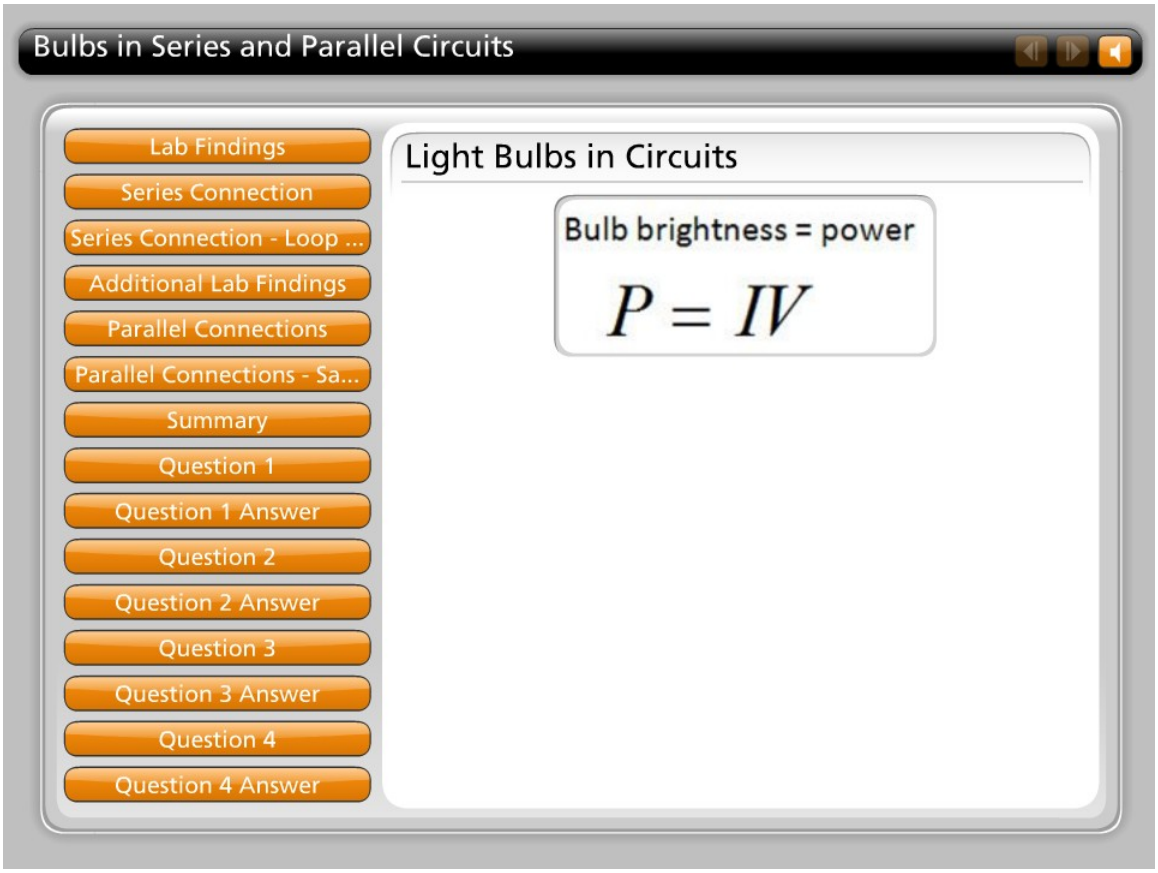
Module 7: Electricity - Electric Charge and Current
Topic 2 Content: Bulb in Series and Parallel Circuits Presentation Notes



In this practice, you will review the relationships between current, voltage and resistance that you explored in the lab activities. Light bulbs were used in this activity because they give a visual indication of the rate power the light bulb consumes. From the previous topic, you probably remember that power is equal to the product of current and voltage. So the bulb brightness is a visual indicator of current and voltage. Comparing bulb brightness in circuits lets us compare the current and voltage.

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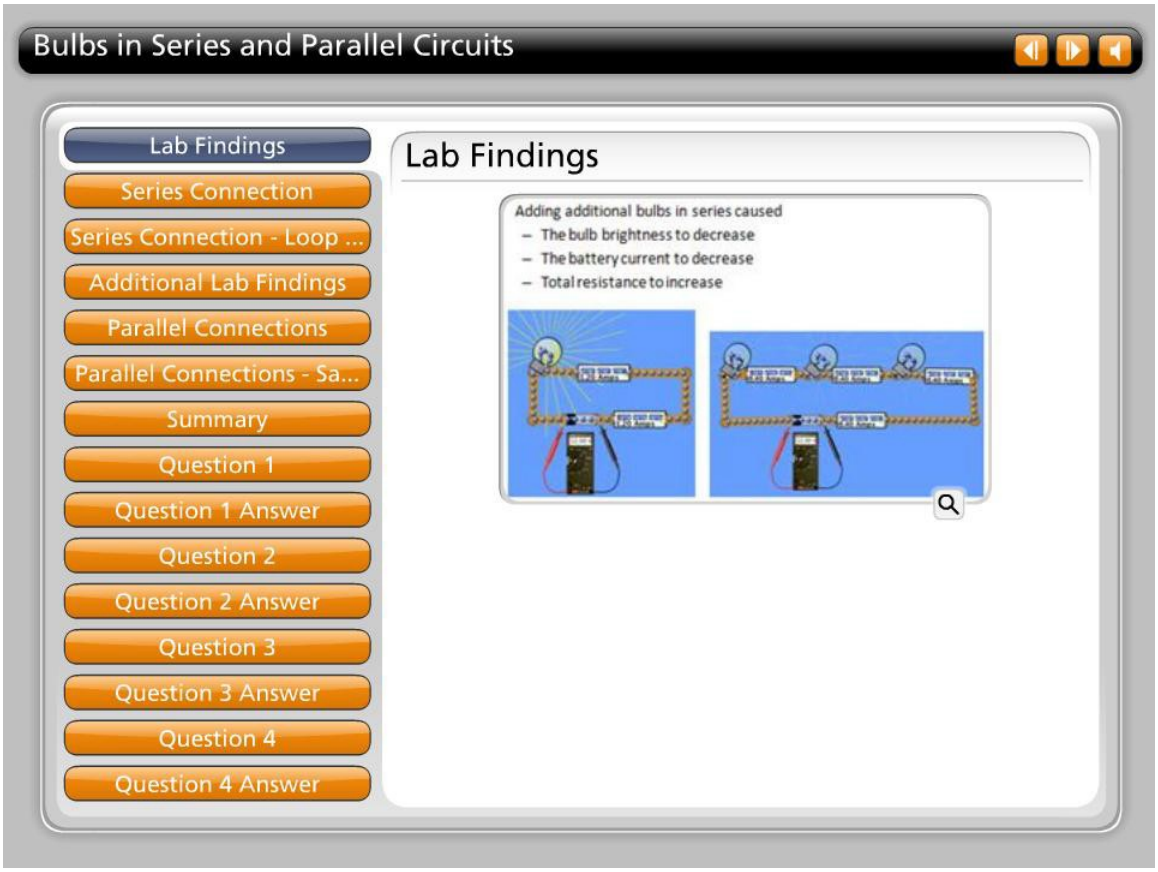

In the simulation, you added one bulb at a time to the circuit and observed the effects. You should have seen that adding additional bulbs in series caused the bulb brightness to decrease and the battery current to decrease. Why did these effects occur?

