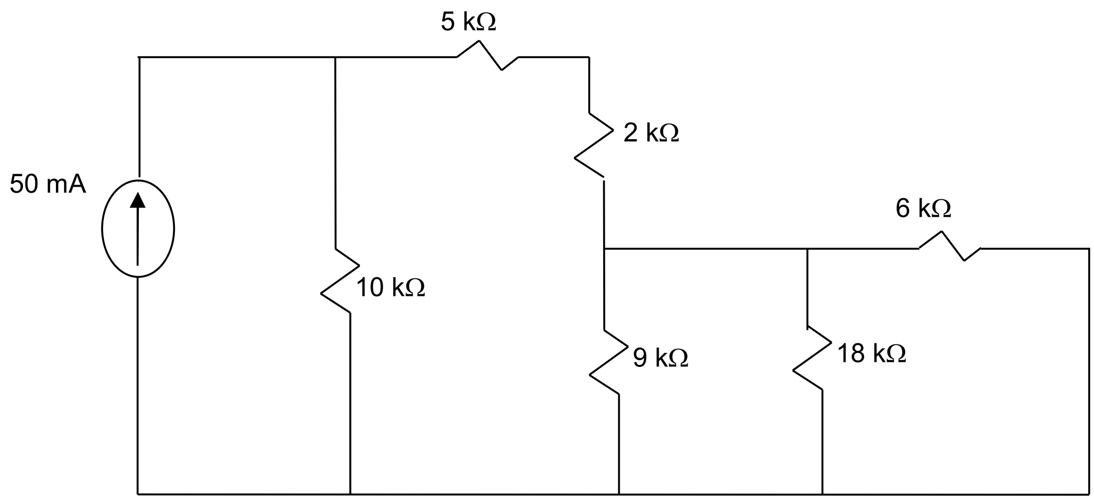
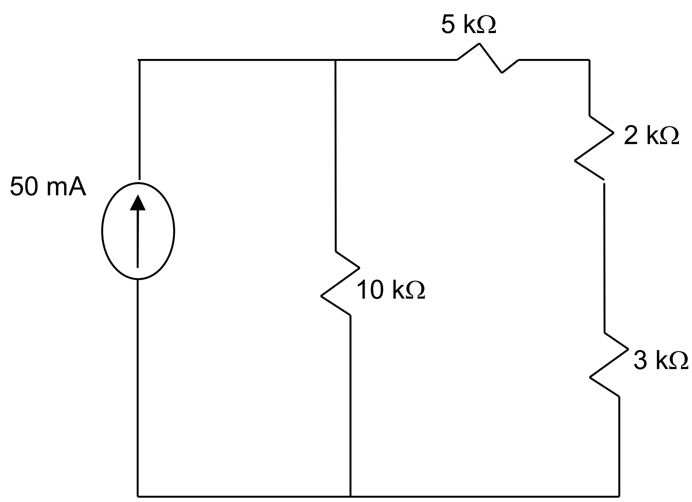
Fundamentals of Electrical Circuits - Chapter 3

1S. For the circuits shown below,
a) identify the resistors connected in parallel
b) Simplify the circuit by replacing parallel connect resistors with equivalent resistor.



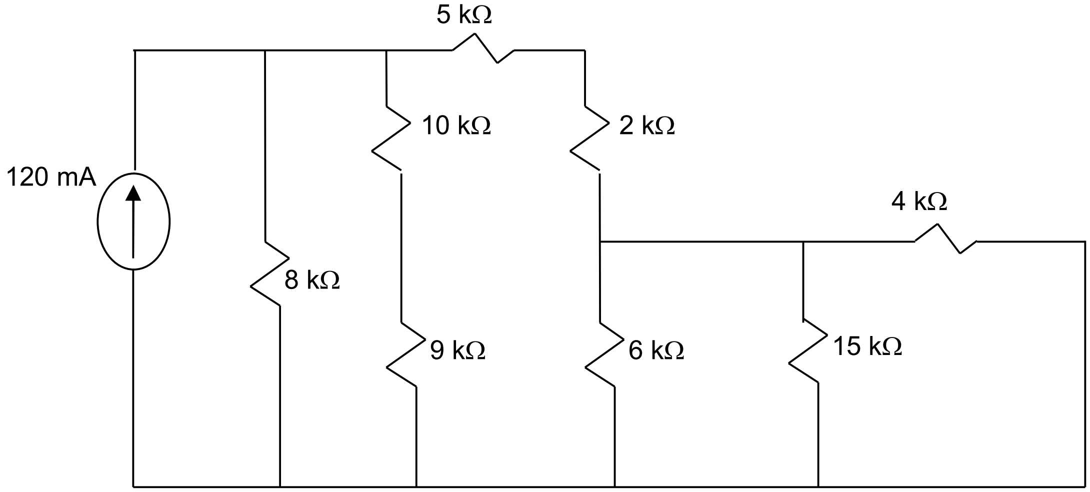
Solution:
a) Resistors in Parallel
9 kΩ || 18 kΩ || 6 kΩ

b) Simplify
Req for parallel Resistors = 1/(1/9 + 1/18 + 1/6) = 3



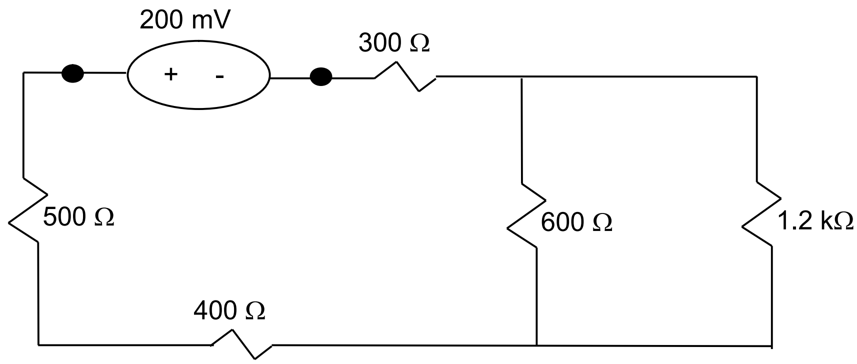
1U. For the circuits shown below,
a) identify the resistors connected in parallel

b) Simplify the circuit by replacing all resistors with equivalent resistor.



Solution:

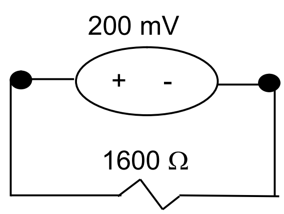
2S. Find the equivalent resistance seen by the source in the following circuit.



