Purdue University

Elmore Family School of Electrical and Computer Engineering

Electrical Engineering Fundamentals I

ECE 20001

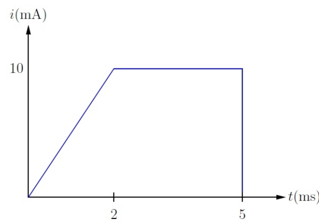
Collection of Practice Problems

August 18, 2022

Contents

1 Power, Current, and Voltage

1.1 The current flowing past a point in a device is shown below. Calculate the total charge through the device.



(1) 60 μC

(2) 20 μC

(3) 50 μC

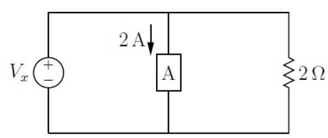
(4) 40 μC

(5) 100 μC

(6) 10 μC

(7) None of the above.

1.2 Find V_x so that the device A below generates 10 W.



(1) -2 V

(2) 2.5 V

(3) 10 V

(4) 0.2 V

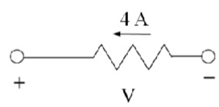
(5) -5 V

(6) -10 V

(7) 2 V

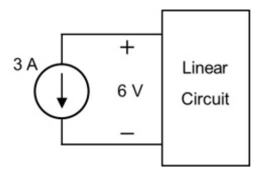
(8) None of the above.

1.3 A resistor of unknown resistance has a 4 A current passing through it as shown. The power absorbed by the resistor is 12 W. Find the voltage (in V) across the resistor for these conditions.



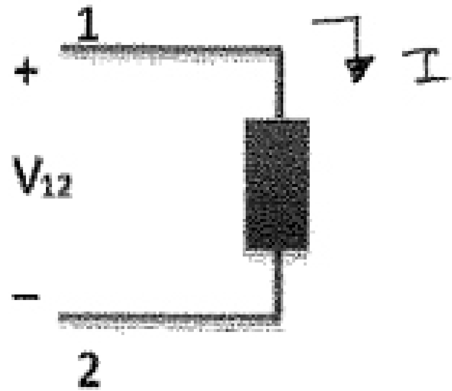
(1) 1 V
(2) 2 V
(3) 3 V
(4) 4 V
(5) -1 V
(6) -2 V
(7) -3 V
(8) -4 V
(9) None of the above

1.4 In the circuit shown below, find the power **delivered** by the current source (in W).



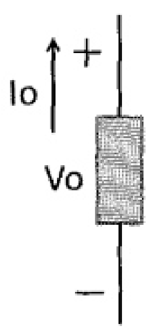
(1) −18
(2) −12
(3) −6
(4) −3
(5) 3
(6) 6
(7) 12
(8) 18
(9) None of the above

1.5 A charge rate of -10C/s passes through the device shown from point 2 to point 1. If the device absorbs 200W of power, find the voltage V_{12} across it.



(1) -20 V
(2) -10 V
(3) -1 V
(4) 0 V
(5) 1 V
(6) 10 V
(7) 20 V
(8) None of the above.

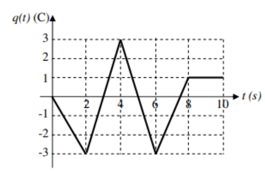
1.6 In the given circuit element below, $V_o = 5V$ and $I_o = 1A$ with the sign convention shown. Please find the power consumed and the power generated.

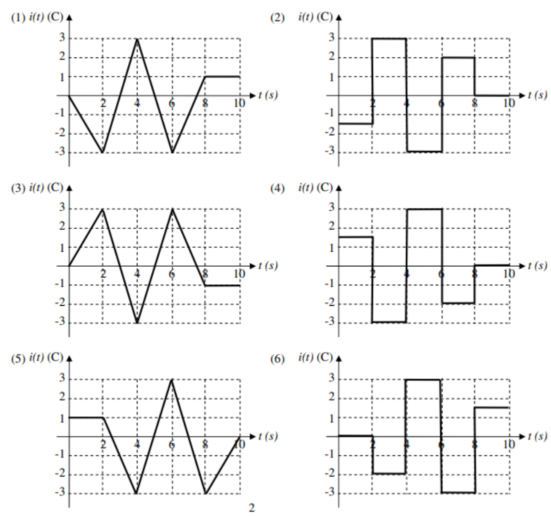


(1) 25W, 25W
(2) -25W, 25W
(3) 5W, 5W

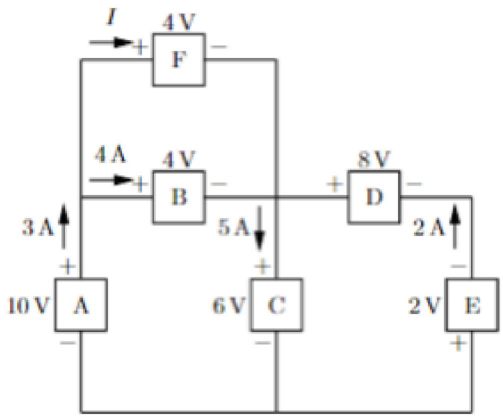
(4) -5W, 5W
(5) 0W, 5W
(6) -25W, -25W
(7) 25W, -25W
(8) -5W, -5W
(9) 5W, -5W
(10) None of the above.

1.7 The charge crossing a boundary in a wire is shown below for $t \geq 0$. Select the current $i(t)$ through it.





1.8 a. Find the power generated or absorbed by each element EXCEPT F. Use the passive sign convention.
b. Use conservation of power to find the power generated or absorbed by element F, and find the current I.



1.9 Fig. 1(a) illustrates the charge flow in a conductor. The net charge accumulated on the right side of the cross-section is shown in Fig 1(b) for the time $0 < t < 4$. The reference current direction is from left to right, as shown in Fig 1(a). Plot the correct current flow in this time period.

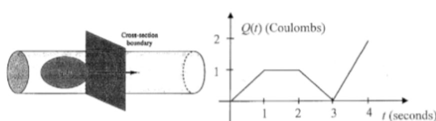
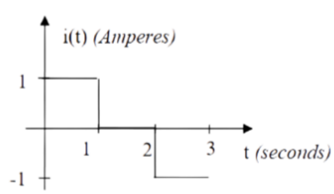
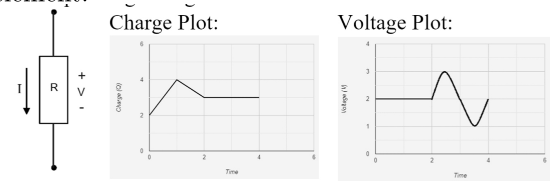


Fig. 1(a) Fig. 1(b)

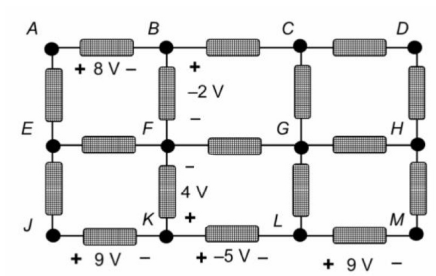
1.10 The figure illustrates below the charge flow in a conductor. The reference current direction is from left to right, as shown. Given $q(0) = 0$, plot the Charge vs. Time Graph given the Current vs. Time graph below.



1.11 The plots of charge flowing through an element and corresponding voltage across it are as follows. Sketch the plot of the power absorbed by the element.

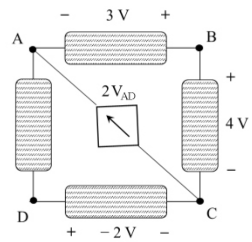


1.12 In the circuit shown, rectangular shapes represent general circuit elements (either resistors or sources). Find the voltage V_{MA} (in V).



(1) 3
(2) -3
(3) 6
(4) -6
(5) 8
(6) -8
(7) 9
(8) -9
(9) None of the choices

1.13 The shaded boxes below are arbitrary circuit elements. Find the power **delivered** by the dependent current source (in W).



(1) −2

(2) −4

(3) −6

(4) 2

(5) 4

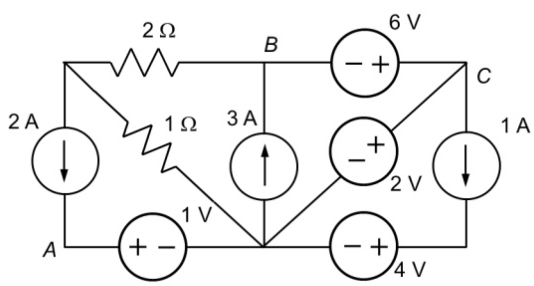
(6) 6

(7) 8

(8) 0

(9) None of the above

1.14 Find the voltage V_{AB} (in V).



(1) 1

(2) 2

(3) 3

(4) 4

(5) 5

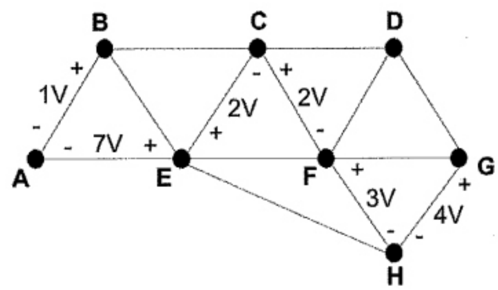
(6) 6

(7) 7

(8) 8

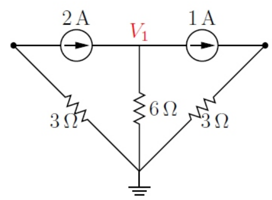
(9) 9

1.15 In the figure below, find the voltage between nodes B and G. Assume that there is some sort of circuit element in between each of the nodes establishing the given voltages.



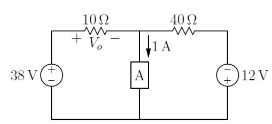
2 Fundamental Laws

2.1 Find the nodal voltage V_1 in the following circuit.

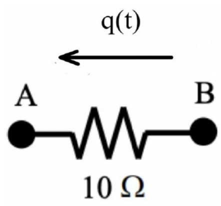


1. 3 V
2. −6 V
3. 6 V
4. 9 V
5. −4 V
6. 0 V
7. −3 V
8. None of the above.

2.2 The power absorbed by element A is 20 W. Find the voltage V_0. All sources are DC.

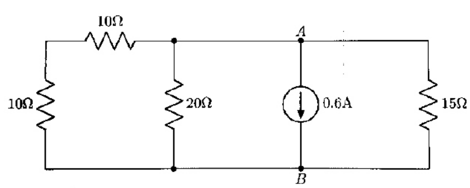


2.3 A positive charge $q(t) = 2(C)$ flows from B to A, find $V_{AB}(= V_A - V_B)$in V:

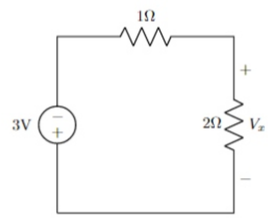


(1) 10
(2) -10
(3) 20
(4) -20
(5) 30
(6) -30
(7) 40
(8) -40
(9) None of the choices

2.4 What is the equivalent resistance, in Ω, as seen by the $0.6A$ current source (node AB)?

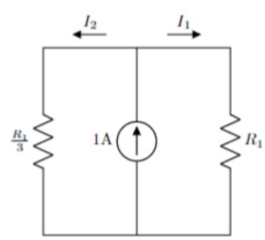


2.5 Find the voltage, V_x.



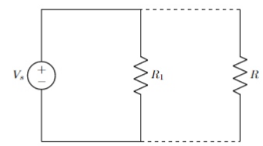
1. 1 V
2. 1.5 V
3. 2 V
4. 3 V
5. -1 V
6. -1.5 V
7. -2 V
8. -3 V
9. None of the above.

2.6 Find the current, I_2



1. 0.25 A
2. 0.5 A
3. 0.75 A
4. 1 A
5. -0.25 A
6. -0.5 A
7. -0.75 A
8. -1 A
9. None of the above.

2.7 When a finite-valued, non-zero resistor is placed in parallel with R_1, what will happen to the power delivered from the source (**question 8**), to the power delivered to R_1 (**question 9**), and to the resistance seen by the source (**question 10**)? **You must explain your reasoning to receive full credit.**



Question 8

1. increases
2. decreases
3. stays the same

Question 9

1. increases
2. decreases
3. stays the same

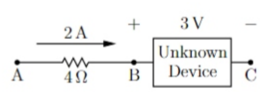
Question 10

1. increases
2. decreases
3. stays the same

2.8 In a circuit with linear elements the equivalent resistance is contributed by ______.

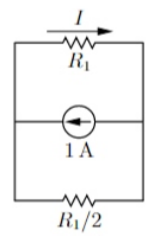
(1) Resistors
(2) Independent sources
(3) Dependent sources
(4) Both (1) and (2)
(5) Both (1) and (3)
(6) Both (2) and (3)
(7) All (1), (2) and (3)
(8) None of the above.

2.9 What is the voltage difference V_{AC} in the following circuit?



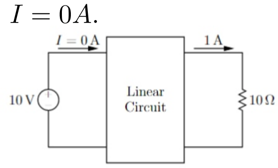
1. 10 V
2. 11 V
3. 12 V
4. −10 V
5. −11 V
6. −12 V
7. 0 V
8. None of the above.

2.10 Calculate the current I through the resistor R_1.



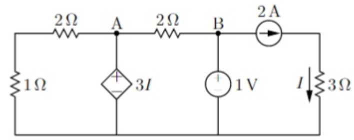
1. $-1\,\mathrm{A}$
2. $-2/3\,\mathrm{A}$
3. $-1/3\,\mathrm{A}$
4. $0\,\mathrm{A}$
5. $1/3\,\mathrm{A}$
6. $2/3\,\mathrm{A}$
7. $1\,\mathrm{A}$
8. None of the above.

2.11 Calculate the power delivered by the independent $10-V$ voltage source. The current $I = 0A$.



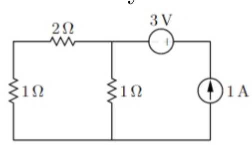
1. $-10\,\mathrm{W}$
2. $-5\,\mathrm{W}$
3. $-2.5\,\mathrm{W}$
4. $0\,\mathrm{W}$
5. $2.5\,\mathrm{W}$
6. $5\,\mathrm{W}$
7. $10\,\mathrm{W}$
8. None of the above.

2.12 Find the nodal voltage V_A in the following circuit.



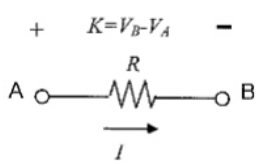
1. 0 V
2. 2 V
3. 4 V
4. 6 V
5. 8 V
6. 10 V
7. 12 V
8. 14 V
9. None of the above.

2.13 Find the power consumed by the 2 Ω resistor in the following circuit.



1. 0 W
2. 1/8 W
3. 1/4 W
4. 1/2 W
5. 1 W
6. 2 W
7. 4 W
8. 8 W
9. None of the above.

2.14 In the following figure we define $K = V_B - V_A$.



The relationship of K and I, as defined in the above figure, is:

(1) $K = IR$
(2) $K = -IR$

(3) Neither

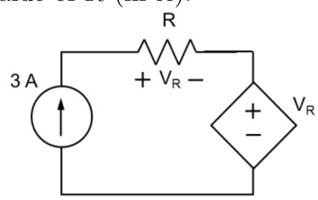
IIn this convention, what would be the power that the resistor dissipates?:

(1) $P = I^2R$

(2) $P = -I^2R$

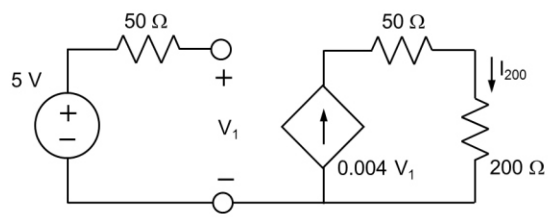
(3) Neither

2.15 In the circuit below, the dependent voltage source absorbs 3W of power. Find the value of R (in Ω).



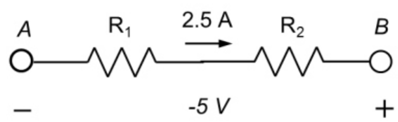
(1) 1
(2) 1/2
(3) 1/3
(4) 1/4
(5) 2/3
(6) 3/4
(7) 2
(8) 3
(9) None of the above

2.16 In the circuit shown, determine the current through the 200Ω resistor (in mA).



1) 10
2) 20
3) 30
4) 40
5) 50
6) 100
7) 200
8) 0
9) Impossible to answer
10) None of the above

2.17 Which of the following resistor combinations is **not** possible?



(1) $R_1 = 1\ \Omega$, $R_2 = 1\ \Omega$

(2) $R_1 = 0\ \Omega$, $R_2 = 2\ \Omega$

(3) $R_1 = 0.5\ \Omega$, $R_2 = 0.5\ \Omega$

(4) $R_1 = 0.5\ \Omega$, $R_2 = 1.5\ \Omega$

(5) $R_1 = 2\ \Omega$, $R_2 = 0\ \Omega$

(6) None of the above

2.18 Solve below:

The voltage drop across a 20 ohm resistor varies with time according to the following:

$$v(t) = 0 \text{ V for } t < 0;\ v(t) = 60 + 40t \text{ V} \quad (t \geq 0)$$

where time (t) is measured in seconds. What is the quantity of charge that passes through the resistor between 1 and 3 sec (in Coulombs):

(1) 4

(2) 6

(3) 8

(4) 10

(5) 12

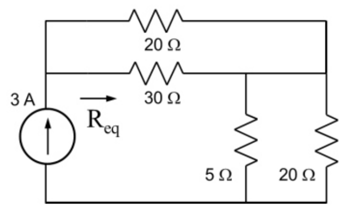
(6) 14

(7) 16

(8) 18

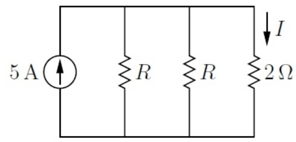
(9) None of the above

2.19 Find the R_{eq} in Ω



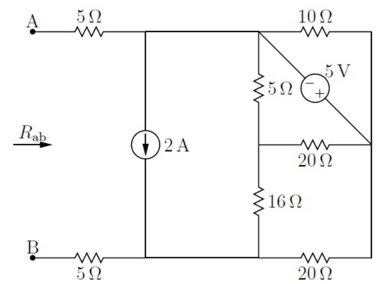
(1) 12
(2) 2
(3) 3
(4) 8
(5) 16
(6) 24
(7) 32
(8) 36
(9) None of the above

2.20 Find the value R so that $I = 2.5A$.



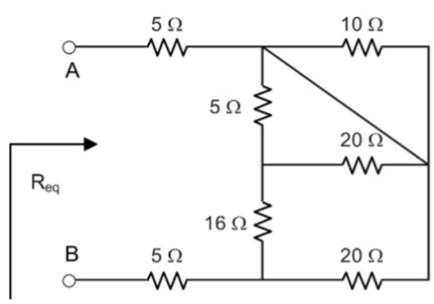
(1) 2 Ω
(2) 8 Ω
(3) 4 Ω
(4) 0.5 Ω
(5) 6 Ω
(6) 0.25 Ω
(7) 1 Ω
(8) None of the above.

2.21 Find the equivalent resistance R_{ab} in the circuit below.



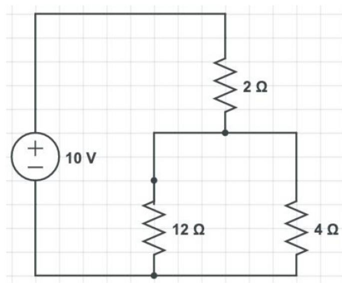
1. $12.5\,\Omega$
2. $10\,\Omega$
3. $15\,\Omega$
4. $25\,\Omega$
5. $2.5\,\Omega$
6. $5\,\Omega$
7. $20\,\Omega$
8. None of the above.

2.22 Find the equivalent resistance (R_{eq}) across Port A and B?



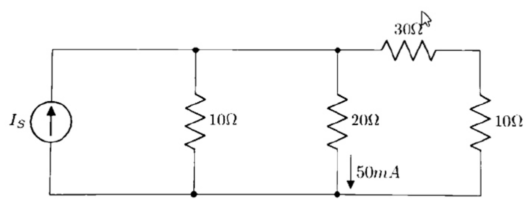
1) 5 Ω
2) 25 Ω
3) 15 Ω
4) 12.5 Ω
5) 10 Ω
6) 20 Ω
7) 2.5 Ω
8) None of the above

2.23 The power P_d absorbed in the 2Ω resistor (in Watts) is:

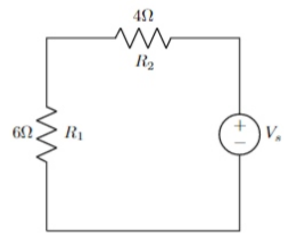


(1) 3
(2) 6
(3) 8
(4) 9
(5) 12
(6) 20
(7) 36
(8) None of the choices

2.24 Determine the source current, I_S, in mA.

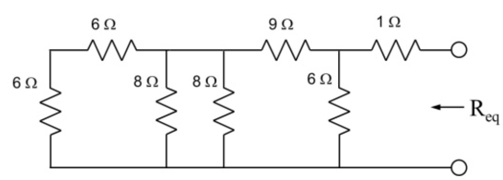


2.25 What must V_s be such that the power absorbed by R_2 is 4 W.



1. 1 V
2. 1.5 V
3. 2 V
4. 4 V
5. 6 V
6. 8 V
7. 9 V
8. 10 V
9. None of the above.

2.26 Find the equivalent resistance for the circuit shown (in Ω).



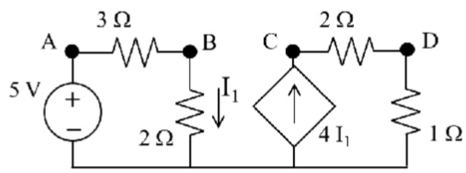
(1) 1
(2) 2
(3) 3
(4) 4
(5) 5
(6) 6
(7) 7
(8) 8
(9) None of the above

2.27 Two resistors with values of 2Ω and 200Ω are connected in parallel. The current through the 2Ω resistor is 1A. Approximately how much total power is consumed by both resistors?

(1) 1W
(2) 2W
(3) 3W

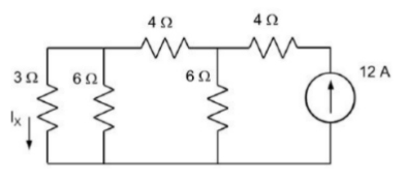
(4) 4W
(5) 5W
(6) 6W
(7) 7W
(8) 8W
(9) None of the above.

2.28 For the circuit below, find the voltage, V_{BC} (in V)



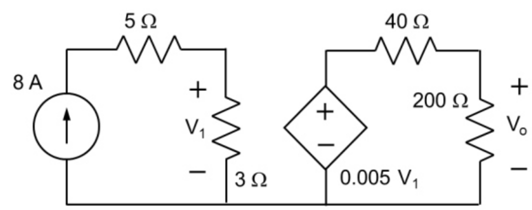
(1) 2
(2) 8
(3) 10
(4) 12
(5) 20
(6) -2
(7) -8
(8) -10
(9) -12
(10) None of the above

2.29 Solve the questions below.



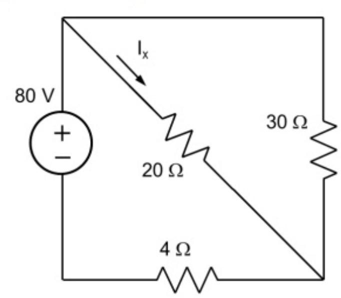
a. Find the equivalent resistance seen by the 12A source.
b. Use the voltage across the 12A source to back-calculate the indicated current.

2.30 In the circuit below, find the value of V_o (in mV).



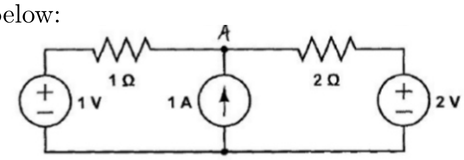
1) 10
2) 20
3) 30
4) 40
5) 50
6) 100
7) 200
8) 0
9) None of the above

2.31 In the circuit shown below, find the current



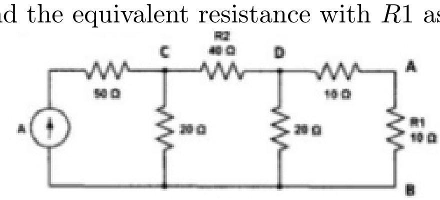
(1) 1 A
(2) 2 A
(3) 3 A
(4) 4 A
(5) 5 A
(6) 6 A
(7) 7 A
(8) 8 A
(9) None of the above

2.32 Solve below:



Find the power generated or absorbed by all elements in the above circuit. Use the active sign convention for sources and the passive sign convention for resistors.

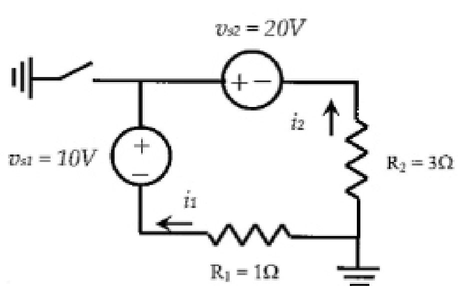
2.33 Find the equivalent resistance with $R1$ as the load (between A and B)



2.34 Assume a parallel combination of infinite number of resistors. The resistors are given by the formula $R_n = 2^n\Omega$, $n = 0, 1, 2, 3, \cdots$ If the current through the first resistor is $1A$, which of the following numbers is closest to the total amount of current that flows through all resistors?

(1) 0.5A
(2) 1A
(3) 1.5A
(4) 2A
(5) 2.5A
(6) 3A
(7) 3.5A
(8) 4A
(9) 4.5A
(10) None of the above.

2.35 Calculate the current i_1 and i_2 (in A) in the following circuit when the switch is open and closed.



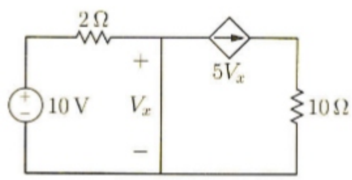
Switch opened:

(1) $i_1 = 5,\ i_2 = -5$
(2) $i_1 = -5,\ i_2 = -5$
(3) $i_1 = -2.5,\ i_2 = 2.5$
(4) $i_1 = 2.5,\ i_2 = -2.5$
(5) $i_1 = 2.5,\ i_2 = 2.5$
(6) $i_1 = -2.5,\ i_2 = -2.5$

Switch closed:

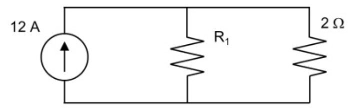
(1) $i_1 = -2.5,\ i_2 = 2.5$
(2) $i_1 = 20/3,\ i_2 = 10$
(3) $i_1 = -10,\ i_2 = -20/3$
(4) $i_1 = 10,\ i_2 = 20/3$
(5) $i_1 = -20/3,\ i_2 = -10$
(6) $i_1 = 10,\ i_2 = -20/3$

2.36 What is the power delivered by the voltage source in the following circuit?

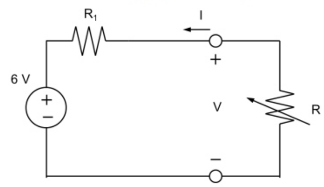


(1) 10W
(2) 20W
(3) 30W
(4) 40W
(5) 50W
(6) 60W
(7) 70W
(8) 80W
(9) None of the above

2.37 A resistor with unknown value, R_1 is connected to a 2 Ω resistor and a 12 A independent current source as shown below. In the configuration, the 2 Ω resistor absorbs 128 W



The same resistor is subsequently connected to a variable resistor (R) and voltage source as shown below. Find the correct current-voltage (I-V) relationship for this configuration.



(1) I = 2 V + 1.5

(2) I = 0.33 V + 6

(3) I = 0.25 V + 1.5

(4) I = 3 V + 1.5

(5) I = 2 V – 6

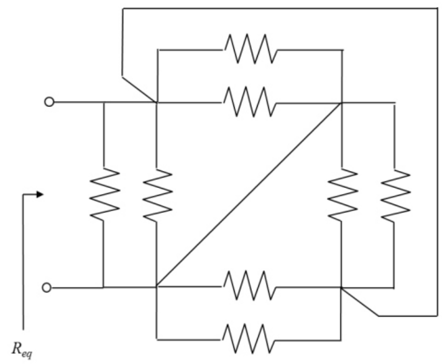
(6) I = 0.33 V – 6

(7) I = 0.25 V – 1.5

(8) I = 3 V – 6

(9) None of the above

2.38 Find the equivalent resistance as shown in the figure if all resistors have the same arbitrary value R.



(1) R/8

(2) R/4

(3) R/2

(4) R

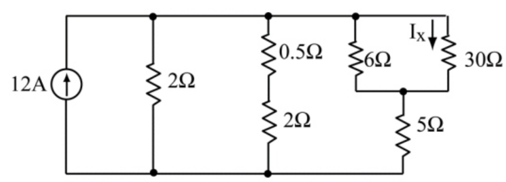
(5) 2R

(6) 4R

(7) 8R

(8) None of the above

2.39 For the circuit below, find the current I_x (in A).



(1) 1

(2) 2

(3) 3

(4) 0.1

(5) 0.2

(6) 0.3

(7) 0.4

(8) None of the above

3 Analysis Using Kirchhoff's Laws

3.1 Nodal analysis is done to find ______ by following ______ using ______.

(1) nodal voltages, KCL, element/branch currents

(2) nodal voltages, KCL, element/branch currents

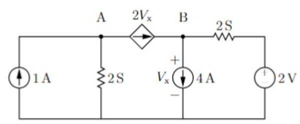
(3) Elemental voltages, KCL, mesh currents

(4) nodal voltages, KCL, mesh currents

(5) Elemental voltages, KCL, element/branch currents

(6) None of the above

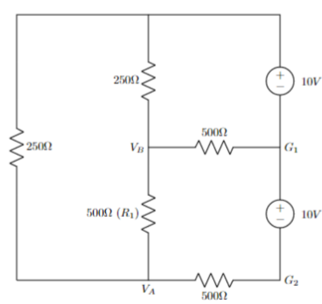
3.2 Which of the following is the current nodal equation for node A in the following circuit? Note that the conductance values are given for the resistors in the circuit.



1. $V_A + V_B = 0$
2. $V_A - V_B = 0$
3. $V_A + V_B = -1$
4. $V_A + V_B = 1$
5. $V_A + V_B = -1/2$
6. $V_A + V_B = 1/2$
7. None of the above.

3.3 Solve the question below:

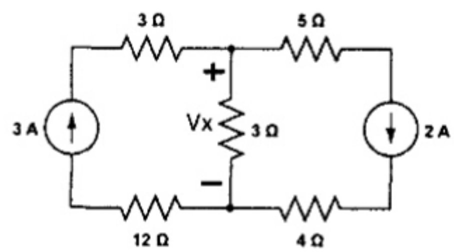
Question # 2



(a) Find the Nodal Voltage V_A, V_B and the voltage across the resistor R_1 using Nodal Analysis when the reference ground is at G_1.

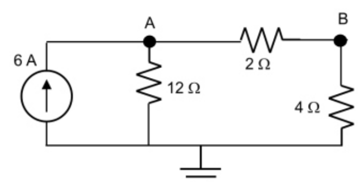
(b) Find the Nodal Voltage V_A, V_B and the voltage across the resistor R_1 using Nodal Analysis when the reference ground is at G_2 and explain how the values of Nodal Voltages and Voltage across the Resistor compare in each case.

