2024Q9 — CIRCUITS, RESISTANCE

Welcome to week 2 of our series on circuits! Today, we'll talk about one of the most common parts of a basic circuit: resistors. Last week, we discussed what a circuit is and how current flows through it. But what happens to the current as it travels? In real life, different components are connected to a circuit to control the flow of energy. A resistor is one of these components, and it works by slowing down and resisting the flow of electrons in the circuit, which is why it's called a resistor.

Think of a funnel that slows down water as it flows through—resistors do something similar for electrical current. As the current passes through a resistor, it's slowed down, and some of the energy is released as heat. This helps manage the flow of electricity in the circuit.

When adding resistors to a circuit, two configurations can be used – *in series* and/or *in parallel*. When two components are in series, they are directly in front of or behind each other; where one component ends, the other one starts. When two resistors are in parallel, they will share the same starting point and ending point, but they branch off into "parallel" paths. Refer to Figures 1 and 2 below. When calculating what the resistance of the circuit is, measured in ohms (or Ω).

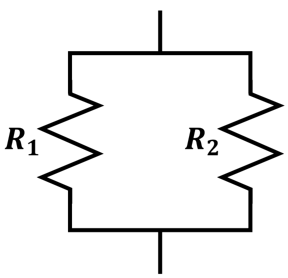

Figure 1: Diagram of two resistors in parallel

Equivalent resistance for parallel resistors:

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

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$$

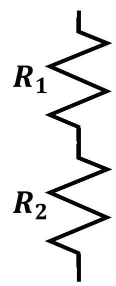

Figure 2: Diagram of two resistors in series

Equivalent resistance for series resistors:

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

R_{eq}, also known as the equivalent resistance, is the "combined" resistance that a combination of resistors creates within a section of a circuit or the full circuit. As you can see in the example below, multiple combinations of resistors are put together and can be solved to eventually find the overall resistance!

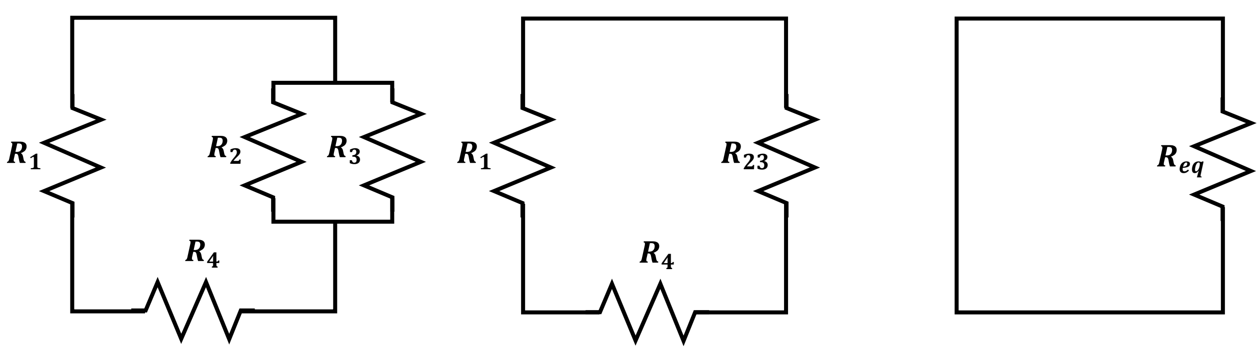

Figure 3: Example configuration of resistors combined to find the overall equivalent resistor

First, R_2 and R_3 are combined to find the equivalent resistor, R_{23}

We now see that R_{23} is in series with R_1 and R_4. These can be combined to form R_{1234}

Since all resistors are now accounted for, $R_{1234} = R_{eq}$, the overall equivalent resistor!

Level 1: Using Figures 4 and 5 below and the values $R_1 = 150\ \Omega$, $R_2 = 60\ \Omega$, $R_3 = 200\Omega$, $R_4 = 120\ \Omega$ and $R_5 = 100\ \Omega$ calculate the equivalent resistance in each of the configurations shown.

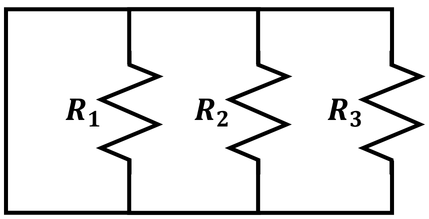

Figure 4

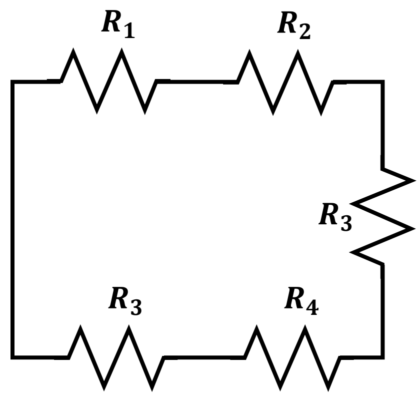

Figure 5

Level 2: Calculate the equivalent resistance of the full circuit shown in Figure 6 using the resistor values $R_1 = 200\ \Omega$, $R_2 = 350\ \Omega$, $R_3 = 50\ \Omega$, $R_4 = 500\ \Omega$, $R_5 = 180\ \Omega$, $R_6 = 100\ \Omega$ and $R_7 = 220\ \Omega$. Pro tip! Start small and find sets of two resistors that seem to be in combination with each other instead of trying to combine them all at once. For example, if you found the equivalent resistance of two resistors in parallel, would that "equivalent resistor" be in series with another resistor?

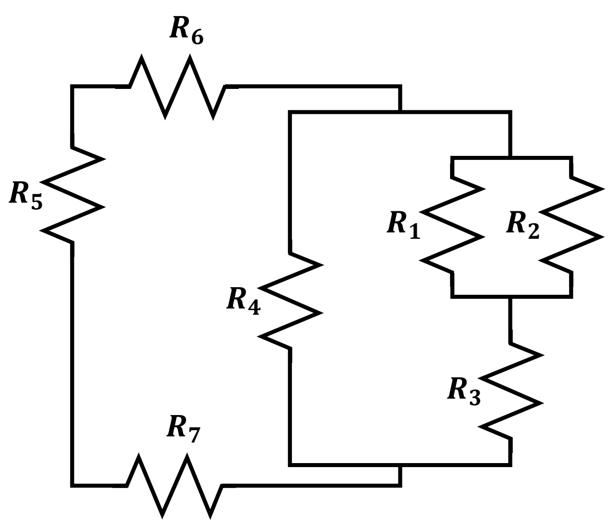

Figure 6