Electric Circuits 1st edition Kang Test Bank

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Chapter 2

Circuit Laws

Test Bank

2.1 A circuit is shown in Figure 1. In this figure,

(a) Label all the nodes (1, 2, 3, ...) in the circuit excluding the ground node which is already labeled as 0.
(b) How many nodes are there?
(c) How many simple nodes are there?
(d) How many essential nodes are there?
(e) How many branches are there?
(f) How many meshes are there? List all meshes.
(g) How many loops (including meshes) are there?
(h) List all loops that are not meshes.

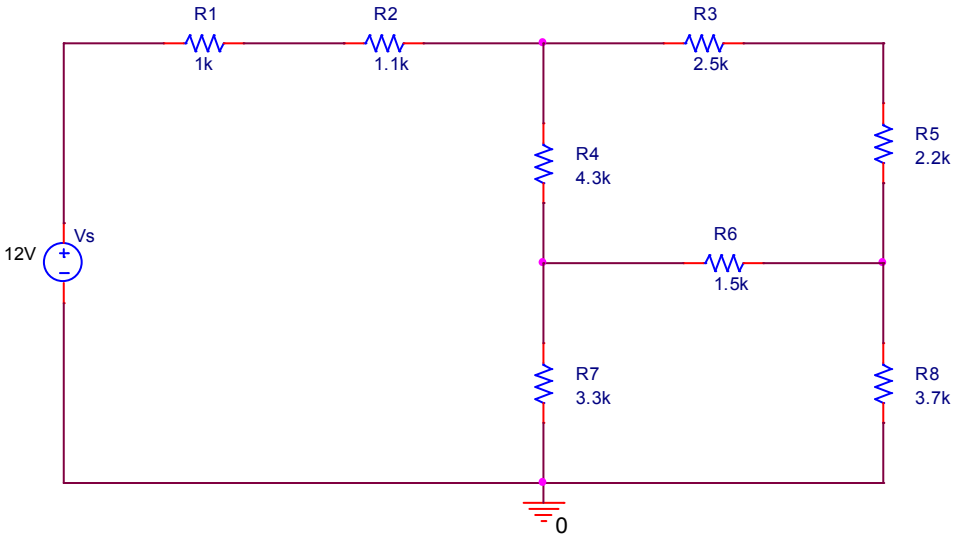
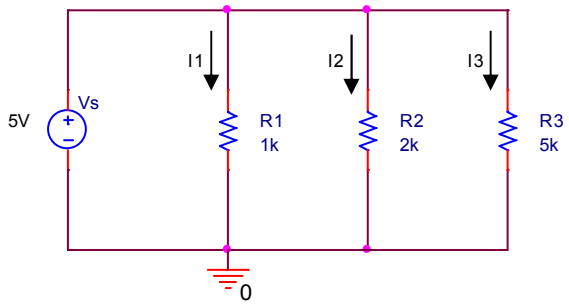


Figure 1

2.2 In the circuit shown below, find the currents I_1, I_2, and I_3. Also, find the powers on R_1, R_2, R_3, and V_s and state whether power is absorbed or released by each element.

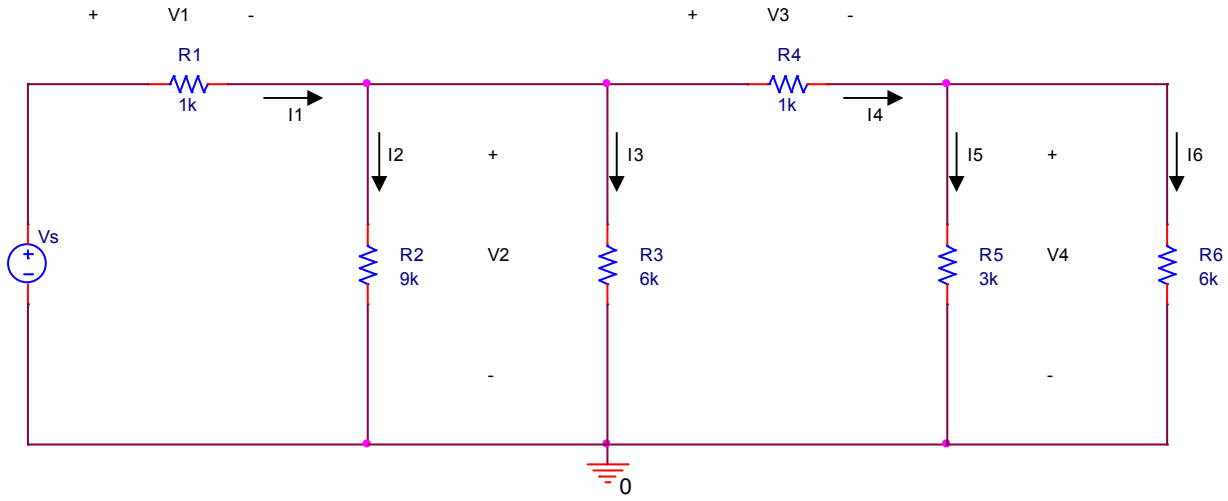


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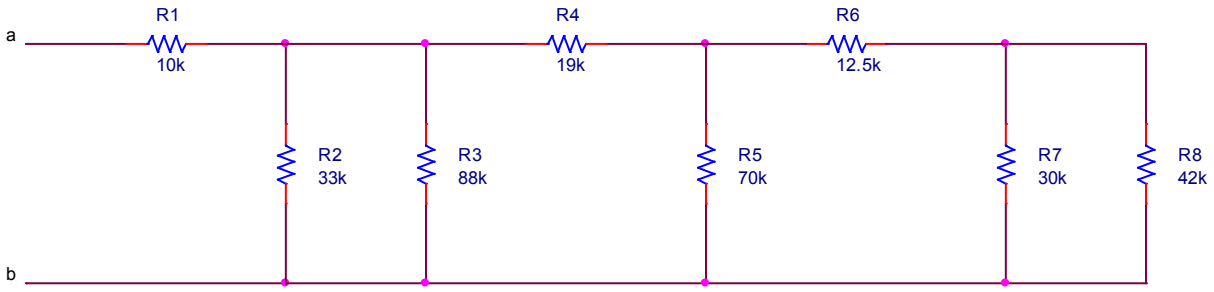
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2.3 The current through resistor R_6 in the circuit shown below is 2 mA, that is, $I_6 = 2$ mA.