Each bulb gets less voltage (the battery voltage is shared across multiple bulbs) so less energy is available to be converted to light. Adding bulbs makes the circuit longer, increasing resistance.

By Ohm's Law, current is equal to voltage divided by resistance. So, if the battery voltage is kept the same, and the resistance increases, less current is delivered by the bulb.

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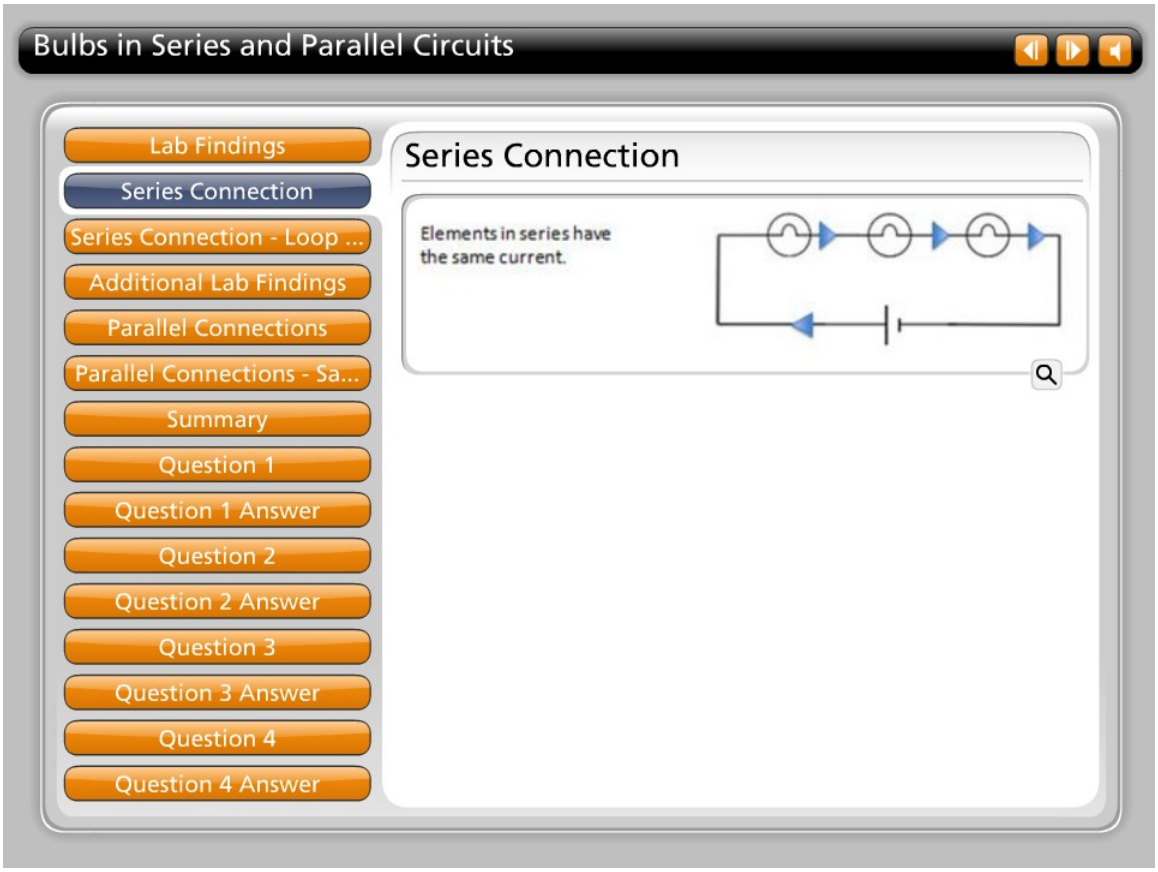

When elements are connected in series, all the current that goes through one must go through the other. In this circuit, each bulb will have the same current as the battery because they are all in series. In this circuit, all of the currents will be the same.

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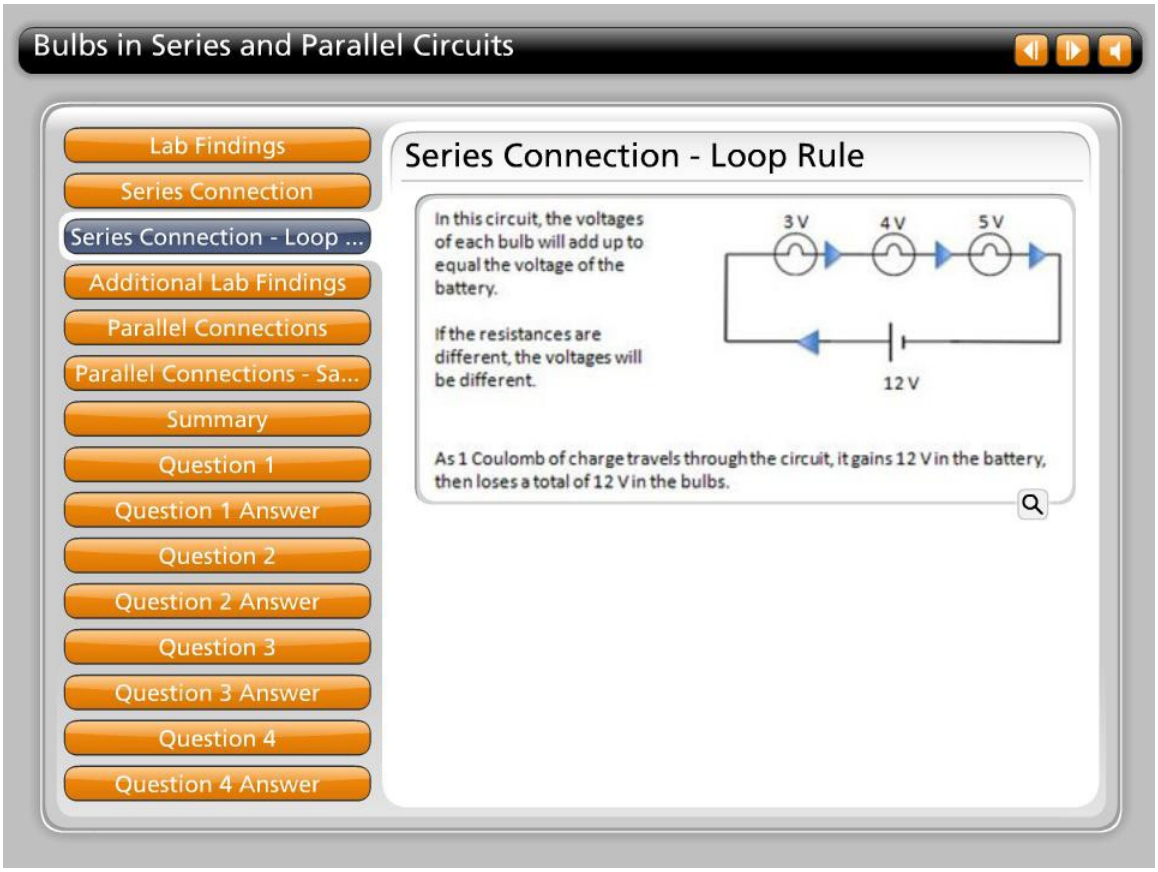

