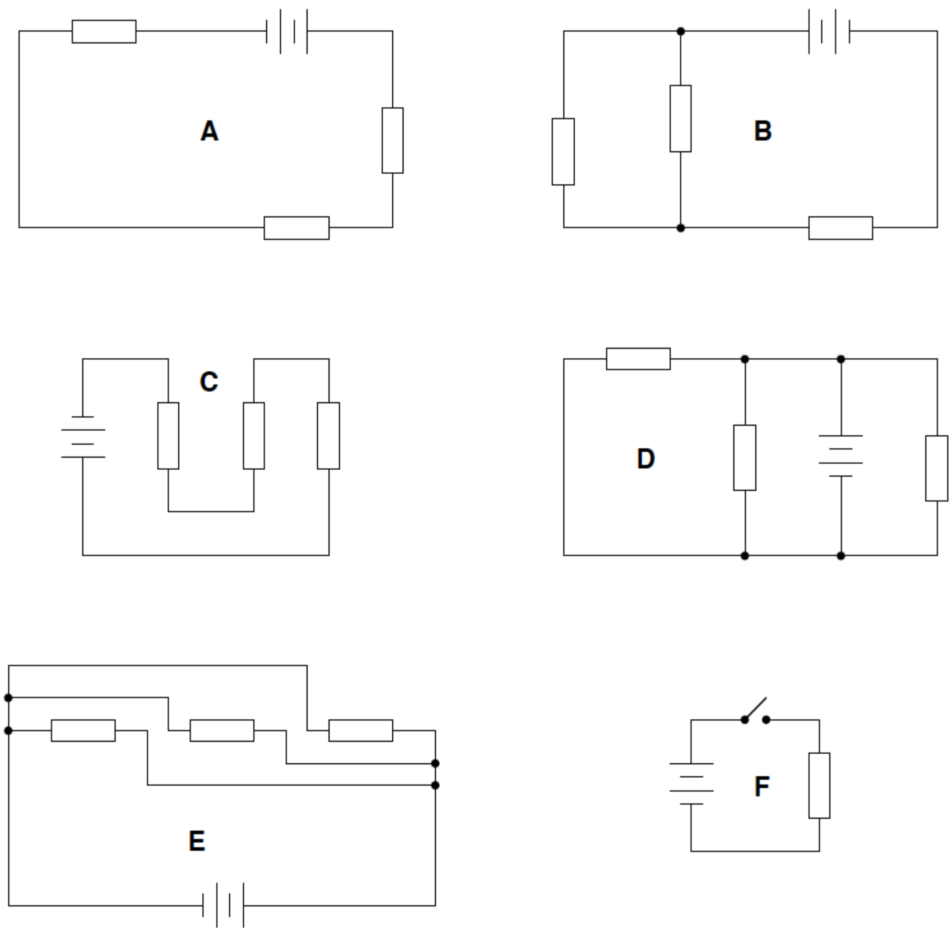
Series DC Circuits

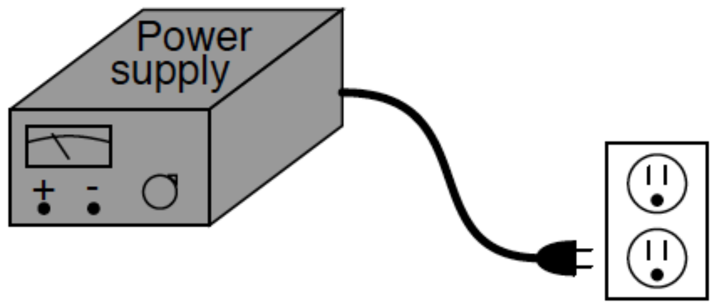
1)

Identify which of these circuits is a *series* circuit (there may be more than one shown!):



2) Most flashlights use multiple 1.5 volt batteries to power a light bulb with a voltage rating of several volts. Draw a schematic diagram of showing how multiple batteries may be connected to achieve a total voltage greater than any one of the batteries' individual voltages.