3.4 In the given circuit below, please find V_x



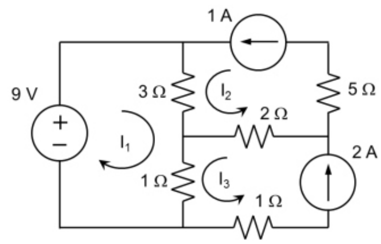
(1) 3
(2) 6
(3) 9
(4) 12
(5) 24
(6) 36
(7) 48
(8) 60
(9) None of the above

3.5 In the circuit shown below, find the nodal voltage V_A (in V).



(1) 3
(2) 6
(3) 9
(4) 12
(5) 24
(6) 36
(7) 48
(8) 60
(9) None of the above

3.6 In the circuit shown below, find the loop current I_1 (in A).



(1) 1

(2) 2

(3) 3

(4) 4

(5) 5

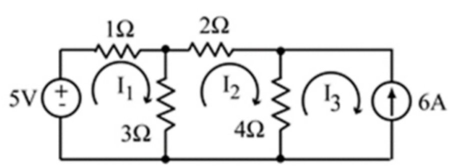
(6) 6

(7) 7

(8) 8

(9) None of the above

3.7 Find the mesh equations of the loops shown below.



(1) $2I_1 - 3I_2 = 5,\quad -3I_1 + 5I_2 = 24$

(2) $2I_1 + 3I_2 = 5,\quad 3I_1 - 5I_2 = 24$

(3) $2I_1 + 3I_2 = 5,\quad -3I_1 + 5I_2 = 24$

(4) $4I_1 + 3I_2 = 5,\quad 3I_1 + 9I_2 = -24$

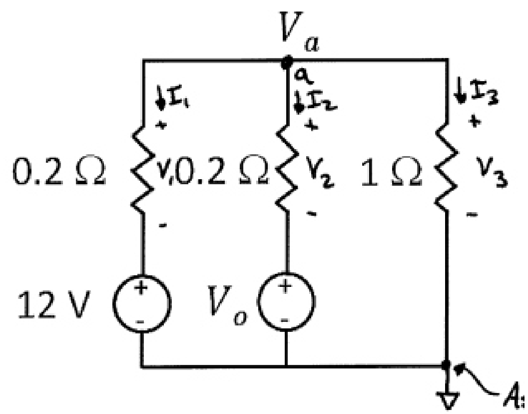
(5) $4I_1 + 3I_2 = 5,\quad 3I_1 - 9I_2 = 24$

(6) $4I_1 - 3I_2 = 5,\quad 3I_1 + 9I_2 = -24$

(7) $4I_1 - 3I_2 = 5,\quad -3I_1 + 9I_2 = -24$

(8) None of the above

3.8 Choose the node equation that can be used to correctly calculate the votlage V_a in this diagram:



(1) $0.2(V_a - 12) + 0.2(V_a - V_0) + V_a = 0$

(2) $5(V_a - 12) + 5(V_a - V_0) + V_a = 0$

(3) $5(V_a + 12) + 5(V_a + V_0) + 2V_a = 0$

(4) $11(V_a - 12 - V_0) = 0$

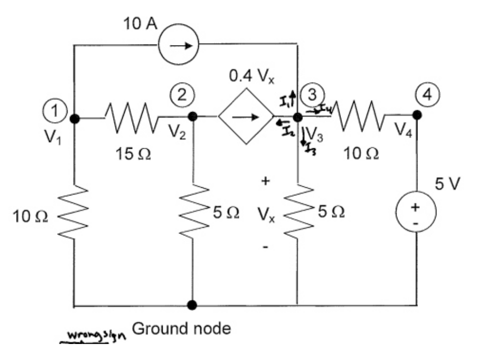
(5) $(V_a - 12)/5 + (V_a - V_0)/5 + V_a = 0$

(6) $V_a = (V_0 + 12)/2$

(7) $V_a = 12 = V_0 + 0.2 + 0.2 + 1$

(8) None of the above

3.9 Which of the following equations correctly describes its corresponding node in the diagram below?



(1) $\frac{V_1}{10} + \frac{V_2 - V_1}{15} + 10 = 0$ (node 1)

(2) $15(V_2 - V_1) + 5V_2 + 0.4V_x = 0$ (node 2)

(3) $0.4V_x + 10 + \frac{V_3 - V_4}{10} + \frac{V_3}{5} = 0$ (node 3)

(4) $\frac{V_3 - V_4}{10} + 5 = 0$ (node 4)

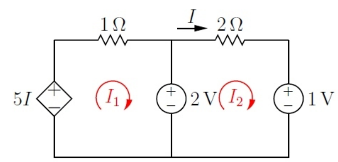
(5) $\frac{V_1}{10} + \frac{V_2}{5} + \frac{V_x}{5} = 0$ (Ground node)

(6) $\frac{V_2 - V_1}{15} + \frac{V_2}{5} + \frac{V_3}{5} = 0$ (node 2)

(7) $-10 - 0.4V_x + \frac{V_3}{5} + \frac{V_3 - 5}{10} = 0$ (node 3)

(8) $\frac{V_2 - V_1}{15} + \frac{V_2}{5} + \frac{V_3}{5} + \frac{V_3 - V_4}{10} + 10 = 0$ (node 2)

3.10 Find the mesh current I_1 in the following circuit.



(1) -3.5 A

(2) 2 A

(3) 1 A

(4) 4 A

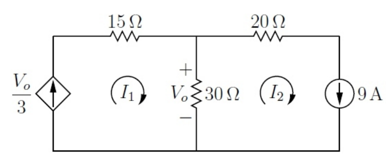
(5) 0.5 A

(6) -0.5 A

(7) -4 A

(8) None of the above.

3.11 Find the mesh current I_1 in the following circuit.



(1) 9 A

(2) -10 A

(3) 1 A

(4) 4 A

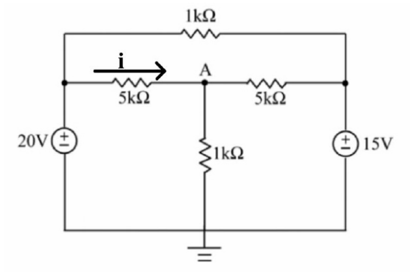
(5) 10 A

(6) -9 A

(7) -4 A

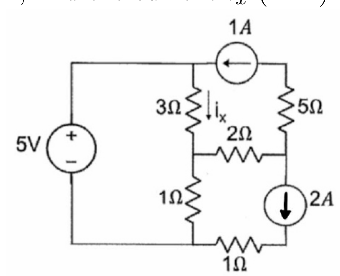
(8) None of the above.

3.12 Find the i in the circuit shown below (in mA)



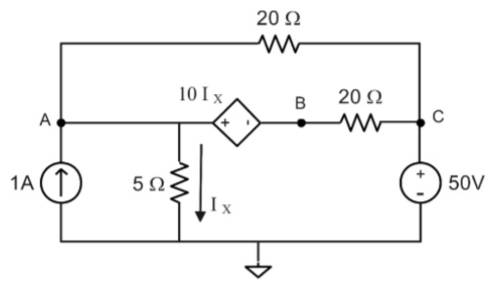
(1) 1
(2) 2
(3) 3
(4) 4
(5) 5
(6) 6
(7) 7
(8) None of the choices

3.13 In the circuit shown, find the current i_x (in A).



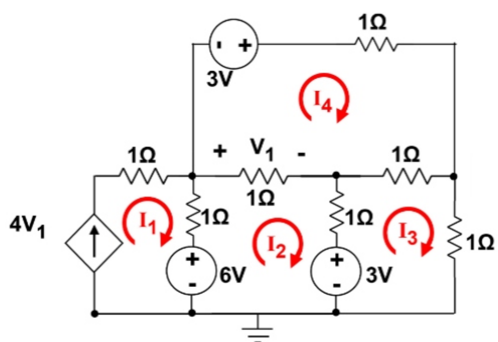
(1) 1
(2) -1
(3) 2
(4) -2
(5) 3
(6) -3
(7) 4
(8) -4
(9) None of the above

3.14 Find the current I_x in the circuit below (in A)



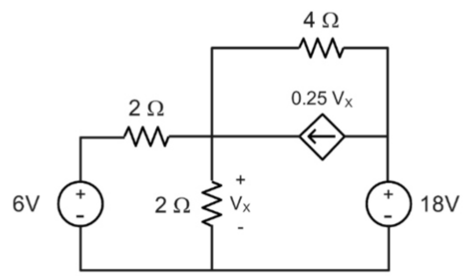
1) 8 A
2) -8 A
3) 2.5 A
4) -2.5 A
5) 10 A
6) -6 A
7) 6 A
8) None of the above

3.15 For the circuit below, the mesh currents $I_2 = 1\text{A}$ and $I_4 = 2\text{A}$. Find the mesh current I_1 and I_3.



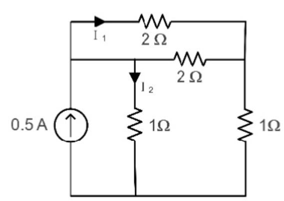
1) I_1 = - 4A, I_3 = 1A
2) I_1 = 4A, I_3 = - 2A
3) I_1 = 4A, I_3 = 4A
4) I_1 = - 4A, I_3 = - 4A
5) I_1 = 12A, I_3 = 2A
6) I_1 = -4A, I_3 = 2A
7) I_1 = -12A, I_3 = -2A
8) None of the above

3.16 Find V_x in the **figure below** using source transformation or any other method.



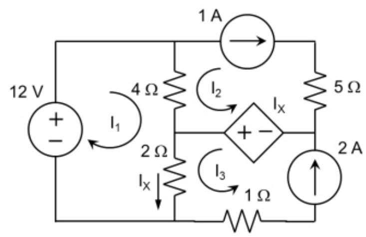
1) –1.5 V
2) +2.5 V
3) –3.0 V
4) +5.5 V
5) –7.5 V
6) +7.5 V
7) +8.0 V
8) None of the above

3.17 Find value of current $I_2 - I_1$?



1) 0 A
2) 0.25 A
3) 1 A
4) 2 A
5) 4 A
6) 10 A
7) 0.5 A
8) None of the above

3.18 In the circuit shown below, find the loop current I_1 (in A).



(1) 1

(2) 2

(3) 3

(4) 4

(5) 5

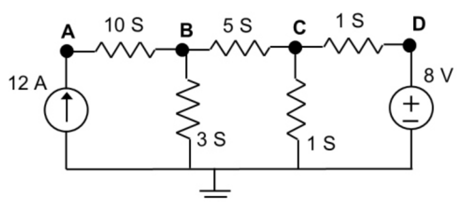
(6) 6

(7) 7

(8) 8

(9) None of the above

3.19 In the circuit below, find nodal voltage V_c (in V).



(1) 1

(2) 2

(3) 3

(4) 4

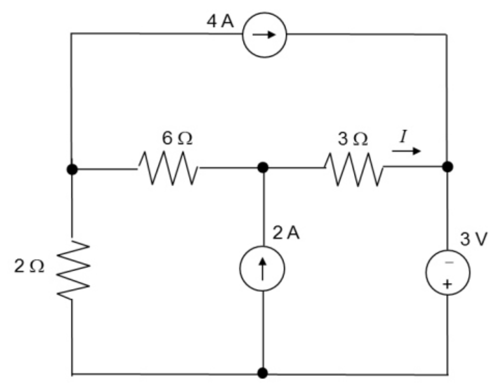
(5) 5

(6) 6

(7) 7

(8) None of the above

3.20 What is the current, I (in A), through the 3Ω resistor in figure?



(1) 5

(2) –5

(3) 3

(4) –3

(5) 2

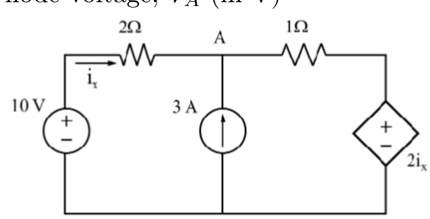
(6) –2

(7) 1

(8) –1

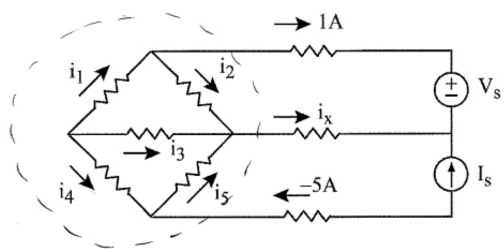
(9) None of the above

3.21 Find the node voltage, V_A (in V)



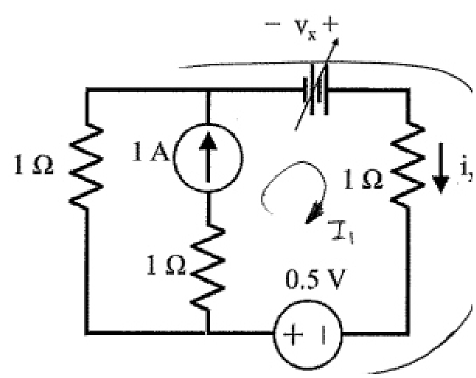
(1) 1.2
(2) 2.4
(3) 3.6
(4) 4.0
(5) 5.0
(6) 6.8
(7) 7.2
(8) 8.0
(9) None of the above

3.22 In the circuit shown below, find the current i_x.



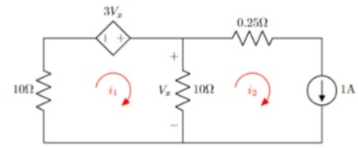
(1) -6A
(2) -4A
(3) -2A
(4) 0A
(5) 2A
(6) 4A
(7) 6A
(8) None of the above

3.23 The circuit below contains a variable voltage source (V_x). Select the value of V_x such that the current i_x is 1 A.



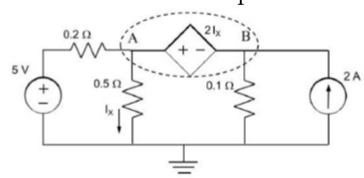
(1) -1V
(2) -0.5V
(3) -0.25V
(4) 0V
(5) 0.25V
(6) 0.5V
(7) 1V
(8) None of the above

3.24 What is the power delivered by the dependent source?



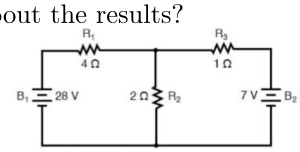
a. Identify the variables needed to find the power delivered by the dependent source.
b. Solve for the required variables in (a) using (1) nodal analysis, (2) mesh analysis.
c. Find the power delivered by the dependent source.

3.25 In the circuit shown, a supernode is drawn around nodes A and B (dashed line). Find the correct nodal equation for the supernode.



a. Derive the equation for the circled supernode.
b. Complete and solve the system of equations for the circuit.

3.26 Solve for the mesh currents in the above circuit in the following scenarios: (a) only B_1 on, (b) only B_2 on, when both B_1 and B_2 on. What do you notice about the results?

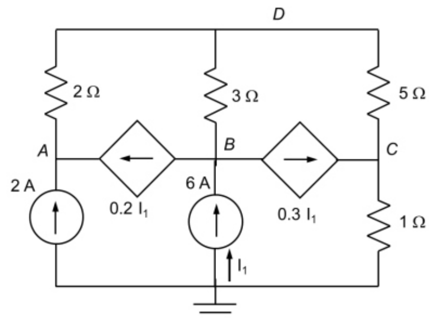


Answer: I_1(left) = 5 A, I_2(right) = 1 A

....

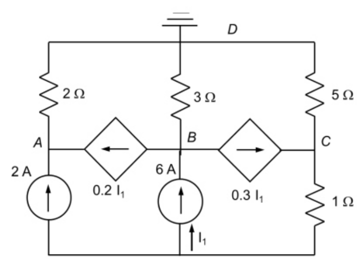
Solve for the two mesh currents in the above circuit in the following scenarios: (a) only B1 on, (b) only B2 on, © both B1 and B2 on. What do you notice about the results?

3.27 In the circuit shown below, find the nodal voltage V_B (in V).



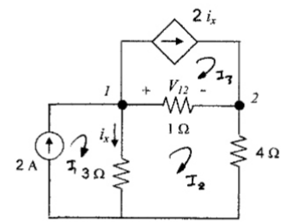
(1) 3
(2) 6
(3) 9
(4) 12
(5) 24
(6) 36
(7) 48
(8) 60
(9) None of the above

3.28 The circuit shown below is the same as in Question 5, except the ground node has been changed. Find the nodal voltage V_B (in V).



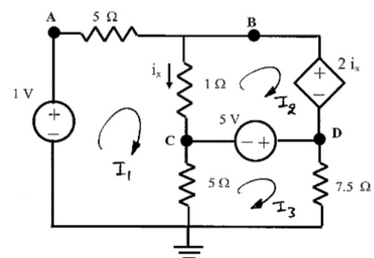
(1) 3
(2) 6
(3) 9
(4) 12
(5) 24
(6) 36
(7) 48
(8) 60
(9) None of the above

3.29 Please find the voltage V_{12} between nodes 1 and 2.



(1) 4V
(2) -4V
(3) 3V
(4) -4V
(5) 1V
(6) 0V
(7) -1V
(8) 5V
(9) -5V
(10) None of the above

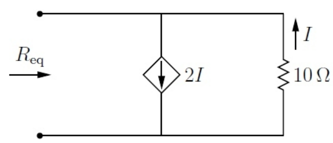
3.30 Find the power delivered by the dependent source (in W) using nodal analysis or mesh analysis:



(1) 60
(2) 50
(3) 40
(4) 40
(5) 25
(6) 20
(7) None of the above

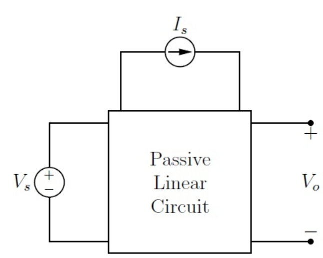
4 Powerful Circuit Theorems

4.1 For the circuit below find R_{eq}.



(1) 5 Ω
(2) -10 Ω
(3) 3 Ω
(4) 12 Ω
(5) 4 Ω
(6) -12 Ω
(7) 0 Ω
(8) None of the above.

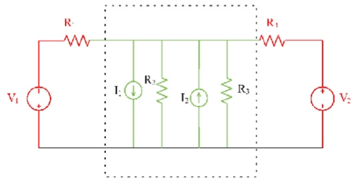
4.2 For the following linear circuit, complete the table below.



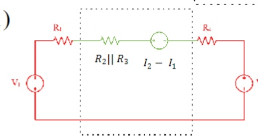
V_s	I_s	V_o
15 V	0 A	5 V
0 V	4 A	8 V
6 V	1 A	?

(1) 4 V
(2) 3 V
(3) 2 V
(4) 5 V
(5) -4 V
(6) 0 V
(7) -3 V
(8) None of the above.

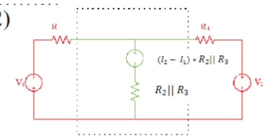
4.3 What is the correct source transformation of the portion inside the box keeping every element outside the box unchanged?



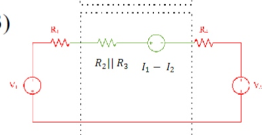
1)



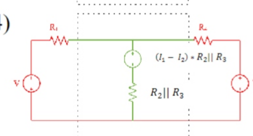
2)



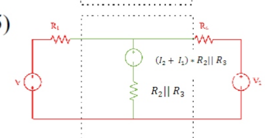
3)



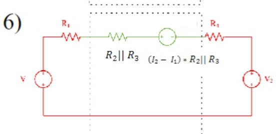
4)



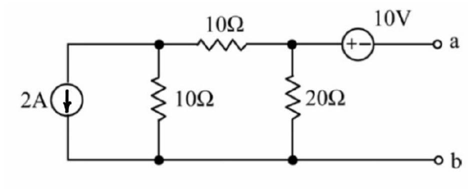
5)

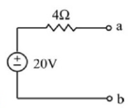


6)

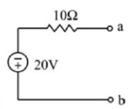


4.4 Which of the circuits, shown as (1) to (7), is equivalent to the following?

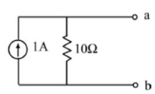




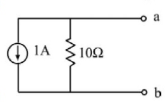
(1)



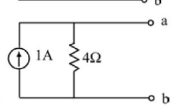
(2)



(3)

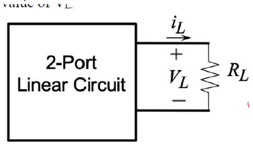


(4)



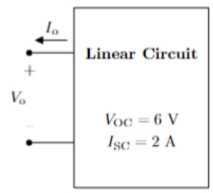
(5)

4.5 Suppose that you take the following measurement on the 2-terminal linear circuit in the box below:
when $R_L = \infty$, you measure $V_L = 32$V
when $R_L = 4\Omega$, you measure $V_L = 8$V
now, if $R_L = 12\Omega$, find the value of V_L.



(1) 0
(2) 6
(3) 8
(4) 9
(5) 12
(6) 14
(7) 15
(8) 16
(9) 18
(10) None of the choices

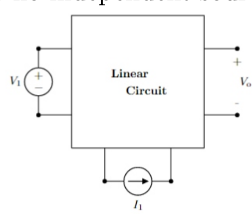
4.6 What is the Norton equivalent representation of the linear circuit?



	I_N(A)	R_N(Ω)
1.	0	2
2.	2	2
3.	3	2
4.	6	2
5.	0	3
6.	2	3
7.	3	3
8.	6	3

9. None of the above.

4.7 What is the value of the voltage V_0 when $V_1 = 3$V and $I_1 = -1$A? Assume that there are no independent sources within the linear circuit box.



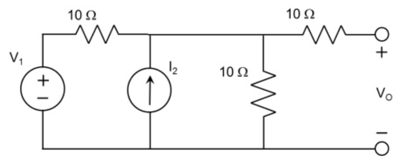
V_1(V)	I_1(A)	V_o(V)
0	1	5
1	0	3
3	-1	?

1. 1 V
2. 3 V
3. 4 V
4. 5 V
5. -1 V
6. -3 V
7. -4 V
8. -5 V
9. None of the above.

4.8 Initial values for the voltage (V_1) and current (I_2 sources in the circuit shown produce an output potential, V_0, equal to 16V. V_0 is a linear function of V_1 and I_2 according to the equation,

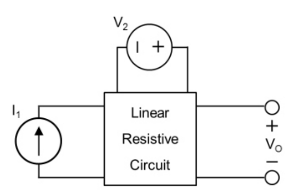
$$V_0 = AV_1 + BI_2.$$

If doubling I_2 changes V_0 to 20V when V_1 remains constant, find V_1 (in V).



(1) 6
(2) 8
(3) 12
(4) 16
(5) 18
(6) 20
(7) 21
(8) 24
(9) None of the above

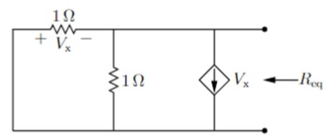
4.9 The linear resistive circuit below contains only resistors and dependent sources. Measurements of V_0 for different input excitations are tabulated below. Find V_0 when $I_1 = 0.2$A and $V_2 = -2$V (in V).



I_1	V_2	V_O
0.1 A	0	8 V
0	4 V	2 V

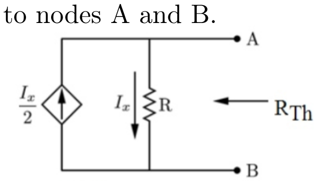
(1) 6
(2) 8
(3) 12
(4) 14
(5) 15
(6) 16
(7) 17
(8) 18
(9) None of the above

4.10 Find the equivalent resistance of the following circuit:



1. 1Ω
2. 2Ω
3. 3Ω
4. 4Ω
5. 5Ω
6. 6Ω
7. 7Ω
8. 8Ω
9. None of the above.

4.11 For the circuit below find the Thevenin equivalent resistance with respect to nodes A and B.



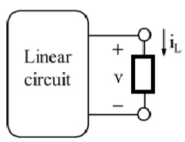
(1) R/2
(2) 2R
(3) R/3
(4) 3R
(5) R/4
(6) 4R
(7) R
(8) None of the above.

4.12 The linear circuit below consists of resistors and sources only. Experiments were performed to evaluate circuit parameters. Two current/voltage relationships were found to be:

$$v = 10V, i_L = 0A$$
$$v = -10V, i_L = 2A$$

Find the value of the Thevenin equivalent resistance, R_{Th}, for the linear circuit (in Ω).

Find the value of the Thevenin equivalent resistance, R_{TH}, for the linear circuit (in Ω).

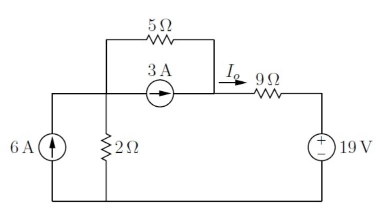


(1) 10
(2) 2
(3) 30
(4) 4
(5) 5
(6) 20
(7) 40
(8) 8
(9) None of the above

4.13 Assume that a linear circuit is excited by two voltage sources: $v_1(t)$ and $v_2(t)$. The circuit is used to power a load resistor R. When only $v_1(v_2)$ is active, the average power consumed on the resistor is $P_1(P_2)$. What is the average power consumed on the resistor R when both sources are active?

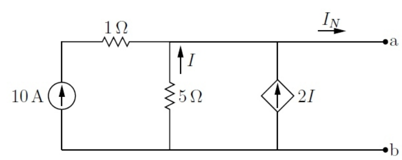
(1) $P_1 + P_2$
(2) P_1
(3) P_2
(4) $\frac{v_1^2}{R} + \frac{v_2^2}{R}$
(5) Cannot be determined with the given information

4.14 For the circuit below find the current I_0.



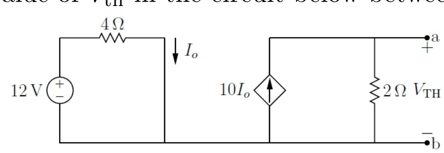
(1) 3 A
(2) -9 A
(3) -1 A
(4) 0.25 A
(5) 4 A
(6) 0.5 A
(7) 9 A
(8) None of the above.

4.15 Find the Norton current I_N in the circuit below.



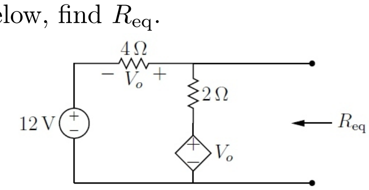
(1) -10 A
(2) 12 A
(3) 0 A
(4) 10 A
(5) 5 A
(6) 0.1 A
(7) -0.1 A
(8) None of the above.

4.16 Find the value of V_{th} in the circuit below between the terminals ab.



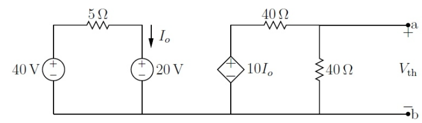
(1) 60 V
(2) -60 V
(3) 0 V
(4) 20 V
(5) 40 V
(6) 30 V
(7) -30 V
(8) None of the above.

4.17 For the circuit below, find R_{eq}.



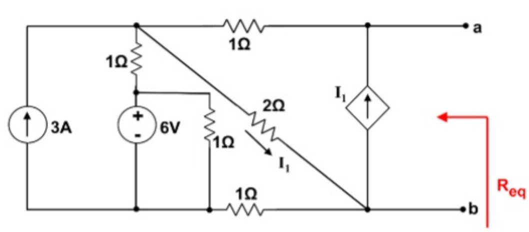
(1) 12.5 Ω
(2) -8 Ω
(3) 10 Ω
(4) -4 Ω
(5) -10 Ω
(6) 20 Ω
(7) 4 Ω
(8) None of the above.

4.18 Find the Thevenin (open circuit) voltage V_{th} in the circuit below between the terminals ab.



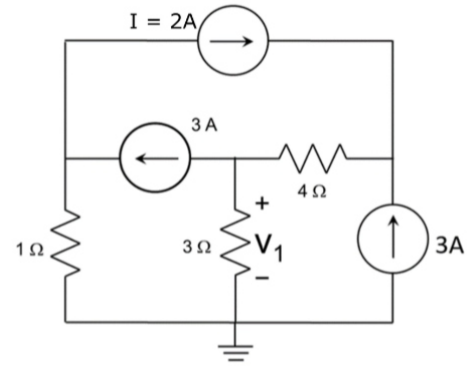
(1) 20 V
(2) -60 V
(3) 0 V
(4) 60 V
(5) 40 V
(6) 30 V
(7) -30 V
(8) None of the above.

4.19 For the circuit below, find the equivalent resistance (R_{eq}) between terminals (a) and (b).



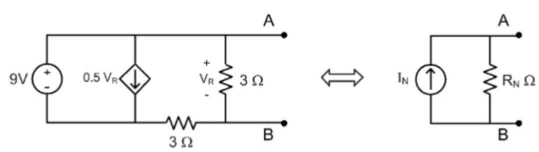
1) 1Ω
2) 2Ω
3) 4Ω
4) 2.2Ω
5) 4.2Ω
6) 8Ω
7) 12Ω
8) None of the above

4.20 If we increase the current source (I) in the figure below from 2A to 4A, find the change in the voltage V_1 in unit of volt?
(Method: $\nabla V_1 = V_{1(\text{for I=4A})} - V_{1(\text{for I=2A})}$)



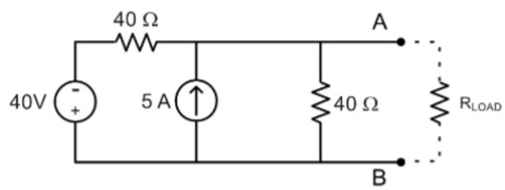
1) $\Delta V_1 = -8$ V
2) $\Delta V_1 = -6$ V
3) $\Delta V_1 = -2$ V
4) $\Delta V_1 = -1$ V
5) $\Delta V_1 = 1$ V
6) $\Delta V_1 = 2$ V
7) $\Delta V_1 = 6$ V
8) None of the above

4.21 Find the Norton equivalent current (I_N) at the terminal AB.



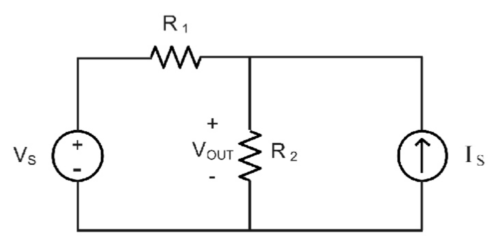
1) $I_N = -3$A
2) $I_N = 3$A
3) $I_N = -1.5$A
4) $I_N = 1$A
5) $I_N = 1.5$A
6) $I_N = 6$A
7) $I_N = -6$A
8) None of the above

4.22 Find the value of R_{load} such that maximum power is delivered across the load. Also, find the value of maximim power delivered to the load (P_{max})?



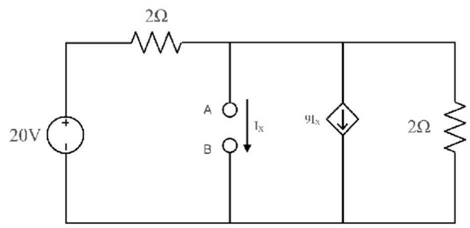
1) $R_{Load} = 20\Omega$ Pmax = 80W
2) $R_{Load} = 10\Omega$ Pmax = 40W
3) $R_{Load} = 15\Omega$ Pmax = 60W
4) $R_{Load} = 10\Omega$ Pmax = 90W
5) $R_{Load} = 20\Omega$ Pmax = 180W
6) $R_{Load} = 25\Omega$ Pmax = 100W
7) $R_{Load} = 10\Omega$ Pmax = 50W
8) None of the above

4.23 In the following figure, using the superposition principle $V_{\text{out}} = \alpha V_s + \beta I_s$. Find the expressions of α and β.



