جامعة الأهرام الكندية
AHRAM CANADIAN UNIVERSITY

Lecture (02)
Series and parallel circuits analysis

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Resistors in series

- So we can define the equivalent resistance of resistors connected in series as follows,

$$R_{\text{eq}} = R_1 + R_2 + R_3 + R_4 + R_5 + R_6 + R_7$$

- applying ohm's law

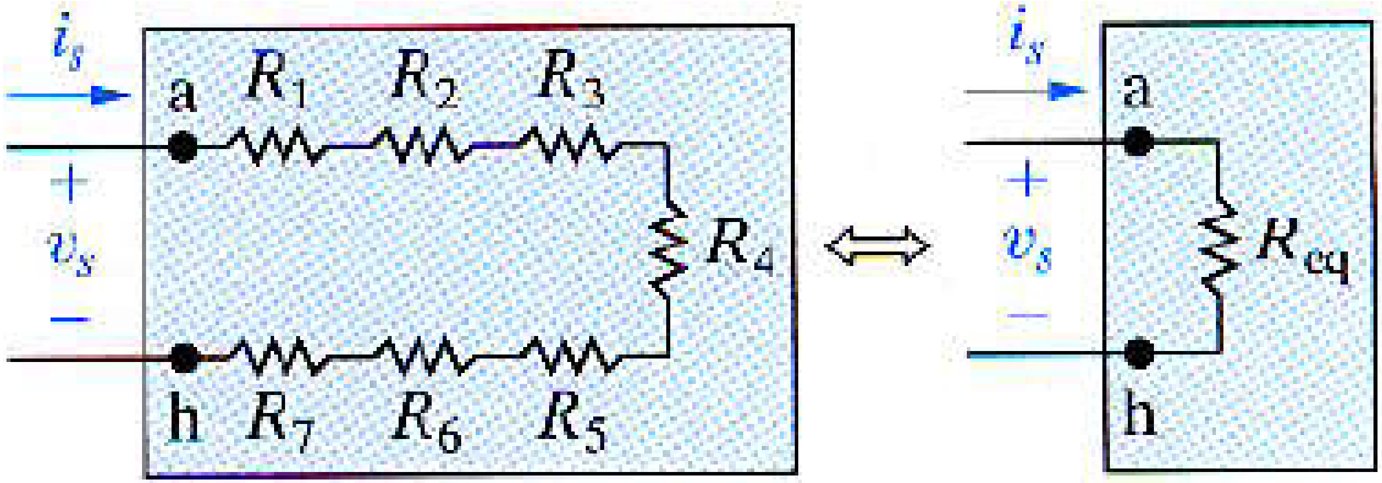
$$v_s = i_s R_{\text{eq}}.$$

- so of K resistors connected is series, R_{eq}

$$R_{\text{eq}} = \sum_{i=1}^{k} R_i = R_1 + R_2 + \cdots + R_k.$$

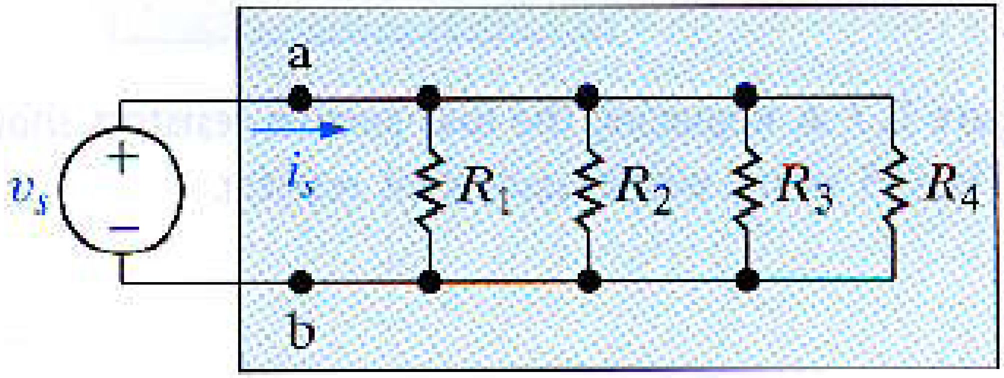
Resistors in series

- Black box concept:



