F: Solve Complete Circuits
Level 3
Prerequisite: Solve Ohm's Law and the Power Formula
Points To: Solve Complete Circuit with Nontraditional Information

Objectives:

$$V = IR$$

$$P = IV$$

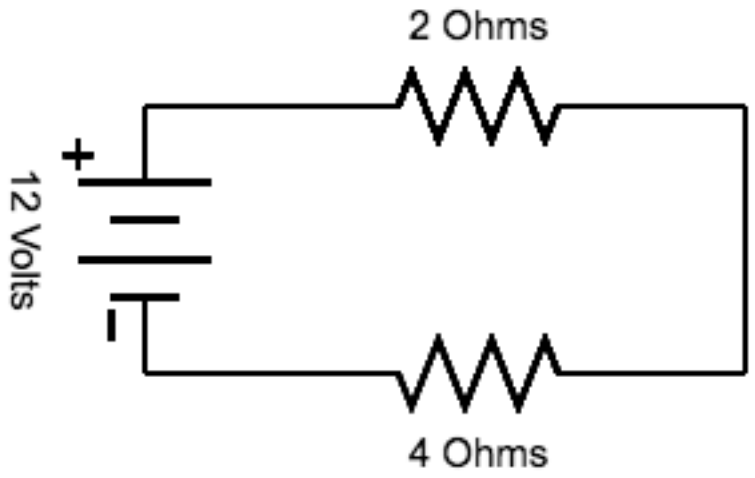
- Given a battery and 2-4 resistors, find the voltage, current, resistance, and power of each element of the circuit and the total circuit (which represents the battery).

- You need to be able to use the two equations above and the series and parallel circuit rules.

Part C: Solving a Series Circuit
The goal of these problems is to identify the voltage, current, and resistance of each element of a series circuit.

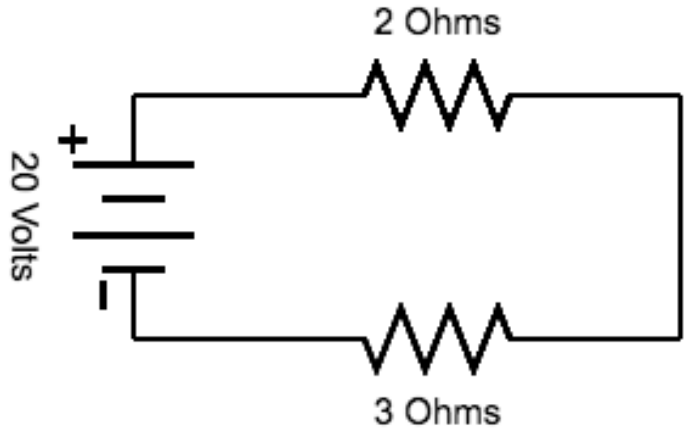
Series Circuit Rules:
1: For each element and the total circuit, the formula V = IR. 2: The *current* is the same for every element. 3: The *voltage* and *resistance* add up to the total for each circuit element.

C.1 A 12-volt battery, a 2-ohm resistor, and a 4-ohm resistor in series.



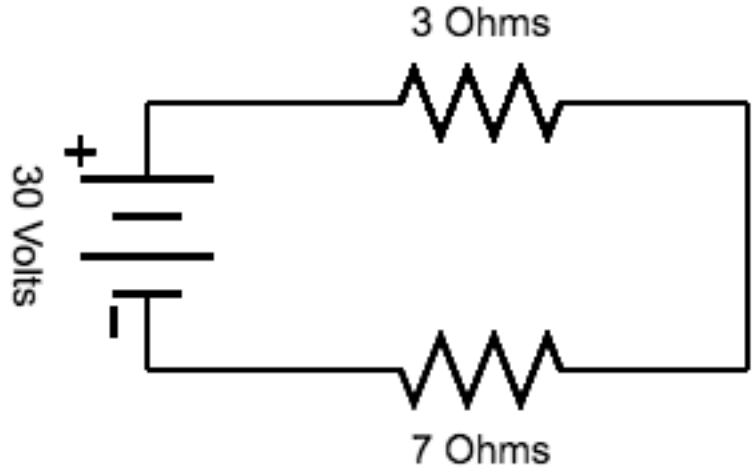
	Resistor 1	Resistor 2	Total Circuit
Voltage (V)			
Current (A)			
Resistance (Ω)			

C.2 A 20-Volt battery, a 2-ohm resistor, and a 3-ohm resistor in series.



