CH 18-2 – Series and Parallel Resistors

Important Ideas

- Kirchhoff's Current Law (KCL), also called the Junction Rule, is that the total current flowing into a junction is equal to the total current flowing out. It is a statement of conservation of charge (also conservation of mass).

- Kirchhoff's Voltage Law (KVL), also called the Loop Rule, is that the sum of potential differences around a closed loop equals zero. It is a statement of conservation of energy.

- A series connection is when the terminal of one device is connected to the terminal of another device with no other devices connected at the this terminal. The current through each device is the same.

- A parallel connection is when each terminal of one device is connected to each terminal of another device. The voltage across each device is the same.

- For resistors in series, the equivalent resistance is

$$R_{eq} = R_1 + R_2 + \cdots$$

The current through each resistor is the same. The total voltage across the resistors is:

$$\Delta V_{total} = \Delta V_1 + \Delta V_2 + \cdots$$

The larger resistor gets a larger share of the voltage. The voltage across a resistor such as R_1 is

$$\Delta V_1 = \Delta V_{total} \left(\frac{R_1}{R_1 + R_2 + \cdots} \right)$$

- For resistors in parallel, the equivalent resistance is

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$$

The voltage across each resistor is the same. The total current flowing into the set of resistors is equal to the sum of the current through each resistor.

$$I_{total} = I_1 + I_2 + \cdots$$

The smaller resistor gets the greater share of the current. Just remember: current takes the path of least resistance. If there is a *short circuit* (a single wire in parallel with a resistor), then all of the current flows through the short circuit.

- The method of substitution can be used to find currents and voltages when there is a single battery. Using the method of substitution, you can replace series resistors with an equivalent resistor and you can replace parallel resistors with an equivalent resistors. Continue replacing resistors until you have a single battery and the equivalent resistance of the circuit. Calculate the current through the battery. Use this to calculate currents and voltages throughout the rest of the circuit.
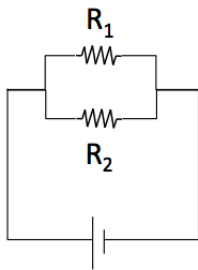
Examples

1. A 1.5 V battery is connected in series with a 5 Ω resistor and a 10 Ω resistor.
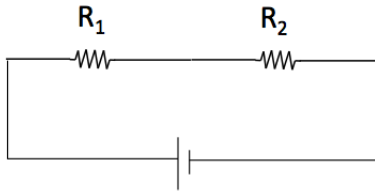
   (a) What is the current through the battery?

   (b) What is the current through each resistor?

   (c) What is the voltage across each resistor?

2. Consider the three resistors and the battery in the circuit shown. Which resistors, if any, are connected in series?
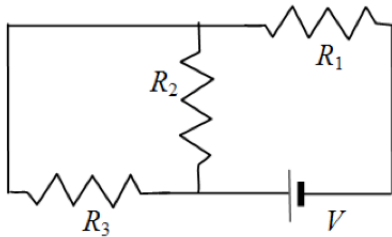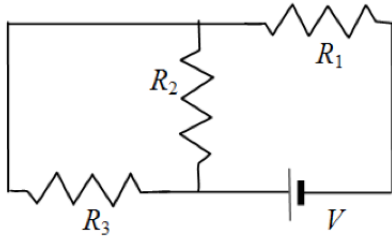

   (a) R_1 and R_2

   (b) R_1 and R_3

   (c) R_2 and R_3

   (d) All three resistors are connected in series.

   (e) None of the resistors are connected in series.

3. A 1.5 V battery is connected in parallel with a 5 Ω resistor and a 10 Ω resistor.

   (a) What is the current through the battery?

   (b) What is the voltage across each resistor?

   (c) What is the current through each resistor?

4. Consider the three resistors and the battery in the circuit shown. Which resistors, if any, are connected in parallel?


   (a) R_1 and R_2
   (b) R_1 and R_3
   (c) R_2 and R_3
   (d) All three resistors are connected in parallel.
   (e) None of the resistors are connected in parallel.

5. Which of the following statements correctly compares the currents I_A, I_B, and I_C through the three resistors?
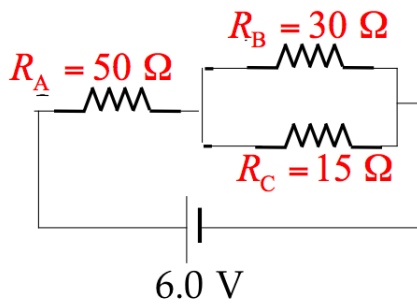

   (a) $I_A > I_B > I_C$
   (b) $I_C > I_B > I_A$
   (c) $I_A > I_C > I_B$
   (d) None of the above

6. Calculate each current in the previous question.

7. Bulbs A and B are connected in parallel. Bulb A is brighter.

   (a) Which bulb has a greater resistance?
   (b) If the bulbs are then connected in series, which bulb will be brighter?

8. If the resistors below are light bulbs, rank the bulbs in terms of brightness.

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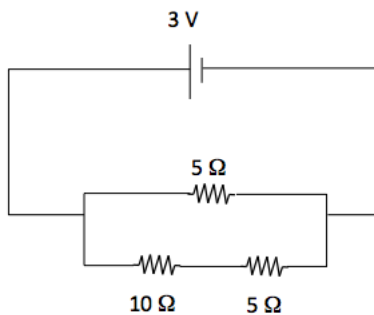
9. In the circuit below, the switch is initially open and bulbs A and B are of equal brightness. When the switch is closed, what happens to the brightness of the two bulbs?
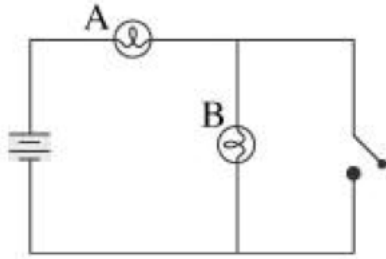
   (a) The brightness of the bulbs is not affected.
   (b) Bulb A becomes brighter, bulb B dimmer.
   (c) Bulb B becomes brighter, bulb A dimmer.
   (d) Both bulbs become brighter.

10. Rank the brightness of bulbs A–D in order from most bright to least bright.
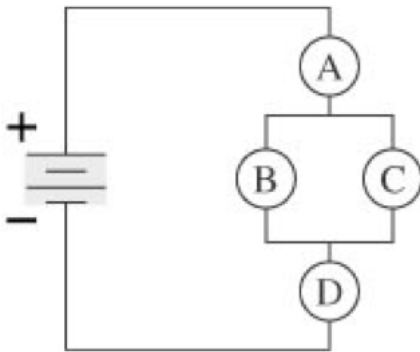
11. For the circuit in the pervious question, describe what, if anything, happens to the brightness of bulbs A, B, and D if bulb C is removed from its socket.

12. In the circuit shown below, rank in order, from most to least bright, the brightness of bulbs A–E.