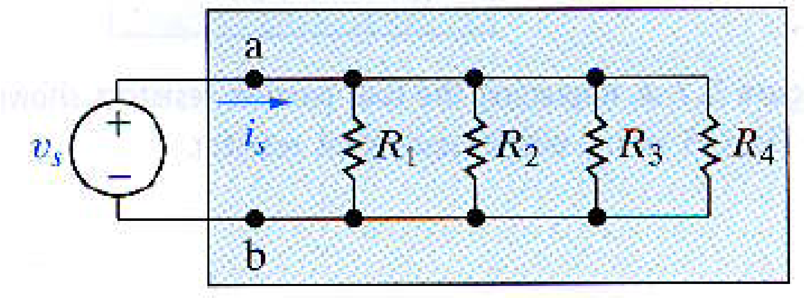
Resistors in parallel

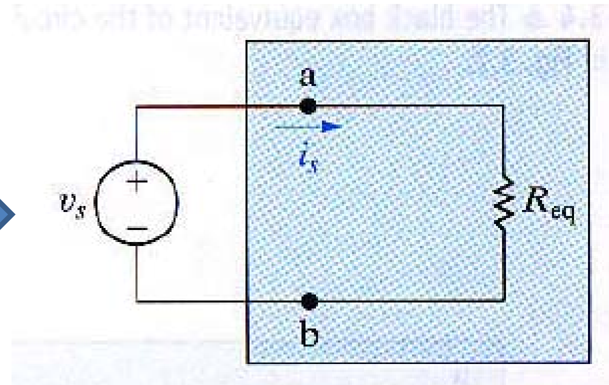
- Two elements are in parallel if they exclusively share a two node.
- Applying KVL @ each loop; Elements in parallel have the same voltage drop, $V_s = V_1 = V_2 = V_3 = V_4$
- Applying KCL @ node a, $I_s = I_1 + I_2 + I_3 + I_4$



Resistors in parallel

- Black box concept:



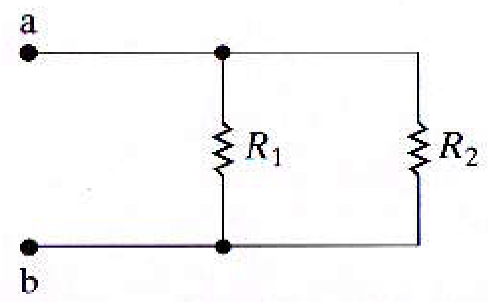


Resistors in parallel

- Many times only two resistors are connected in parallel

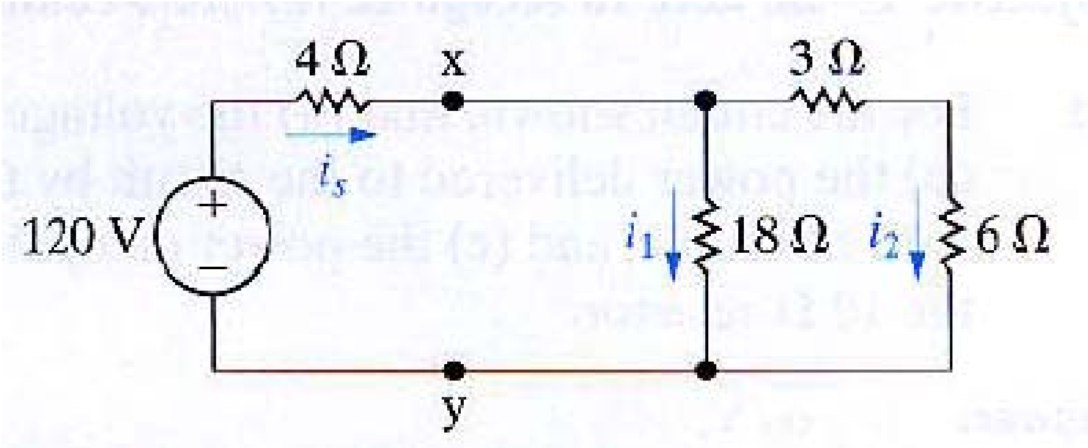
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_2 + R_1}{R_1 R_2},$$

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}.$$



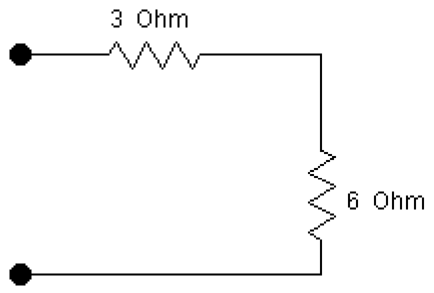
Example 1

- calculate i_{120v}, $i_{18\Omega}$, $i_{6\Omega}$.



