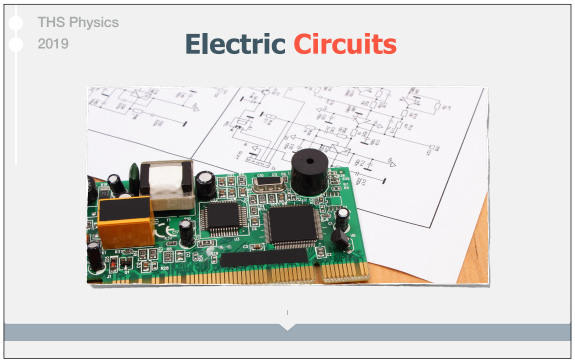
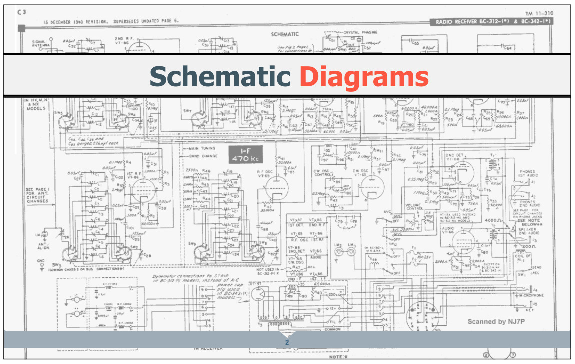
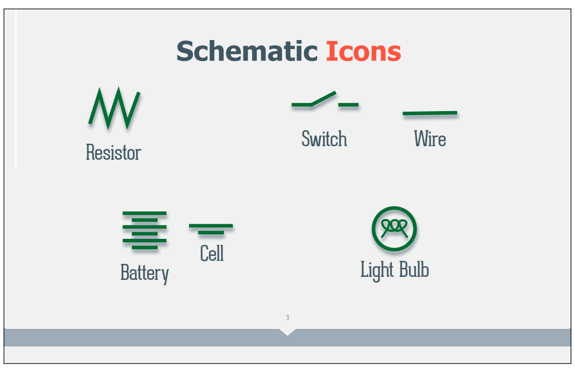

THS Physics
2019
Electric Circuits

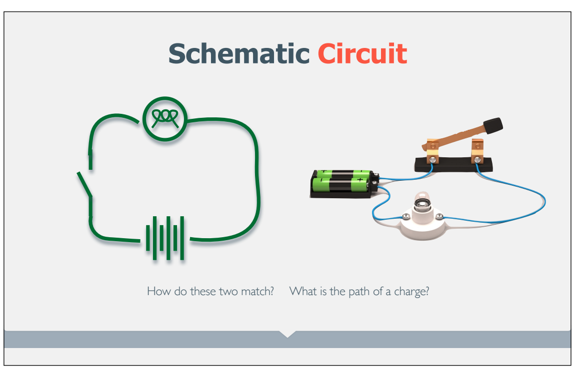
1


Schematic Diagrams

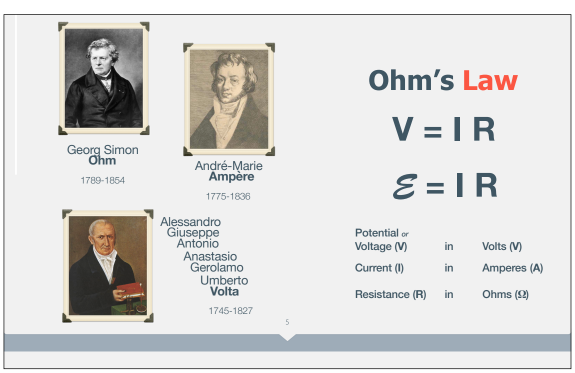
2


Schematic Icons
Resistor
Switch
Wire
Battery
Cell
Light Bulb

3


Schematic Circuit
How do these two match?
What is the path of a charge?

4

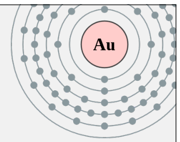

Georg Simon Ohm
1789-1854
André-Marie Ampère
1775-1836
Alessandro Giuseppe Antonio Anastasio Gerolamo Umberto Volta
1745-1827
Ohm's Law
V = I R
ℰ = I R
Potential or Voltage (V) in Volts (V)
Current (I) in Amperes (A)
Resistance (R) in Ohms (Ω)

5

6

Electric Charge

Charles-Augustin **de Coulomb**
1736-1806



- The charge of a single electron is 1.6021×10^{-19} Coulombs
- or... it would take 6.241×10^{18} electrons to have a Coulomb of charge
- 1 Ampere is a current of that many electrons every second.