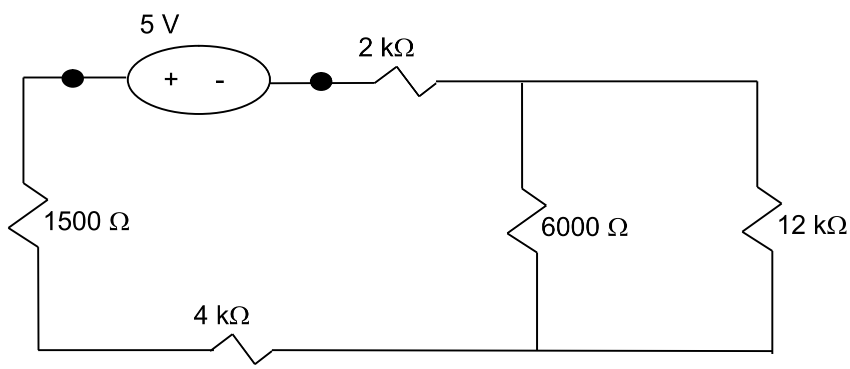
Solution:

Simplify?

Req = (1200 || 600) + 300 + 400 + 500 = 1/(1/1200 + 1/600) + 1200 = 1600 Ω

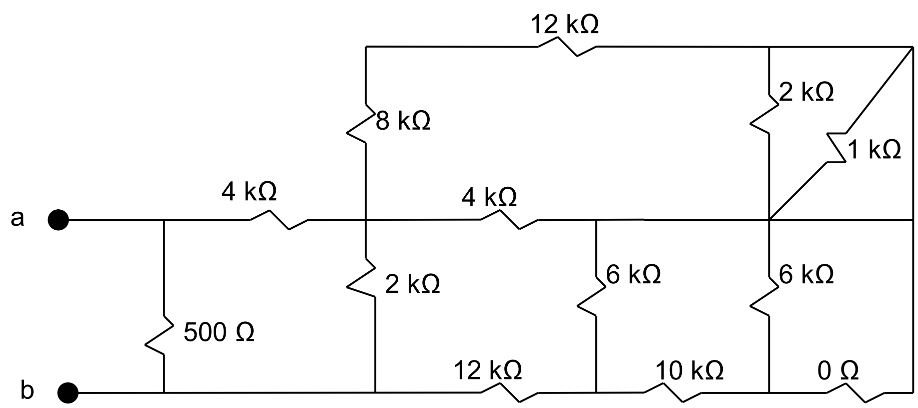


2Ua. Find the equivalent resistance seen by the source in the following circuit.



Solution:

2Ub. Find the equivalent resistance (R_{ab}) in the following circuit with respect to terminals ab.



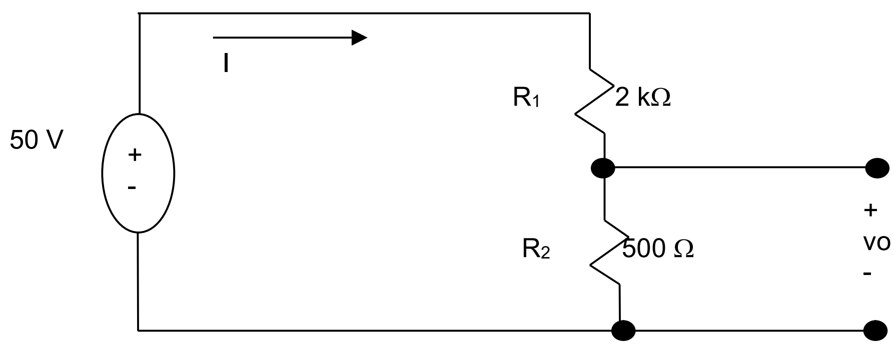
Solution:

3S. For the following circuit,

a) Calculate the no-load voltage v_o in the voltage-divider.

b) Calculate the power dissipated in R1 and R2.

c) Assuming that only 1/4 W resistor are available. The no-load voltage is to be the same as in (a). Specify the smallest value of R1 and R2.



Solution:

a) find no-load vo?

vo = I R_2

$vo = (50 / (R_1 + R_2))*R_2 = (50/(2000+500))*500 = 10$ V

b) Powers?

$P_{R1} = R_1 * (50 / (R_1 + R_2))^2 = 2000 * (50 / 2500)^2 = 0.8$ W
$P_{R2} = R_2 * (50 / (R_1 + R_2))^2 = 500 * (50 / 2500)^2 = 0.2$ W

c) Given: $P_{Max} \le ¼$ W & vo = 10 V ; Find possible value of R_1 & R_2

vo = 10 V → $vo = (50 / (R_1 + R_2))* R_2 = 10$ → $R_1 / R_2 = 4$
$P_{Max} \le ¼$ W → $vo^2/R_2 \le ¼$ W → $10^2/R_2 \le ¼$ W → $R_2 \ge 400\ \Omega$
$P_{Max} \le ¼$ W → $vo^2/R_1 \le ¼$ W → $40^2/R_1 \le ¼$ W → $R_1 \ge 6400\ \Omega$

The values of R1 & R2 must satisfy 3 rules: $R_1 \ge 6400\ \Omega$, $R_2 \ge 400\ \Omega$ & $R_1 / R_2 = 4$
There fore the Minimum value → $R_1 = 6400\ \Omega$ → $R_2 = R_1/4 = 1600\ \Omega$,

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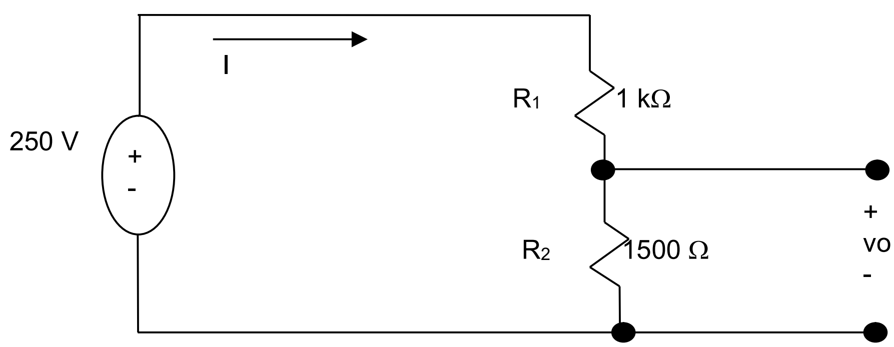
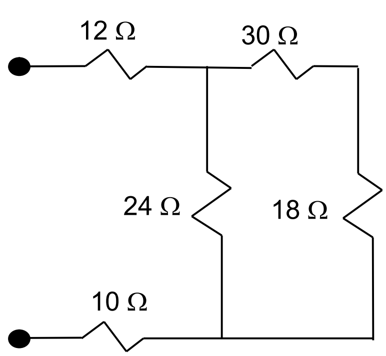
3U. For the following circuit,
a) Calculate the no-load voltage vo for the voltage-divider.
b) Calculate the power dissipated in R1 and R2.
c) Assuming that only 0.25 W resistor are available. The no-load voltage (Vo) is to be the same as in part (a). Specify the value of R1 and R2 that meets the limitations.

