Series and Parallel Circuits

This activity uses Tinkercad® circuits to look at the difference between series and parallel circuits in two ways. The first is by connecting resistors together in series and parallel and measuring resistance. The second is by connecting light bulbs to a battery in series and parallel and observing the differences.

If you are not familiar with how to use Tinkercad® circuits then watch the **"Introduction to Tinkercad®"** video before using the following steps:

1. Log in to your account on the Tinkercad® website and create a new circuit

2. Open the **Components** menu, select **"All Components",** find the **Multimeter** and drag it into the workspace. Instead of looking through the list, you can click the search window and start typing the name of any component you are searching for.

3. Drag **three resistors** into the workspace and close the **Components** menu.

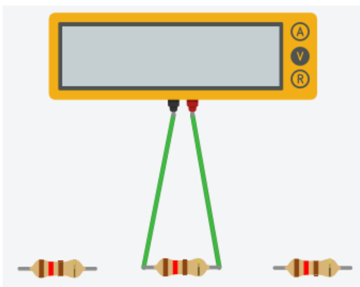
Note: *New resistors on Tinkercad® always start as 1kΩ by default, which is 1000Ω (The Ω symbol is Ohms, the standard unit of resistance). These will be coloured with bands of brown, black, red and gold. The bands are codes for the resistance value. More information can be found at this link:* https://en.wikipedia.org/wiki/Electronic_color_code

4. Click to select a **resistor** then click the **"rotate"** button multiple times until it has rotated to horizontal. Now change the value of the resistor from **1kΩ** to **120Ω** by using the blue resistor menu to the top-right.

5. Repeat the previous step until all three resistors are **120Ω** and horizontal.

6. Connect a wire from the terminals of the multimeter to either side of the **middle resistor.**

7. Your workspace should look similar to the picture below.



"Autodesk screen shots reprinted courtesy of Autodesk, Inc."

8. Click the **"Start Simulation"** button. The multimeter display will turn on.

9. You will see that the multimeter has three buttons labelled **"A", "V"** and **"R".** These represent different modes for measuring current **(A = Amps),** voltage and resistance.

Change the mode to measure resistance by clicking **"R".**

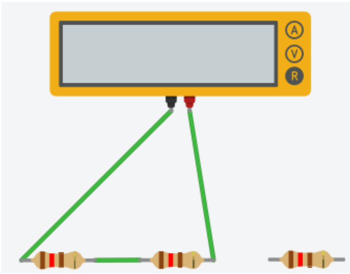
10. You will see that it measures the resistor at its value of **120Ω.**

11. Click the **"Stop Simulation"** button.

12. Click on one of the two wires and it will be highlighted with circles as handles at each end.

13. Click and drag the wire by the handle so that it moves from the resistor to connect to the far side of another resistor.

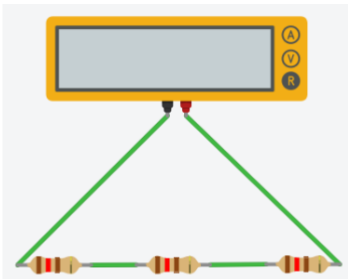
14. Now connect a new wire which will join these two resistors together, as in the picture below.



"Autodesk screen shots reprinted courtesy of Autodesk, Inc."

15. Start the simulation and notice the effect on total resistance when two resistors are connected in **series**. What is the reading?

16. Stop the simulation and move the other wire to the other resistor and connect a new wire so that all three resistors are connected in series, as in the picture below.



17. Start the simulation again and notice the **total resistance** of the three resistors in series.

18. What is the reading?

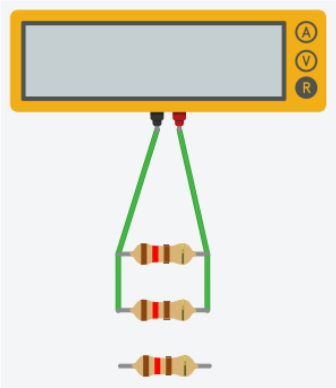
19. Now stop the simulation, select and delete all wires. Do not delete the resistors or multimeter.

20. Move the three resistors so they are **stacked** above each other.

21. Connect a wire from each terminal of the multimeter to each end of the closest resistor.

22. Connect a wire between each end of that resistor to the one below.

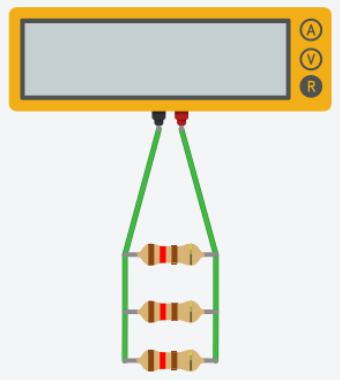
23. Your circuit should look similar to the diagram below.



