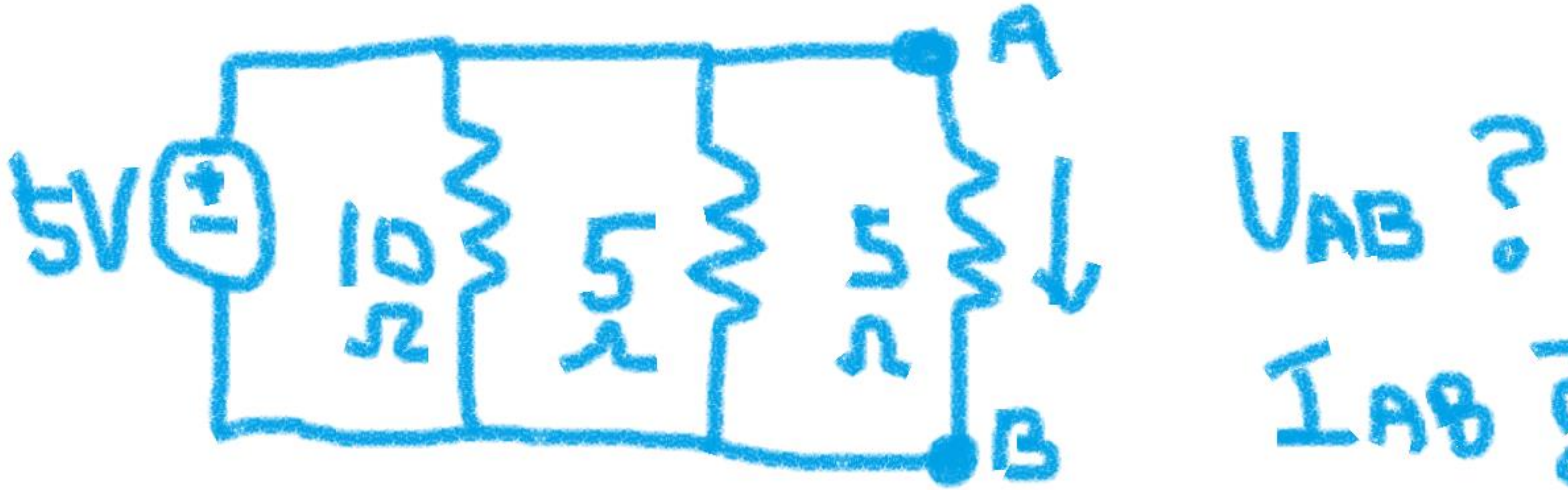
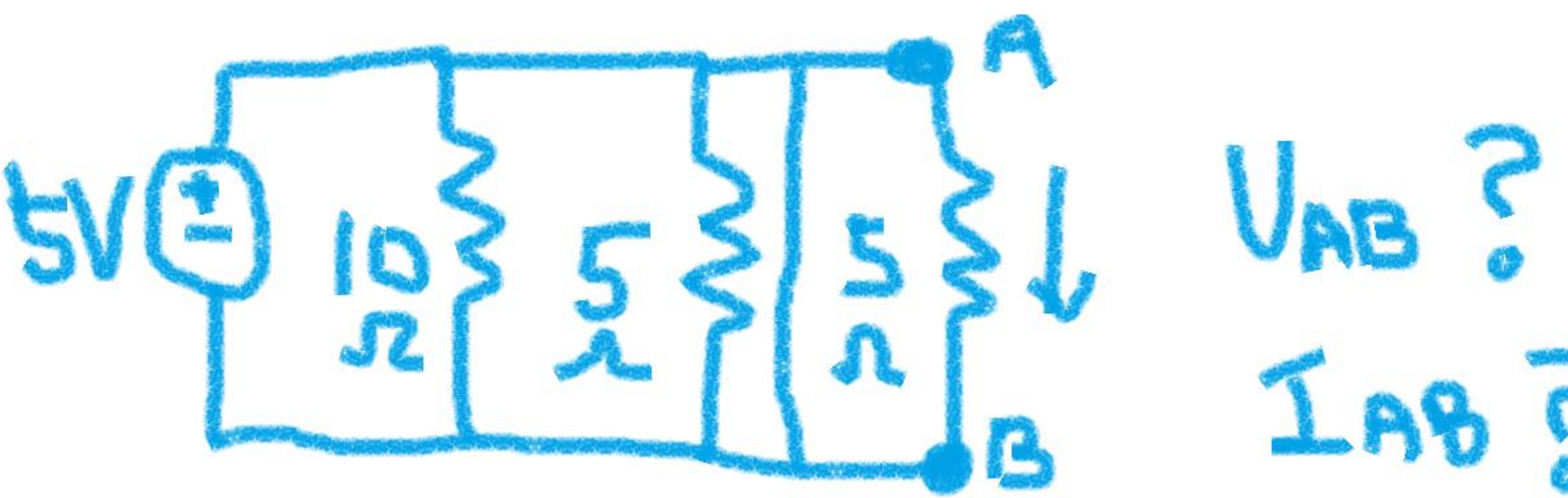
CET 141: Day 2

