_{Th,V_1} = 0.5\,V_1 + 4$$

For $$V_1 = 8\text{ V}$$

$$V_{Th,8\,\text{V}} = 0.5\times 8 + 4 = 8 = V_{oc} \qquad \text{(open circuit voltage)}$$

SOL 5.3.3 Option (C) is correct.

Power transferred to R_L will be maximum when R_L is equal to the Thevenin resistance seen at the load terminals. To obtain Thevenin resistance, we set all independent sources zero(i.e. short circuit voltage source and open circuit current source) as shown in figure.



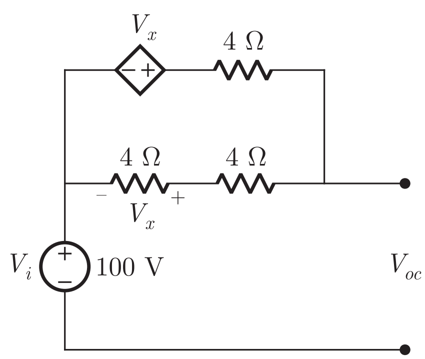
$$R_{Th} = (10\,||\,10) + 10 = \frac{10\times 10}{10+10} + 10 = 15\,\Omega$$

SOL 5.3.4 Option (C) is correct.

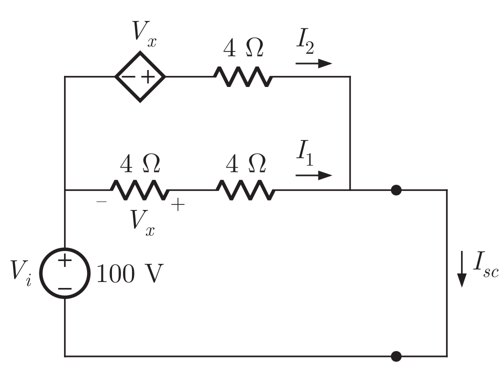
For maximum power transfer, the load resistance R_L must be equal to Thevenin resistance R_{Th} seen at the load terminals. i.e. $R_L = R_{Th}$. Thevenin resistance is given by

$$R_{Th} = \frac{\text{Open circuit voltage}}{\text{Short circuit current}} = \frac{V_{oc}}{I_{sc}}$$

The open circuit voltage can be obtained using the circuit shown below



The open circuit voltage is $V_{oc} = 100$ V. Short circuit current is determined using following circuit



From figure, $I_1 = \frac{100}{8} = 12.5 \text{ A}$

$$V_x = -4 \times 12.5 = -50 \text{ V}$$

$$I_2 = \frac{100 + V_x}{4} = \frac{100 - 50}{4} = 12.5 \text{ A}$$

$$I_{sc} = I_1 + I_2 = 25 \text{ A}$$

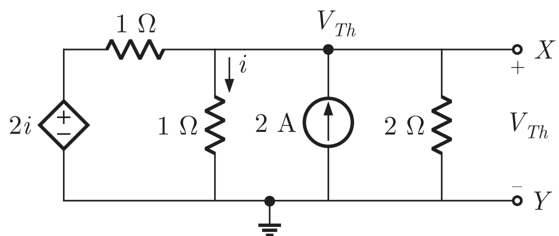
So, $R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{100}{25} = 4\,\Omega$

Thus, for maximum power transfer $R_L = R_{Th} = 4\,\Omega$.

SOL 5.3.5 Option (D) is correct.

$$R_{Th} = \frac{\text{Open circuit voltage}\,(V_{oc})}{\text{Short circuit current}\,(I_{sc})} = \frac{V_{Th}}{I_{sc}}$$

Here V_{Th} is voltage across node also. Applying nodal analysis we get



$$\frac{V_{Th}}{2} + \frac{V_{Th}}{1} + \frac{V_{Th} - 2i}{1} = 2$$

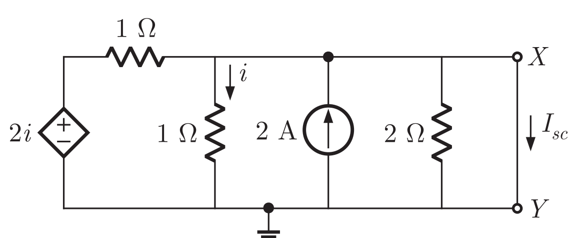
From the circuit, $i = \frac{V_{Th}}{1} = V_{Th}$

