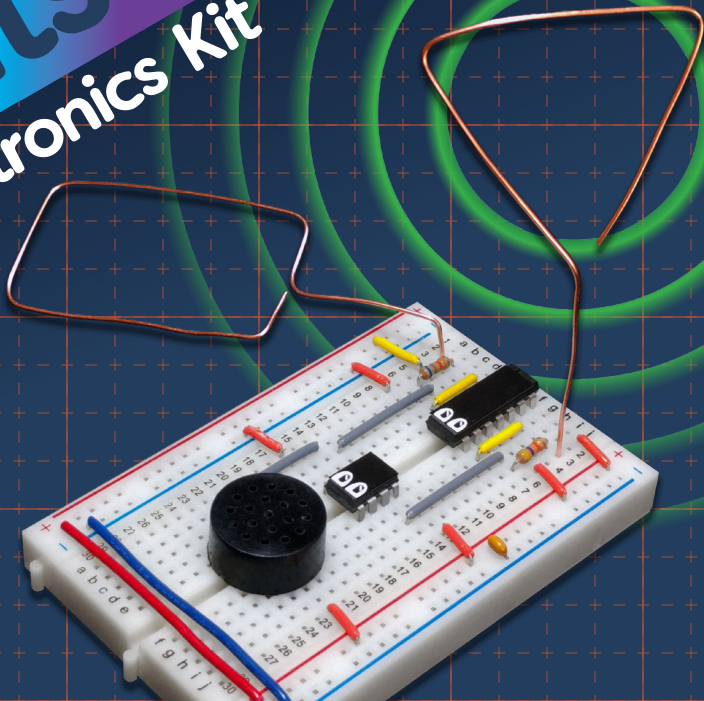
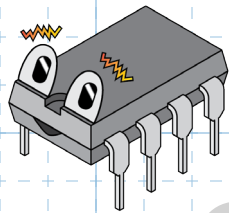


Microkits

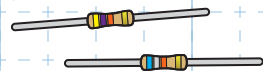
Theremin Electronics Kit



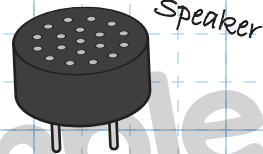
Greetings, I'm Micro! Today I'll be helping you build your own circuit. We'll be using these parts (including me!) to build a theremin.



Two Resistors

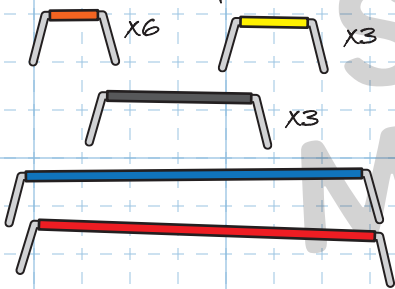


Capacitor



Speaker

A Bunch of Wires

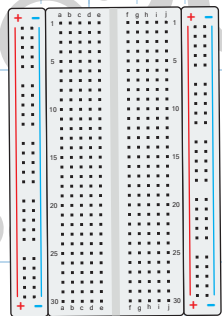


TICK



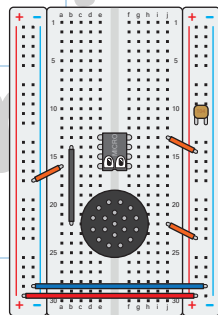
MICRO

Two Copper Antennas

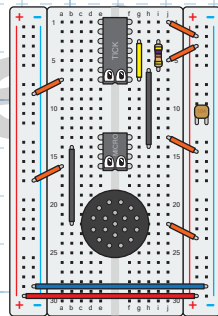


And A Circuit Building Block

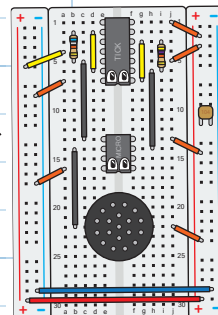
We're building the circuit in three stages. That way, we can check our work as we go. Don't worry about making mistakes, because we can fix them along the way. And once we're done, you'll have a really cool way to experiment with physics and music!