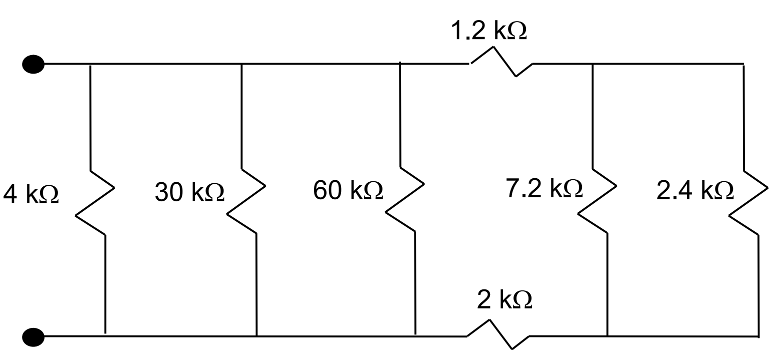


Solution: Not Provided

4S. Use voltage division or current division to find the specified voltages or currents:
a) Suppose the voltage drop across the 24 Ω resistor in the following circuit A is 40 V, positive at the top of the resistor. What is the voltage drop across the 18 Ω resistor?
b) Suppose the current in the 10 Ω resistor in the following circuit A is 60 mA, flowing from left to right. What is the current flowing in the 30 Ω resistor?
c) Suppose the current in the 1.2 kΩ resistor in the following circuit B is 9 mA, flowing from left to right. What is the current in the 30 kΩ resistor?
d) Suppose the voltage drop across the 4 kΩ resistor in the following circuit B is 50 V, Positive at top of the resistor. What is the voltage drop across the 2.4 kΩ resistor?



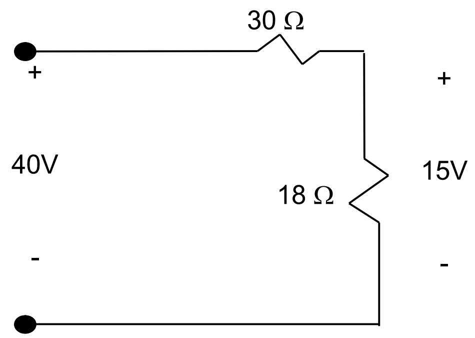
(A)



(B)

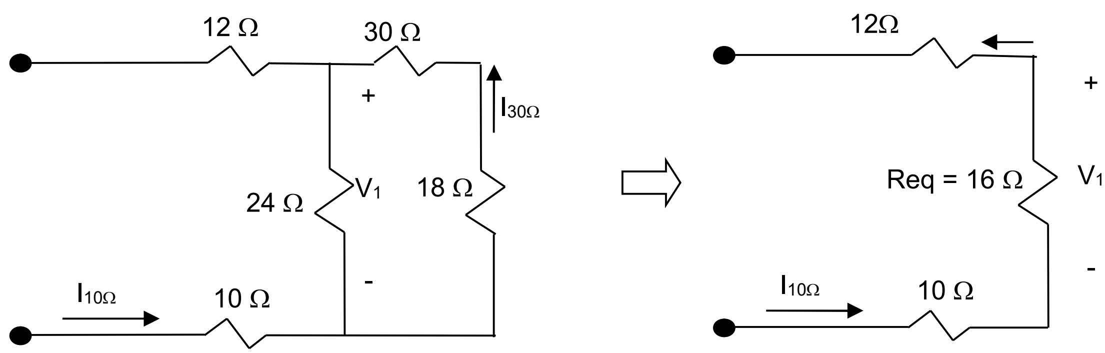
Solution:

a) Given $V_{24\Omega} = 40V$, Find $V_{18\Omega}$



$V_{18\Omega}$ = IR = (40 /(30 + 18))* 18 = 15 V

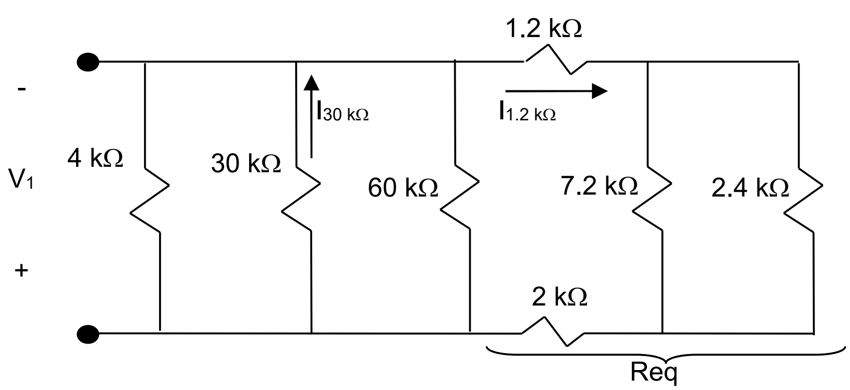
b) Given $I_{10\Omega}$ = 60 mA, Find $I_{30\Omega}$ = ?



Req = 24 || (18 + 30) = 16 Ω → V_1 = 16 * 60 = 960 mV

$I_{30\Omega}$ = V1 / (30 + 18) = 960 / 48 = 20 mA

c) Given $I_{1.2\,k\Omega}$ = 9 mA, Find $I_{30\Omega}$ = ?



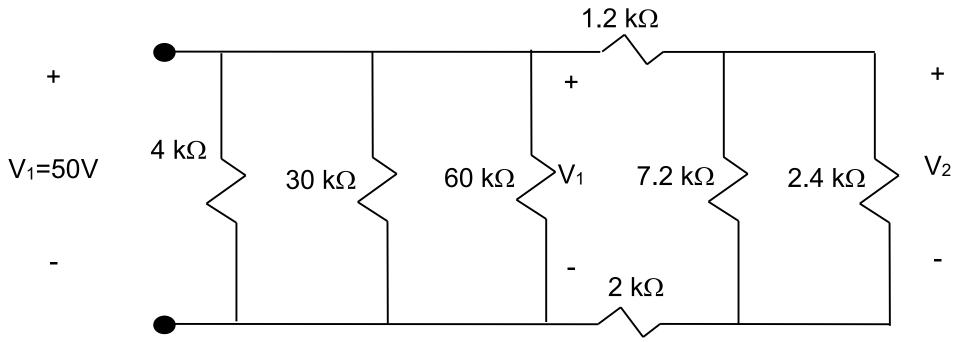
Current Divider

Req = (1.2 + 7.2 || 2.4 + 2)= 5 kΩ

V1 = (9 mA)(5 kΩ) = 45 V

$I_{30\Omega}$ = V1 / 30 = 45/30 = 1.5 mA

d) Given $V_{30k\Omega}$ = 50 V, Find $V_{2.4\Omega}$ = ?