Therefore,

$$\frac{V_{Th}}{2} + \frac{V_{Th}}{1} + \frac{V_{Th} - 2\,V_{Th}}{1} = 2$$

or, $V_{Th} = 4 \text{ volt}$

From the figure shown below it may be easily seen that the short circuit current at terminal XY is $I_{sc} = 2$ A because $i = 0$ due to short circuit of 1 Ω resistor and all current will pass through short circuit.



Therefore $R_{th} = \frac{V_{Th}}{I_{sc}} = \frac{4}{2} = 2\,\Omega$

SOL 5.3.6 Option (C) is correct.

Maximum power will be transferred when $R_L = R_{Th} = 100\,\Omega$

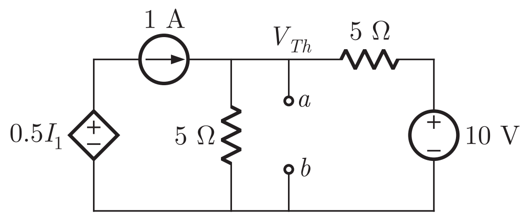
In this case voltage across R_L is 5 V, therefore

$$P_{max} = \frac{V_{Th}^2}{4R} = \frac{(10)^2}{4 \times 100} = 0.25 \text{ W}$$

SOL 5.3.7 Option (B) is correct.

$$R_{Th} = \frac{\text{Open circuit voltage}}{\text{Short circuit current}} = \frac{V_{Th}}{I_{sc}}$$

Thevenin voltage (Open circuit voltage):



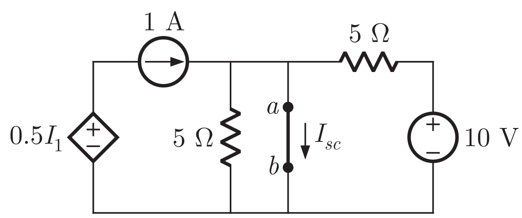
Applying KCL at node we get

$$\frac{V_{Th}}{5} + \frac{V_{Th} - 10}{5} = 1$$

or, $$V_{Th} = 7.5$$

Short Circuit Current:

Short circuit current through terminal a, b is obtained as follows.



$$I_{sc} = 1 + \frac{10}{5} = 3 \text{ A}$$

Thevenin resistance,

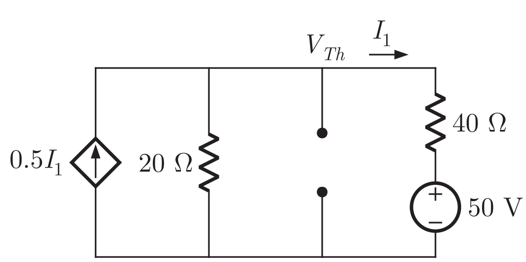
$$R_{Th} = \frac{V_{Th}}{I_{sc}} = \frac{7.5}{3} = 2.5\,\Omega$$

Note: Here current source being in series with dependent voltage source makes it ineffective.

SOL 5.3.8 Option (A) is correct.

For maximum power delivered, load resistance R_L must be equal to Thevenin resistance R_{Th} seen from the load terminals.

$$R_{Th} = \frac{\text{Open circuit voltage}\,(V_{oc})}{\text{Short circuit current}\,(I_{sc})} = \frac{V_{Th}}{I_{sc}}$$



Applying KCL at Node, we get

$$0.5I_1 = \frac{V_{Th}}{20} + I_1$$

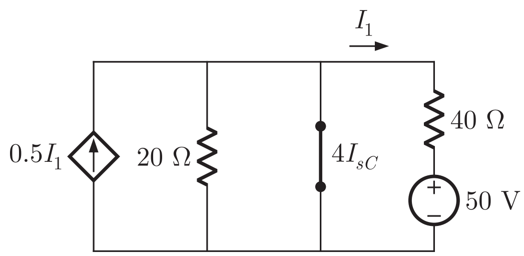
or $$V_{Th} + 10I_1 = 0$$

but $$I_1 = \frac{V_{Th} - 50}{40}$$

Thus, $$V_{Th} + \frac{V_{Th} - 50}{4} = 0$$

or $$V_{Th} = 10 \text{ V}$$

For I_{sc} the circuit is shown in figure below.



