DC Series Circuits

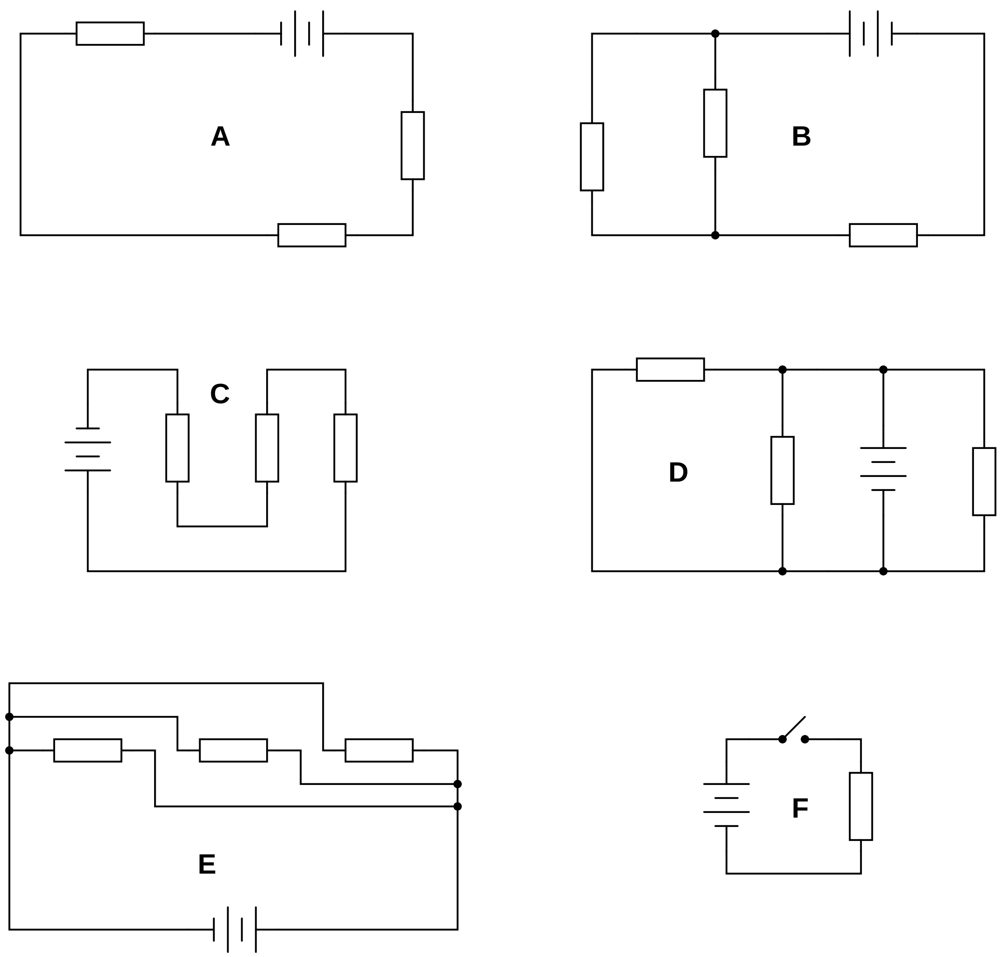
These worksheets are a required part of the course in Digital Electronics. They are also available at the course website, http://frontiernet.net/ hsweet/

Name...

Questions

Question 1

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



file 01717

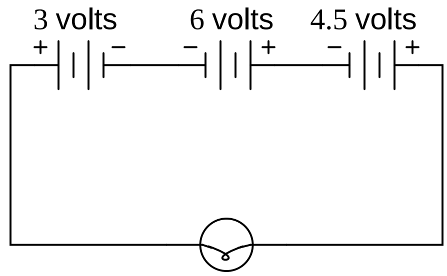
Question 2

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.

file 00038

Question 3

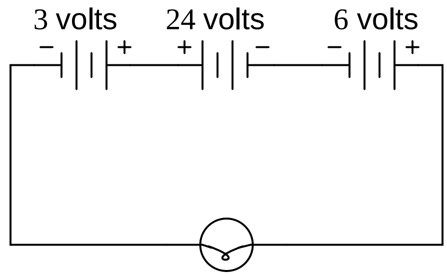
How much voltage does the light bulb receive in this circuit? Explain your answer.



