ECE 2210 Resistors, Ohm's Law, Dividers, Etc.

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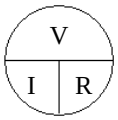
1/28/06,
9/5/08,
8/21/23

Ohm's law (resistors)

$V = I \cdot R$

$I = \frac{V}{R}$

$R = \frac{V}{I}$ definition of resistance and the unit "Ω"



The resistor color code as used on small resistors may be attached to this set of notes. For additional practical information see textbook section 3.5.

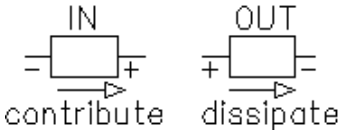
Power

flow $\frac{m^3}{sec}$ pressure $\frac{N}{m^3}$ flow x pressure: $\frac{m^3}{sec} \cdot \frac{N}{m^2} = \frac{m}{sec} \cdot \frac{N}{1} = \frac{N \cdot m}{sec} = \frac{Joule}{sec} = W$ = power

same for electricity power $P = I \cdot V$

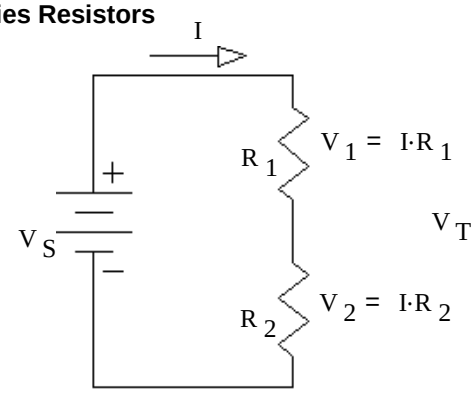
Power dissipated by resistors: $P = V \cdot I = \frac{V^2}{R} = I^2 \cdot R$

$P_{IN} = P_{OUT}$



Basic electrical quantities		**Unit**
Resistance	$R = \frac{V}{I}$	Ohm (Ω, kΩ, MΩ,...)
Conductance	$G = \frac{1}{R}$	Siemens (S, also mho, old unit)
Power energy/time	$P = V \cdot I$	Watt (W, mW, kW, MW,...)

Series Resistors



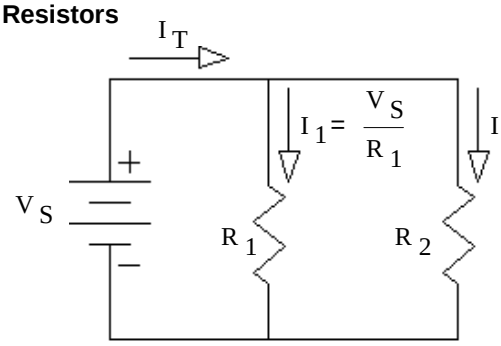
$V_T = V_1 + V_2$

$R_{eq} = \frac{V_T}{I} = \frac{V_1 + V_2}{I} = \frac{V_1}{I} + \frac{V_2}{I} = R_1 + R_2$

$R_{eq} = R_1 + R_2$

Resistors are in series if and only if exactly the **same current** flows through each resistor.

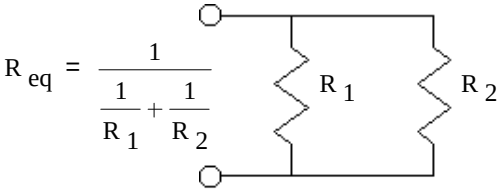
Parallel Resistors



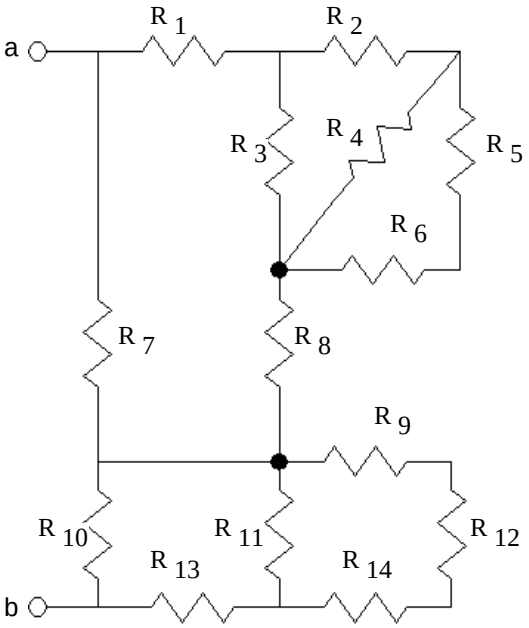
$I_T = \frac{V_S}{R_1} + \frac{V_S}{R_2}$