When elements are connected in series, the voltages will add up to the voltage of the source. In this circuit, each charge gains 12 volts as it goes through the battery, and then loses a total of twelve volts as it goes through the bulbs, returning to its original voltage. In this case, each bulb has the same current, but different voltages. The bulb in this circuit with the biggest voltage would be the brightest.

This idea that the sum of the voltage drops must equal the voltage gain in a circuit is called Kirchoff's Loop Rule. This rule is related to conservation of energy. It sets energy losses equal to energy gains for the charges moving through the circuit.

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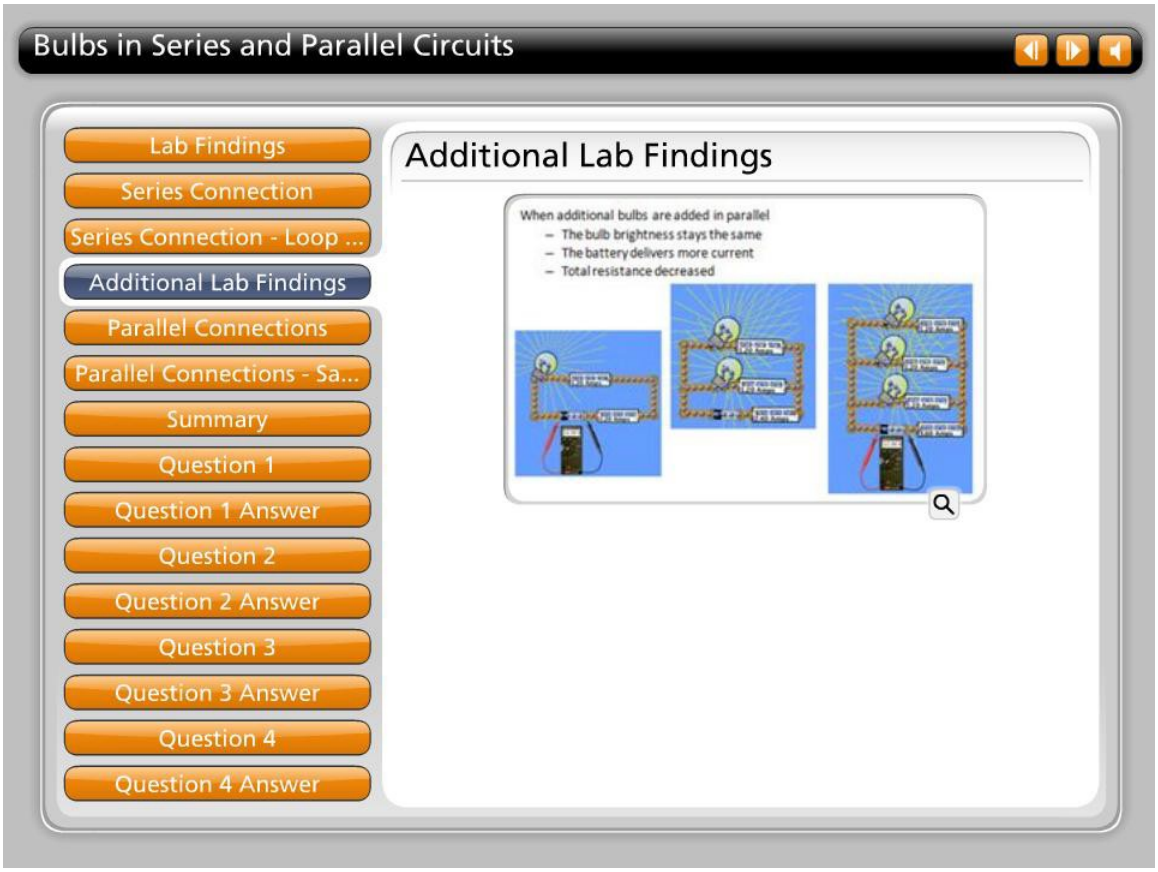
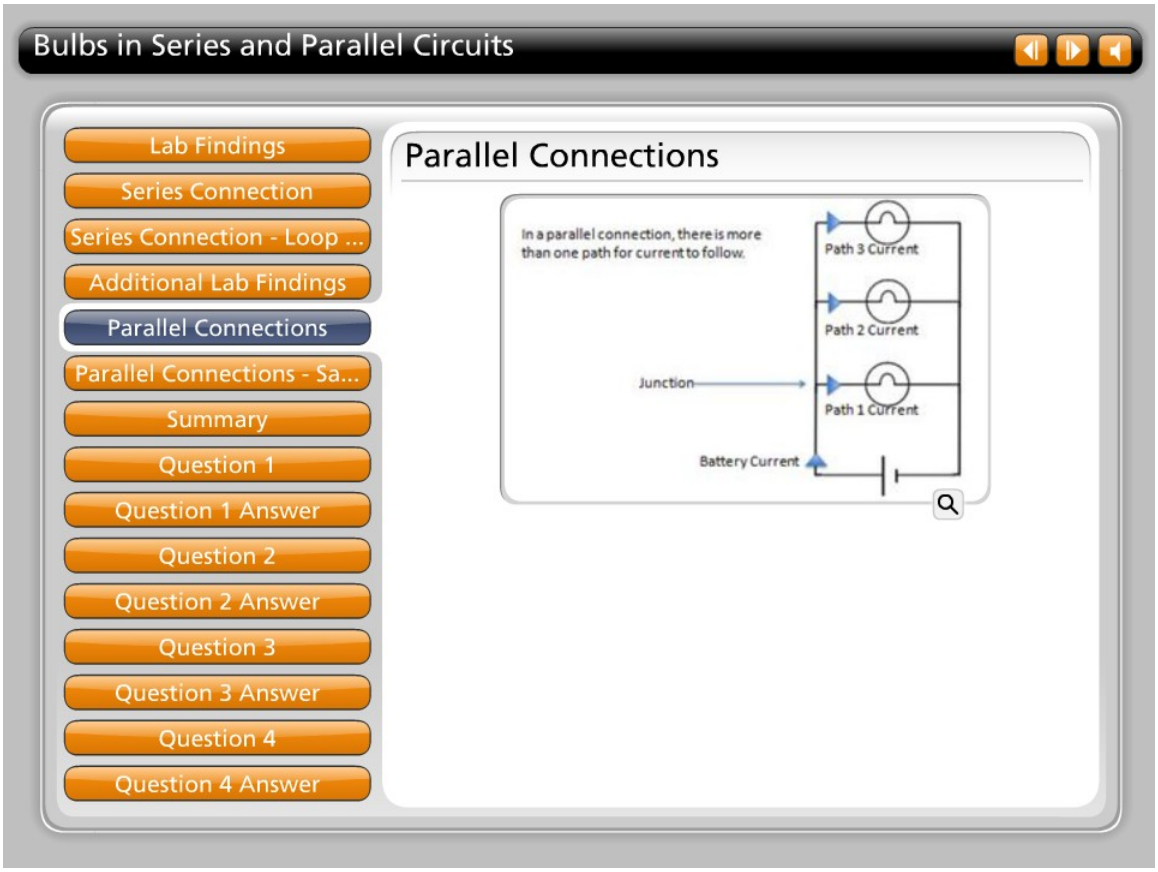