Also, identify the polarity of the voltage across the light bulb (mark with "+" and "-" signs).
file 01719

Question 4

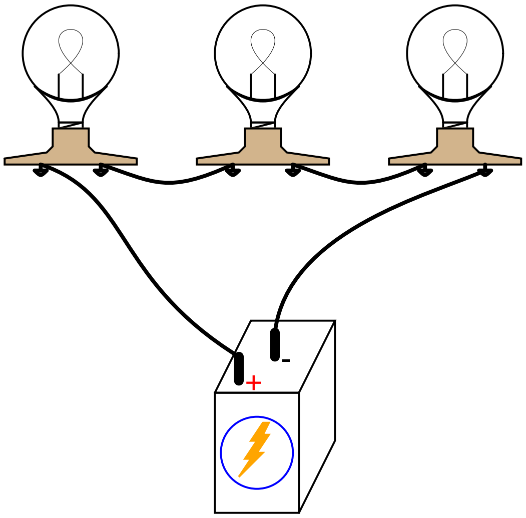
How much voltage does the light bulb receive in this circuit? Explain your answer.



Also, identify the polarity of the voltage across the light bulb (mark with "+" and "-" signs).
file 01720

Question 5

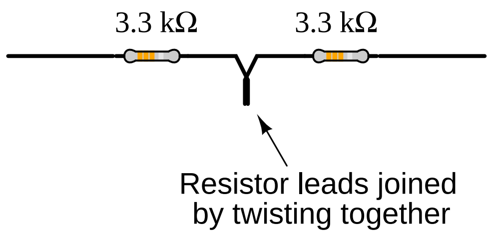
Re-draw this circuit in the form of a schematic diagram:



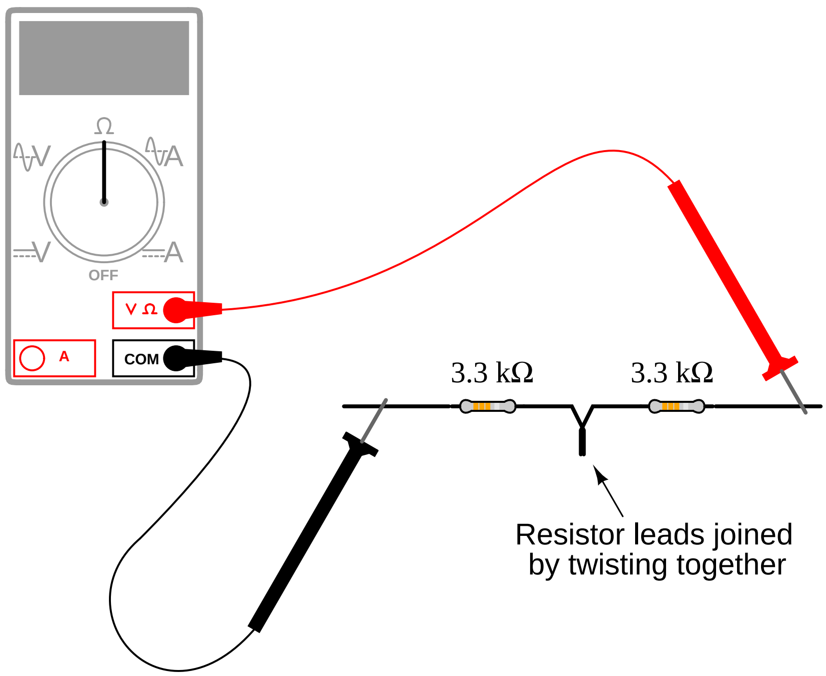
file 00068

Question 6

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?