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

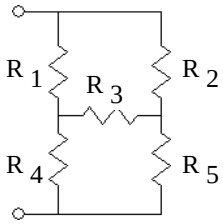
Resistors are in parallel if and only if the **same voltage** is across each resistor.



Series and Parallel (Look back at circuits on last page of Intro notes)



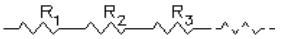
All resistor-only networks can be reduced to a single equivalent, but not always by means of series and parallel concepts.



a O

b O

Voltage Divider



series: $R_{eq} = R_1 + R_2 + R_3 + \ldots$

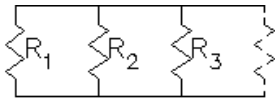
Exactly the **same current** through each resistor

Voltage divider:

$$V_{Rn} = V_{total} \cdot \frac{R_n}{R_1 + R_2 + R_3 + \ldots}$$

Current Divider

parallel: $R_{eq} = \dfrac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$

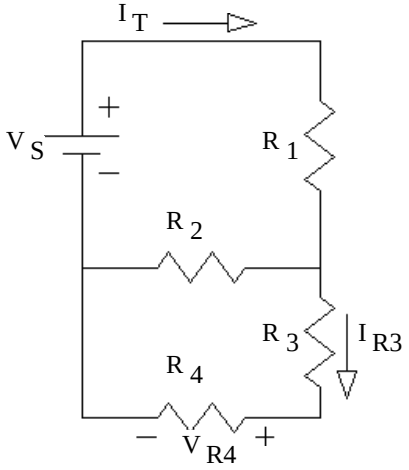


Exactly the **same voltage** across each resistor

current divider:

$$I_{Rn} = I_{total} \cdot \frac{\frac{1}{R_n}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$$

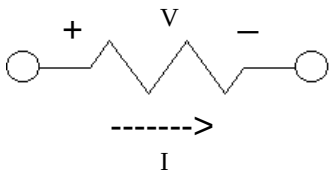
May have to combine some resistors first to get series and parallel resistors to use with divider expressions.

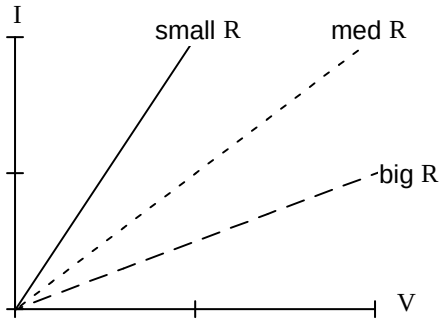


V_{R4} =

I_T =

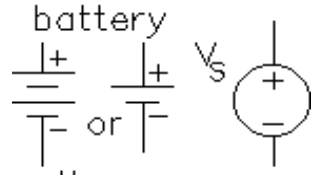
I_{R3} =



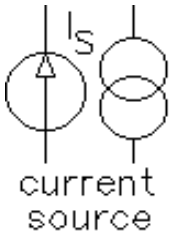


$$R = \frac{1}{\text{slope}} = \frac{\Delta V}{\Delta I}$$

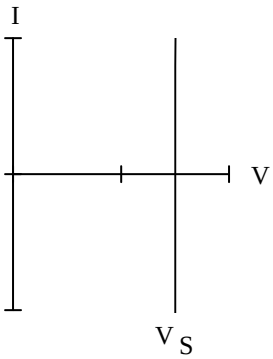
Sources

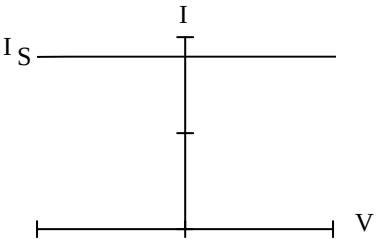


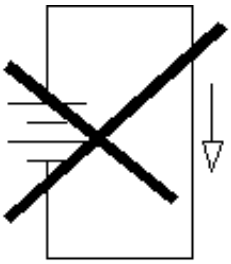
Battery Cell



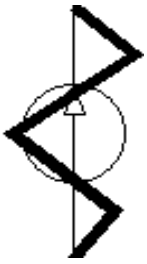
Less intuitive, less like sources we are used to seeing.



