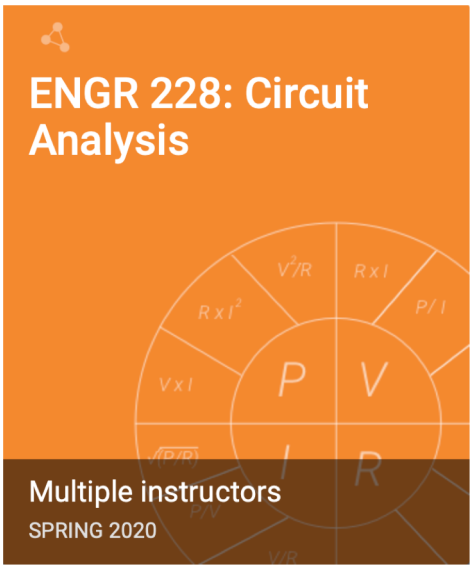


Chapter 2.3

Resistive Circuits

Kirchhoff's Law

Engr228 - Circuit Analysis

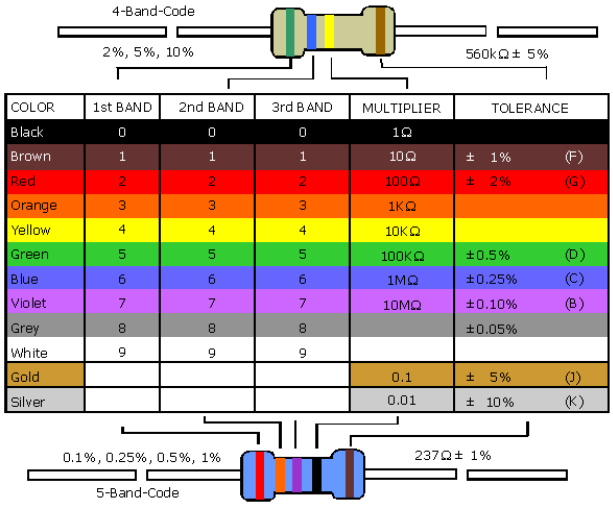
Spring 2020

Dr Curtis Nelson

Section 2.3 Objective

- Learn to apply Kirchhoff's laws.

Resistor Color Code Chart



COLOR	1st BAND	2nd BAND	3rd BAND	MULTIPLIER	TOLERANCE	
Black	0	0	0	1Ω		
Brown	1	1	1	10Ω	± 1%	(F)
Red	2	2	2	100Ω	± 2%	(G)
Orange	3	3	3	1KΩ		
Yellow	4	4	4	10KΩ		
Green	5	5	5	100KΩ	±0.5%	(D)
Blue	6	6	6	1MΩ	±0.25%	(C)
Violet	7	7	7	10MΩ	±0.10%	(B)
Grey	8	8	8		±0.05%	
White	9	9	9			
Gold				0.1	± 5%	(J)
Silver				0.01	± 10%	(K)

Ohm's Law

- The relationship between voltage, current, and resistance is defined by *Ohm's law* which states that

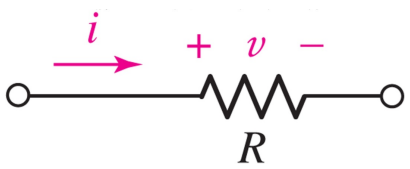
$$V = IR$$

where

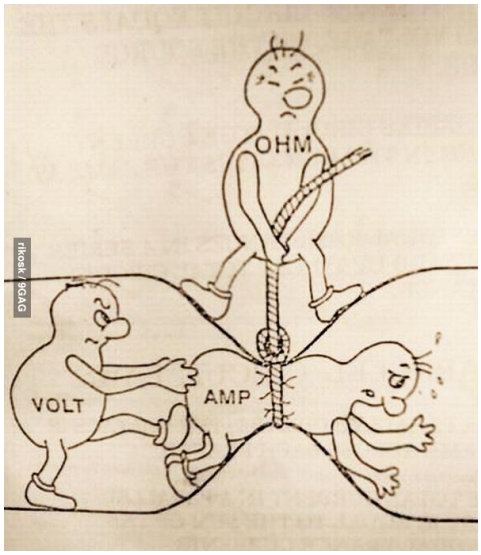
V = the voltage in volts;

I = the current in amps;

R = the resistance in ohms.

