Applying Voltage to Our Circuits: How Do We Draw Our Circuits? How Much Current Flows?

An attempt to convey some basic intuition about electricity.

Unit-04 of N

Review

Term	Meaning
Voltage	It's like *force* or *pressure*. In our circuits it's our *forcing function*, or *stimulus*, or *excitation*. Its unit is *Volts (V)*. We *apply* voltage.
Current	It's the *flow rate* of electricity. It's the rate at which *charge* flows past a given point in our circuit. The unit of *charge* is the *Coulomb (Q)*. When 1 *Coulomb (1 Q)* of charge flows through a given point in our circuit in one second, we call that rate of flow 1 *Ampere (A)*. Current is a result of applying voltage so we say our circuit *draws* currents. We didn't actually cover *Coulombs* as a unit of charge but it's a good fact and a good concept to know.
Resistance	Back in Unit 1 we mentioned resistance as a characteristic of an electronic system. We see it again and learn its unit which is the Ohm.

Concepts and Vocabulary for Unit-04

By the end of this section you should have an introductory understanding of the following:

1. Circuit
    1. A connected arrangement of electronic parts which actually contains a number of closed-loop current paths.
        1. This is sometimes called “circuitry”.
    2. One complete closed-loop current path by itself or as part of a larger arrangement.
        1. This is sometimes called a “loop”.
2. Circuit Elements (or Components)
    1. These are the various electronic devices we connect to build our desired circuit.
3. Pictorial wiring diagrams
    1. Seldom used in industry, pictorial diagrams help people build electronic circuits by making it easier to recognize components and how their pins are connected.

Concepts and Vocabulary for Unit-04 (cont'd)

By the end of this section you should have an introductory understanding of the following:

4. Schematic diagrams
    1. Schematic diagrams are the most common industry (and hobbyist) method for describing an electronic system's circuitry.
    2. Schematic diagrams consist of:
        1. electrical symbols,
        2. wires,
        3. reference designators,
        4. labels, attributes, (many names),
        5. general text.
5. Computing current flow
    1. Ohm's Law (first exposure).
6. Series circuits (first exposure).

An Automotive Incandescent 12V Lamp

The silver/grey button is one contact of the bulb

First contact

Black plastic insulator

Filament
This specially coated wire is heated when current flows and glows giving off light.

The yellowish metallic bulb body is the other contact of the bulb

Second Contact

The Electrical Circuit

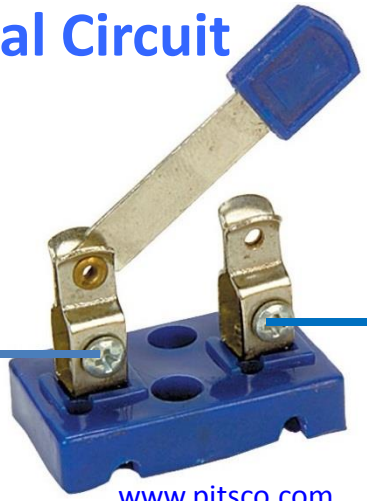
These blue lines represent conducting wires

The opened switch prevents current from flowing as we don't yet have a complete circuit

Our power supply is a 12V automobile battery

+

–



www.pitsco.com
W59395

Our "*load*" is a 12V Automotive Lamp

The Electrical Circuit (cont'd)

red arrows indicate conventional current flow

Closing the switch completes our circuit allowing current to flow through the lamp

Our power supply is a 12V automobile battery

+

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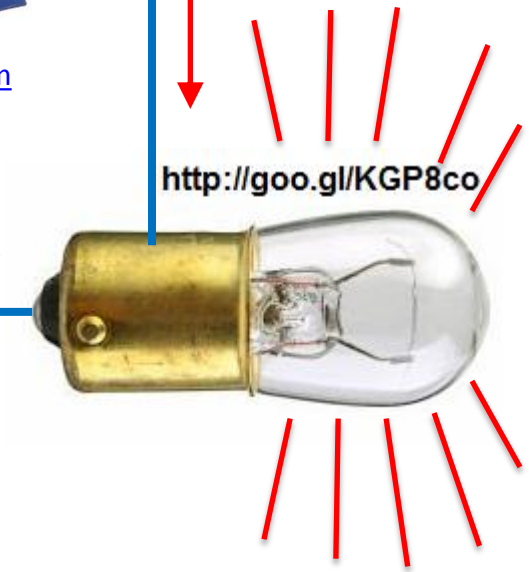
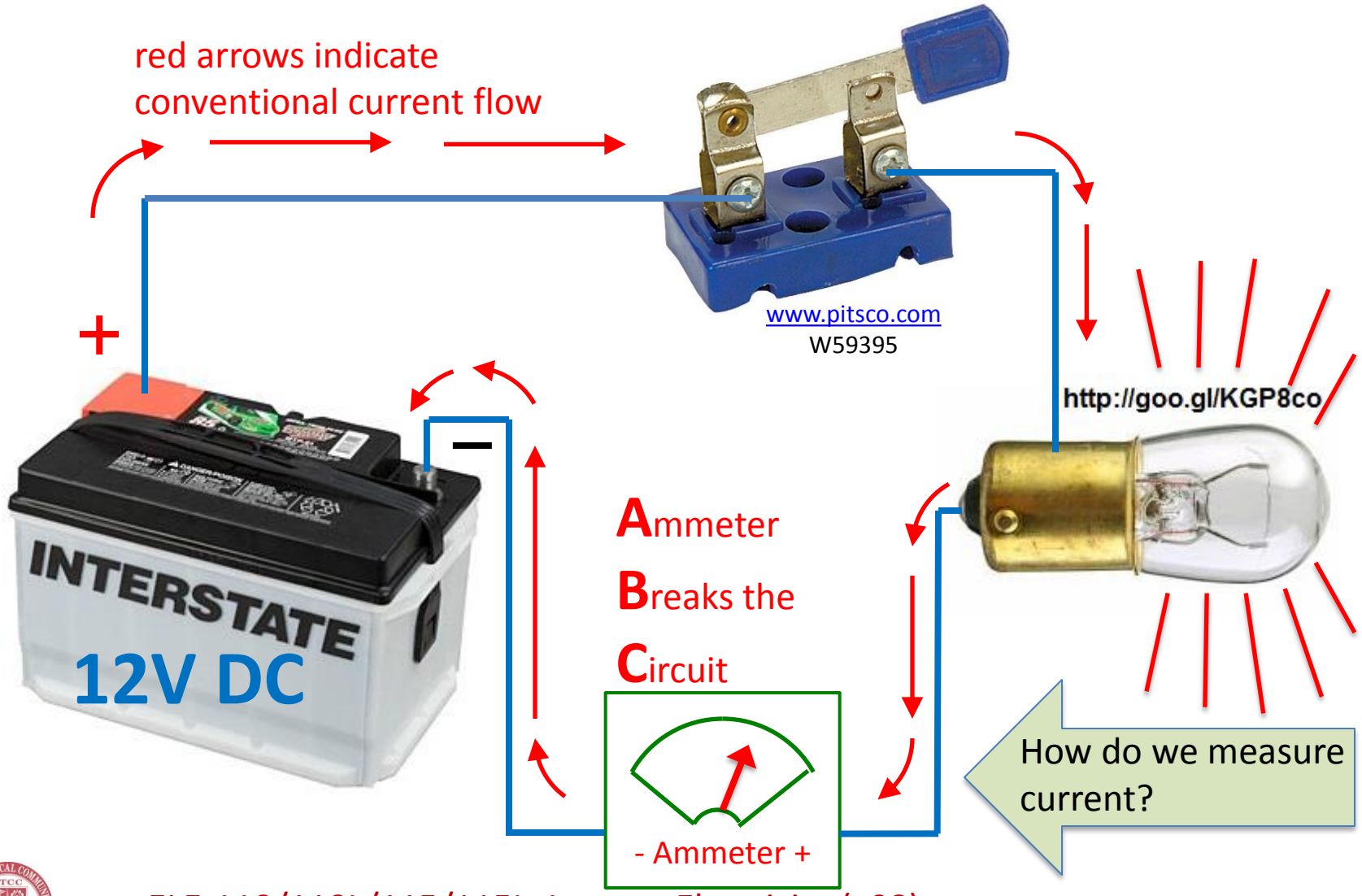