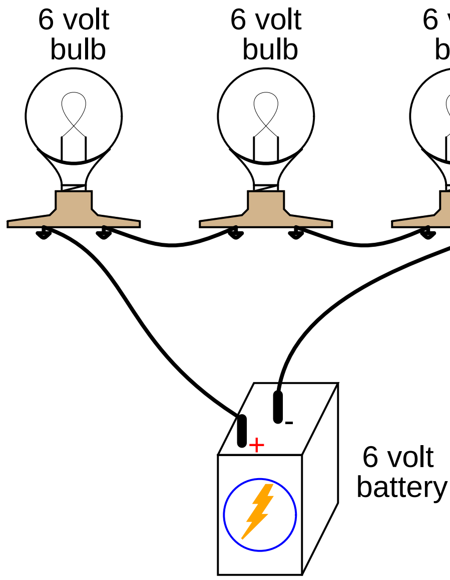


Explain the reasoning behind your answer, and try to formulate a generalization for all combinations of series resistances.

file 01721

Question 7

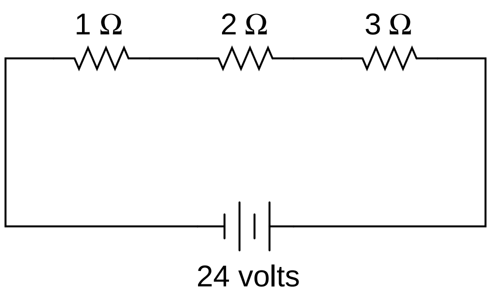
What would happen if three 6-volt light bulbs were connected as shown to a 6-volt battery? How would their brightnesses compare to just having a single 6-volt light bulb connected to a 6-volt battery?



file 00035

Question 8

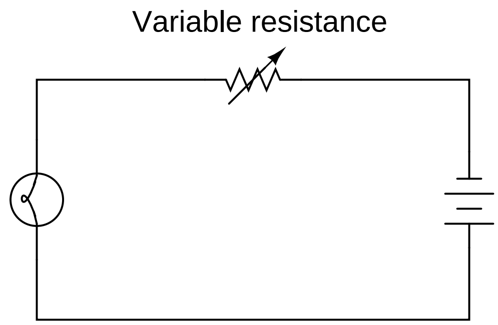
In this circuit, four resistors receive the same amount of current (4 amps) from a single source. Calculate the amount of voltage "dropped" by each resistor, as well as the amount of power dissipated by each resistor:



file 00090

Question 9

The brightness of a light bulb – or the power dissipated by any electrical load, for that matter – may be varied by inserting a variable resistance in the circuit, like this:

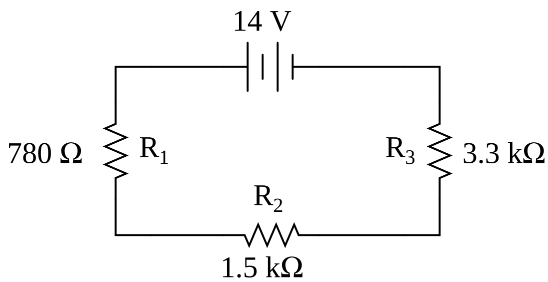


This method of electrical power control is not without its disadvantages, though. Consider an example where the circuit current is 5 amps, the variable resistance is 2 Ω, and the lamp drops 20 volts of voltage across its terminals. Calculate the power dissipated by the lamp, the power dissipated by the variable resistance, and the total power provided by the voltage source. Then, explain why this method of power control is not ideal.

file 00104

Question 10

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				

file 01957

Question 11

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 . . ."