7

Electric Power

$$P = IV$$

$$P = V^2/R$$

$$P = I^2R$$

Power (Watt)

8

Resistors in Series

- The Charges have to "fight" through every resistor. This decreases the total current.

Voltage: $V_T = V_1 + V_2 + V_3$

Current: $I_T = I_1 = I_2 = I_3$

Resistance: $R_T = R_1 + R_2 + R_3$

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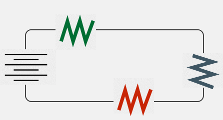
Resistors in Series

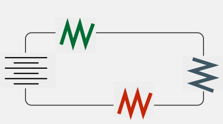


The current starts at the top of the battery and follows a single path, clockwise, around the circuit.

	V (V)	I (A)	R (Ω)	P (W)
R_1			2	
R_2			4	
R_3			6	
TOTAL	24			

10

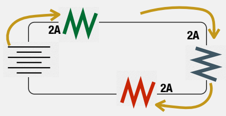
Resistors in Series



Start with the total resistance, a simple sum of the individual values

	V (V)	I (A)	R (Ω)	P (W)
R_1			2	
R_2			4	
R_3			6	
TOTAL	24		12	

Resistors in Series

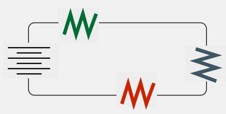


In a series circuit, there is only one current, so that value can be applied to each resistor.

	V (V)	I (A)	R (Ω)	P (W)
R_1		2	2	
R_2		2	4	
R_3		2	6	
TOTAL	24	2	12	

12

Resistors in Series



When you have two values for a resistor, equations will get you the other numbers.

$V = I R$

$V_1 = 2 \times 2 = 4$ Volts

	V (V)	I (A)	R (Ω)	P (W)
R_1	4	2	2	
R_2	8	2	4	
R_3	12	2	6	
TOTAL	24	2	12	

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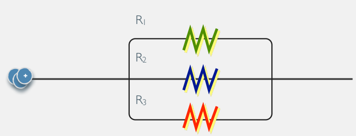
Resistors in Parallel



- The Charges have a choice of paths to follow.
- This decreases the total resistance.

Voltage: $V_T = V_1 = V_2 = V_3$

Current: $I_T = I_1 + I_2 + I_3$

Resistance: $1/R_T = 1/R_1 + 1/R_2 + 1/R_3$

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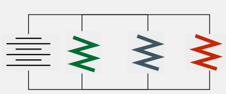
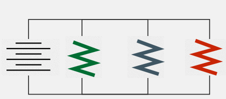
Resistors in Parallel



	V (V)	I (A)	R (Ω)	P (W)
R_1			120	
R_2			60	
R_3			10	
TOTAL	12			

16

Resistors in Parallel



Add the resistors inversely.

$1/R_T = 1/R_1 + 1/R_2 + 1/R_3$

$1/R_T = 1/120 + 1/60 + 1/10$

$R_T = 8\ \Omega$

	V (V)	I (A)	R (Ω)	P (W)
R_1			120	
R_2			60	
R_3			10	
TOTAL	12		8 Ω	

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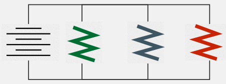
18

Resistors in Parallel



If you are given the total Voltage (EMF), resistors in parallel all have the same Voltage.

	V (V)	I (A)	R (Ω)	P (W)
R_1	12		120	
R_2	12		60	
R_3	12		10	
TOTAL	12		8 Ω	

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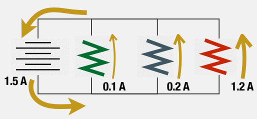
Resistors in Parallel



Use Ohm's Law to find the currents

$V = I R$

$12 = I_1 \times 120$

$I_1 = 0.1$ Amperes

	V (V)	I (A)	R (Ω)	P (W)
R_1	12	0.1	120	
R_2	12	0.2	60	
R_3	12	1.2	10	
TOTAL	12	1.5	8 Ω	

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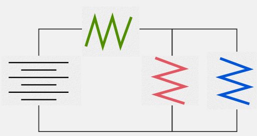
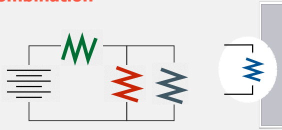
Resistors in Combination Circuits



- Some of the resistors are in Series, some are in Parallel
- Find simple groups that are only one or the other
- Find an Equivalent Resistance for that section
- Keep combining the sections until the circuit is simple

22

Resistors in Combination



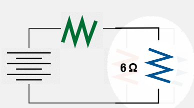
This one starts with the parallel component.