When additional bulbs are added in parallel, the bulb brightness stays the same. Each bulb is connected across the battery terminals. Each bulb gets the full battery voltage, so they are equally bright. However, the battery delivers more current. Looking at the three different circuits, you can see that the battery delivers one point two amps with one bulb, two point four amps with two bulbs and three point six amps with three bulbs. Why does this happen? Adding additional bulbs in parallel increases the area for current flow, decreasing resistance. By Ohm's Law, current is voltage divided by resistance. When voltage is constant and resistance decreases, current increases.

Parallel circuits are used in your home. Most electrical fixtures and outlets in your home are at one hundred and twenty volts. They are wired in parallel. Every time you turn on another appliance in your home, more current is drawn. This could create a dangerous situation if too much current is drawn at once, so circuit breakers are used to limit the amount of current. Most circuit breakers in your house are set at twenty amps. The circuit breaker opens the circuit if the current exceeds the set value.



Elements that are connected in parallel have the same voltage, even if the resistances are different. In this circuit, each bulb has the same voltage as the battery. If the resistances are different the current through each branch will be different. The branch with the least resistance will get the most current, since current likes to follow the path of least resistance. Since power is equal to current times voltage, the bulb in this circuit with the largest current will be the brightest. If the bulbs are identical, they will be equally bright.

You might have noticed that for any loop, the voltage gain in the battery is equal to the voltage drop across the bulb. Charges can only follow one of the three paths as they go around the circuit. No matter which path they take, the voltage drop must be equal to the voltage gain.

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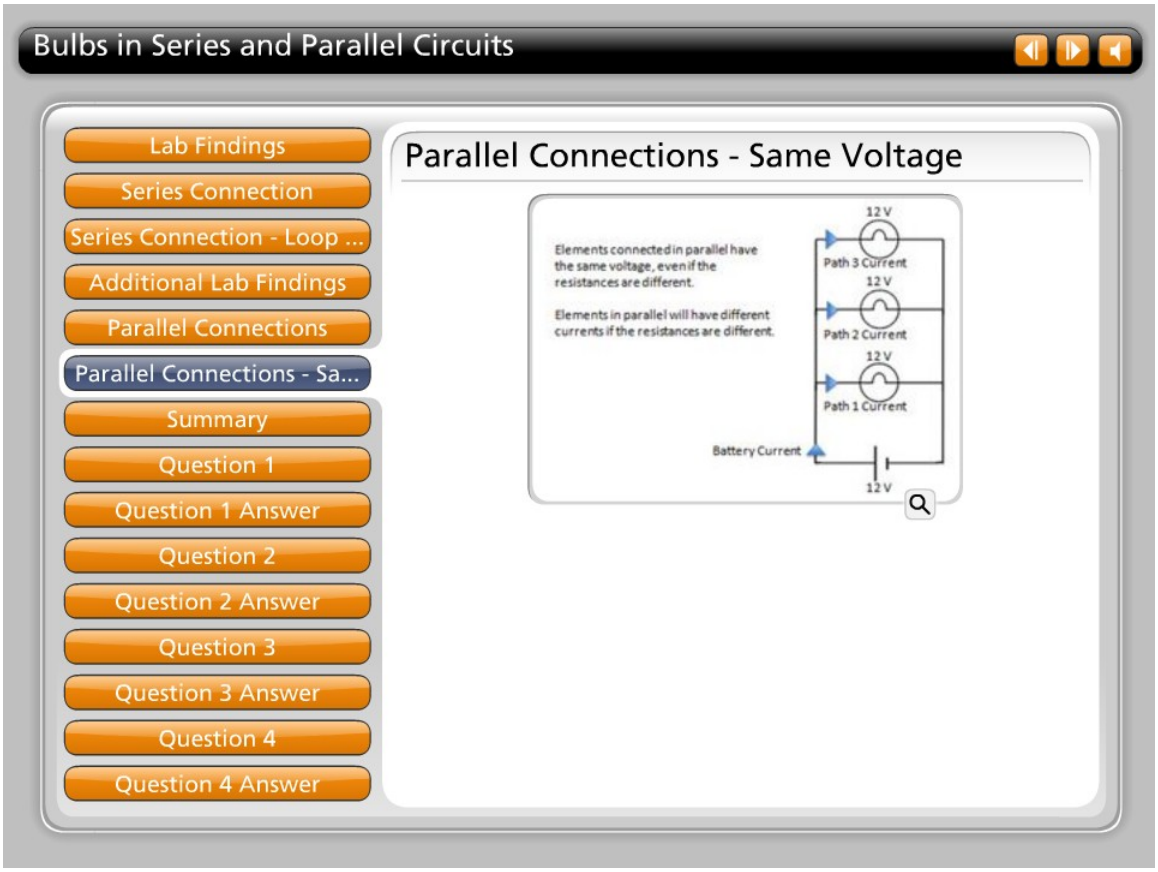