(a) Use Ohm's law to find the voltage V_4 across R_6.
(b) Use Ohm's law to find the current I_5 through R_5.
(c) Use KCL to find the current I_4 through R_4.
(d) Use Ohm's law to find the voltage V_3 across R_4.
(e) Use KVL to find the voltage V_2 across R_3.
(f) Use Ohm's law to find the current I_3 through R_3.
(g) Use Ohm's law to find the current I_2 through R_2.
(h) Use KCL to find the current I_1 through R_1.
(i) Use Ohm's law to find the voltage V_1 across R_1.
(j) Use KVL to find the voltage V_s.



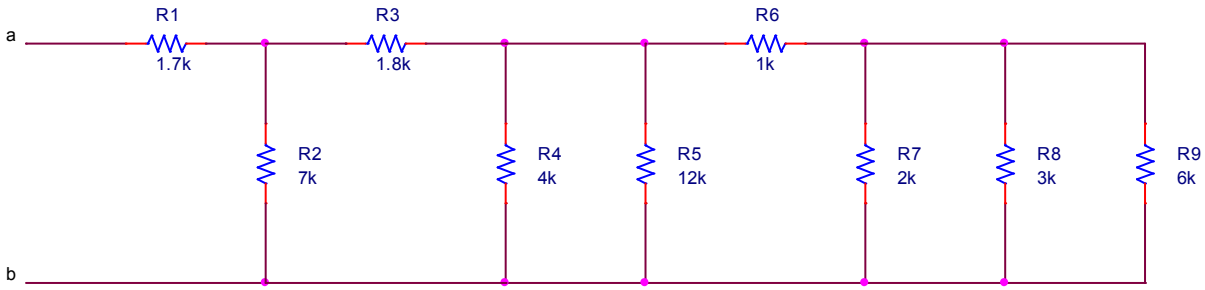
2.4 Find the equivalent resistance between terminals *a* and *b* of the circuit shown below.



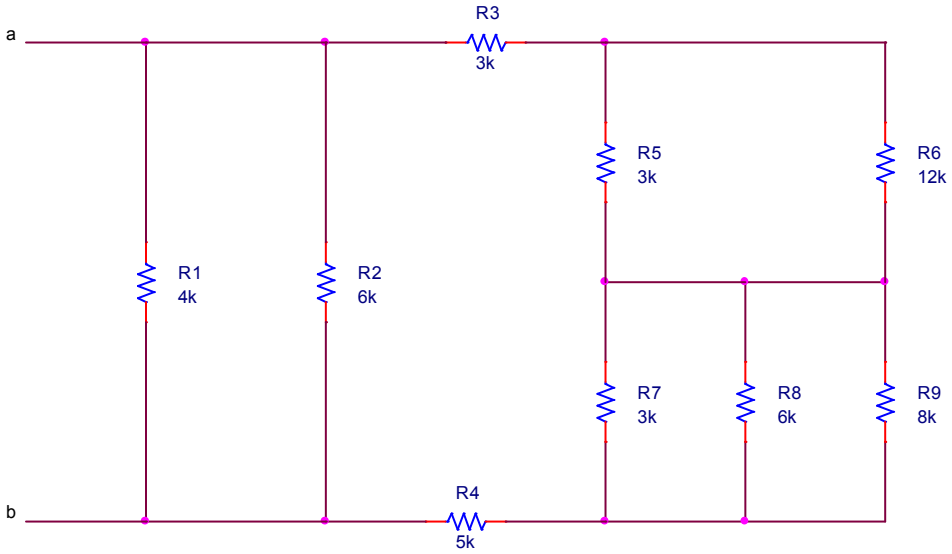
2.5 Find the equivalent resistance between terminals *a* and *b* of the circuit shown below.

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2.6 Find the equivalent resistance between terminals *a* and *b* of the circuit shown below.