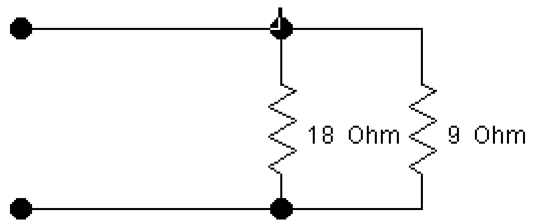
Example 1 solution

- 3Ω in series with 6Ω; $R_{eq}=8\Omega$



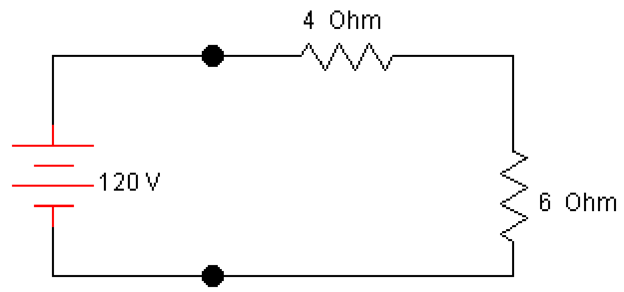
- 9Ω in parallel with 18Ω

  $R_{eq}=9x18 / (9+18) = 6\Omega$



- Ohm:

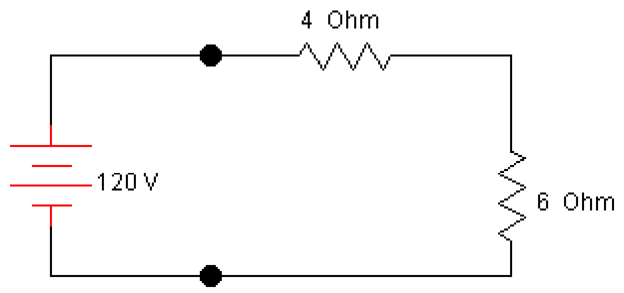
  $I_{120v} = 120/(6+4) = 12A$



Example 1 solution (2)

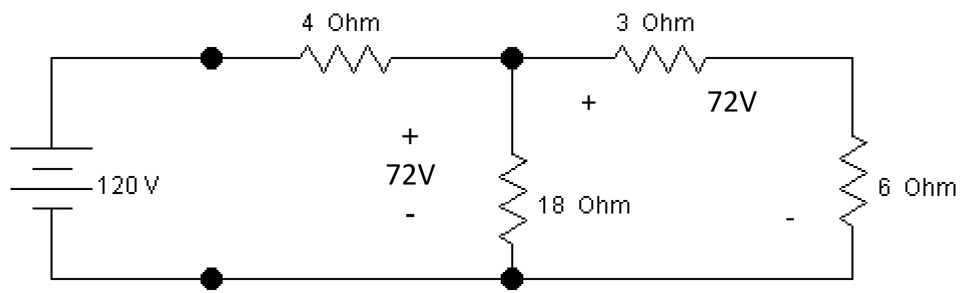
- Ohm:

  $V_{6\Omega} = 12 \times 6 = 72V$



- Ohm:

  $I_{18\Omega} = 72/18 = 4A$



- Ohm:

  $I_{6\Omega} = 72/(3+6) = 8A$

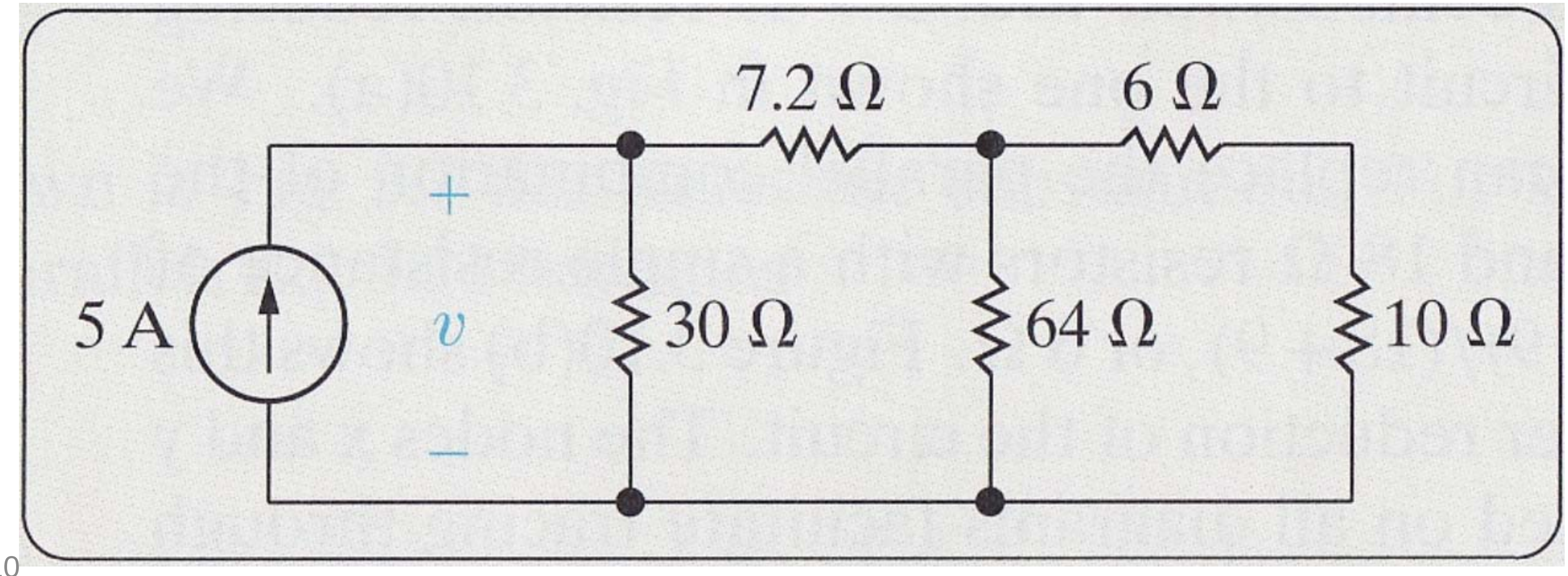
Example 2

find;

A. V_{5A}

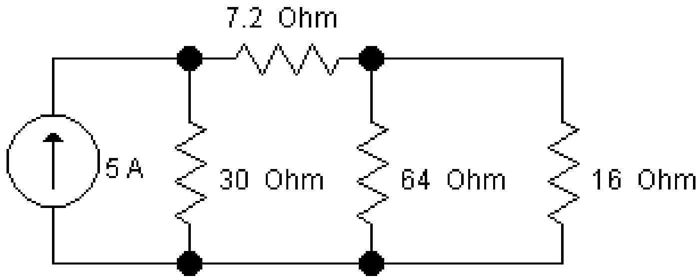
B. Power delivered by current source

C. Power dissipated by 10Ω

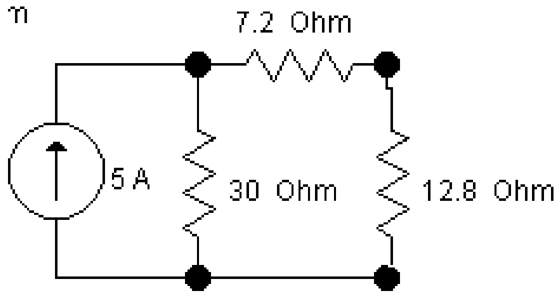


Example 2 solution

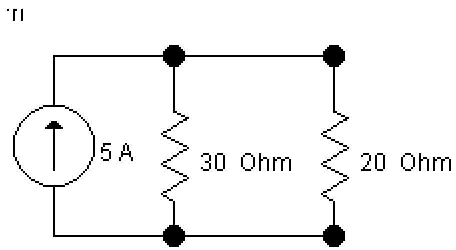
- 6Ω in series with 10 Ω, R_{eq}=16Ω



- 16Ω in parallel with 64Ω;
  R_{eq}=(16x64)/(16+64)=12.8Ω



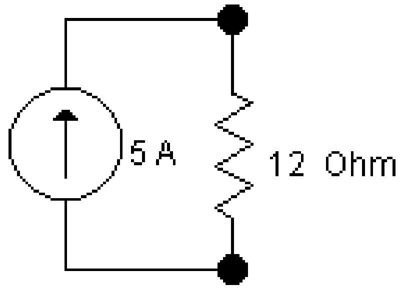
- 12.8 Ω in series with 7.2 Ω; R_{eq}=20Ω



Example 2 solution (2)