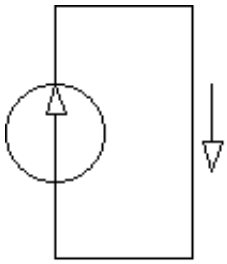




Doesn't make sense with for ideal voltage sources and ideal wires

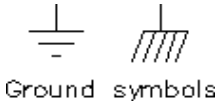


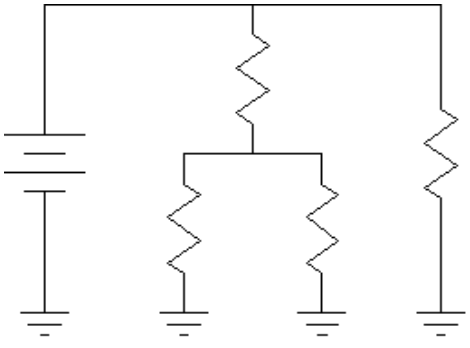
Doesn't make sense for ideal current sources

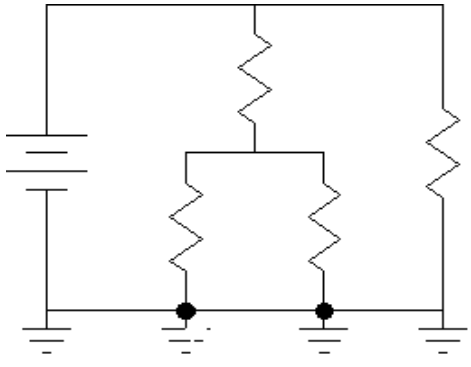


Must have a path for the current to flow

Ground

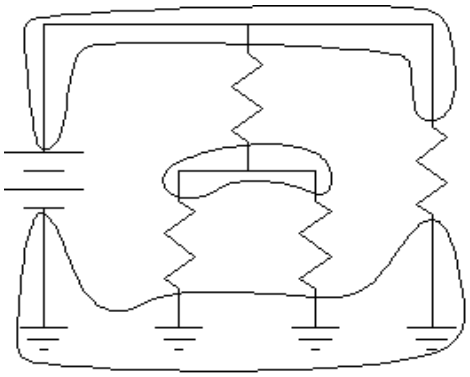






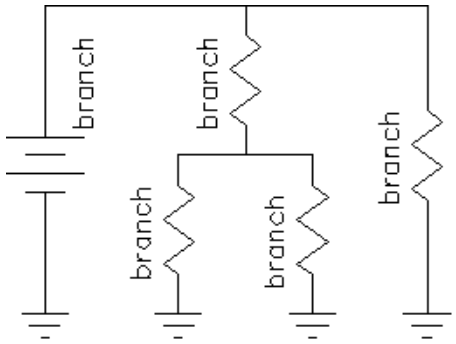
Ground is considered zero volts and is a reference for other voltages.

Node = all points connected by wire, all at same voltage (potential)