$$I_{sc} = 0.5I_1 - I_1 = -0.5I_1$$

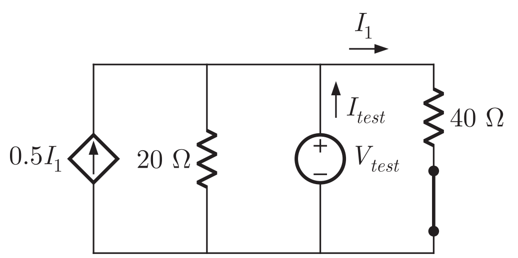
but $$I_1 = -\frac{50}{40} = -1.25 \text{ A}$$

$$I_{sc} = -0.5 \times -12.5 = 0.625 \text{ A}$$

So, $$R_{th} = \frac{V_{Th}}{I_{sc}} = \frac{10}{0.625} = 16\,\Omega$$

Alternate Method:

Thevenin resistance can be obtained by setting all independent source to zero and put a test source across the load terminals as shown.



Writing KCL at top node

$$\frac{V_{test}}{20} + \frac{V_{test}}{40} = I_{test} + 0.5I_1$$

$$\frac{3}{40}V_{test} = I_{test} + 0.5\left(\frac{V_{test}}{40}\right) \qquad (I_1 = V_{test}/40)$$

$$\left(\frac{3}{40} - \frac{1}{80}\right)V_{test} = I_{test}$$

$$\frac{1}{16}V_{test} = I_{test}$$

Thevenin resistance,

$$R_{Th} = \frac{V_{test}}{I_{test}} = 16\,\Omega$$

SOL 5.3.9 Option (C) is correct.

This can be solved by reciprocity theorem. But we have to take care that the polarity of voltage source have the same correspondence with branch current in each of the circuit.

In figure (B) and figure (C), polarity of voltage source is reversed with respect to direction of branch current so

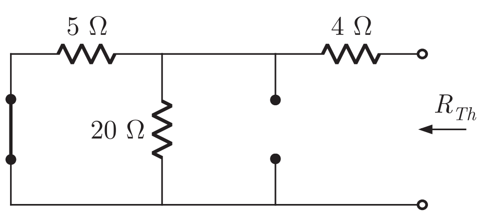
$$\frac{V_1}{I_1} = -\frac{V_2}{I_2}$$

$$\frac{10}{2} = \frac{-20}{I}$$

$$I = -4\text{ A}$$

SOL 5.3.10 Option (C) is correct.

For maximum power transfer R_L should be equal to R_{Th} at same terminal. To obtain R_{Th} set all independent sources to zero as shown below



$$R_{Th} = (5\,\Omega\,||\,20\,\Omega) + 4\,\Omega$$

$$= \frac{5\times 20}{5+20} + 4 = 4+4 = 8\,\Omega$$

SOL 5.3.11 Option (A) is correct.

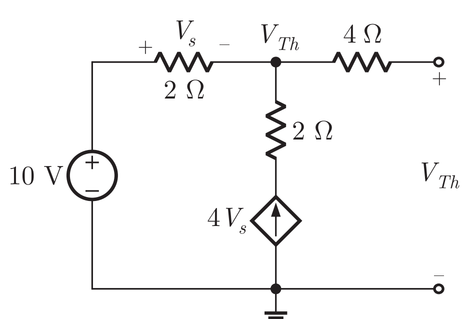
Superposition theorem is applicable to only linear circuits.

SOL 5.3.12 Option (D) is correct.

V can not be determined without knowing the elements in box.

SOL 5.3.13 Option ( ) is correct.