- 30Ω in parallel with 20Ω,

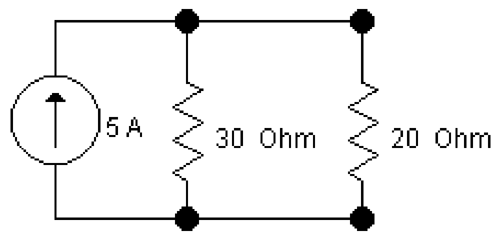
  $R_{eq}=(20x30)/(20+30)=12\Omega$



- Ohm:

  $V_{5A}=5x12=60V$

  $P_5A=VxI=15x60=300W$

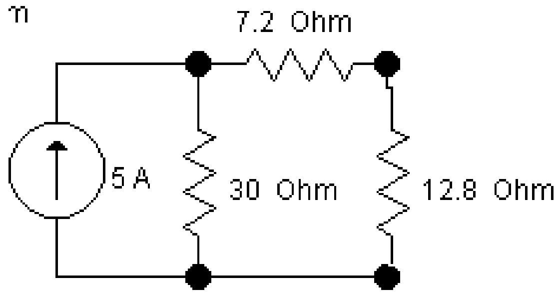


- Ohm:

  $I_{20\Omega}=60/20=3A$

- Ohm:

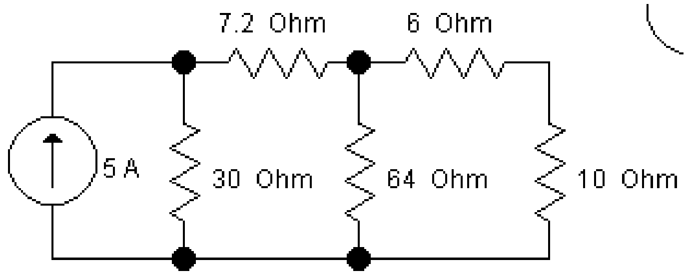
  $V_{12.8\Omega}=3x12.8=38.4V$



Example 2 solution (3)

- Ohm:

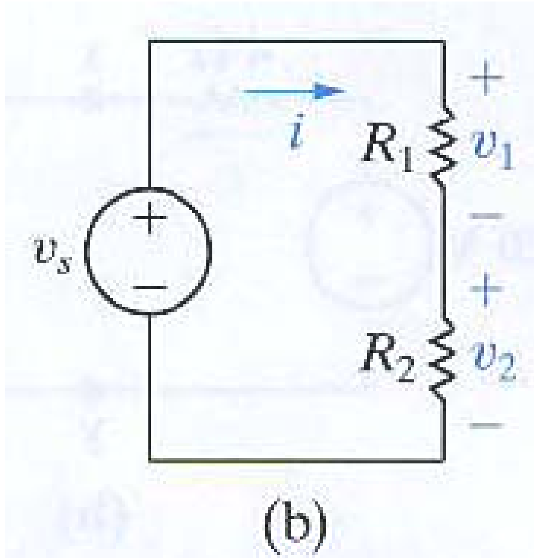
  $I_{6\Omega,10\Omega}$=38.4/(6+10)=2.4A



- $P_{10\Omega}$ = $(2.4)^2$ x 10=57.6W

Voltage division and current division

1. Voltage divider circuit;



- Applying KVL around the circuit

$$v_s = iR_1 + iR_2,$$

$$i = \frac{v_s}{R_1 + R_2}.$$

- Using ohm's law

$$v_1 = iR_1 = v_s \frac{R_1}{R_1 + R_2},$$

$$v_2 = iR_2 = v_s \frac{R_2}{R_1 + R_2}.$$

Voltage division and current division (2)

Consider connecting R_L to R_2,

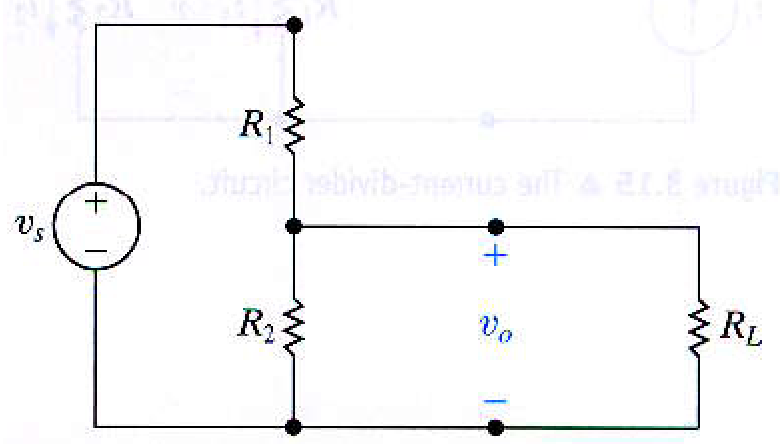
$$v_o = \frac{R_{eq}}{R_1 + R_{eq}} v_s,$$