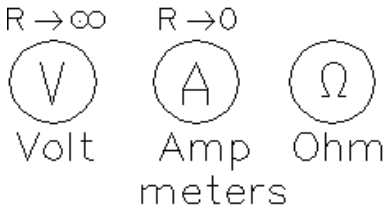


ground is a node

Branch = all parts with the same current



Meters

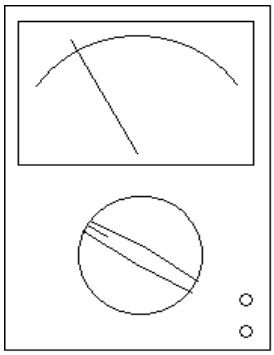


ideally: voltmeter — open

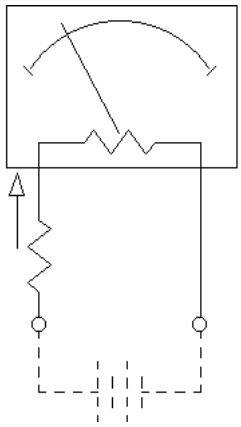
ammeter — short

Analog meters

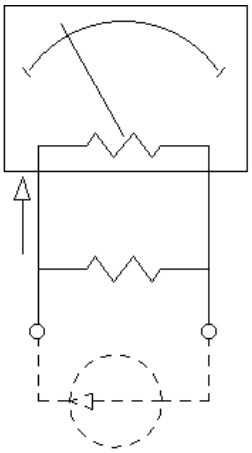
multimeter



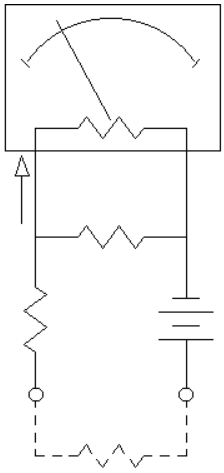
voltmeter



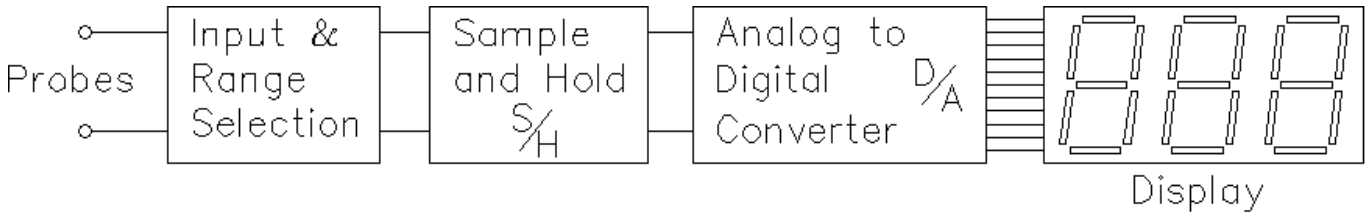
ammeter



Ohmmeter

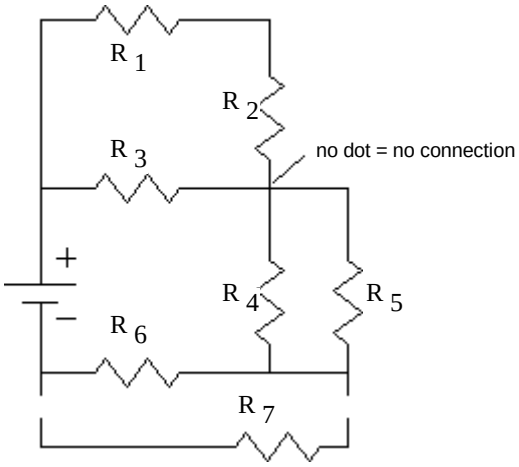


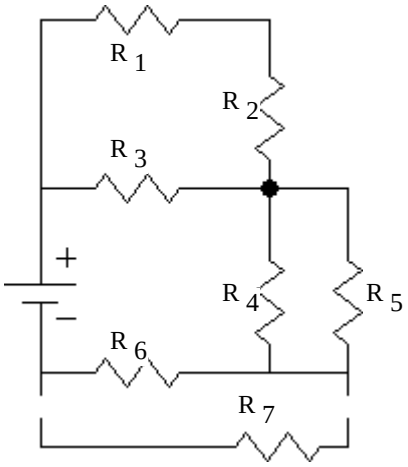
Digital meter

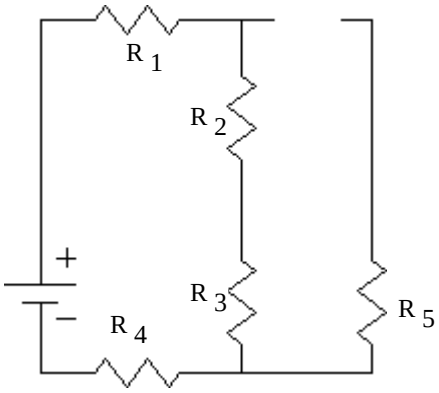


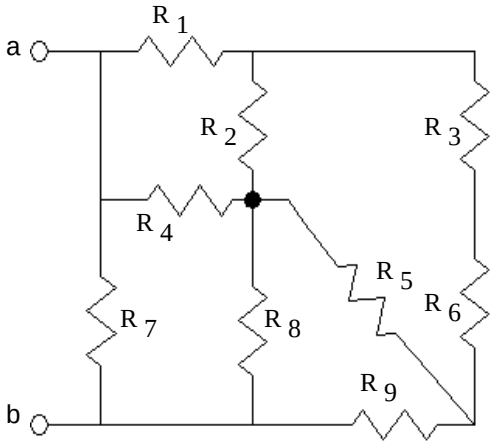
Additional Examples (time permitting)