Make another resistor that will replace R_2 and R_3.

	V (V)	I (A)	R (Ω)	P (W)
R_1			4	
R_2			18	
R_3			9	
TOTAL	60			

23

Resistors in Combination

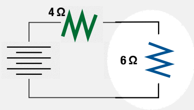


A parallel combination of 18 and 9 can be replaced by a 6 ohm resistor.

With that equivalent resistor replacing R_2 and R_3 the circuit looks like a simple series circuit.

	V (V)	I (A)	R (Ω)	P (W)
R_1			4	
R_2			18	
R_3			9	
TOTAL	60			

Resistors
in Combination

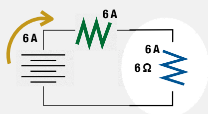


The new series of 6 and 4 creates a total resistance of 10 ohms.

	V (V)	I (A)	R (Ω)	P (W)
R_1			4	
R_2			18	
R_3			9	
TOTAL	60		10	

24

Resistors
in Combination



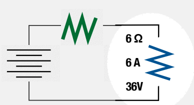
Use Ohm's Law to find a total current of 6 amperes.

This is the current throughout each series section.

	V (V)	I (A)	R (Ω)	P (W)
R_1		6	4	
R_2			18	
R_3			9	
TOTAL	60	6	10	

25

Resistors
in Combination



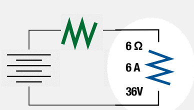
Solve for 3 values of the replacement resistor.

V, I, and R

	V (V)	I (A)	R (Ω)	P (W)
R_1		6	4	
R_2			18	
R_3			9	
TOTAL	60	6	10	

26

Resistors
in Combination

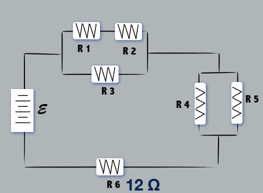


Uncover the original circuit, keep the voltage for parallel components.

(if the original is a series, keep the current)