Where

$$R_{eq} = \frac{R_2 R_L}{R_2 + R_L}.$$

then

$$v_o = \frac{R_2}{R_1[1 + (R_2/R_L)] + R_2} v_s.$$



- If R_L tend to ∞, we can ignore its effect

Voltage division and current division (3)

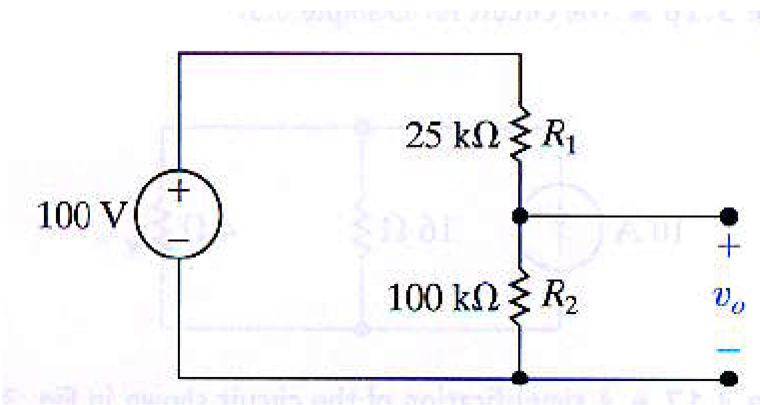
- Each resistor comes tolerance which effect it value and of course voltage across it’s terminal.
- If R=100KΩ, with tolerance of 10%

  maximum expected value = 110KΩ

  minimum expected value = 90 Ω

Example 3

Find maximum and minimum voltage drop across R2, taking into consideration that each resistor has 10% tolerance.

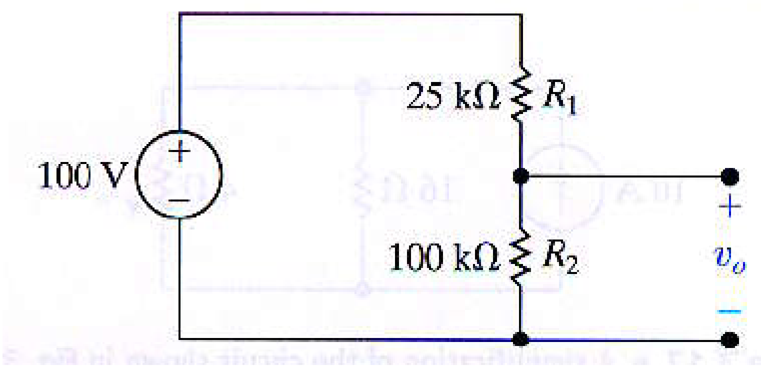


Example 3 solution

- Ohm:

  V=IxR if R is fixed V α I

  if I is fixed V α R



- So the bigger R == bigger voltage drop, and vice versa
- To calculate $V_{o,max}$ set R_1 to minimum and R_2 to maximum

  R_{1min}=25-((25x10)/100)=22.5Ω

  R_{2max}=100+((100x10)/100)=110Ω
- Voltage Division rule:

  $V_{o,max}$=100x((110/(110+22.5))=83.02V

Example 3 solution (2)

- To calculate $V_{o,min}$; set R_1 to maximum, and R_2 to minimum

  R1max=25+((25x10)/100)=27.5Ω

  R2min=100-((100x10)/100)=90Ω

- Voltage division:

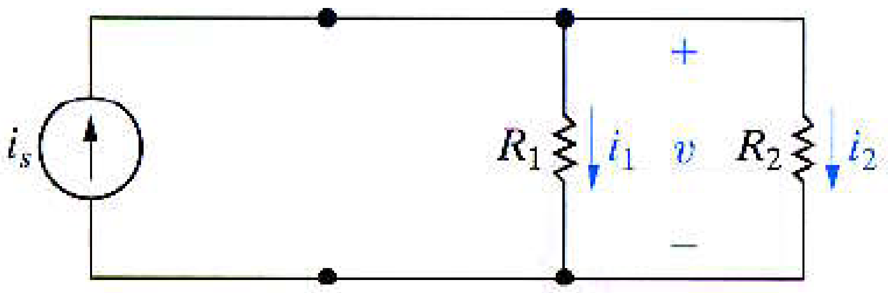
  $V_{o,min}$=100x(90/(90+27.5))=76.60V

Voltage division and current division

2. Current divider circuit;

- Ohm:

$$v = i_1 R_1 = i_2 R_2 = \frac{R_1 R_2}{R_1 + R_2} i_s.$$



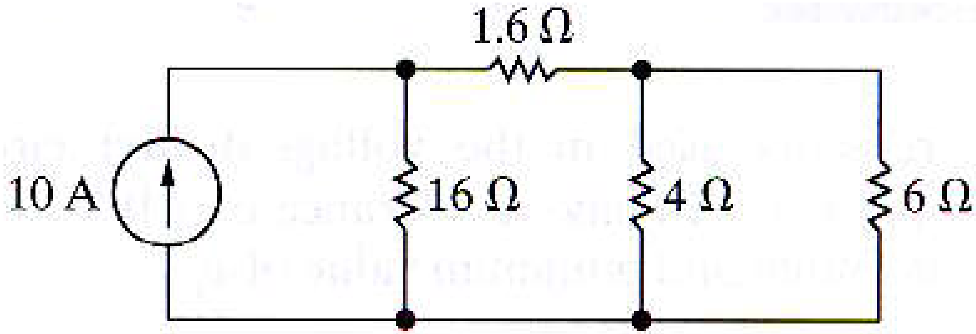
- Then:

$$i_1 = \frac{R_2}{R_1 + R_2} i_s,$$

$$i_2 = \frac{R_1}{R_1 + R_2} i_s.$$

Example 4

find power dissipated in 6Ω resistor



Example 4 solution

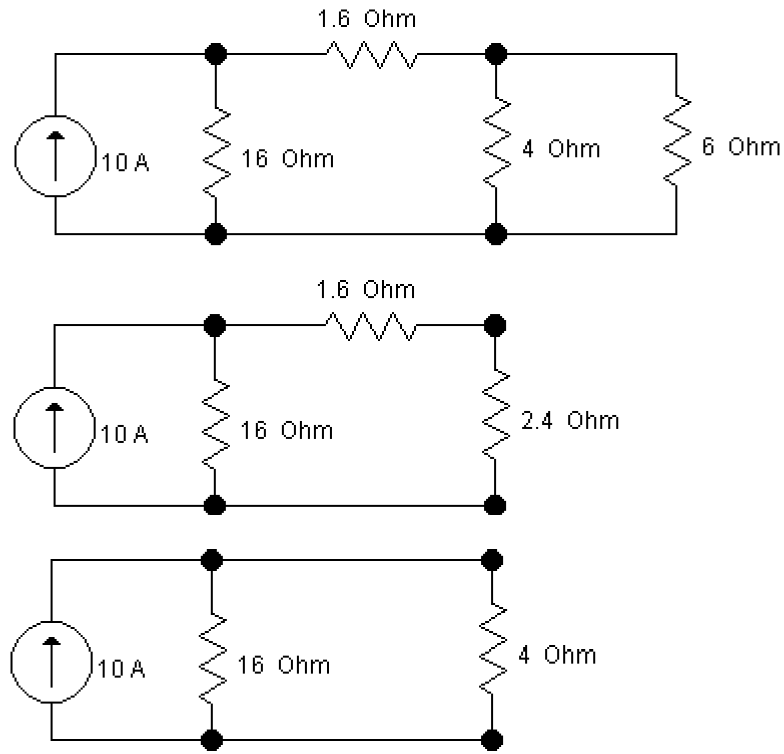
- 4 Ω in parallel with 6 Ω;

  $R_{eq}=(4x6)/(4+6)=2.4\ \Omega$
- 1.6 Ω in series with 2.4 Ω

  $R_{eq}=4\ \Omega$
- Current division rule:

  $I_4=10x(16/(4+16))=8A$
- Current division rule:

  $I_6=8x(4/(6+4))=3.2A$
- $P_{6\ \Omega}=(3.2)^2x6=61.44w$



Thanks,…

See you next week (ISA),…