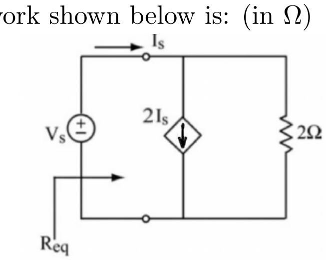
1) $\alpha = \frac{R_1}{R_1+R_2}$; $\beta = \frac{R_1R_2}{R_1+R_2}$
2) $\alpha = \frac{R_1}{R_1-R_2}$; $\beta = \frac{R_2}{R_1-R_2}$
3) $\alpha = \frac{R_2}{R_1+R_2}$; $\beta = \frac{R_1R_2}{R_1+R_2}$
4) $\alpha = \frac{R_2}{R_1-R_2}$; $\beta = \frac{R_1}{R_1-R_2}$
5) $\alpha = \frac{R_1}{R_1+R_2}$; $\beta = \frac{R_2}{R_1+R_2}$
6) None of the above

4.24 Find the equivalent resistance $R_{\mathbf{eq}}$ across terminals **AB**.



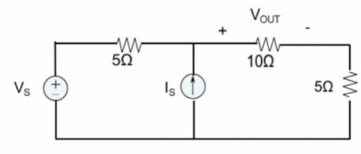
1) 1 Ω
2) 5 Ω
3) 2.5 Ω
4) 10 Ω
5) 15 Ω
6) 25 Ω
7) 12.5 Ω
8) None of the above.

4.25 The R_{eq} of the network shown below is: (in Ω)



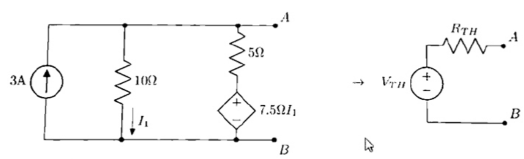
(1) 1
(2) 2
(3) 3
(4) 4
(5) 5
(6) 6
(7) 7
(8) None of the choices

4.26 In the circuit shown below, V_{OUT} can be written as a linear combination of V_s and I_s, i.e., $V_{\text{OUT}} = \alpha V_s + \beta I_s$. What are the correct values for α and β?

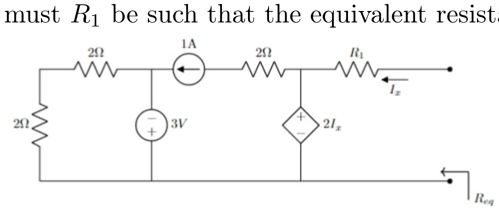


(1) α = 0.25, β = 0.25
(2) α = 0.5, β = 0.75
(3) α = 0.75, β = 0.25
(4) α = 0.5, β = 2.5
(5) α = 0.25, β = 1.25
(6) α = 0.5, β = 1.25
(7) α = 0.75, β = 1.25
(8) α = 0.25, β = 3.75
(9) None of the choices

4.27 Reduce the following circuit to its Thevenin equivalent.

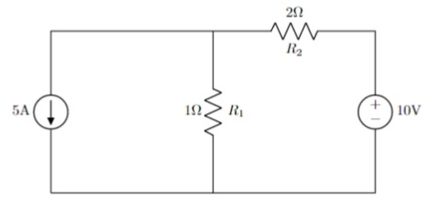


4.28 What must R_1 be such that the equivalent resistance, R_{eq}, is 5Ω?



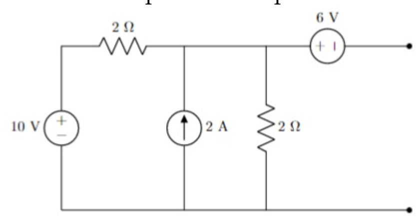
1. 0 Ω
2. 1 Ω
3. 2 Ω
4. 3 Ω
5. 4 Ω
6. 5 Ω
7. 6 Ω
8. 7 Ω
9. None of the above.

4.29 Find the absolute value of the voltage across R_1.



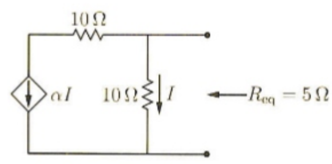
1. 0 V
2. 1 V
3. 2 V
4. 3 V
5. 4 V
6. 5 V
7. 6 V
8. 7 V
9. None of the above.

4.30 What is the Thevenin equivalent representation of the circuit?



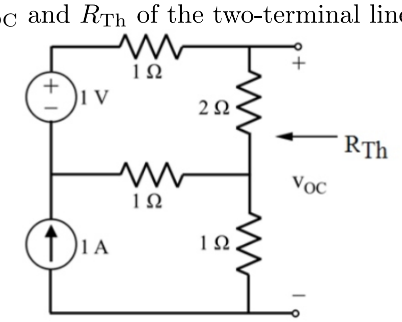
	V_{Th}(V)	R_{Th}(Ω)
1.	1	1
2.	1	2
3.	1	4
4.	1	0
5.	13	1
6.	13	2
7.	13	4
8.	13	0
9.	None of the above.	

4.31 The equivalent resistance of the following circuit is 5Ω. Calculate the value of α.



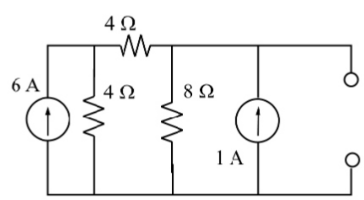
(1) -3
(2) -2
(3) -1
(4) 0
(5) 1
(6) 2
(7) 3
(8) None of the above.

4.32 Find the $V_{\rm OC}$ and $R_{\rm Th}$ of the two-terminal linear network shown below.



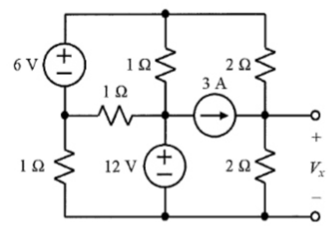
(1) $V_{\rm OC} = 0$V and $R_{\rm Th} = 0\Omega$
(2) $V_{\rm OC} = 1$V and $R_{\rm Th} = 0\Omega$
(3) $V_{\rm OC} = 1$V and $R_{\rm Th} = 1\Omega$
(4) $V_{\rm OC} = 2$V and $R_{\rm Th} = 1\Omega$
(5) $V_{\rm OC} = 1$V and $R_{\rm Th} = 2\Omega$
(6) $V_{\rm OC} = 2$V and $R_{\rm Th} = 2\Omega$
(7) $V_{\rm OC} = 2$V and $R_{\rm Th} = 3\Omega$
(8) $V_{\rm OC} = 3$V and $R_{\rm Th} = 3\Omega$
(9) None of the above.

4.33 Using the source transformation or any other analysis technique, find the value of the Norton Equivalent current source (in A) for the circuit below.



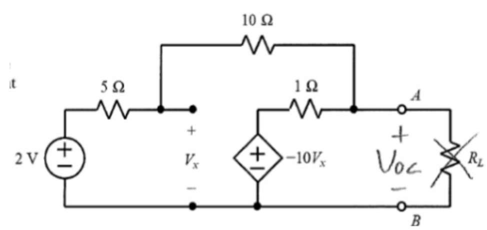
(1) 1
(2) 2
(3) 3
(4) 4
(5) 5
(6) 6
(7) 7
(8) 8
(9) 9
(10) None of the above

4.34 Solve the problems below:



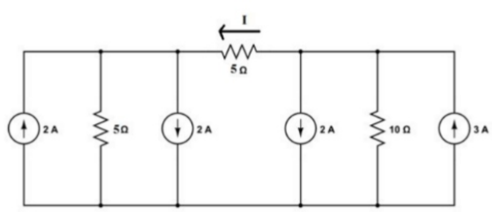
a. Determine the contributions of each of the sources to the output voltage Vx.
b. Suppose the 3A source was oriented in the direction opposite the one indicated in the schematic. Find the new value of V_x.

4.35 Solve the problems below:



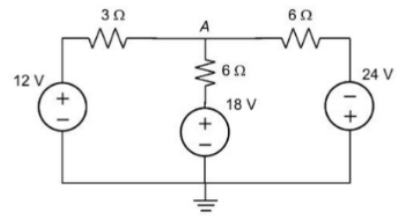
a. Find the Thevenin equivalent circuit.
b. Find the load resistance that absorbs the most power from this circuit and calculate the maximum power.

4.36 Solve below:



Find the indicated current using a. nodal analysis, b. superposition.

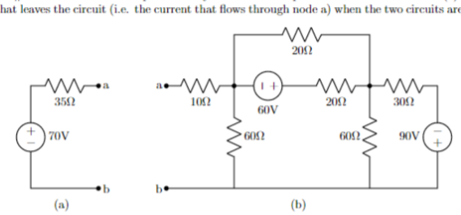
4.37 Find the indicated node voltage using (a) source transformation, (b) superposition.



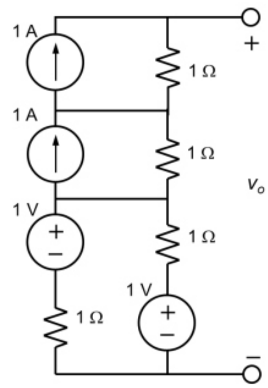
Find the indicated node voltage using a. source transformation, b. superposition.

4.38 A source that is represented by its Thevenin equivalent circuit is shown in (a). Find the current that leaves the circuit (i.e. the current that flows through node a) when the two circutis are attached.

Question #1 A source that is represented by its Thévenin equivalent circuit is shown in (a). Find the current that leaves the circuit (i.e. the current that flows through node a) when the two circuits are attached.



4.39 In the circuit below, find v_0 (in V).



(1) 1

(2) 2

(3) 3

(4) 4

(5) 0.5

(6) 1.5

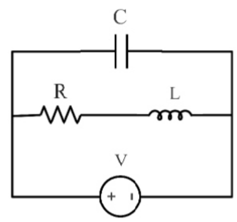
(7) 2.5

(8) 3.5

(9) None of the above

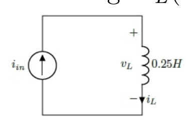
5 Capacitors and Inductors

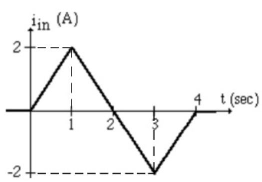
5.1 In the following circuit, as **DC steady state**, the energy stored in the capacitor is the same as the energy stored in the inductor. Find the relation between R, L, C?



1) $L^2 = CR^2$
2) $L = RC^2$
3) $L^2 = CR$
4) $C^2 = L^2R$
5) $C = LR^2$
6) $L = CR^2$
7) $L = CR$
8) None of the above

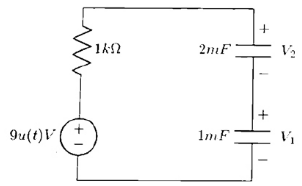
5.2 The current in the circuit below has a triangular shape as shown. Determine the inductor's voltage $v_L(t)$ at $t = 2.5$ sec (in V).



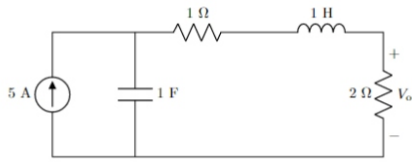


(1) 0
(2) 0.5
(3) -0.5
(4) 1
(5) -1
(6) 2
(7) -2
(8) None of the above

5.3 In the circuit below, the voltage source was turned on at $t = 0$ sec. It is known that $V_1(0^-) = 0$ and $V_2(0^-) = 0$. Find the energy, in mJ, stored in the 1mF capacitor when the circuit reaches steady state.

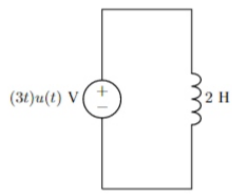


5.4 What is V_0 under DC steady-state conditions?



1. $5e^{\frac{-t}{3}}$ V
2. $5e^{-3t}$ V
3. $10e^{\frac{-t}{3}}$ V
4. $10e^{-3t}$ V
5. 0 V
6. 5 V
7. 10 V
8. 15 V
9. None of the above.

5.5 How much magnetic energy is stored in the inductor at time $t = 2$s?

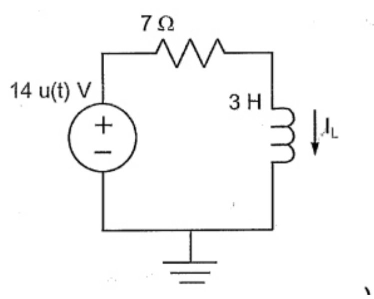


1. 0 J
2. 1 J
3. 2 J
4. 3 J
5. 6 J
6. 9 J
7. 12 J
8. 18 J
9. None of the above.

5.6 A 1-nF capacitor is connected to a 1.6-V source. If the voltage is increased to 3.2V, approximately how many **additional** electrons will be accumulated to the negatively-charged plate? The electron charge is 1.6 x 10^{-19}C.

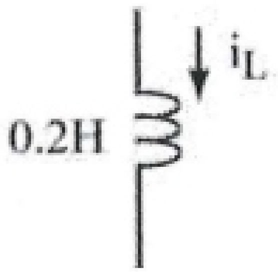
(1) 1 million
(2) 10 million
(3) 1 billion
(4) 10 billion
(5) 1 trillion
(6) 10 trillion
(7) None of the above

5.7 Find the energy stored (in J) in the inductor at $t = \infty$.



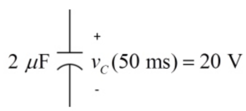
(1) 1
(2) 2
(3) 3
(4) 4
(5) 5
(6) 6
(7) 7
(8) 0
(9) None of the above

5.8 The current in the inductor shown below is found to be $i_L(t) = \sqrt{10}\sin(\pi t)$A. Find the instantenous energy stored in the inductor at time $t = 0.5$s.



(1) $0.1\sqrt{10}$J
(2) 1J
(3) 0.5J
(4) 10J
(5) $\sin(\pi t)$J
(6) $\sin^2(\pi t)$J
(7) 0J
(8) None of the above

5.9 A 2 μF capacitor is charged to a voltage of 20V in 50ms. Assuming the energy stored in the capacitor was initially 0J, what is the energy stored in the capacitor at time $t = 50$ms.

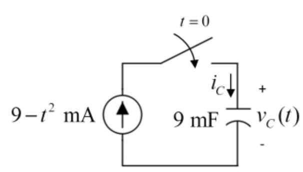


(1) $W_C = 0$ J (2) $W_C = 20$ mJ (3) $W_C = 40$ mJ (4) $W_C = 80$ mJ

(5) $W_C = 100$ μJ (6) $W_C = 200$ μJ (7) $W_C = 300$ μJ (8) $W_C = 400$ μJ

(9) None of the above

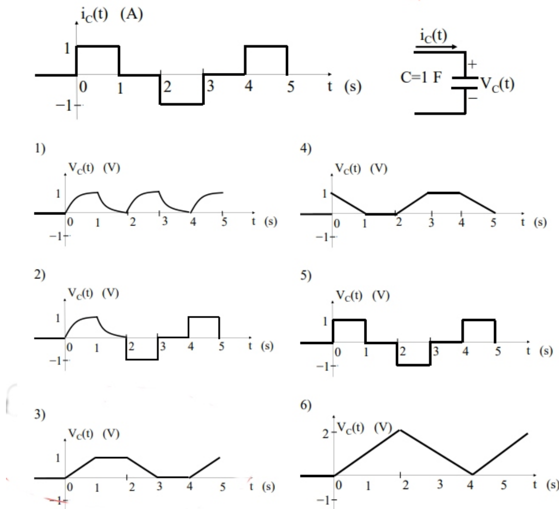
5.10 A 9mF capacitor has an initial voltage of $v_c = 5$V. If the current through the capacitor is given by $i_c(t) = 9 - t^2$mA for $t \geq 0$s, what is $v_c(3)$?



(1) 1 V (2) 2 V (3) 3 V (4) 4 V (5) 5 V

(6) 6 V (7) 7 V (8) 8 V (9) 9 V (10) None of these

5.11 The current $i_c(t)$ flowing through a capacitor of capacitance $C = 1\text{F}$ is shown in the figure below. The current before $t = 0$ is 0. Which of the following figures represent the voltage $V_c(t)$?



5.12 Solve the questions below:

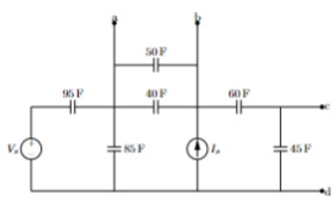


Figure 5.67

a. Find the equivalent capacitance seen by terminals a and b.
b. Find the equivalent capacitance seen by terminals c and d.

5.13 One thousand 1-mH inductors are connected in parallel. Their combination is connected in parallel to a 10-Ω resistor. What is the time constant of the resulting circuit?

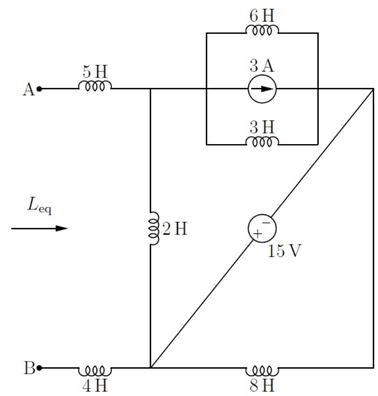
(1) 1 ns
(2) 10 ns
(3) 100 ns
(4) 1000 ns
(5) 1000 ns

(6) 10000 ns

(7) 100000 ns

(8) None of the above

5.14 Find the equivalent inductance as seen from port AB.



(1) 9H

(2) 20H

(3) 18H

(4) 10H

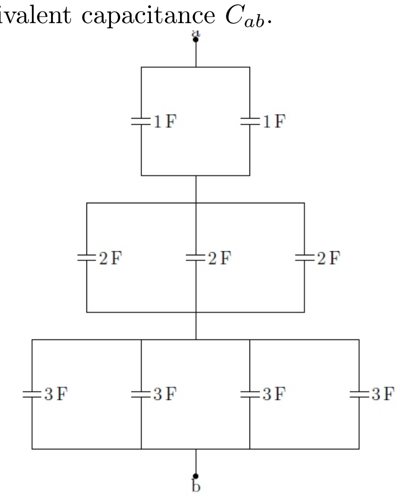
(5) 12.5H

(6) 11H

(7) 15H

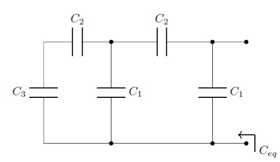
(8) None of the above

5.15 Find the equivalent capacitance C_{ab}.



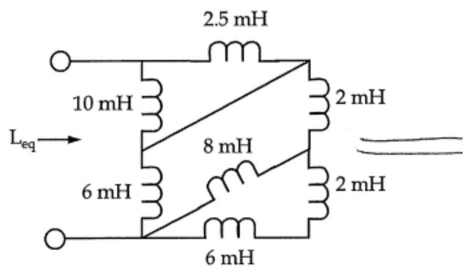
1. 4 F
2. $\frac{23}{12}$ F
3. $\frac{4}{3}$ F
4. $\frac{3}{4}$ F
5. $\frac{12}{23}$ F
6. $\frac{1}{4}$ F
7. 1 F
8. None of the above.

5.16 For the circuit shown below, $C_1 = 18$mF, and $C_2 = C_3 = 12$mF. Find the equivalent capacitance (in mF).



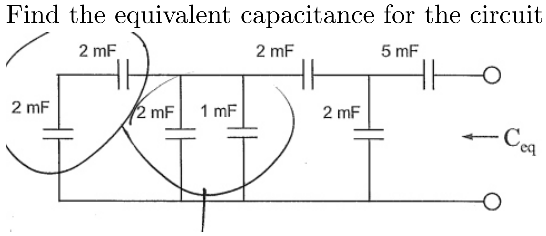
(1) 7.5
(2) 12
(3) 16
(4) 26
(5) 28
(6) 32
(7) None of the above

5.17 Find the equivalent inductance, L_{eq}, as shown in the figure (in mH).



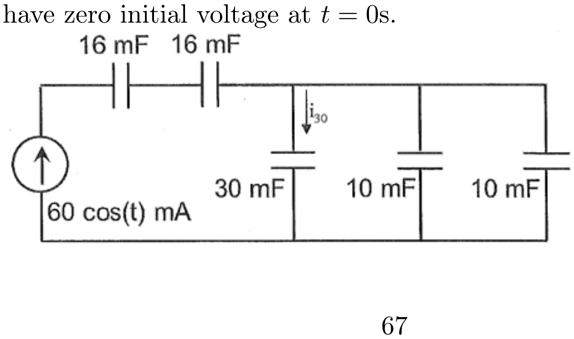
(1) 1
(2) 2
(3) 3
(4) 4
(5) 5
(6) 6
(7) 7
(8) 8
(9) None of the above

5.18 Find the equivalent capacitance for the circuit shown (in mF)



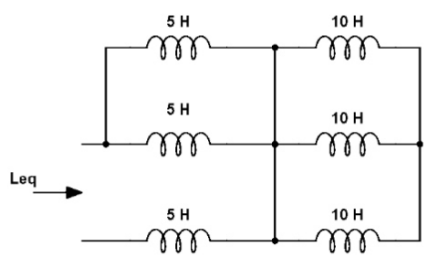
(1) 1
(2) 2
(3) 3
(4) 4
(5) 5
(6) 6
(7) 7
(8) 8
(9) None of the above

5.19 Find the current (i_{30}) through the 30 mF capacitor assuming all capacitor have zero initial voltage at $t = 0$s.



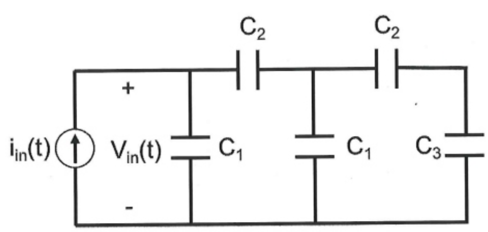
(1) $15\cos(t)$mA
(2) $24\cos(t)$mA
(3) $30\cos(t)$mA
(4) $36\cos(t)$mA
(5) $40\cos(t)$mA
(6) $48\cos(t)$mA
(7) $56\cos(t)$mA
(8) $60\cos(t)$mA
(9) None of the above.

5.20 Find the equivalent inductance:



(1) $L_{eq} = 2.5$H
(2) $L_{eq} = 3.33$H
(3) $L_{eq} = 5$H
(4) $L_{eq} = 6.66$H
(5) $L_{eq} = 7.5$H
(6) $L_{eq} = 10$H
(7) $L_{eq} = 10.83$H
(8) None of the above

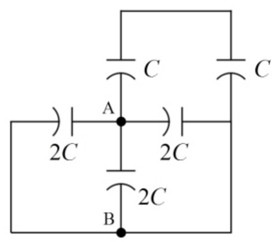
5.21 For the circuit shown below, $C_1 = 8$mF, $C_2 = 6$mF, and $C_3 = 12$mF. Find the equivalent capacitance as seen by the current source.



(1) 8mF
(2) 6mF
(3) 12mF
(4) 24mF

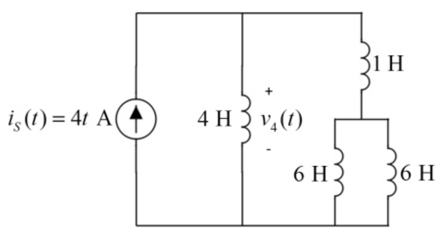
(5) 4mF
(6) 3mF
(7) 28mF
(8) 32mF
(9) 20mF
(10) None of the above

5.22 Find the equivalent capacitance seen between nodes A and B, in terms of capacitance C.



(1) 0.5C (2) 2C (3) 2.5C (4) 4C (5) 4.5C
(6) 6C (7) 6.5C (8) 8C (9) 8.5C (10) None of the above

5.23 What is the voltage $v_4(t)$ across the 4H inductor?

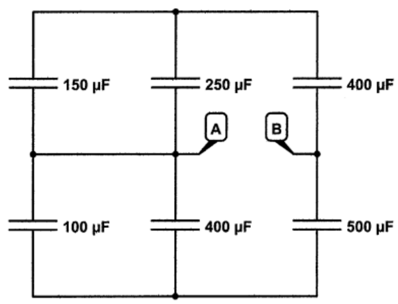


(1) 2 V (2) 4 V (3) 8 V (4) 16 V (5) 2t V
(6) 4t V (7) 8t V (8) 16t V (9) 0 V (10) None of the above

5.24 Please find the equivalent capacitance between nodes A and B, C_{eq}.

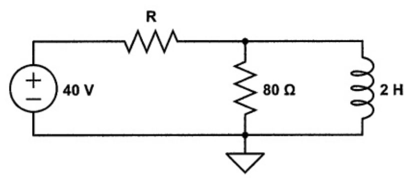
Question 5.

Please find the equivalent capacitance between nodes A and B, Ceq



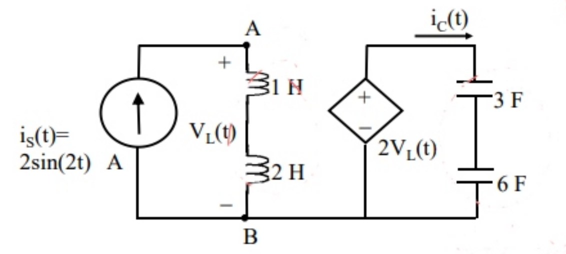
1) Ceq = 100μF
2) Ceq = 150μF
3) Ceq = 200μF
4) Ceq = 250μF
5) Ceq = 300μF
6) Ceq = 350μF
7) Ceq = 400μF
→ 8) Ceq = 450μF
9) Ceq = 500μF
10) none of the above

5.25 Please find the resistance R in the following circuit so the steady-state (DC conditions) energy stored in the inductor is 1J.



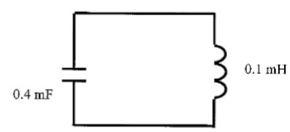
(1) 10Ω
(2) 20Ω
(3) 30Ω
(4) 40Ω
(5) 50Ω
(6) 60Ω
(7) 70Ω
(8) 80Ω
(9) 90Ω
(10) None of the above

5.26 For the circuit shown below, $i_s(t) = 2\sin(2t)$A, and $V_L(t)$ is the voltage drop from node A to node B. Find $i_c(t)$.



(1) $-96\sin(2t)$A
(2) $-24\sin(2t)$A
(3) $-12\sin(2t)$A
(4) $48\sin(2t)$A
(5) $24\sin(2t)$A
(6) $12\sin(2t)$A
(7) None of the above

5.27 At $t = t_0$, the current in the circuit below is zero and the voltage across the capacitor is 3V. At a late time instant $t = t_1$, the capacitor voltage is measured to be zero. The circuit current at $t = t_1$ is:



(1) 12A
(2) 3A
(3) 0.25A
(4) 5A
(5) 4A
(6) 1A
(7) None of the above

5.28 Find the total energy stored in the circuit shown below:

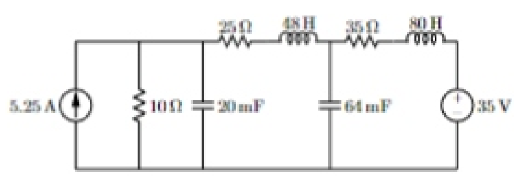
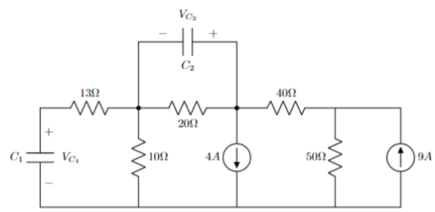


Figure 5.84

5.29 Solve the problems below:

Question #3 The circuit has reached a steady state (i.e. capacitors appear as opens).

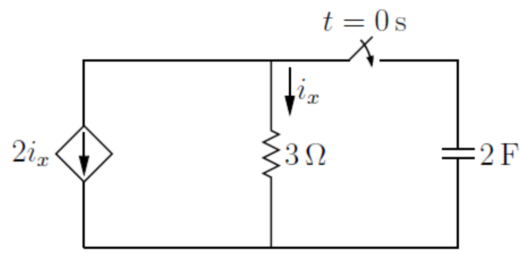


(a) Find the values of the voltages V_{C_1} and V_{C_2} across the capacitors.

(b) The energy stored in each capacitor is $W_{C_1} = 225J$ and $W_{C_2} = 450J$. Find the values of their capacitance. Assume that before the circuit turned on, both capacitors were initially discharged.

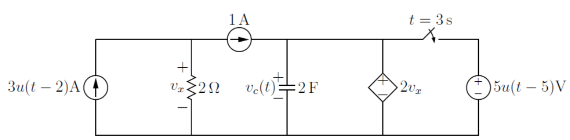
6 First-Order Circuit Analysis

6.1 Find the time constant τ for the following circuit for $t > 0$.



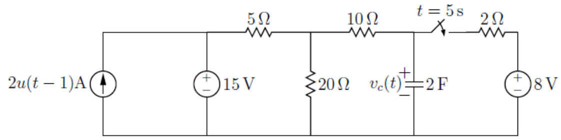
(1) 4s
(2) 0.2s
(3) 2s
(4) 0.5s
(5) 5s
(6) 0.25s
(7) 1s
(8) None of the above

6.2 Find $v_c(t = 2s)$ in the following circuit.



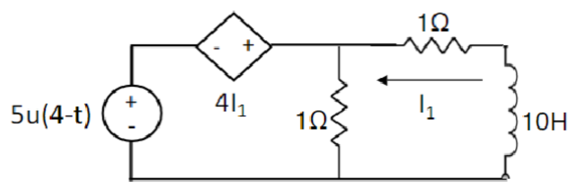
(1) -4 V
(2) 5 V
(3) 4 V
(4) 3 V
(5) -2 V
(6) 8 V
(7) -3 V
(8) None of the above

6.3 Find $v_c(t = 1s) = v_c(1)$ in the following circuit.



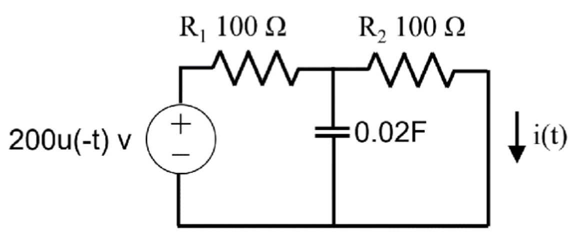
(1) 12 V
(2) -8 V
(3) 4 V
(4) 7 V
(5) -6 V
(6) 8 V
(7) -7 V
(8) None of the above

6.4 Find the time constant for the following first order circuit.



(1) 4 seconds
(2) 2 seconds
(3) 5 seconds
(4) 0.25 second
(5) 20 seconds
(6) 0.5 second
(7) 1 second
(8) None of the above

6.5 For the linear circuit shown in the figure below, which of the following statement is correct?



(1) The current through the voltage source is a continuous function of time.
(2) The current through the resistor R_2 is a continuous function of time.
(3) The current through the capacitor is a continuous function of time.
(4) Reducing the voltage value of the voltage source by half will double the time constant.
(5) Reducing the voltage value of the voltage source by half will reduce the time constant by half.
(6) The time constant of the circuit is independent of the value of R_1.
(7) None of the above

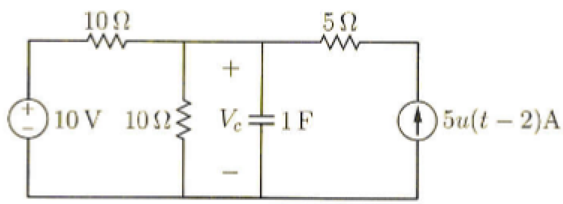
6.6 The following is the voltage across a capacitor (in volts) of a first order RC circuit.

$$v_c(t) = 10\exp(-\frac{t}{5}), \text{ for } t > 0$$

Which of the following is a correct statement for this first order circuit?