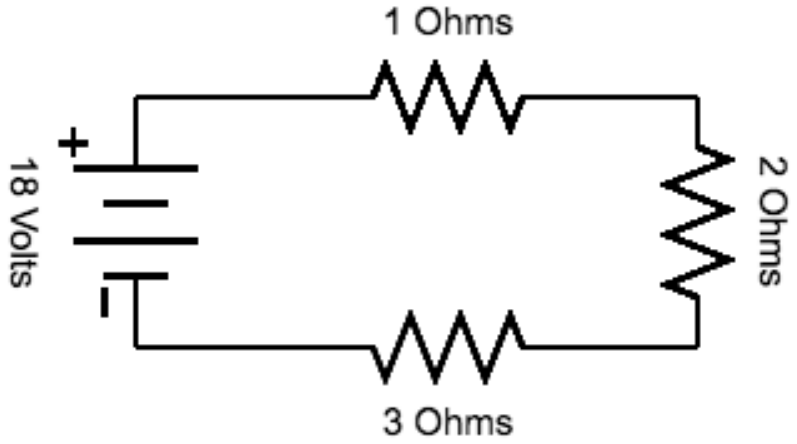
	Resistor 1	Resistor 2	Total Circuit
Voltage (V)			
Current (A)			
Resistance (Ω)			

C.3 A 30-volt battery, a 3-ohm resistor, and a 7-ohm resistor in series.



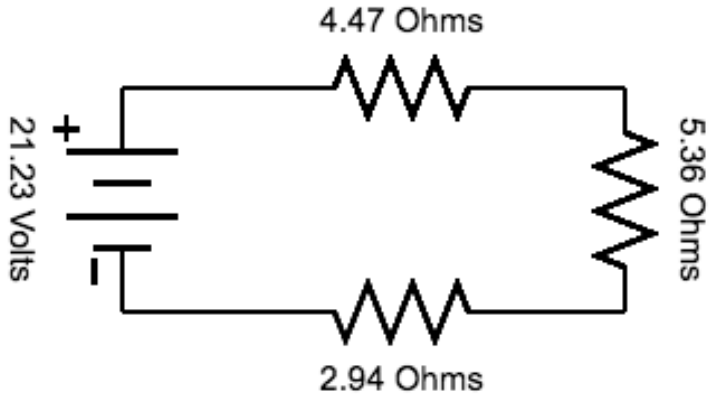
	Resistor 1	Resistor 2	Total Circuit
Voltage (V)			
Current (A)			
Resistance (Ω)			

C.4 An 18-volt battery, a 1-ohm resistor, a 2-ohm resistor, and a 3-ohm resistor in series.



	Resistor 1	Resistor 2	Resistor 3	Total Circuit
Voltage (V)				
Current (A)				
Resistance (Ω)				

C.5 A 21.23-volt battery, a 4.47-ohm resistor, and a 5.36-ohm resistor, and a 2.94-ohm resistor in series. [use a calculator for this problem, round each cell of the table to two decimal places]



	Resistor 1	Resistor 2	Resistor 3	Total Circuit
Voltage (V)				
Current (A)				
Resistance (Ω)				

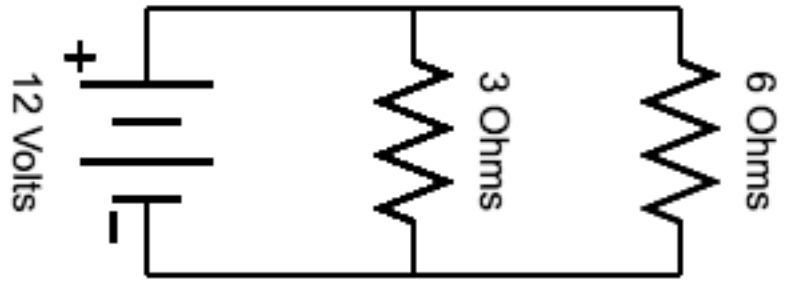
Part D: Solving Parallel circuit problems

In a parallel circuit, the rules are slightly different.