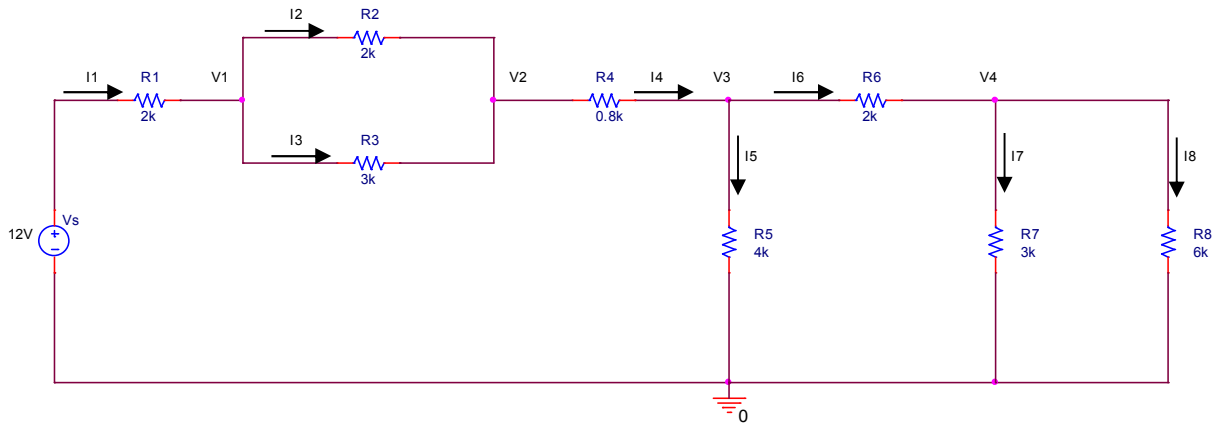


2.7 In the circuit shown below,

(a) Find $R_a = R_7 \parallel R_8$.
(b) Find $R_b = R_6 + R_a$.
(c) Find $R_c = R_5 \parallel R_b$.
(d) Find $R_d = R_2 \parallel R_3$.
(e) Redraw the circuit consisting of V_s, R_1, R_d, R_4, and R_c. Find the equivalent resistance R_{eq} seen from the voltage source.
(f) Find the current I_1 through R_1, R_d, R_4, and R_c.
(g) Find the voltage across R_1, voltage across R_d, voltage across R_4, and voltage across R_c.
(h) Find the voltage V_1, voltage V_2, and voltage V_3.
(i) Find the currents I_5 and I_6.
(j) Find the voltage V_4, and currents I_7 and I_8.

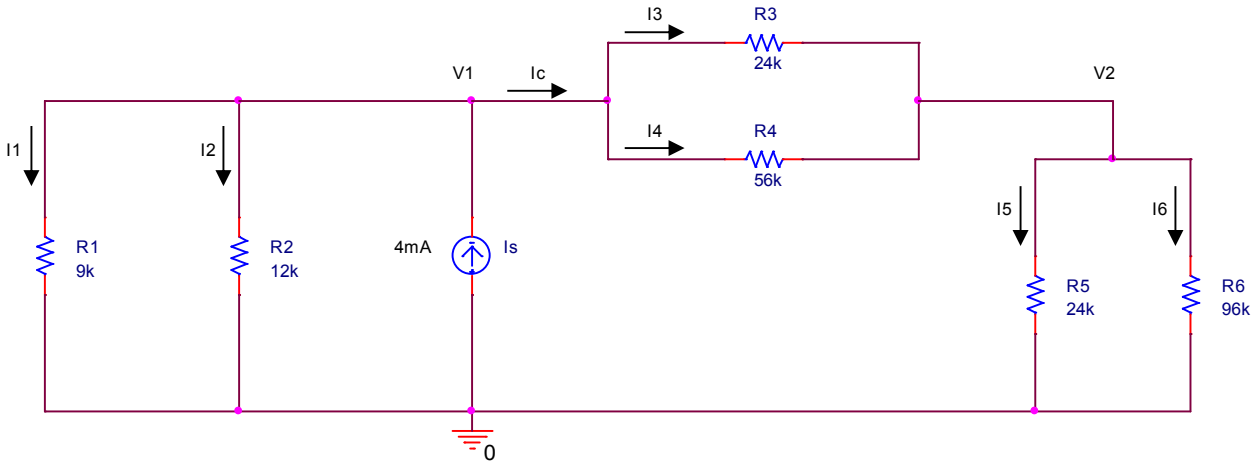
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2.8 In the circuit shown below,

(a) Find the equivalent resistances $R_a = R_3 \parallel R_4$, $R_b = R_5 \parallel R_6$, and $R_c = R_a + R_b$.
(b) Redraw the circuit consisting of I_s, R_1, R_2, R_c.
(c) Use the current divider rule to find the currents I_1, I_2, I_c.
(d) Use the current divider rule to find the currents I_3, I_4, I_5, I_6.
(e) Find the voltages V_1, V_2.