Thevenin Voltage (open circuit voltage) **:**



Writing KCL

$$\frac{V_{Th}-10}{2} = 4V_s$$

$$V_{Th} = 8V_s + 10 \quad ...(i)$$

$$10 - V_{Th} = V_s \quad ...(ii)$$

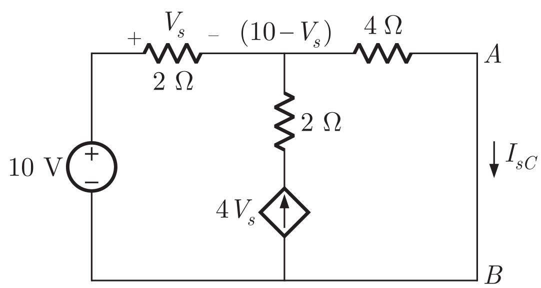
From equation (i) and (ii)

$$V_{Th} = 8(10 - V_{Th}) + 10 = 80 - 8V_{Th} + 10 = 10\text{ V}$$

Thevenin resistance :

$$R_{Th} = \frac{V_{Th}}{I_{sc}}$$

I_{sc} is short circuit current through terminal A, B



$$I_{sc} = \frac{10 - V_s}{4} \quad ...(iii)$$

Writing KCL at top center node

$$\frac{V_s}{2} + 4V_s = I_{sc}$$

$$\frac{9}{2}V_s = I_{sc}$$

$$V_s = \frac{2}{9}I_{sc}$$

Substituting V_s into equation (iii)

$$4I_{sc} = 10 - \frac{2}{9}I_{sc}$$

Substituting V_s in to equation (i)

$$4I_{sc} = 10 - \frac{2}{9}I_{sc}$$

$$\frac{38}{9}I_{sc} = 10$$

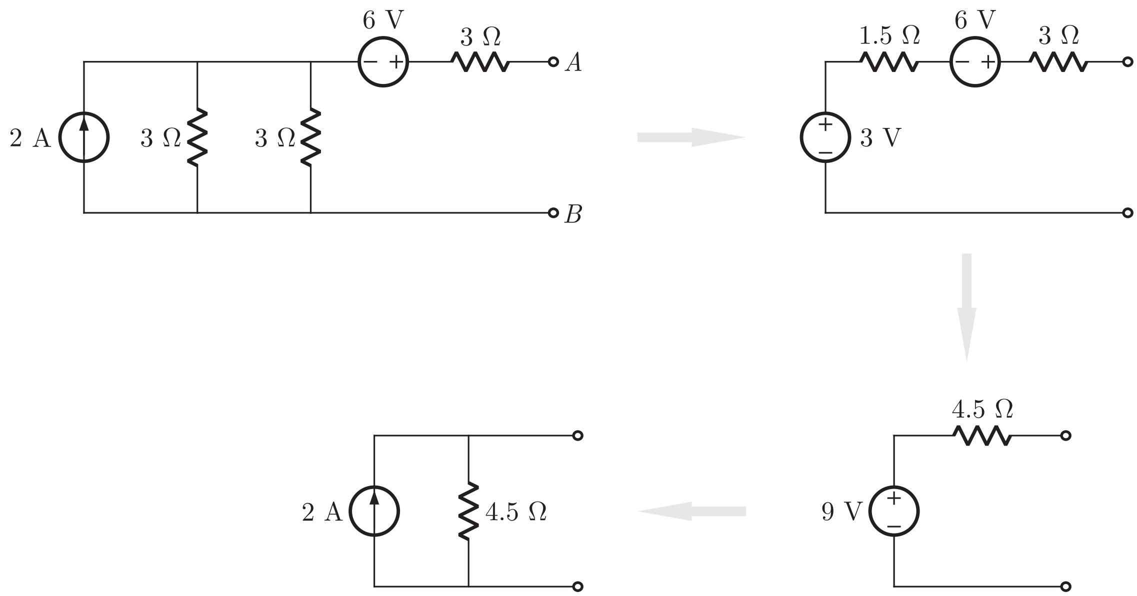
$$I_{sc} = \frac{90}{38}\text{ A}$$

$$R_{Th} = \frac{10}{90/38} = \frac{38}{9}\text{ A}$$

None of the option is correct.

SOL 5.3.14 Option (B) is correct.