	V (V)	I (A)	R (Ω)	P (W)
R_1	24	6	4	
R_2	36		18	
R_3	36		9	
TOTAL	60	6	10	

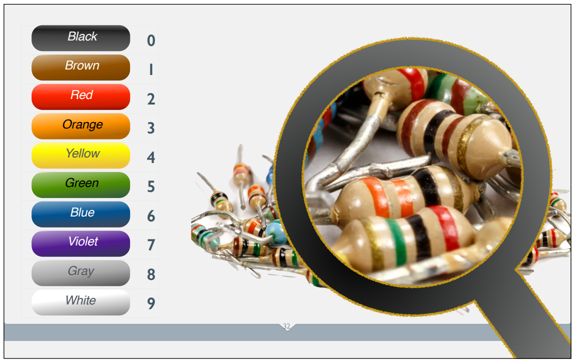
27



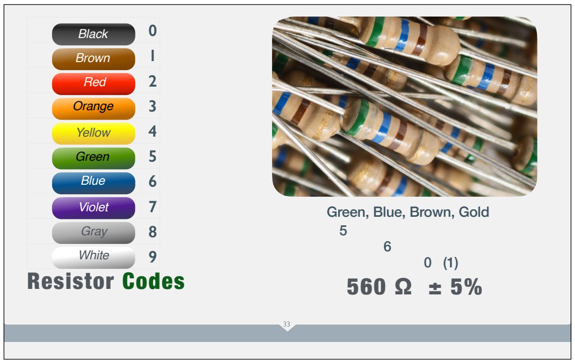
Practice

	V	I	R	P
1			10	
2			5	
3			30	
4			40	
5			10	
6			12	
T	180			

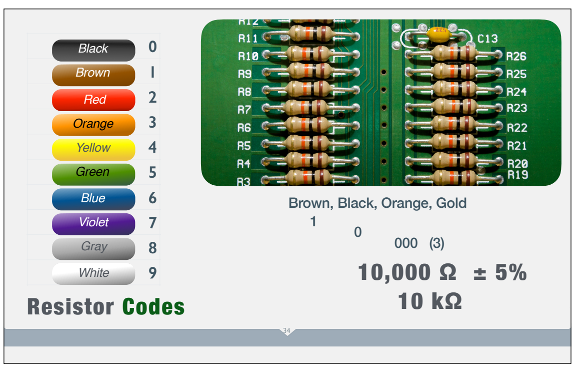
30


Black 0
Brown 1
Red 2
Orange 3
Yellow 4
Green 5
Blue 6
Violet 7
Gray 8
White 9

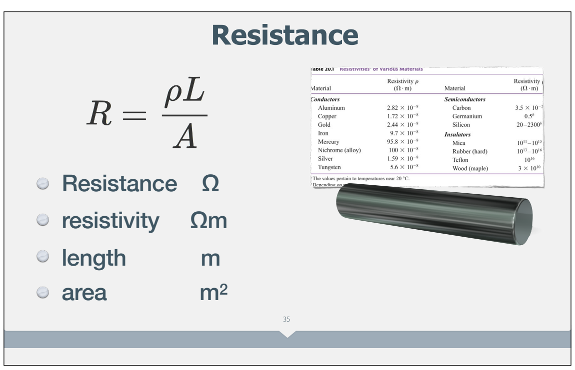
32


Black 0
Brown 1
Red 2
Orange 3
Yellow 4
Green 5
Blue 6
Violet 7
Gray 8
White 9
Resistor Codes
Green, Blue, Brown, Gold
5
6
0 (1)
560 Ω ± 5%

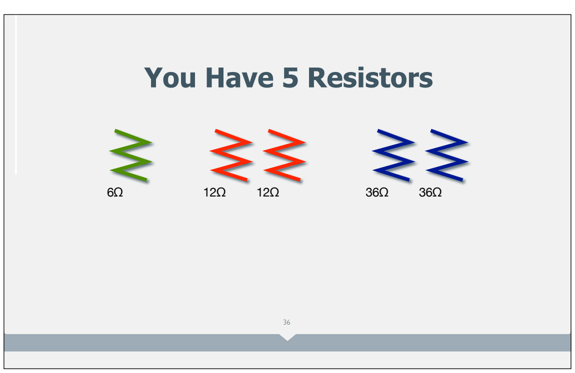
33


Black 0
Brown 1
Red 2
Orange 3
Yellow 4
Green 5
Blue 6
Violet 7
Gray 8
White 9
Resistor Codes
Brown, Black, Orange, Gold
1
0
000 (3)
10,000 Ω ± 5%
10 kΩ

34


Resistance
$R = \frac{\rho L}{A}$
Resistance Ω
resistivity Ωm
length m
area m²

35

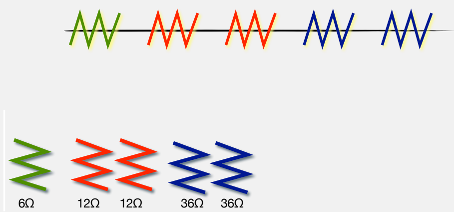

You Have 5 Resistors
6Ω
12Ω
12Ω
36Ω
36Ω

36

37

Biggest Possible Total?

102 Ω



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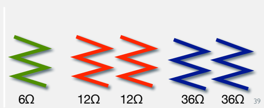
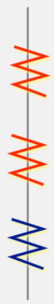
How could you get...

60 Ω





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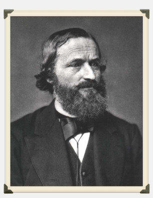
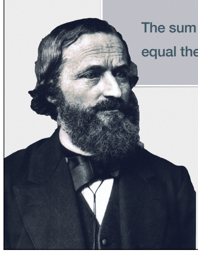
Kirchhoff's Rules



Gustav Robert
Kirchhoff
1824-1887

44

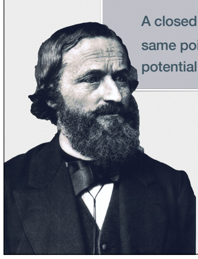


The Point Rule-

The sum of current going in to a point must equal the sum of current coming out.