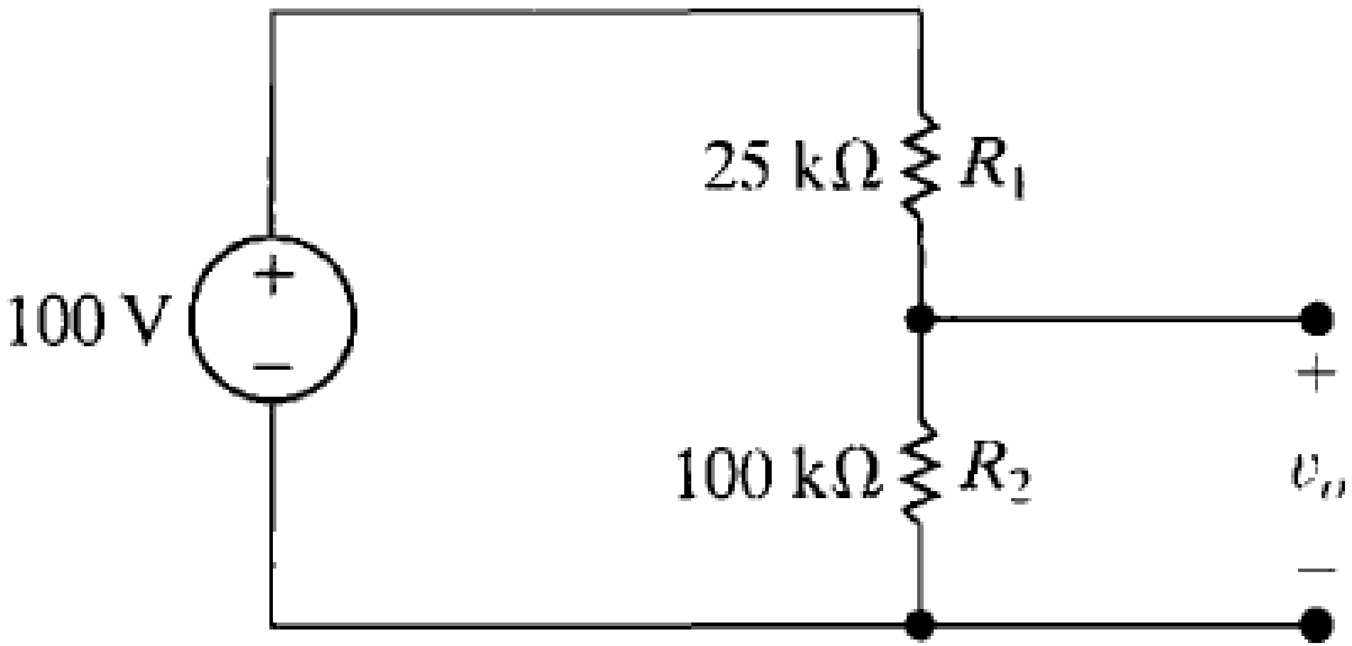
Dr. Noori KIM

Warm up ourselves


5V
10 Ω
5 Ω
5 Ω
A
B
V_AB ?
I_AB ?

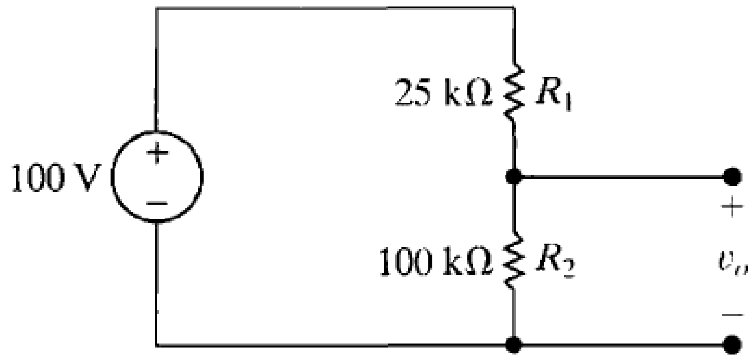

5V
10 Ω
5 Ω
5 Ω
A
B
V_AB ?
I_AB ?

- Find the value of v_o



$$v_o = 100V \frac{100k}{100k + 25k} = 80V$$

- The resistors used in the voltage-divider circuits have a tolerance of ±10%. Find the maximum and minimum value of v_0

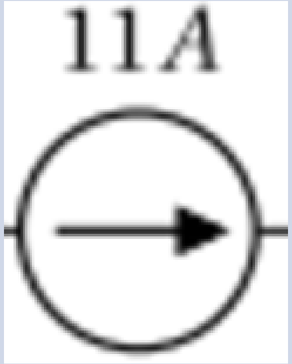
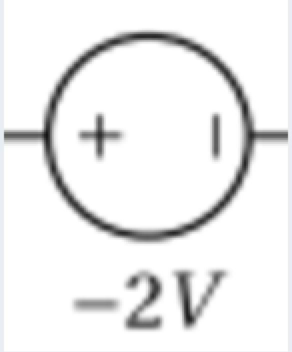
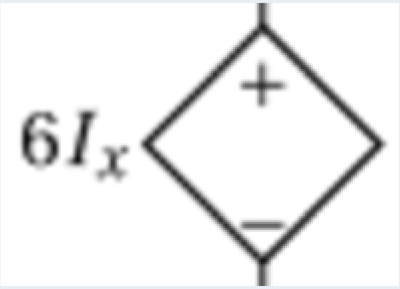


- The maximum value of v_0 occurs when *R2* is 10% high and *R1* is 10% low
- The minimum value of v_0 occurs when *R2* is 10% low and *R1* is 10% high

$$v_o(\max) = \frac{(100)(110)}{110 + 22.5} = 83.02\ \text{V}. \qquad v_o(\min) = \frac{(100)(90)}{90 + 27.5} = 76.60\ \text{V}$$

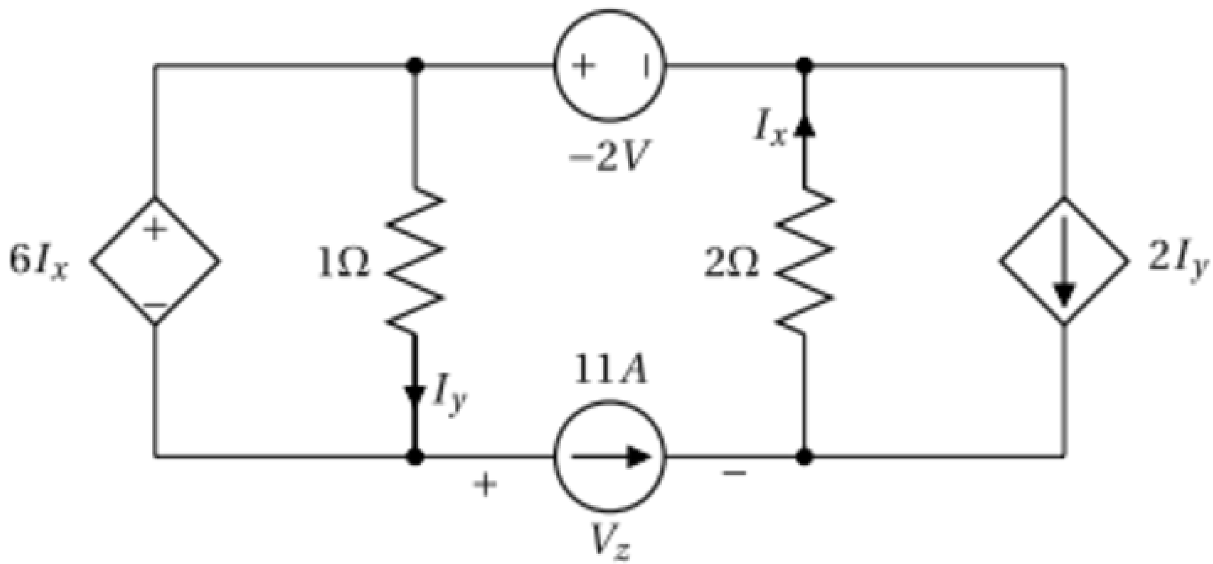
Thus, in making the decision to use 10% resistors in this voltage divider,
we recognize that the no-load output voltage will lie between 76.60 and 83.02 V.