Stage 1: Audio and Power

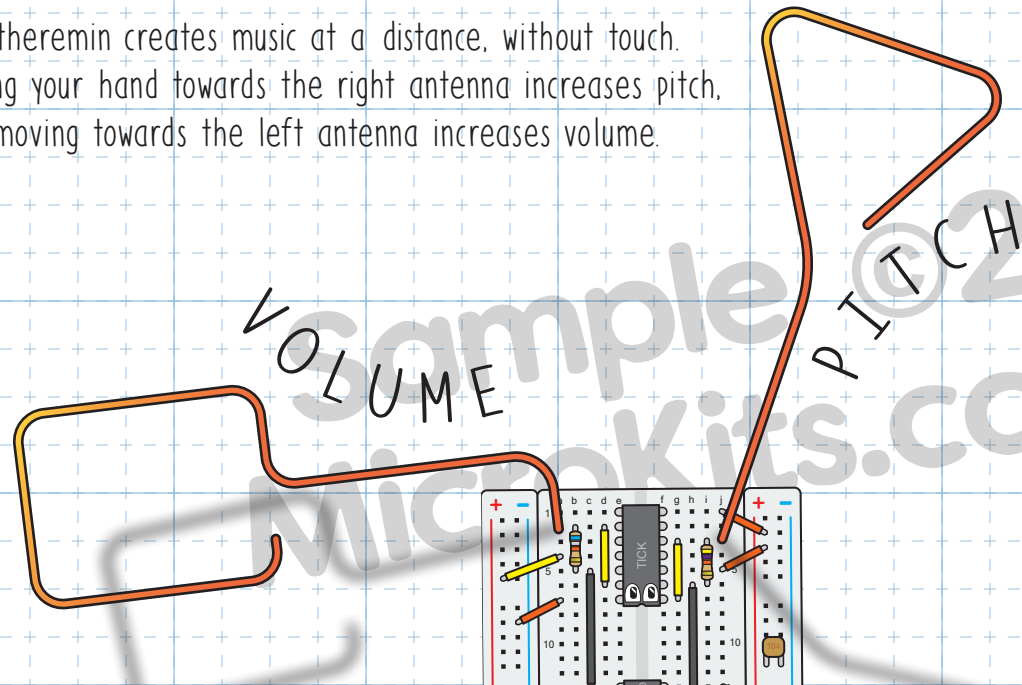


Stage 2: Pitch Control

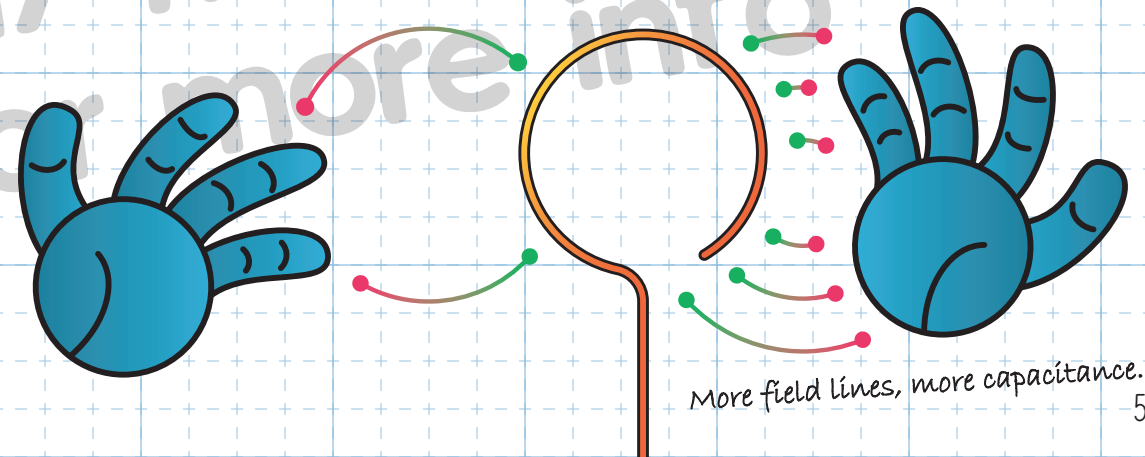


Stage 3: Volume Control

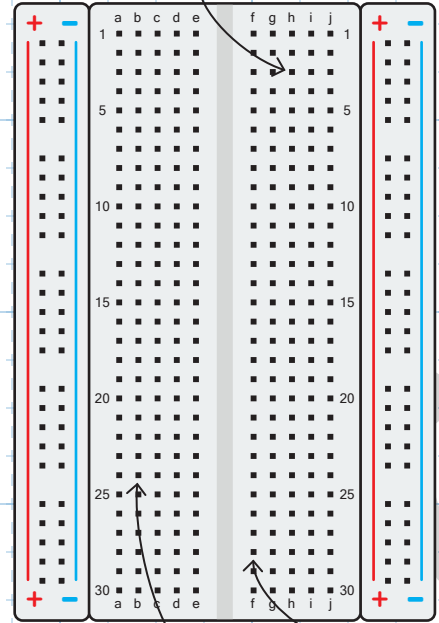
The theremin creates music at a distance, without touch. Moving your hand towards the right antenna increases pitch, and moving towards the left antenna increases volume.



Your theremin senses capacitance to figure out what note to play. Capacitance is how easy it is to store energy between objects in an electric field. By moving things (like your hands) closer to the theremin, you increase capacitance.



This is point H3

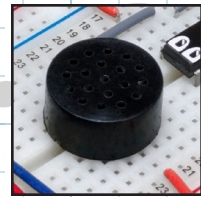
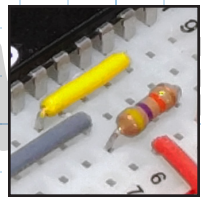
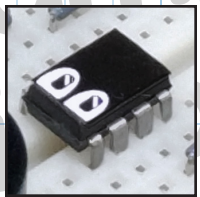


6 B24 F28

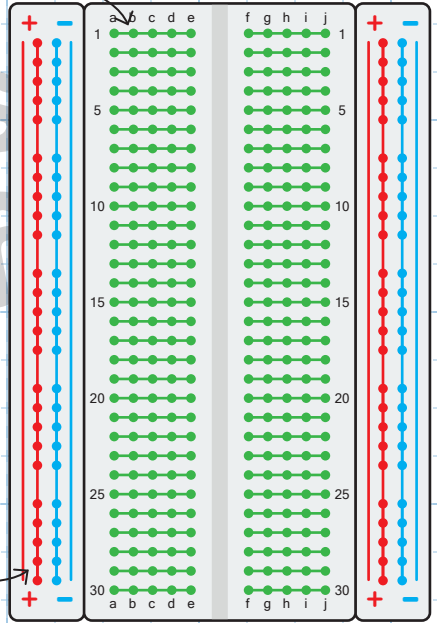