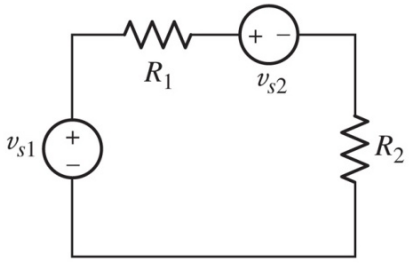


Ohm's Law Illustrated



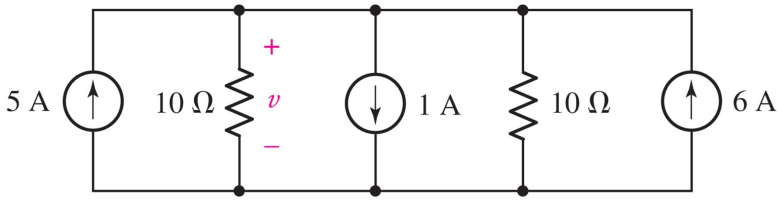
Series Connections

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

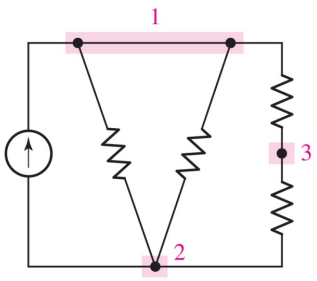


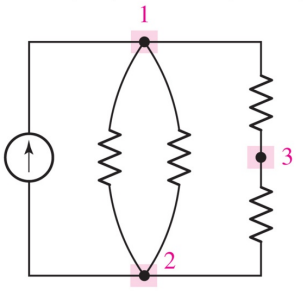
Parallel Connections

- 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.***



Nodes, Paths, Loops, Branches

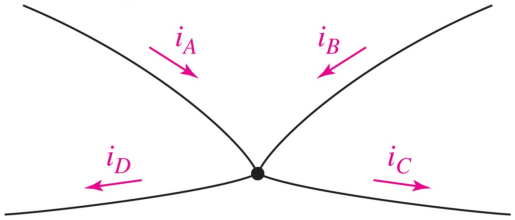




- These two circuits are equivalent.
- There are three *nodes* and five *branches:*
  - *Node*: a point at which two or more elements have a common connection;
  - *Path*: a sequence of nodes;
  - *Branch*: a single path in a circuit composed of one simple element and the node at each end of that element;
  - *Loop*: a closed path.

Kirchhoff's Current Law

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



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

KCL: Alternative Forms

- Current *IN* is positive:

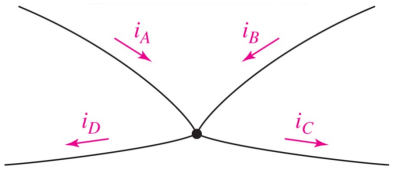
  $i_A + i_B + (-i_C) + (-i_D) = 0$

- Current *OUT* is positive:

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

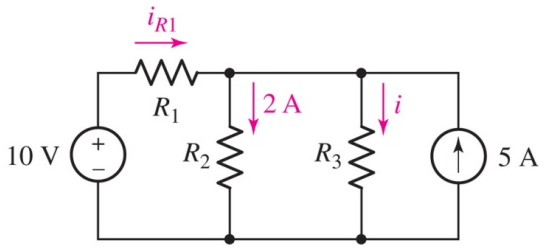
- Current *IN* = Current *OUT:*

  $i_A + i_B = i_C + i_D$



KCL Application

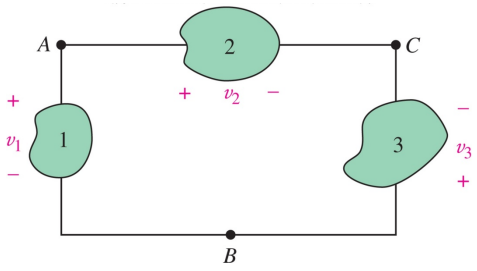
Find the current through resistor R_3 if it is known that the voltage source supplies a current of 3 A.