$$\Sigma I_{in} = \Sigma I_{out}$$
$$\Sigma I = 0$$

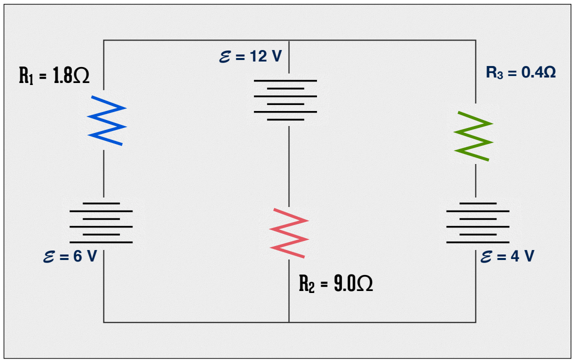
45



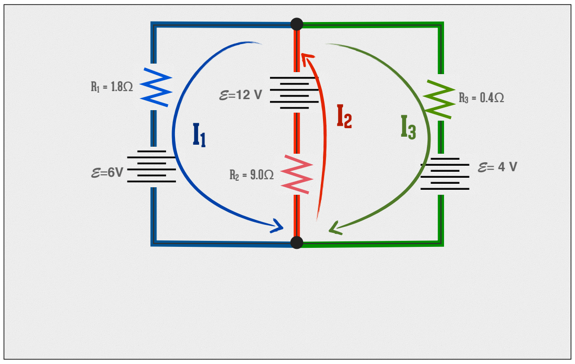
The Loop Rule-

A closed path that begins and ends at the same point will have no net change in potential.

$$\Sigma V = 0$$


R1 = 1.8Ω
ℰ = 12 V
R3 = 0.4Ω
ℰ = 6 V
ℰ = 4 V
R2 = 9.0Ω

46


R1 = 1.8Ω
ℰ=12 V
I2
I3
R3 = 0.4Ω
I1
ℰ=6V
R2 = 9.0Ω
ℰ= 4 V

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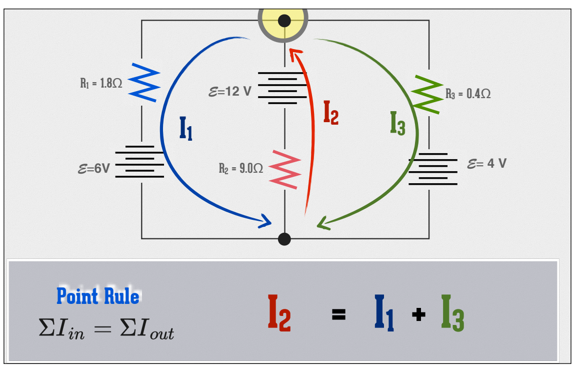
R1 = 1.8Ω
ℰ=12 V
I2
I3
R3 = 0.4Ω
I1
ℰ=6V
R2 = 9.0Ω
ℰ= 4 V
Point Rule
$\Sigma I_{in} = \Sigma I_{out}$
$I_2 = I_1 + I_3$

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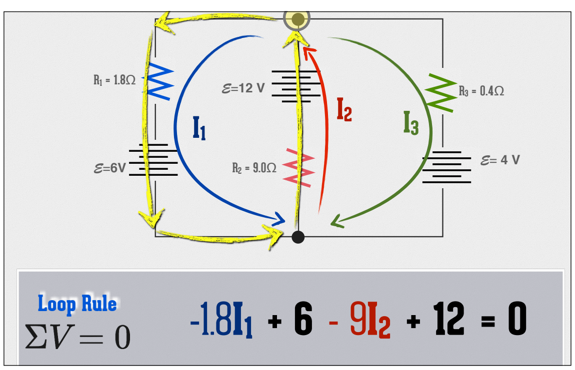
R1 = 1.8Ω
ℰ=12 V
I2
I3
R3 = 0.4Ω
I1
ℰ=6V
R2 = 9.0Ω
ℰ= 4 V
Loop Rule
$\Sigma V = 0$
$-1.8I_1 + 6 - 9I_2 + 12 = 0$

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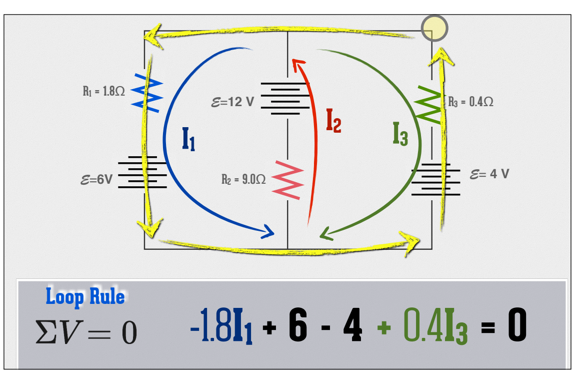
R1 = 1.8Ω
ℰ=12 V
I2
I3
R3 = 0.4Ω
I1
ℰ=6V
R2 = 9.0Ω
ℰ= 4 V
Loop Rule
$\Sigma V = 0$
$-1.8I_1 + 6 - 4 + 0.4I_3 = 0$

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