Using source transformation

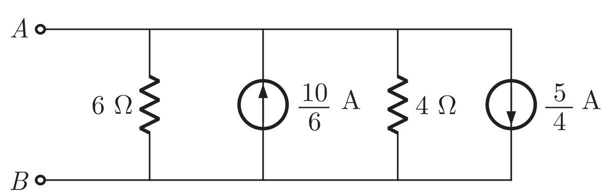


So, $I_N = 2\text{ A}$

$R_N = 4.5\,\Omega$

SOL 5.3.15 Option (B) is correct.

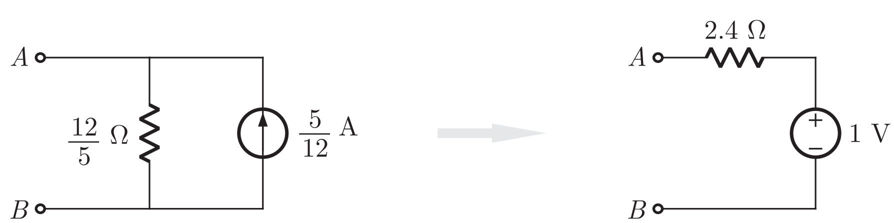
Using source transformation



Adding parallel connected current source and combining the resistance

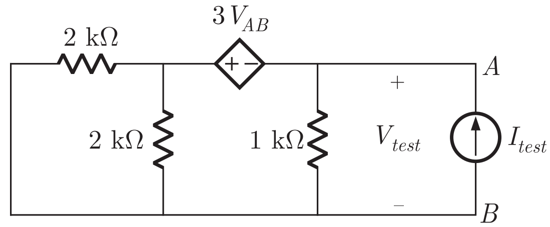
$$I = \frac{10}{6} - \frac{5}{4} = \frac{5}{12}\text{ A}$$

$$R = \frac{12}{5}\,\Omega = 2.4\,\Omega$$



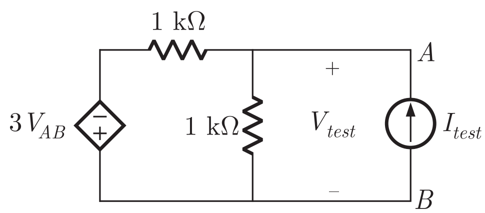
SOL 5.3.16 Option (B) is correct.

To obtain equivalent Thevenin resistance put a test source across A, B and set independent source to zero.



$$R_{Th} = \frac{V_{test}}{I_{test}}$$

Simplifying above circuit we have



Writing node equation at top right node

$$\frac{V_{test} + 3V_{AB}}{1\text{k}} + \frac{V_{test}}{1\text{k}} = I_{test}$$

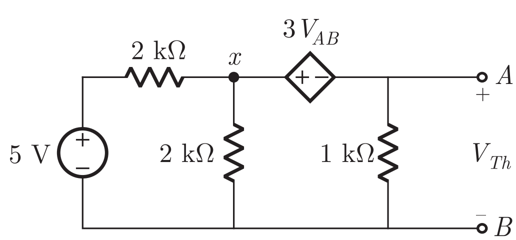
$$\frac{V_{test} + 3V_{test}}{1000} + \frac{V_{test}}{1000} = I_{test} \qquad (V_{AB} = V_{test})$$

$$5V_{test} = 1000 I_{test}$$

$$R_{Th} = \frac{V_{test}}{I_{test}} = 200\,\Omega = 0.2\,\text{k}\Omega$$

SOL 5.3.17 Option (D) is correct.

Thevenin voltage or open circuit voltage across A, B can be computed using the circuit below.



Writing node equation at node x

$$\frac{(V_{Th} + 3V_{AB}) - 5}{2\text{k}} + \frac{V_{Th} + 3V_{AB}}{2\text{k}} + \frac{V_{Th}}{1\text{k}} = 0$$

$$V_{Th} + 3V_{AB} - 5 + V_{Th} + 3V_{AB} + 2V_{Th} = 0$$

$$10V_{Th} - 5 = 0 \qquad (V_{AB} = V_{Th})$$

$$V_{Th} = 0.5\text{ V}$$

SOL 5.3.18 Option (B) is correct.

$$V + I = 100 \qquad \text{...(i)}$$

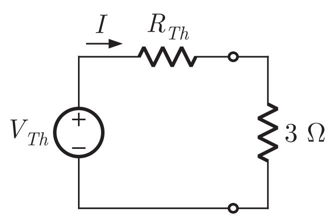
Applying KVL in the loop

$$V - 1I = 0 \qquad \text{...(ii)}$$

From equation (i) and (ii)

$$2I = 100 \Rightarrow I = 50\text{ A}$$

SOL 5.3.19 Option (A) is correct.