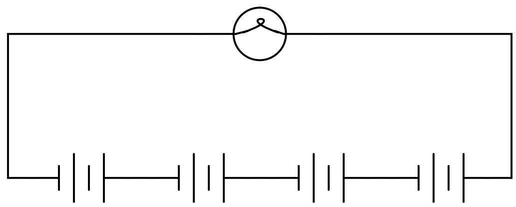
"In a series circuit, power . . ."

For each of these rules, explain *why* it is true.
file 00291

Answer 1

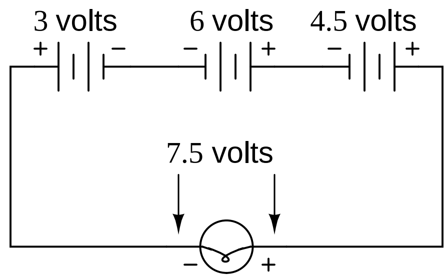
Circuits **A**, **C**, and **F** are *series* circuits.

Answer 2



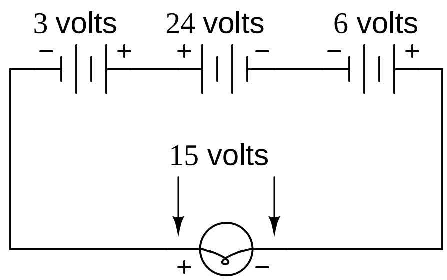
Follow-up question: if each of these batteries outputs a voltage of 1.5 volts, how much voltage does the light bulb experience?

Answer 3



Follow-up question: draw the direction of current in this circuit.

Answer 4



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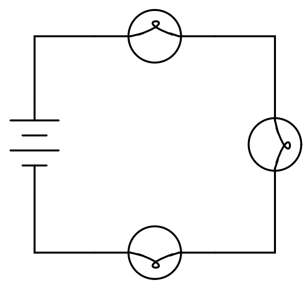
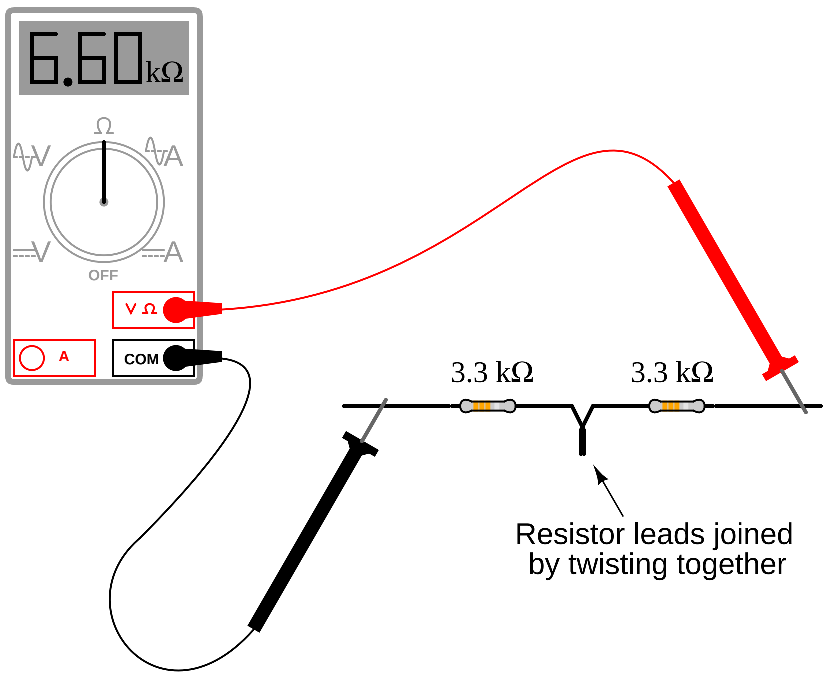


Answer 6



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 7

The three light bulbs would glow dimly.