Req = 7.2 || 2.4 = 1 / (1/7.2 + 1/2.4) = 1.8 kΩ
V2 = (V1/ (1.2 + 1.8 + 2))*1.8 = (50/5)*1.8 = 18 V

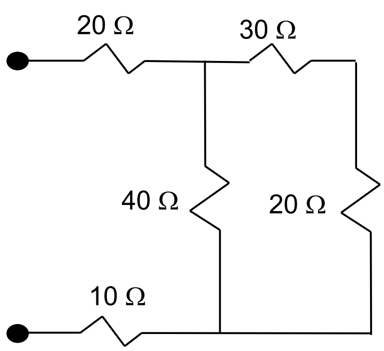
4U. Use voltage division or current division to find the specified voltages or currents:

a) Suppose the voltage drop across the 40 Ω resistor in the following circuit A is 40 V, positive at the top of the resistor. What is the voltage drop across the 10 Ω resistor?

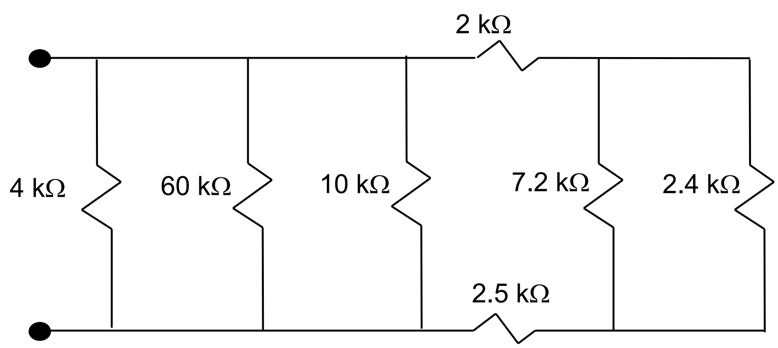
b) Suppose the current in the 10 Ω resistor in the following circuit A is 60 mA, flowing from left to right. What is the current flowing in the 30 Ω resistor?

c) Suppose the current in the 2 kΩ resistor in the following circuit B is 10 mA, flowing from left to right. What is the current in the 60 kΩ resistor?

d) Suppose the voltage drop across the 4 kΩ resistor in the following circuit B is 50 V, Positive at top of the resistor. What is the voltage drop across the 2.4 kΩ resistor?



(A)



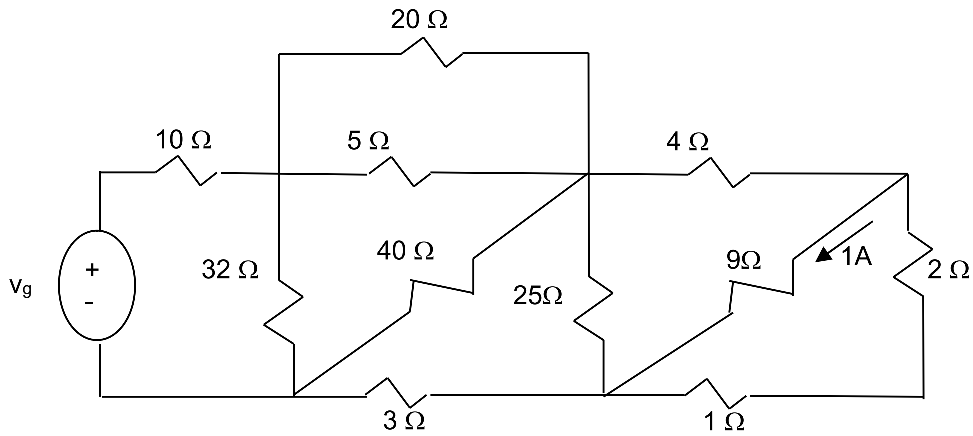
(B)

Solution:

5S. The Current in the 9 Ω resistor in the circuit shown below is 1A.

a) Find v_g.

b) Find the power dissipated in the 20 Ω resistor.

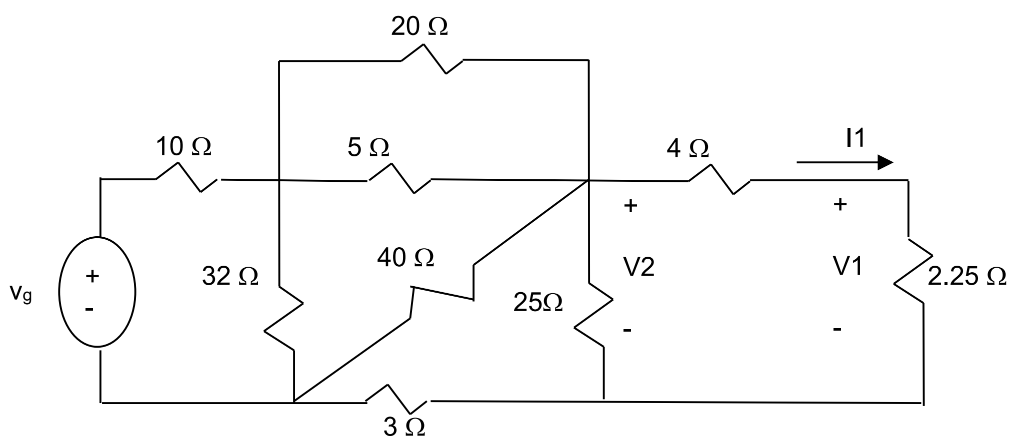


Solution:

a) Vg = ?