Answer: i = 6 A

Kirchhoff's Voltage Law

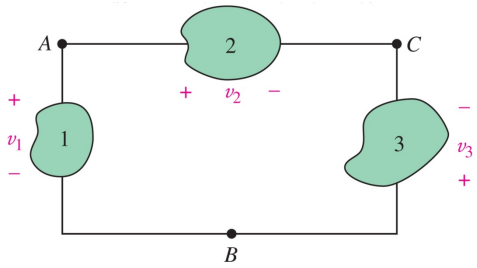
- Kirchhoff's Voltage Law (KVL) states that the algebraic sum of the voltages around any closed path is zero.



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

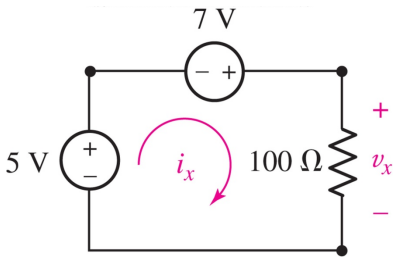
KVL: Alternative Forms

- Sum of *RISES* is zero (clockwise from B):
  $v_1 + (-v_2) + v_3 = 0$
- Sum of *DROPS* is zero (clockwise from B):
  $(-v_1) + v_2 + (-v_3) = 0$
- Sum of *RISES* is equal to sum of *DROPS* (clockwise from B):
  $v_1 + v_2 = v_3$



KVL Application

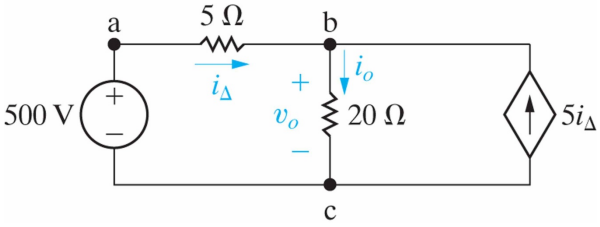
Find the current i_x and the voltage v_x



Answer: $v_x = 12$ *V and* $i_x = 120$ *mA*

Circuit Analysis with Dependent Sources

- Circuits that contain dependent sources can be analyzed using Ohm's and Kirchhoff's laws.
- A dependent source generally adds another equation to the solution process.



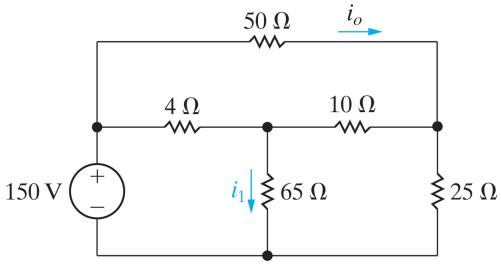
Textbook Problem 2.22 (Nilsson 10E)

The current i_0 is 1 A.

A) Find i_1.

B) Find the power dissipated in each resistor.

C) Verify that the power developed = power absorbed.