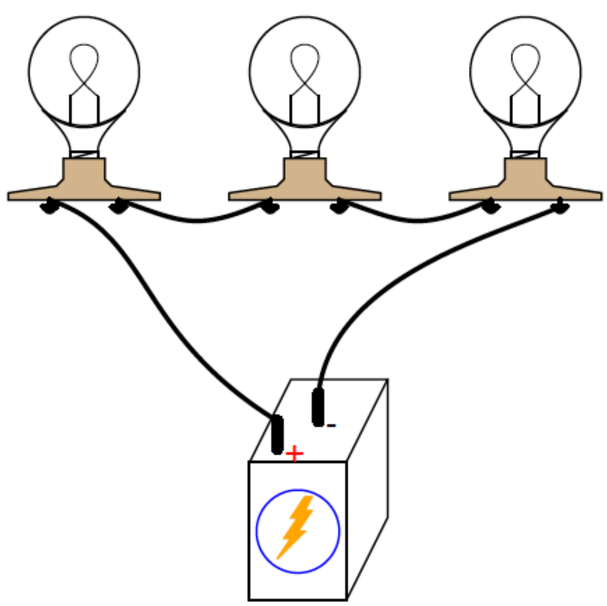
3) A technician wants to energize a 24 volt motor, but lacks a 24 volt battery to do it with. Instead, she has access to several ”power supply” units which convert 120 volt AC power from a power receptacle into low-voltage DC power that is adjustable over a range of 0 to 15 volts. Each of these power supplies is a box with a power cord, voltage adjustment knob, and two output terminals for connection with the DC voltage it produces:



Draw a picture of how this technician might use power supplies to energize the 24 volt motor.

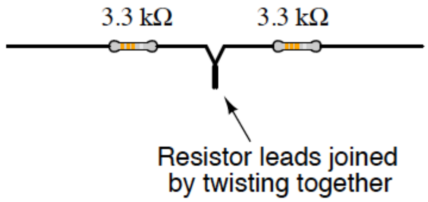
4)

Re-draw this circuit in the form of a schematic diagram:

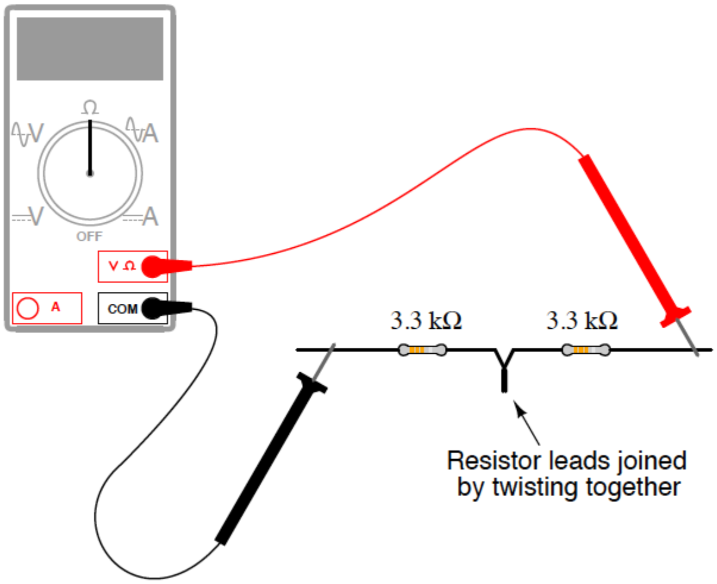


5)

Suppose I connect two resistors in series with one another, like this:

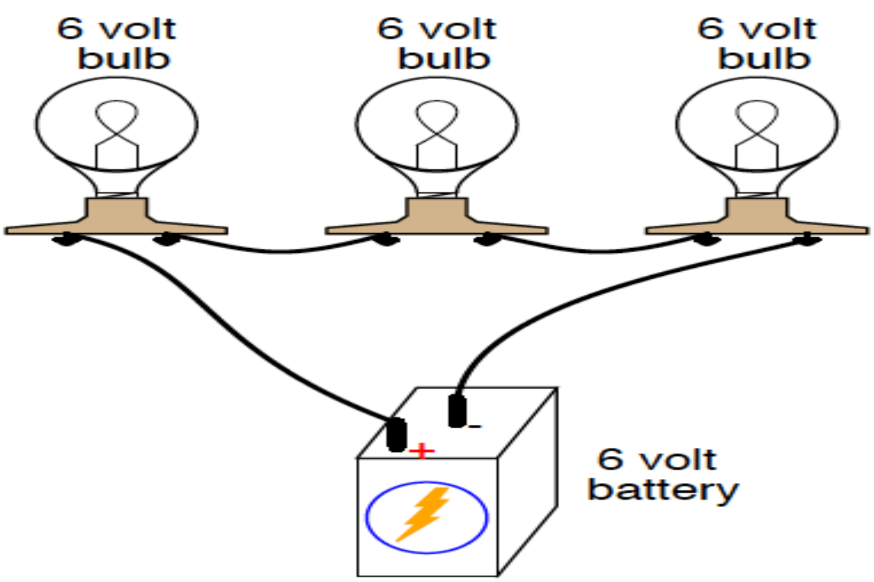


How much electrical resistance would you expect an ohmmeter to indicate if it were connected across the combination of these two series-connected resistors?



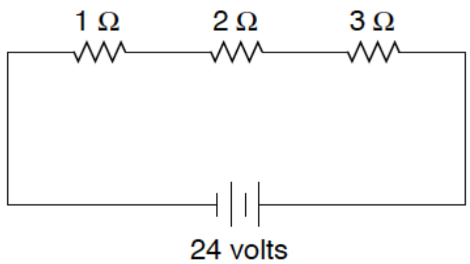
Explain the reasoning behind your answer, and try to formulate a generalization for all combinations of series resistances.

6) Qualitatively compare the voltage and current for each of the three light bulbs in this circuit (assume the three light bulbs are absolutely identical):



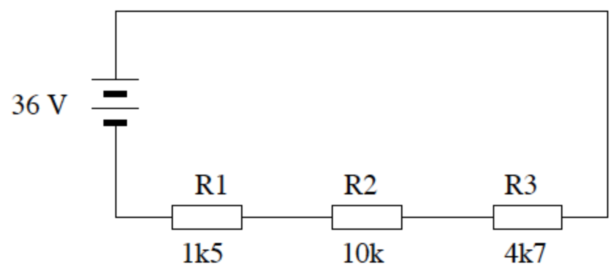
7)

In this circuit, three resistors receive the same amount of current (4 amps) from a single source. Calculate the amount of voltage "dropped" by each resistor, as well as the amount of power dissipated by each resistor:



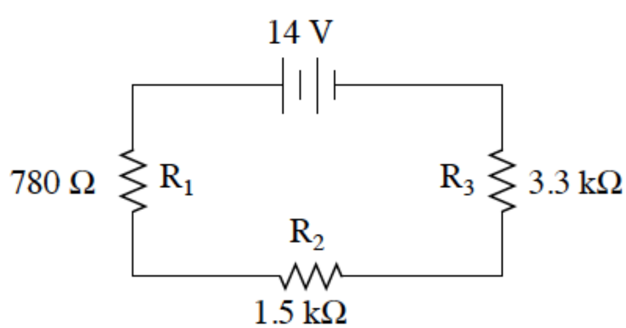
8)

Explain, step by step, how to calculate the amount of current (I) that will go through each resistor in this series circuit, and also the voltage (V) dropped by each resistor:



9)

Complete the table of values for this circuit:

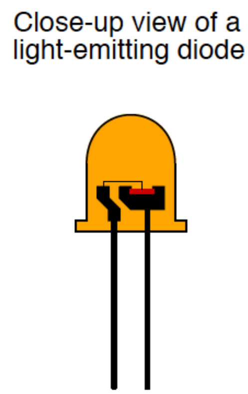


	R_1	R_2	R_3	Total
V				
I				
R	780 Ω	1.5 kΩ	3.3 kΩ	
P				

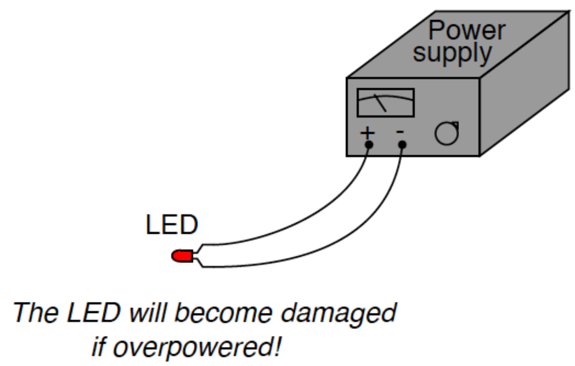
10) In a series circuit, certain general rules may be stated with regard to quantities of voltage, current, resistance, and power. Express these rules, using your own words:
"In a series circuit, voltage . . ."
"In a series circuit, current . . ."
"In a series circuit, resistance . . ."
"In a series circuit, power . . ."