The circuit building block holds wires and parts on a grid. With it, you can make connections without tools. Each point on the grid has a name. The grid has rows from 1 to 30 and columns from a to j.

Push the wire or part **fully** into the correct point.

Examples of correctly placed parts:



Grid



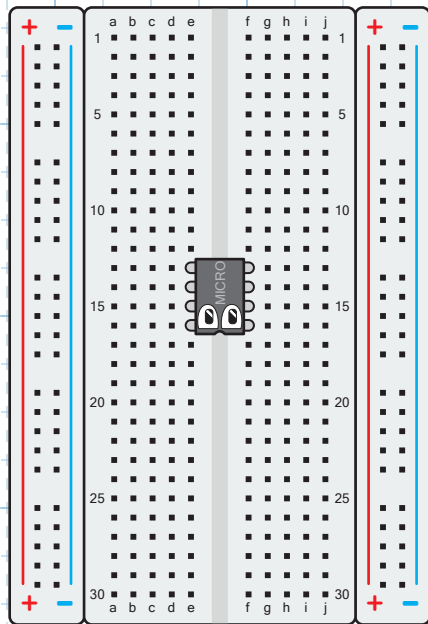
Power

The graph to the right shows how different points are electrically connected inside the building board. The points act like wires to connect different parts.

Points on the same row of the grid connect horizontally, but not across the middle.

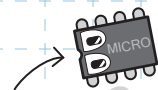
On each side of the grid are a pair of strips, marked "+" Positive and "-" Negative. These points connect vertically and will help deliver power to different parts of the circuit.

Stage 1: Audio & Power



8

- Place the building board with **Row 1** on top.

