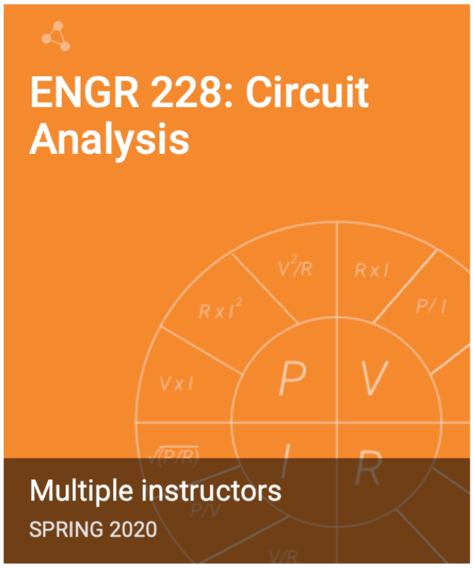


Chapter 2.4

Resistive Circuits

Voltage and Current Division

Engr228 - Circuit Analysis

Spring 2020

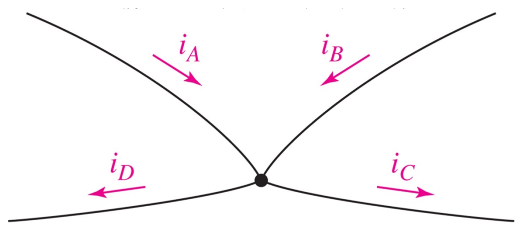
Dr Curtis Nelson

Section 2.4 Objective

- Understand voltage and current division.

Kirchhoff's Current Law

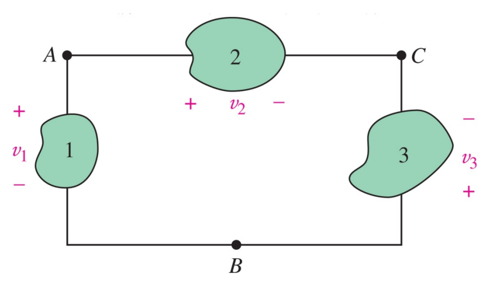
- Kirchhoff's Current Law (KCL) states that the algebraic sum of all currents entering a node is **zero**.



$$i_A + i_B + (-i_C) + (-i_D) = 0$$

Kirchhoff's Voltage Law

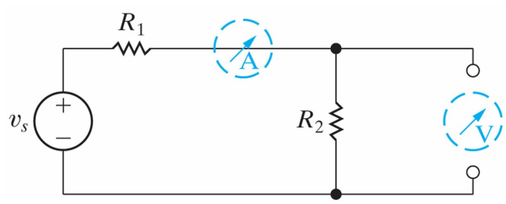
- Kirchhoff's Voltage Law (KVL) states that the algebraic sum of the voltages around any closed path is zero.



$$-v_1 + v_2 + -v_3 = 0$$

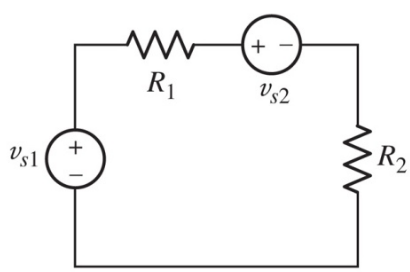
Measuring Voltage, Current, and Resistance

- An ideal meter has no effect on the circuit variable being measured.
- That means when an ideal *ammeter is placed in series* to measure the current through an element, it should have an equivalent resistance of 0 Ω.
- That means when an ideal *voltmeter is placed in parallel* to measure the voltage across an element, it should have an equivalent resistance of ∞ Ω.

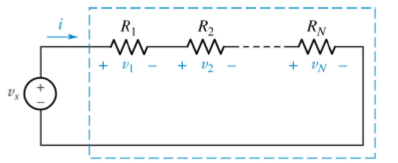


Series Connections

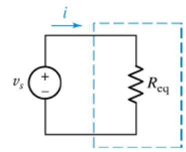
- Elements connected head-to-tail and carrying the same current are said to be connected in ***series.***



Resistors in Series



(a)



(b)

$$v_s = v_1 + v_2 + \cdots + v_N$$

$$v_s = R_1 i + R_2 i + \cdots + R_N i$$

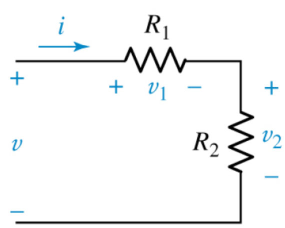
$$= (R_1 + R_2 + \cdots + R_N) i$$

$$v_s = R_{eq} i$$

$$\boxed{R_{eq} = R_1 + R_2 + \cdots + R_N}$$

Voltage Division

Resistors in series "share" the voltage applied to them.



$$i = \frac{v}{R_1 + R_2}$$

$$v_2 = i R_2 = \left(\frac{v}{R_1 + R_2}\right) R_2$$

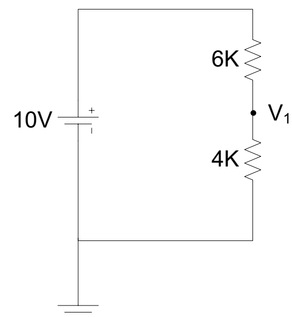
$$v_2 = \frac{R_2}{R_1 + R_2} v$$

$$v = v_1 + v_2$$

$$= i(R_1 + R_2)$$

Voltage Divider Example

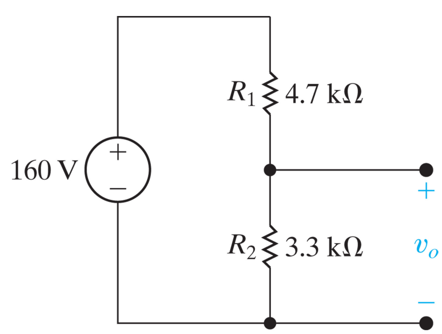
Calculate V_1 using the voltage divider equation.