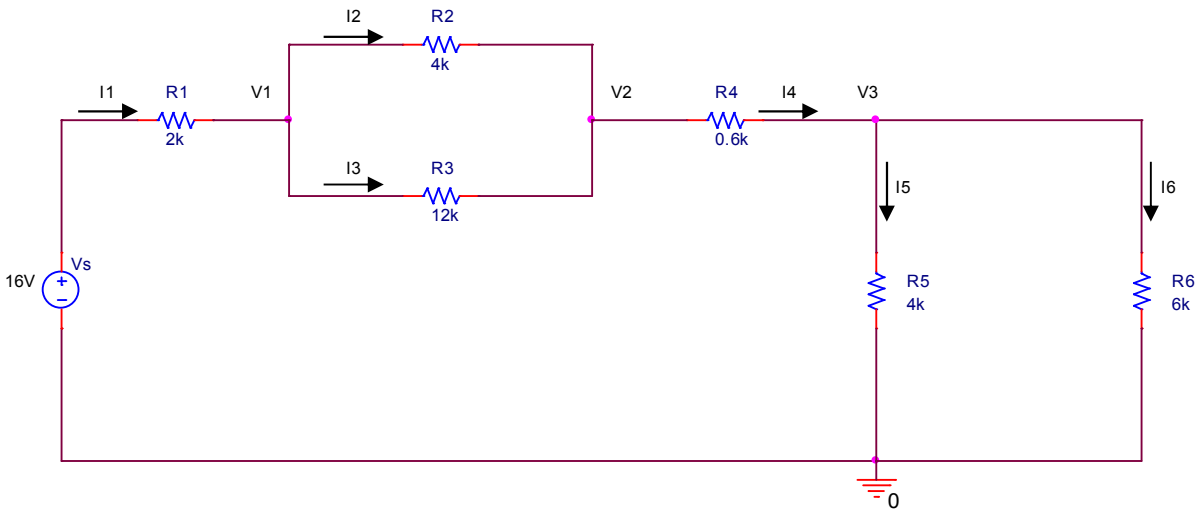


2.9 In the circuit shown below,

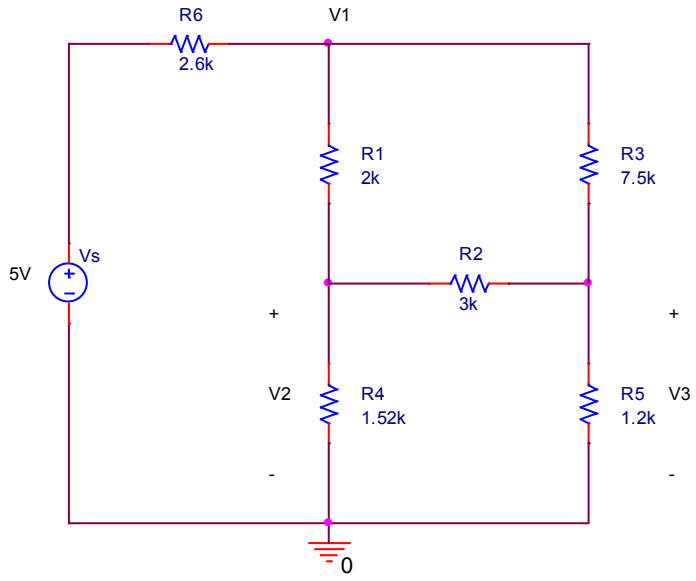
(a) Find $R_a = R_5 \parallel R_6$ and $R_b = R_3 \parallel R_4$.
(b) Redraw the circuit consisting of V_s, R_1, R_b, R_4, and R_a. Find the equivalent resistance R_{eq} seen from the voltage source.
(c) Find the current I_1 through R_1, R_b, R_4, and R_a.
(d) Find the voltage across R_1, voltage across R_b, voltage across R_4, and voltage across R_a.
(e) Find the voltage V_1, voltage V_2, and voltage V_3.
(f) Find the currents I_2, I_3, I_5 and I_6.

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2.10 Find V_1, V_2, and V_3 in the circuit shown below.



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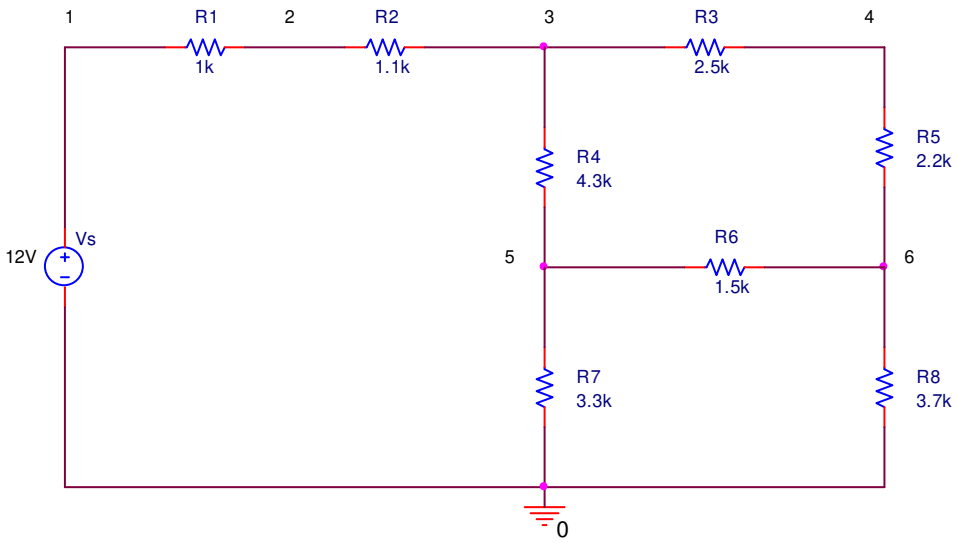
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Solutions to Test Bank

Chapter 2

2.1

(a)



(b)

There are 7 nodes (0, 1, 2, 3, 4, 5, 6).

(c)

There are 3 simple nodes (1, 2, 4). Simple node connects two elements.

(d)

There are 4 essential nodes (1, 2, 4). Essential node connects three or more elements.

(e)

There are 9 branches.

(f)

There are three meshes:

V_s - R_1 - R_2 - R_4 - R_7
R_4 - R_3 - R_5 - R_6
R_7 - R_6 - R_8

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(g)

There are 7 loops.

(h)

V_s - R_1 - R_2 - R_3 - R_5 - R_8
V_s - R_1 - R_2 - R_3 - R_5 - R_6 - R_7
V_s - R_1 - R_2 - R_4 - R_6 - R_8
R_7 - R_4 - R_3 - R_5 - R_8

2.2

Application of Ohm's law yields

$$I_1 = \frac{V_s}{R_1} = \frac{5\,\text{V}}{1\,k\Omega} = 5\,\text{mA}$$

$$I_2 = \frac{V_s}{R_2} = \frac{5\,\text{V}}{2\,k\Omega} = 2.5\,\text{mA}$$

$$I_3 = \frac{V_s}{R_3} = \frac{5\,\text{V}}{5\,k\Omega} = 1\,\text{mA}$$

$p_1 = V_s \times I_1 = 5\ \text{V} \times 5\ \text{mA} = 25\ \text{mW}$ (absorbed)