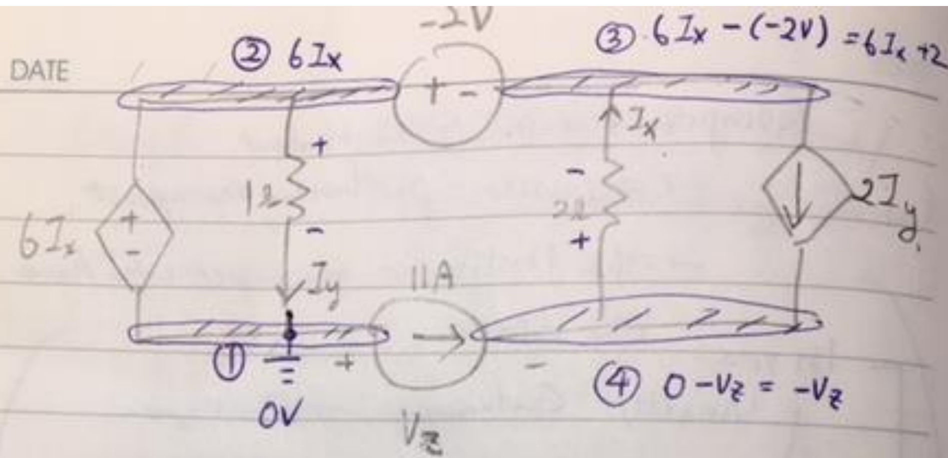
Electrical Sources

	Independent (Circle)	Dependent (Diamond)
Current (Arrow)		
Voltage (Polarity)		

Dependent sources

- A **dependent source**
  - a voltage **source** or a current **source**
  - whose value depends on a voltage or current <u>somewhere</u> else in the network.





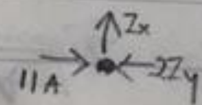
$\boxed{I_x,\ I_y,\ V_z}$?

From ③, ④

⑤ $I_x = \dfrac{-V_z - (6I_x + 2)}{2}$ $\quad 2I_x = -V_z - 6I_x - 2$

$8I_x + V_z = -2$

⑥ at ④



$I_x = 11 + 2I_y$.

⑦ at ②

$I_y = \dfrac{6I_x - 0}{1} = 6I_x$.

From ⑤, ⑥, ⑦

$I_x = 11 + 2(6I_x) \Rightarrow I_x = -1A$

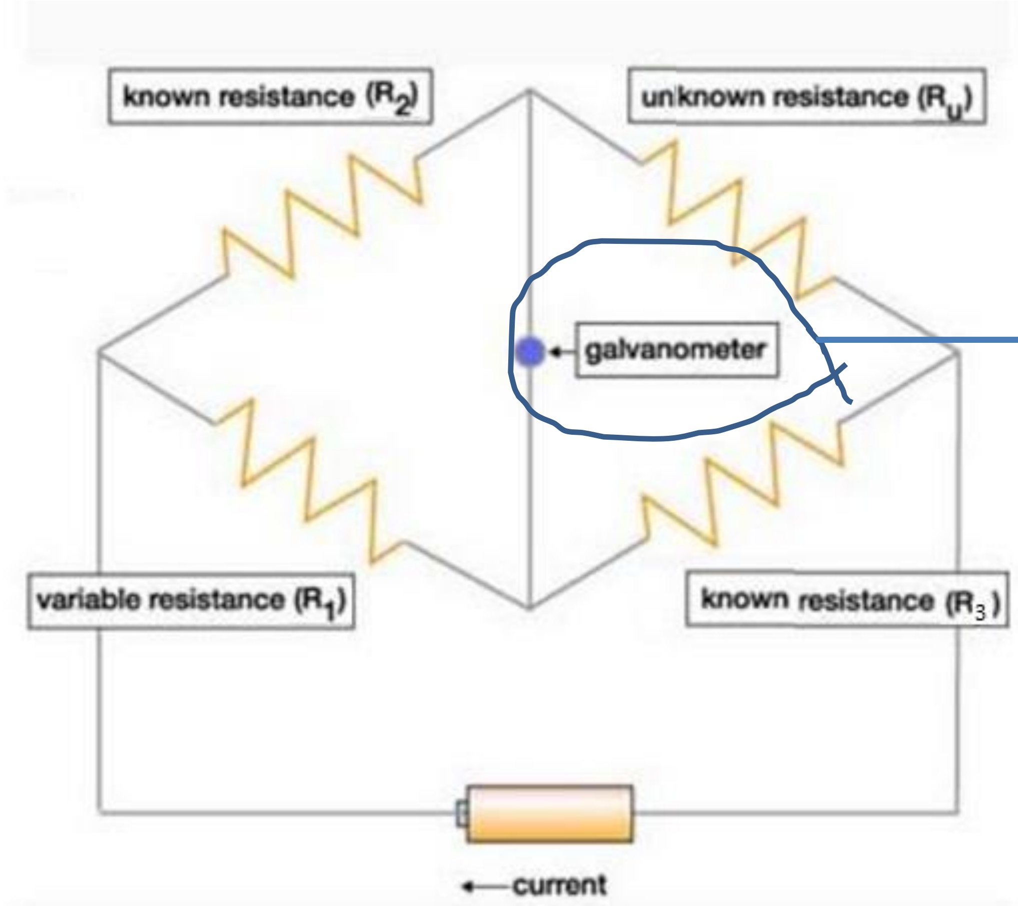
$-1 = 11 + 2I_y \quad -12 = 2I_y \quad I_y = -6A$