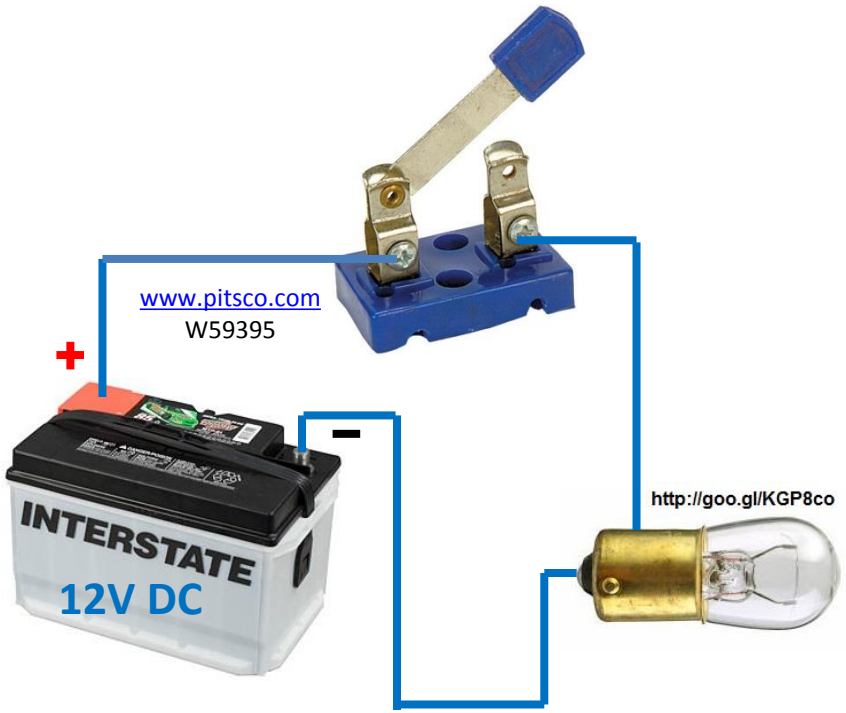
Our "*load*" is a 12V Automotive Lamp

The Electrical Circuit (cont'd)

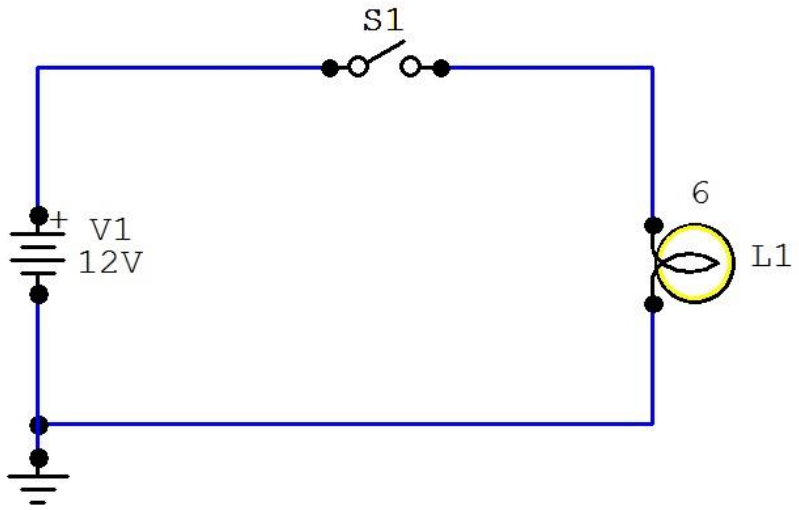


The Electrical Circuit (cont'd)

Now we show our first circuit in both *pictorial form* and *schematic form*.



pictorial form

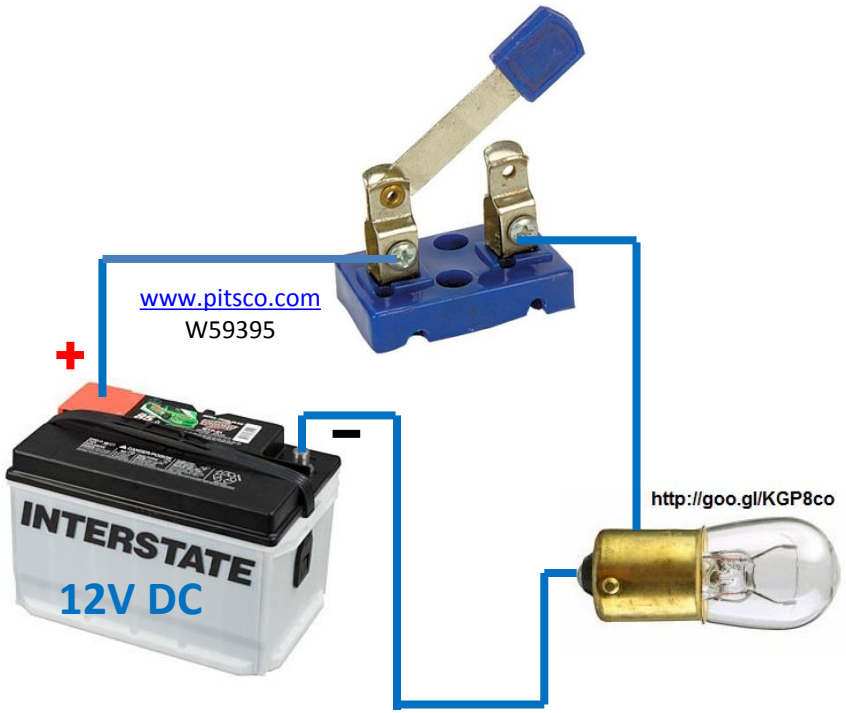


schematic form

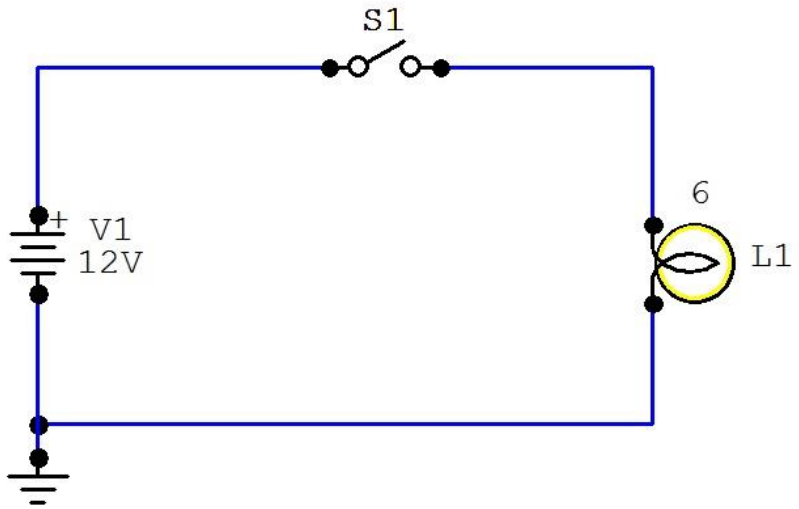
The Electrical Circuit (cont'd)

Schematic diagrams consist of:

- electrical symbols,
- wires (i.e. conductors),
- reference designators,
- labels, attributes, (many names)
- and general text.



pictorial form



schematic form

The Electrical Circuit (cont'd)

Schematic diagrams consist of:

- ***electrical symbols***,
- wires,
- reference designators,
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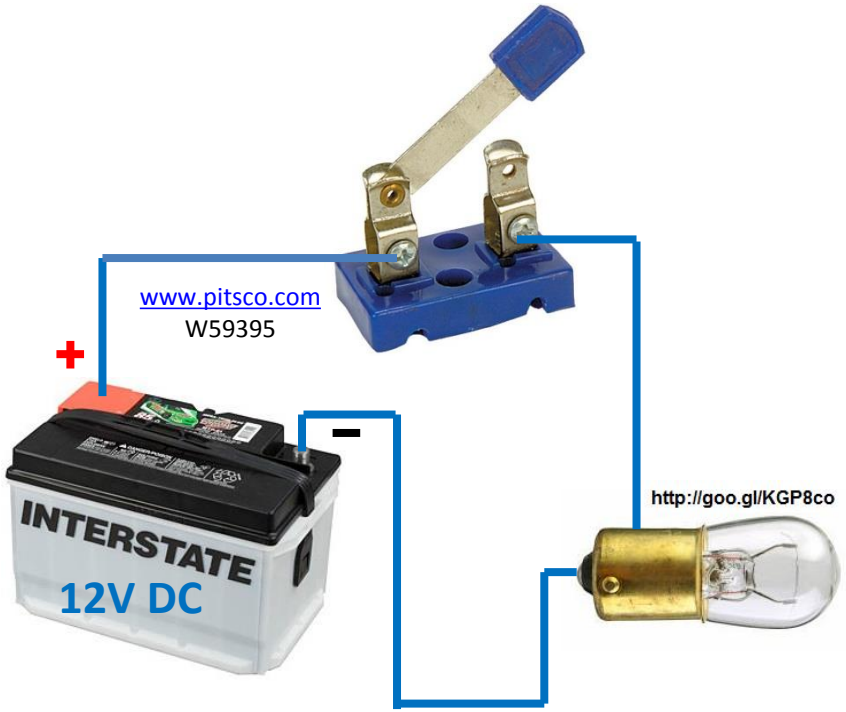
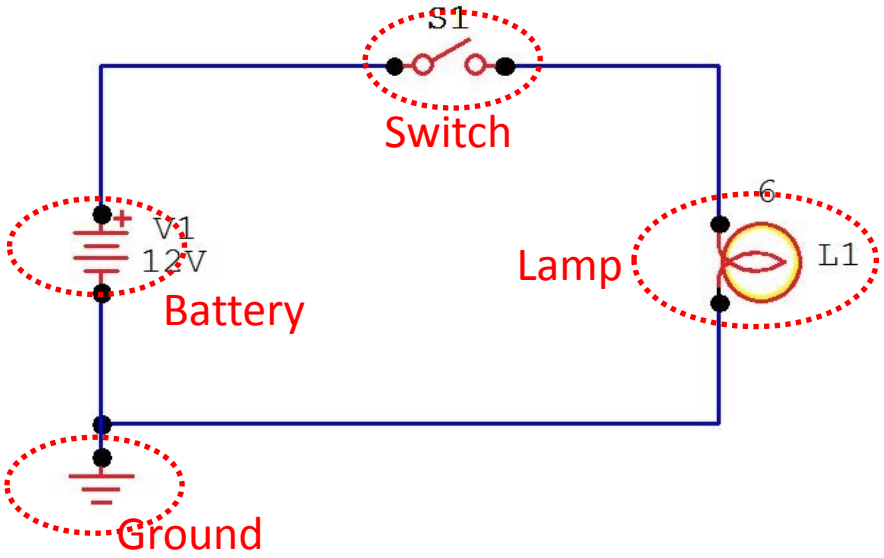


pictorial form

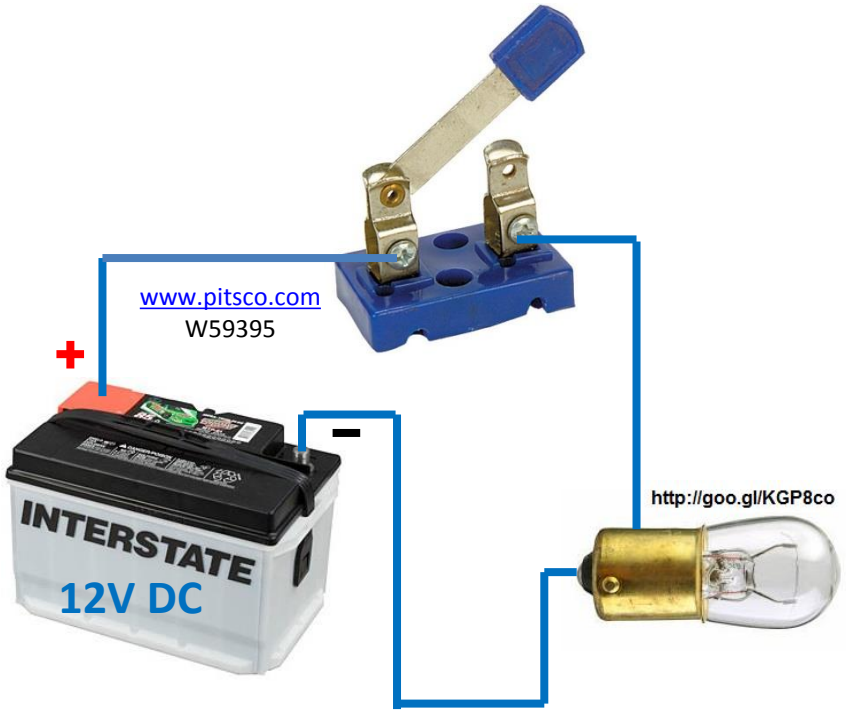


schematic form

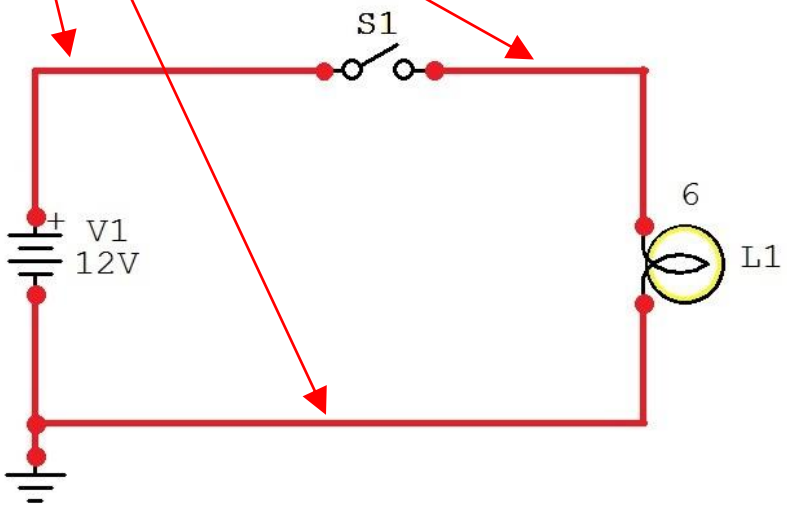
The Electrical Circuit (cont'd)

Schematic diagrams consist of:

- electrical symbols,
- ***wires***,
- reference designators,
- labels, attributes, (many names)
- general text.