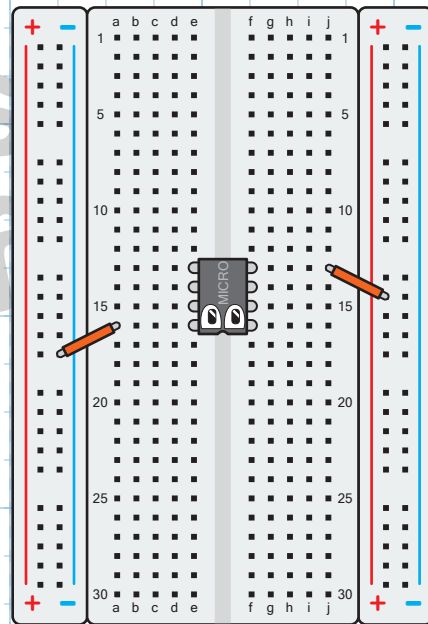


- Find me, Micro. I have 8 metal legs, called pins.
Place the pins in rows 13 to 16 and column E & F.
Make sure I **lay flat** on the block, and make sure my eyes point down. **Direction matters!**

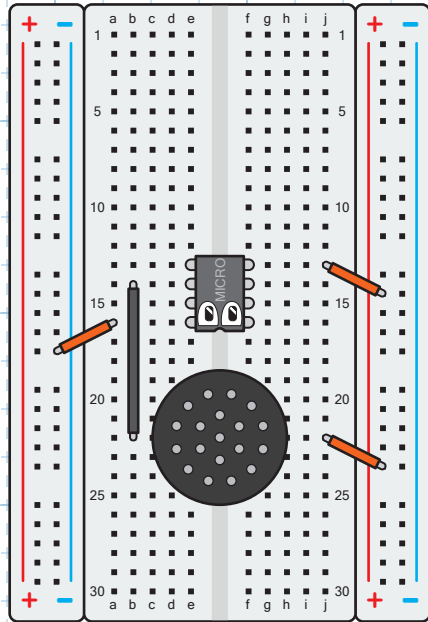
Micro can be programmed to do different things, like being a theremin!

- Connect A16 to the “-” strip using an orange wire.
- Connect J13 to the “+” strip using an orange wire.

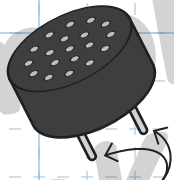
Wires connect sections of the building block together, so that electrical power and signals can flow to parts.



9

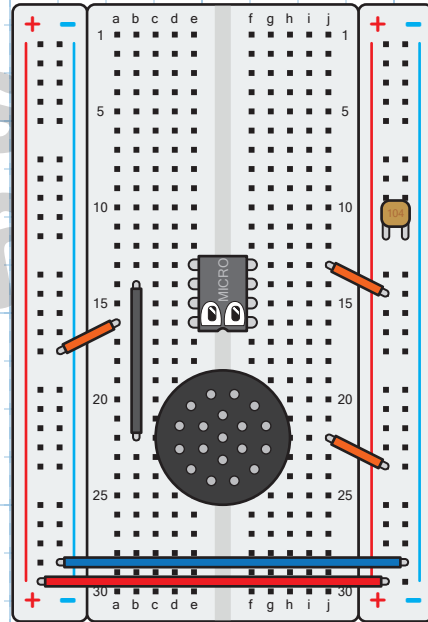


- Connect B14 to B22 with a gray wire.
- Connect J22 to the "+" strip using an orange wire.