$8\cdot(-1) + V_z = -2 \rightarrow V_z = 6V$

Wheatstone bridge

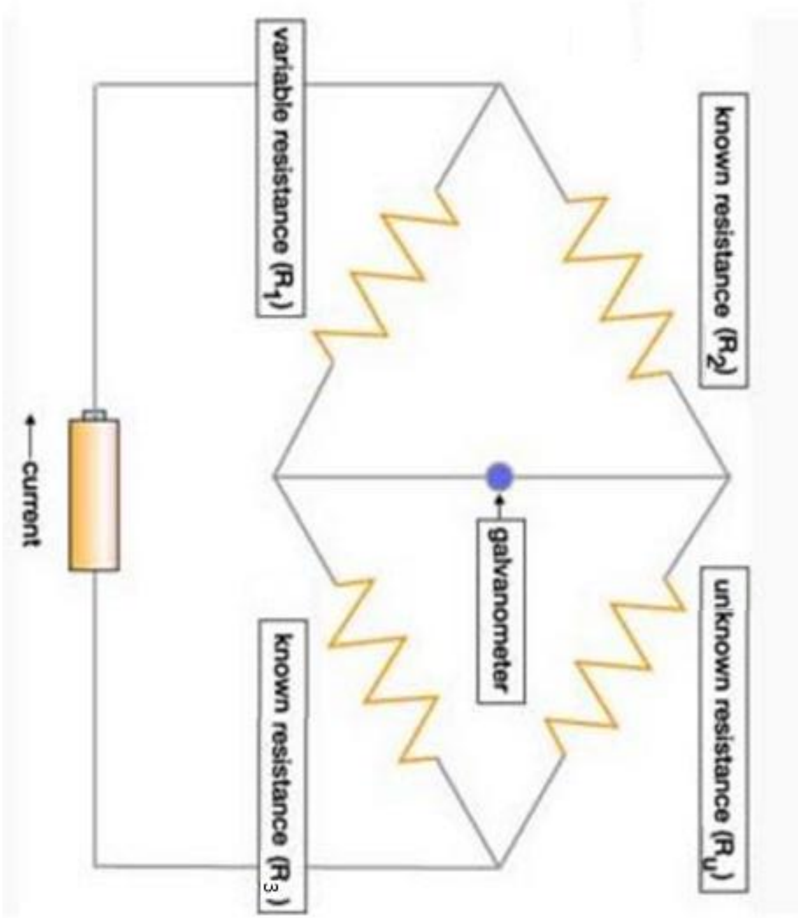
- A device which is used to measure the electrical resistance by comparison method
- To measure an unknown resistance by passing current through the unknown resistor
- Brief History:
  – First founded by Samuel Hunter Christie in 1833
  – Sir Charles **Wheatstone** claimed the various applications of the device and showed its importance to the people (the device name after him)

- R1, R2, R3 and Ru
- Ru is the resistor whose resistance is to be found and R1 is the only adjustable resistor (in this setting)



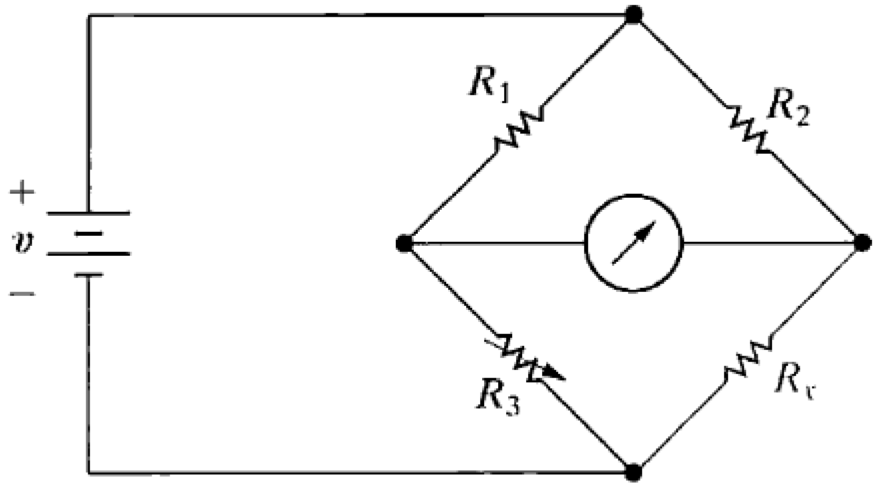
When does it read zero?

=



- Known path: R2, R3 = Unknown path: Ru, R1
  - The reading current at the galvanometer=0
  - Varying R1 to find Ru: **Ru = (R3*R2)/R1**
  - **Or varying one of variable resistors among R1, R2, or R3**

- The bridge circuit shown is balanced when R1= 100Ω, R2 = 1000 Ω, and R3 = 150 Ω. The bridge is energized from a 5 V dc source. What is the value of *Rx?*



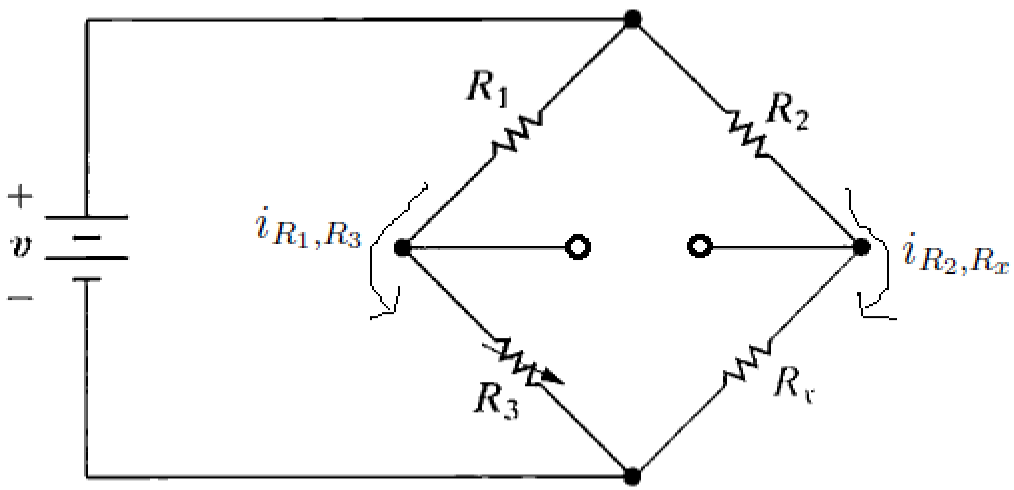
$$100R_x = (1000)(150) \qquad \text{so} \qquad R_x = \frac{(1000)(150)}{100} = 1500\,\Omega = 1.5\text{ k}\Omega$$