pictorial form



schematic form

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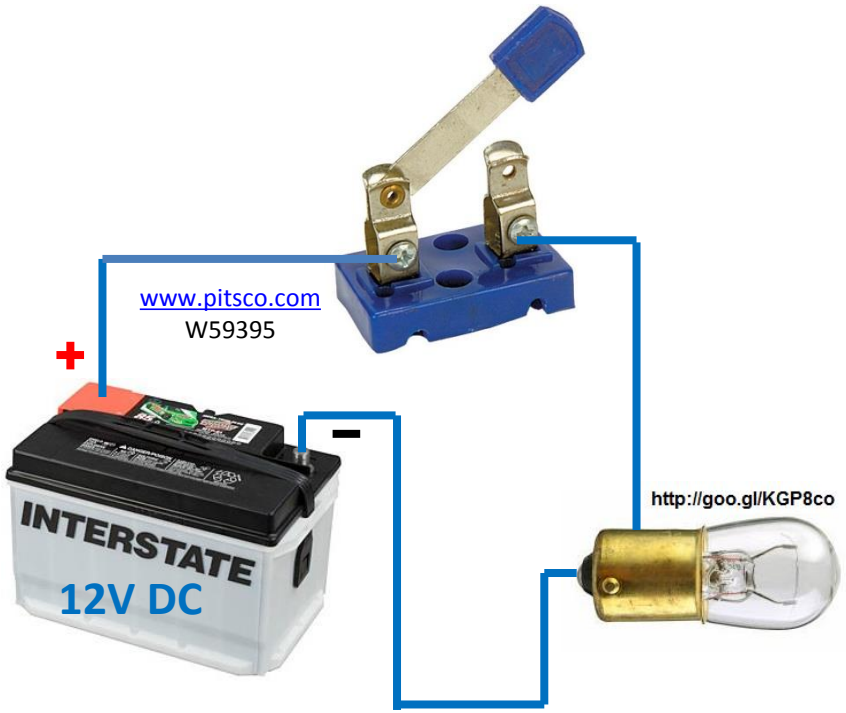
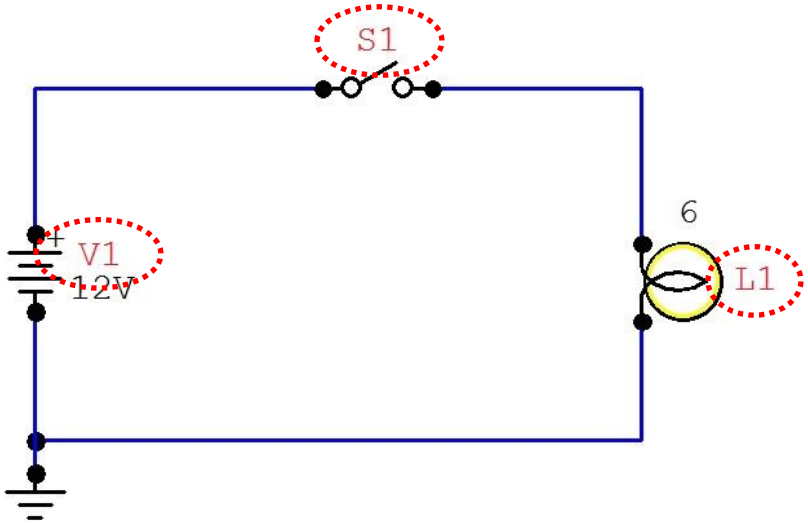


pictorial form



schematic form

The Electrical Circuit (cont'd)

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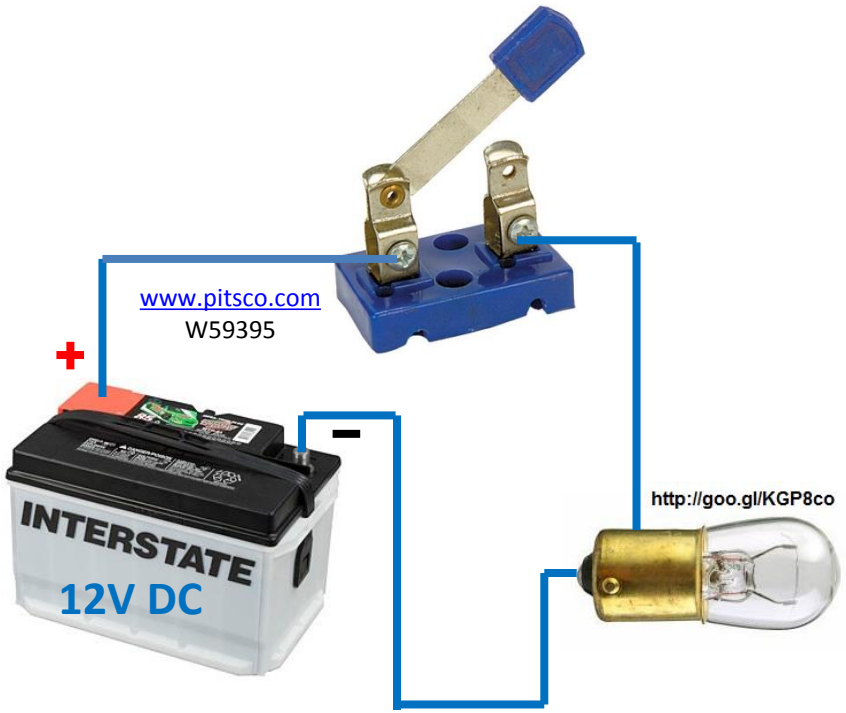
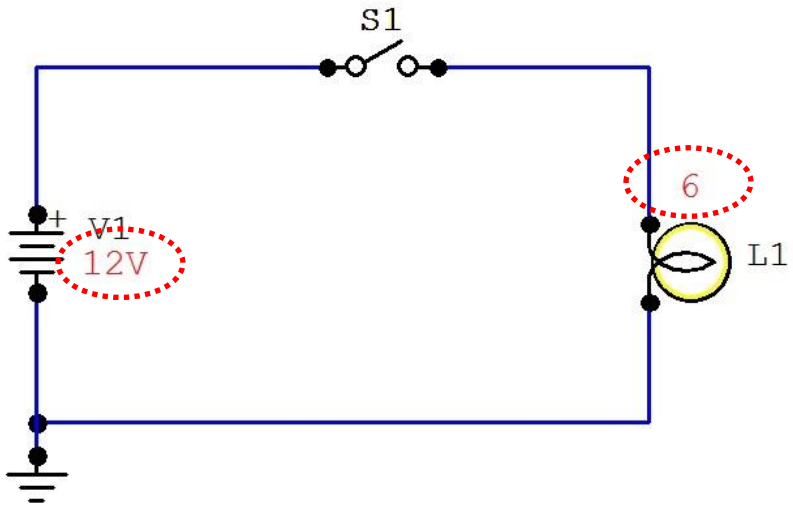


pictorial form



schematic form

The Electrical Circuit (cont'd)

Schematic diagrams consist of:

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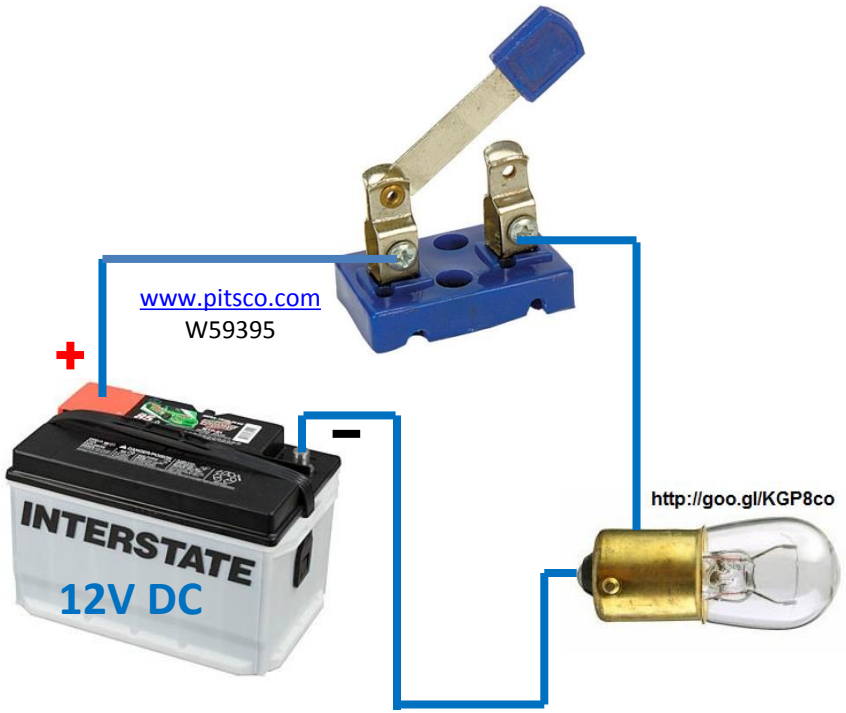
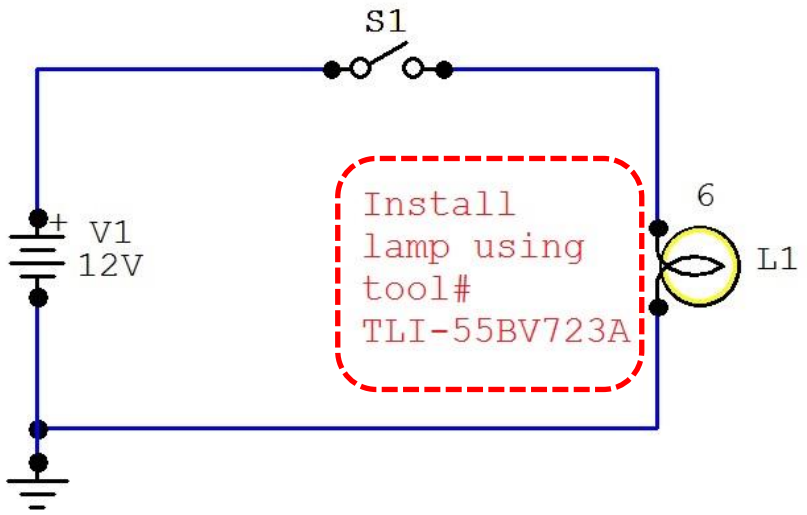