11)

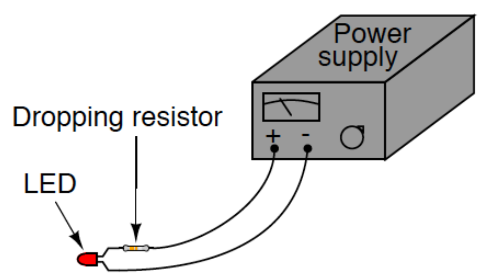
Light-emitting diodes, or *LEDs*, are rugged and highly efficient sources of light. They are far more rugged and efficient than incandescent lamps, and they also have the ability to switch on and off much faster because there is no filament inside needing to heat or cool:



LEDs are low voltage devices, typically rated in the range of 1.5 to 2 volts DC maximum. Single diodes generally draw low currents as well, about 20 milliamps each. The problem is, how do you operate an LED from a typical electronic power source, which may output 24 volts DC or more?



The answer is to use a *series dropping resistor*:



Calculate the necessary resistance value and minimum power rating of a series dropping resistor for an LED rated at 1.7 volts and 20 mA, and a power supply voltage of 24 volts.

12) Calculate the necessary series "dropping" resistor value to operate a 1.6 volt, 20 mA LED from a 15 volt DC power source. Also, calculate the power dissipated by the resistor while operating.

R = $\qquad$ P_R =

13) Calculate the necessary series "dropping" resistor value to operate a 1.8 volt, 20 mA LED from a 34 volt DC power source. Also, calculate the power dissipated by the resistor while operating.

R = $\qquad$ P_R =

14) The formula for calculating total resistance of three series-connected resistors is as follows:

$R = R_1 + R_2 + R_3$

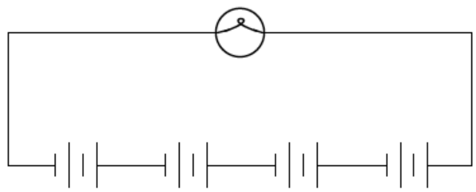
Algebraically manipulate this equation to solve for one of the series resistances (R_1) in terms of the other two series resistances (R_2 and R_3) and the total resistance (R). In other words, write a formula that solves for R_1 in terms of all the other variables.

Answer Key

Answer 1

Circuits **A**, **C**, and **F** are *series* circuits.

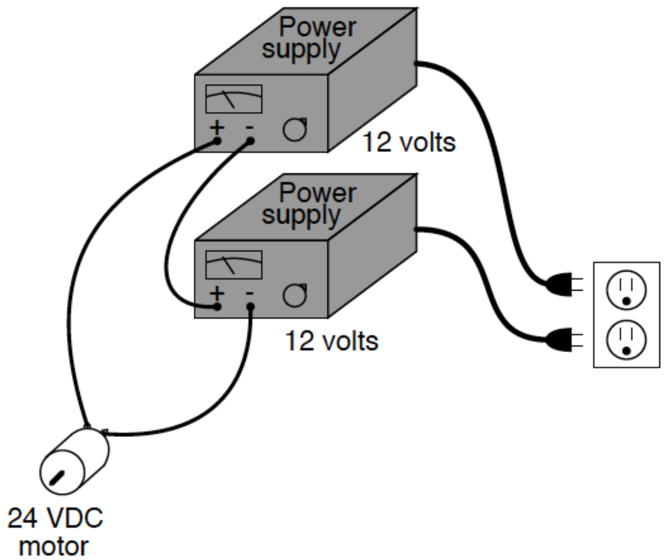
Answer 2



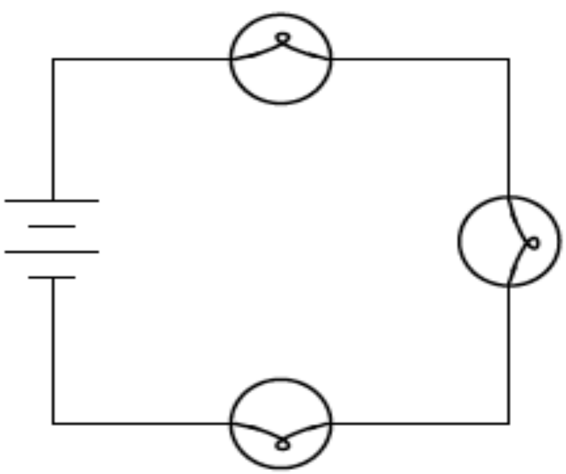
Follow-up question: if each of these batteries outputs a voltage of 1.5 volts, how much voltage does the light bulb experience?