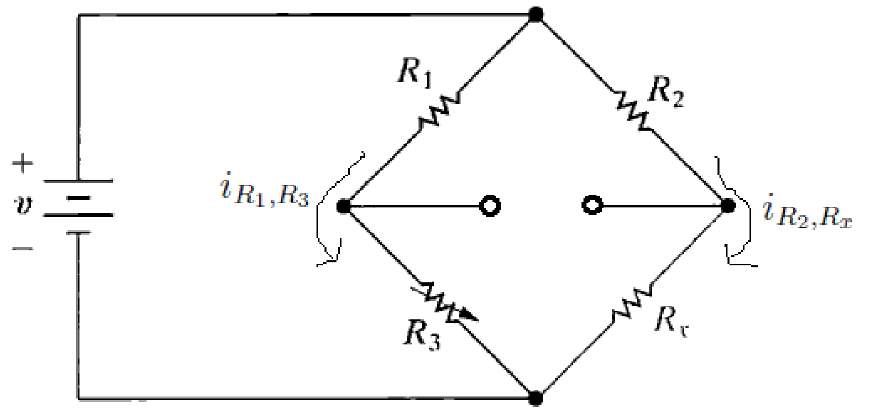
- Suppose each bridge resistor is capable of dissipating 250 mW. Can the bridge be left in the balanced state without exceeding the power-dissipating capacity of the resistors (without damaging the bridge)?

Hint>>

➢ Calculate dissipating power for each resistor and compare it to 250mW

➢ When the bridge is balanced, there is no current flowing through the meter, so the meter acts like an open circuit.





$$i_{R_1,R_3} = \frac{5\text{ V}}{100\,\Omega + 150\,\Omega} = 20\text{ mA} \quad i_{R_2,R_x} = \frac{5\text{ V}}{1000 + 1500} = 2\text{ mA}$$

$p = Ri^2$:

$p_{100\Omega} =$

$p_{150\,\Omega} =$

$p_{1000\Omega} =$

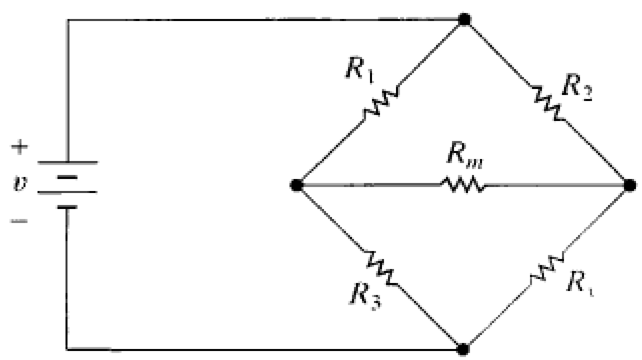
$p_{1500\,\Omega} =$

$\left.\right\}$ << 250 mW

<u>The bridge can be left in the balanced state without exceeding the power-dissipating capacity of the resistors</u>

Delta-to-Wye Equivalent Circuits

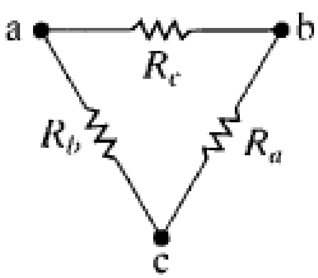
- From the Wheatstone bridge, we replace the galvanometer with its equivalent resistance *Rm*,

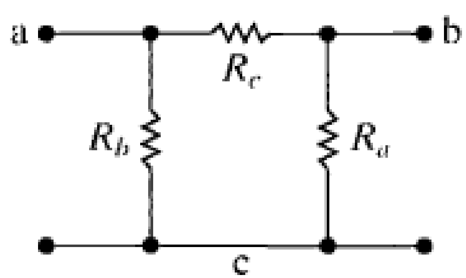


delta (Δ) interconnection

or

Pi (π) interconnection





as the Δ can be shaped into a π without disturbing the electrical equivalence of each node

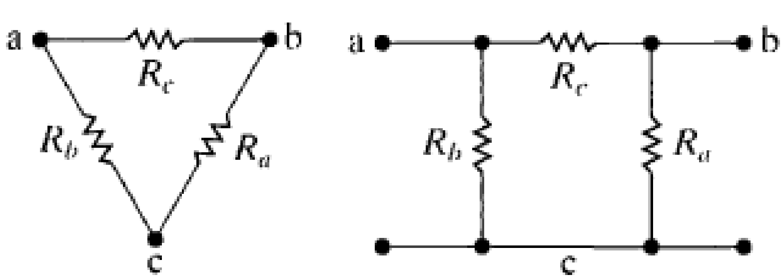


Figure 3.29 ▲ A Δ configuration viewed as a π configuration.

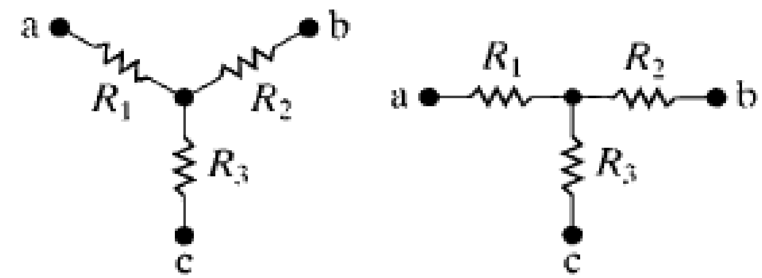


Figure 3.30 ▲ A Y structure viewed as a T structure.

Transformations without disturbing the electrical equivalence

Then, how about this?