Answer 8

$E_{1\Omega} = 4$ volts
$E_{2\Omega} = 8$ volts
$E_{3\Omega} = 12$ volts

$P_{1\Omega} = 16$ watts
$P_{2\Omega} = 32$ watts
$P_{3\Omega} = 48$ watts

Answer 9

$P_{lamp} = 100$ watts
$P_{resistance} = 50$ watts
$P_{total} = 150$ watts

Answer 10

	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 11

"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, resistance*s add to equal the total.*"

"In a series circuit, power *dissipations add to equal the total.*"

Notes 1

The purpose of this question is to get students to identify what distinguishing characteristic uniquely identifies a circuit as being "series." Once this has been identified, there are several conclusions which may be deduced (regarding voltage drops, currents, resistances, etc.).

Circuit **F** is thrown in the mix just to show students that the non-battery components don't have to all be the same (resistors) in order for a circuit to qualify as "series."

Notes 2

Ask the students where they would place a switch to control the light bulb in the circuit shown in the answer.

Notes 3

This is a very fundamental concept that students must learn: how to determine the total voltage in a series circuit where opposing voltage sources exist. One thing mistake students sometimes make is to try to discern polarity by looking at the polarity signs at the end terminals of the end battery; i.e. at the 3-volt battery's left-hand terminal, and the 4.5-volt battery's right-hand terminal, then try to transfer those signs down to the load terminals. This is *not* an accurate way to tell polarity, but it seems to "work" for them in some situations. This problem is one example of a situation where this faulty technique most definitely does not work!

Have your students collectively agree on a procedure they may use to accurate discern series voltage sums and polarities. Guide their discussion, helping them identify principles that are true and valid for all series circuits.

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Notes 5

One of the more difficult skills for students to develop is the ability to translate the layout of a real-world circuit into a neat schematic diagram. Developing this skill requires lots of practice.

It is very worthwhile for students to discuss how they solve problems such as these with each other. For those students who have trouble visualizing shapes, a simple hint or "trick" to use when translating schematics to illustrations or visa-versa may be invaluable.

Notes 6

The concept of series (total) resistance, in relation to individual resistances, usually does not present any difficulties to new students. Parallel resistances are a bit trickier, though . . .

Notes 7

Here, the important principle of voltage "drops" in a series circuit is highlighted. This question serves to further define, in practical ways, what the term "series" really means.

Notes 8

The answers to this question should not create any surprises, especially when students understand electrical resistance in terms of *friction*: resistors with greater resistance (more friction to electron motion) require greater voltage (push) to get the same amount of current through them. Resistors with greater resistance (friction) will also dissipate more power in the form of heat, given the same amount of current.

Another purpose of this question is to instill in students' minds the concept of components in a simple series circuit all sharing the same amount of current.

Challenge your students to recognize any mathematical patterns in the respective voltage drops and power dissipations. What can be said, mathematically, about the voltage drop across the 2 Ω resistor versus the 1 Ω resistor, for example?

Notes 9

Discuss the concept of energy conservation: that energy can neither be created nor destroyed, but merely changed between different forms. Based on this principle, the sum of all power dissipations in a circuit must equal the total amount of power supplied by the energy source, regardless of how the components are connected together.

Notes 10

Discuss with your students what a good procedure might be for calculating the unknown values in this problem, and also how they might check their work.

Notes 11

Rules of series and parallel circuits are very important for students to comprehend. However, a trend I have noticed in many students is the habit of memorizing rather than understanding these rules. Students will work hard to memorize the rules without really comprehending *why* the rules are true, and therefore often fail to recall or apply the rules properly.

An illustrative technique I have found very useful is to have students create their own example circuits in which to test these rules. Simple series and parallel circuits pose little challenge to construct, and therefore serve as excellent learning tools. What could be better, or more authoritative, than learning principles of circuits from real experiments? This is known as *primary research*, and it constitutes the foundation of scientific inquiry. The greatest problem you will have as an instructor is encouraging your students to take the initiative to build these demonstration circuits on their own, because they are so used to having teachers simply *tell* them how things work. This is a shame, and it reflects poorly on the state of modern education.