(1) The time constant is 0.2s
(2) The initial voltage at $t = 0^-$ is zero.
(3) Both (4) and (7) are true.
(4) The steady state value is zero.
(5) Both (6) and (7) are true.
(6) The transient response is zero.
(7) The final voltage at $t = \infty$ is 10V.
(8) None of the above

6.7 Calculate the voltage across the capacitor at $t = 2$s

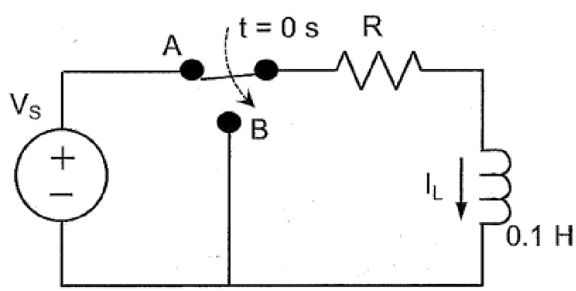


(1) 0V
(2) 1V
(3) 2V
(4) 3V
(5) 4V
(6) 5V
(7) None of the above

6.8 The voltage source (V_s) and the resistor (R) in the RL circuit below are unknown. The switch has been at position A for a long time and it turns to position B at $t = 0$s. The inductor current $i_t(t)$ for $t > 0$ is,

$$i_L(t) = 6e^{-5t}A$$

Find V_s(in V).



(1) 1
(2) 2
(3) 3
(4) 4

(5) 5
(6) 6
(7) 7
(8) 8
(9) None of the above

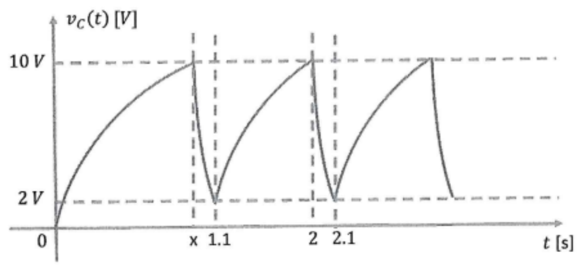
6.9 The capacitor voltage in a driven, first-order RC circuit with a constant voltage source is:

$$v_c(t) = 5 - 8e^{-4t}V \text{ for } t \geq 0$$

Find the value of $v_c(0^-)$(in V).

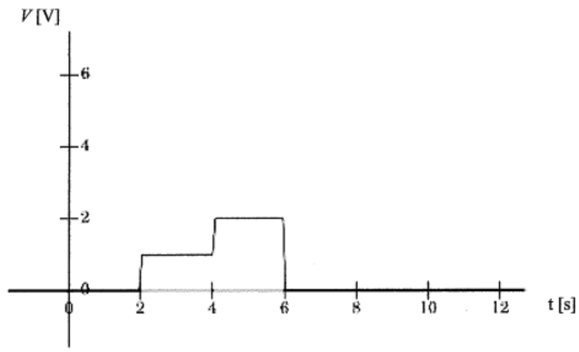
(1) 1
(2) 2
(3) 3
(4) 4
(5) 5
(6) -1
(7) -2
(8) -3
(9) There is insufficient information
(10) None of the above

6.10 The following graph presents an approximate saw-tooth voltage measured across a capacitor that has been generated by a 1[st] order RC circuit during successive charging and discharging cycles.



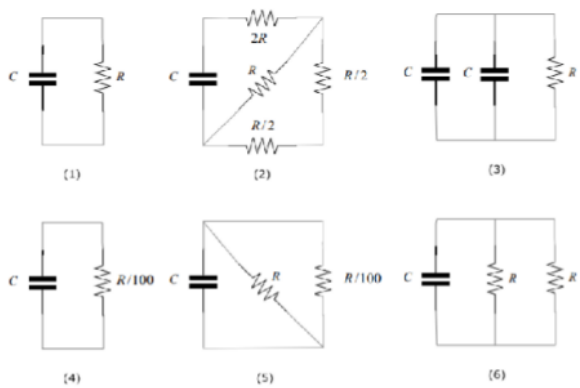
(1) The time constants of the charging and discharging cycles are the same.
(2) Both the charging and discharging cycles consume energy.
(3) The current through the capacitor may not be continuous.
(4) The energy stored in the capacitor at the end of the charging cycle is higher than the energy stored in the capacitor at the end of the discharging cycle.
(5) $v_c\left(0^-\right) = 0$ V
(6) The current through the capacitor can be found by $i_C(t) = C\frac{dv_C(t)}{dt}$ for $1.1 < t < 2$.

6.11 Which of the following equations best represents the following graph?

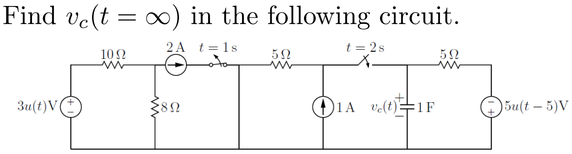


(1) $u(t-2)+u(t-6)$
(2) $u(t-2)+u(t-4)-u(t-6)$
(3) $u(t-2)-u(t-4)+2u(t-6)$
(4) $4u(t-2)+2u(t-4)-4$
(5) $1+u(t-4)-2u(t-6)$
(6) $u(t-2)+u(t-4)-4$
(7) $u(t-2)+u(t-4)+u(t-6)$
(8) $1+u(t-4)-2$
(9) $u(t-2)+u(t-4)-2u(t-6)$
(10) None of the above

6.12 Which of the following circuits has the longest discharge time? All capacitors are assumed to have the same preloaded charge. Sort the discharge times of the below RC circuits from least to greatest.

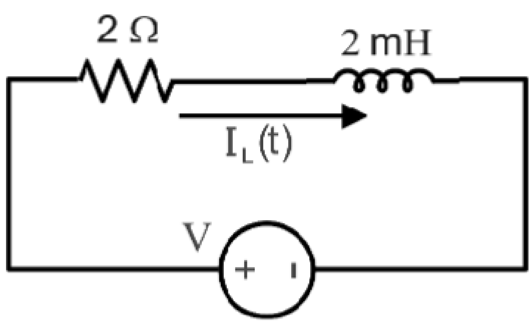


6.13 Find $v_c(t=\infty)$ in the following circuit.



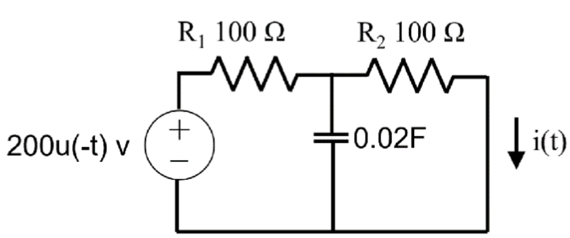
(1) -5V
(2) 0V
(3) 2V
(4) 3V
(5) 5V
(6) 7V
(7) 8V
(8) None of the above

6.14 An independent voltage source, resistor R, and inductor L are connected in series as shown in the figure below. The source voltage is given by $v_s = 10u(-t) - 5u(t)$. What are the initial current, $i_L(t < 0^-)$ and the final current. $i_L(t = \infty)$ through the inductor?



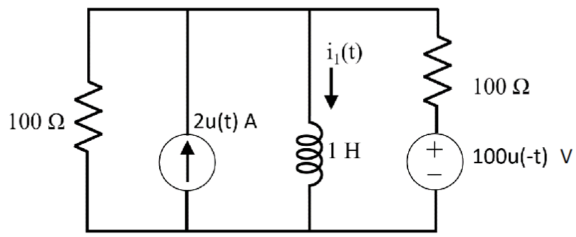
(1) $i_L\left(\text{t} < 0^-\right) = 5$ A; $i_L(t = \infty) = -2.5$ A
(2) $i_L\left(\text{t} < 0^-\right) = -20$ A; $i_L(t = \infty) = 20$ A
(3) $i_L\left(\text{t} < 0^-\right) = -10$ A; $i_L(t = \infty) = 5$ A
(4) $i_L\left(\text{t} < 0^-\right) = 5$ A; $i_L(t = \infty) = -5$ A
(5) $i_L\left(\text{t} < 0^-\right) = 7.5$ A; $i_L(t = \infty) = -7.5$ A
(6) $i_L\left(\text{t} < 0^-\right) = -2.5$ A; $i_L(t = \infty) = 10$ A
(7) $i_L\left(\text{t} < 0^-\right) = 20$ A; $i_L(t = \infty) = -10$ A
(8) None of the above

6.15 In the following circuit, find the time constant in the unit of second.



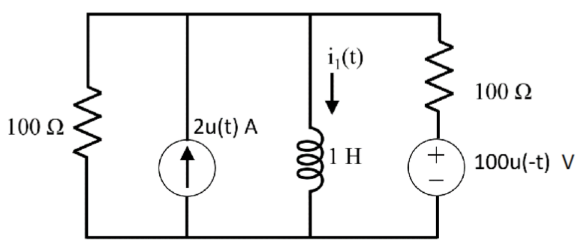
(1) 0.02 sec
(2) 0.2 sec
(3) 0.5 sec
(4) 1 sec
(5) 2 sec
(6) 4 sec
(7) 50 sec
(8) None of the above

6.16 In the linear circuit below, find $i_1(0)$ in the unit of Ampere.



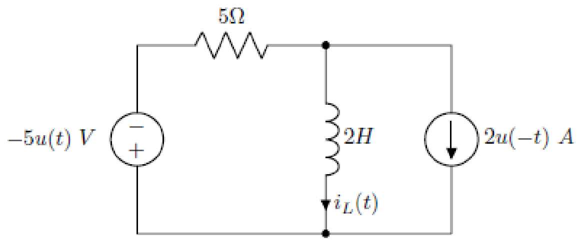
(1) 0 A
(2) 0.25 A
(3) 1 A
(4) 0.5 A
(5) 2 A
(6) 4 A
(7) 10 A
(8) None of the above

6.17 For the same linear circuit used in the previous question, find $i_1(\infty)$ in the unit of Ampere.



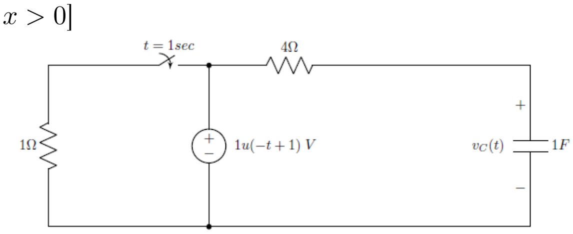
(1) 0 A
(2) 0.25 A
(3) 1 A
(4) 0.5 A
(5) 4 A
(6) 2 A
(7) 10 A
(8) None of the above

6.18 Find the inductor current $i_L(t)$ for $t \geq 0$s (in A).
[Hint: $u(-x)$ is a step function that is on for $x < 0$, and turns off for $x > 0$]



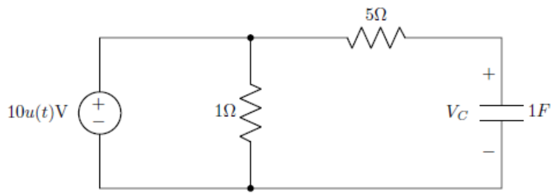
(1) $1 - 3e^{-2.5t}$
(2) $1 - 1e^{-2.5t}$
(3) $1 - 3e^{0.4t}$
(4) $1 - 1e^{-0.4t}$
(5) $-1 - 1e^{-2.5t}$
(6) $-1 - 3e^{-2.5t}$
(7) $-1 - 3e^{-0.4t}$
(8) $-1 - 3e^{-0.4t}$
(9) None of the above

6.19 Find $v_c(t)$ (in V) for $t \geq 1$s
[Hint: $u(-x)$ is a step function that is on for $x < 0$, and turns off for $x > 0$]



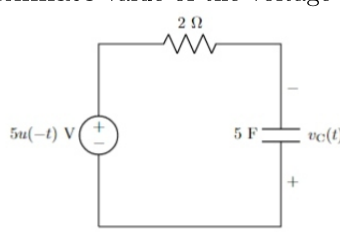
(1) $e^{-0.25(t-1)}$
(2) $e^{-4(t-1)}$
(3) $e^{-0.25t}$
(4) e^{-4t}
(5) $4e^{-0.25(t-1)}$
(6) $4e^{-4(t-1)}$
(7) $4e^{-0.25t}$
(8) $4e^{-4t}$
(9) None of the above

6.20 For the following circuit, determine the final condition $V_C(\infty)$ (in V), and the time constant τ (in seconds):



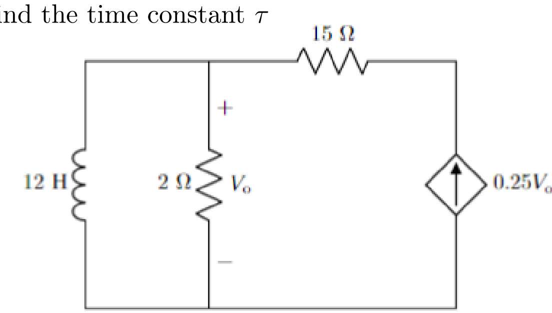
(1) $V_C(\infty) = 10\text{V}$, $\tau = 5\text{s}$
(2) $V_C(\infty) = 10\text{V}$, $\tau = 6\text{s}$
(3) $V_C(\infty) = 8.33\text{V}$, $\tau = 5\text{s}$
(4) $V_C(\infty) = 8.33\text{V}$, $\tau = 6\text{s}$
(5) $V_C(\infty) = 2\text{V}$, $\tau = 5\text{s}$
(6) $V_C(\infty) = 2\text{V}$, $\tau = 6\text{s}$
(7) $V_C(\infty) = 10\text{V}$, $\tau = 0.833\text{s}$
(8) $V_C(\infty) = 8\text{V}$, $\tau = 0.833\text{s}$
(9) None of the above.

6.21 What is the **approximate** value of the voltage $v_C(t)$ at $t = 10\text{s}$?



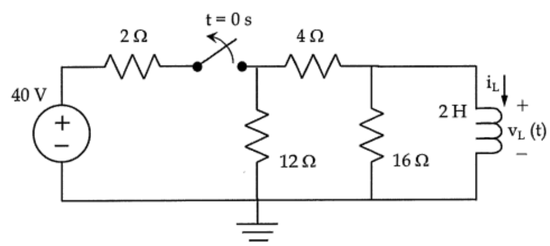
(1) -5 V
(2) -4 V
(3) -2 V
(4) 0 V
(5) 2 V
(6) 4 V
(7) 5 V
(8) None of the above

6.22 Find the time constant τ



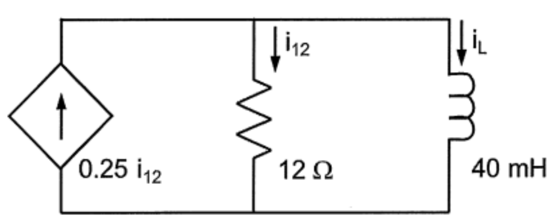
(1) 1 s
(2) 2 s
(3) 3 s
(4) 4 s
(5) 1/3 s
(6) 12 s
(7) 17 s
(8) 48 s
(9) None of the above

6.23 The switch in the circuit opens at $t = 0$s after being closed for a long time. Find the value of $i_L(0^-)$ in A.



(1) 1
(2) 2
(3) 3
(4) 4
(5) 5
(6) 6
(7) 7
(8) 8
(9) None of the above

6.24 At $t = 0$s, the inductor current is $i_L(0) = 5$mA. Find the time constant for the discharging inductor when $t > 0$s (in ms).



(1) 1
(2) 2
(3) 3
(4) 4

(5) 5

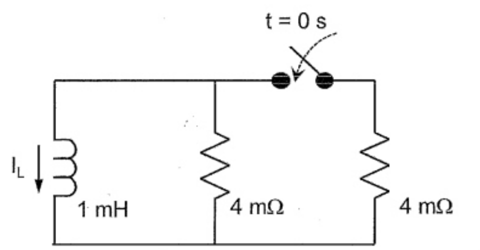
(6) 6

(7) 7

(8) 8

(9) None of the above

6.25 The switch in the circuit closes at $t = 0$s. The inductor current just before the switch is closed is $i_L(0^-) = 2$A. Find the value for $i_L(t)$ at $t = 2$s (in A).



(1) $e^{-0.25}$

(2) $e^{-0.5}$

(3) e^{-1}

(4) $2e^{-0.25}$

(5) $2e^{-0.5}$

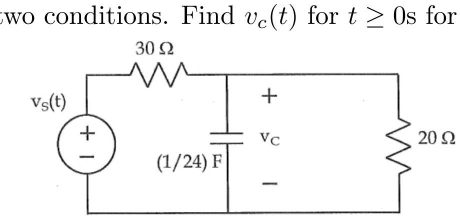
(6) $2e^{-2}$

(7) $2e^{-4}$

(8) 2

(9) None of the above

6.26 The response $v_c(t)$ for $t \geq 0$s in the circuit below are listed in the table for two conditions. Find $v_c(t)$ for $t \geq 0$s for the third condition (in V).



Condition	$v_c(0^-)$	$v_s(t)$	$v_c(t)$
1	2 V	0	$2e^{-2t}$ V
2	0	5u(t) V	$2(1-e^{-2t})$V
3	10 V	15u(t) V	?

(1) $4 + e^{-2t}$

(2) $4 - e^{-2t}$

(3) $5 + e^{-2t}$

(4) $5 - e^{-2t}$

(5) $6 + 4e^{-2t}$

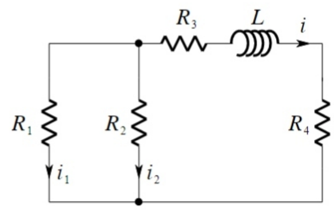
(6) $6 - 4e^{-2t}$

(7) $9 + 4e^{-2t}$

(8) $9 - 4e^{-2t}$

(9) None of the above

6.27 Given that the current through the inductor at time $t = 0$s is 2A, i.e. $i(t = 0s) = 2$A, what is the current, $i_2(t)$ (as shown on the figure below) flowing through the resistor, R_2, at time $t > 0$s? Assume all resistors are 1 Ω, $R_1 = R_2 = R_3 = R_4 = 1\Omega$, and $L = 5$H.



(1) $i_2(t) = -2e^{-\frac{t}{2}}$ A

(2) $i_2(t) = 2e^{-\frac{t}{2}}$ A

(3) $i_2(t) = -e^{-2t}$ A

(4) $i_2(t) = e^{-\frac{2t}{5}}$ A

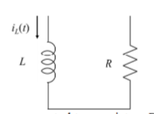
(5) $i_2(t) = 2e^{-\frac{t}{2}}$ A

(6) $i_2(t) = -e^{-\frac{5t}{2}}$ A

(7) $i_2(t) = -e^{-\frac{5t}{2}}$ A

(8) None of the above

6.28 Solve below:



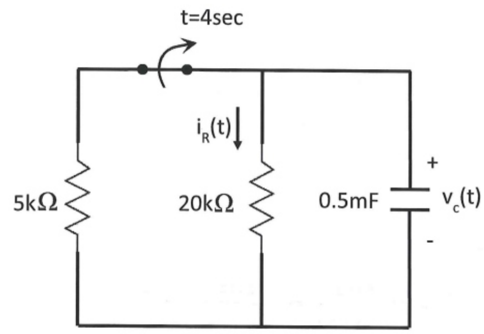
The current through an inductor when connected to a resistor, R, in a zero-input (undriven), first-order RL circuit is:

$i_L(t) = 2\,e^{-3t}$ A $\qquad t \geq 0$

The instantaneous stored energy in the inductor at t = 0 is known to be 400 mJ. Find the value of the resistance to which the inductor is connected (in Ω).

1) 0.1
2) 0.2
3) 0.3
4) 0.4
5) 0.5
6) 0.6
7) 0.7
8) 0.8
9) 0.9
10) none of the above

6.29 In the circuit shown below, $v_c(0^-) = 20$V, and the switch opens at $t = 4$s. Find $v_c(t)$ at $t = 14$s/



(1) e^{-3}

(2) $-e^{-3}$

(3) 0.4

(4) e^{-3}

(5) $20e^{-3}$

(6) $-20e^{-3}$

(7) $5e^{-3}$

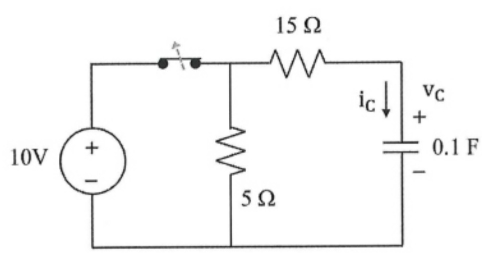
(8) $-5e^{-3}$

(9) $4e^{-2}$

(10) $4e^{-3}$

(11) None of the above

6.30 The switch is opened at time $t = 0$s after being closed (as shown) for a long time. Find the current i_c at $t > 0$s.



(1) $-0.5e^{-t/2}$

(2) $0.5e^{-t/2}$

(3) $-0.25e^{-t/2}$

(4) $10e^{-t/2}$

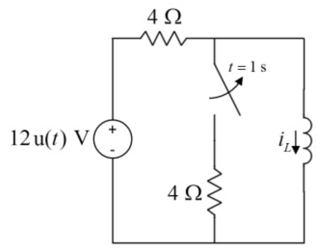
(5) $-0.5e^{-2t}$

(6) $0.5e^{-2t}$

(7) $10e^{-2t}$

(8) None of the above

6.31 Use the circuit for questions 8, 9, and 10. The switch is closed for a long time and then opened at $t = 1$s. At $t = 0^-$, the inductor current is known to be $i_L(0^-) = 0$A.



For $0 \le t < 1$ s, what is the time constant, τ?

(1) $\tau = 0$ s (2) $\tau = \frac{1}{4}$ s (3) $\tau = \frac{1}{2}$ s (4) $\tau = 1$ s (5) $\tau = 2$ s

(6) $\tau = 4$s (7) $\tau = 8$s (8) $\tau = 16$s (9) $\tau = \infty$s (10) None of the above

For $t \ge 1$ s, what is the time constant, τ?

(1) $\tau = 0$ s (2) $\tau = \frac{1}{4}$ s (3) $\tau = \frac{1}{2}$ s (4) $\tau = 1$ s (5) $\tau = 2$ s

(6) $\tau = 4$s (7) $\tau = 8$s (8) $\tau = 16$s (9) $\tau = \infty$s (10) None of the above

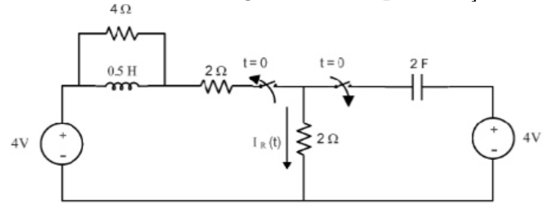
As $t \to \infty$, what is $i_L(\infty)$?

(1) $i_L(\infty) = 1$ A (2) $i_L(\infty) = 2$ A (3) $i_L(\infty) = 3$ A (4) $i_L(\infty) = 4$ A

(5) $i_L(\infty) = 5$ A (6) $i_L(\infty) = 6$ A (7) $i_L(\infty) = 8$ A (8) $i_L(\infty) = 12$ A

(9) $i_L(\infty) = 0$ A (10) None of the above

6.32 Find the current flowing through the 2Ω resistor, $I_R(t)$. [Assume no initial charge on the capacitor.]

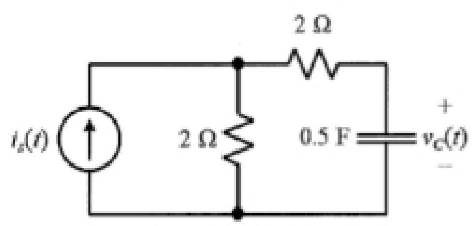


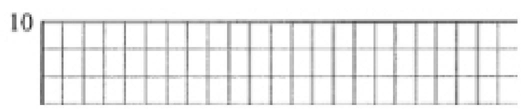
6.33 The expression for the current source is:

$$i_s(t) = 5u(t) - 3u(t-2)A$$

where $u()$ is the unit step function.

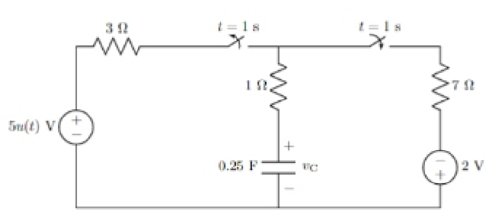
- Sketch $v_c(t)$ for $t \geq 0$.
- Express $v_c(t)$ for $t \geq 0$.
- Calculate the value of $v_c(t)$ at each of the following times:
  - $t = 1$s
  - $t = 2$s
  - $t = 3$s





6.34 Analyzing the circuit below, please find:

- The approximate value of $v_c(1)$, to the closest whole number.
- The value of $v_c(\infty)$.
- The approximate instance in time ($t > 0$) when the value of the voltage $v_c(t)$ is zero.



6.35 The circuit below has two sources and two switches. Switch $S1$ opens at $t = 0$s and switch $S2$ opens at $t = 1$s. You are to determine the capacitor voltage for $t \geq 0$ns per the question below.

Workout Problem. The circuit below has two sources and two switches. Switch S1 opens at t = 0 seconds and switch S2 opens at t = 1 second. You are to determine the capacitor voltage for $t \geq 0$ as per the questions below.

(a) (8 pts) Draw an equivalent circuit valid for $t < 0$ and then compute $v_C(0-)$.

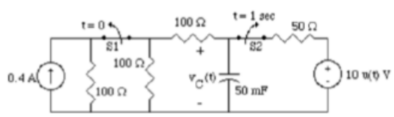
(b) (3 pts) Find $v_C(0+)$. Explain/justify.

(c) (16 pts) Draw the equivalent circuit which includes the capacitor, valid for $0 < t < 1$, and compute $v_C(t)$ for $0 < t < 1$. Indicate the formula for the capacitor voltage and give the numerical values for the quantities in the formula.

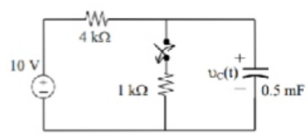
(d) (3 pts) Find $v_C(1-)$ and $v_C(1+)$.

(e) (8 pts) Draw the equivalent circuit which includes the capacitor, valid for $t \geq 1$, and compute $v_C(t)$ for $t \geq 1$. Again you must specify a formula and the various numerical quantities in the formula.

(f) (2 pts) Provide a rough sketch of the response for $t \geq 0$.



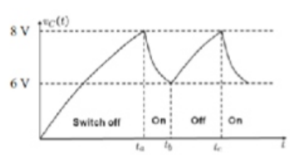
6.36 The switch in the figure shown below is originally open at $t = 0$s. It closes when $v_c \geq 8$V and opens when $v_c \leq 6$V. Assume $v_c(0) = 0$V.



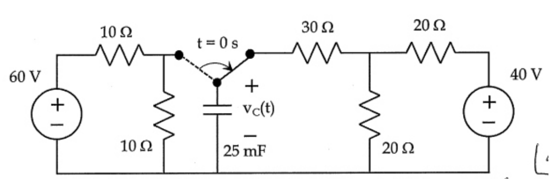
The capacitor voltage is:

$$v_c(t) = \begin{cases} 10\text{V}\,(1 - e^{-0.5t}) & 0 < t < t_a \\ 2\text{V} + 6\text{V}e^{-2.5(t-t_a)} & t_a < t < t_b \\ 10\text{V} - 4\text{V}e^{-0.5(t-t_b)} & t_b < t < t_c \\ \vdots & \end{cases}$$

as plotted to the right. Calculate $t_b - t_a$



6.37 In the circuit below, the switch moves from the left position to the right position at $t = 0$s. Find the $v_c(t)$ for $t \geq 0$s (in V):



(1) $40 - e^{-2t}$

(2) $20 = 20e^{-0.5t}$

(3) $30 + 20e^{-0.5t}$

(4) $40 + 10e^{-2t}$

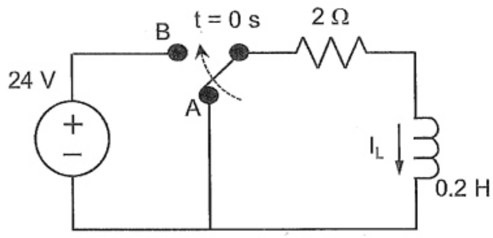
(5) $30 + 20e^{-2t}$

(6) $30 + 5e^{-t}$

(7) $20 - 10e^{-t}$

(8) None of the above

6.38 The switch in the RL circuit below has been at position A for a long time and it turns to position B at $t = 0$s. Find the inductor current (in A) as a function of time for $t \geq 0$s.



(1) $12 - 12e^{-10t}$

(2) $12 - 6e^{-10t}$

(3) $12 - 12e^{-t/10}$

(4) $18 - 18e^{-10t}$

(5) $18 - 18e^{-t/10}$

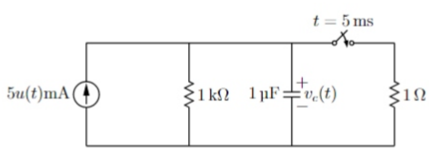
(6) $24 - 24e^{-10t}$

(7) $24 - 24e^{-t/10}$

(8) $24 - 6e^{-10t}$

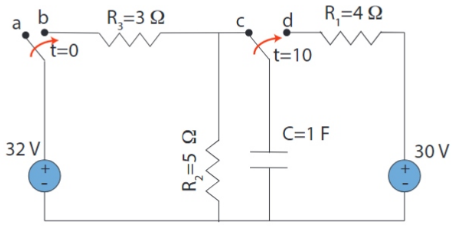
(9) None of the above

6.39 Calculate $v_c(t)$ for $t \geq 0$s in the following circuit:

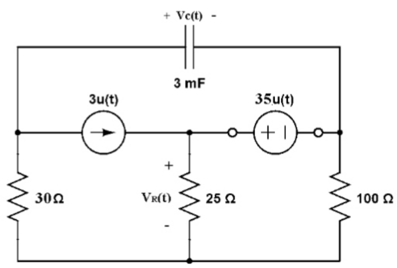


The switch has been open for a long time and is closed at $t = 5$ ms.

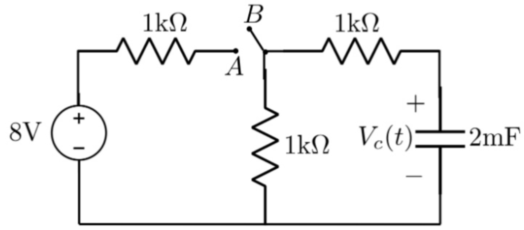
6.40 For time $t < 0$s, the capacitor is discharged, i.e. $v(t < 0) = 0$. At time $t = 0$s, the switch moves from node "a" to node "b" and at time $t = 10$s, the switch is flipped from node "c" to "d". Which plot is the closest description of the voltage across the capacitor, $v_c(t)$?