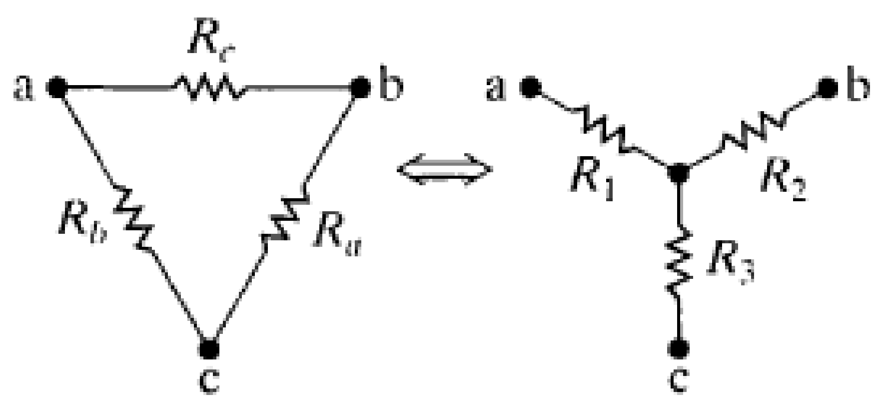
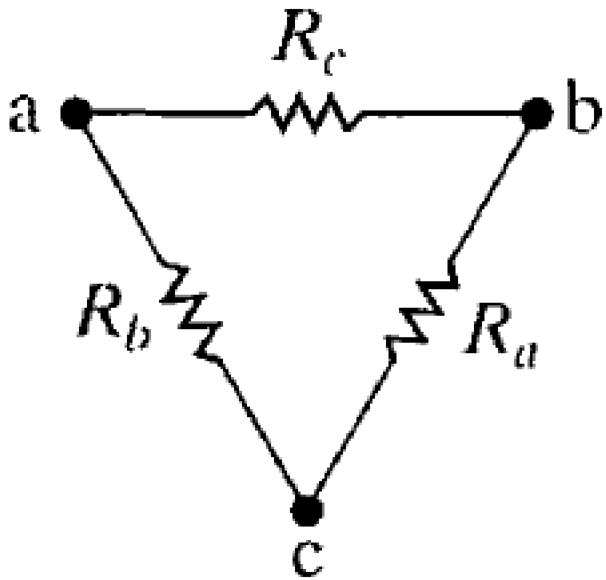
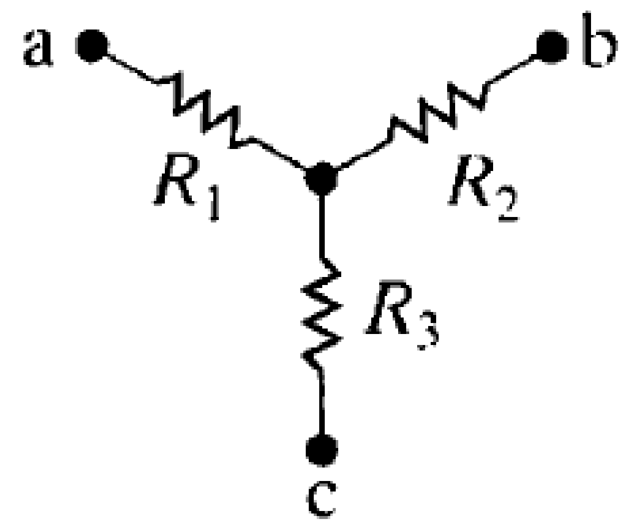


Figure 3.31 ▲ The Δ-to-Y transformation.

Basic idea of the transformation



Two parallel resistors viewed as two series resistors



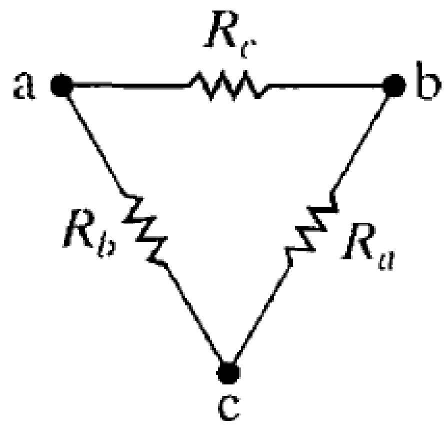
$$R_{ab} = \frac{R_c(R_a + R_b)}{R_a + R_b + R_c} = R_1 + R_2$$

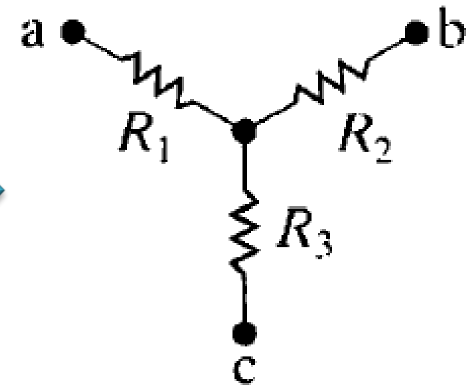
$$R_{bc} = \frac{R_a(R_b + R_c)}{R_a + R_b + R_c} = R_2 + R_3$$