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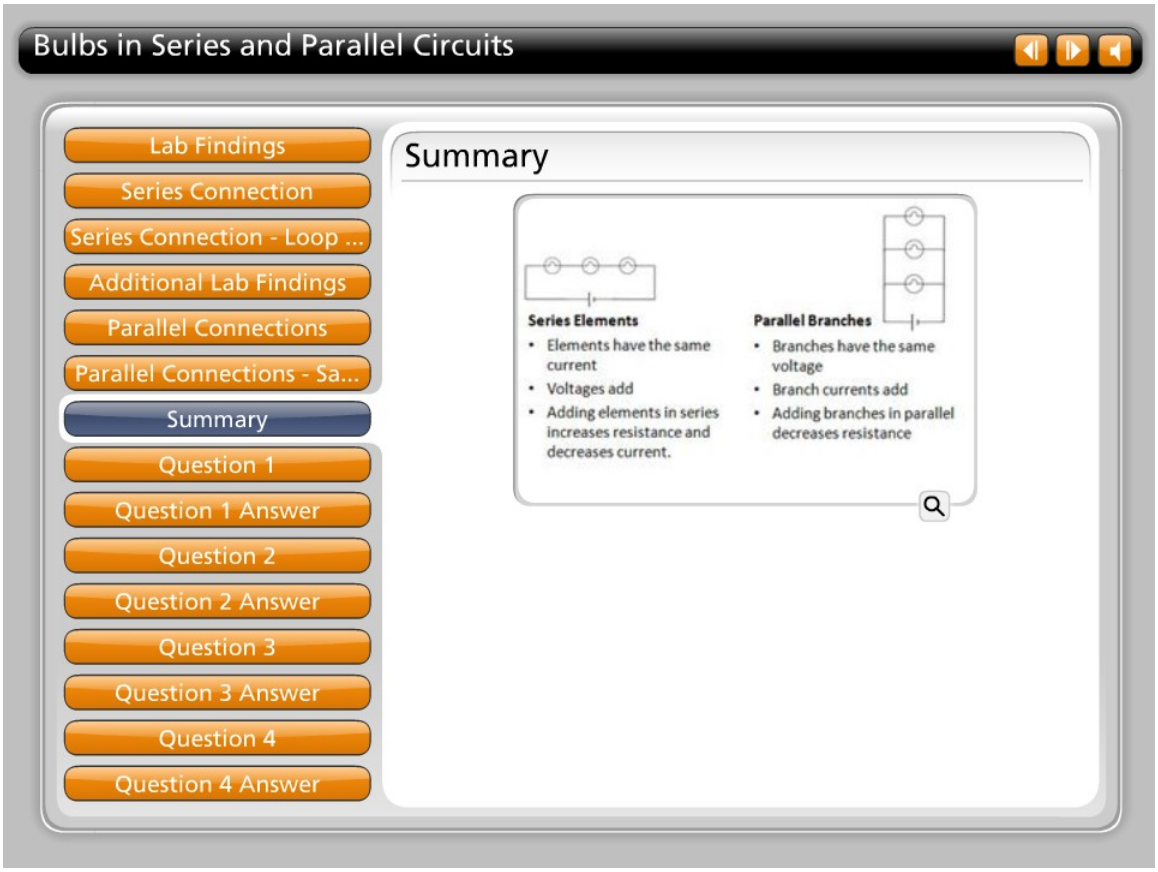
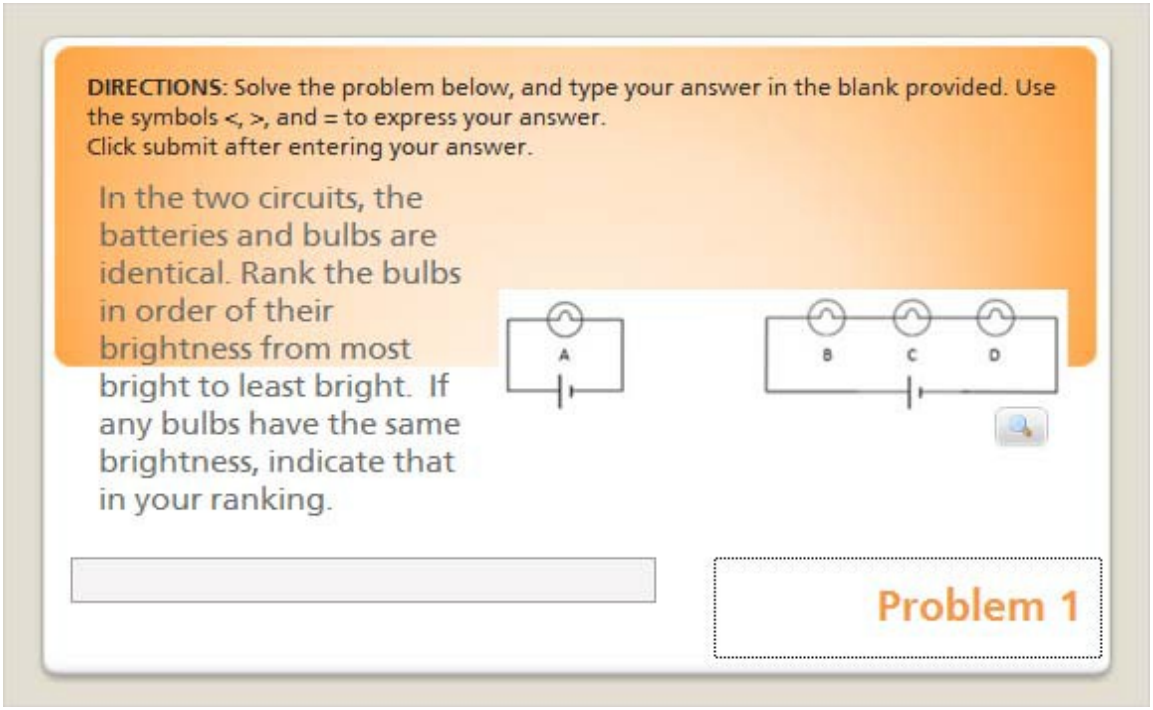


From the simulation activity you have learned some important ideas about series and parallel connections. Light bulbs give a visual indication of the current through the bulb and the voltage across the bulb.

Each element in series has the same current. As charges travel through a series circuit, the voltage drops add up. The total of the voltage drops in a circuit should equal the voltage gain of the battery. Adding elements in series increases the total resistance and causes the battery current to decrease.

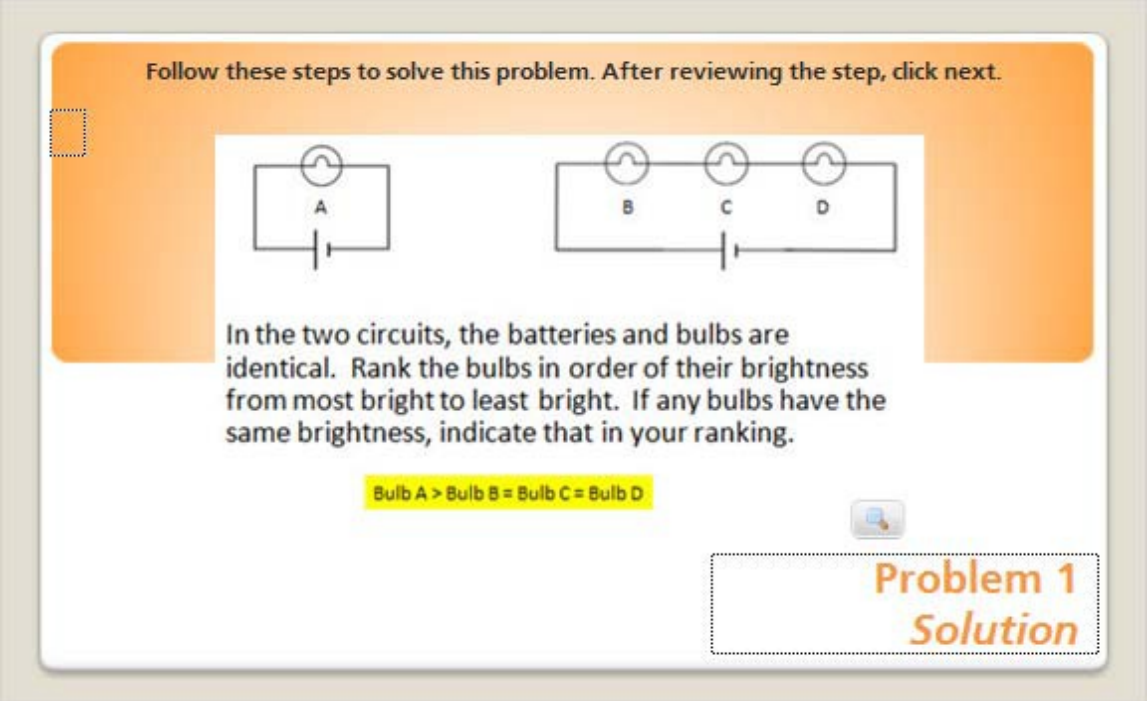
When elements are connected in parallel they will have the same voltage. The currents through each path add up to the total circuit current. Adding elements in parallel decreases the total resistance and causes the battery current to decrease.

You will apply these ideas in more complicated circuit arrangements in the next topic. Let's test your understanding of these relationships with some examples.



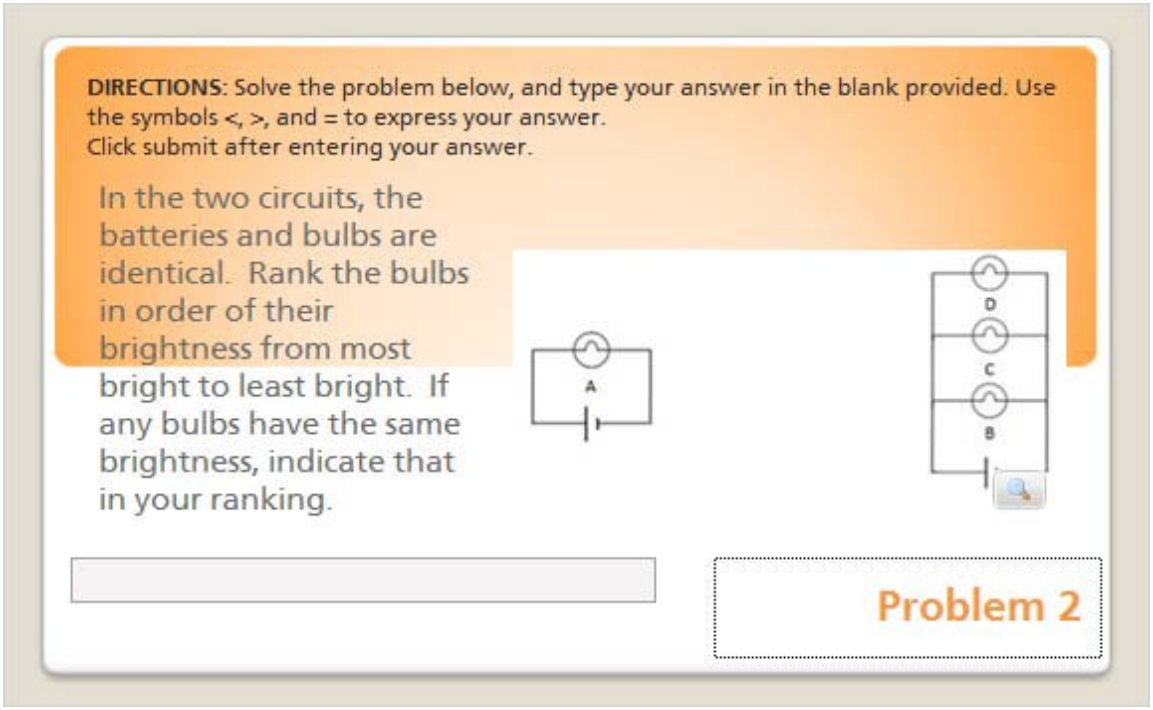
Problem 1

In the two circuits, the batteries and bulbs are identical. Rank the bulbs in order of their brightness from most bright to least bright. If any bulbs have the same brightness, indicate that in your ranking.



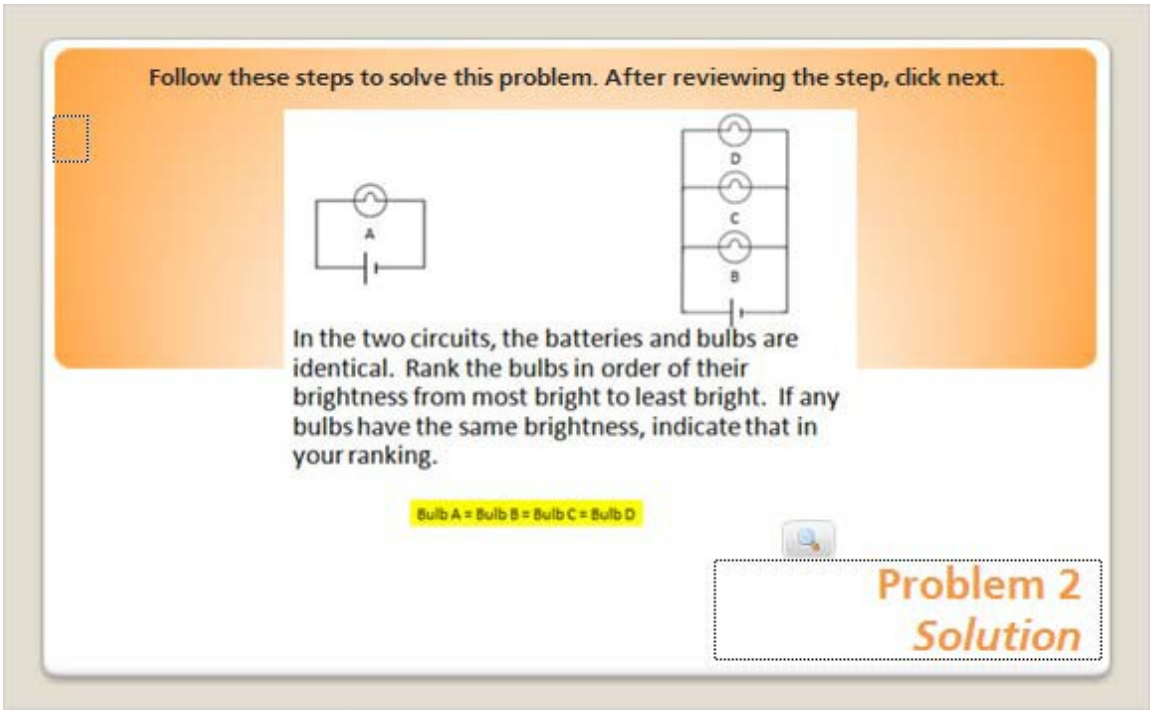
Problem 1 Solution

The correct ranking is bulb A is the brightest bulb, bulbs B, C, and D are equally bright but less bright than A. This is because bulb brightness is a visual representation of power, and power equals current times voltage. Bulb A has a greater current and greater voltage than the other three bulbs since it has the same voltage as the battery. Bulbs B, C, and D each get one third of the battery voltage and have one-third the current of bulb A so they will be much less bright.
Since B, C, and D are in series they have the same current. Therefore the power of B, C, and D will be one ninth of the power of bulb A.



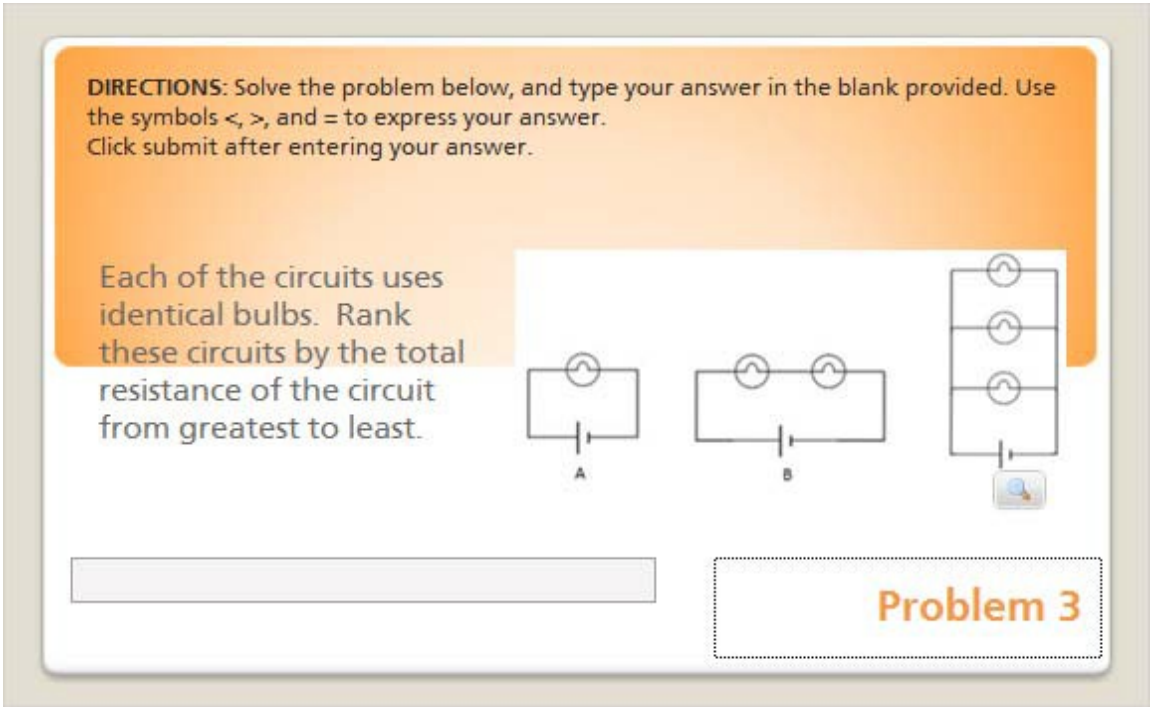
Problem 2

In the two circuits, the batteries and bulbs are identical. Rank the bulbs in order of their brightness from most bright to least bright. If any bulbs have the same brightness, indicate that in your ranking.