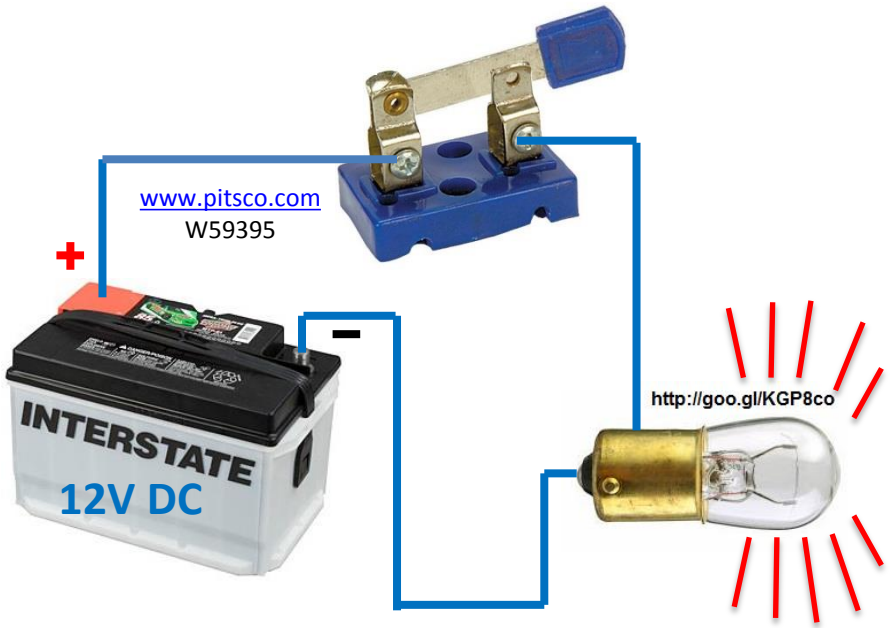
pictorial form



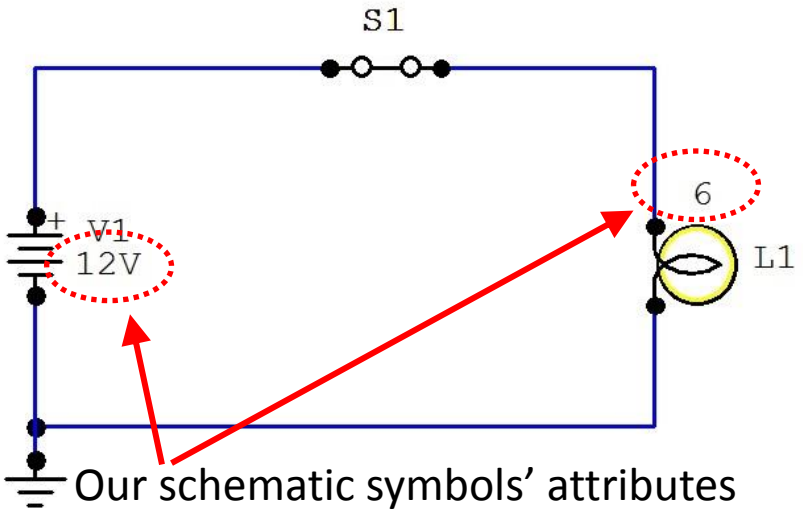
schematic form

The Electrical Load (cont'd)

We have a 12V power supply. How much current flows in our circuit?



pictorial form

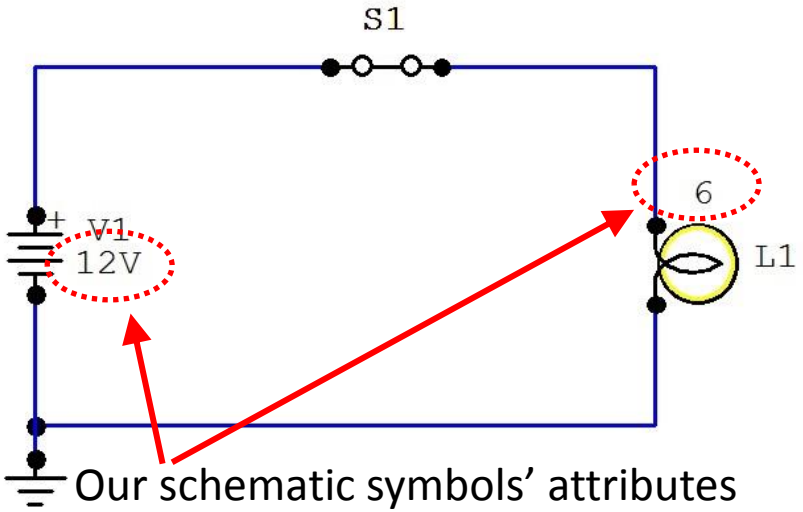


Our schematic symbols' attributes tell us that we have a 12V supply and a 6 Ohm (or 6Ω) resistance in our lamp. "Ohm" is the unit of electrical resistance.

schematic form

The Electrical Load (cont'd)

We have a 12V power supply. How much current flows in our circuit?



Our schematic symbols' attributes tell us that we have a 12V supply and a 6 Ohm (or 6Ω) resistance in our lamp.

schematic form

George Simon Ohm
(https://en.wikipedia.org/wiki/Georg_Ohm)
discovered a relationship we use to this day to find the amount of current flowing in our circuit:

Ohm's Law:

$$V = IR$$

V = Voltage in Volts (V)
I = Current in Amperes (A)
R = Resistance in Ohms (Ω)

Dividing both side by R gives:

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

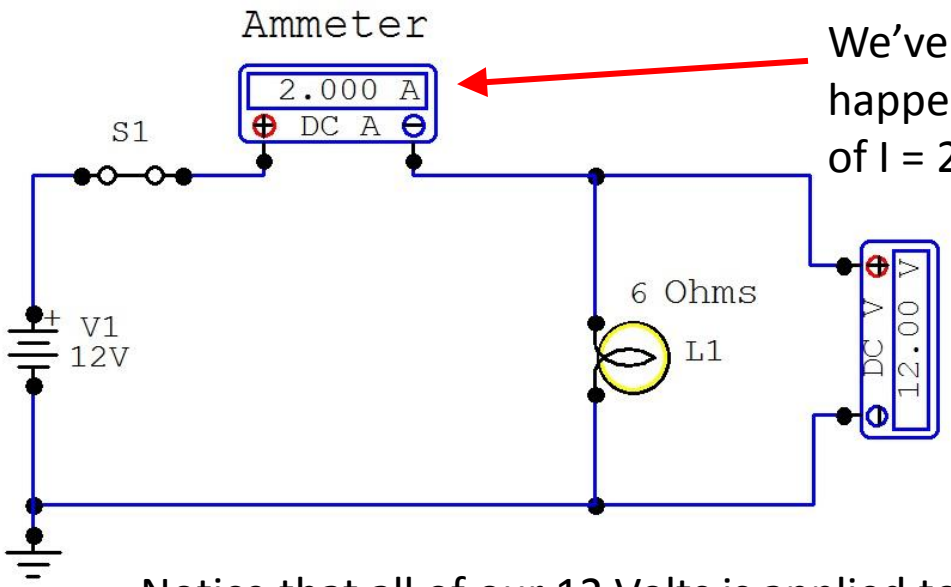
$$I(in\ Amperes\ or\ A) = \frac{12\ (Volts\ or\ V)}{6\ (Ohms\ or\ \Omega)}$$

$$I = 2A$$

The Electrical Load (cont'd)

We have a 12V power supply. How much current flows in our circuit?