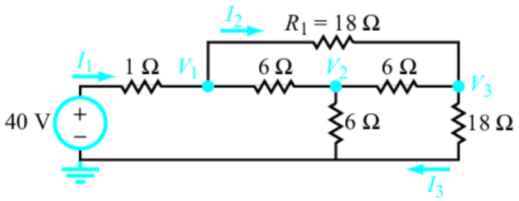
A) $i_1 = 2A$

B) $P_4 = 100W$ $P_{50} = 50W$ $P_{10} = 90W$ $P_{65} = 260W$ $P_{25} = 400W$

C) $P_{150V} = 900W$ = *sum of powers dissipated in the 5 resistors.*

Zybook Exercise 2.3.13

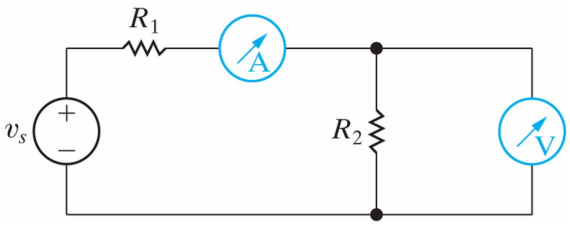
Exercise 2.3.13



(a) Given that in the circuit above, $I_1 = 4\text{A}$, $I_2 = 1\text{A}$, and $I_3 = 1\text{A}$, determine node voltages V_1,V_2, and V_3.

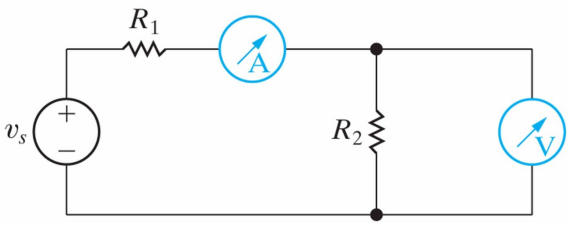
Measuring Voltage and Current

- An ***ammeter*** is an instrument designed to measure current; it is placed in *series* with the circuit element whose current is being measured.
- A ***voltmeter*** is an instrument designed to measure voltage; it is placed in *parallel* with the element whose voltage is being measured.

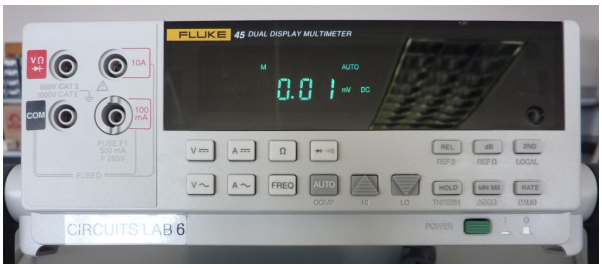


Measuring Resistance

- An ***ohmmeter*** is an instrument designed to measure resistance; it is placed in *parallel* with the resistive circuit whose resistance is being measured. Note that accurate measurements of resistance require that the resistive circuit have no energy present (no voltage or current).
- Often, one instrument – called a ***multimeter*** – is used to measure all three parameters, but not all at once.

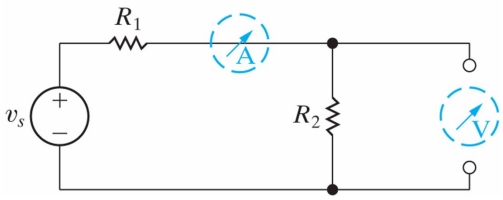


Fluke Multimeters



Measuring Voltage, Current, and Resistance

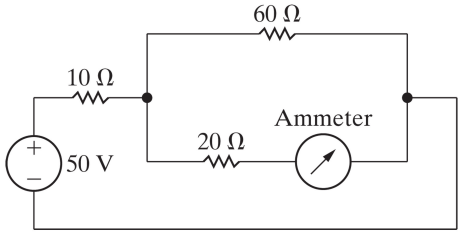
- An ideal meter has no effect on the circuit variable being measured.
- That means when an ideal *ammeter is placed in series* to measure the current through an element, it should have an equivalent resistance of 0 Ω.
- That means when an ideal *voltmeter is placed in parallel* to measure the voltage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



Textbook Problem 3.39 (Nilsson 11th)

An ammeter with an internal resistance of 0.1Ω is used in the circuit below. Find the percentage error in the measured value using the following formula:

*%Error = [(Measured value – True value)/True value]*100%*



Answer: % error = -0.347%

Section 2.3 Summary

- Section 2.3: You learned to apply Kirchhoff's laws.