Answer 3

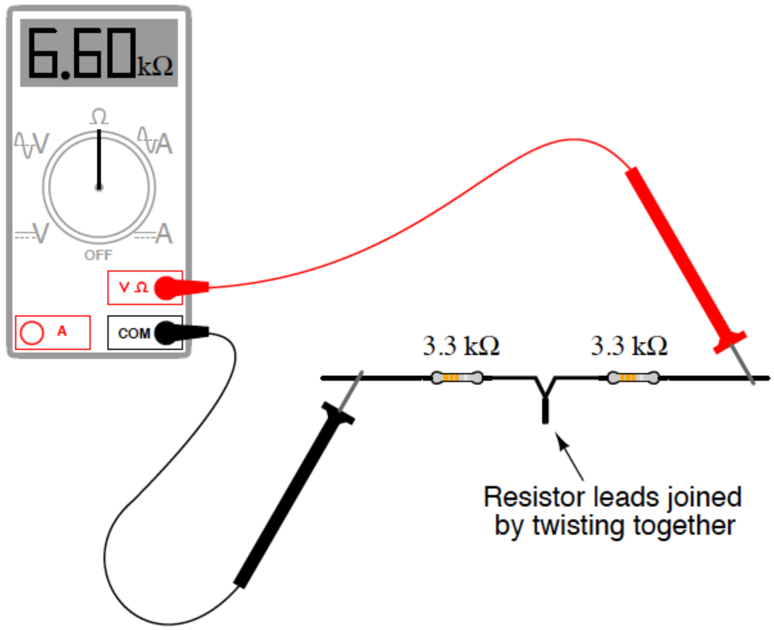
This is perhaps the most direct solution (setting each power supply to output 12 volts):



Answer 4



Answer 5)



Follow-up question: how much resistance would you expect the ohmmeter to register if there were *three* similarly-sized resistors connected in series instead of two? What if there were *four* resistors?

Answer 6)
The current through each of the lights bulbs is guaranteed to be equal. The voltage across each of the light bulbs, in this particular case (with identical bulbs), happens to be equal.

Answer 7)
$\mathbf{E}_1$ = 4 volts
$\mathbf{E}_2$ = 8 volts
$\mathbf{E}_3$ = 12 volts
$\mathbf{P}_1$ = 16 watts
$\mathbf{P}_2$ = 32 watts
$\mathbf{P}_3$ = 48 watts

Answer 8)
$\mathbf{I}_{R1}$ = 2.22 mA ; $\mathbf{V}_{R1}$ = 3.33 V
$\mathbf{I}_{R2}$ = 2.22 mA ; $\mathbf{V}_{R2}$ = 22.2 V
$\mathbf{I}_{R3}$ = 2.22 mA ; $\mathbf{V}_{R3}$ = 10.4 V

Answer 9)

	R_1	R_2	R_3	Total
V	1.957 V	3.763 V	8.280 V	14 V
I	2.509 mA	2.509 mA	2.509 mA	2.509 mA
R	780 Ω	1.5 kΩ	3.3 kΩ	5.58 kΩ
P	4.910 mW	9.442 mW	20.77 mW	35.13 mW

Answer 10) **"In a series circuit, voltage** drops add to equal the total.**"**
"In a series circuit, current is equal through all components.**"**
"In a series circuit, resistances add to equal the total.**"**

Answer 11) $\mathbf{R}_{dropping}$ = 1115 ohms, with a power rating of at least 0.446 watts (1/2 watt would be ideal).

Answer 12) R = 670 P_R = 0.268 W

Answer 13) R = 1.61 k P_R = 0.644 W

Answer 14) $\mathbf{R}_1 = \mathbf{R} - (\mathbf{R}_2 + \mathbf{R}_3)$ or $\mathbf{R}_1 = \mathbf{R} - \mathbf{R}_2 - \mathbf{R}_3$