6.41 In the circuit below, both sources are activated at $t = 0$s. If the capacitor was initially discharged at $t = 0$s, the voltage in the 25 Ω resistor at $t = 15$s is $V_R(0.15) = 67 - 48.8e^{-1}$V. Find the voltage $V_R(0.15)$ if the capacitor had an intial charge of $V_C(0) = 3$V.



6.42 In the circuit, $V_c(0) = 1$V and the switch is at position A a t time $t = 0$s. The switch moves to position B whenever $V_C(t) = 3$V, and moves to position A whenever $V_C(t) = 1$V. Find the period of the voltage waveform generated across the capacitor.



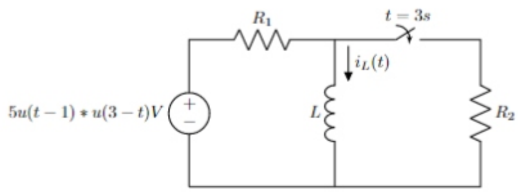
6.43 Find:

Note: The current through the inductor is intially zero.

(a) find an new expression for the current $i_L(t)$ for $-\infty < t < 1s$

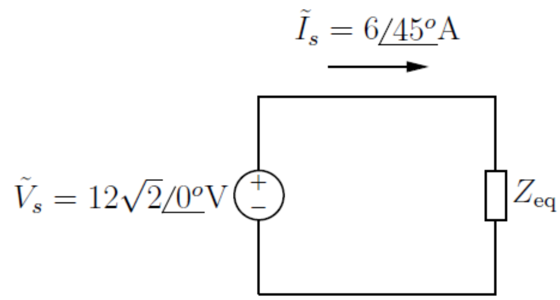
(b) find an new expression for the current $i_L(t)$ for $1s < t < 3s$

(c) find an new expression for the current $i_L(t)$ for $3s < t < \infty$



7 AC Circuit Analysis

7.1 For the circuit below, find the elements that make Z_{eq}. (Components in the possible answers below are assumed to be connected in series)



(1) C

(2) L and C

(3) R and L

(4) R

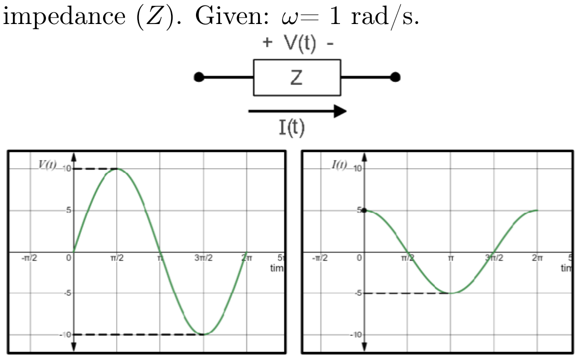
(5) R and C

(6) L

(7) 2R and L

(8) None of the above.

7.2 Which of the following unknown circuit elements in represented by the impedance (Z). Given: ω= 1 rad/s.



(1) Resistor of 2Ω and Inductor of 0.5 H

(2) Capacitor of 2 F

(3) Resistor of 2Ω and Capacitor of 0.5 F

(4) Inductor of 2 H

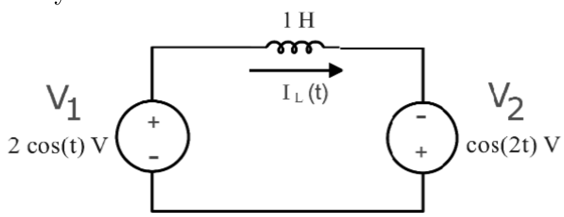
(5) Resistor of 2Ω and Inductor of 2 H

(6) Inductor of 0.5 H

(7) Capacitor of 0.5 F

(8) Resistor of 2Ω and Capacitor of 2 F

7.3 An inductor is connect to two voltage sources of **different** frequencies. Which of the following is **NOT** correct option for the above circuit in steady state?



(1) The phasor for $I_L(t)$ when only V_1 is ON is $\tilde{I}_L = 2\angle-90^{\circ}$

(2) The phasor for $I_L(t)$ when only V_2 is ON is $\tilde{I}_L = 0.5\angle-90^{\circ}$

(3) The phasor for $I_L(t)$ when both V_1 and V_2 are ON is $\tilde{I}_L = 2\angle-90^{\circ} + 0.5\angle-90^{\circ}$

(4) The phasor for $I_L(t)$ when both V_1 and V_2 are ON cannot be defined.

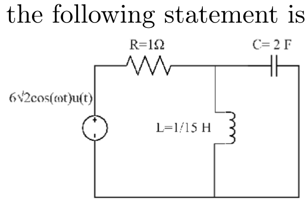
(5) When only V_1 is ON $I_L(t) = 2\cos(t-90^{\circ})$

(6) When only V_2 is ON $I_L(t) = 0.5\cos(2t-90^{\circ})$

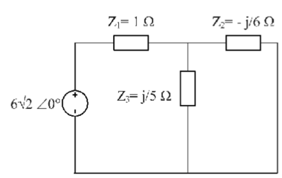
(7) When both V_1 and V_2 are ON $I_L(t) = 2\sin(t) + 0.5\sin(2t)$

(8) None of the above.

7.4 A time-domain and a phasor-domain circuit are shown below, which of the following statement is correct?



'Circuit A'



'Circuit B'

(1) 'Circuit A ' can be transformed into 'Circuit B ' for all $\mathbf{t} > \mathbf{0}$ and $\omega = 3$ rad/s.

(2) 'Circuit A ' can be transformed into 'Circuit B ' for all $\mathbf{t} > \mathbf{0}$ and $\omega = 1$ rad/s.

(3) 'Circuit A ' can be transformed into 'Circuit B' only for $\mathbf{t} \to \infty$ and $\omega = 1$ rad/s.

(4) 'Circuit A' can be transformed into 'Circuit B' only for $\mathbf{t} \to \infty$ and $\omega = 3$ rad/s.

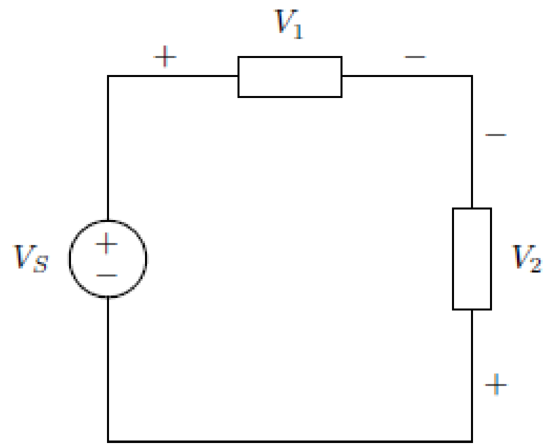
(5) 'Circuit A' can be transformed into 'Circuit B' for all $\mathbf{t} > \mathbf{0}$ and all $\boldsymbol{\omega}$.

(6) 'Circuit A ' can be transformed into 'Circuit B' for all $\mathbf{t} < \mathbf{0}$ and all ω.

7.5 For the circuit shown, it is known that the phasor voltage across the two unknown impedances are:

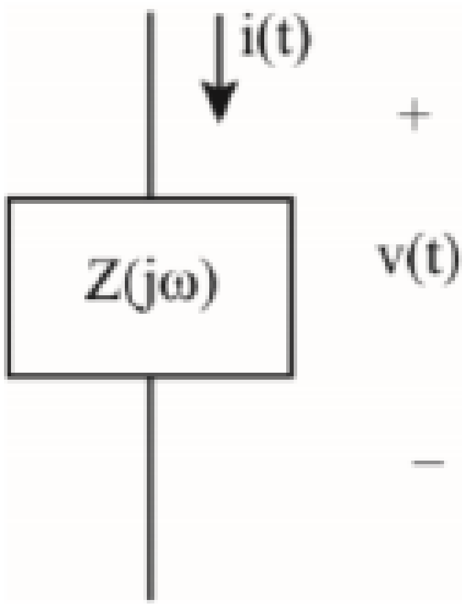
$$V_1 = (5 + 7j)\text{V},\ V_2 = (3 - j)\text{V}$$

What is the value of V_s? [Hint: Be mindful of the indicated voltage polarities]



(1) -3+j
(2) -5-7j
(3) -8-6j
(4) -2-8j
(5) -3-j
(6) 5+7j
(7) 8+6j
(8) 2+8j
(9) None of the above.

7.6 In the circuit shown below the current leads the voltage by 45^o. Find the circuit elements that are most likely in the box marked $Z(jw)$.

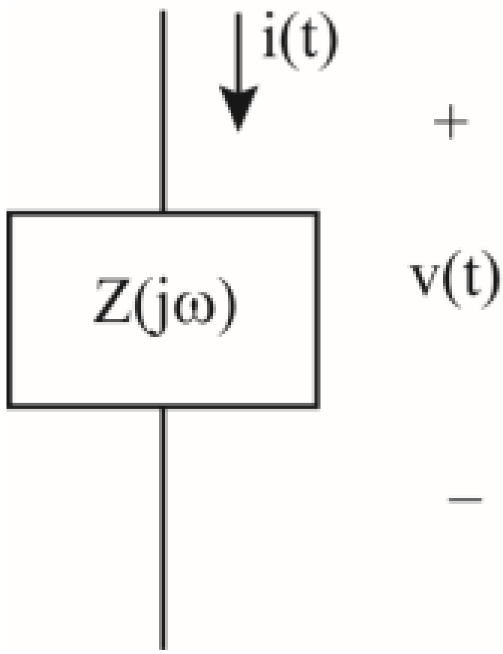


(1) R
(2) L
(3) C
(4) R in series with C
(5) R in series with L
(6) None of the above.

7.7 The phasor of a sinusoidal voltage of 100 rad s^{-1} is $(-2 + j2)$V. What is the equivalent time domain voltage?

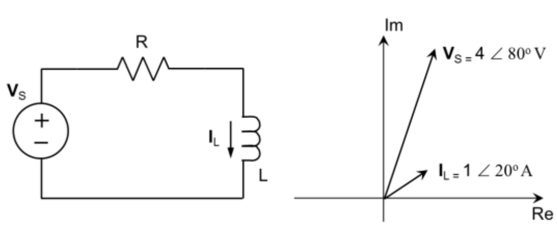
(1) $\sqrt{2}\cos(100t + 135^o$V
(2) $\sqrt{2}\cos(100t - 135^o$V
(3) $\sqrt{2}\cos(100t + 45^o$V
(4) $2\sqrt{2}\cos(100t + 135^o$V
(5) $2\sqrt{2}\cos(100t + 135^o$V
(6) $2\sqrt{2}\cos(100t - 135^o$V
(7) $2\sqrt{2}\cos(100t + 45^o$V
(8) $2\sqrt{2}\cos(100t - 45^o$V
(9) None of the above.

7.8 The current lags the voltage by 35^o in the circuit shown below. Find the circuit elements that are likely in the box marked $Z(jw)$.



(1) R only
(2) L only
(3) C only
(4) R and
(5) R and C
(6) L and C
(7) None of the above.

7.9 The circuit below is in sinusoidal steady state. The voltage and current are given in phasor form in the graph below, and frequency is 10 $rads^{-1}$. Find the values of R and L.

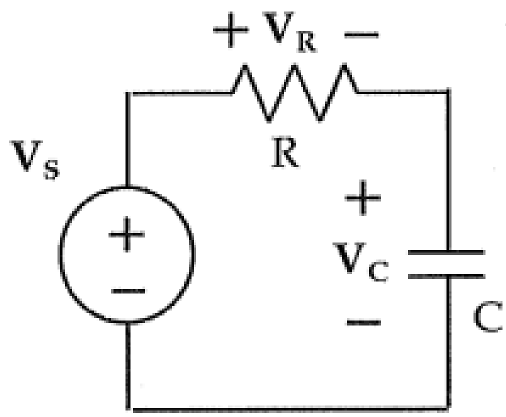


(1) R=2Ω; L=0.035H
(2) R=2Ω; L=0.346H
(3) R=2Ω; L=3.464H
(4) R=2.5Ω; L=0.035H
(5) R=2.5Ω; L=0.346H
(6) R=2.5Ω; L=3.464H
(7) R=4Ω; L=0.035H
(8) R=4Ω; L=0.0346H
(9) R=4Ω; L=3.464H

7.10 For the circuit shown, it is known that the phasor voltage across the resistor and capacitor are:

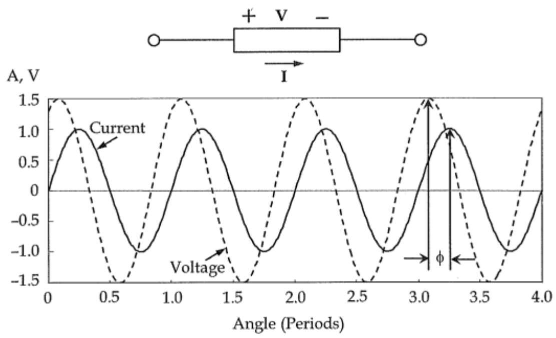
$$V_R = 3 + j3 \text{ and } V_C = 5 + j3$$

Find the source voltage in time domain (in V).



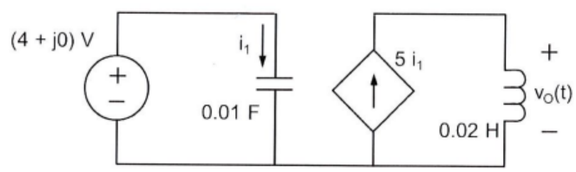
(1) $V_s(t) = 3\cos(\omega t + 35.26^o)$
(2) $V_s(t) = 3\cos(\omega t - 53.72^o)$
(3) $V_s(t) = 6\cos(\omega t)$
(4) $V_s(t) = 6\cos(\omega t - 35.26^o)$
(5) $V_s(t) = 8\cos(\omega t)$
(6) $V_s(t) = 9\cos(\omega t - 70.64^o)$
(7) $V_s(t) = 10\cos(\omega t + 36.87^o)$
(8) $V_s(t) = 10\cos(\omega t)$
(9) None of the above.

7.11 The rectangle below represents a group of passive circuit elementss with a resistor and an inductor or capacitor. Waveforms for the current through and the voltage across the group are shown in the plot. The magnitude of the phase shift is $\Phi = 0.2\pi$. Find the impedance of the group (in Ω).



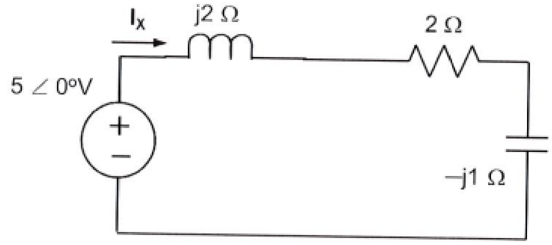
(1) 1+j
(2) 1-j
(3) 1.21+j0.88
(4) 1.21-j0.88
(5) 1.48+j0.56
(6) 1.48-j0.56
(7) 1.75-j1.25
(8) 1.75-j1.25
(9) None of the above.

7.12 Assuming $\omega = 100$ rad/s in the circui below, find the phasor form of $v_0(t)$.



(1) $(40 + 20j)$V
(2) $(-40 + 20j)$V
(3) $(20 + 40j)$V
(4) $(20 + 40j)$V
(5) $(10 + 10j)$V
(6) $(10 - 10j)$V
(7) 40V
(8) -40V
(9) None of the above.

7.13 Find the phasor current I_x (in A):



(1) $3.1\angle 153.4^o$
(2) $0.2\angle -26.6^o$
(3) $2.2\angle 63.4^o$
(4) $2.2\angle 153.4^o$
(5) $0.2\angle 63.4^o$
(6) $2.2\angle -26.6^o$
(7) $3.1\angle -63.4^o$
(8) $0.2\angle -63.4^o$
(9) None of the above

7.14 The complex exponential forcing function in a circuit operating in sinusoidal steady state is given by $V = 20je^{j\omega t}$V. What is the corresponding real forcing function?

(1) $20\cos(\omega t)$V
(2) $-20\cos(\omega t)$V
(3) $20\sin(\omega t)$V
(4) $-20\sin(\omega t)$V
(5) $20\cos(\omega t) + 20\sin(\omega t)$V V
(6) $20\cos(\omega t) - 20\sin(\omega t)$V V
(7) $-20\cos(\omega t) + 20\sin(\omega t)$V V
(8) $-20\cos(\omega t) - 20\sin(\omega t)$V
(9) None of the above

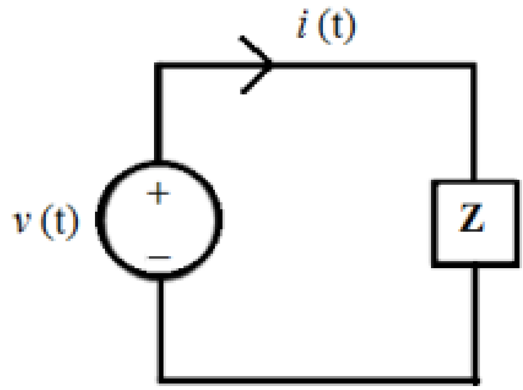
7.15 Find the phasor below that represents the voltage $v(t) = 2\cos(t) + 3\sin(t)$V:

(1) 5 V
(2) 1 V
(3) -1 V
(4) 2+3j V
(5) 2-3j V
(6) -2+3j V
(7) -2-3j V
(8) 3j V
(9) None of the above

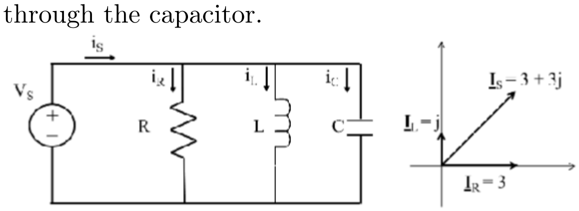
7.16 Given the following pair of voltage and current:

$$v(t) = 550\sin(10t + 40^o)\text{V},\ i(t) = 11\sin(10t - 50^o)\text{A} \tag{1}$$

in the circuit below, what is the most likely the element 'Z'?



7.17 Given the phasor currents below, determine the phasor current (in A) through the capacitor.



7.18 Given that $v_1(t) = 5\cos(\omega t)$, $v_2(t) = 3\sin(\omega t)$, and $v_3(t) = -4\sin(\omega t - 50)$

(1) $v_1(t)$, $v_2(t)$, $v_3(t)$
(2) $v_1(t)$, $v_3(t)$, $v_2(t)$
(3) $v_2(t)$, $v_3(t)$, $v_1(t)$
(4) $v_2(t)$, $v_1(t)$, $v_3(t)$
(5) $v_3(t)$, $v_2(t)$, $v_1(t)$
(6) $v_3(t)$, $v_1(t)$, $v_2(t)$

7.19 For the circuit below, the current $i_s(t) = 2\cos(10t + 10^o) + 4$A. Find the $i(t)$. (Hint: The current has a DC component)

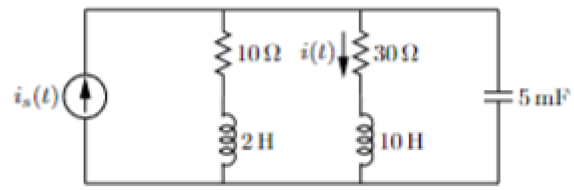
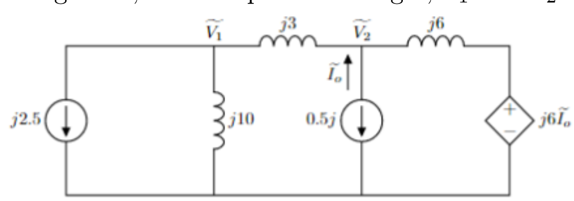
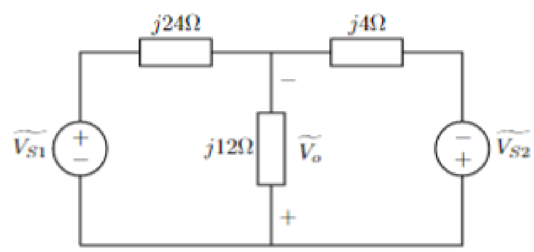


Figure 8.64

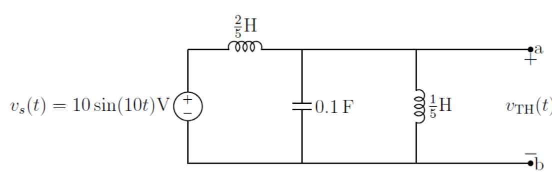
7.20 Using KCL, find the phasor voltages, $\tilde{V_1}$ and $\tilde{V_2}$



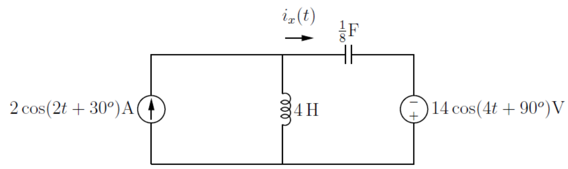
7.21 Using the principles of superposition, find $\tilde{V_0}$ when $\tilde{V_{S1}} = 3j$ and $\tilde{V_{S2}} = 9$. Your analysis include obtaining an expression for $\tilde{V_0}$ in terms of arbitrary source voltage $\tilde{V_{S1}}$ and $\tilde{V_{S2}}$



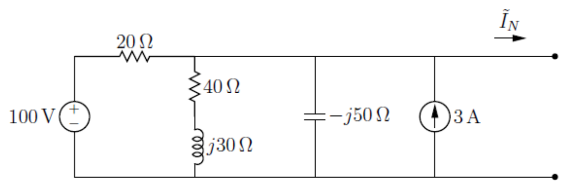
7.22 Find the Thevenin equivalent voltage in the following sinusoidal steay state circuit at the terminal ab.



7.23 For the circuit below, find $i_x(t)$.

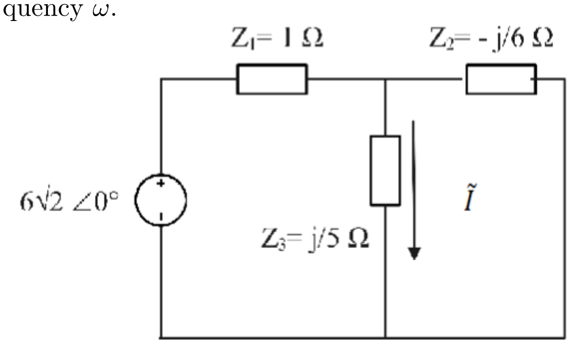


7.24 Find the Norton (short circuit) currrent $\tilde{I_N}$.

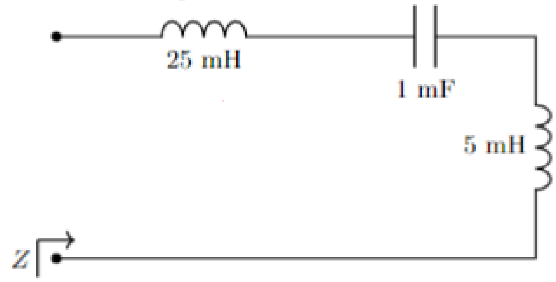


(1) 2A
(2) 0A
(3) 3A
(4) 5A
(5) 4A
(6) 8A
(7) -2A
(8) None of the above.

7.25 Find the time domain current flowing through Z_3 if the source has frequency ω.

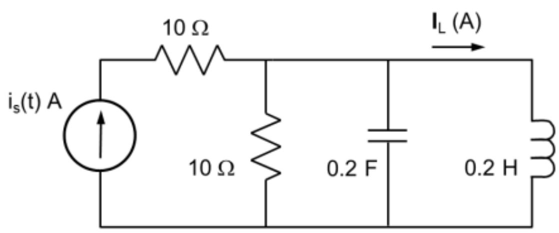


7.26 What is the impedance, Z, at 200 rad s^{-1}?



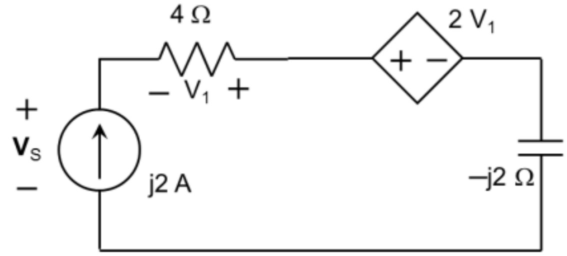
(1) $j\Omega$
(2) $-j\Omega$
(3) $j5\Omega$
(4) $-j5\Omega$
(5) $j6\Omega$
(6) $-j6\Omega$
(7) $j4\Omega$
(8) $-j4\Omega$
(9) None of the above.

7.27 In the circuit below, $i_s(t) = \cos(5t)$A. Find the sinusoidal steady state phasor current through the inductor (I_L) in A.



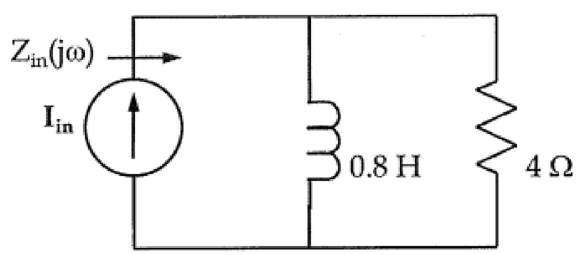
(1) $1\angle 45^o$
(2) $1\angle -90^o$
(3) $10\angle 90^o$
(4) $10\angle -90^o$
(5) $0.2\angle -45^o$
(6) $0.2\angle -60^o$
(7) $0.1\angle -45^o$
(8) $0.1\angle -90^o$
(9) None of the above

7.28 Using KVL, find the phasor voltage V_s (in V).



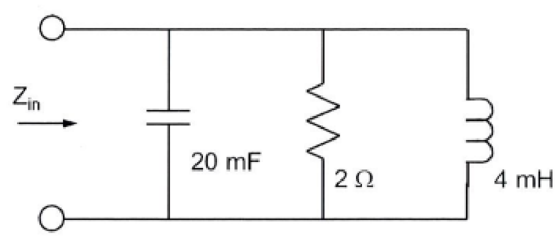
(1) $(4 - j)$
(2) $(-4j)$
(3) $(2 + 3j)$
(4) $(4 - 8j)$
(5) $(4 + j)$
(6) $(4 - 3j)$
(7) (2)
(8) $(2 - 8j)$
(9) None of the above.

7.29 Find the input impedance, $Z_{\text{in}}(j\omega)$, at $\omega = 5$rad/s. (in Ω).



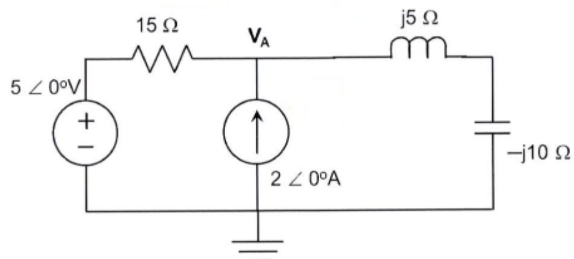
(1) $(1 + j)$
(2) $(2 + j2)$
(3) $(2 - j)$
(4) $(3 + j)$
(5) $(3 - j2)$
(6) $(4 + j4)$
(7) $(4 - j2)$
(8) $(4 - j4)$
(9) None of the above.

7.30 Assuming $\omega = 100$rad/s, find the impedance for the circuit shown (in Ω).



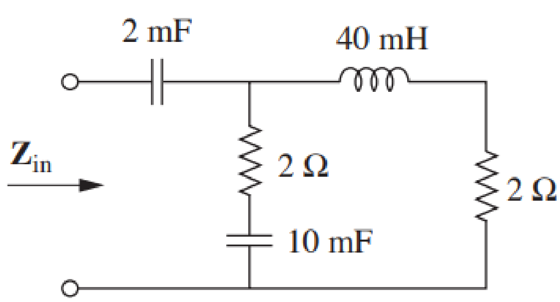
(1) $(0.707 + j0.707)$
(2) $(0.707 + j0.707)$
(3) $(1 + j)$
(4) $(1 - j)$
(5) $(1.414 + j1.414)$
(6) $(1.414 - j1.414)$
(7) $(2 + j2)$
(8) $(2 - j2)$
(9) None of the above.

7.31 Find the phasor voltage V_A (in V).

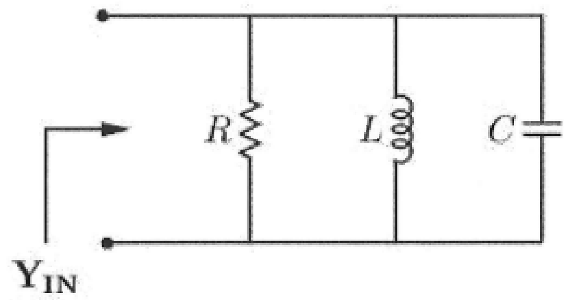


(1) (5)
(2) $(5 - j5)$
(3) $(5 + j5)$
(4) $(1 - j10)$
(5) $(-13.7 + 10)$
(6) $(3.5 - j10.5)$
(7) $(2.5 + j20)$
(8) $(-5 + j5)$
(9) None of the above.

7.32 Find the input impedance Z_{in} of the circuit in the figure below. Assume that the circuit operates at $\omega = 50\text{rad/s}$.

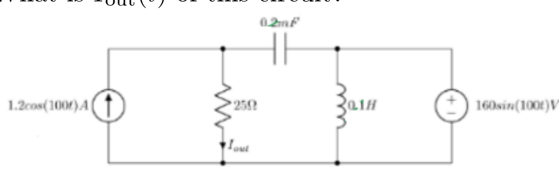


7.33 Given $R = 10\,\Omega$, $L = 1\,H$, and $\omega = 10\,rad\,s^{-1}$, find the value of C such that $Y_{IN} = 0.1\,S$.



(1) (C=1mF)
(2) (C=10mF)
(3) (C=100mF)
(4) (C=1F)
(5) (C=10F)
(6) (C=100F)
(7) (C=1000F)
(8) None of the above.

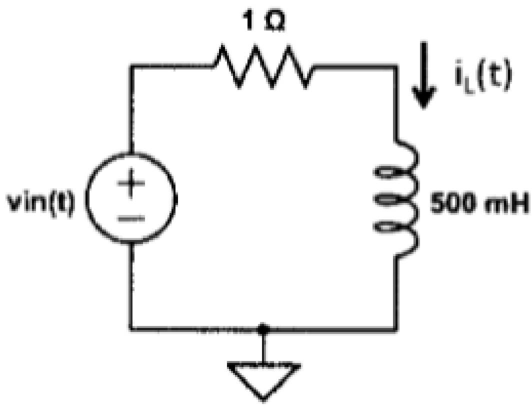
7.34 What is $I_{\text{out}}(t)$ of this circuit?