"Autodesk screen shots reprinted courtesy of Autodesk, Inc."

24. Start the simulation and notice the difference in the total resistance of two **120Ω** resistors. They are in **parallel** with the multimeter because each terminal connects to both resistors. What is the reading?

25. Stop the simulation and connect the third resistor so it is also in **parallel**, as in the picture below. Start the simulation. What is the reading now?



Explanation

When a multimeter measures resistance, it applies a voltage between its terminals and uses Ohm's Law to calculate the resistance between the two.

When the three resistors were in series, the current only had one path it could travel between the terminals. All current had to pass through all resistors, and was impeded a little more by each one. From the point of view of the multimeter, the circuit looked the same as though it was a circuit with a single 360Ω resistor.

When the three resistors were in parallel, the current could flow through three separate paths of equal resistance, so one third of the current flowed through each path. From the point of view of the multimeter, the circuit looked the same as though it had a single circuit through a 40Ω resistor.

Now let's look at what happens in terms of voltage and current in series and parallel circuits by looking at the brightness of light bulbs.

26. Stop the simulation. **Delete** all wires and resistors. Do not delete the multimeter.

27. Open the **components** menu and find the **light bulb**. Add three light bulbs to your workspace.

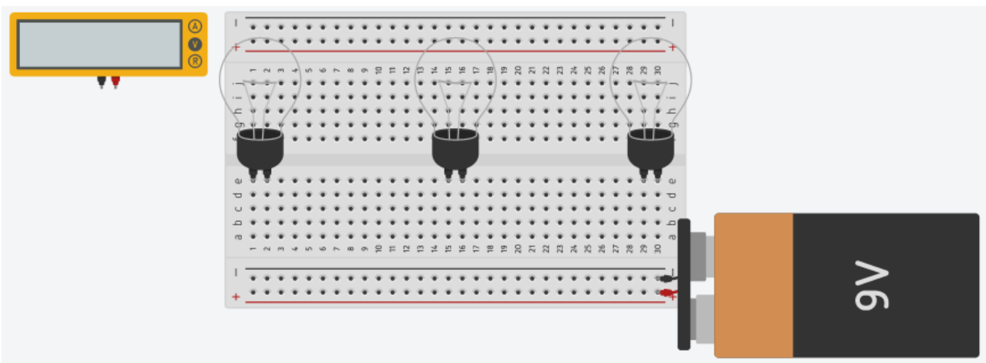
The filament in an incandescent light bulb has similar properties to a normal resistor but is designed to emit light. The brightness of the light increases with an increase in the amount of current flowing through it.

28. Also add the **9V battery** and the breadboard called **"Breadboard Small"** from the components menu. You may need to zoom out by using the scroll wheel on your mouse to fit them all in your view.

29. Leaving the 9V battery lying on its side, connect its terminals to the holes labelled + and - on the **lower-right** corner of the breadboard (see picture below to confirm).

As you hover your mouse over various holes on the breadboard, you will notice some green circles appear in the row or column or column near the hole your mouse is over. Holes in the highlighted row or column are all electrically connected to each other. You will also notice a grid reference for each hole to make it easier to refer to, e.g. b6 or h24

30. Position the three light bulbs along row 'e' in the following way: one bulb can be connected to e1 and e2, another to e15 and e16 and the other one to e29 and e30.
31. Make sure the multimeter is to the left of the breadboard. A picture of this is below.

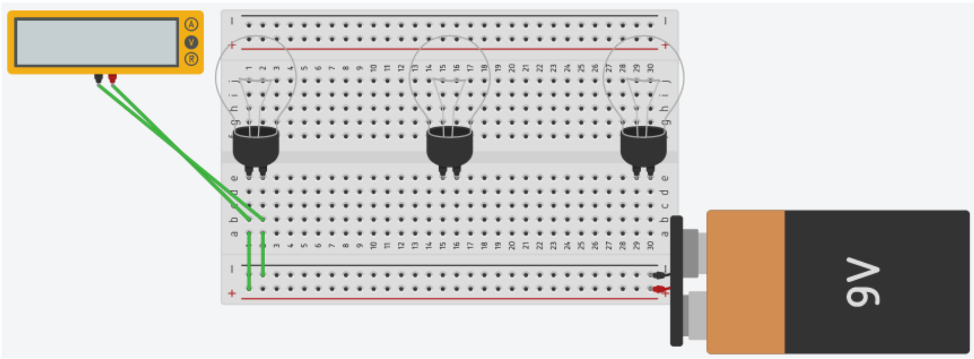


"Autodesk screen shots reprinted courtesy of Autodesk, Inc."