Parallel Circuit Rules:

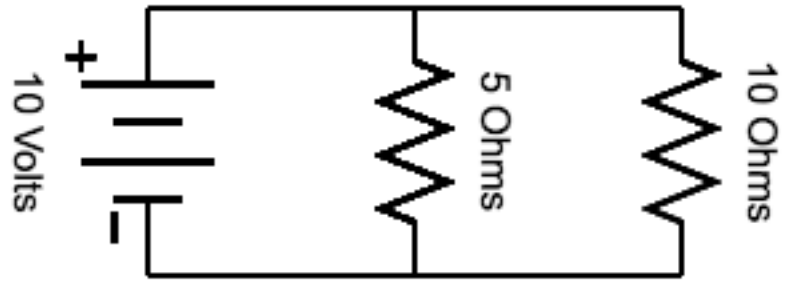
1: For each element and the total circuit, the formula V = IR.
2: The *voltage* is the same for every element.
3: The *current* adds up to the total for each circuit element.
4: The *resistance* DOES NOT add up to the total.

D.1. A parallel circuit with a 12-Volt battery, a 3-Ohm resistor, and a 6-Ohm resistor:



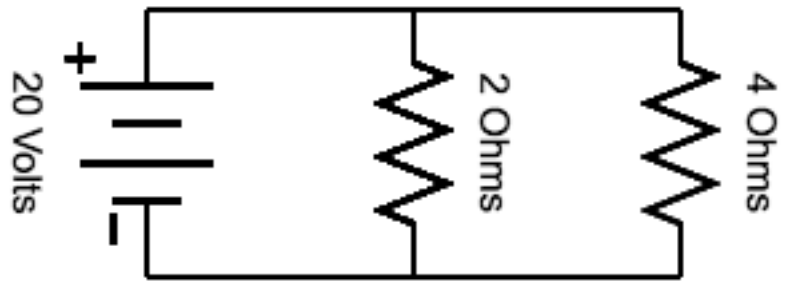
	Resistor 1	Resistor 2	Total Circuit
Voltage (V)			
Current (A)			
Resistance (Ω)			

D.2 a parallel circuit with a 10 Volt battery, a 5-Ohm resistor, and a 10-Ohm resistor:



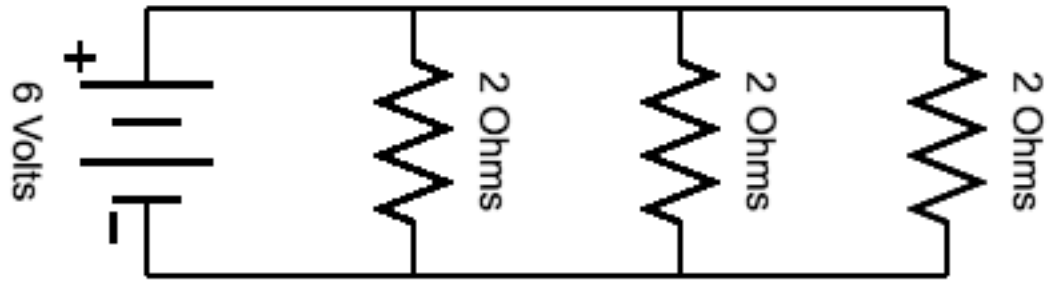
	Resistor 1	Resistor 2	Total Circuit
Voltage (V)			
Current (A)			
Resistance (Ω)			

D.3 a parallel circuit with a 20 Volt battery, a 2 Ohm resistor, and a 4 Ohm resistor:



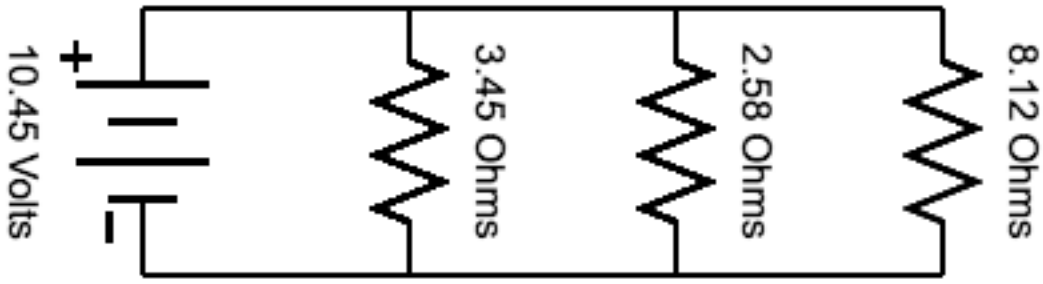
	Resistor 1	Resistor 2	Total Circuit
Voltage (V)			
Current (A)			
Resistance (Ω)			

D.4 A parallel circuit with a 6-volt battery and *three* 2-ohm resistors.



	Resistor 1	Resistor 2	Resistor 3	Total Circuit
Voltage (V)				
Current (A)				
Resistance (Ω)				

D.5 A parallel circuit with a 10.45-volt battery, a 3.45-ohm resistor, a 2.58-ohm resistor, and a 8.12-ohm resistor. [use a calculator, round the answers to two decimal places]



	Resistor 1	Resistor 2	Resistor 3	Total Circuit
Voltage (V)				
Current (A)				
Resistance (Ω)				

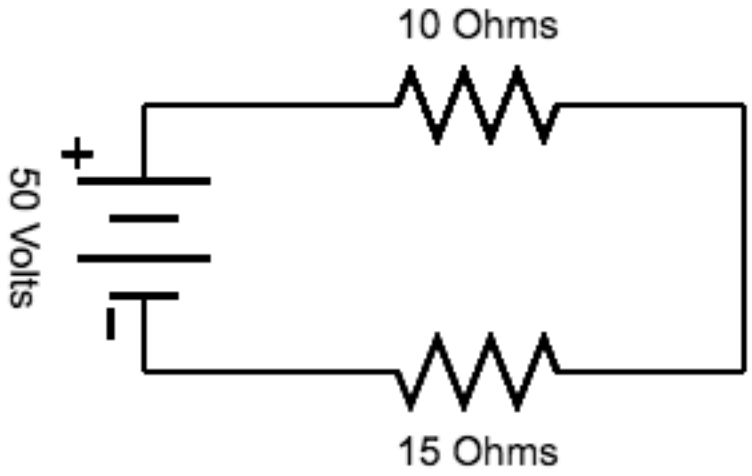
D.6 Which rule is the same for series and parallel circuits?

D.7 Which rules are different for series and parallel circuits?

Part F: Solving circuit problems with power

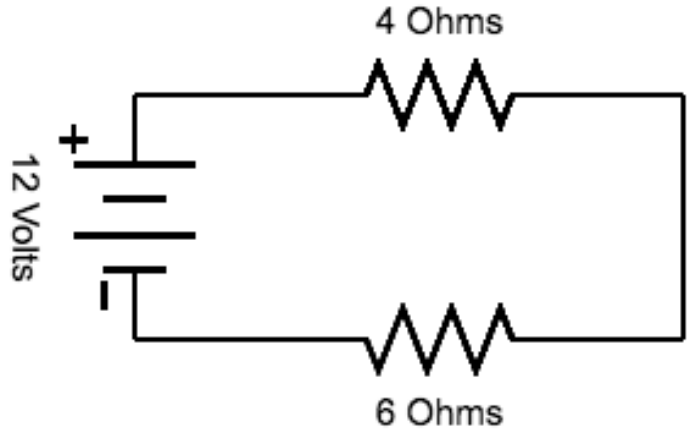
New Rule: In both series and parallel circuits, the formula P = IV applies for each element.