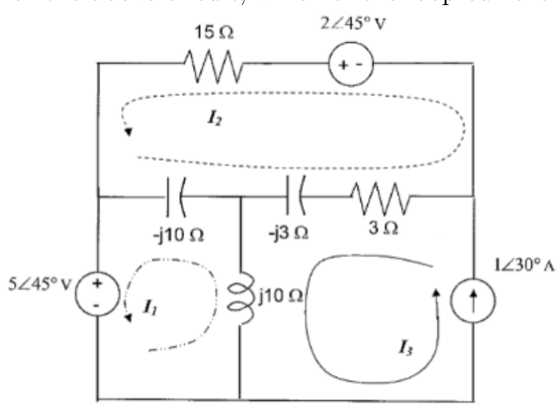
7.35 Please find $i_L(t)$ given the circuit below for the specified $v_{\text{in}}(t)$:

(1) $v_{in}(t) = 5u(t)$

(2) $v_{in}(t) = 5\cos(2t)$



7.36 For the above circuit, which of the loop current equation is wrong?



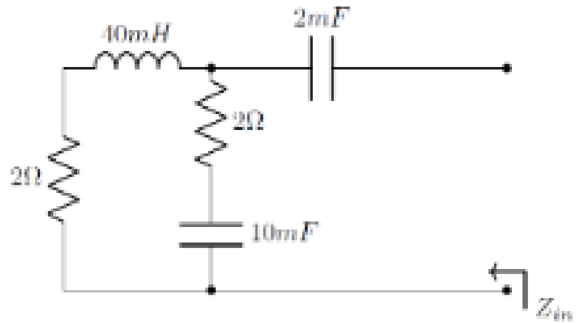
(1) $j10I_2 - j10I_3 = -5\angle 45^o$

(2) $j10I_1 + (18 - j13)I_2 - (3 - j3)I_3 = 2\angle 45^o$

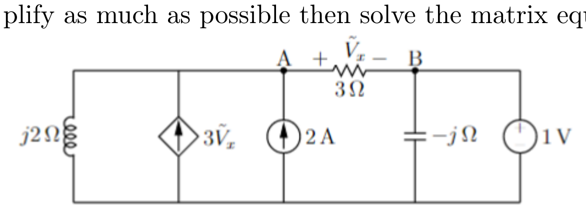
(3) $j10(I_3 - I_1) + (3 - j3)(I_3 - I_2) = 0$

- One of these equations is wrong. Identify the wrong one and correct it.
- Solve the system of equations for the mesh currents I1, I2, I3.

7.37 Find the input impedance Z_{in} (in Ω) of the circuit in the figure below. Assume that the circuit operateat $\omega = 25\text{rad/s}$.

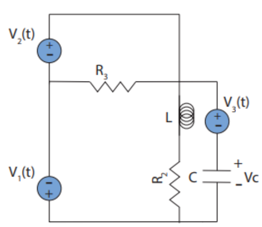


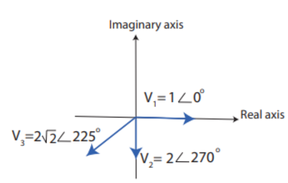
7.38 Write the nodal equation in a matrix formfor the following circuit. Simplify as much as possible then solve the matrix equation.



$$\begin{bmatrix} \quad & \quad \\ \quad & \quad \end{bmatrix} \begin{bmatrix} \tilde{V}_{\text{A}} \\ \tilde{V}_{\text{B}} \end{bmatrix} = \begin{bmatrix} \quad \\ \quad \end{bmatrix}$$

7.39 Given the phasor voltages V_1, V_2, and V_3 below, determine the phasor voltage across the capacitor as shown on the circuit below.





(1) $1\angle 0^\circ\,\text{V}$
(2) $1\angle 180^\circ\,\text{V}$
(3) $2\sqrt{2}\angle 225^\circ\,\text{V}$
(4) $-2\sqrt{2}\angle 225^\circ\,\text{V}$

(5) $1 - 2\sqrt{2}\angle 45^{\circ}$ V

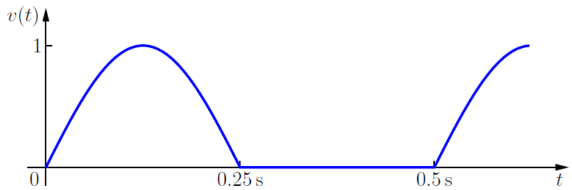
(6) $1 - 2\sqrt{2}\angle 225^{\circ}$ V

(7) $2(1 - \sqrt{2})\angle 225^{\circ}$ V

(8) None of the above

8 Frequency Response and Complex Power

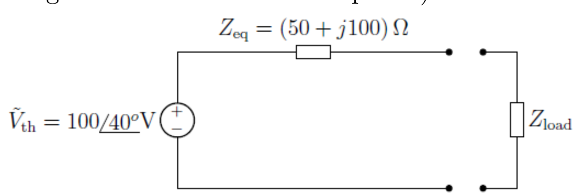
8.1 Find the RMS value of the following periodic voltage. (Hint: $\sin^2(x) = \frac{1-\cos(2x)}{2}$)



$$v(t) = \begin{cases} \sin(4\pi t)\,\mathrm{V}, & 0\,\mathrm{s} < t < 0.25\,\mathrm{s} \\ 0\,\mathrm{V}, & 0.25\,\mathrm{s} < t < 0.5\,\mathrm{s}. \end{cases}$$

(1) 1V
(2) 0.25V
(3) 5V
(4) 0.2V
(5) 0.5V
(6) 1.5V
(7) 2V
(8) None of the above.

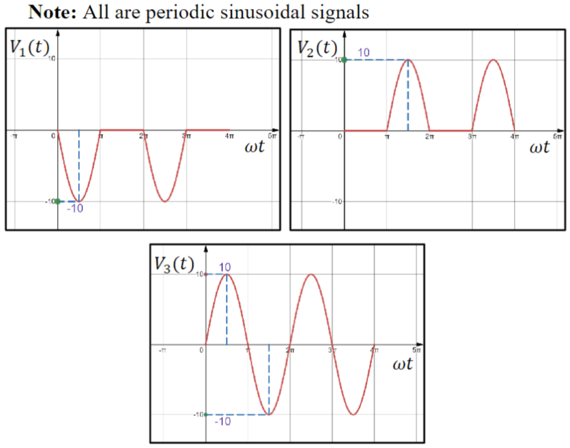
8.2 A system is represented with its equivalent Thevenin circuit as seen below. The source voltage is represented by its amplitude, and angle. Find the maximum power absorbed by the load $P_{\mathrm{load}}(\max)$. (The load Z_{load} is designed to absorb maximum power)



(1) 70 W
(2) 25 W
(3) 100 W
(4) 20 W
(5) 50 W
(6) 40 W
(7) 30 W
(8) None of the above

8.3 Which of the following statement is correct?
[Select the most complete answer.]

Note: All are periodic sinusoidal signals



(1) $V_{rms_3} > V_{rms_1} + V_{rms_2}$

(2) $V_{rms_3} = V_{rms_1} + V_{rms_2}$

(3) $V_{rms_1} = -V_{rms_2}$

(4) ${V_{rms_1}}^2 + {V_{rms_2}}^2 = {V_{rms_3}}^2$

(5) $V_{rms_1} = V_{rms_2}$

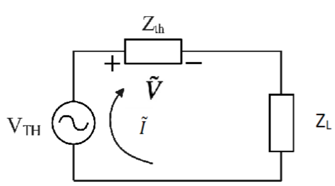
(6) Both (3) and (5)

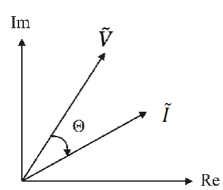
(7) Both (4) and (5)

(8) None of the above

8.4 Which of the following statement is correct?
[Select the most complete answer.]

Note: $Z_{th} = R_{th} + j\,X_{th}$ $Z_L = R_L + j\,X_L$





(1) Reactance (X_L) should be inductive to maximize the transferred power.

(2) Reactance (X_L) should be capacitive to maximize the transferred power.

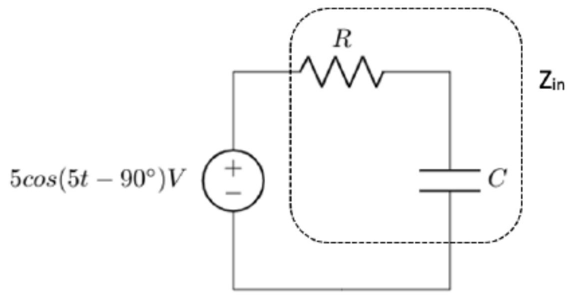
(3) $Z_L = Z_{th}^*$ maximizes the transferred power.

(4) Both (1) and (3)

(5) Both (2) and (3)

(6) All (1), (2) and (3)

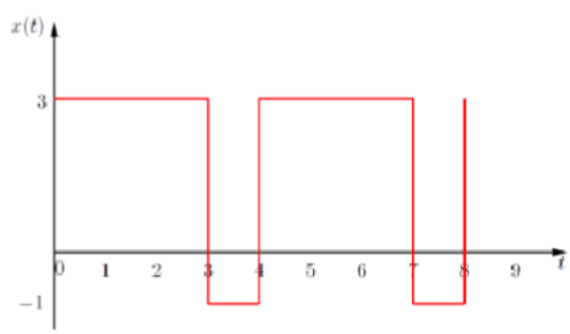
8.5 The input impedance Z_{in} in the circuit below is $0.5\angle -60^o\Omega$. The voltage of the source is $5\cos(5t - 90^o)$V. Find the average power generated by the source (in W).



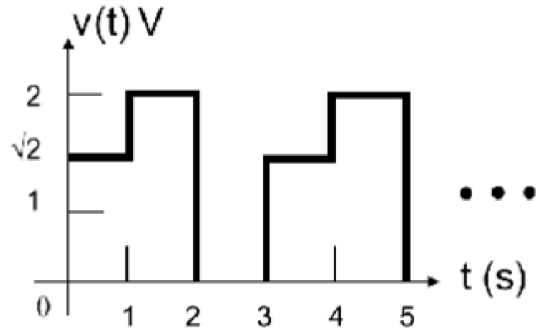
(1) 0
(2) 2.5
(3) 5
(4) 7.5
(5) 10
(6) 12.5
(7) 25
(8) None of the above

8.6 An unknown impedance Z is excited by a voltage source $v(t) = 5\cos(10t + 70°)$ V. The current through the impedance (passive sign convention) is given by $i(t) = 2\cos(\omega t + \theta)$ A. If the average power absorbed by this impedance is 2.5 W, please find
a) The frequency ω.
b) The phase θ.
c) The impedance Z.

8.7 The first two periods of a periodic signal $x(t)$ are shown below. Please calculate its effective (rms) value X_{rms}

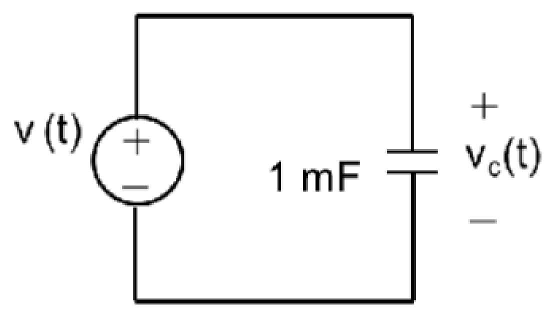


8.8 Find the effective (rms) voltage for the waveform shown below (in V).



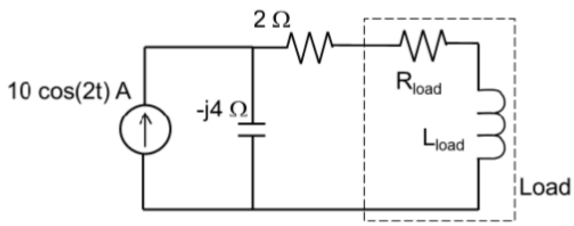
(1) 1
(2) 2
(3) $\sqrt{3}$
(4) 4
(5) $\sqrt{2}$
(6) 6
(7) $2\sqrt{2}$
(8) $(2/3)\sqrt{3}$
(9) None of the above

8.9 Find the reactive power (in VAR) for the capacitor (rms) voltage given a source voltage of $v(t) = 50\sqrt{2}\sin(10t)V$



(1) 25
(2) -25
(3) 50
(4) -50
(5) 100
(6) -100
(7) 50 $\sqrt{2}$
(8) -50 $\sqrt{2}$
(9) None of the above

8.10 In the circuit below, choose the load impedance for maximum power transfer to the load resistor R_{load}



(1) 1+j
(2) 1-j
(3) 1+2j
(4) 1-2j
(5) 2+4j
(6) 2-4j
(7) 2+2j
(8) 2-2j
(9) None of the above

8.11 In sinusoidal steady state the voltage across a load and the current through the load are (passive sign convention)
$\tilde{V}_{\text{rms}} = -5\text{jV}, \tilde{I}_{\text{rms}} = 2\text{jA}$
What is the apparent power consumed by this load?
What is the complex power consumed by the load?

(1) 10 VA
(2) -10 VA
(3) 10j VA
(4) -10j VA
(5) 2.5 VA
(6) -2.5 VA
(7) 2.5j VA
(8) -2.5j VA
(9) 0 VA
(10) None of the above

8.12 What is the real power (in W) consumed by the load in previous question? What is the reactive power (in VAR) consumed by the load in previous question?

(1) 10
(2) -10
(3) 10j
(4) -10j
(5) 2.5
(6) -2.5

(7) 2.5j

(8) -2.5j

(9) 0

(10) None of the above

8.13 A periodic current has a maximum value of 2.2 A and a minimum value of −2.2 A. Which of the following choice is not possible for its rms value?

(1) 2.5 A

(2) 2 A

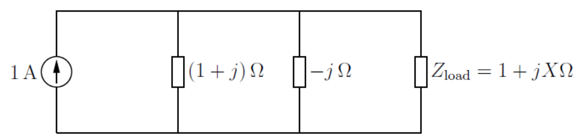
(3) 1.5 A

(4) 1 A

(5) 0.5 A

(6) Any value is possible

8.14 Determine the value X in Ω such that the load $Z_{\text{load}} = 1 + jX\Omega$ absorbs the maximum amount of power.



(1) 2Ω

(2) 0Ω

(3) -1Ω

(4) 0.5Ω

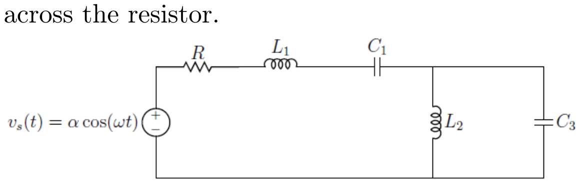
(5) 4Ω

(6) 1Ω

(7) -2Ω

(8) None of the above

8.15 Find the finite angular frequency ω in rad/s that will minimize the voltage across the resistor.



(1) $\omega = \frac{1}{\sqrt{L_1 C_3}}$

(2) $\omega = \frac{1}{\sqrt{R L_1}}$

(3) $\omega = L_1 + R$

(4) $\omega = \frac{L_1 L_2}{C_3}$

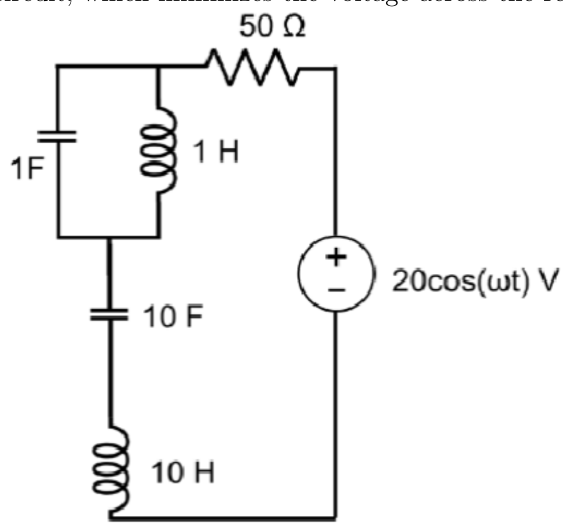
(5) $\omega = \frac{1}{\sqrt{L_2 C_3}}$

(6) $\omega = \frac{L_2}{C_3}$

(7) $\omega = \frac{L_2}{C_3} + L_1$

(8) None of the above

8.16 Find the nonzero finite value of ω in unit of rad/sec for the following circuit, which minimizes the voltage across the resistor.



(1) 5 rad/s

(2) 1 rad/s

(3) 10 rad/s

(4) 0.02 rad/s

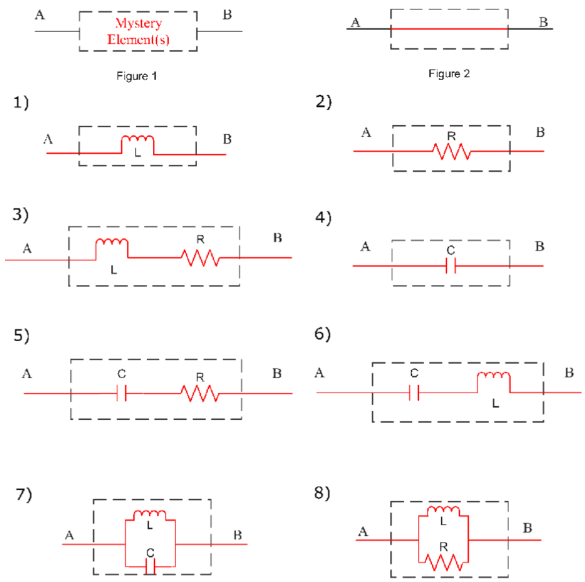
(5) 20 rad/s

(6) 0.1 rad/s

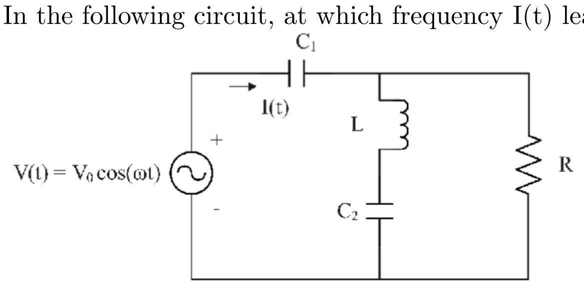
(7) 0.2 rad/s

(8) None of the above

8.17 If in sinusoidal steady state the circuit shown in Fig 1, becomes equivalent to a "short" (circuit shown in Fig. 2) at a finite frequency ($0 < \omega < \infty$). Identify which circuit will constitute for the mystery element.



8.18 In the following circuit, at which frequency I(t) leads V(t) by 90°?



(1) $\omega = \frac{1}{RC_1}$

(2) $\omega = \frac{1}{\sqrt{LC_1}}$

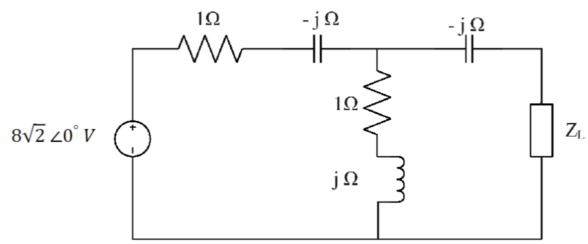
(3) $\omega = \frac{1}{\sqrt{LC_2}}$

(4) $\omega = \frac{1}{\sqrt{L(C_1+C_2)}}$

(5) $\omega = \frac{1}{R(C_1+C_2)}$

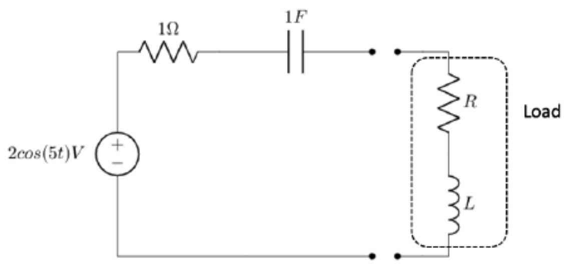
(6) $\omega = \frac{1}{R(\frac{C_1 C_2}{C_1+C_2})}$

8.19 Find the maximum average power transferred to Z_L?



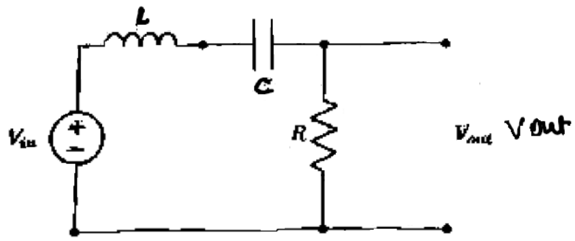
(1) 1 W
(2) 2 W
(3) 4 W
(4) 5 W
(5) 8 W
(6) $4\sqrt{2}$ W
(7) $12\sqrt{2}$ W
(8) None of the above

8.20 The voltage source in the circuit has voltage of $2\cos(5t)$V. Find the value of R and L such that their load extracts the maximum average power out of the two-terminal network below.

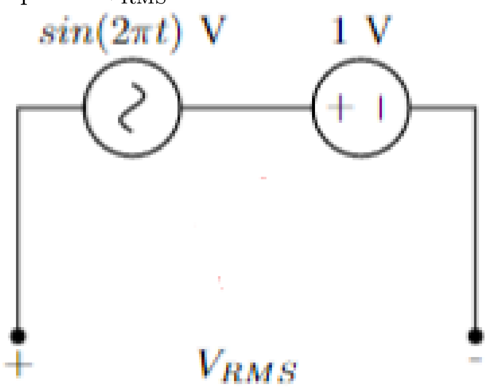


(1) $R = 1\Omega$, $L = 0.04H$
(2) $R = 1\Omega$, $L = 1H$
(3) $R = 1\Omega$, $L = 4H$
(4) $R = 1\Omega$, $L = 0.02H$
(5) $R = 2\Omega$, $L = 0.04H$
(6) $R = 2\Omega$, $L = 1H$
(7) $R = 2\Omega$, $L = 0.02H$
(8) $R = 2\Omega$, $L = 4H$
(9) None of the above

8.21 Find the transfer function $H(\omega) = \frac{V_{\text{out}}}{V_{\text{in}}}$ of the circuit at $\omega = 10$ rad/s if $L = 0.1H, C = 0.05F, R = 1\Omega$



8.22 A sinusoidal source is connected in series with a 1 V DC offset. What is the expected V_{RMS} value?



(1) $1 - \frac{1}{\sqrt{2}} \approx 0.293$ V

(2) 0.5 V

(3) $\frac{1}{\sqrt{2}} = \frac{\sqrt{2}}{2} \approx 0.707$ V

(4) $\sqrt{\frac{2}{3}} \approx 0.816$ V

(5) 1 V

(6) $\sqrt{\frac{3}{2}} \approx 1.22$ V

(7) $1 + \frac{1}{\sqrt{2}} \approx 1.707$ V

(8) 2 V

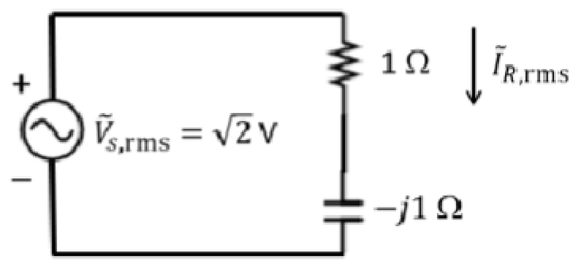
(9) None of the above

8.23 When a passive device is connected to a source of $100\cos(10t - 20°)$ V rms it absorbs an average power of 100 W. It is also known that the phase of its impedance is 60 degrees. Calculate the current through the device. It is given that $\cos(60°) = 0.5$

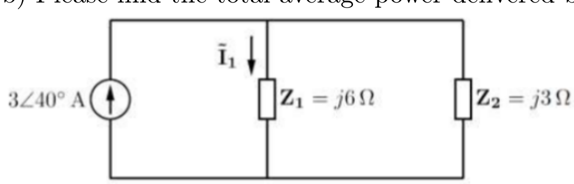
(1) 0 A rms

(2) 0.3 A rms
(3) 0.5 A rms
(4) 1 A rms
(5) 1.3 A rms
(6) 1.5 A rms
(7) 2 A rms
(8) None of the above

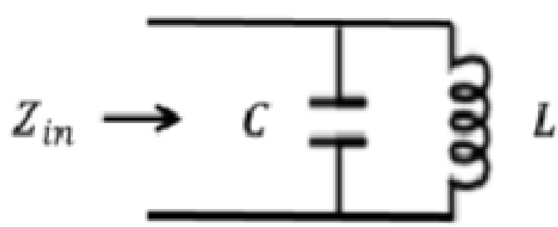
8.24 This circuit below is given in the phasor domain. Please calculate:
(a) The current $\tilde{I}_{R,\text{ rms}}$ through the resistor.
(b) The average power consumed by the resistor.
(c) The average power consumed by the capacitor.
(d) The average power consumed by the resistor if the frequency ω is doubled and the capacitance value is reduced by a factor of 2.



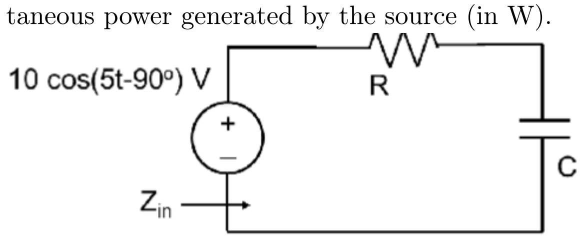
8.25 a) The circuit below is drawn in the phasor domain. If the excitation frequency is 10 rad/s, please find the time-domain current $i_1(t)$.
b) Please find the total average power delivered by the current source.



8.26 For the following circuit please calculate the frequency ω such that the input impedance is infinite i.e. $Z_{\text{in}}(\omega) = \infty$. The frequency should be expressed as a function of L and C.

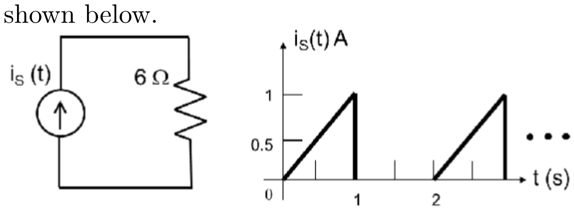


8.27 The input impedance in the circuit below is $1\angle -60°\Omega$. Find the instantaneous power generated by the source (in W).



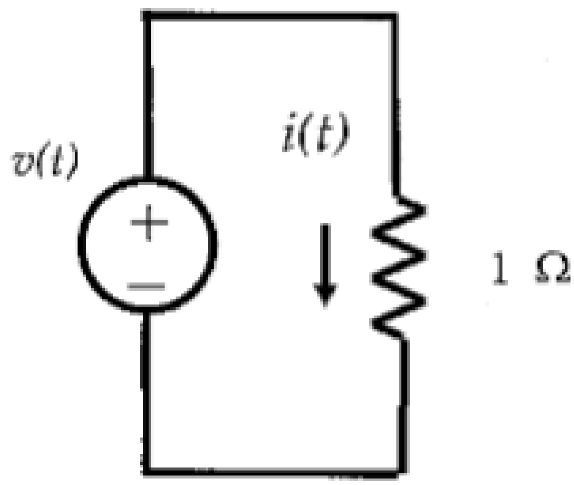
(1) $100 + 50\cos(10t - 60°)$
(2) $100 + 25\cos(10t - 120°)$
(3) $25 + 25\cos(10t - 60°)$
(4) $25 + 50\cos(10t - 120°)$
(5) $50 + 25\cos(10t - 60°)$
(6) $50 + 50\cos(10t - 60°)$
(7) $75 + 50\cos(10t - 120°)$
(8) $75 + 25\cos(10t - 60°)$
(9) 100
(10) None of the above

8.28 Find the average power (in W) absorbed by the 6Ω resistor in the circuit shown below.



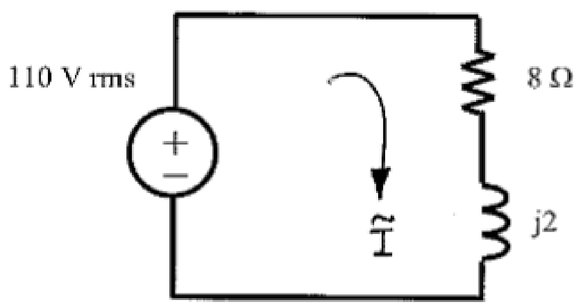
(1) 1
(2) 2
(3) 3
(4) 0.5
(5) 0.33
(6) 6
(7) 12
(8) 1.5
(9) None of the above

8.29 In the circuit below the source is given by
$v(t) = \cos(2t - 30°) + \cos(2t + 60°)$, in Volts.
The maximum current $i_{\max}$ (in A) that flows through the resistor is given by



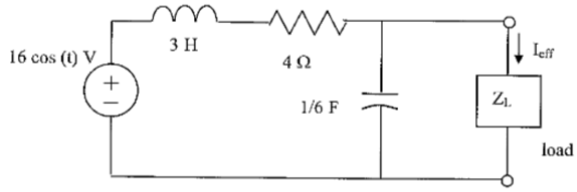
(1) 0.500
(2) 0.707
(3) 1.000
(4) 1.414
(5) 1.732
(6) 2.000

8.30 The apparent power supplied by the 110Vrms source is



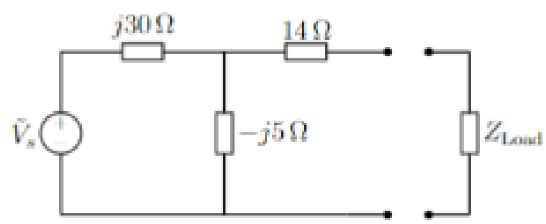
(1) 756.3 VA
(2) 1512.5 VA
(3) 1467.3 VA
(4) 733.7 VA
(5) 6050 VA
(6) 2201.1 VA

8.31 Select the correct value for the magnitude of the effective current I_{eff} (in A) that flows through the load if maximum average power is transferred to the load.



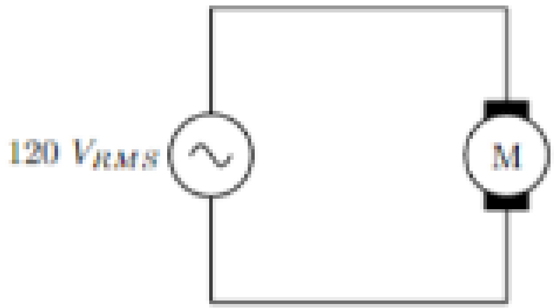
(1) 1.18
(2) 2.24
(3) 3.66
(4) 4.0
(5) 5.5
(6) 7.26

8.32 For the circuit shown in the figure, find the load elements that maximize the average power absorbed by the load Z_{Load}. The frequency of the source voltage is 100 rad/s. (Components in the answer selections below are assumed to be connected in series.)
a. Find the Thevenin voltage and source impedance of the left portion of the circuit.
b. Find the load impedance that maximizes average power.
c. Find the circuit elements that create the desired load impedance at 100 rad/s.



(1) R = 14Ω and C = 16 F
(2) R = 14Ω and L = 16 H
(3) R = 14Ω and C = 1.667 mF
(4) R = 14Ω
(5) R = 14Ω
(6) R = 14Ω and L = 60 mH
(7) I = 60 mH
(8) I = 16 H
(9) None of the above

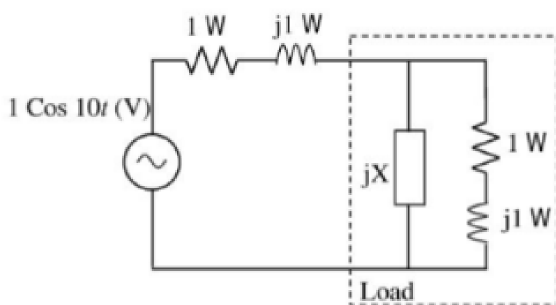
8.33 An inefficient 60 W motor is plugged into an AC outlet. The circuit schematic of this is shown below. Due to the inductive windingy, current lags voltage by 30°. What is the RMS current through it?