Power transferred to the load

$$P = I^2 R_L = \left(\frac{10}{R_{Th} + R_L}\right)^2 R_L$$

For maximum power transfer R_{Th}, should be minimum.

$$R_{Th} = \frac{6R}{6+R} = 0$$

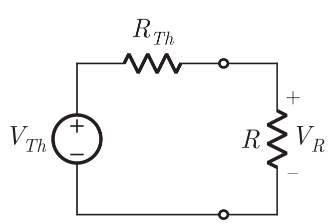
$$R = 0$$

Note :

Do not get confused with maximum power transfer theorem. According to maximum power transfer theorem if R_L is variable and R_{Th} is fixed then power dissipated by R_L is maximum when $R_L = R_{Th}$.

SOL 5.3.20 Option (A) is correct.

Let Thevenin equivalent voltage of dc network is V_{Th} and Thevenin resistance is R_{Th}.



$$V_R = \frac{R}{R + R_{Th}} V_{Th}$$

$$20 = \frac{10}{10 + R_{Th}} V_{Th} \qquad \text{...(i)}$$

$$30 = \frac{20}{20 + R_{Th}} V_{Th} \qquad \text{...(ii)}$$

Dividing equation (i) and (ii)

$$\frac{2}{3} = \frac{10}{20}\left(\frac{20 + R_{Th}}{10 + R_{Th}}\right)$$

$$40 + 4R_{Th} = 60 + 3R_{Th}$$

$$R_{Th} = 20\,\Omega$$

Substituting R_{Th} into equation (i)

$$20 = \frac{10}{10+20} V_{Th}$$

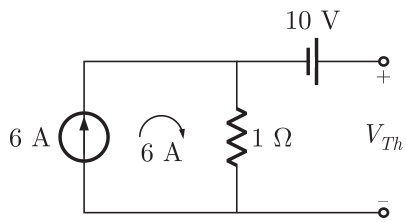
$$V_{Th} = 60\text{ V}$$

For $R = 80\,\Omega$, $\quad V_R = \frac{80}{80+20}(60) = 48\text{ V}$

SOL 5.3.21 Option (C) is correct.

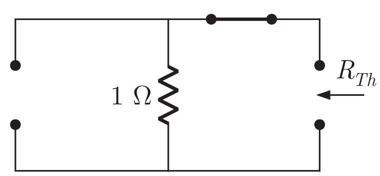
We obtain Thevenin equivalent across R.

Thevenin voltage (Open circuit voltage) **:**



$$V_{Th} = (6 \times 1) + 10 = 16\text{ V}$$

Thevenin resistance :



$$R_{Th} = 1\,\Omega$$

For maximum power transfer

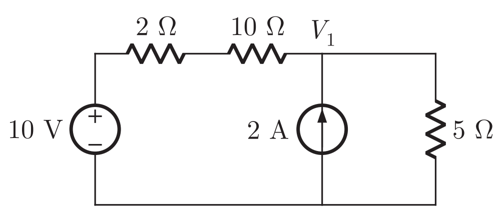
$$R = R_{Th} = 1\,\Omega$$

The maximum power will be

$$P_{\max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{(16)^2}{4} = 64\text{ W}$$

SOL 5.3.22 Option (B) is correct.

Transforming the 5 A current source into equivalent voltage source



Writing node equation

$$\frac{V_1 - 10}{12} + \frac{V_1}{5} = 2$$

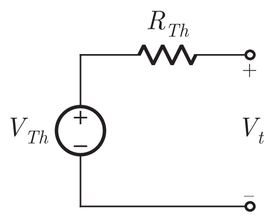
$$5V_1 - 50 + 12V_1 = 120$$
$$17V_1 = 170$$
$$V_1 = 10\text{ V}$$

Current in $5\,\Omega$ resistor

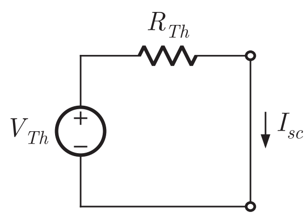
$$I_{5\,\Omega} = \frac{V_1}{5} = \frac{10}{5} = 2\text{ A}$$

SOL 5.3.23 Option (C) is correct.