$I_{9\Omega}$ = 1 A → $V_{9\Omega}$ = 9 * 1 = 9 V

Req1 = (1+2) || 9 = 2.25 Ω

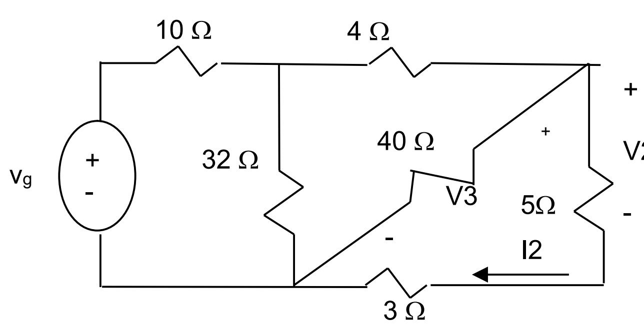


I1 = V1/2.25 = 9/2.25 = 4 A

V2 = I1 * (4+2.25) = 25 V

Req2 = (4 + 2.25) || 25 = 5 Ω

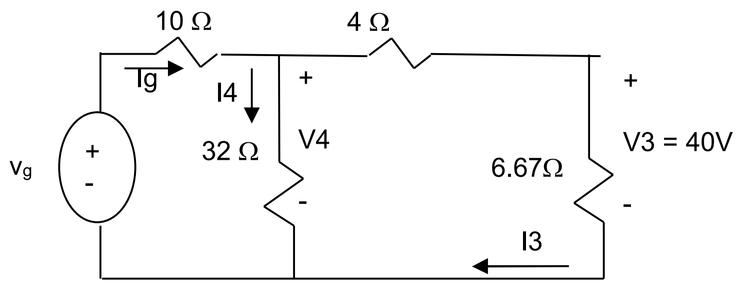
Req3 = (20 || 5) = 4 Ω



I2 = V2/5 = 25/5 = 5A

V3 = I2 * (5 + 3) = 40 V

Req4 = ((5+3) || 40) = 6.67 Ω



I3 = V3/6.67 = 40/6.67 = 6 A
V4 = I3 * (4 + 6.67) = 6 * 10.67 = 64 V

I4 = (V4)/32 = 2 A

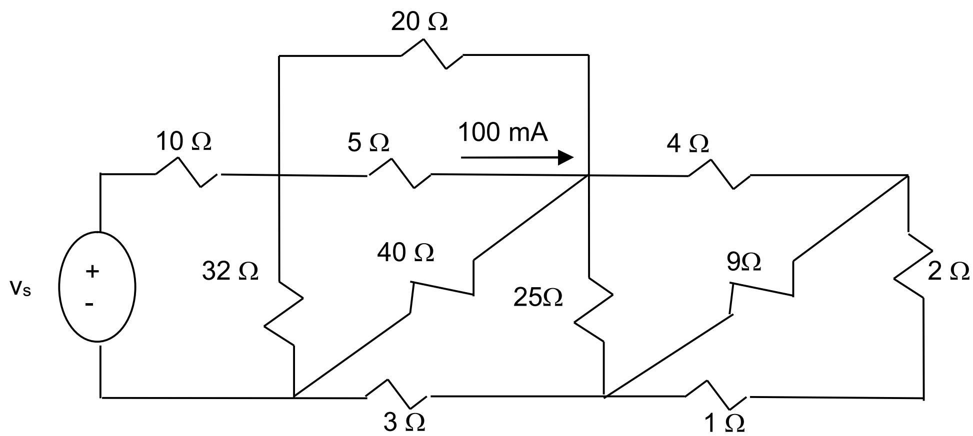
KCL → -Ig + I4 + I3 = 0 → Ig = 8 A

KVL → -Vg + (10*8) + (32*2)= 0 → Vg = 144 V

b) $P_{20\Omega}$ = ?
Using I3 → $V_{4\Omega}$ = 6 * 4 = 24 V which is the same as $V_{20\Omega}$
$P_{20\Omega} = (V_{20\Omega})^2/20 = (24)^2/20 = 28.8$ W

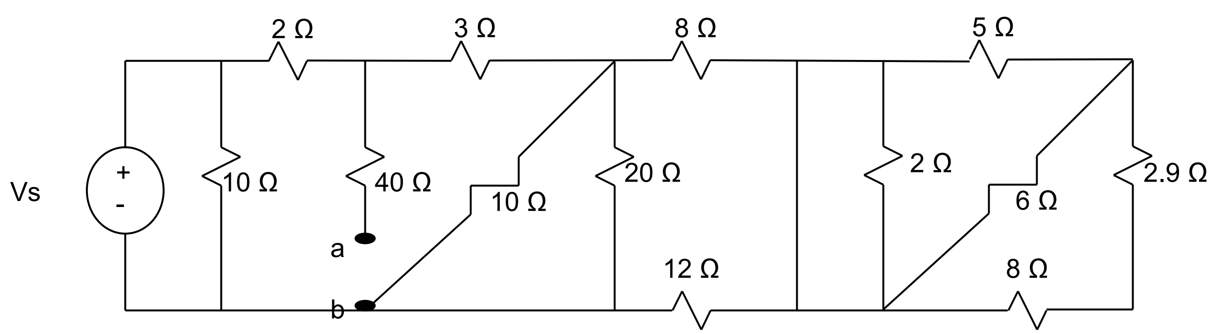
5U. The Current in the 5 Ω resistor in the circuit shown below is 100 mA.

a) Find v_s.
b) Find the power dissipated in the 40 Ω resistor.



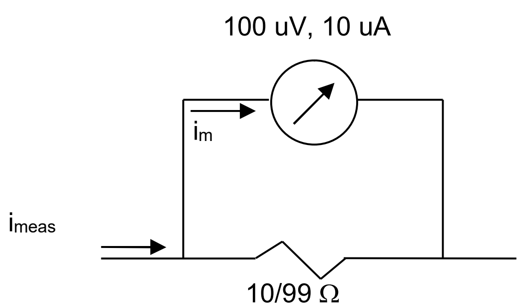
Solution:

5Ub. Find the power delivered by the source (Vs = 10 Volts) in the following circuit.



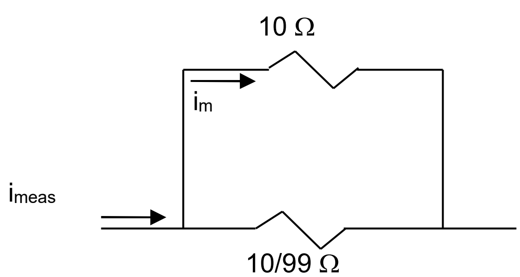
Solution:

6S. a) For the following ammeter circuit, show that the current in d'Arsonval movement is always 1/100th of the current being measured.



b) What would the fraction be if the 50 uV, 2 uA movement were used in a 1A ammeter?
c) Would you expect a uniform scale on a d'Arsonval Ammeter?

Solution:
a) Internal Resistanct of d'Arsonval = R_{DA} = 100 uV / 10 uA = 10 Ω so we can redraw a ohmic equivalent:

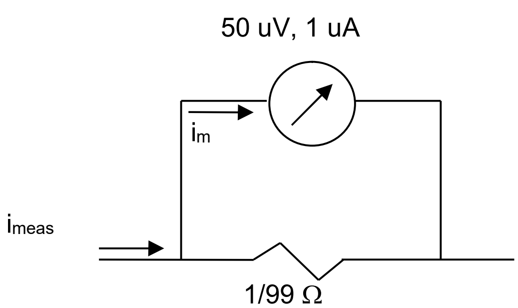


Apply the current divider → $i_m = i_{meas}$ (10/99 /(10/99 + 10)) → i_m / i_{meas} = 1/100
We

b) Ratio = i_m / i_{meas} = 2 uA / 1 A = 1/500,000

c) Yes, if d'Arsonval is assumed to be ideal.

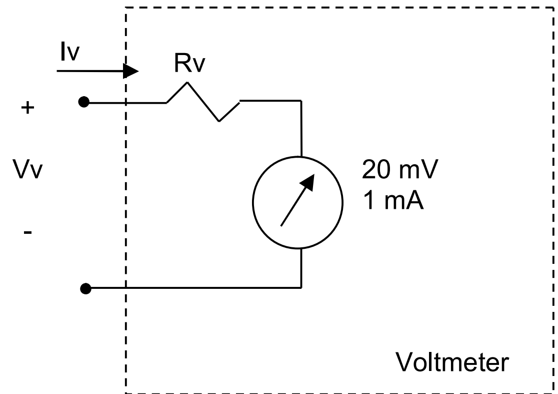
6U. a) For the following ammeter circuit, what is the ratio of current through d'Arsonval movement (i_m) to tthe current being measured (i_{meas}).



b) What would the fraction be if the 80 uV, 10 uA movement were used in a 1A ammeter?
c) Would you expect a uniform scale on a d'Arsonval Ammeter?