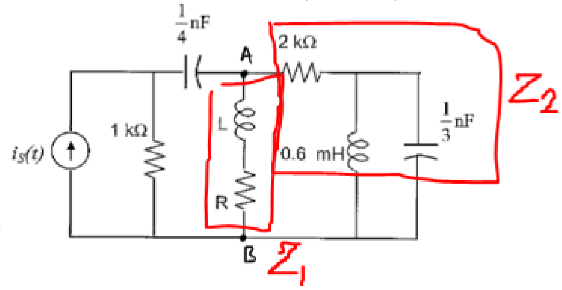
8.34 Find what reactive element is required in the following circuit to achieve maximum power transfer to the load.

a. Derive an expression for the load impedance in terms of the reactive component X. What is the load impedance required for maximum power transfer?

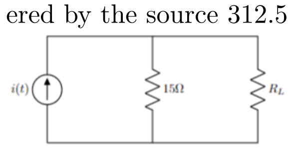
b. Solve for X and identify the circuit element that achieves this value at 10 rad/s.

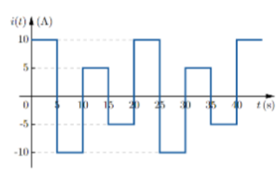


8.35 In the following figure, $i_S(t) = 5\sqrt{2}\cos\left(2\times 10^6 t\right)$ (in mA). One needs to find the value of R and L, such that the power consumed by the resistor R is maximized.
In this circuit, two complex load impedances Z_1 and Z_2 are connected to a non-ideal source.
a. Find the source impedance using source transformations.
b. Find the component circuit elements R and L that make up Z_1 at the given frequency.
c. Can the conditions for maximum power transfer discussed in lecture be applied to Z_2? Explain why or why not.

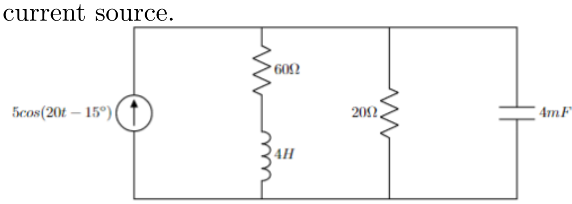


8.36 Consider the circuit below, where $i(t)$ is given by the periodic signal in the adjacent plot.
1. Find I_{rms} of the input signal $i(t)$.
2. Find the load resistance R_L that makes the total average power delivered by the source 312.5 W.

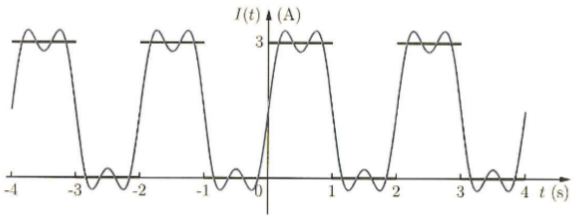




8.37 Find the instantaneous power delivered by the source and the total average power absorbed by the circuit.
Hint: You may want to first find the equivalent impedance seen by the current source.

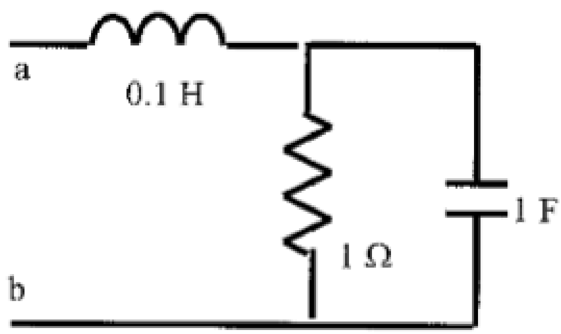


8.38 What is the approximate rms value of the following current?



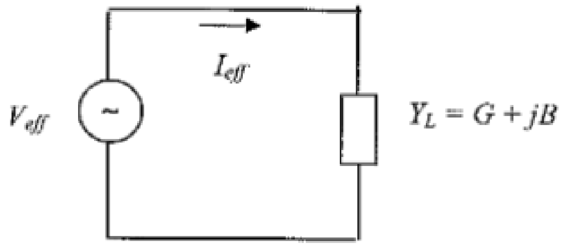
(1) $\frac{3}{\sqrt{2}}$ A rms
(2) $3\sqrt{2}$ A rms
(3) $\frac{2}{\sqrt{2}}$ A rms
(4) $2\sqrt{2}$ A rms
(5) $\sqrt{2}$ A rms
(6) $\frac{1}{\sqrt{2}}$ A rms
(7) 1 A rms
(8) 0 A rms
(9) None of the above

8.39 The frequency at which the network between terminals "a" and "b" behaves in a purely resistive manner is:



(1) $3/\pi$ Hz
(2) 3π Hz
(3) $4/\pi$ Hz
(4) 4π Hz
(5) $1.5/\pi$ Hz
(6) $1/\pi$ Hz

8.40 Consider a load with an admittance of $Y_L = G + jB$ connected to an ideal sinusoidal source with an effective value of V_{eff}. In sinusoidal steady state which of the following equations can be used to calculate the real average power absorbed by the load?



(1) $P_{au} = G\,|I_{\text{eff}}|^2$

(2) $P_{au} = G\,|V_{\text{eff}}|^2$

(3) $P_{au} = B\,|I_{\text{eff}}|^2$

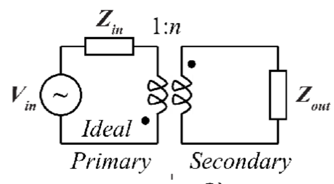
(4) $P_{au} = B\,|V_{\text{eff}}|^2$

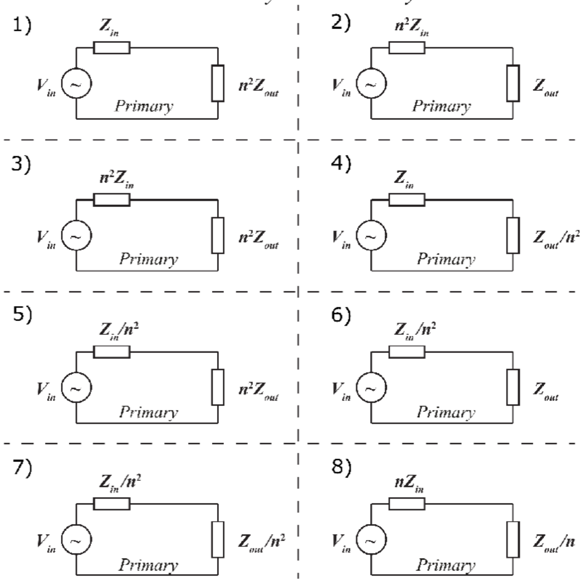
(5) $P_{au} = G\,|I_{\text{eff}}|^2 + B\,|V_{\text{eff}}|^2$

(6) $P_{au} = G\,|V_{\text{eff}}|^2 + B\,|I_{\text{eff}}|^2$

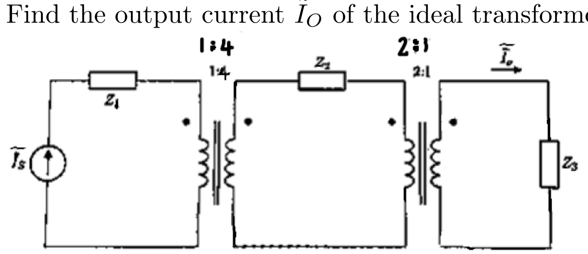
9 Ideal Transformers

9.1 Choose an equivalent scheme for a general circuit with an idea transformer (see the picture to the right) from the set below:

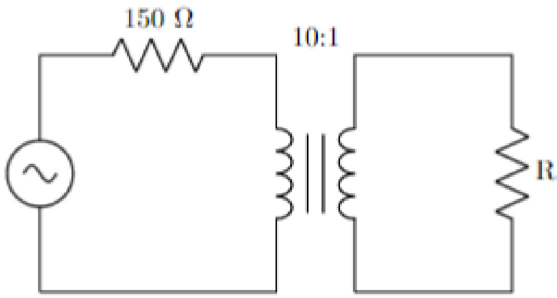




9.2 Find the output current $\tilde{I}_O$ of the ideal transformer. Given $\tilde{I}_S = 2A$

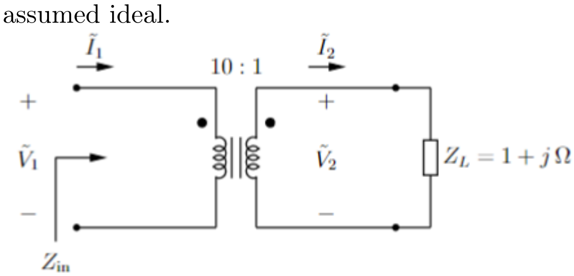


9.3 What must R be such that it absorbs maximum power?

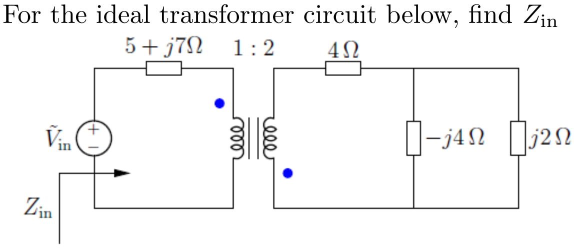


(1) 1.5 Ω
(2) 15 Ω
(3) 150 Ω
(4) 1.5 k Ω
(5) 15 k Ω
(6) 0.75 Ω
(7) 7.5 Ω
(8) 75 Ω
(9) None of the above

9.4 Find the input impedance of the following circuit. The transformer is assumed ideal.



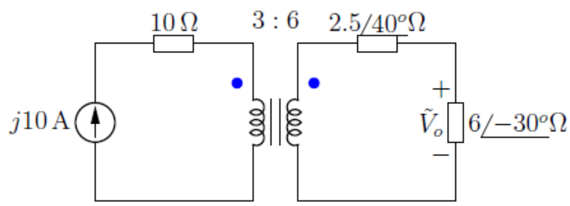
9.5 For the ideal transformer circuit below, find $Z_{\rm in}$



(1) (5 + j7) Ω
(2) (7 + j9) Ω
(3) (21 + j23) Ω

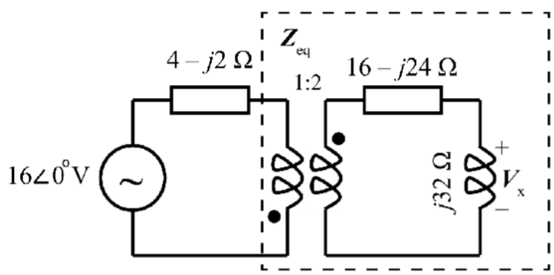
(4) (5 - j7) Ω
(5) (4 + j4) Ω
(6) (6 + j8) Ω
(7) (13 + j15) Ω
(8) None of the above

9.6 For the ideal transformer circuit below, find the output voltage $\hat{V}_O$



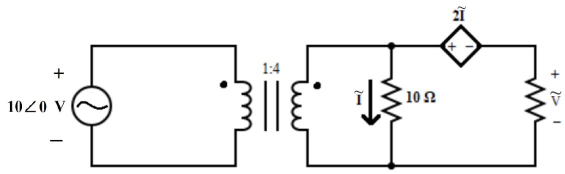
(1) $30.5\ \angle -60^{\circ}\,V$
(2) $30\ \angle 120^{\circ}\,V$
(3) $10\ \angle 60^{\circ}\,V$
(4) $30\ \angle 60^{\circ}\,V$
(5) $30\ \angle 0^{\circ}\,V$
(6) $36.2\ \angle 80^{\circ}\,V$
(7) $42.5\ \angle 100^{\circ}\,V$
(8) None of the above

9.7 From the ideal transformer figure shown below, find the voltage V_X



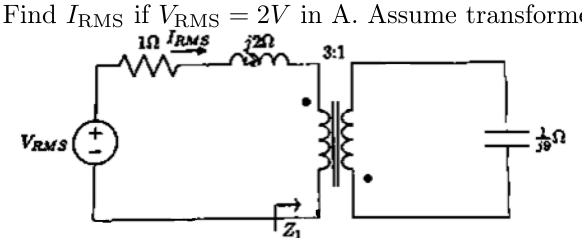
(1) $V_X = 32\angle -90^{\circ}\,V$
(2) $V_X = 64\angle -90^{\circ}\,V$
(3) $V_X = 32\angle -45^{\circ}\,V$
(4) $V_X = 64\angle +90^{\circ}\,V$
(5) $V_X = 32\angle +45^{\circ}\,V$
(6) $V_X = 64\angle -45^{\circ}\,V$
(7) $V_X = 64\angle 0^{\circ}\,V$
(8) None of the above

9.8 Solve for $\tilde{V}$ assuming an ideal transformer.

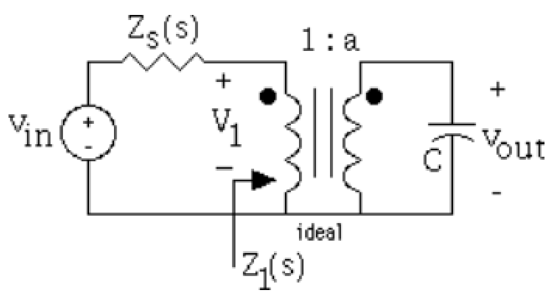


(1) 32 V
(2) 10 V
(3) 40 V
(4) 8 V
(5) 15 V
(6) -10 V
(7) -40 V

9.9 Find I_{RMS} if $V_{\text{RMS}} = 2V$ in A. Assume transformer is ideal.



9.10 For the transformer circuit shown below, $a = 0.5, C = 4F, Z_S(\omega) = 1\Omega$. Then $Z_I(\omega) =$:



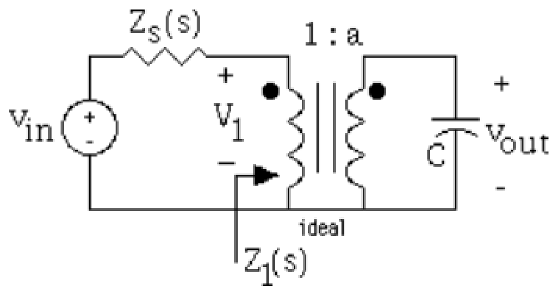
(1) $16j\omega$
(2) $\frac{1}{j\omega}$
(3) $\frac{1}{16j\omega}$
(4) $\frac{1}{4j\omega}$
(5) $0.5j\omega$
(6) $\frac{2}{j\omega}$

(7) $\frac{1}{8j\omega}$

(8) $\frac{8}{j\omega}$

(9) None of the above

9.11 In the circuit below $Z_S(\omega) = 2\Omega, C = \frac{1}{25}F$. The transfer function of $H(\omega) = \frac{V_{\text{out}}(\omega)}{V_{\text{in}}(\omega)} =$:



(1) $\frac{1}{2(25)^2 j\omega+1}$

(2) $\frac{1}{50j\omega+1}$

(3) $\frac{1}{2j\omega+1}$

(4) $\frac{5}{2j\omega+1}$

(5) $\frac{0.5}{2j\omega+1}$

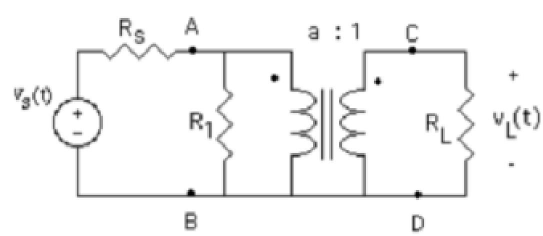
(6) $\frac{5}{50j\omega+1}$

(7) $\frac{2}{2j\omega+1}$

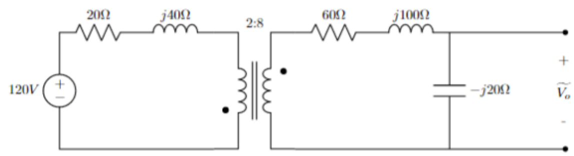
(8) $\frac{5}{2(25)^2 j\omega+1}$

(9) None of the above

9.12 For the circuit below, $R_S = 10\Omega, R_i = 40\Omega$ and the LOAD resistor is $R_L = \frac{1}{8}$. The value of the turns ratio a for maximum power transfer to the load resistor is $a =$:



9.13 Consider the circuit below. Note that the voltage source is AC, and the frequency has already been accounted for all impedance shown.



(1) 11.8 $\angle 27.82^\circ\, V$
(2) 11.8 $\angle 152.18^\circ\, V$
(3) 11.8 $\angle -27.82^\circ\, V$
(4) 11.8 $\angle -152.18^\circ\, V$
(5) 59 $\angle -170.95^\circ\, V$
(6) 59 $\angle 170.95^\circ\, V$
(7) None of the above

9.14 For the circuit in Fig 9.41, find the output current $\tilde{I}_O$ and the equivalent impedance seen by the source at the primary side of the ideal transformer.

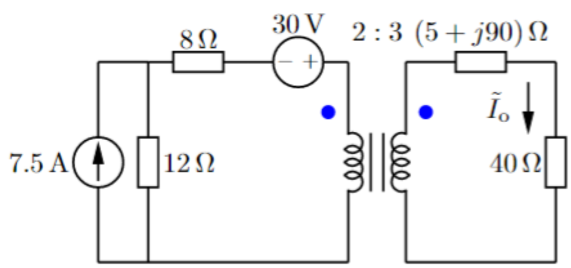
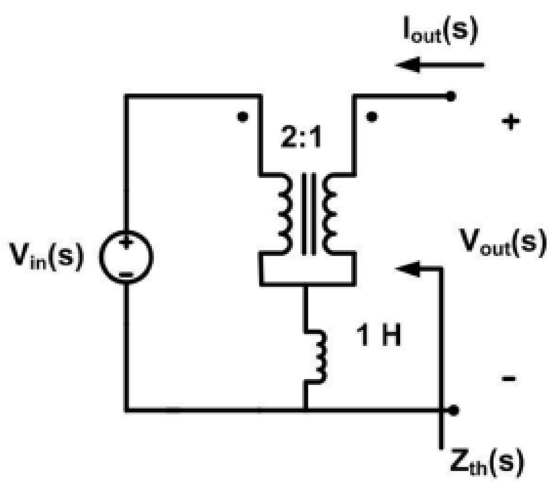


Figure 9.41

9.15 For the circuit given below. the Thevenin equivalent impedance $Z_{\text{th}}(\omega)$ is



(1) $\frac{j\omega}{2}$

(2) $\frac{2}{j\omega}$

(3) $j\omega$

(4) $2j\omega$

(5) 1

(6) 2

(7) $\frac{j\omega}{4}$

(8) $8j\omega$

(9) None of the above

10 Semiconductors

10.1 An intrinsic semiconductor is found to have 1×10^{14} holes in its valence band. How many electrons are in its conduction band?

10.2 An intrinsic silicon crystal is heated to 380 K. Estimate the number of electrons in its conduction band (Hint: see Figure 10.16).

10.3 Which of the following is true for a p-type semiconductor when zero volts is applied across it? In the options below, n is the free electron density, p is the hole density and T is temperature.

(1) n = p only in the extrinsic T region but not in the other regions
(2) n > p only in the extrinsic T region but not in the other regions
(3) n > p irrespective of T
(4) p = n only in the freeze-out region but not in the other regions
(5) $np = n_i^2$ irrespective of T
(6) None of the above

10.4 Explain what a hole is as clearly as possible. You should address its properties and its role in a semiconductor. Your explanation should be primarily verbal, but you may include equations and diagrams.

10.5 Explain the difference between the conduction band and the valence band in a semiconductor as clearly as possible. Your explanation should be primarily verbal with diagrams to support the verbal.

10.6 As temperature increases for a doped semiconductor, what is the correct sequence of regions?

(1) intrinsic → extrinsic → freeze-out
(2) intrinsic → freeze-out → extrinsic
(3) extrinsic → intrinsic → freeze-out
(4) extrinsic → freeze-out → intrinsic
(5) freeze-out → intrinsic → extrinsic
(6) freeze-out → extrinsic → intrinsic

10.7 As temperature increases, which electron is more likely to be released into the conduction band first?

(1) 5th electron not bonded to a neighboring Silicon atom (i.e. dopant)
(2) An electron bonded between the n-type dopant and Silicon
(3) An electron bonded between two silicon atoms

10.8 It is safe to say that column III and V elements in the periodic table contribute what?

(1) electrons and holes, respectively
(2) holes and electrons, respectively
(3) neither and holes, respectively
(4) neither and electrons, respectively
(5) holes and neither, respectively
(6) electrons and neither, respectively

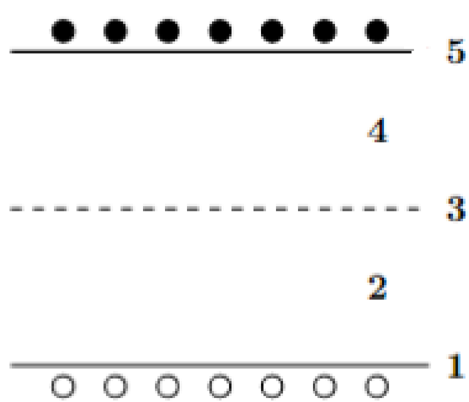
10.9 Two different samples of the semiconductor gallium arsenic (GaAs) were doped by silicon (Si), but in a different manner. In the first sample, the silicon atoms replaced some of the gallium (Gs) atoms. In the second sample, the silicon atoms replaced some of the arsenic (As) atoms. What kind of doping p-type or n-type in those tow samples did this lead in?

10.10 If the bandgap energy increased what would happen to the intrinsic carrier concentration?

10.11 For a intrinsic semiconductor, what would happen to the number of free carriers if the temperature were increased?

(1) increase
(2) decrease
(3) no change

10.12 Please indicate where: the conduction band is.



(1) 1
(2) 2
(3) 3
(4) 4
(5) 5

10.13 A student made the following statement. "At sufficiently high temperature every semiconductor becomes intrinsic regardless of its doping level". Discuss if this is true or false and explain why.

10.14 A p-type silicon piece is doped with $N_A = 10^{16}$ cm^{-3} Boron atoms. Calculate the electron concentration 7 assuming room temperature and $n_i = 10^{10}$ cm^{-3}.

(1) 10^6 cm^{-3}
(2) 10^5 cm^{-3}
(3) 10^3 cm^{-3}
(4) 10^{21} cm^{-3}
(5) 10^{26} cm^{-3}
(6) 10^{11} cm^{-3}
(7) 10^4 cm^{-3}
(8) None of the above

10.15 A silicon sample is doped with group III (Boron) atoms with dopant density = 10^{16} cm^{-3}. What are the values for the free electron density (n) and hole density (p) in the extrinsic-T region? Use the intrinsic carrier concentration of silicon $n_i = 10^{10}$ cm^{-3}

(1) $n = 10^{16}$ cm^{-3}; $p = 10^{16}$ cm^{-3}
(2) $n = 10^{16}$ cm^{-3}; $p = 10^4$ cm^{-3}
(3) $n = 10^4$ cm^{-3}; $p = 10^{16}$ cm^{-3}
(4) $n = 10^{10}$ cm^{-3}; $p = 10^{10}$ cm^{-3}
(5) $n = 10^{16}$ cm^{-3}; $p = 10^{10}$ cm^{-3}
(6) $n = 10^4$ cm^{-3}; $p = 10^{10}$ cm^{-3}
(7) $n = 10^4$ cm^{-3}; $p = 10^4$ cm^{-3}
(8) None of the above

10.16 Consider an n-type silicon for which the dopant concentration is $N_D = 10^{16} cm^{-3}$. Find: (1) Find the electron and the hole concentration at $T = 300K$, (2) Repeat the above for $T = 500K$. Use the true n_i value given in class.

10.17 Estimate amount of free electrons and holds in N-doped silicon wafer. (a) at room temperature with $10^{14} cm^{-3}$ doping level, and (b) at $650K$ with $10^{15} cm^{-3}$ doping level

10.18 A photon with wavelength $950nm$ impinges upon an intrinsic Silicon wafer (band gap energy is $1.1eV$). It excites an electron form the valence band (previously bonding to Si atoms) into the conduction band. What must be the kinetic energy of the electron in the conduction band in Joules? Igore any thermal contributions.

10.19 A silicon piece has been doped with boron atoms at a concentration of $10^{14} cm^{-3}$. Calculate the electron concentration in the silicon piece at room temperature.

10.20 A semiconductor water with the intrinsic concentration of $n_i = 10^{13} cm^{-3}$ is uniformly doped n-type with donor concentration $N_D = 15^1 5 cm^{-3}$. Assume that all impurities are ionized, what is the whole concentration?

10.21 Fill in the missing cntries in the table below for silicon (Si). The first line has been filled in to provide guidance and values. Please show all calculations for electron and hole concentrations and provide a brief explanation for all choices in the first tow columns.

Doping Concentration	n-type, p-type, or intrinsic	Temperature	Electron Concentration	Hole Concentration
No dopants	intrinisic	25 °C	$n = 10^{10}$ cm^{-3}	$p = 10^{10}$ cm^{-3}
	intrinisic	-40 °C		
No dopants		100 °C		
$N_d = 10^{15}$ cm^{-3}		25 °C		
$N_d = 10^{15}$ cm^{-3}		100 °C		
$N_d = 10^{16}$ cm^{-3}		25 °C		
$N_a = 10^{16}$ cm^{-3}		25 °C		
		25 °C	$n = 10^{14}$ cm^{-3}	
		25 °C		$p = 10^{14}$ cm^{-3}

11 PN Junctions and Diodes

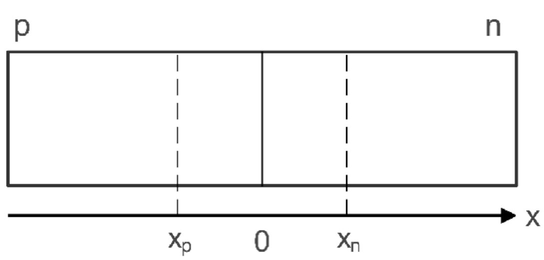
11.1 Intrinsic silicon with a cross sectional area of 10^{-4} cm becomes a PN junction when it is doped with $N_D = 10^{16}$ cm^{-3} on one side and $N_A = 10^{18}$ cm^{-3} on the other. Use $\epsilon_r = 11.7$ for silicon. Assume room temperature (300 K). Find:

(1) The built in voltage V_{bi}.
(2) The width of the depletion region in micrometers.
(3) The magnitude of the charge stored on either side of the depletion region in pC.

11.2 A silicon pn junction is doped with Phosphorus (n-side), and Boron (p-side). Assume that $V_T = \frac{kT}{q}$ is 26mV, and that the built-in voltage is $V_{bi} =$ 0.6 V. Calculate the new V_{bi} if the Boron doping concentration is increased by 15 times and the phosphorus concentration remains unchanged.

(1) 0.75 V
(2) 0.67 V
(3) 0.8 V
(4) 0.7 V
(5) 0.6 V
(6) 0.57 V
(7) 0.5 V
(8) None of the above

11.3 Which of the following is correct for a p-n junction? N_D is net donor dopant density, N_A is net acceptor dopant density



(1) Depletion region has negative charges on the n side and positive charges on the p side
(2) If $N_D > N_A$, then $x_n > x_p$
(3) The built-in potential (V_{bi}) increases if N_D is increased.
(4) The built-in potential (V_{bi}) decreases if N_A is increased.
(5) Both (2) and (3) are correct.
(6) None of the above

11.4 The width of the depletion region on the n-side (x_n) and p side ($\mathrm{x_p}$) is 0.5μm. Which of the following is the built-in potential in the $\mathrm{p-n}$ junction? Note: N_D is the donor dopant density on the n-side, $\mathrm{n_i}$ is the intrinsic carrier concentration, kT/q is the thermal voltage.

(1) $V_{bi} = \left(\frac{kT}{q}\right) \ln\left(\frac{N_D}{n_i}\right)$

(2) $V_{bi} = \left(\frac{kT}{q}\right) \ln\left(\frac{n_i}{N_D}\right)$

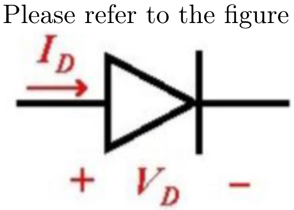
(3) $V_{bi} = 2\left(\frac{kT}{q}\right) \ln\left(1 + \frac{N_D}{n_i}\right)$

(4) $V_{bi} = 2\left(\frac{kT}{q}\right) \ln\left(\frac{N_D}{n_i}\right)$

(5) $V_{bi} = \left(\frac{kT}{q}\right) \ln\left(1 - \frac{N_A}{n_i}\right)$

(6) Cannot be determined from the information above

11.5 For the ideal diode model, which of the following statements is true? Please refer to the figure below for the definitions of V_D and I_D.



(1) In the forward bias regime, $V_D = 0$ and $I_D < 0$

(2) In the forward bias regime, $V_D < 0$ and $I_D > 0$

(3) In the reverse bias regime, $V_D = 0$ and $I_D < 0$

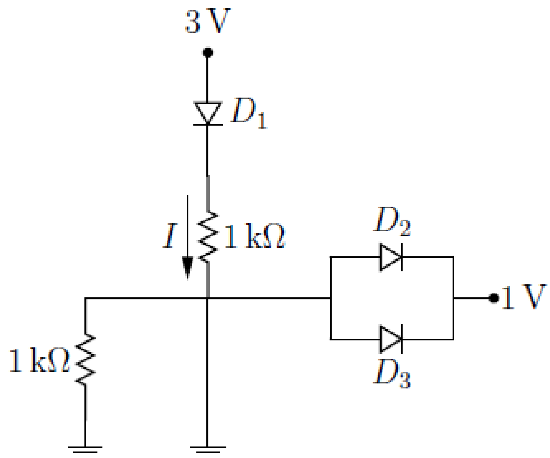
(4) In the reverse bias regime, $\mathrm{V_D} < 0$ and $\mathrm{I_D} = 0$

(5) The ideal diode approximates the diode as a short, irrespective of the bias conditions.

(6) None of the above

11.6 Consider a silicon pn junction at room temperature. The charge stored in the p side of the depletion region is -5 pC. What is the charge in the n side of the depletion region?

11.7 Find the current I in the following circuit. All the diodes in this circuit are ideal



(1) 0.5 mA

(2) 1 mA

(3) 3 mA

(4) 0.125 mA

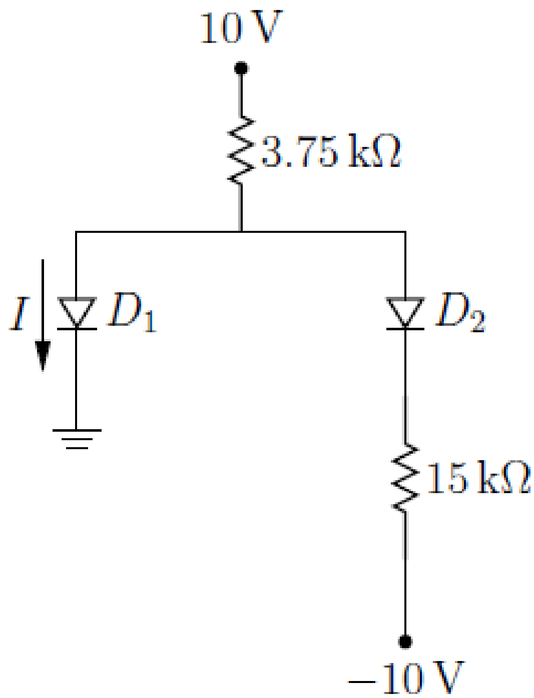
(5) 0.25 mA

(6) 4 mA

(7) 2 mA

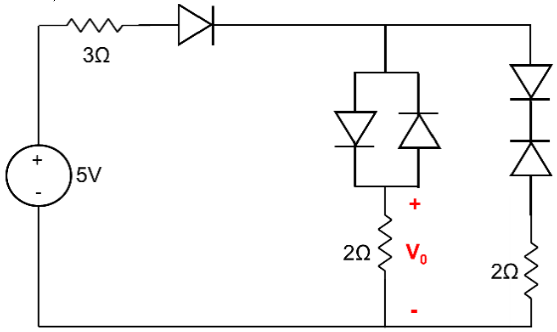
(8) None of the above.