$p_2 = V_s \times I_2 = 5\ \text{V} \times 2.5\ \text{mA} = 12.5\ \text{mW}$ (absorbed)

$p_3 = V_s \times I_3 = 5\ \text{V} \times 1\ \text{mA} = 5\ \text{mW}$ (absorbed)

$p_{Vs} = V_s \times (-I_1 - I_2 - I_3) = -5\ \text{V} \times 8.5\ \text{mA} = -42.5\ \text{mW}$ (released)

$p_1 + p_2 + p_3 + p_{Vs} = 0$

2.3

(a)

$V_4 = R_6 I_6 = 6\ \text{k}\Omega \times 2\ \text{mA} = 12\ \text{V}$

(b)

$$I_5 = \frac{V_4}{R_5} = \frac{12\,\text{V}}{3\,k\Omega} = 4\,\text{mA}$$

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(c)

$I_4 = I_5 + I_6 = 4\text{ mA} + 2\text{ mA} = 6\text{ mA}$

(d)

$V_3 = R_4 I_4 = 1\text{ k}\Omega \times 6\text{ mA} = 6\text{ V}$

(e)

$V_2 = V_3 + V_4 = 12\text{ V} + 6\text{ V} = 18\text{ V}$

(f)

$$I_3 = \frac{V_2}{R_3} = \frac{18\,\text{V}}{6\,k\Omega} = 3\,\text{mA}$$

(g)

$$I_2 = \frac{V_2}{R_2} = \frac{18\,\text{V}}{9\,k\Omega} = 2\,\text{mA}$$

(h)

$I_1 = I_2 + I_3 + I_4 = 2\text{ mA} + 3\text{ mA} + 6\text{ mA} = 11\text{ mA}$

(i)

$V_1 = R_1 I_1 = 1\text{ k}\Omega \times 11\text{ mA} = 11\text{ V}$

(j)

$V_s = V_1 + V_2 = 11\text{ V} + 18\text{ V} = 29\text{ V}$

2.4

$R_{eq} = 25\text{ k}\Omega$

```
% Chapter 2, Test Bank, 2.4
clear all;format long;
R1=10000;R2=33000;R3=88000;R4=19000;R5=70000;R6=12500;R7=30000;R8=42000;
Ra=P([R7,R8])
Rb=R6+Ra
Rc=P([R5,Rb])
Rd=R4+Rc
Re=P([R2,R3,Rd])
Req=R1+Re
```


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```
Answer:
Ra =
       17500
Rb =
       30000
Rc =
       21000
Rd =
       40000
Re =
       15000
Req =
       25000
```

2.5

$R_{eq} = 3.8\ k\Omega$

```
% Chapter 2, Test Bank, 2.5
clear all;format long;
R1=1700;R2=7000;R3=1800;R4=4000;R5=12000;R6=1000;R7=2000;R8=3000;R9=6000;
Ra=P([R7,R8,R9])
Rb=R6+Ra
Rc=P([R4,R5,Rb])
Rd=R3+Rc
Re=P([R2,Rd])
Req=R1+Re

Answer:
Ra =
        1000
Rb =
        2000
Rc =
        1200
Rd =
        3000
Re =
        2100
Req =
        3800
```

2.6

$R_{eq} = 2\ k\Omega$

```
% Chapter 2, Test Bank, 2.6
clear all;format long;
R1=4000;R2=6000;R3=3000;R4=5000;R5=3000;R6=12000;R7=3000;R8=6000;R9=8000;
Ra=P([R7,R8,R9])
Rb=P([R5,R6])
Rc=R3+Rb+Ra+R4
Req=P([R1,R2,Rc])

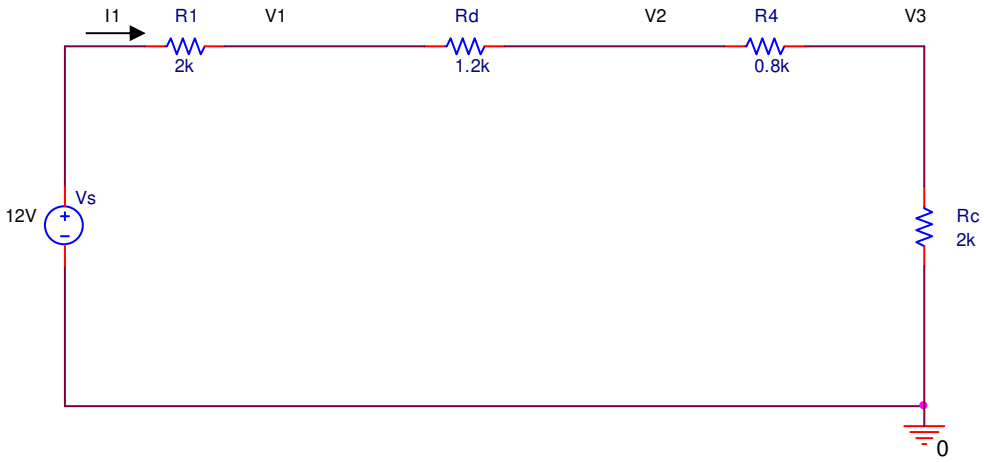
Answer:
Ra =
        1600
Rb =
        2400
Rc =
       12000
Req =
        2000
```


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2.7

(a) $R_a = R_7 \parallel R_8 = 2\ k\Omega$
(b) $R_b = R_6 + R_a = 4\ k\Omega$
(c) $R_c = R_5 \parallel R_b = 2\ k\Omega$
(d) $R_d = R_2 \parallel R_3 = 1.2\ k\Omega$
(e) $R_{eq} = R_1 + R_d + R_4 + R_c = 6\ k\Omega$



(f) $I_1 = V_s/R_{eq} = 12\ V/6\ k\Omega = 2\ mA$
(g) $V_{R1} = R_1 I_1 = 2\ k\Omega \times 2\ mA = 4\ V$
$V_{Rd} = R_d I_1 = 1.2\ k\Omega \times 2\ mA = 2.4\ V$
$V_{R4} = R_4 I_1 = 0.8\ k\Omega \times 2\ mA = 1.6\ V$
$V_{Rc} = R_c I_1 = 2\ k\Omega \times 2\ mA = 4\ V$
(h) $V_1 = V_s - V_{R1} = 12\ V - 4\ V = 8\ V$
$V_2 = V_1 - V_{Rd} = 8\ V - 2.4\ V = 5.6\ V$
$V_3 = V_2 - V_{R4} = 5.6\ V - 1.6\ V = 4\ V$
(i)

$$I_5 = \frac{V_3}{R_5} = \frac{4\,\text{V}}{4\,k\Omega} = 1\,\text{mA}$$

$$I_6 = \frac{V_3}{R_b} = \frac{4\,\text{V}}{4\,k\Omega} = 1\,\text{mA}$$

(j)
$V_4 = V_3 - R_6 I_6 = 4\ V - 2\ k\Omega \times 1\ mA = 4\ V - 2\ V = 2\ V$

$$I_7 = \frac{V_4}{R_7} = \frac{2\,\text{V}}{3\,k\Omega} = 0.6667\,\text{mA}$$

$$I_8 = \frac{V_4}{R_8} = \frac{2\,\text{V}}{6\,k\Omega} = 0.3333\,\text{mA}$$