Let the circuit is

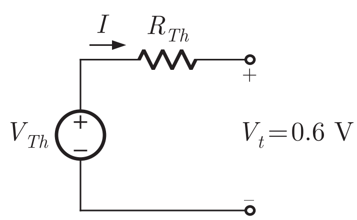


Short circuit current $I_{sc} = 75\text{ mA}$



$$I_{sc} = \frac{V_{Th}}{R_{Th}} = 75\text{ mA} \qquad \text{...(i)}$$

$$V_t = 0.6, \qquad I = 70\text{ mA}$$



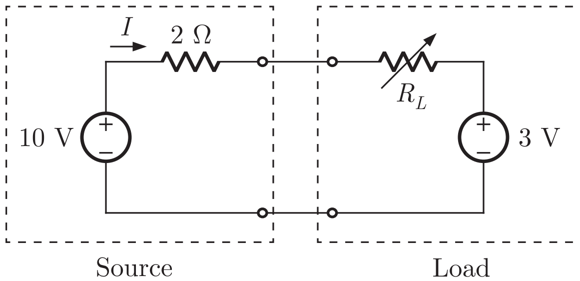
$$I = \frac{V_{Th} - 0.6}{R_{Th}} = 70\text{ mA}$$

$$V_{Th} - 0.6 = 70 \times 10^{-3} R_{Th} \qquad \text{...(ii)}$$

From equation (i) and (ii)

$$75 \times 10^{-3} R_{Th} - 0.6 = 70 \times 10^{-3} R_{Th}$$
$$5 \times 10^{-3} R_{Th} = 0.6$$
$$R_{Th} = 120\,\Omega$$

SOL 5.3.24 Option (C) is correct.



Current in the circuit

$$I = \frac{10-3}{2+R_L} = \frac{7}{2+R_L}$$

Power delivered from source to load will be sum of power absorbed by R_L and power absorbed by 3 V source

$$P = \left(\frac{7}{2+R_L}\right)^2 R_L + \left(\frac{7}{2+R_L}\right) \times 3$$

$$= \frac{49R_L + 21(2+R_L)}{(2+R_L)^2}$$

$$= \frac{(42+70R_L)}{(2+R_L)^2}$$

For maximum power transfer $\frac{dP}{dR_L} = 0$

$$\frac{(2+R_L)^2[0+70] - (42+70R_L)[4(2+R_L)]}{(2+R_L)^4} = 0$$

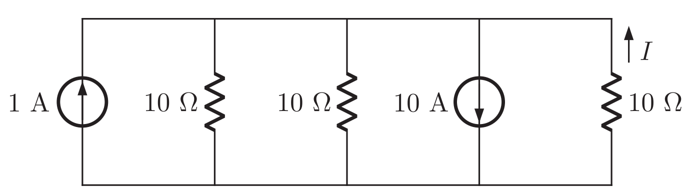
$$(2+R_L)(70) - (42+70R_L)(2) = 0$$

$$140 + 70R_L - 84 - 140R_L = 0$$

$$R_L = \frac{4}{5} = 0.8\,\Omega$$

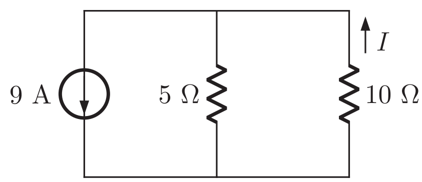
SOL 5.3.25 Option (A) is correct.

Transforming 10 V source into equivalent current source



$$10\,\Omega \,||\, 10\,\Omega = 5\,\Omega$$

$$10\text{ A} - 1\text{ A} = 9\text{ A}$$



$$I = \frac{5}{5+10}(9) \qquad \text{(Using current division)}$$
$$= 3 \text{ A}$$

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