Solution:

7S. A d'Arsonval voltmeter is shown below. Find the value of Rv for each of the following full Scale Readings:
a) 50 V
b) 5 V
c) 250 mV
d) 25 mV

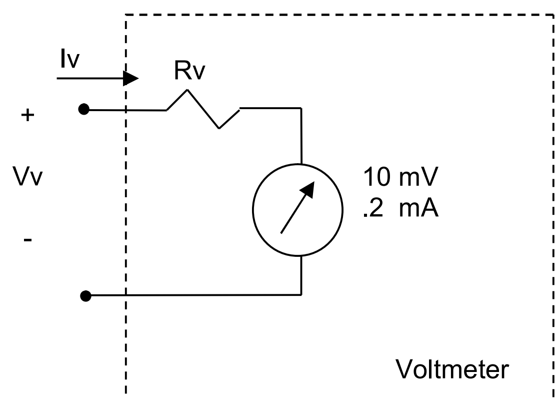


Solution:

* We know that d'Arsonval movement has Ram = 20 mV / 1mA = 20 Ω
* In general we have Vv = Iv (Rv + 20) Since Max V is given in the question, we should use I= 1mA which is causes maximum movement as the Iv

a) Vv=50 V → 50 = .001(Rv + 20) -→ Rv= 49,980 Ω
b) Vv=5 V → 5 = .001(Rv + 20) -→ Rv= 4,980 Ω
c) Vv=250 mV → .250 = .001(Rv + 20) -→ Rv= 230 Ω
d) Vv=25 mV → .025 = .001(Rv + 20) -→ Rv= 5 Ω

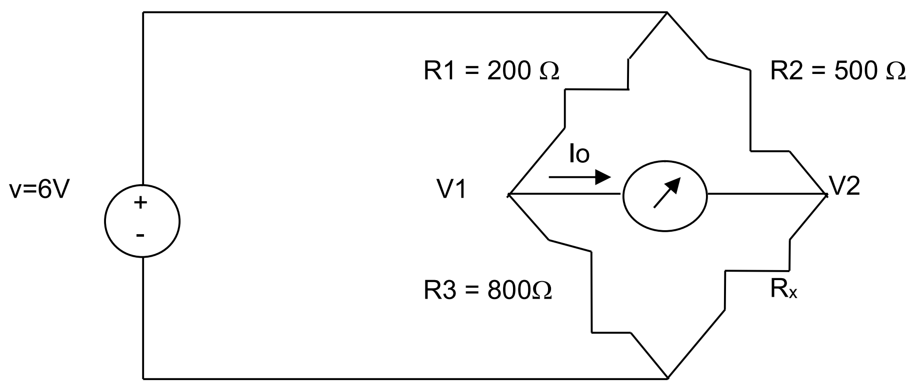
7U. A d'Arsonval voltmeter is shown below. Find the value of Rv for each of the following full Scale Readings:
a) 100 V
b)25 V
c) 500 mV
d) 5 mV



Solution:

8S. The bridge circuit shown below is energized from a 6V dc source. The bridge is balanced when R_1=200Ω ,R_2=500Ω and R_3=800Ω.
a) What is the value R_x.
b) How much current (in milliamperes) does the dc source supply?

c) Which resistor in the circuit absorbs the most power? How much power does it absorb?
d) Which resistor absorbs the least power? How much power does it absorb?



Solution:

a) Balanced Bridge → Io = 0 and $V_1 = V_2$
Currents through R1 and R3 are the same I1
Current through R2 and Rx are the same I2
V = 6 = I1*(200 + 800) → I1 = 6 mA
V1 = 800 * 6 mA = 4.8 V = V2

$V_{R1} = V_{R2}$ → 200*I1 = 500*I2 → 200*6= 500*I2 → I2 = 2.4 mA
$V_{R3} = V_{Rx}$ → 800*I1 = R_x*I2 → 800*6= R_x*2.4 → R_x = 2,000 Ω

b) I = current of dc source = ?
I = I1 + I2 = 6 + 2.4 = 8.4 mA

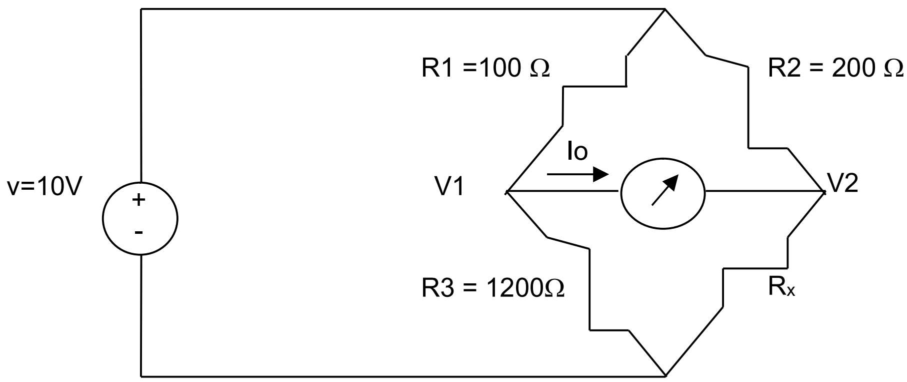
c) Which resistor absorbs most power?
$P_{R1} = (200)*(6*10^{-3})^2 = 7.2$ mW
$P_{R2} = (500)*(2.4*10^{-3})^2 = 2.88$ mW
$P_{R3} = (800)*(6*10^{-3})^2 = 28.8$ mW
$P_{Rx} = (2000)*(2.4*10^{-3})^2 = 11.5$ mW

R3 = 800 Ω absorbs the most power equal to 28.8 mW

d) Which resistor absorbs least power?
R2 = 500 Ω absorbs the most power equal to 2.88 mW

8U. The bridge circuit shown below is energized from a 10V dc source. The bridge is balanced when R_1=100Ω ,R_2=200Ω and R_3=1200Ω.

a) What is the value R_x.
b) How much current (in milliamperes) does the dc source supply?
c) Which resistor in the circuit absorbs the most power? How much power does it absorb?
d) Which resistor absorbs the least power? How much power does it absorb?