Here is the result of simulating our circuit in a computer simulator program:



We've added a simulated ammeter which happens to indicate our computed value of I = 2A.

Here we've added a simulated voltmeter.

Notice that all of our 12 Volts is applied to the lamp. In simulation, no voltage is "used up" by our wires or our ammeter. This would not be the case in actual practice but real wires and real ammeters are so near the ideal that our measurements in the lab would for all practical purposes be the very close to our simulated results.

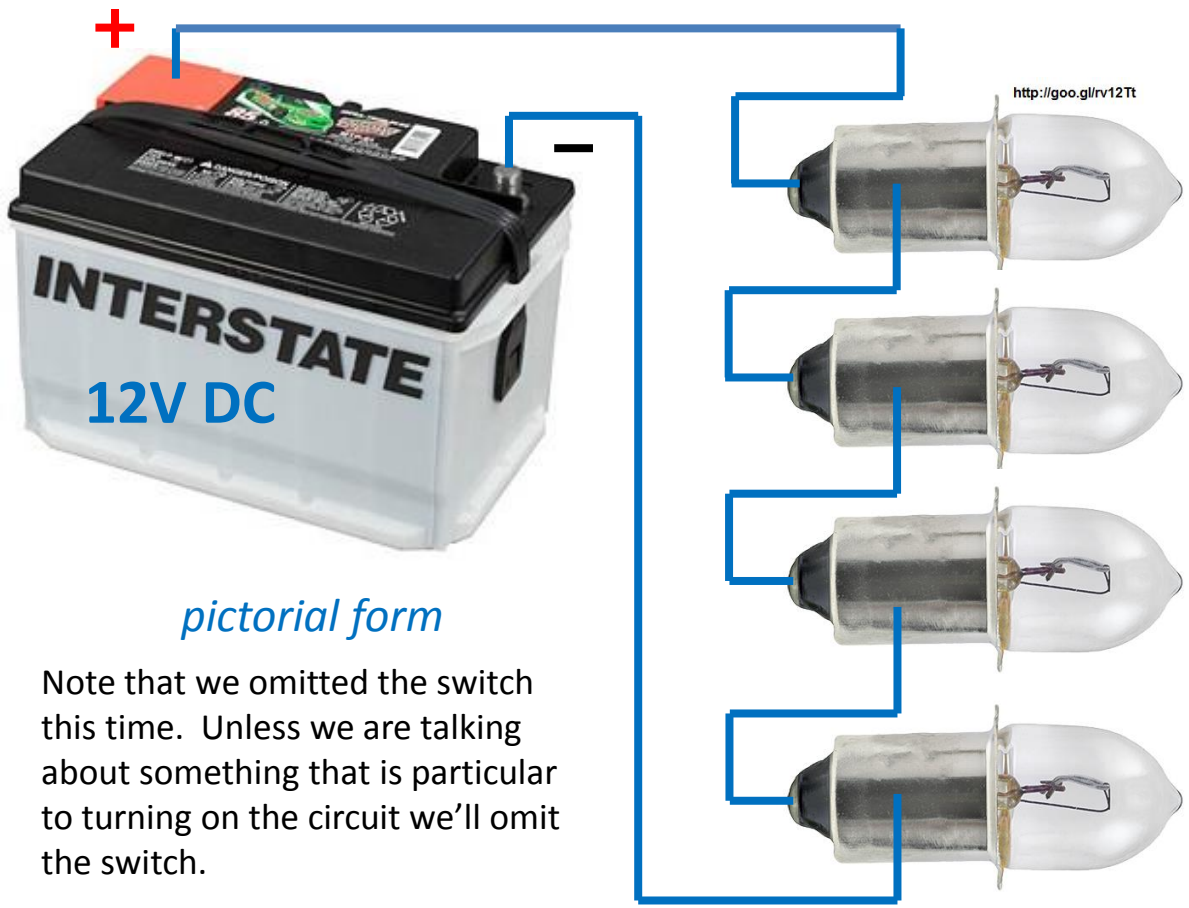
Series Circuit

Series Circuit

When we connect electronics components “end-to-end”, we say they are connected in series. The blue dots below represent some kind of electrical joining of the components be it using *solder* (a melted and re-solidified soft metal alloy pronounced “*sod’ der*” or by some other means of connection. Schematics may or may not show the dots but we assume that the connection is there.

There is only one path for the electrical current to flow and that is *through every series connected component* so *we could break open the circuit path at any point and measure the **same** current*.

Series Circuit

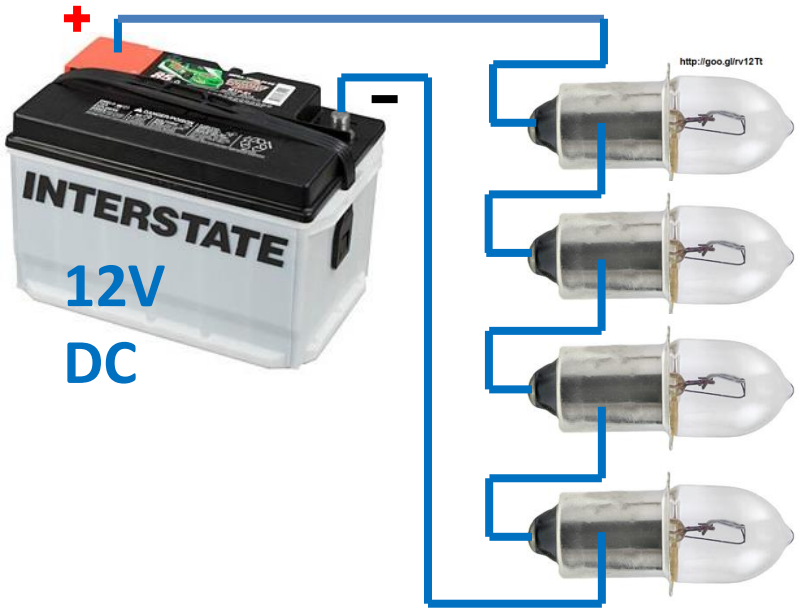


pictorial form

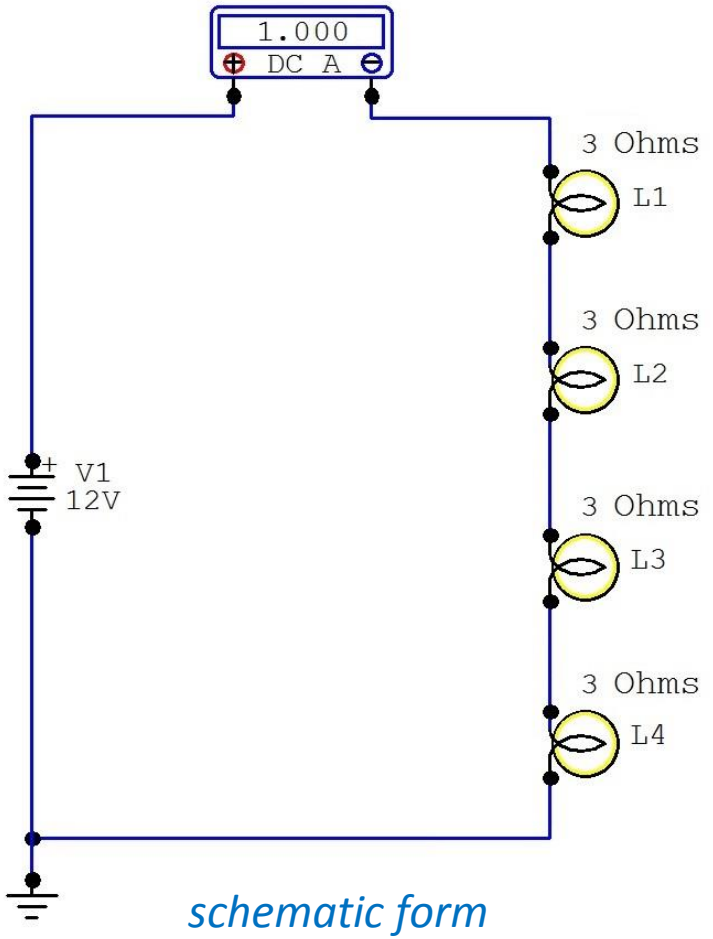
Note that we omitted the switch this time. Unless we are talking about something that is particular to turning on the circuit we'll omit the switch.