```
% Chapter 2, Test Bank, 2.7
Vs=12;
R1=2000;R2=2000;R3=3000;R4=800;R5=4000;R6=2000;R7=3000;R8=6000;
Ra=P([R7,R8])
Rb=R6+Ra
```


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```
Rc=P([R5,Rb])
Rd=P([R2,R3])
Req=R1+Rd+R4+Rc
I1=Vs/Req
VR1=R1*I1
VRd=Rd*I1
VR4=R4*I1
VRc=Rc*I1
Sum1=VR1+VRd+VR4+VRc
V1=Vs-VR1
V2=Vs-VR1-VRd
V3=V2-VR4
I5=V3/R5
I6=V3/Rb
V4=V3-R6*I6
I7=V4/R7
I8=V4/R8

Answers:
Ra =
        2000
Rb =
        4000
Rc =
        2000
Rd =
        1200
Req =
        6000
I1 =
   0.002000000000000
VR1 =
     4
VRd =
   2.400000000000000
VR4 =
   1.600000000000000
VRc =
     4
Sum1 =
    12
V1 =
     8
V2 =
   5.600000000000000
V3 =
   4.000000000000000
I5 =
     9.999999999999998e-04
I6 =
     9.999999999999998e-04
V4 =
     2
I7 =
     6.666666666666666e-04
I8 =
     3.333333333333333e-04
```

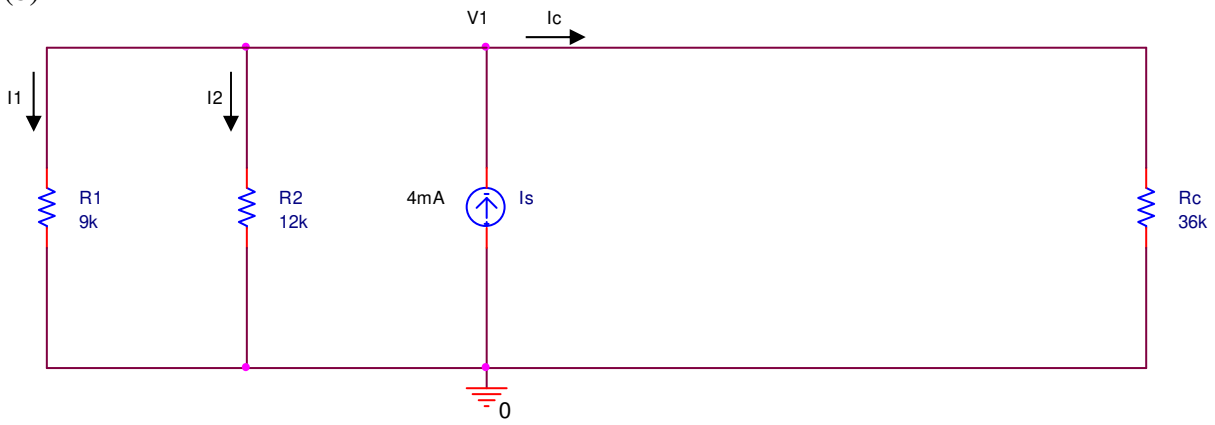
2.8

(a) $R_a = R_3 \parallel R_4 = 16.8\ k\Omega$, $R_b = R_5 \parallel R_6 = 19.2\ k\Omega$, $R_c = R_a + R_b = 36\ k\Omega$

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(b)