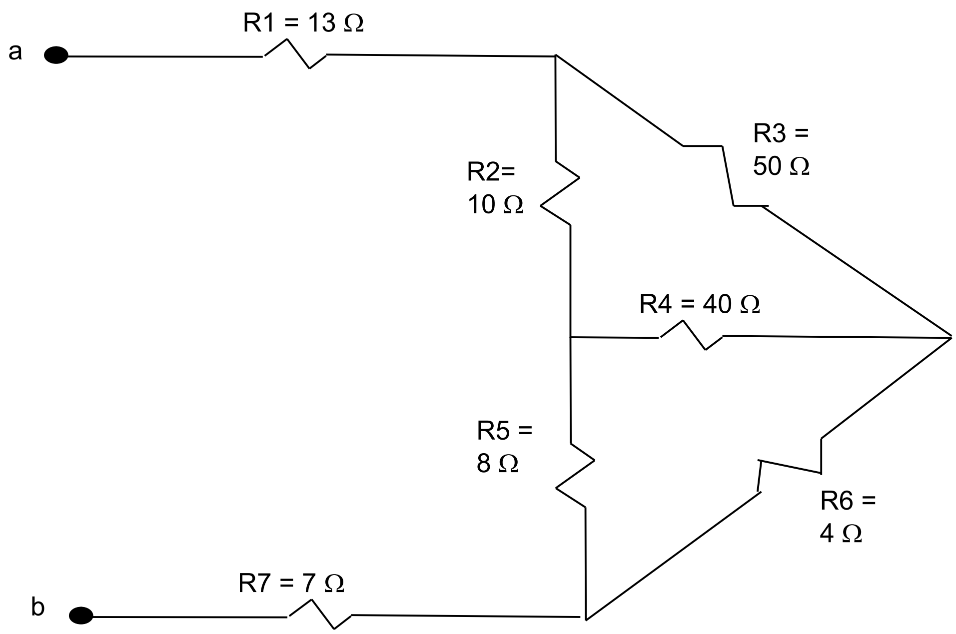


Solution:

9S. a) Find the equivalent resistance Rab in the circuit shown below by using Δ-to-Y transformation involving the resistors R2,, R3 and R4.

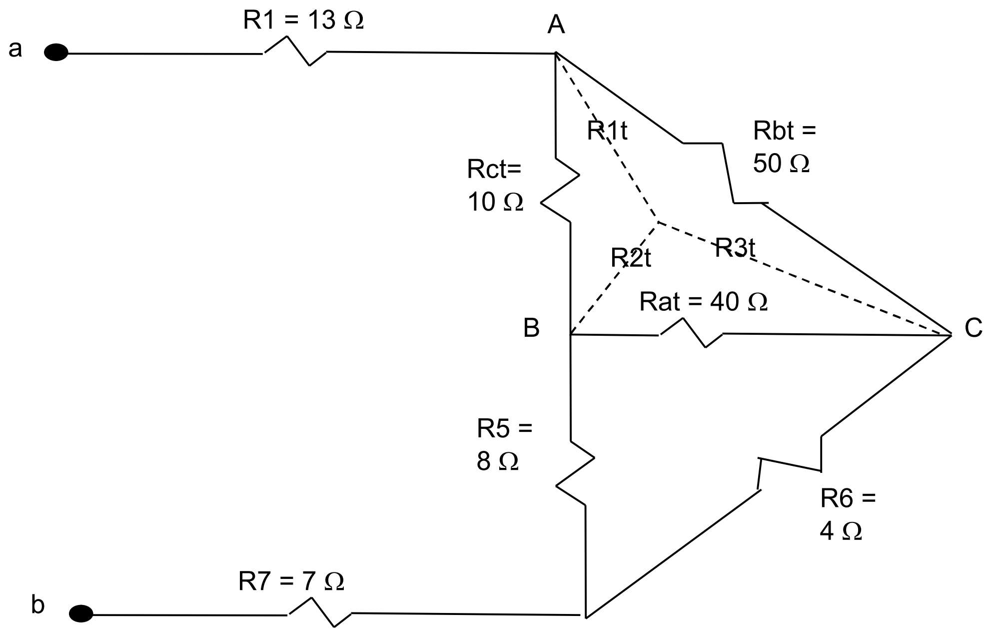
b) Repeat (a) using a Y-to-Δ transformation involving resistors R2, R4 and R5.

c) Give two additional Δ-to-Y or Y-to-Δ transformations that could be used to find Rab.



Solution:

a) Δ-to-Y transformation with R2, R3 and R4.