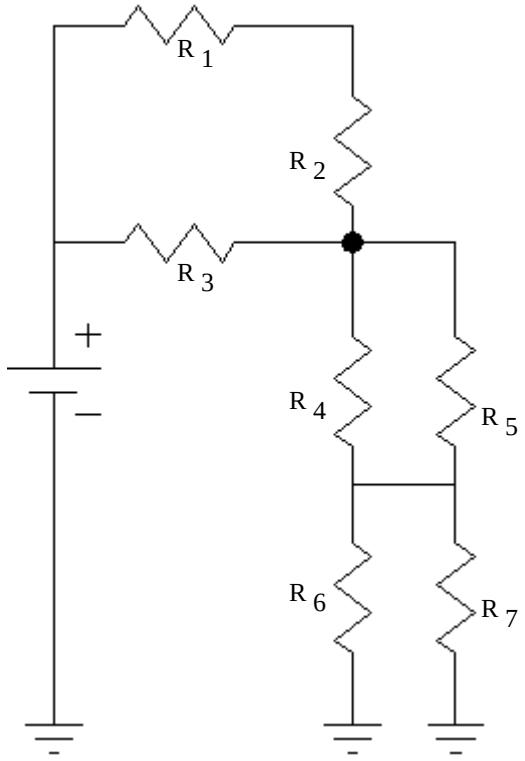
Take notes in class

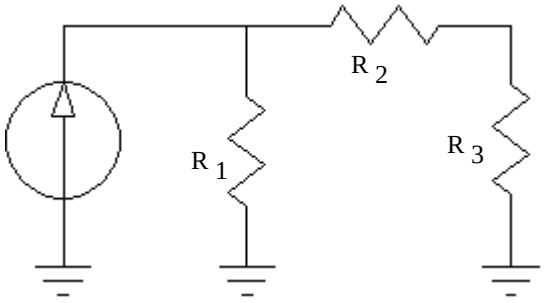


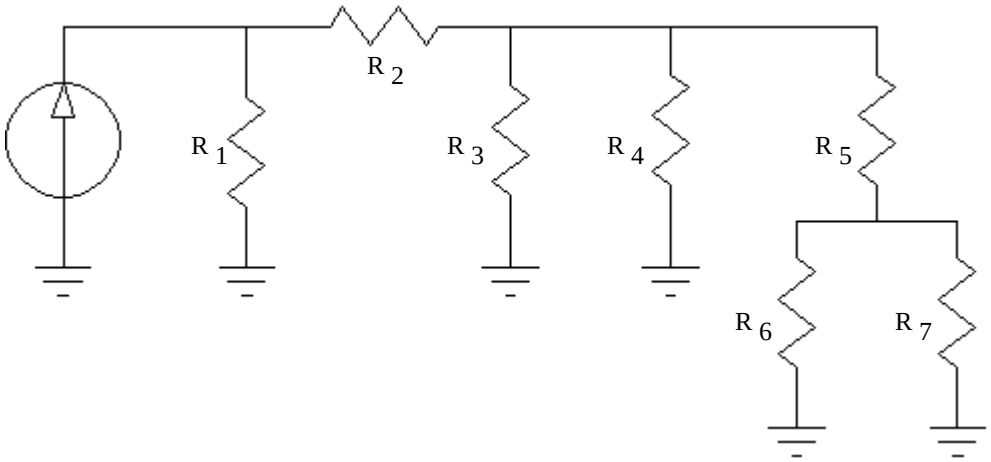







R 1
R 2
R 3
+
–
R 4
R 5
R 6
R 7


R 2
R 1
R 3


R 2
R 1
R 3
R 4
R 5
R 6
R 7

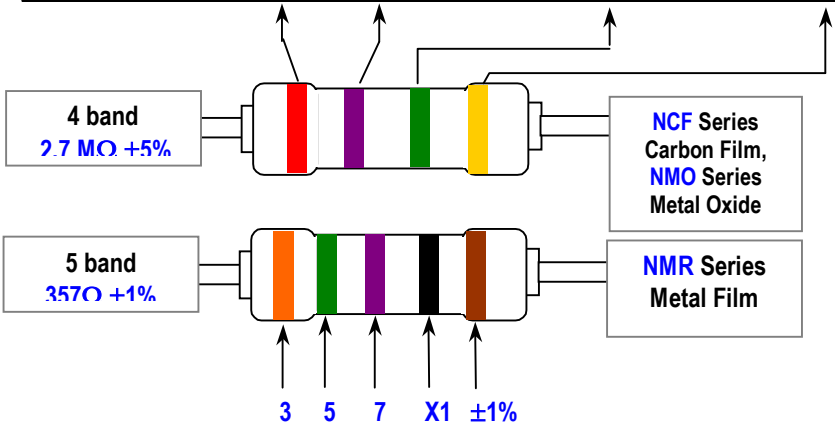
PRODUCT GUIDE FROM NIC Components

RESISTOR COLOR CODING CHART

PRODUCTS: AXIAL LEADED RESISTORS
SERIES: NCF, NMR & NMO

Resistor Color Coding Chart

Color		Significant Figure 1st	2nd	3rd	Multiplier	Tolerance
Black		0	0	0	1	-
Brown		1	1	1	10	F (±1%)
Red		2	2	2	100	G (±2%)
Orange		3	3	3	1,000	-
Yellow		4	4	4	10,000	-
Green		5	5	5	100,000	D (±0.5%)
Blue		6	6	6	1,000,000	C (±0.25%)
Violet		7	7	7	10,000,000	B (±0.1%)
Grey		8	8	8	-	-
White		9	9	9	-	-
Gold		-	-	-	0.1	J (±5%)
Silver		-	-	-	0.01	K (±10%)



Standard ±5% (J) Values

E24
1.1
1.2
1.3
1.5