Four, 3 Volt, 3Ω, lamps connected "end-to-end" to form a single path for current.

Series Circuit (cont'd):

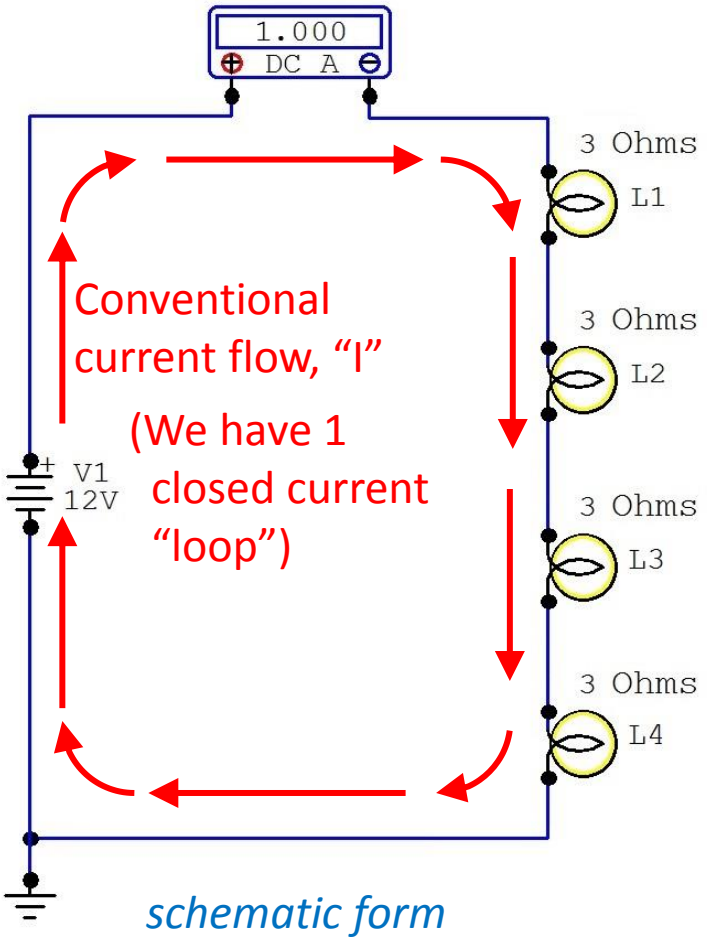


pictorial form



schematic form
(from circuit simulator)

Series Circuit (cont'd):



schematic form

(circuit simulator program)

Here we have the schematic representation of our circuit with four lamps connected "end-to-end" or in *series*.

Since our current passes through each of the four lamps, it is affected by each lamp's resistance. The total resistance experienced by our current, I, is therefore:

$$R_{Total} = 3\Omega + 3\Omega + 3\Omega + 3\Omega = 12\Omega$$

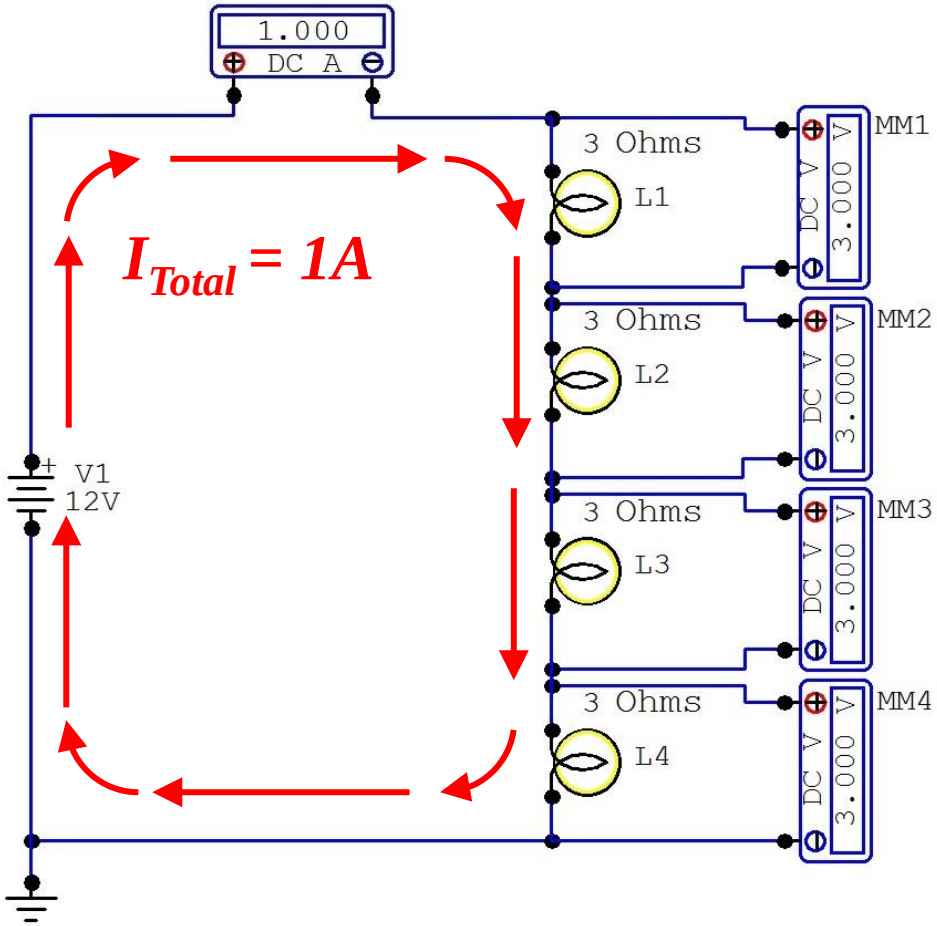
$$R_{Total} = 12\Omega$$

By *Ohm's Law*:

$$I_{Total} = \frac{V_{Total}}{R_{Total}} = \frac{12V}{12\Omega} = 1A$$

Notice that the ammeter in our simulation reads 1 Ampere (1 A).

Series Circuit (cont'd):



Let's look at our circuit again, this time with voltmeters across each of the four lamps.

What voltage should be present across each lamp?

Back in slide 16 we learned:

Ohm's Law:

$$V = IR$$

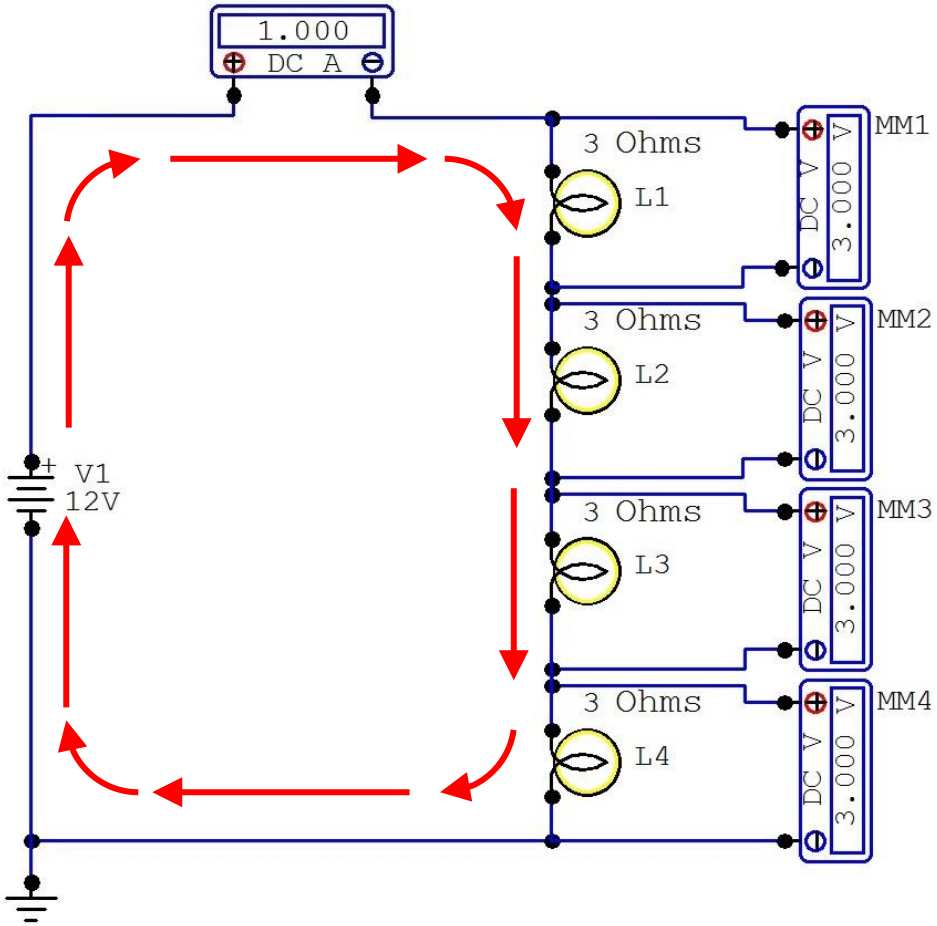
The current through each lamp is the same as the total current. The current must flow in a complete circuit and there are no "off ramps" for current to exit our system. So:

$$V_{lamp} = I_{lamp} \cdot R_{lamp}$$

$$V_{lamp} = I_{Total} \cdot R_{lamp}$$

$$V_{lamp} = 1A \cdot 3\Omega = 3V$$

Series Circuit (cont'd):



The voltage across every lamp in our circuit happens to be the same because the same I_{Total} flows through all of them and they all have the same resistance, R_{lamp}, and *V = IR (Ohm's Law)*.

Now just to close out this *series circuit*, let's see how the total voltage, V_{Total}, is "used up" in our circuit...

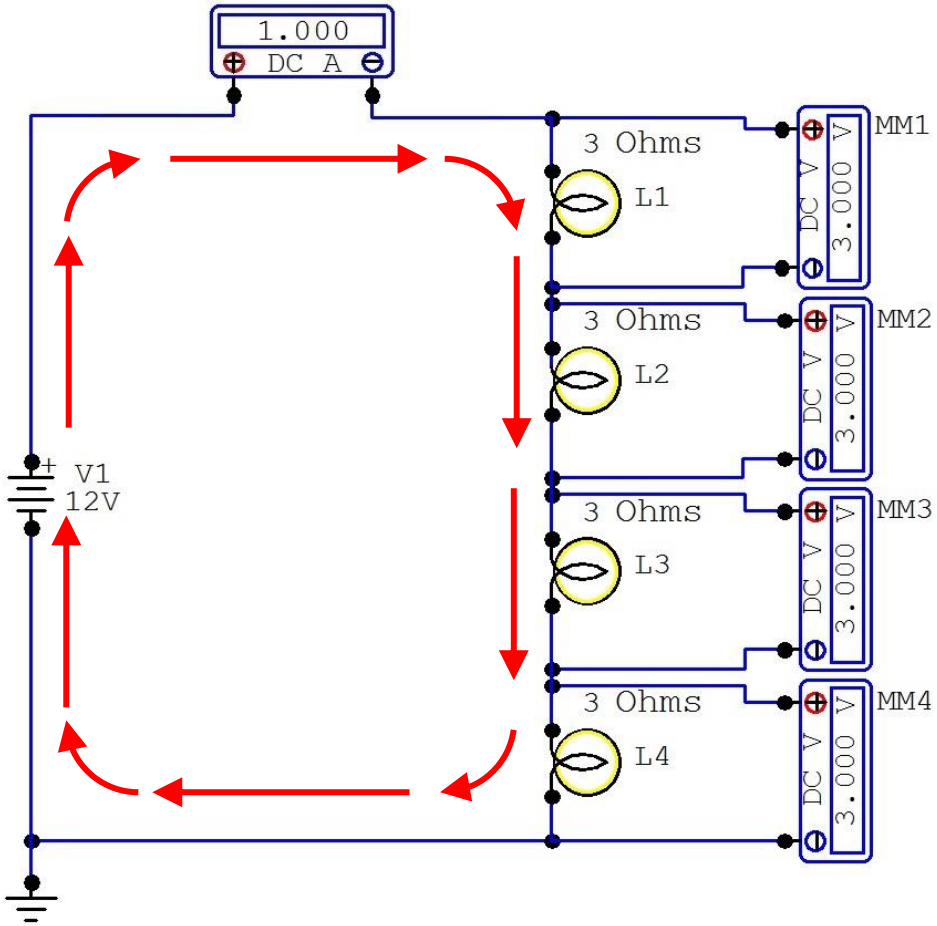
$$V_{Total} = V_{lamp_1} + V_{lamp_2} + V_{lamp_3} + V_{lamp_4}$$

$$12V = 3V + 3V + 3V + 3V$$

So all the voltages across our lamps add up to the supply voltage. The voltages across the lamps are called *voltage drops* and the supply voltage is called a voltage rise (more about this later).

The fact that the sum of all the voltage drops should equal the magnitude of the sum of all the voltage rises around a closed loop is called *Kirchhoff's Voltage Law* or *KVL*.

Series Circuit (cont'd):



The fact that the sum of all the voltage drops should equal the magnitude of the sum of all the voltage rises around a closed loop is called:

Kirchhoff's Voltage Law or *KVL*.

Some people count Voltage rises as negative (-) and voltage drops as positive (+) in which case the sum of all the voltage rises and drops around a given loop always equals zero. That is a more classical statement of the same law.

Voltage and Current Relation: Ohm's Law

MEMORIZE THE NEXT SLIDE!

(HINT: It's one simple formula written three ways)

Voltage and Current Relation: Ohm's Law

Voltage (Volts) = Current (I in Amps) * Resistance (Ohms)

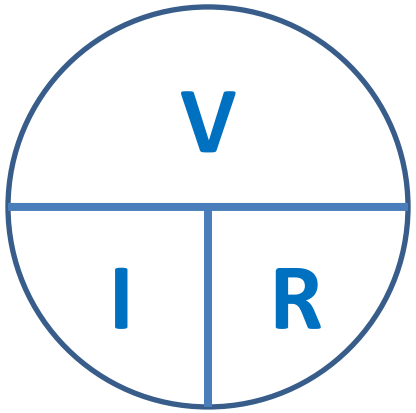
$$V = I \cdot R$$

Current (I in Amps) = Voltage (Volts) / Resistance (Ohms)

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

Resistance (Ohms) = Voltage (Volts) / Current (I in Amps)

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



In the figure above, cover over the quantity you want to find and you'll have the formula for that quantity.

Concepts and Vocabulary Review for Unit-04

By the end of this section you should have an introductory understanding of the following:

1. *Circuit*
    1. A connected arrangement of electronic parts which actually contains a number of closed-loop current paths.
        1. This is sometimes called “circuitry”.
    2. One complete closed-loop current path by itself or as part of a larger arrangement.
        1. This is sometimes called a “loop”.
2. *Circuit Elements (or Components)*
    1. These are the various electronic devices we connect to build our desired circuit.
3. *Pictorial wiring diagrams*
    1. Seldom used in industry, pictorial diagrams help people build electronic circuits by making component recognition and orientation more obvious.

Concepts and Vocabulary Review for Unit-04 (cont'd)

By the end of this section you should have an introductory understanding of the following:

4. *Schematic diagrams*
    1. Schematic diagrams are the most common industry (and hobbyist) method for describing an electronic system's circuitry.
    2. Schematic diagrams consist of: electrical symbols, wires, reference designators, labels, attributes, (many names), and general text.
5. *Computing current flow: Ohm's Law (first exposure)*
    1. **MEMORIZE Slide # 28**.
6. *Series circuits (first exposure)*.
    1. The current through every element in a series circuit is the same as the total current for the circuit (so find the I_{Total} first using V_{Total} divided by R_{Total}).
    2. *The voltages across each element in the series circuit add up to the total supply voltage. We call this Kirchhoff's Voltage Law or KVL.* (more about this later).

The End