(c)

$$I_1 = I_s \times \frac{\frac{1}{R_1}}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_c}} = 4\,\text{mA} \times \frac{\frac{1}{9000}}{\frac{1}{9000}+\frac{1}{12000}+\frac{1}{36000}} = 4\,\text{mA} \times \frac{\frac{36000}{9000}}{\frac{36000}{9000}+\frac{36000}{12000}+\frac{36000}{36000}}$$

$$= 4\,\text{mA} \times \frac{4}{4+3+1} = 2\,\text{mA}$$

$$I_2 = I_s \times \frac{\frac{1}{R_2}}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_c}} = 4\,\text{mA} \times \frac{\frac{1}{12000}}{\frac{1}{9000}+\frac{1}{12000}+\frac{1}{36000}} = 4\,\text{mA} \times \frac{\frac{36000}{12000}}{\frac{36000}{9000}+\frac{36000}{12000}+\frac{36000}{36000}}$$

$$= 4\,\text{mA} \times \frac{3}{4+3+1} = 1.5\,\text{mA}$$

$$I_c = I_s \times \frac{\frac{1}{R_c}}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_c}} = 4\,\text{mA} \times \frac{\frac{1}{36000}}{\frac{1}{9000}+\frac{1}{12000}+\frac{1}{36000}} = 4\,\text{mA} \times \frac{\frac{36000}{36000}}{\frac{36000}{9000}+\frac{36000}{12000}+\frac{36000}{36000}}$$

$$= 4\,\text{mA} \times \frac{1}{4+3+1} = 0.5\,\text{mA}$$

(d)

$$I_3 = I_c \times \frac{R_4}{R_3+R_4} = 0.5\,\text{mA} \times \frac{56}{24+56}\,k\Omega = 0.35\,\text{mA}$$

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$$I_4 = I_c \times \frac{R_3}{R_3 + R_4} = 0.5\,\text{mA} \times \frac{24}{24+56}\,k\Omega = 0.15\,\text{mA}$$

$$I_5 = I_c \times \frac{R_6}{R_5 + R_6} = 0.5\,\text{mA} \times \frac{96}{24+96}\,k\Omega = 0.4\,\text{mA}$$

$$I_6 = I_c \times \frac{R_5}{R_5 + R_6} = 0.5\,\text{mA} \times \frac{24}{24+96}\,k\Omega = 0.1\,\text{mA}$$

(e)

$V_1 = R_1 I_1 = 9\ \text{k}\Omega \times 2\ \text{mA} = 18\ \text{V}$

$V_2 = R_5 I_5 = 24\ \text{k}\Omega \times 0.4\ \text{mA} = 9.6\ \text{V}$

```
% Chapter 2, Test Bank, 2.8
clear all;format long;
Is=4e-3;
R1=9000;R2=12000;R3=24000;R4=56000;R5=24000;R6=96000;
Ra=P([R3,R4])
Rb=P([R5,R6])
Rc=Ra+Rb
I1=Is/R1/(1/R1+1/R2+1/Rc)
I2=Is/R2/(1/R1+1/R2+1/Rc)
Ic=Is/Rc/(1/R1+1/R2+1/Rc)
I3=Ic/R3/(1/R3+1/R4)
I4=Ic/R4/(1/R3+1/R4)
I5=Ic/R5/(1/R5+1/R6)
I6=Ic/R6/(1/R5+1/R6)
V1=R1*I1
V2=R5*I5
VR3=R3*I3
Vloop=-V1+VR3+V2

Answers:
Ra =
       16800
Rb =
       19200
Rc =
       36000
I1 =
   0.002000000000000
I2 =
   0.001500000000000
Ic =
     5.000000000000000e-04
I3 =
     3.500000000000000e-04
I4 =
     1.500000000000000e-04
I5 =
     4.000000000000001e-04
I6 =
     1.000000000000000e-04
V1 =
    18
V2 =
   9.600000000000001
VR3 =
   8.400000000000000
Vloop =
     1.776356839400251e-15
```

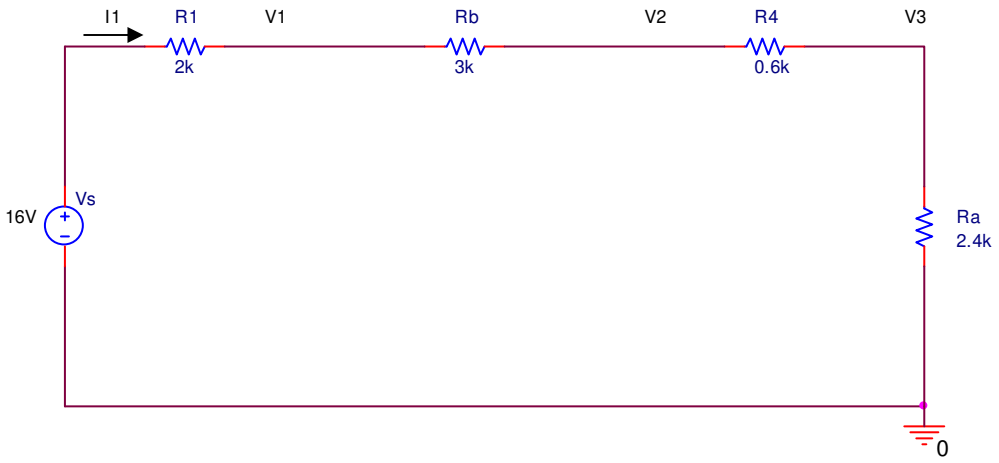

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2.9

(a) $R_a = R_5 \parallel R_6 = 2.4\ k\Omega$, $R_b = R_3 \parallel R_4 = 3\ k\Omega$.