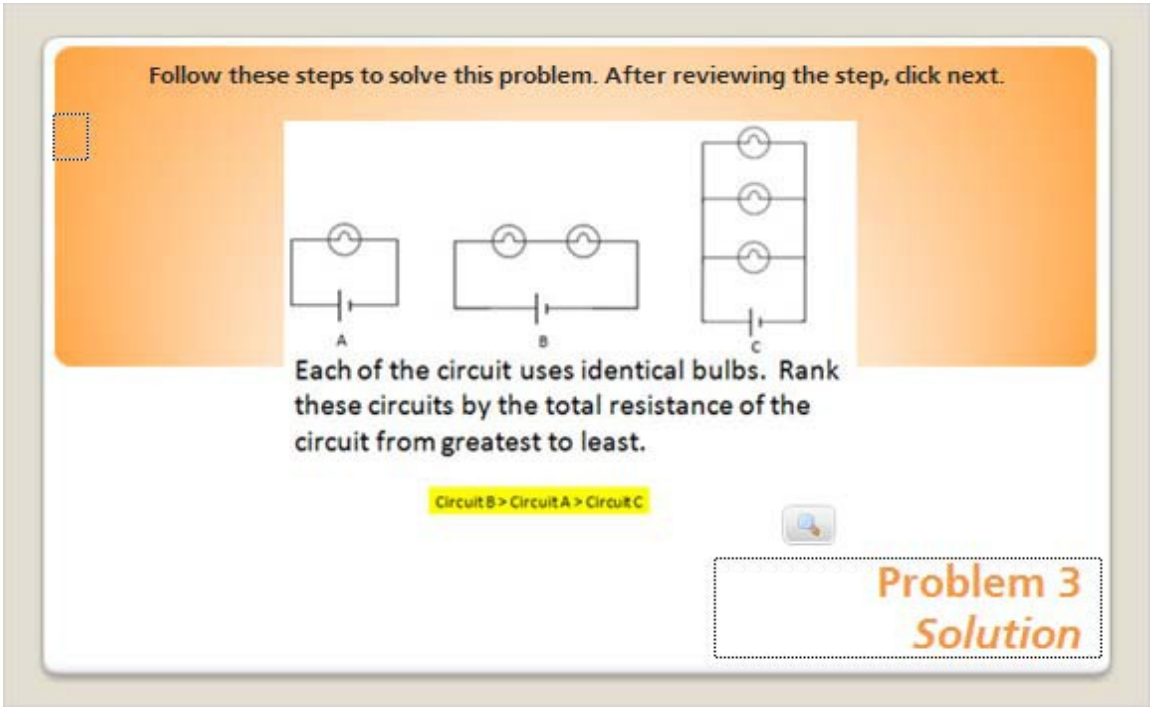
Problem 2 Solution

All of the bulbs are equally bright. Each bulb has the same voltage as the battery and each bulb has the same current.



Problem 3

Each of the circuit uses identical bulbs. Rank these circuits by the total resistance of the circuit from greatest to least.

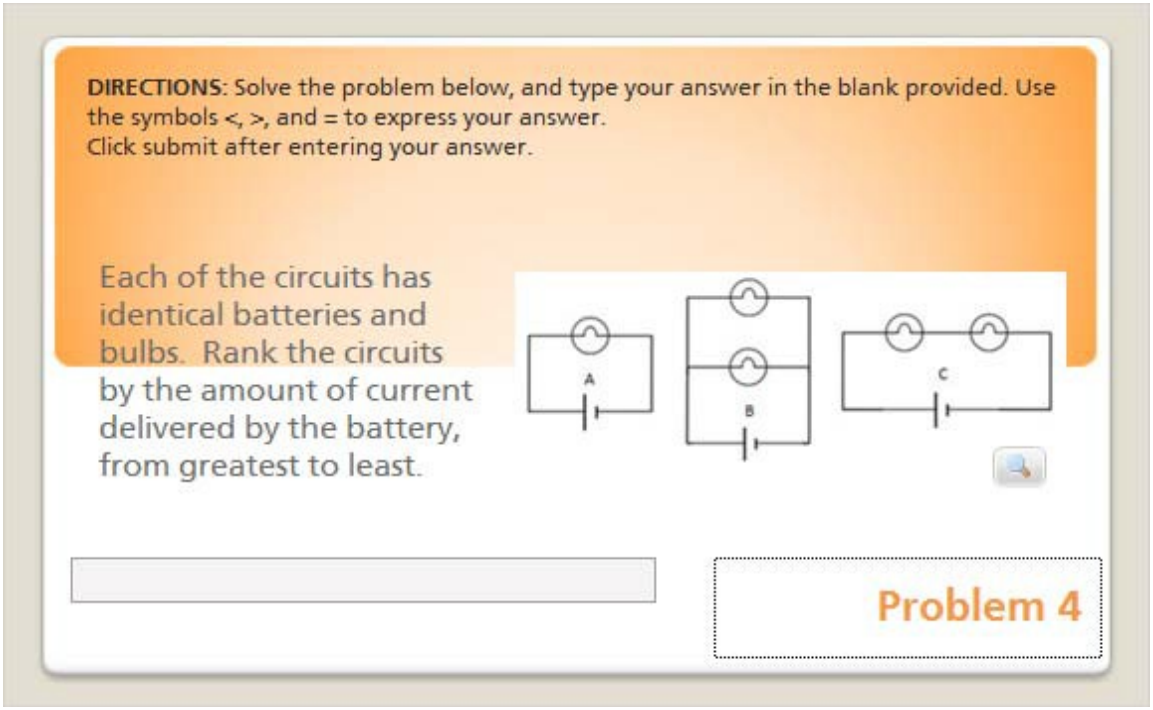


Problem 3 Solution

Circuit B has the greatest total resistance. When two bulbs are put in series, this lengthens the circuit and increases the resistance. Circuit B has double the resistance of circuit A.

Circuit A has the next largest total resistance.

Circuit C has the least resistance. When bulbs are put in parallel, this increases the flow area and decreases the total resistance of the circuit. Circuit C has one-third the resistance of circuit A.



Problem 4

Each of the circuits has identical batteries and bulbs. Rank the circuits by the amount of current delivered by the battery, from greatest to least.

Problem 4 Solution

Circuit B will have the largest current. When bulbs are added in parallel, each bulb gets the full battery voltage and has the same current, so the battery is delivering twice the current that it would be for Circuit A.

Circuit C has the least current. When bulbs are added in series, each bulb gets half of the battery voltage, so the current through each is half what it would be for Circuit A.