$$R_{ca} = \frac{R_b(R_c + R_a)}{R_a + R_b + R_c} = R_1 + R_3$$

Solve for R1, R2, and R3 in terms of Ra, Rb, and Rc

Preserve node a, b, c voltages





$$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1},$$

$$R_b = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2},$$

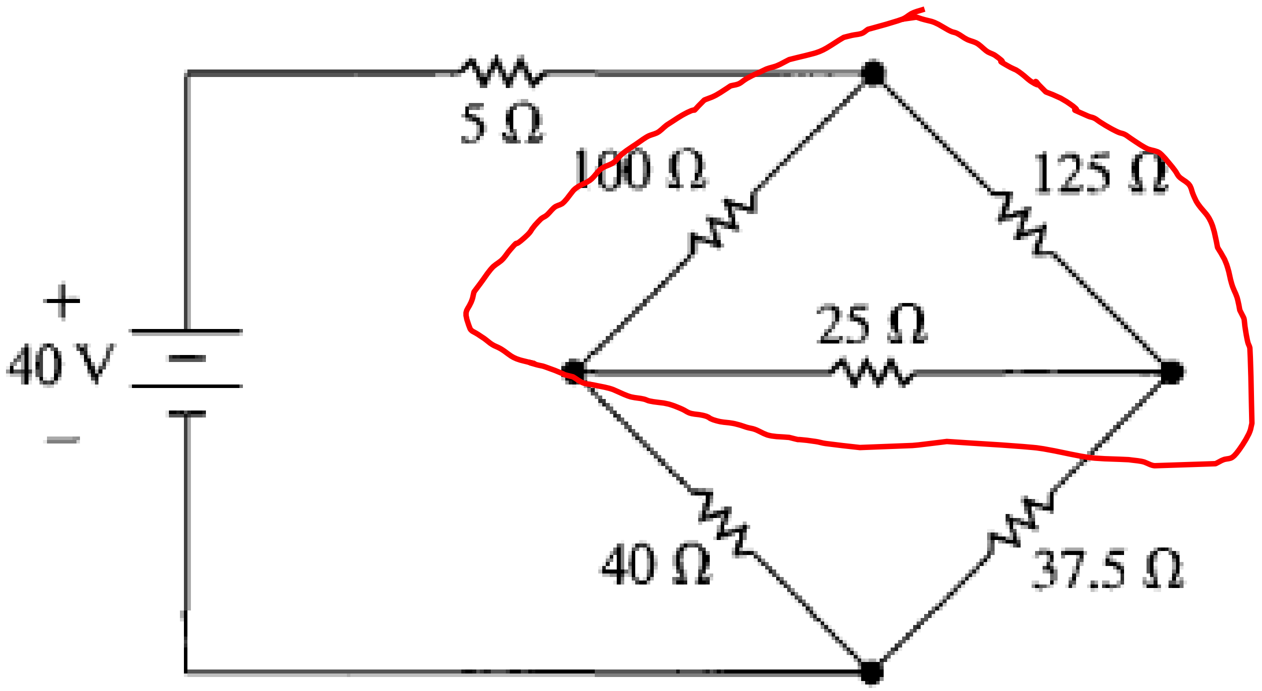
$$R_c = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}.$$

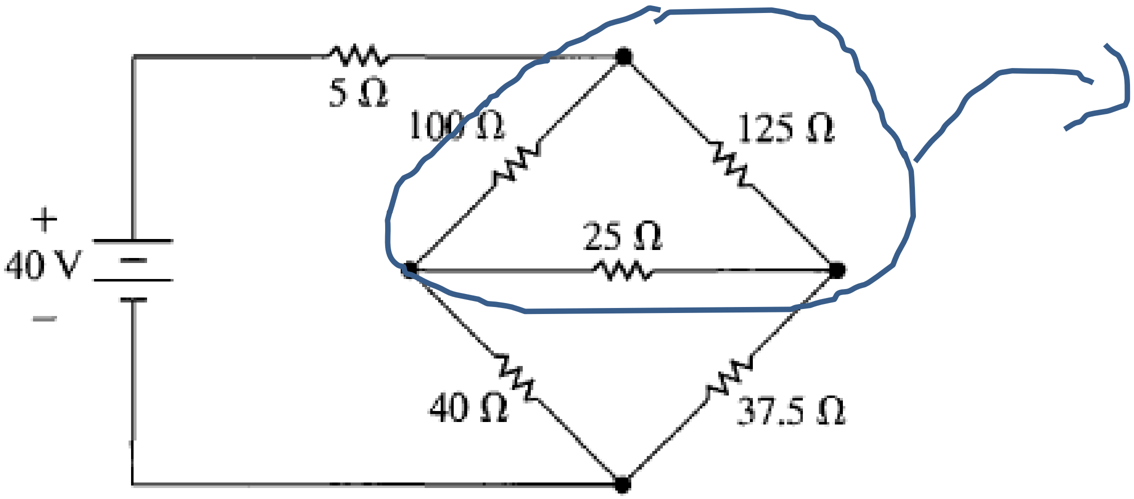
$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c},$$

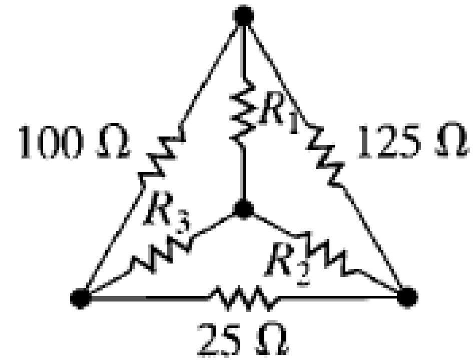
$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c},$$

$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}.$$

- Find the current and power supplied by the 40V source



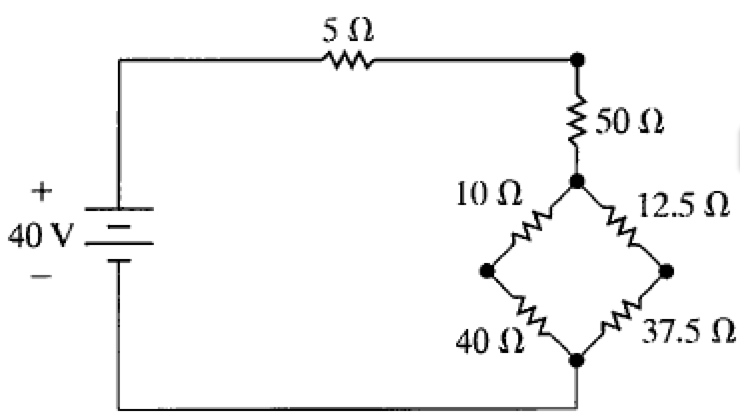


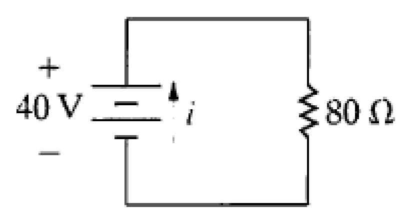


$$R_1 = \frac{100 \times 125}{250} = 50\ \Omega,$$

$$R_2 = \frac{125 \times 25}{250} = 12.5\ \Omega,$$

$$R_3 = \frac{100 \times 25}{250} = 10\ \Omega.$$

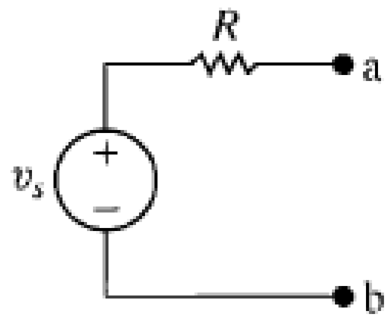




$$R_{eq} = 55 + \frac{(50)(50)}{100} = 80\ \Omega.$$

The 40 V source delivers 0.5 A and 20 W to the circuit.