11.8 Find the current I in the following circuit. All the diodes in this circuit are ideal.



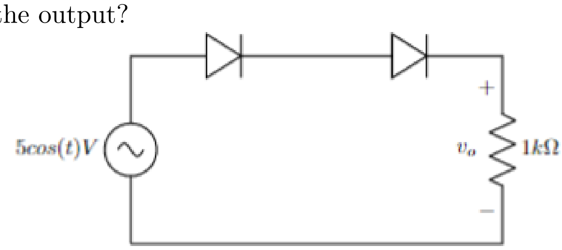
(1) 0.5 mA
(2) 1 mA
(3) 0 mA
(4) 2 mA
(5) 0.2 mA
(6) 4 mA
(7) 5 mA
(8) None of the above.

11.9 In the circuit shown below, find the value of V_0. (Assume the ideal diode model).



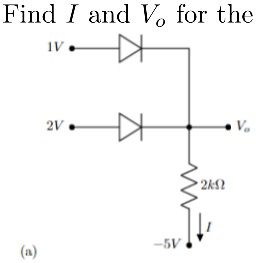
(1) $V_0 = 1$ V
(2) $V_0 = 1.25$ V
(3) $V_0 = 2$ V
(4) $V_0 = 2.5$ V
(5) $V_0 = 3$ V
(6) $V_0 = 4$ V
(7) $V_0 = 5$ V
(8) None of the above.

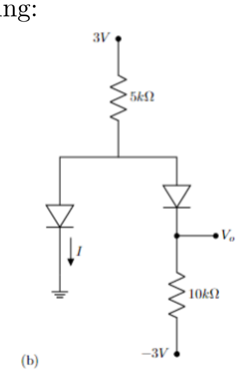
11.10 Assuming the diodes are ideal, what is the average DC' voltage seen at the output?



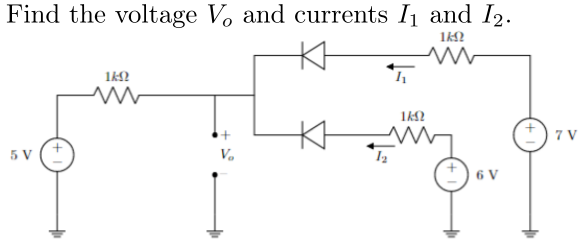
(1) $\frac{5}{\pi\sqrt{2}}$
(2) $\frac{5}{2\sqrt{2}}$
(3) $\frac{5}{\pi}$
(4) $\frac{10}{\pi}$
(5) $\frac{5}{\sqrt{2}}$
(6) $\frac{5}{2\pi}$

11.11 Find I and V_o for the following:

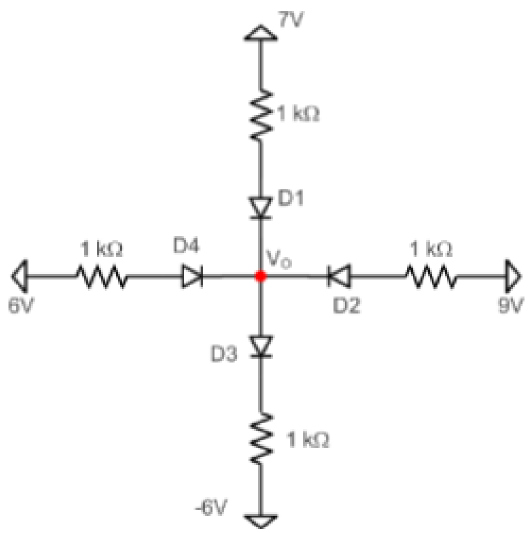




11.12 Find the voltage V_o and currents I_1 and I_2.

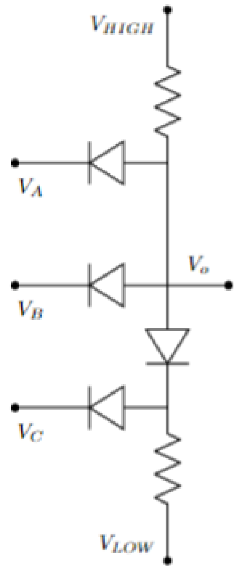


11.13 Find the voltage V_o at the junction of the diodes (marked as red). Assume all the diodes are ideal.



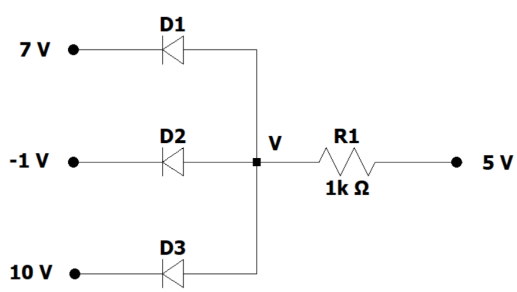
(1) 4 V
(2) 0 V
(3) 2 V
(4) 1 V
(5) -4 V
(6) -2 V
(7) -2.5 V

11.14 Which logic function does the circuit implement?



(1) (A and B) and C
(2) (A or B) and C
(3) A and (B or C)
(4) (A and B) or C
(5) A or (B and C)
(6) (A or B) or C

11.15 Find the voltage V in the following circuit.



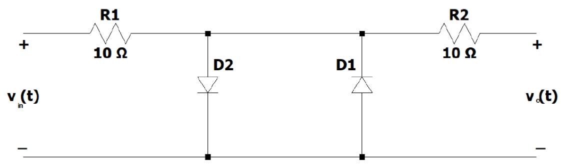
(1) -3 V
(2) -2 V
(3) -1 V
(4) 0 V

(5) 1 V

(6) 2 V

(7) 3 V

11.16 If $v_{in} = 5u(t) - 5u(t-2)V$, determine the voltage v_o at $t = 1s$.



(1) -10 V

(2) -5 V

(3) -2.5 V

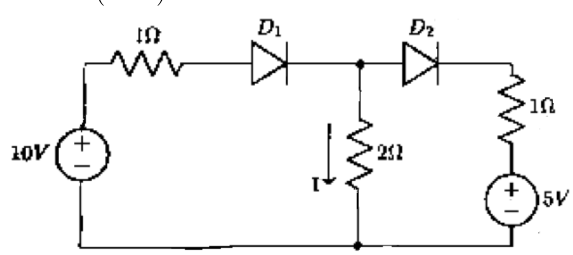
(4) 0 V

(5) 2.5 V

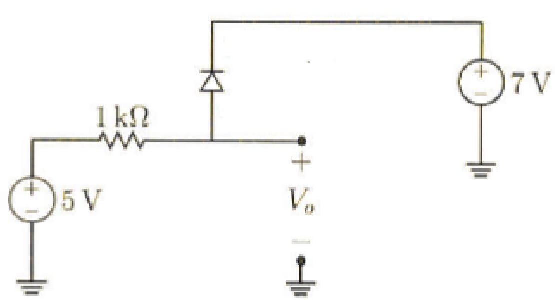
(6) 5 V

(7) 10 V

11.17 Assume diodes D_1 and D_2 are ideal, find the current I, through the 2Ω resistor (in A)

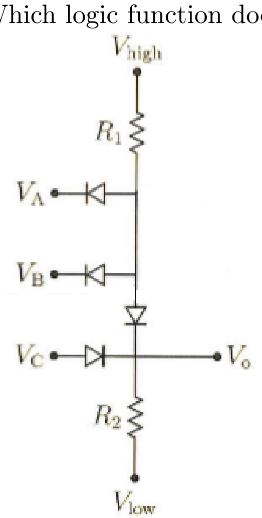


11.18 In the following circuit the diode is ideal. Calculate V_o.



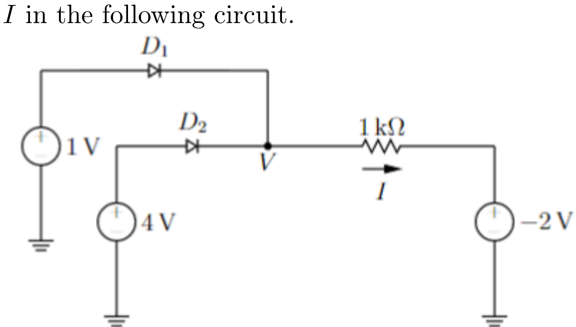
(1) 0 V
(2) 1 V
(3) 2 V
(4) 3 V
(5) 4 V
(6) 5 V
(7) 6 V
(8) 7 V

11.19 Which logic function does the following diode circuit implement?

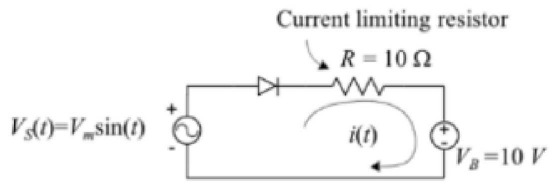


(1) (A AND B) OR C
(2) A AND (B OR C)
(3) A AND B AND C
(4) A OR B OR C
(5) A OR (B AND C)
(6) (A OR B) AND C
(7) None of the above.

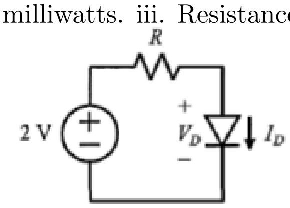
11.20 Assuming that the diodes are ideal, calculate the voltage V and the current I in the following circuit.



11.21 Consider the battery charging circuit in the figure bedow, $V_m = 20V, R = 10\Omega$ and $V_B = 10V$. Assume the diode is ideal. Find the peak value of $i(t)$ and the percentage of each cycle in which the diode is forward biased.



11.22 This problem has two distinct parts, one on this page and one on the next page. Calculate the following if $I_D = 5$ mA: i. Power supplied by the source P_S in milliwatts. ii. Power absorbed by the diode P_D in milliwatts. iii. Resistance value R in ohms.



12 MOS Transistors

12.1 In a MOSFET, the gate voltage turns the transistor ON and OFF by controlling the ________________

(1) Density of minority carriers in substrate.
(2) Density of majority carriers in substrate.
(3) Density of minority carriers in source.
(4) Density of majority carriers in drain.
(5) Density of electrons in metal layer.
(6) None of the above.

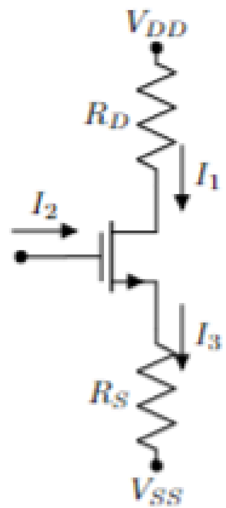
12.2 $I_{DS} - V_{DS}$ characteristics of a MOSFET resembles a linear resistor in the ________________

(1) Saturation region and Large $\mathrm{V_{DS}}$.
(2) Triode region and Small $\mathrm{V_{DS}}$.
(3) Saturation region and Small $\mathrm{V_{DS}}$.
(4) Triode region and Large V_{DS}.
(5) Cut-off region and Small V_{DS}.
(6) None of the above.

12.3 A MOSFET, makes a good analog amplifier if the transistor is biased within:

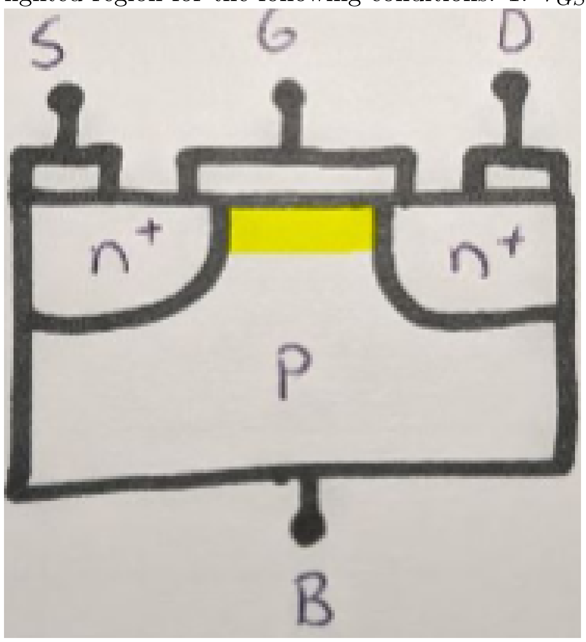
(1) Triode and Saturation edge.
(2) Triode region.
(3) Saturation region.
(4) Both (1) and (3).
(5) Both (1) and (2).
(6) None of the above.

12.4 Which condition(s) are true for an ideal transistor in DC conditions?

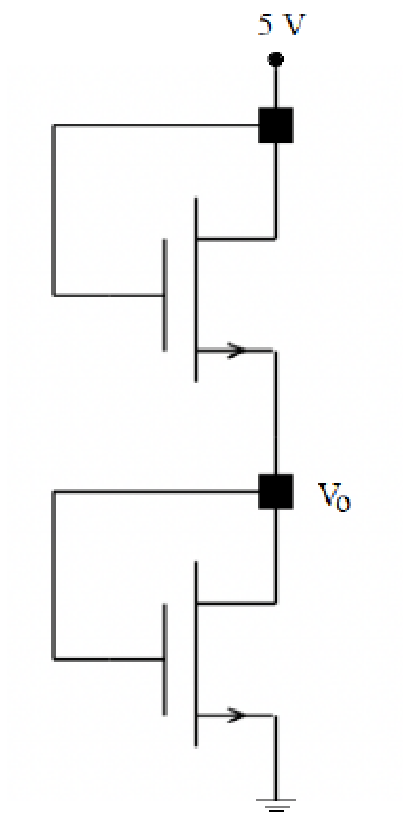


(1) $I_1 + I_2 = I_3$
(2) $I_1 = I_3$
(3) $I_2 = I_3$
(4) $I_1 = 0$
(5) $I_2 = 0$
(6) Option 1 and 4
(7) Option 2 and 5
(8) Option 3 and 4

12.5 If the threshold voltage is 4 V, what are the majority carriers in the highlighted region for the following conditions. 1. $V_{GS} = 3$ V; 2. $V_{GS} = 5$ V



12.6 Find V_o in the following circuit. The transistors are identical. Hint: the drain-gate connection implies a specific mode of operation.

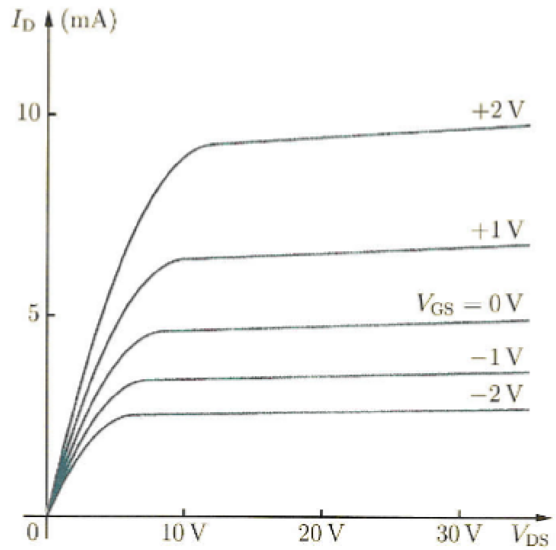


(1) 0 V
(2) 1 V
(3) 1.5 V
(4) 2 V
(5) 2.5 V
(6) 3 V
(7) 3.5 V

12.7 Which of the following statements is FALSE for typical conditions at room temperature?

(1) The band gap of a metal is larger than that of an insulator.
(2) A p-doped semiconductor has fewer free electrons than an intrinsic one.
(3) The conduction band of an insulator is practically empty.
(4) Doping with a donor results in an n-type semiconductor.
(5) Diffusion current may exist in the absence of electric field.
(6) The threshold voltage of a typical Silicon diode is in the order of 0.7 V.
(7) Electrons are the dominant carriers in the source region of an nMOS transistor.

12.8 A student brings you the following measurement characteristic on an nMOS transistor like the ones we discussed in class. You think this is not correct. Why?

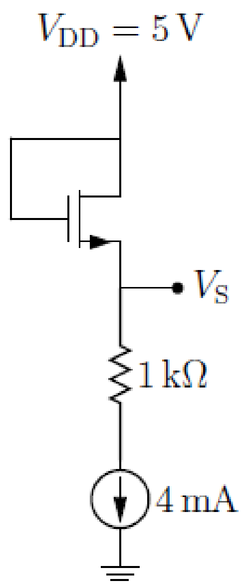


(1) The current should not be zero for zero $V_{DS.}$.
(2) The current cannot grow almost linearly for small V_{DS}.
(3) The current cannot be almost constant for larger V_{DS}.
(4) The current cannot increase for increasing V_{GS}.
(5) The current cannot be positive.
(6) The current cannot depend on both V_{DS} and V_{GS}.
(7) Current cannot flow for negative V_{GS}.

12.9 An nMOS inverter implements which of the following gates?

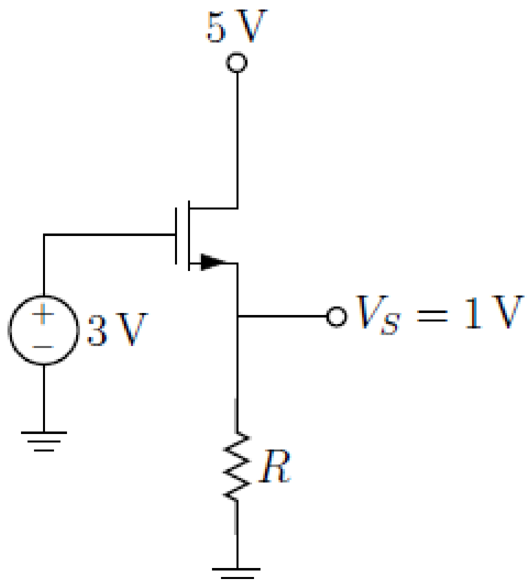
(1) AND
(2) NOT
(3) NAND
(4) NOR
(5) XOR
(6) OR
(7) None of the above.

12.10 Find the voltage V_S. The transistor parameters are $k = 2$ mA/V^2, $V_T =$ 1 V.



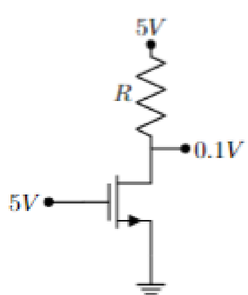
(1) 2 V
(2) 3 V
(3) −6 V
(4) 6 V
(5) −4 V
(6) 1 V
(7) −3 V
(8) None of the above.

12.11 Find the value of the resistance such that $V_S = 1$ V. The transistor parameters are $k = 1$ mA/V^2, $V_T = 1$ V.

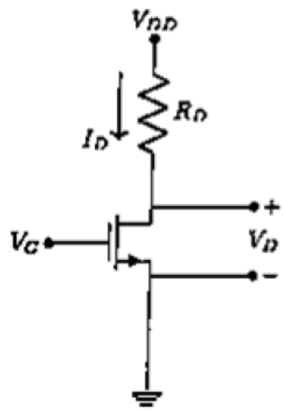


(1) 0.5kΩ
(2) 2kΩ
(3) 1kΩ
(4) 3kΩ
(5) 4kΩ
(6) 0.25kΩ
(7) 5kΩ
(8) None of the above.

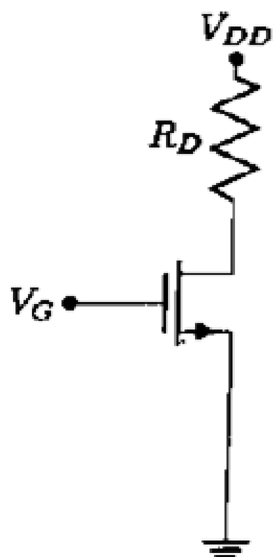
12.12 What is the power dissipated by the transistor below? Needed: $V_t = 1V$ and $k = 1mA/V^2$.



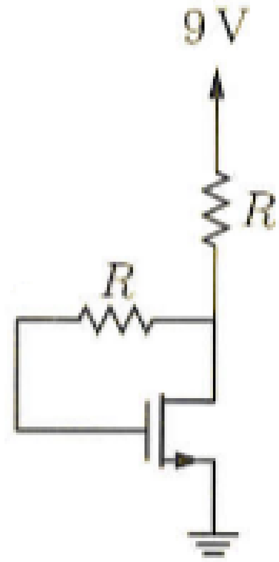
12.13 Find the drain resistance R_D, in $k\Omega$, such that the drain voltage. V_D will be 1.0 V when the gate voltage V_G is 2.8 V. The supply voltage is $V_{DD} = 10V$, the MOSFET threshold voltage is $V_T = 0.8V$, and the transconductance parameter is $k = 2.0$ mA/V^2.



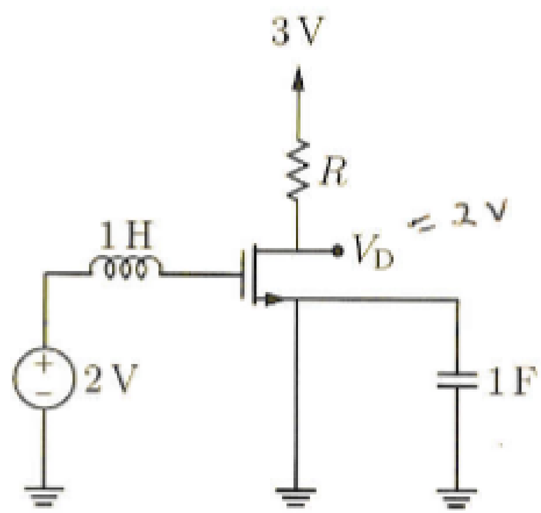
12.14 Which of the following gate voltages V_G, would drive the transistor to operate in Triode Region? (If multiple gate voltages are in Triode region; you must chose the correct combination of voltages that are in triode instead of just one). Assume $V_{DD} = 6V, R_D = 1k\Omega, V_T = 2.5V$ and $k = 2$ mA/V^2



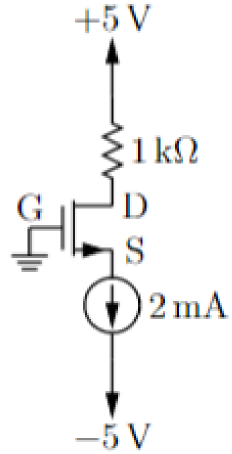
12.15 For the following circuit calculate the resistance value R such that the transistor current is 2 mA. Assume that $V_{\mathrm{T}} = 1$ V and $k = 1$ mA V^{-2}.



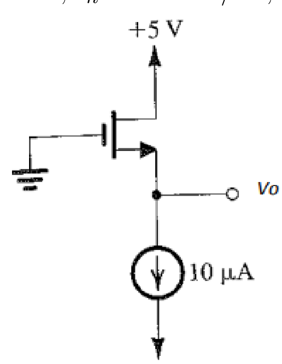
12.16 For the following circuit calculate the resistance value R such that the drain voltage is 2 V. Assume that $V_T = 1$ V and $k = 1$ mA V^{-2}.



12.17 Find the voltage V_{DS} in the following circuit. For the transistor we know $V_{\mathrm{T}} = 1$ V and $k = 1$ mA/V^2.

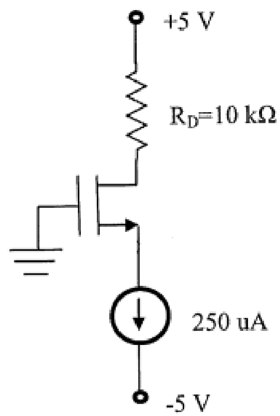


12.18 For the MOS circuit shown below what is the value of V_o? Assume $V_{tn} = 0.8$ V, $k_n = 0.5$ mA/N^2, and $\lambda = 0$



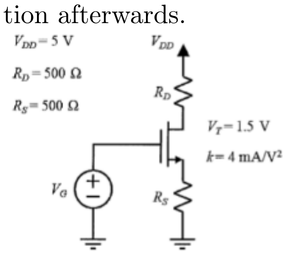
(1) $V_o = 0.6$ V
(2) $V_o = 5$ V
(3) $V_o = -0.6$ V
(4) $V_o = 1$ V
(5) $V_o = -1$ V
(6) None of the above

12.19 For the circuit shown below what is V_{DS} ? Assume $V_{TN} = 0.8$ V, $k_n{}' = 160\mu A/V^2$ and $W/L = 3$

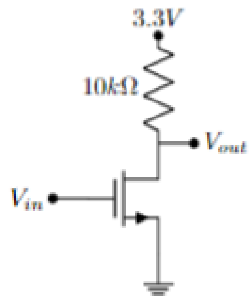


(1) 2.5 V
(2) 5 V
(3) 3.2 V
(4) 6.8 V
(5) 0.7 V
(6) 4.3 V
(7) None of the above

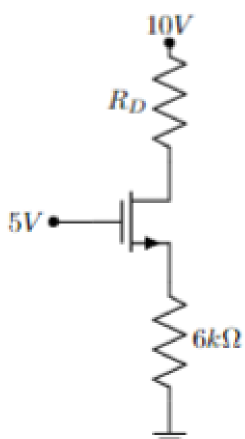
12.20 Determine the operating point $Q = (V_{DS}, I_D)$ if $V_G = 3.5$ V.
a. Do the analysis assuming triode. Explain where the analysis goes wrong.
b. Do the analysis assuming saturation. Make sure to verify the assumption afterwards.



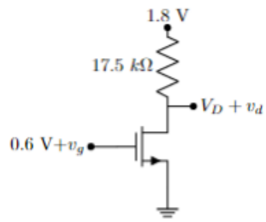
12.21 The MOS device below has parameters $V_t = 0.5V$ and $k = 4mA/V^2$. Find the minimum value for V_{in} that guarantes that $V_{\text{out}} \leq 0.8$ V. Hint: similar to the diode circuit problems, you will need to guess the mode of operation of the transistor and then verify your guess.



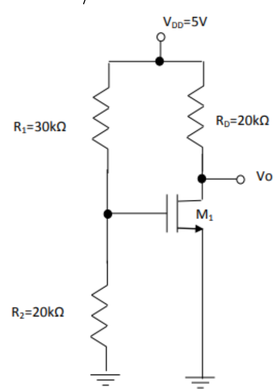
12.22 The MOS transistor in the circuit below has parameters $V_t = 1V$ and $k = 1mA/V^2$. For purposes of analysis assume the transistor is in saturation.
(1) Derive an equation for V_s, the voltage at the source of the transistor. This will be a quadratic equation and thus can be left implicitly in terms of V_s.
(2) The equation derived in (a) is a quadratic equation and thus has two solutions. Identify the "incorroct" solution and explain why it is physically impossible.
(3) Find the largest value of R_D that will guarantee that the device remains in saturation.



12.23 Given the MOS transistor below, what is the voltage gain (i.e $\frac{\Delta V_D}{\Delta V_G}$)? Hint: Find the quiescent point (DC point) then vary V_G by ± 0.01 V to find V_D for different V_G. $\Delta V_D = V_{D1} - V_{D2}$ and $\Delta V_G = V_{G1} - V_{G2}$. Needed: $V_t = 0.4$ V and $k = 4$ mA/V^2.

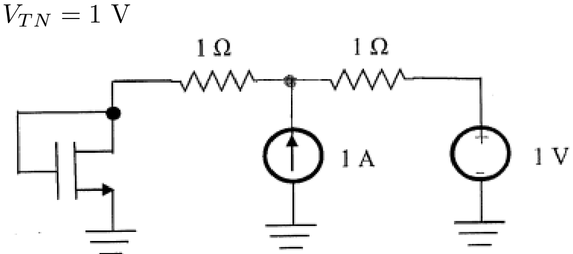


12.24 For the MOS circuit shown below, V_O =?$\lambda = 0, V_{TN} = 1$ V, $K_N =$ 0.2 mA/V^2



(1) 4 V
(2) 2.5 V
(3) 2 V
(4) 3.5 V
(5) 3 V
(6) None of the above

12.25 What is I_D for the circuit shown below? Assume $K_n = 1$ A/V^2 and $V_{TN} = 1$ V



(1) 0.1 A

(2) 1 A

(3) 0.2 A

(4) 0.5 A

(5) 0.4 A

(6) 0 A (transistor is in cut off)

(7) None of the above

12.26 In the circuit in Figure 3 , the current reading from the ammeter is 4 mA with the switch open, and 3 mA with the switch closed, where $i_{DS} = (K/2)\left(v_{GS} - V_T\right)^2$. What are V_T and K?

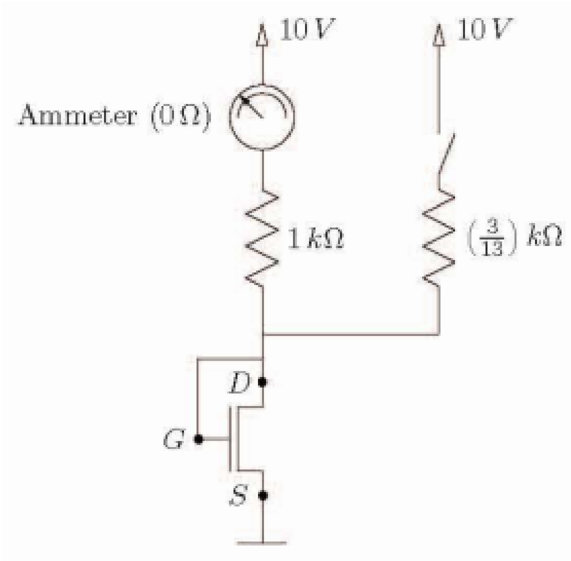


Figure 3.

12.27 Consider the circuit shown in Figure 12. The parameters characterizing the behavior of the MOSFET are $K = 2mA/V^2$, and $V_T = 1V$, and $i_{DS} = (K/2)(v_{GS} - V_T)^2$. Determine the value of V_O, the DC component of the output voltage. Assume that $v_i = 0$.

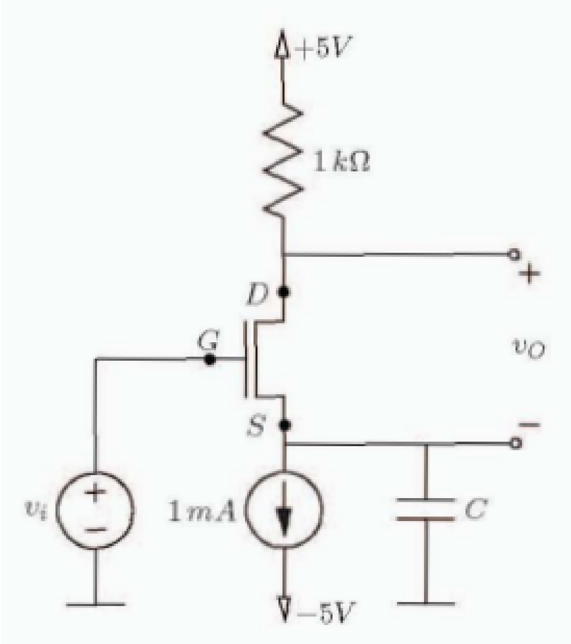


Figure 12.