1.6
1.8
2.0
2.2
2.4
2.7
3.0
3.3
3.6
3.9
4.3
4.7
5.1
6.2
6.8
7.5
8.2
9.1

Standard ±1% (F) Values

E96	E96	E96	E96
1.00	1.78	3.16	5.62
1.02	1.82	3.24	5.76
1.05	1.87	3.32	5.90
1.07	1.91	3.40	6.04
1.10	1.96	3.48	6.19
1.13	2.00	3.57	6.34
1.15	2.05	3.65	6.49
1.18	2.10	3.74	6.65
1.21	2.15	3.83	6.81
1.24	2.21	3.92	6.98
1.27	2.26	4.02	7.15
1.30	2.32	4.12	7.32
1.33	2.37	4.22	7.50
1.37	2.43	4.32	7.68
1.40	2.49	4.42	7.87
1.43	2.55	4.53	8.06
1.47	2.61	4.64	8.25
1.50	2.67	4.75	8.45
1.54	2.74	4.87	8.66
1.58	2.80	4.99	8.87
1.62	2.87	5.11	9.09
1.65	2.94	5.23	9.31
1.69	3.01	5.36	9.53
1.74	3.09	5.49	9.76

Ohm = **Ω**
1000 = **K**
1Million = **M**
1ohm = 0.001 K
10 ohm = 0.01 K
100 ohm = 0.1K
1000 ohm = 1.0K
10,000 ohm = 10K
100,000 ohm = 100K =0.1M
1,000,000 ohm = 1000K = 1M

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