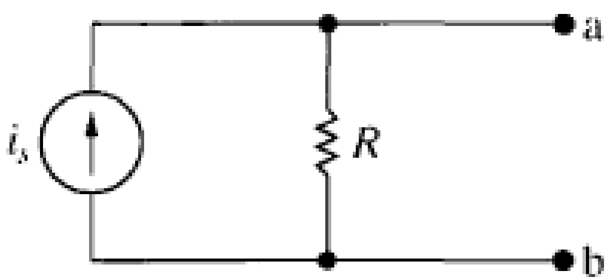
Source transformation



(a)

$V_{ab}=V_s*R_L/(R+R_L)$

Where $i_s=v_s/R$

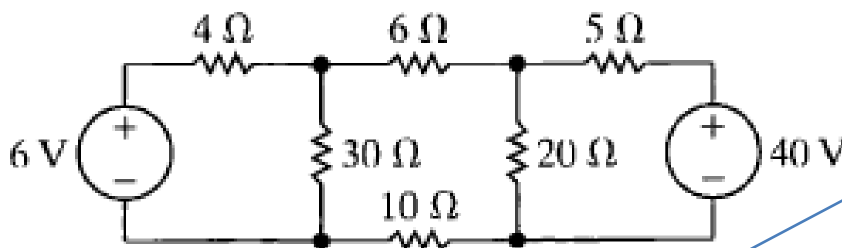


(b)

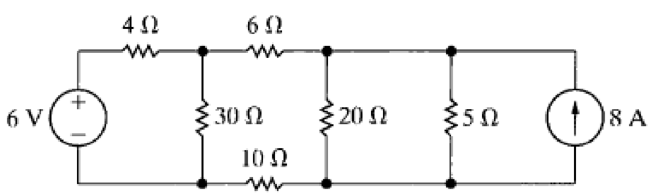
$V_{ab}=I_s*(R_L*R)/(R+R_L)$

Figure 4.36 ▲ Source transformations.

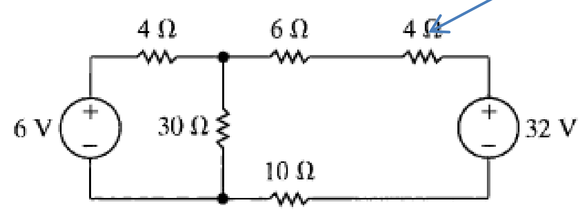
- Find the power associated with the 6 V source.



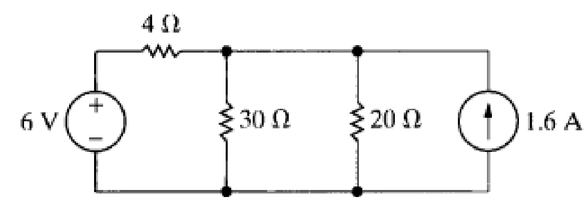
20||5=20*5/(20+5)
=4ohm
4ohm*8A=32V(S.Trans)



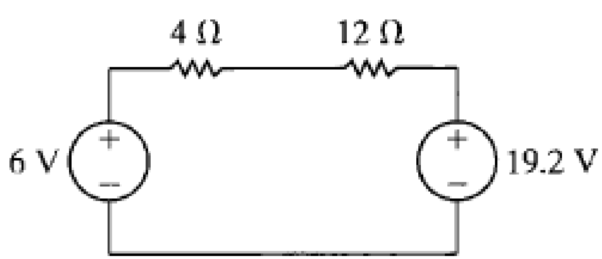
(a) First step



(b) Second step



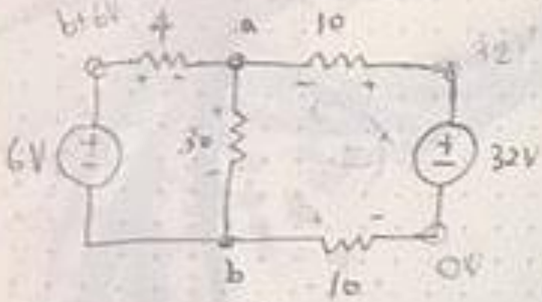
(c) Third step



(d) Fourth step

The current in the direction of the voltage drop across the 6 V source is (19.2 - 6)/16, or 0.825 A

p_{6V} = (0.825)(6) = 4.95 W.



$V_{ab} \boxed{?} V_{a'b'}$

$\Updownarrow$

1652
908
744

$V_{ab} \Rightarrow$

$\rightarrow a \leftarrow$

$\downarrow$

$$\frac{6+b-a}{4} + \frac{32-a}{10} = \frac{a-b}{30}$$

$$\frac{b-0}{10} = \frac{32-a}{10} \quad \langle b = 32-a \rangle$$

$$\frac{6+32-a-a}{4} + \frac{32-a}{10} = \frac{a-32+a}{30}$$

$$(38-2a)30 + (32-a)12 = 4(2a-32)$$

$$1140 - 60a + 384 - 12a = 8a - 128$$

$$80a = 1140 + 384 + 128$$

$$a = \frac{1652}{80} \quad b = \frac{2560-1652}{80} = \frac{908}{80}$$

32
12
64
32
384

384
128
512
+1140
1652

$$V_{ab} = \frac{1652}{80} - \frac{908}{80} = \frac{744}{80}\,V$$

$$= \frac{186}{20} = \frac{93}{10}$$

$V_{a'b'}$ $b' = 0$

$$\left(\frac{6-a'}{4} + \frac{32-a'}{20} = \frac{a'}{30}\right) \times 120$$

$$30(6-a') + 6(32-a') = 4a'$$

$$180 - 30a' + 192 - 6a' = 4a'$$

$$372 = 40a'$$

$$a' = \frac{372}{40} = \frac{93}{10}$$

$$V_{a'b'} = \frac{93}{10}$$