DC, AC and Diodes

This activity uses Tinkercad's® circuit simulator to show how a diode works. It compares alternating current (AC) with direct current (DC) and demonstrates the effects of adding a diode to both DC and AC circuits.

In simple terms, a diode (pictured above) is a component that will conduct, or let current flow, in one direction and not the other. If we think of the water pipe analogy, this is like a one-way valve. Unlike a resistor, which will act the same no matter which way around it is connected in a circuit, which way around a diode is installed does make a difference.

To demonstrate this, we will use Tinkercad® Circuits to place a diode in a basic DC circuit. 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, find the **power supply** and drag it into the workspace.

3. Add the **light bulb** to the right of the power supply.

4. Drag a **resistor** in to the work space. Leave it at its default value of 1kΩ and place it below the light bulb.

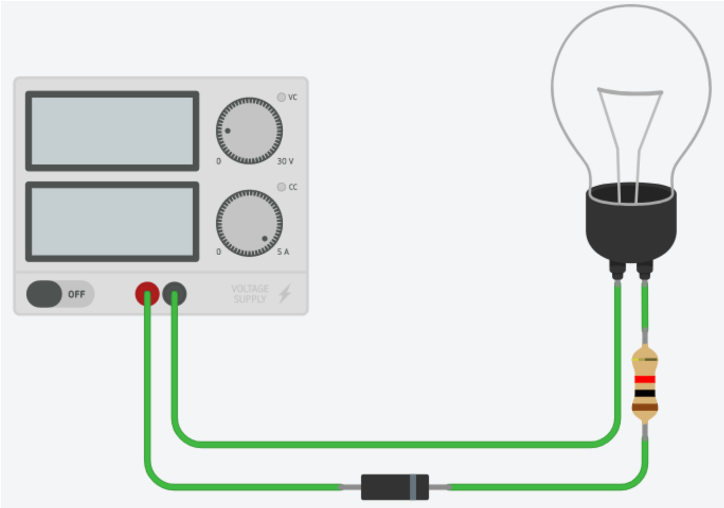
5. Add a **diode** to the work space. Click it to select and rotate it so the grey band is to the right, pointing towards the light bulb rather than the power supply.

6. Connect a wire from the **red (positive) terminal** of the power supply to the end of the **diode** which does not have the grey band. This is called the diode's ***anode*.**

7. Connect a wire from the **side of the diode with the grey band (called *cathode*)** to the resistor.

8. Connect a wire from the other side of the resistor to the light bulb.

9. Connect a wire from the other terminal of the light bulb back to the black (negative) terminal of the power supply. Your circuit should look similar to the picture below.



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

10. Click "Start Simulation" which will turn on the power supply.

Does the light turn on? How much current does the lower window of the power supply show is flowing?

11. Stop the simulation and **delete** the two wires connected to the diode.

12. Select the diode and rotate it **180** degrees.

13. Connect the wires back up so that it is the same as before except the diode is **facing the opposite direction.**

14. Click **"Start Simulation"** which will turn on the power supply.

Does the light turn on? How much current does the lower window of the power supply show is flowing?

This circuit was an example of a DC (direct current) circuit because the voltage was always 5 Volts in only one direction. The direction that the current will attempt to flow in a DC circuit is from positive to negative. An AC (alternating current) circuit continuously changes, or alternates between one direction and then the other.

We will now connect an **AC** circuit using Tinkercad® and view the changes in voltage on an oscilloscope.

15. **Delete** all components from your workspace except for the **1kΩ resistor.**

16. Open the **Components** menu and find the **function generator.** Drag it into the left-hand side of your workspace.

17. Find the **oscilloscope** in the menu and place it to the right-hand side of the function generator in your workspace.

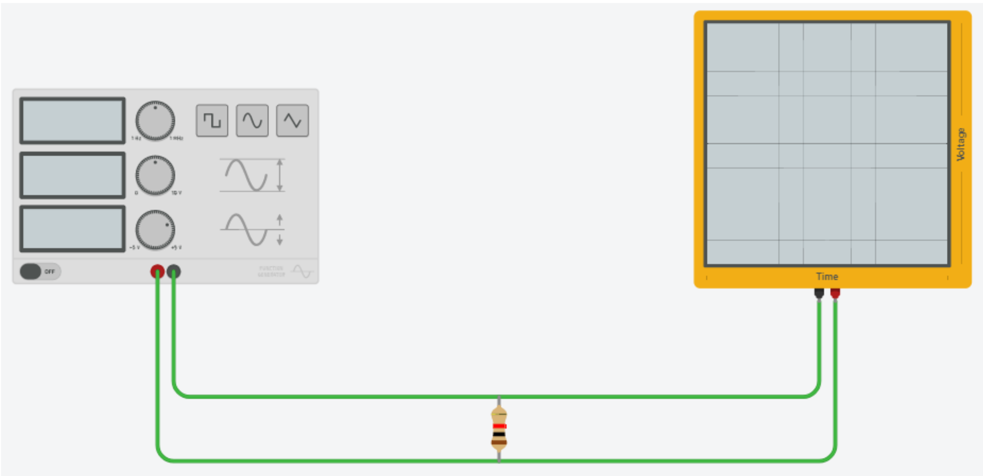
18. Make sure the resistor is in between the function generator and the oscilloscope and is rotated to **vertical**.

19. Connect a wire from the **red terminal** of the function generator to the lower end of the resistor.

20. Connect a wire from the **black terminal** of the function generator to the other end of the resistor.

21. Now connect a wire from the red terminal of the oscilloscope to the lower end of the resistor.

22. Finally, connect a wire from the red terminal of the oscilloscope to the other end of the resistor. Your circuit should look similar to the picture below.



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

The oscilloscope shows lines on its screen which indicate any changes in voltage over a set time period. A function generator is a power supply which provides a varying voltage, resulting in alternating current (AC). In the circuit pictured above, the oscilloscope is connected for measuring the voltage difference between one side of the resistor and the other.

23. Start the simulation.

24. Click the function generator so that a window appears in the top-right corner to allow you to adjust settings by typing, rather than using the dials.

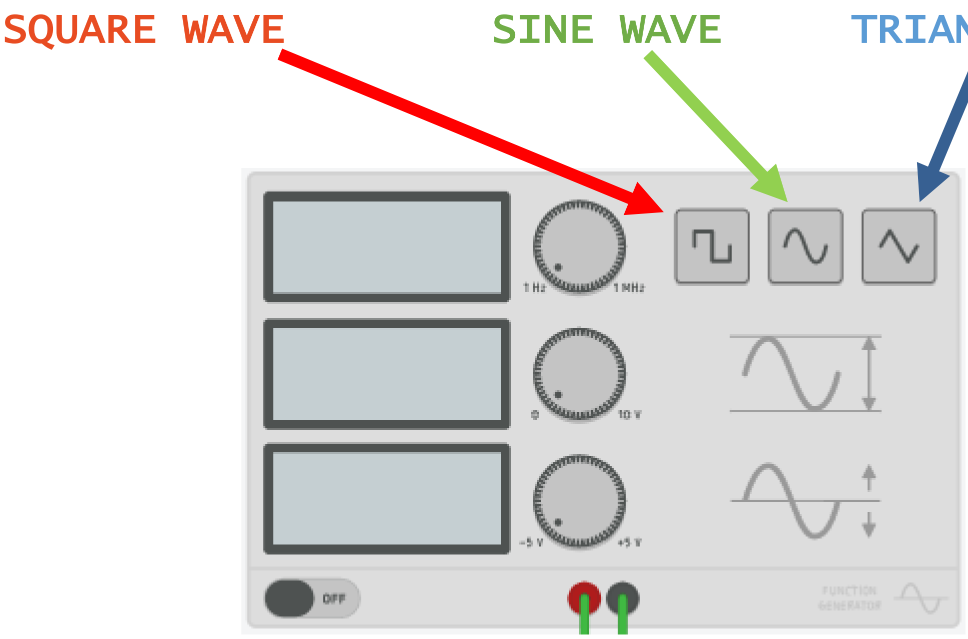
25. Change the frequency from **1000Hz to 5Hz.** 5Hz (Hertz) means 5 cycles per second.

26. Leave the amplitude unchanged at **5V.**

27. Change the dc offset from **2.50V to 0V**

On the screen of the oscilloscope you are seeing a representation of any changes in voltage for each 1 second period of time. The horizontal parts of the blue line at the top are when the output is a steady positive voltage and the horizontal parts of the blue line at the bottom are when the output is a steady negative voltage (i.e. in the opposite direction to positive, as though the red and black terminals were reversed). The vertical parts of the blue line show that the change from positive to negative is instant. This is called a "square wave".

28. Change the output of the function generator **from a square wave to a triangle wave** and notice the difference on the oscilloscope. See the picture below for the correct button.



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

You will notice that there is a more gradual transition between positive and negative voltages than for a square wave and it does not remain steady at the peak positive and negative voltages for any period of time.

29. Change the function generator to output a **sine wave** and notice the difference in the waveform on the oscilloscope.

Now we are going to add a diode to this circuit.

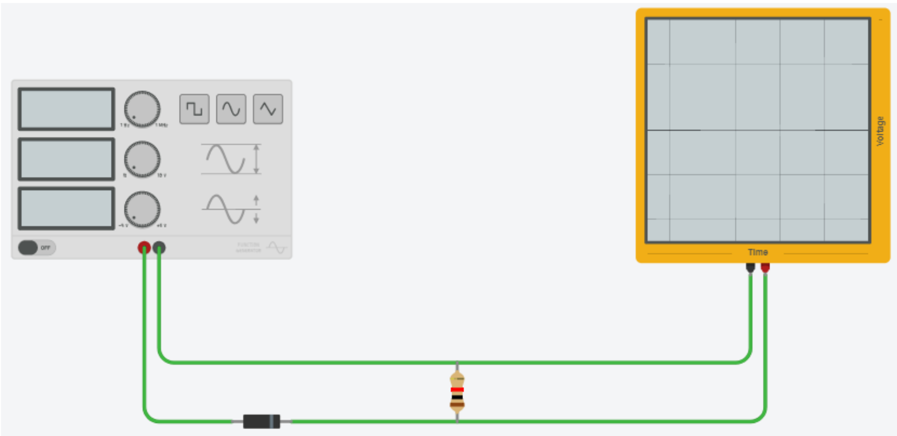
30. Stop the simulation.

31. Open the **Components** menu and add a **diode** to the workspace.

32. Click to select the wire that connects the red terminal of the function generator to the resistor. **Delete this wire.**

33. Move the diode to the area where the deleted wire was and rotate it so that the cathode (the side with the grey band) points towards the resistor.

34. Connect a wire from the red terminal of the function generator to the anode of the diode and another wire from the cathode (grey band end) to the resistor. The diode should now be in series with the resistor, as in the picture below.



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

35. Start the simulation and notice the difference in the waveform on the oscilloscope.

What effect has the addition of the diode to the circuit had on the original sine wave?

You should only see the parts of the sine wave that were above the centre line of the oscilloscope. The centre line, in this case, represents 0V. This is because the diode is allowing the circuit to conduct from positive to negative but not from negative to positive.

36. Try switching the function generator to a **square wave and then to a triangle wave** and you will see the diode has the same effect on these.

37. Now stop the simulation and **delete** the wires on either side of the diode.

38. Rotate the diode **180 degrees** so it faces the opposite way.

39. **Reconnect the wires** that were just deleted so that the circuit is the same as before except that the diode is in the opposite direction.

40. Start the simulation.

What effect has this had on the waveforms of the square, sine and triangle waveform as viewed on the oscilloscope?

Diodes are used for different purposes. One use is to rectify an AC waveform to make it into a DC waveform.

In this activity, you saw that a diode can remove all negative parts of an AC wave to leave only the positive parts, or vice-versa. In this case, the resulting output is not very smooth but can still be useful as a DC voltage for some applications. This is called a half-wave rectifier.

By using diodes in more complex configurations (full-wave rectification) and adding other components (such as capacitors) you can rectify an AC wave in to a consistent and smooth DC voltage.