(b) $R_{eq} = 8\ k\Omega$



(c)

$$I_1 = \frac{V_s}{R_{eq}} = \frac{16\,\text{V}}{8\,k\Omega} = 2\,\text{mA}$$

(d)

$V_{R1} = R_1 I_1 = 2\ k\Omega \times 2\ mA = 4\ V$
$V_{Rb} = R_b I_1 = 3\ k\Omega \times 2\ mA = 6\ V$
$V_{R4} = R_4 I_1 = 0.6\ k\Omega \times 2\ mA = 1.2\ V$
$V_{Ra} = R_a I_1 = 2.4\ k\Omega \times 2\ mA = 4.8\ V$

(e)

$V_1 = V_s - V_{R1} = 16\ V - 4\ V = 12\ V$
$V_2 = V_1 - V_{Rb} = 12\ V - 6\ V = 6\ V$
$V_3 = V_2 - V_{R4} = 6\ V - 1.2\ V = 4.8\ V$

(f)

$$I_2 = \frac{V_{R_b}}{R_2} = \frac{6\,\text{V}}{4\,k\Omega} = 1.5\,\text{mA}$$

$$I_3 = \frac{V_{R_b}}{R_3} = \frac{6\,\text{V}}{12\,k\Omega} = 0.5\,\text{mA}$$

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$$I_5 = \frac{V_{R_a}}{R_5} = \frac{4.8\,\text{V}}{4\,k\Omega} = 1.2\,\text{mA}$$

$$I_6 = \frac{V_{R_a}}{R_6} = \frac{4.8\,\text{V}}{6\,k\Omega} = 0.8\,\text{mA}$$

```
%Chapter 2, Test Bank, 2.9
clear all;
Vs=16;
R1=2000;R2=4000;R3=12000;R4=600;R5=4000;R6=6000;
Ra=P([R5,R6])
Rb=P([R2,R3])
Req=R1+Rb+R4+Ra
I1=Vs/Req
VR1=R1*I1
VRb=Rb*I1
VR4=R4*I1
VRa=Ra*I1
V1=Vs-VR1
V2=V1-VRb
V3=V2-VR4
I2=VRb/R2
I3=VRb/R3
I5=V3/R5
I6=V3/R6

Answers:
Ra =
        2400
Rb =
        3000
Req =
        8000
I1 =
   0.002000000000000
VR1 =
     4
VRb =
     6
VR4 =
   1.200000000000000
VRa =
   4.800000000000000
V1 =
    12
V2 =
     6
V3 =
   4.800000000000000
I2 =
   0.001500000000000
I3 =
     5.000000000000000e-04
I5 =
   0.001200000000000
I6 =
     7.999999999999999e-04
```

2.10

Delta to wye conversion:

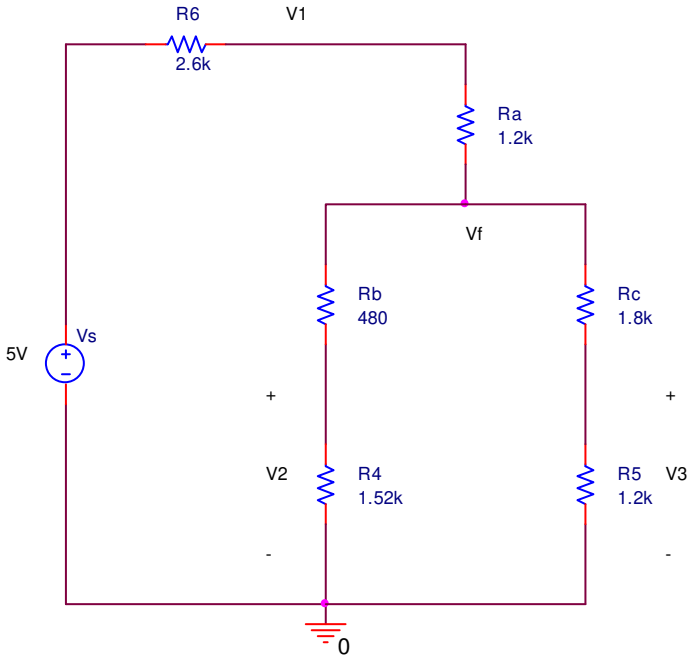
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$$R_a = \frac{R_1 R_3}{R_1 + R_2 + R_3} = 1.2\ \text{k}\Omega$$

$$R_b = \frac{R_1 R_2}{R_1 + R_2 + R_3} = 480\ \Omega$$

$$R_c = \frac{R_2 R_3}{R_1 + R_2 + R_3} = 1.8\ \text{k}\Omega$$



$R_d = R_b + R_4 = 2\ \text{k}\Omega$
$R_e = R_c + R_5 = 3\ \text{k}\Omega$
$R_f = R_d \parallel R_e = 1.2\ \text{k}\Omega$

Voltage Divider rule:

$$V_1 = V_s \times \frac{R_a + R_f}{R_6 + R_a + R_f} = 2.4\,\text{V}$$

$$V_f = V_s \times \frac{R_f}{R_6 + R_a + R_f} = 1.2\,\text{V}$$

$$V_2 = V_f \times \frac{R_4}{R_b + R_4} = 0.912\,\text{V}$$

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$$V_3 = V_f \times \frac{R_5}{R_c + R_5} = 0.48\,\text{V}$$

```
% Chapter 2, Test Bank, 2.10
clear all;
Vs=5;R1=2000;R2=3000;R3=7500;R4=1520;R5=1200;R6=2600;
[Ra,Rb,Rc]=D2Y([R1,R2,R3])
Rd=Rb+R4
Re=Rc+R5
Rf=P([Rd,Re])
V1=Vs*(Ra+Rf)/(R6+Ra+Rf)
Vf=Vs*(Rf)/(R6+Ra+Rf)
V2=Vf*R4/Rd
V3=Vf*R5/Re

Answers:
Ra =
        1200
Rb =
   480
Rc =
        1800
Rd =
        2000
Re =
        3000
Rf =
        1200
V1 =
   2.400000000000000
Vf =
   1.200000000000000
V2 =
   0.912000000000000
V3 =
   0.480000000000000
```


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