$V_1 = 4.00V$

Textbook Problem 3.12 (Nilsson 10th)

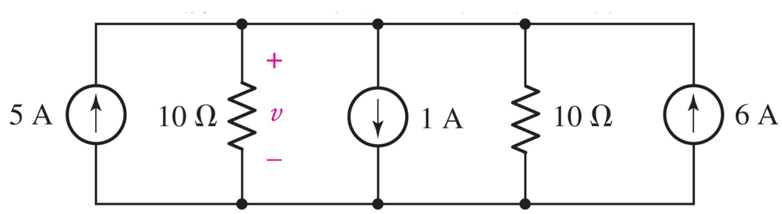
Find the voltage v_0 and the power dissipated in both resistors.



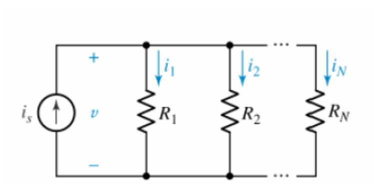
$v_0 = 66V$
$P_{R1} = 1.88W$
$P_{R2} = 1.32W$

Parallel Connections

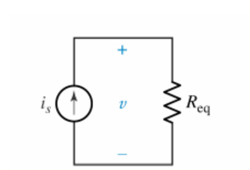
- Elements in a circuit connected head-to-head and tail-to-tail have a common voltage across them and are said to be connected in ***parallel.***



Resistors in Parallel



(a)



(b)

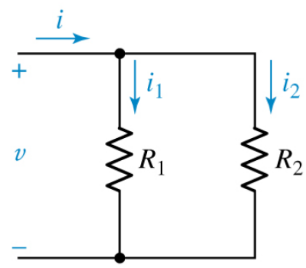
$$i_s = i_1 + i_2 + \cdots + i_N$$

$$i_S = \frac{v}{R_1} + \frac{v}{R_2} + \cdots + \frac{v}{R_N} = \frac{v}{R_{eq}}$$

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

Two Resistors in Parallel

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

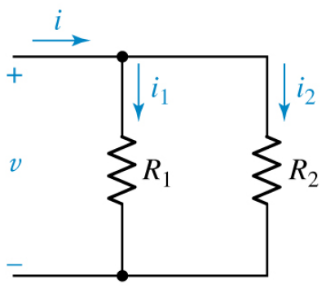


$$\boxed{R_{eq} = \frac{R_1 R_2}{R_1 + R_2}}$$

Connecting resistors in parallel makes the equivalent resistance ***smaller. Always.***

Current Division

Resistors in parallel "share" the current through them.

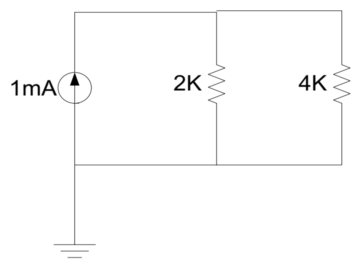


$$i_2 = \frac{v}{R_2} = \frac{i(R_1 \| R_2)}{R_2} = \frac{i}{R_2} \frac{R_1 R_2}{R_1 + R_2}$$

$$\boxed{i_2 = i \frac{R_1}{R_1 + R_2}}$$

Current Divider Example

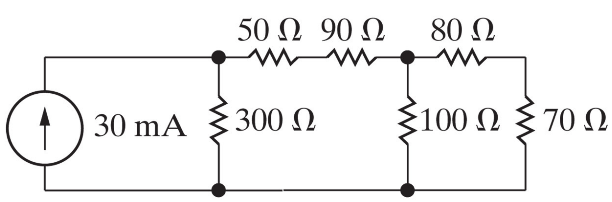
Calculate the current in the two resistors below using the current divider equation.



$i_{2K} = 0.667mA$
$i_{4K} = 0.333mA$

Textbook Problem 3.2d (Nilsson 11th)

Compute the equivalent resistance seen by the 30 mA source.

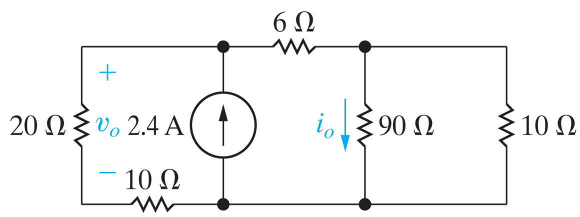


(d)

Answer: R = 120Ω

Textbook Problem 3.19 (Nilsson 11th)

For the current divider shown below, calculate i_0 and v_0.



Answer: $i_0 = 0.16A$ and $v_0 = 16V$

Section 2.4 Summary

- You learned how to recognize and apply the laws of voltage and current division.