F.1 A *series* circuit has a 50-volt battery, a 10-ohm resistor, and a 15-ohm resistor.



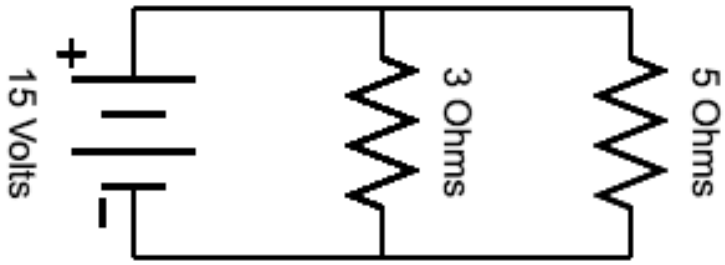
	Resistor 1	Resistor 2	Total Circuit
Voltage (V)			
Current (A)			
Resistance (Ω)			
Power (W)			

F.2 A *series* circuit has a 12-volt battery, and four-ohm resistor, and a six-ohm resistor.



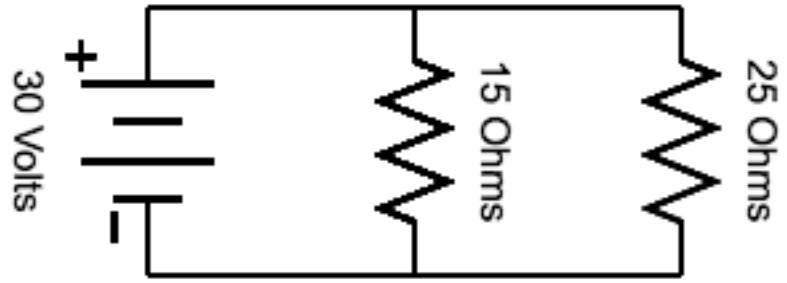
	Resistor 1	Resistor 2	Total Circuit
Voltage (V)			
Current (A)			
Resistance (Ω)			
Power (W)			

F.3 A *parallel* circuit has a 15-volt battery, a 3-ohm resistor and a 5-ohm resistor.



	Resistor 1	Resistor 2	Total Circuit
Voltage (V)			
Current (A)			
Resistance (Ω)			
Power (W)			

F.4 A *parallel* circuit has a 30-volt battery, a 15-ohm resistor and a 25-ohm resistor.



	Resistor 1	Resistor 2	Total Circuit
Voltage (V)			
Current (A)			
Resistance (Ω)			
Power (W)			

Part G: Which type of circuit has brighter light bulbs?

By now, you should have used the wire kits to build basic series and parallel circuits. Which type of circuit had brighter light bulbs?

We are going to mathematically sow *why* this rule is true:

You use two D-batteries. Each one has a voltage of 1.5 volts.
What is the total voltage of your circuit?

Assume that each light bulb has a resistance of 20 Ohms.

First, imagine you connect the light bulbs in series. Draw a circuit diagram of your circuit. Include the voltage of the batteries and resistance of the light bulbs in your circuit:

Solve the circuit:

	Light Bulb 1	Light Bulb 2	Total Circuit
Voltage (V)			
Current (A)			
Resistance (Ω)			
Power (W)			

What is the power of each bulb in the series circuit?

Second, you connect the light bulbs in parallel. Draw a circuit diagram of your circuit. Include the voltage of the batteries and resistance of the light bulbs in your circuit:

	Light Bulb 1	Light Bulb 2	Total Circuit
Voltage (V)			
Current (A)			
Resistance (Ω)			
Power (W)			

What is the power of each bulb in the parallel circuit?

The *power* of a light bulb shows how much light energy each bulb generates. A light bulb with more power is a brighter light bulb. A light bulb with less power is a dimmer light bulb.