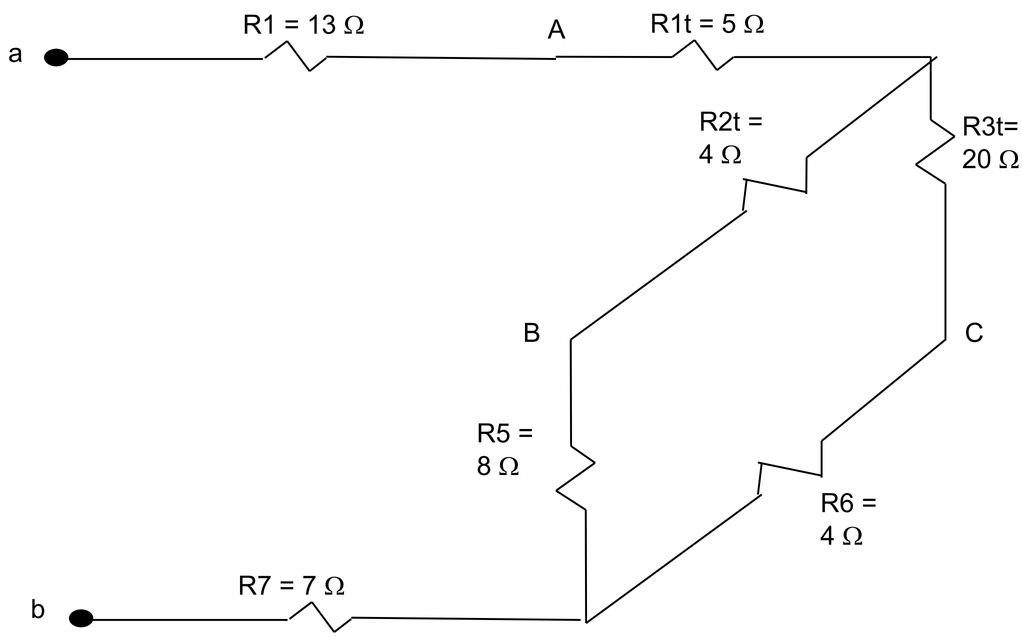


$$R1t = \frac{RbtRct}{Rat + Rbt + Rct} = \frac{10*50}{40+10+50} = 5\Omega$$

$$R2t = \frac{RatRct}{Rat + Rbt + Rct} = \frac{40*10}{40+10+50} = 4\Omega$$

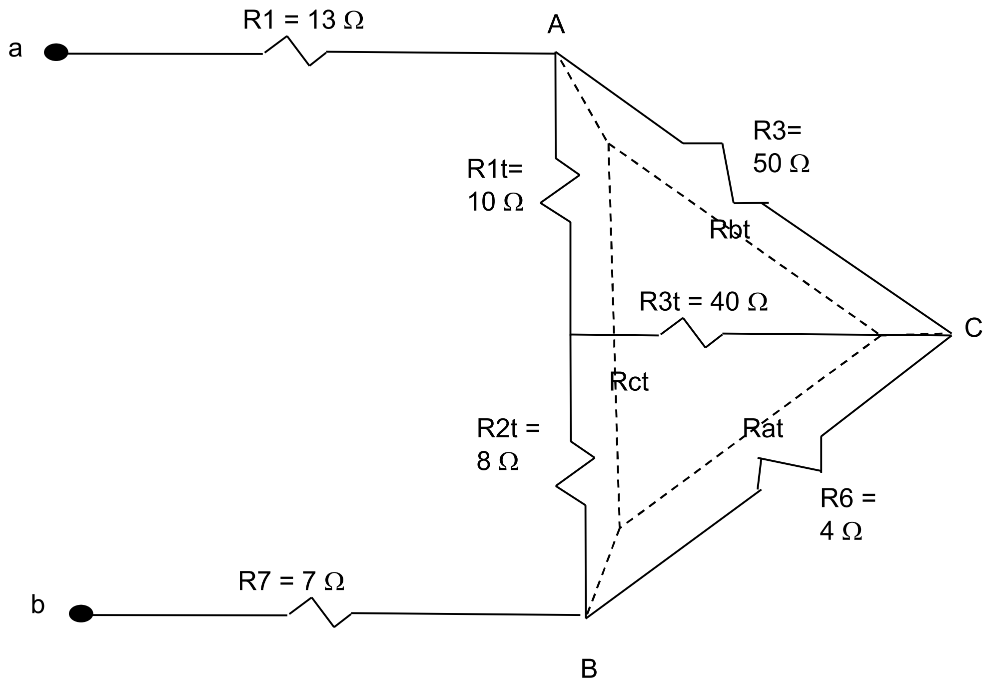
$$R3t = \frac{RatRbt}{Rat + Rbt + Rct} = \frac{40*50}{40+10+50} = 20\Omega$$

New Circuit with Transformation



Req(ab) = 13 + 5 + ((8+4) || (20+4)) + 7 = 33 Ω

b) Y-to-Δ transformation with R2, R4 and R5.



$$Rat = \frac{R1tR2t + R2tR3t + R3tR1t}{R1t} = \frac{10*8 + 8*40 + 40*10}{10} = 80\Omega$$

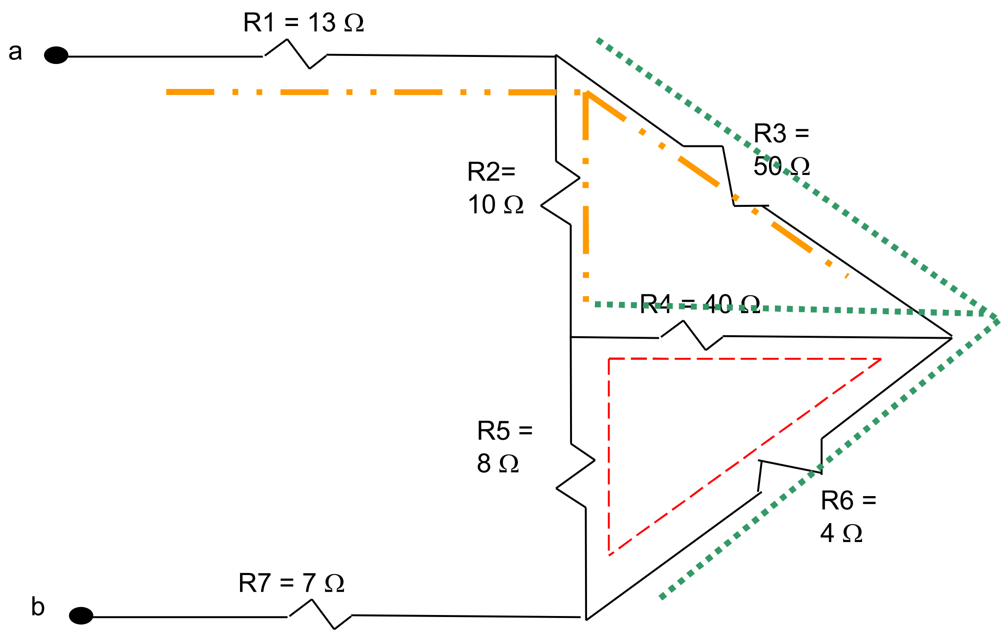
$$Rbt = \frac{R1tR2t + R2tR3t + R3tR1t}{R2t} = \frac{10*8 + 8*40 + 40*10}{8} = 100\Omega$$

$$Rct = \frac{R1tR2t + R2tR3t + R3tR1t}{R3t} = \frac{10*8 + 8*40 + 40*10}{40} = 20\Omega$$

New Circuit with Transformation

Req(ab) = 13 + 20 || ((50 || 100) + (4 || 80)) + 7 = 33 Ω

c) Identify at least a couple of transforms



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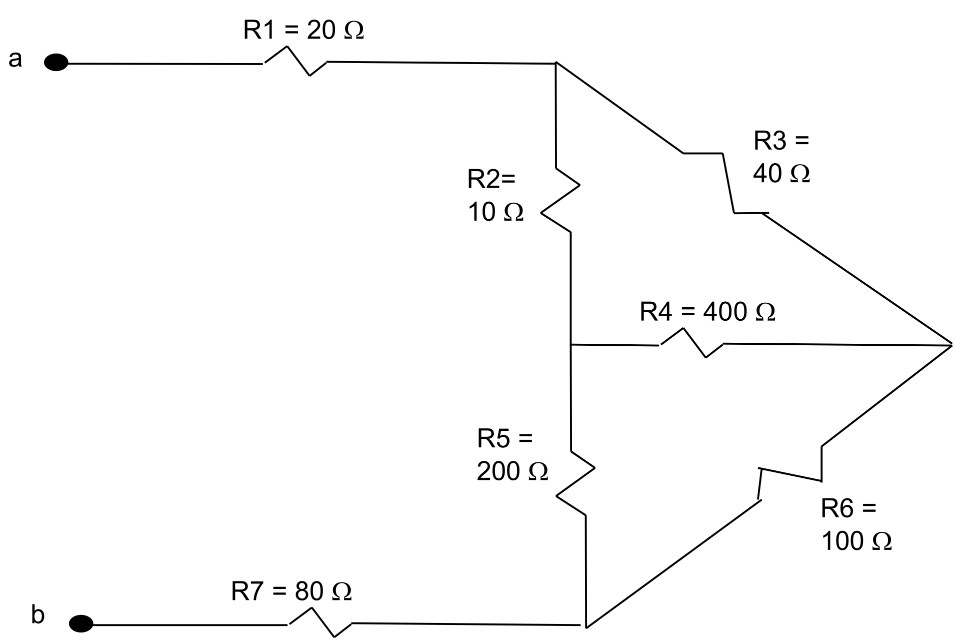

Solution: