

3D Design and Printing in Tinkercad

Learning Outcomes

Students will be able to:

- identify the different parts of the opening screen
- create simple electronic circuits using electrical components
- simulate the electronic circuit
- incorporate circuit assemblies in 3D designs

Electronic Circuits with Tinkercad

An electronic circuit consists of a variety of electronic components such as LED's, switches, resistors and a power source. Tinkercad is a free online service for creating 3D shapes and developing digital prototypes of electronic components. The digital prototype includes basic circuits with LED lights, battery, switches, buzzers, etc.

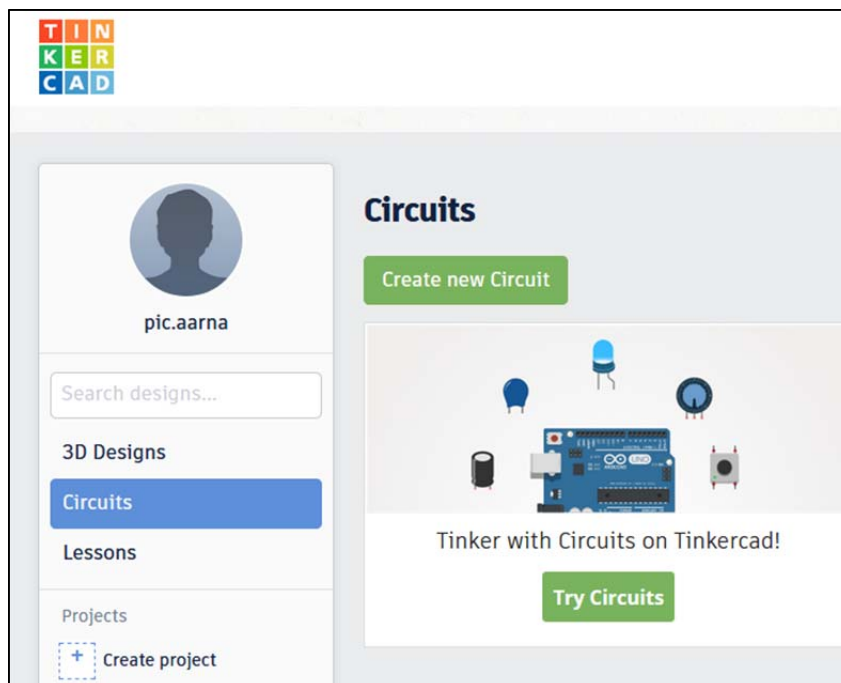
The Prototyping process used in Tinkercad is a process where we can develop electronic circuits using the components in a flexible manner that can be quickly updated, modified and tested within the browser, before building it in real life.

To start creating circuits, perform the following steps.

Step 1: Log on to www.tinkercad.com.

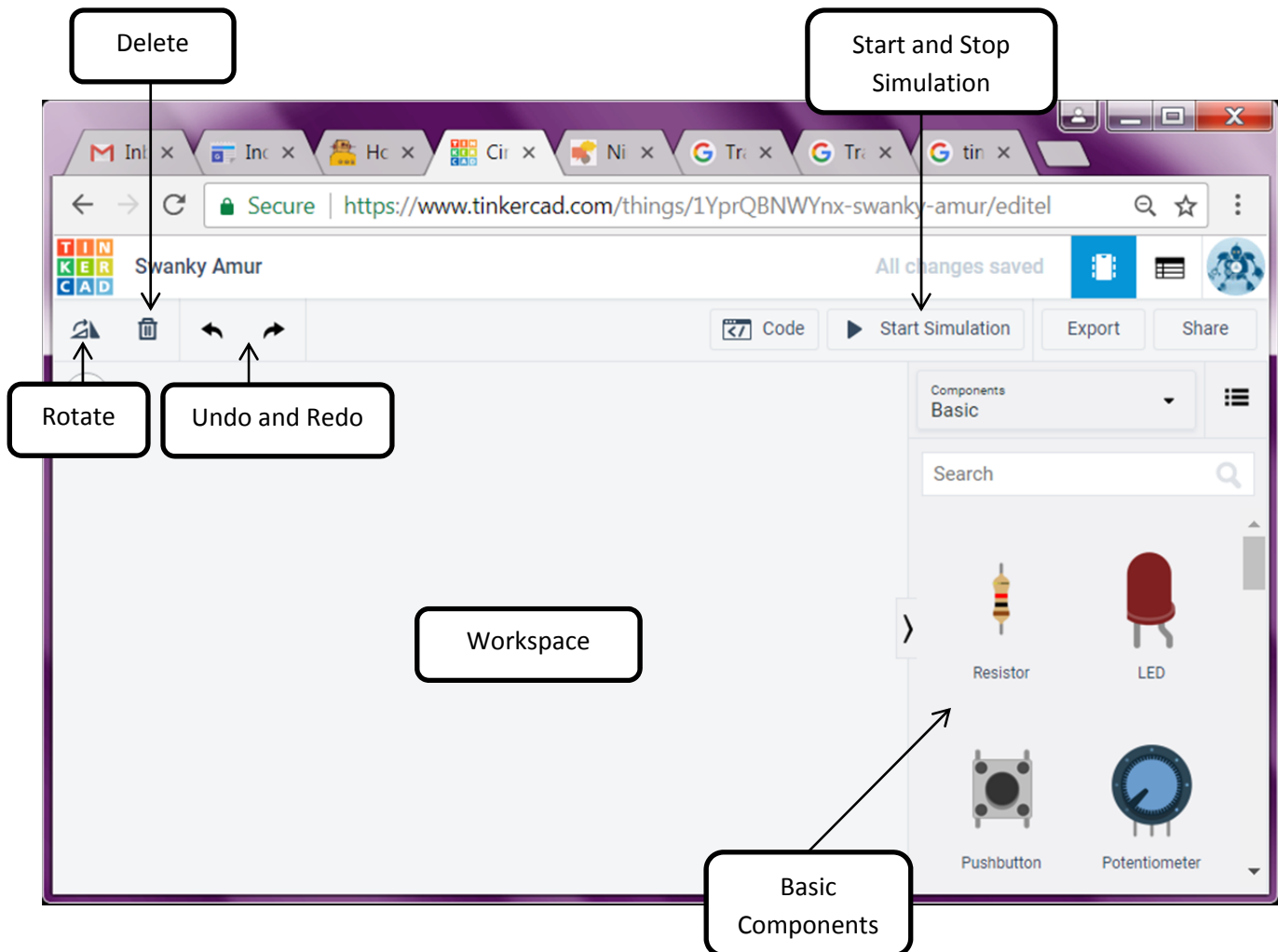
Step 2: Sign in to your account and then click **Circuits**.

Step 3: Click **Create new Circuit** button.



3D Design and Printing in Tinkercad

Opening Screen of TinkerCAD Circuits



Workspace

It is an area where the electronic components and 3D objects are placed.

Components of a circuit

Tinkercad displays the electronic components used to create circuits in the panel usually at the right side of the page. Some of the electronic components used to create circuits are.

- Basic components – It consists of a battery, push button, resistor, LED, capacitor, etc.
- Circuit Assembly - Circuit assemblies are simple, pre-made circuits that can be incorporated into the 3D designs. Some of the circuit assemblies available are glow circuit, move circuit and spin circuit.

Rotate

It is used to rotate by 360 degrees any component placed onto the workspace.

3D Design and Printing in Tinkercad

Start/Stop Simulation

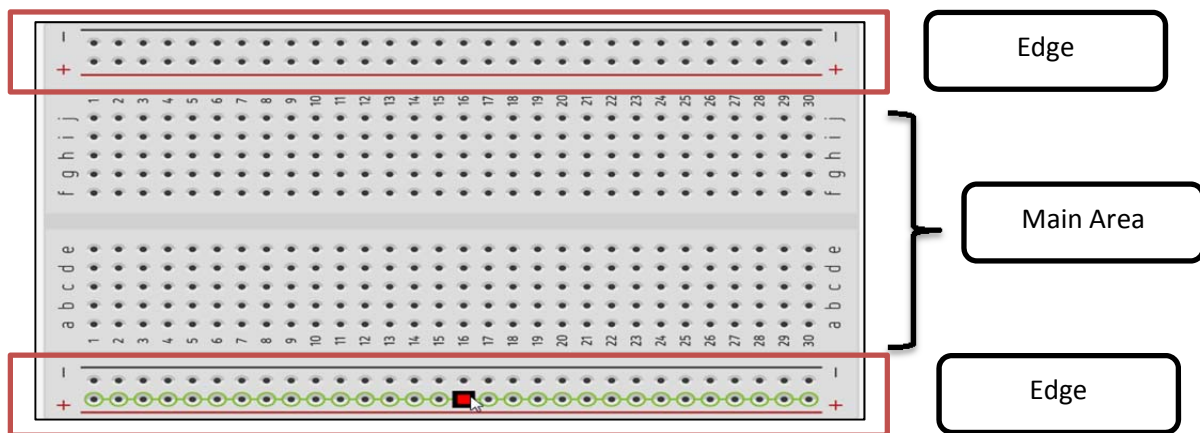
Simulation is an imitation of an operation of a real-world process or system. In Tinkercad, Start/Stop Simulation tests the working of the circuits and the components.

Electronic Circuit using Components

An electronic circuit is built using different components. The components are assembled using a breadboard. A breadboard is a piece of plastic that has several holes. These holes are used to hold different electronic components.

The breadboard has a grid of thirty by ten holes in the main area. The rows are numbered 1 to 30 and the columns are labeled with the letters 'a' through 'j.' The columns 'a' through 'e' are separated from columns 'f' through 'j'.

The edges of the board contain two columns with the same number of rows. These columns and rows are used for power supply. The components in the main area of the board will tap into these columns to draw electric current.



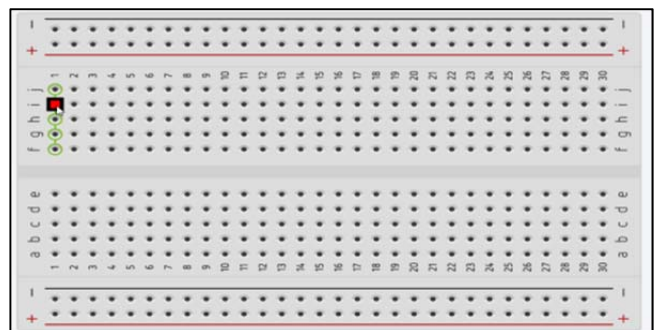
Using Breadboard

Perform the following steps to use the breadboard in Tinkercad.

Step 1: Locate the breadboard from the right panel and click it once. The breadboard will be selected and temporarily attached to the mouse pointer.

Step 2: Move the mouse pointer onto the workspace and click the mouse button to place the breadboard onto the workspace.

Step 3: Click on the zoom to fit button, so the breadboard is centered and magnified.



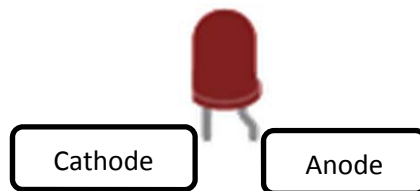
Step 4: Move the mouse pointer over one of the holes in the main area of the board. The hole will be identified with a red square and a black border. The other holes will be identified with green circles.

3D Design and Printing in Tinkercad

These green circles indicate that each hole in the row is connected to each other. There is a wire that connects these holes internally within the same row.

Creating Circuits using a breadboard, LED and battery

A Light Emitting Diode (LED) is an electronic device that emits light when an electric current passes through it. An LED has one connection called a Cathode and another called Anode. The difference is important because the anode must be connected to the positive end of an electronic circuit. The current flows in only one direction through an LED. The LED anode in the circuit is identified by a bent lead. This is where the positive terminal of the battery must be connected.



Did You Know?

Since LED require less electricity, they are also useful for lighting homes, businesses and cities. Their low power consumption makes them ideal device for conserving energy.

The battery is used in an electronic circuit to push electric current through the component. In Tinkercad circuits, batteries are available with 1.5V, 9V. The battery is labeled with its voltage (V). The voltage indicates the pressure from the electronic circuit power source.

Perform the following steps to create a basic closed circuit with LED, battery and breadboard.

Step 1: Locate the breadboard from the right panel and click it once. The breadboard will be selected and attached to the mouse pointer. Move the mouse pointer onto the workspace and click the mouse button to place the breadboard onto the workspace.

Step 2: Click **Components** and select **Basic** and click on the LED. It will attach itself to the mouse pointer.

Step 3: Place the LED onto the breadboard so that each wire of the LED is in a hole (the two holes that are not connected).

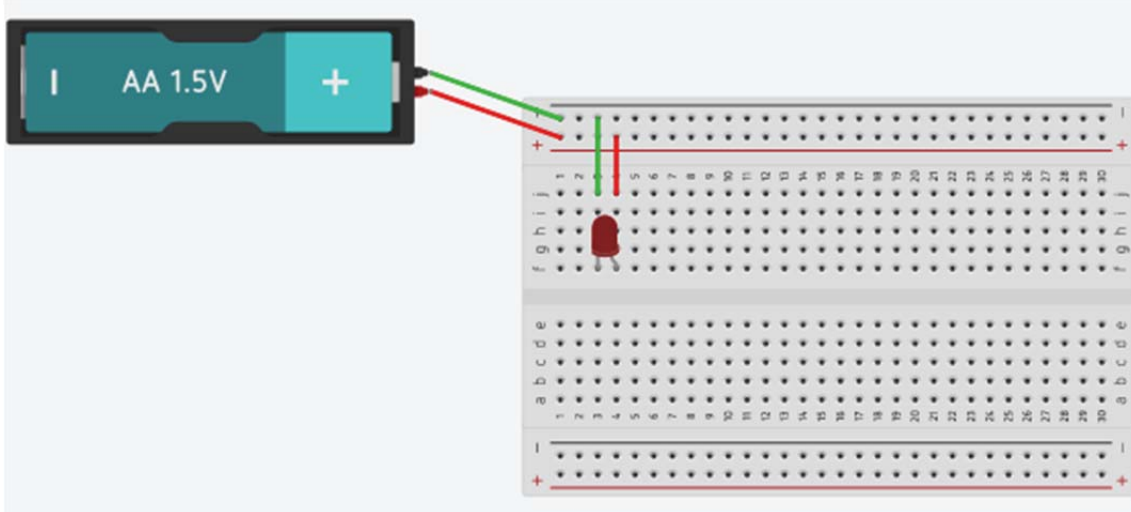
Step 4: Place a 1.5 Volts AA battery along the left side of the breadboard.

Step 5: Click the battery. A blue border appears. Click the **Rotate** button in the button bar. This will rotate the component clockwise about 30 degrees each. Click the button three times to rotate the battery 90-degrees clockwise such that the terminals of the battery are facing the breadboard.

3D Design and Printing in Tinkercad

Step 6: Move the mouse pointer to the top terminal of the battery. A square will appear over the terminal with a label as a negative battery terminal. Click once on the terminal and move the mouse pointer to the first hole in the negative column and click on it. Repeat the process with a positive terminal and place it on the positive hole on the breadboard.

Step 7: Select the positive terminal wire and click the color selector. Select the red colour. Repeat the



process for negative terminal wire and change the wire colour to green.

Step 8: Click on Row 4 Column 'j' to begin a jumper wire. Connect the other end of the wire to the positive column.

Step 9: Connect another wire from Row 3 Column 'j' to the negative terminal column.

Step 10: Change the colour of the wires coming from the battery.

Step 11: Click The **Start Simulation** button. The LED on the breadboard will change to a lighter colour to simulate that LED has turned on.

Learning by Doing

To the above circuit with LED, battery and breadboard, add one more battery by clicking the battery configuration panel and click the battery count selector. Select two batteries. Start Simulation. Write your observation.

The LED light will show star over it. It indicates that the LED blew out. The LED blew because it received too much voltage than it requires. In the physical world, it would mean that our LED is no longer good and needs to be replaced.

Shortcut Key

To Zoom in on the component hold the Control key and press the Plus key.

3D Design and Printing in Tinkercad

Did You Know?

The wire coming from a component is often called a lead. (Pronounced like the word lead in leader)

Electronic Circuit with Resistors

When the circuit with LED had two batteries, the LED got damaged. The LED was damaged because it received too much voltage. LEDs are low voltage components and do not need much electricity to get them to emit light. When constructing circuits, we have a variety of components that require different voltages and current. A resistor is used to restrict the flow of current to electrical components. Electrical current is measured in 'Amps'.

Ohm's Law is used to understand what is going on when we use resistors in a circuit. It states that we can calculate the amount of voltage in a circuit by multiplying the electrical current by the resistance in the circuit.

Voltage = Current X Resistance

$$V = I \times R$$

The formula can be manipulated to find the current in a circuit. To find the current in a circuit, we divide the voltage by the resistance.

Current = Voltage/Resistance

$$I = V/R$$

The formula to find the resistance in a circuit, divide voltage by current.

Resistance = Voltage / Current

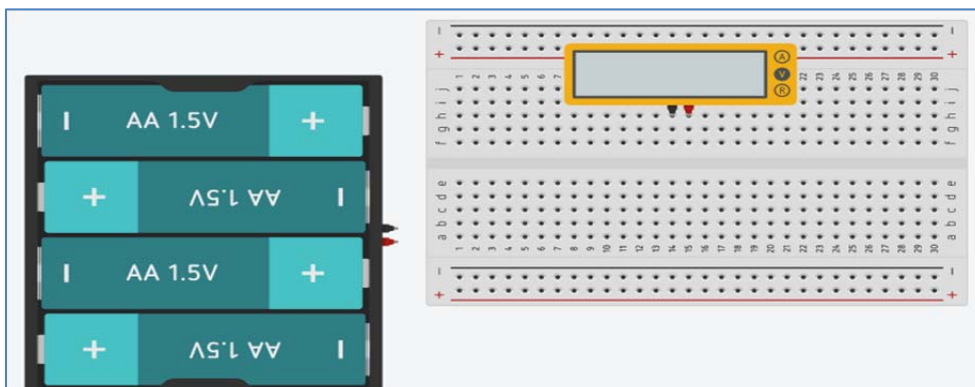
$$R = V/I$$

Perform the following steps to calculate the current flow across the circuit

Step 1: Place the breadboard onto the workspace.

Step 2: Place AA battery with 1.5 Volts along the left side of the breadboard. Go to the battery options panel and change the battery count from one to four. Click the Rotate button, so the terminals on the battery pack are facing the breadboard. Move the battery terminals near the positive and negative rails at the bottom of the breadboard.

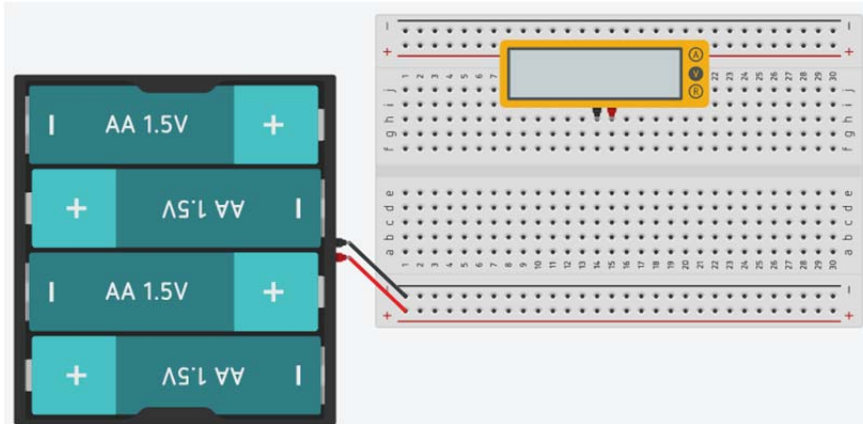
Step 3: Place a Multi-meter component from the components list near the center of the breadboard in the upper half. Make sure to leave columns 'f' and 'g' available, so we make jumper wire connections. (Multi-meter is used to measure electrical current, voltage, resistance and other value.)



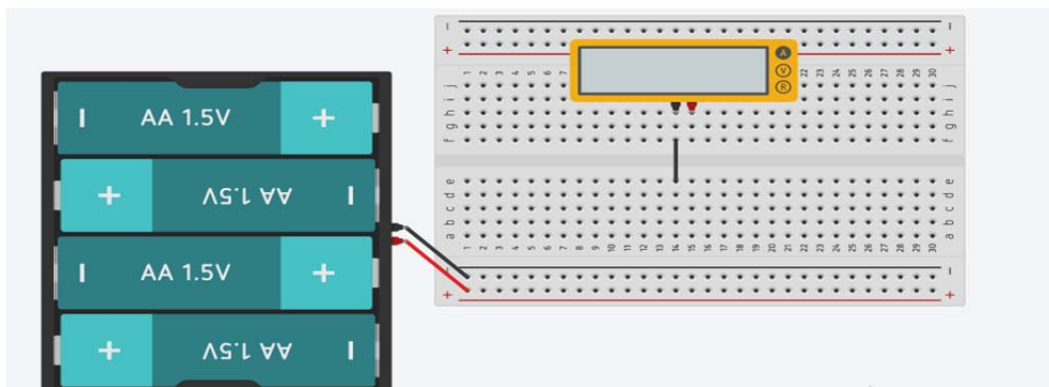
3D Design and Printing in Tinkercad

Step 4: Connect the jumper wires from negative battery terminal to the negative rail on the breadboard and the positive battery terminal to positive rail of the breadboard.

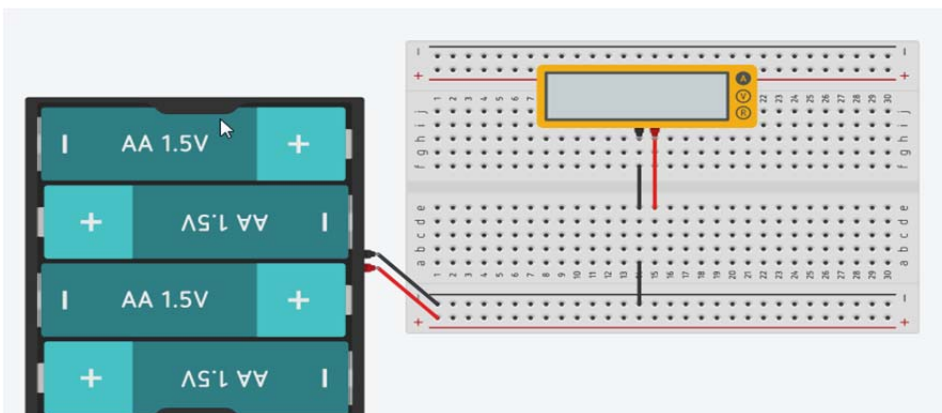
Step 5: Change the colour of the wires, black for negative and red for positive.



Step 6: Add a jumper wire that connects the negative end of the multi-meter across the gap to the other side of the breadboard.



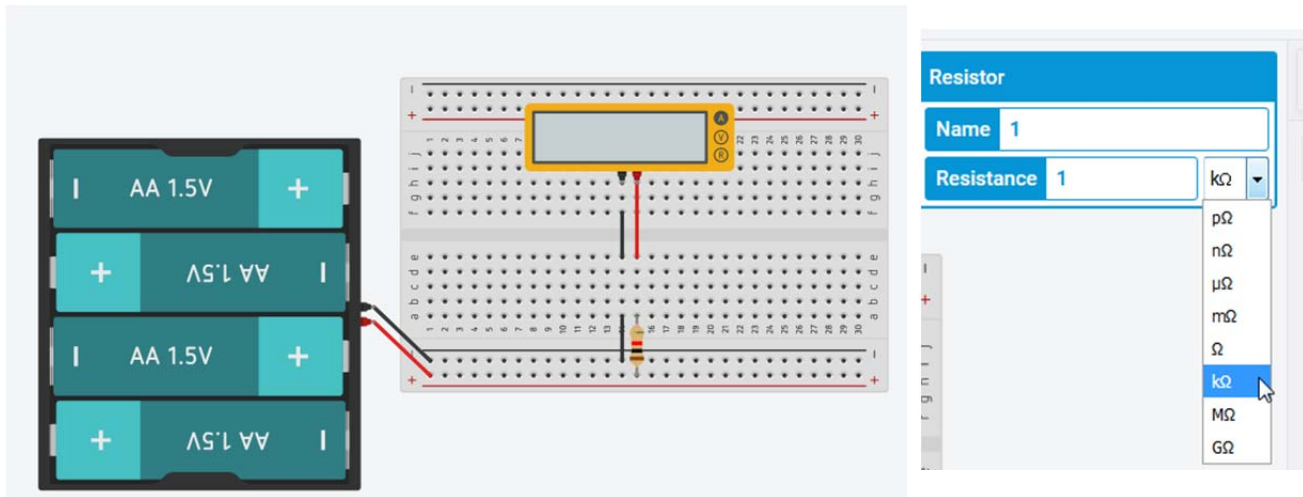
Connect two more jumper wires. One will connect the positive terminal of the Multi-meter to the lower half of the breadboard. The other jumper wire will connect the negative rail to the multi-meter.



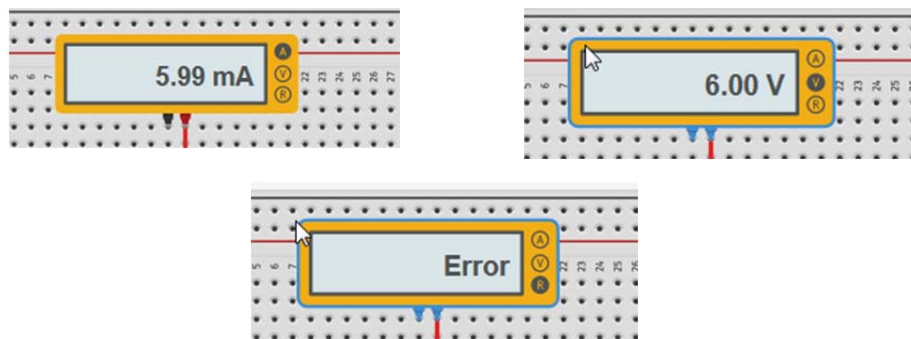
Step 7: Place the resistor on the breadboard so that one end connects to the positive rail and the other end is opposite the positive terminal of the Multi-meter. The resistance of the resistor is measured at 1 Kilo-Ohm. The omega symbol (Ω) represents ohms. Click the symbol selector to see the other

3D Design and Printing in Tinkercad

measurement symbols for Ohms. In our circuits, we will be using milli-ohms and kilo-ohms. Make sure the resistance unit of measure is set to kilo-ohms and click the Start Simulation button.



Step 8: The Multi-meter measures that there is 5.99 milli-amps flowing through the circuit. The Multi-meter has three measurements. The 'A' measures Amps or Current, V for voltage and R for resistance. Click on the letter 'V' on the meter. The meter indicates that there is 6 volts going through the circuit. Click on the letter 'R' on the meter. The meter displays an error message. We are getting an error message because the connection to measure the resistance across a resistor is different from the one we are using currently. The error doesn't mean much because we know that resistance value is 1 kilo-ohm. It is set on the resistor configuration panel.



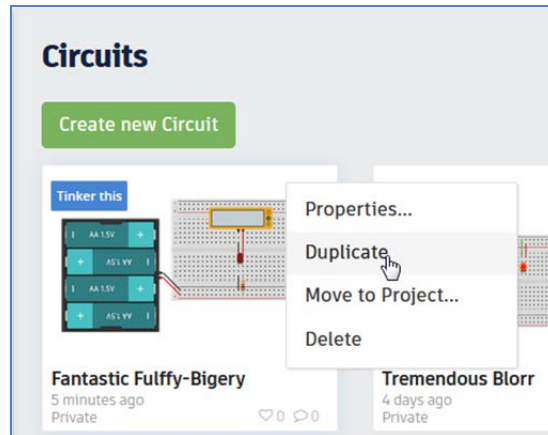
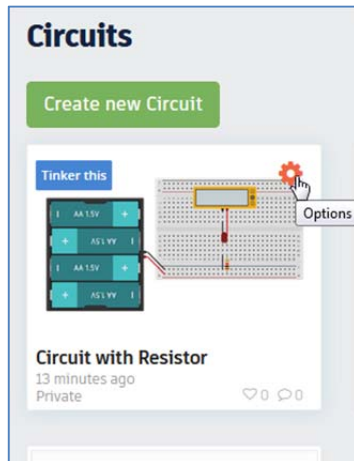
Electronic Circuits with an LED and Resistor

We know that an LED will stop working and can be damaged if we apply too much voltage. We will use the circuit with multi-meter and resistor created earlier to find how a resistor works in an LED circuit to ensure that the LED do not get damaged.

Perform the following steps to duplicate the previous project and tinker it.

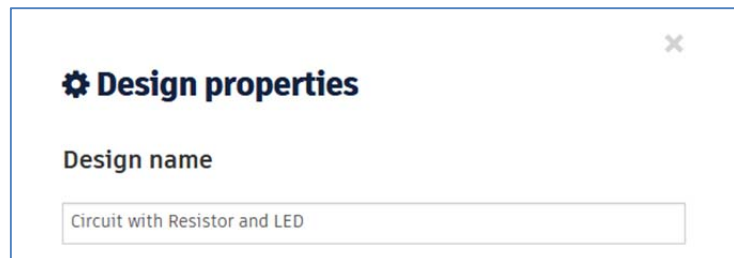
Step 1: Hover mouse over the preview of the previous project and click on the gear icon. Select the option to duplicate the design. A duplicate of the project will be created and placed on the main page. The word copy will be attached to the beginning of the project.

3D Design and Printing in Tinkercad

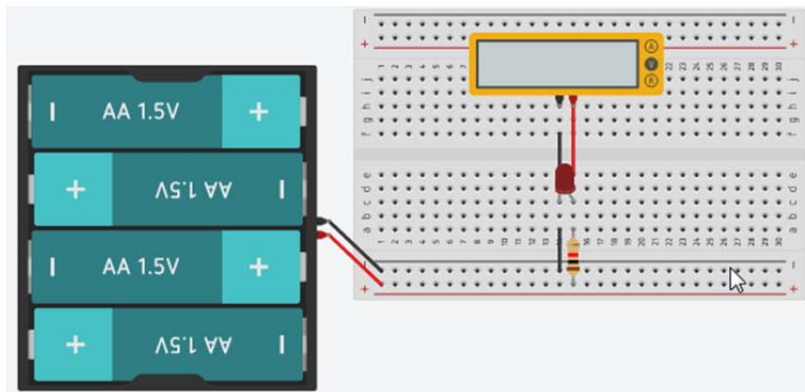


Step 2: Move the mouse over the project and click the gear icon. Click the properties option and give a name to the design. Click the Save Changes button.

Step 3: Move the mouse over the design preview box and click the button 'Tinker This'.



Step 4: Place the LED above the resistor so that the Anode of LED is in the same row as the resistor. (Anode must be connected to positive voltage. The Anode is the one with bent wire.)

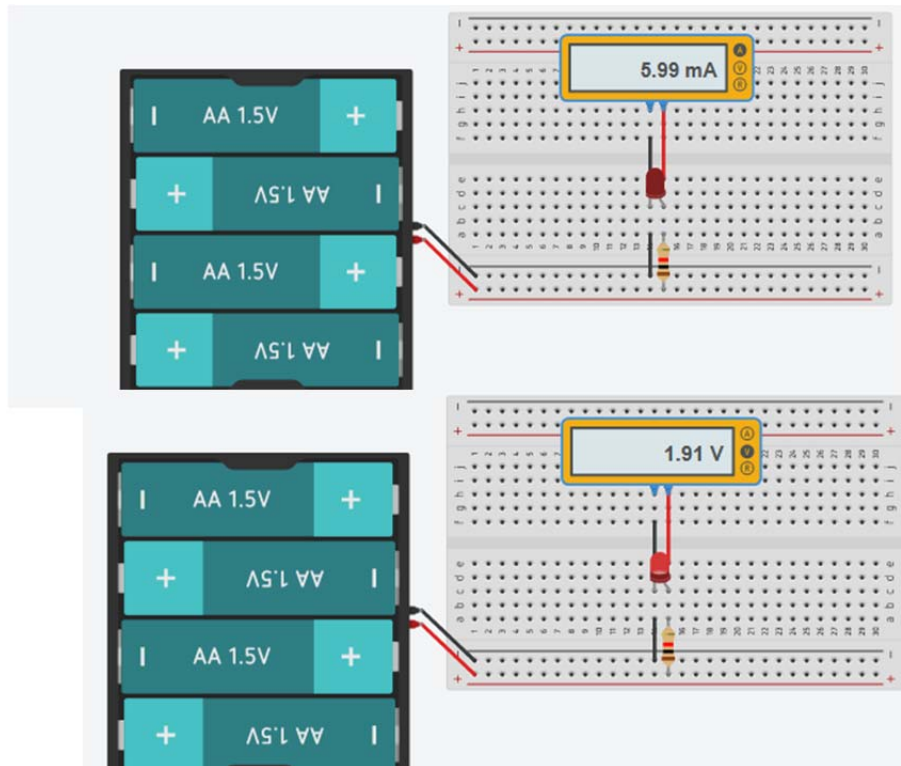


Step 5: Click the Start Simulation button. The meter will read 5.99mA (milliamps) which is the same current that we measured previously. The LED is not lit because the meter is shorting out the circuit.

Step 6: Click on the letter 'V' in the meter to measure voltage. The meter will read as 1.91V. Three 1.5 Volt battery powers the circuit. This provides a total of 4.5 volts to the circuit. The meter shows that there is a drop of 2.59 ($4.5 - 1.91 = 2.59$) across the circuit. The voltage has dropped because the current is not affected by the LED, but it does affect the voltage in a circuit. Resistors affect current and components like LEDs affect voltage or the power consumed in the circuit.

3D Design and Printing in Tinkercad

Look at the LED. The LED is lit. The resistor prevented damage to the LED. In a real application, the use of resistors in an LED circuit is to lengthen the life of the LED while maintaining the brightness of the LED.



Electronic Circuits using Circuit Assembly

Glow circuit assembly

A glow circuit assembly combines a light emitting diode (LED) and a coin cell battery to light up a 3D design. It has a corresponding 'hole' to cut out a void big enough to assemble after printing.

The two shapes required to design a glowing circuit are:

- Glow holder
- Glow cutout - The Glow Cutout is what you use to make the hole/space in your design where the printed Glow holder will be inserted.

Note

When you import the shape onto the Tinkercad workplane, illustrations of the LED and coin cell battery are shown together with the GLOW shape, but it will not export along with the holder. They are there only to show you where the light sits in the holder and how high it is. This is helpful to make sure your design doesn't interfere with the LED and for knowing where to put cut-outs for light to shine through.

3D Design and Printing in Tinkercad

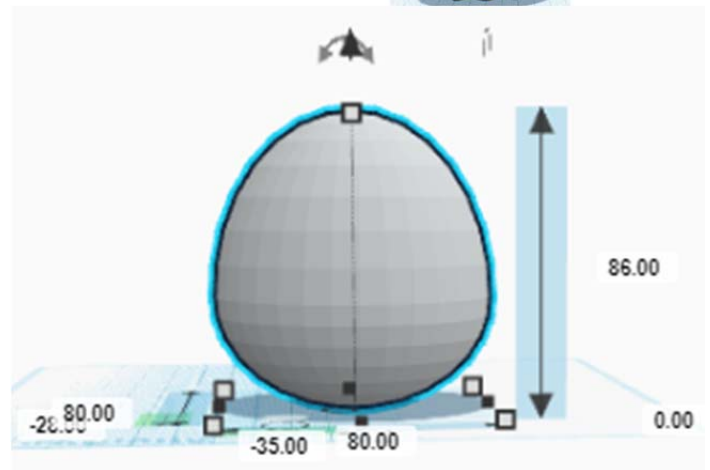
Designing the Egg Lamp and incorporating glow circuit assembly

Performs the following steps to design a 3D lamp

➤ Resizing and Dividing the Egg

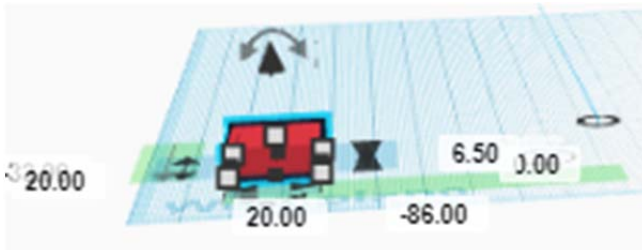
Step 1: Click the **Basic Shapes** drop-down menu on the right-hand side of the screen. Click **Characters** menu, drag egg shape on the workplane.

Step 2: Resize the egg shape to 80mm X 80mm by selecting the egg, holding shift and clicking and dragging one of the corner white boxes. You can also type 80 into the length and width dimension boxes. Change the height to 86mm.

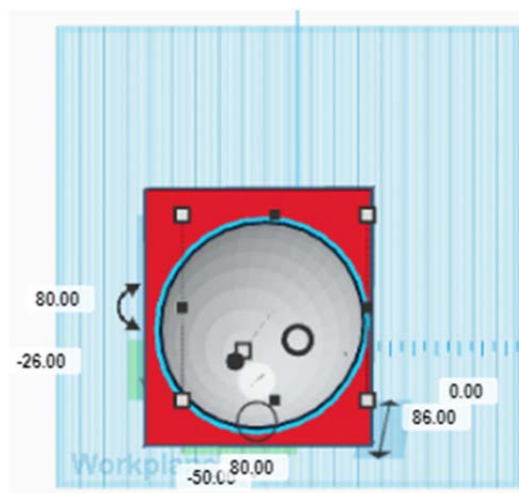


Step 3: Click the **Basic Shapes** and drag a **Box** onto the workplane.

Step 4: Make the height of the box 6.5mm.

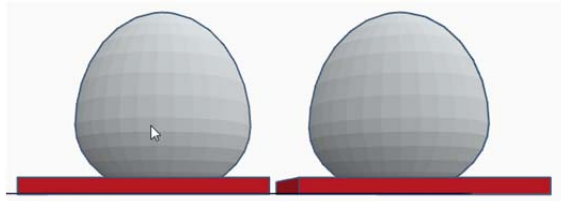


Step 5: Switch on the **Top View** and resize the length and width such that it is big enough to cover the entire egg.

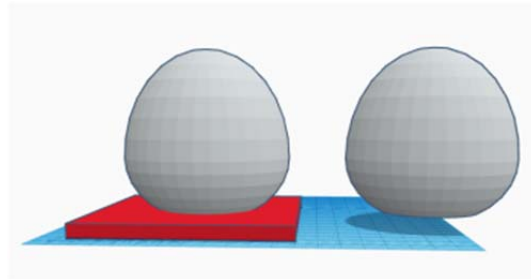
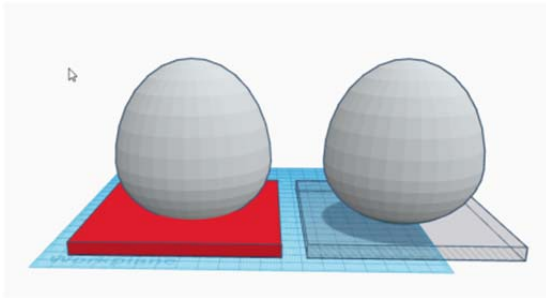


Step 6: Select the egg and the box. Duplicate it. Drag the duplicated shapes next to the original shape by pressing the shift key.

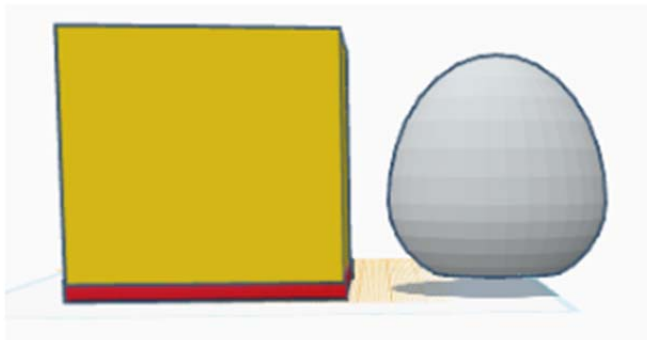
3D Design and Printing in Tinkercad



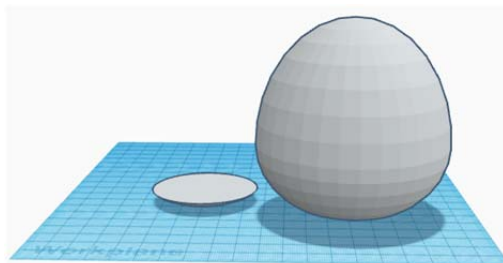
Step 7: Select the box at the right and make a **Hole**. Select both the right egg and box and **Group** them. This will remove the bottom part of the egg.



Step 8: Click and drag a new Workplane and place it at the top of the box below the left egg. Place Box over the new workplane. Resize the Box such that it completely covers the rest of the left egg. (The new box colour is changed to yellow to identify the difference)



Step 9: Select only the lower Box and delete it. Make the yellow box a Hole and Group it. The bottom of the egg will be left which will match with the top part of the other egg.



Step 10: Move the egg bottom off the workplane. Lower the egg top such that it is sitting on the workplane.

3D Design and Printing in Tinkercad

➤ Shelling the Egg

Step 1: Duplicate the egg. Move it aside and resize it to 77mm X 77mm and height 84mm.

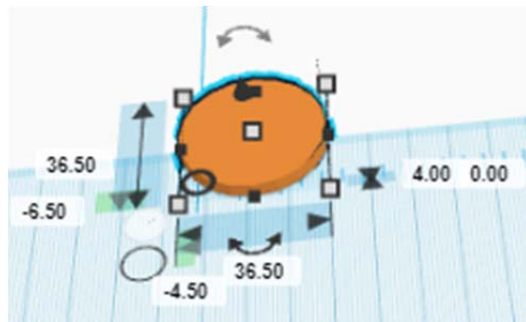
Step 2: Set the original egg **Transparent** (To check the transparent option, click Solid and click on the checkbox next to Transparent option.)

Step 3: Place the resized egg inside the original egg. Select both the eggs. Click **Align** and then click appropriate black dots to center the inner egg with outer as shown below.



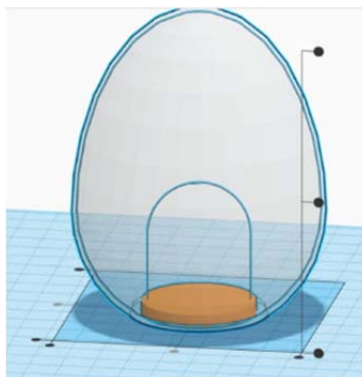
Step 4: Highlight the inner egg top only by selecting both, holding down SHIFT, and then clicking on the outer egg, which will deselect it, leaving the inner egg top still selected. Make the inner egg a hole.

Step 5: Place the cylinder shape onto the workplane. Resize it such that it is 36.5 X 36.5 X 4mm.



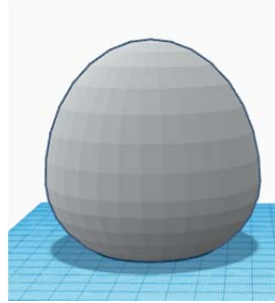
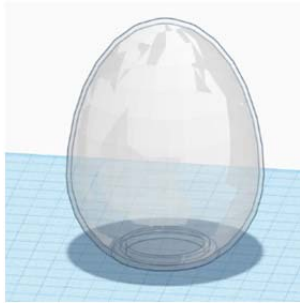
Step 4: Place the glow cutout from the Circuit Assemblies on the top of the cylinder. Group them.

Step 16: Select all the three shapes and click on Align. Click the length and width black dots to align all the three components.



3D Design and Printing in Tinkercad

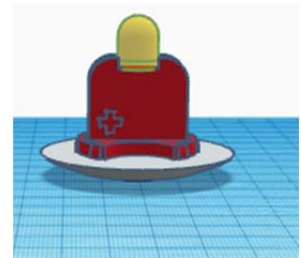
Step 5: Select the outer egg and inner egg and Group them. Select the egg top and click **Transparent** to uncheck it.



➤ Incorporating Glow Circuit Assembly

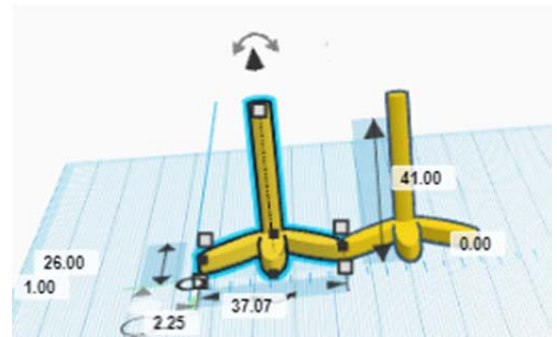
Step 1: Drag a Glow holder onto Workplane from Circuit Assemblies. Select both the egg bottom and Glow Holder and align them. Select the Glow Holder and raise it to 6.5mm off the Workplane so that it is sitting on top of the egg bottom.

Step 2: Select both the holder and the egg bottom and click on Group.

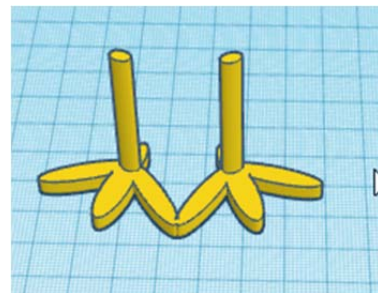
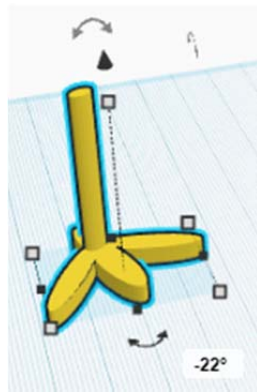
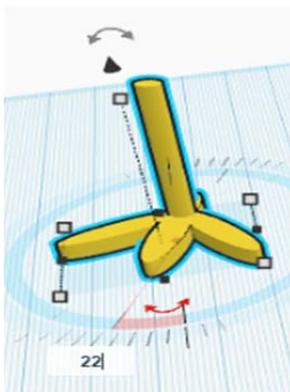


➤ Making Legs

Step 1: Move the holder to the side of the workplane. Drag in one Chick Foot from the **Characters** and resize it to be 37.07mm wide and 41mm long. Duplicate the newly enlarged foot and drag it to the right while holding the Shift key. This will move the duplicated leg in the same axis next to the original one.



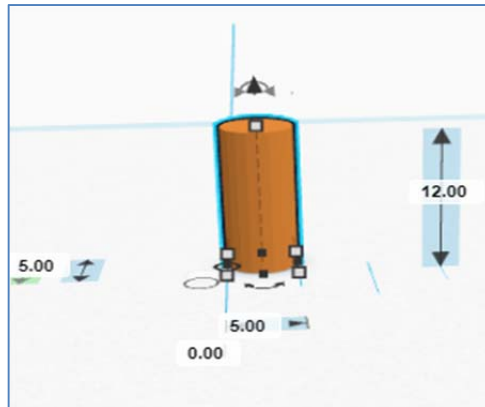
Step 2: Go to the Top view and Rotate the left foot (your left) 22 degree and right foot (your right) -22 degree. Move the right foot towards the left until they slightly overlap. Select them and Group them.



3D Design and Printing in Tinkercad

Making a Hole to fit the legs

Step 1: Drag a Cylinder onto the workplane from the Basic Shapes menu. Resize the cylinder to 5 X 5 X 12mm. Move the cylinder to the top of one of the leg



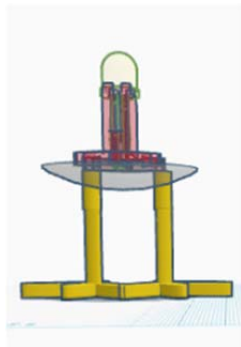
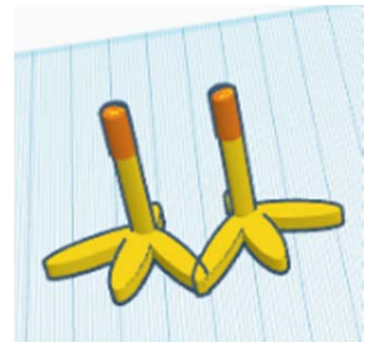
Note that we will make another set of legs that will have a slightly larger diameter to create a good tolerance fit for the printed ones.

Step 2: Go to the Top view and turn the **Snap Grid** off. This will help you to use only mouse pointer to move the components. Zoom in and place the cylinders so that they are centered on each leg. Duplicate the cylinder and place it on another leg.

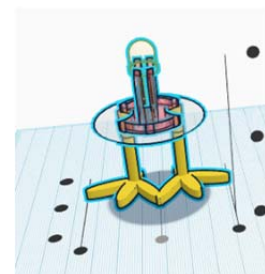
Step 3: Select the legs and cylinders and Group them, making them one piece.

Step 4: Select the legs with cylinder and duplicate them and keep aside.

Step 5: Select the egg bottom and holder and make it Transparent. Raise it up and move it so that it sits on top of the legs. Move the holder downwards such that it makes hole but make sure it meets the line where the egg bottom and Glow holder are joined.



tep 5: Select the legs and egg bottom and holder. Align them.



3D Design and Printing in Tinkercad

Step 6: Make the legs a **Hole**. Select the egg bottom and holder and click **Transparent** to uncheck it. Select all and Group it. This will create holes in the bottom.



Note – After creating the holes in bottom egg, delete the cylinders from the legs that were kept aside. Cylinders were used so that legs fit properly to the bottom of the egg.

➤ Printing and Assembling

3D printers have a problem while printing tall, thin objects. To handle this issue, it is advisable to build a thin wall, that is slightly taller than the object, around these kinds of shapes to help keep the filament flowing. Since the legs are so thin and spindly, it is recommended for it. Step 1: Build a boundary around the legs using the two cylinders, resizing it and then creating a hole. Place this boundary around the legs when printing. Print the top egg and bottom egg with 20% infill density and legs with 50% infill density.



Step 2: Place the coin battery (3 Volts) in the holder with the positive side of the battery facing the same as the '+' sign on the holder.



Step 3: Use a wire cutter to trim about a ½ inch off of each LED (10 mm big) Lead, making sure to keep the length differences. (The longer pin is positive and the shorter one is negative.)



3D Design and Printing in Tinkercad

Step 4: Insert the **LED** into the holder, with the longer **POSITIVE (+)** pin going on the side of the holder with the '+'.
with the '+'.



Link - <http://www.instructables.com/id/LED-Egg-Night-Light/>

Move Circuit Assembly

A move circuit assembly combines a vibration motor, slide switch and a coin cell battery to move 3D design. The two shapes required to design a move circuit are:

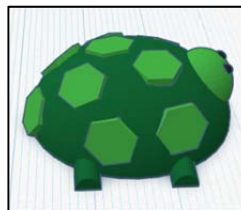
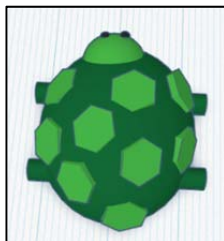
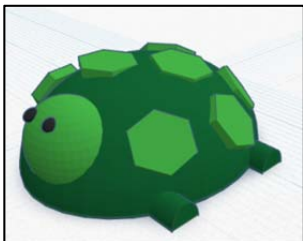
- Move holder
- Move cutout - The **move Cutout** is what you use to make the hole/space in your design where the printed move holder will be inserted.

Designing a Tortoise and incorporating the move circuit assembly

Perform the following steps to use a move circuit assembly in a tortoise.

➤ Designing a Tortoise

Step 1: Use the shapes half sphere, round roof, polygon and sphere to design a tortoise. Refer the figures to design it. Use Align and Group wherever required.



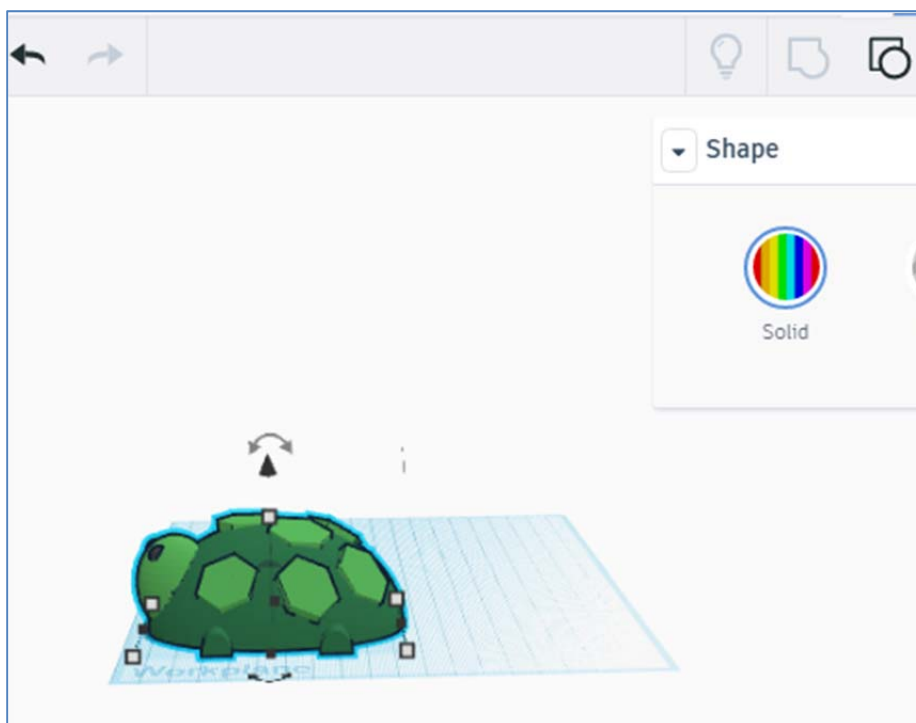
3D Design and Printing in Tinkercad

➤ Incorporating the Move Circuit Assembly

Step 1: Drag a Move cut out and move circuit assembly onto the Workplane from Circuit Assemblies. Select the tortoise, move circuit assembly and move circuit holder and then align them.

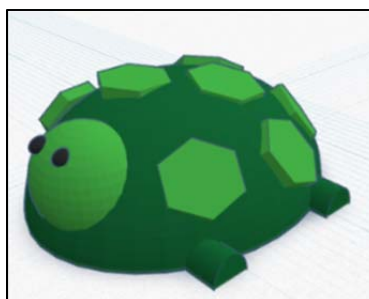
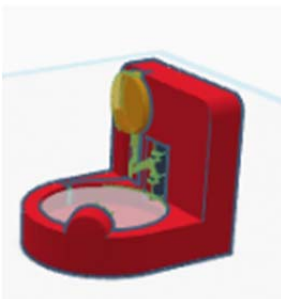


Step 2: Select the tortoise, move circuit assembly and move circuit holder and click on Group.



➤ Printing and assembling Move Circuit Assembly

Step 1: Export the tortoise, and holder as .STL files for printing.



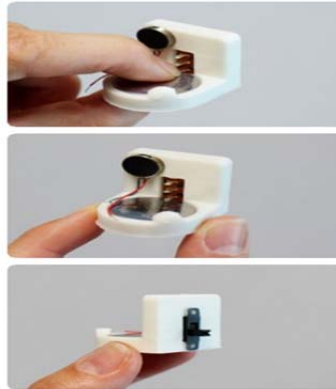
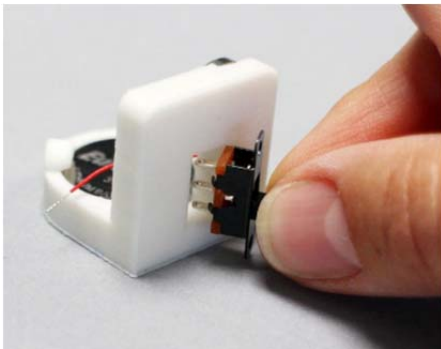
3D Design and Printing in Tinkercad

Step 2: Stick the vibration motor to the 3D printed holder.

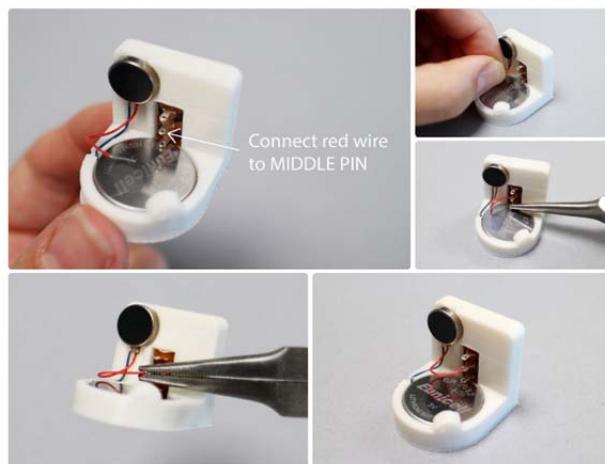
Step 3: Add coin battery into the holder with the positive side facing up. The negative side of the battery must be touching the blue wires from the vibration motor.



Step 4: Press the switch into place in the holder, so the pins face in towards the wires and battery. Press down on the battery when inserting the switch to ensure the battery is underneath the bottom switch pin.



Step 5: Connect the vibration motor and slideswitch. Thread the positive wire from the vibration motor into the hole of the middle pin of slide switch; ensure that the wire does not touch the bottom pin of the switch.



3D Design and Printing in Tinkercad

Step 6: Turn the Move Circuit Assembly on by sliding the switch to the bottom position. At this point, your assembly should be moving.

Link - <http://www.instructables.com/id/Move-Circuit-Assembly/>

Spin Circuit Assembly

The Spin circuit assembly consists of a few different parts: a 3D printed holder. A gear motor and 2 AA batteries. It is used to spin any part of a 3D design. The two shapes required to design a spin circuit are:

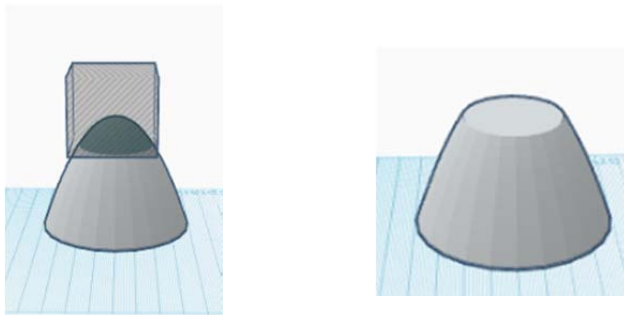
- Spin holder
- Spin cutout

Designing a windmill and incorporating spin circuit assembly

Perform the following steps to design a windmill and incorporate spin circuit assembly.

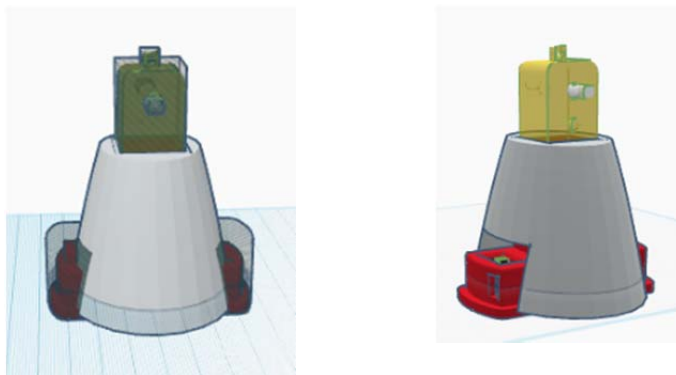
➤ Designing a windmill and incorporating spin circuit assembly

Step 1: Place a Paraboloid shape onto the workspace. Cut the top of it using the box cutout.



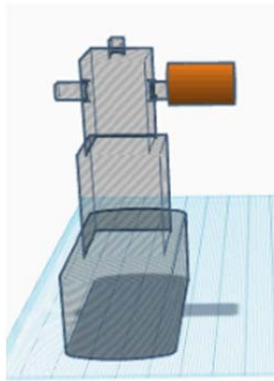
Step 2: Place a spin cutout and spin circuit assembly onto the Workplane.

Step 3: Select the spin cutout and paraboloid and Group it. A place to insert spin circuit assembly will be created. Place the Spin circuit assembly and align it.

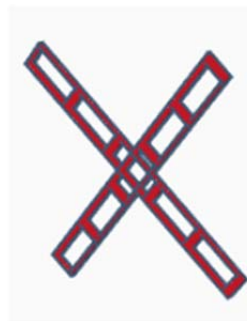
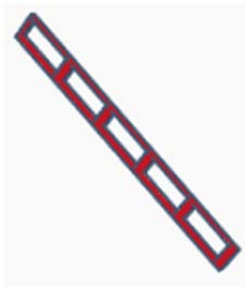


Step 4: Place a cylinder onto the Workplane. Reduce it such that its height is 21.07 and diameter is 11.40. Insert the rotatory shaft of spin cutout into the cylinder and create a hole in the cylinder.

3D Design and Printing in Tinkercad



Step 5: Use the box and Hole option to design the fan. Create one fan, duplicate it and flip it. Arrange the fan as shown in the figure below.

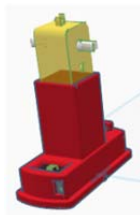


Step 6: Fit the rotatory shaft into the hollow of the cylinder. Place the fan such that it fits to the cylinder as shown in the figure.



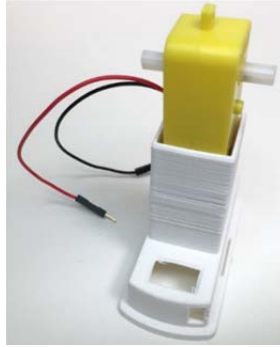
➤ Printing and Assembling Spin Circuit Assembly

Step 1: Export the different parts of a windmill and holder as .STL files for printing. (Make sure you print paraboloid, circuit holder, cylinder and fan separately.)



Step 2: Position the holder such that the hole of the battery box switch is facing towards you. Press the gear motor into the holder with the cables facing to the left.

3D Design and Printing in Tinkercad



Step 3: Thread the two wires of the motor through the ring one-by-one.



Step 4: Insert the battery box into the holder from the bottom, threading the battery wire through the hole on the side of the holder.



Step 5: Wrap the red wire from the battery box around the pin at the end of the motor's red wire.

Similarly, connect the black wire from the battery box to the black wire of the motor.

Step 6: Insert the batteries and Turn on the switch on the battery box. Check that the motor turns on. If the motor does not turn on, check the connections.

Step 7: Place the holder inside the paraboloid shape. Paste the cylinder to the center of the fan. Add cylinder to the rotatory shaft of the motor.

Step 8: Turn on the switch. The fan should spin.

Link - <http://www.instructables.com/id/Spin-Circuit-Assembly/>



3D Design and Printing in Tinkercad

Exercise

1. Fill in the blanks

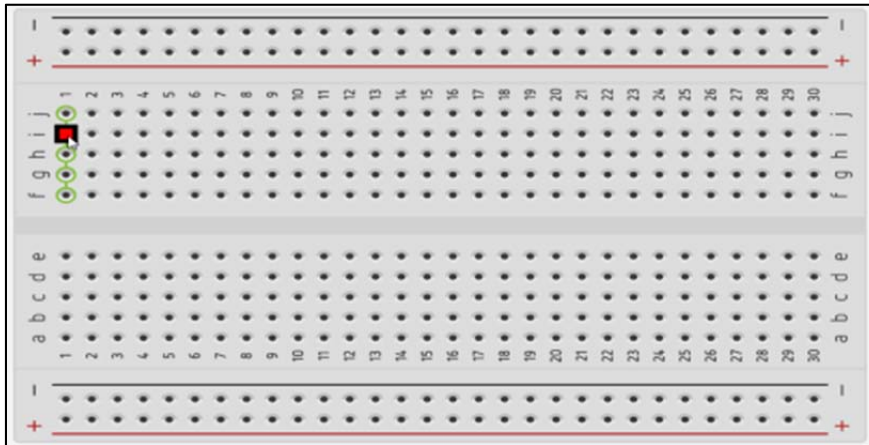
- A process in Tinkercad where we can develop electronic circuits that can be quickly updated, modified and tested is called _____.
- In Tinkercad, _____ tests the working of the circuits and the components.
- The device used to assemble and connect the various components is known as _____.
- In an electronic circuit with LED, the positive end of the circuit should be connected to _____ and negative end should be connected to _____ of the LED.
- A _____ is used to restrict the flow of current to electrical components.

2. Label the following

- Anode and Cathode in an LED



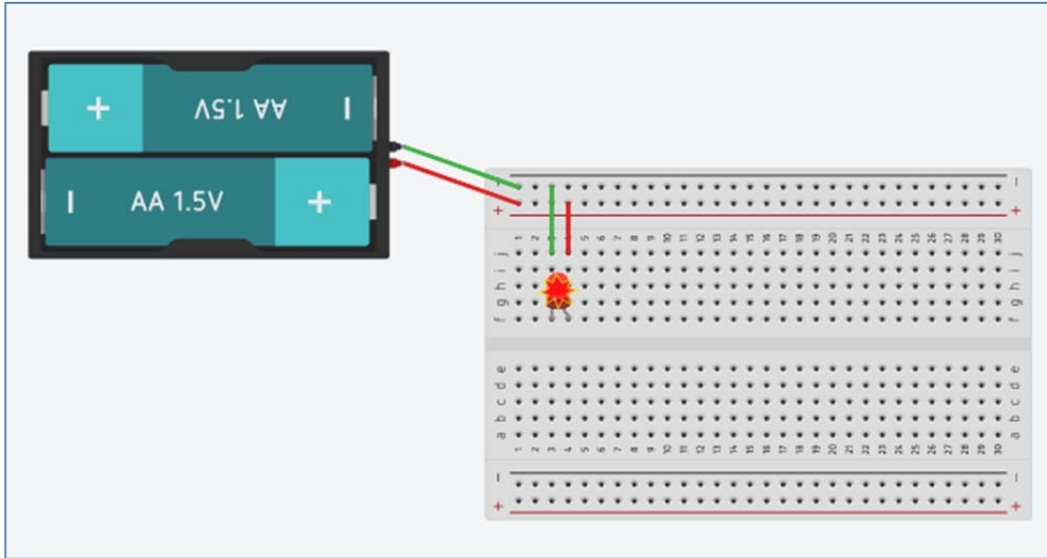
- Different parts of breadboard



3. Answer the following questions

- Explain the use of 'Transparent' option in Tinkercad.
- Explain the following components used in an electronic circuit.
 - Breadboard
 - LED
 - Resistor
- What are circuit assemblies? Explain with the help of glow circuit assembly.
- List the electronic components used in spin circuit assembly.
- Observe the circuit given below. What has happened to the LED? Give reasons for your answer.

3D Design and Printing in Tinkercad

[illegible]