32. First we will connect a single **light bulb** to the **battery.** Connect a wire from column 1 of the positive power rail (the very lowest, left-most hole) up to **a1.**

33. Connect another wire from column 2 of the negative rail to **a2.**

34. Now connect a wire from the **red terminal of the multimeter to b1** and from the **black terminal of the multimeter to b2**. These wires will cross over each other.



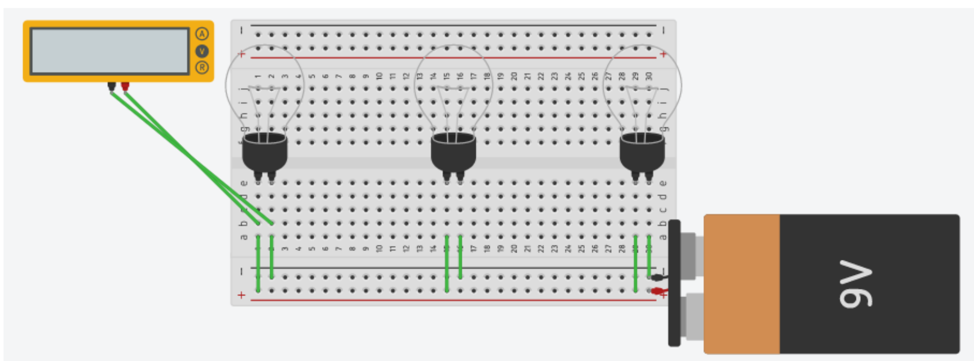
"Autodesk screen shots
reprinted courtesy of
Autodesk, Inc."

35. **Start the simulation**. Click the **'V'** on the multimeter to change the mode back to measuring **Volts.** Take notice of the light bulb's brightness. What is the reading on the multimeter?

36. Stop the simulation. Now we will connect the other two light bulbs to the battery in **parallel**. Connect a wire from the positive rail to **a15** and from the negative rail to **a16.**

37. Also connect a wire from the positive rail to a29 and from the negative rail to a30.

38. **Start** the simulation. Is the brightness of the light bulbs noticeably different? Is there much change in the voltage across the first light bulb measured on the multimeter?

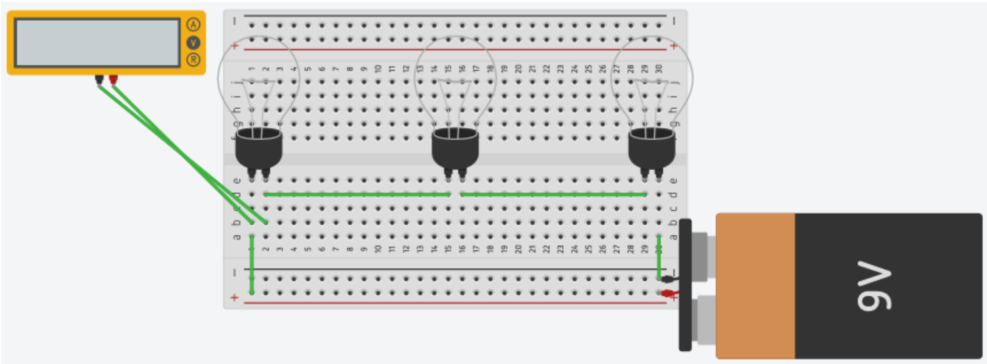


39. Now we will change the circuit so the light bulbs are all in **series** with the battery.

40. Stop the simulation and delete the four wires that connect to **a2, a15, a16 and a29.**

41. Connect a wire from **d2 to d15.**

42. Connect a wire from **d16 to d29.** You circuit should look similar to the picture below.



"Autodesk screen shots reprinted courtesy of Autodesk, Inc."

43. Start the simulation. Do you notice a difference in the brightness of the light bulbs? How has the voltage reading on the multimeter changed?

Explanation

When the light bulbs were connected in parallel with the battery, the current could flow from the positive terminal, through a light bulb and back to the negative terminal of the battery separately without having to pass through the other bulbs. They act as three separate circuits despite having the same power source. This is why the brightness of the bulbs and the voltage across were virtually the same as when a single bulb was connected to the battery.

When the light bulbs were connected in series with the battery, the current had to flow through all three light bulbs before returning to the battery. The light bulbs had to share so that each one could only have one third of the battery's voltage, and were much less bright.

You may notice that the multimeter showed displayed slightly less than a third. Any slight differences can be explained by the limitations of the amount of current a battery can supply. This discrepancy would increase if you added more light bulb circuits. You may like to try this activity again and replace the 9V battery with the "Power Supply", and set it to 9V. It can supply far more current than the battery.