Explain how the mathematics connects with what you observe in real life:

C.1

	Resistor 1	Resistor 2	Total Circuit
Voltage (V)	4	8	12
Current (A)	2	2	2
Resistance (Ω)	2	4	6

C.2

	Resistor 1	Resistor 2	Total Circuit
Voltage (V)	8	12	20
Current (A)	4	4	4
Resistance (Ω)	2	3	5

C.3

	Resistor 1	Resistor 2	Total Circuit
Voltage (V)	9	21	30
Current (A)	3	3	3
Resistance (Ω)	3	7	10

C.4

	Resistor 1	Resistor 2	Resistor 3	Total Circuit
Voltage (V)	3	6	9	18
Current (A)	3	3	3	3
Resistance (Ω)	1	2	3	6

C.5

	Resistor 1	Resistor 2	Resistor 3	Total Circuit

Voltage (V)	7.43	8.91	4.89	21.23
Current (A)	1.66	1.66	1.66	1.66
Resistance (Ω)	4.47	5.36	2.94	12.77

Results are rounded to 3 significant figures.

D.1

	Resistor 1	Resistor 2	Total Circuit
Voltage (V)	12	12	12
Current (A)	4	2	6
Resistance (Ω)	3	6	2

D.2

	Resistor 1	Resistor 2	Total Circuit
Voltage (V)	10	10	10
Current (A)	2	1	3
Resistance (Ω)	5	10	3.33

D.3

	Resistor 1	Resistor 2	Total Circuit
Voltage (V)	20	20	20
Current (A)	10	5	15
Resistance (Ω)	2	4	1.33

D.4

	Resistor 1	Resistor 2	Resistor 3	Total Circuit
Voltage (V)	6	6	6	6
Current (A)	3	3	3	9
Resistance (Ω)	2	2	2	0.667

D.5

	Resistor 1	Resistor 2	Resistor 3	Total Circuit
Voltage (V)	10.45	10.45	10.45	10.45
Current (A)	3.03	4.05	1.29	8.37
Resistance (Ω)	3.45	2.58	8.12	1.25

All results are rounded to three significant figures.

D.6 Ohm's Law applies to both series and parallel circuits.
D.7 In a series circuit, voltage adds and current is constant.
In a parallel circuit, current adds, and voltage is constant
In a series circuit, resistance adds up, while it does not in a parallel circuit.

F.1

	Resistor 1	Resistor 2	Total Circuit
Voltage (V)	20	30	50
Current (A)	2	2	2
Resistance (Ω)	10	15	25
Power (W)	40	60	100

F.2

	Resistor 1	Resistor 2	Total Circuit
Voltage (V)	4.8	7.2	12
Current (A)	1.2	1.2	1.2
Resistance (Ω)	4	6	10
Power (W)	5.76	8.64	14.4

F.3

	Resistor 1	Resistor 2	Total Circuit
Voltage (V)	15	15	15
Current (A)	5	3	8
Resistance (Ω)	3	5	1.875
Power (W)	75	45	120

F.4

	Resistor 1	Resistor 2	Total Circuit
Voltage (V)	30	30	30
Current (A)	2	1.2	3.2

Resistance (Ω)	15	25	9.375
Power (W)	60	36	96

Part G:

For a series circuit:

	Light Bulb 1	Light Bulb 2	Total Circuit
Voltage (V)	1.5	1.5	3.0
Current (A)	0.075	0.075	0.075
Resistance (Ω)	20	20	40
Power (W)	0.1125	0.1125	0.225

For a parallel circuit:

	Light Bulb 1	Light Bulb 2	Total Circuit
Voltage (V)	3.0	3.0	3.0
Current (A)	0.15	0.15	0.30
Resistance (Ω)	20	20	1
Power (W)	0.45	0.45	0.9

In the series circuit, each light bulb has a power of 0.1125 Watts.
In the parallel circuit, each light bulb has a power of 0.45 Watts, four times higher.
Power describes the brightness of the light bulb, which means that the bulbs in parallel should be four times brighter. This is approximately what we observe.

[Note: This calculation is slightly incorrect because light bulbs do not perfectly follow Ohm's Law, but it communicates the important point about series and parallel circuits.]