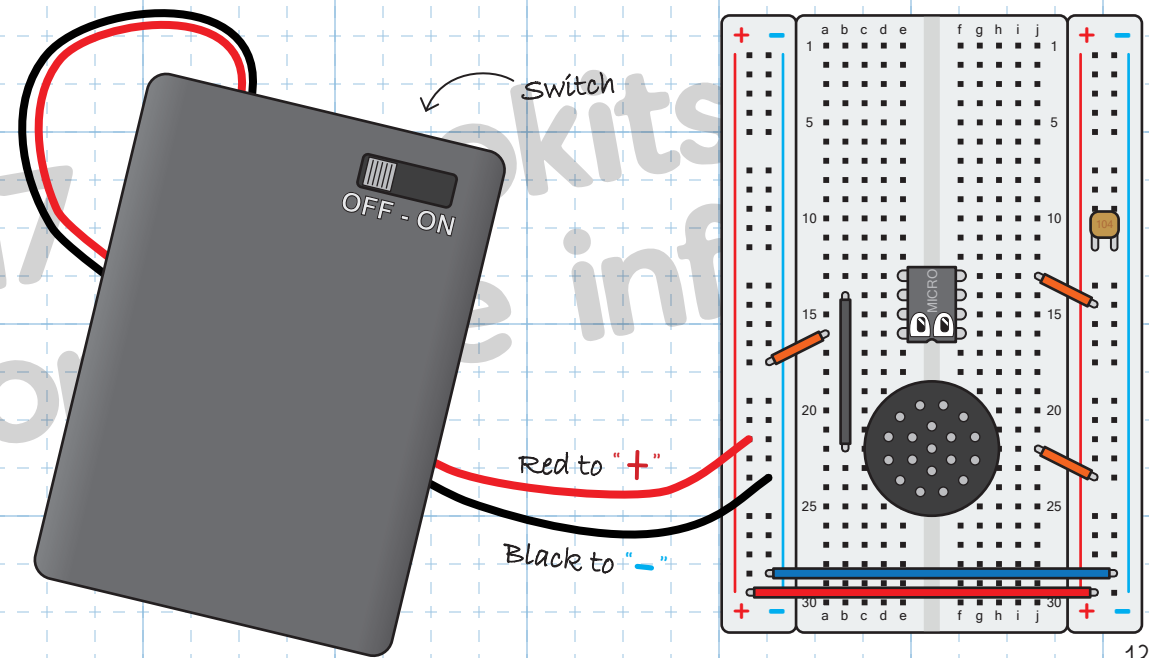
- The speaker has two pins. Place the pins on row 22, in columns E & F (either direction will work).

- Place the capacitor between the "+" strip and the "-" strip in the location shown.
- Connect the "-" strip on the left to "-" on the right using a long blue wire.
- Connect the "+" strip on the left to "+" on the right using a long red wire.



- Find the switch on the battery pack. For now, make sure it is set to **"OFF"**.
- Open the battery holder and install three **new** AA batteries. Check the battery holder to see the correct way to place the batteries.
- The battery pack has two wires. Plug the red wire into the **"+"** strip and the black wire into the **"-"** strip, as shown. **Direction matters!**
- Double check your progress to make sure everything is connected correctly:

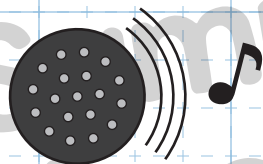
- | | |
|---------------------------------|----------------------------------|
| □ No loose wires or parts | □ Battery plugged in correctly |
| □ Parts are in the correct spot | □ Micro facing correct direction |



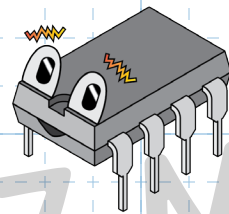


Important: Turn the power **OFF** immediately if the circuit does not work. Leaving power on could damage or overheat the battery or Micro.

When you're ready, turn the power **ON**. What happens? You'll know your circuit is working when the you hear a tone! This means that power and speakers work.

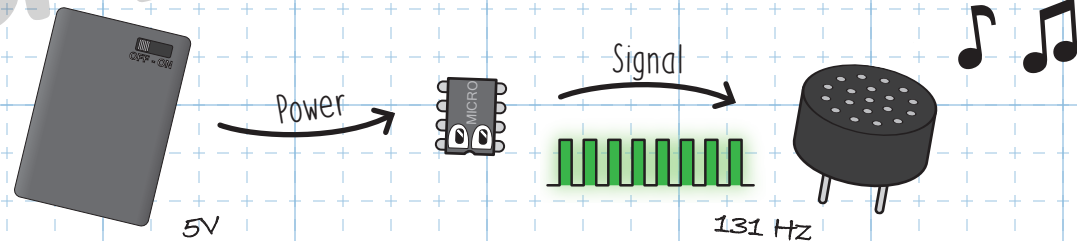


If nothing happens, don't worry! Just turn the power **OFF** and check for mistakes, a process called troubleshooting. With a bit of looking you'll find what to fix.

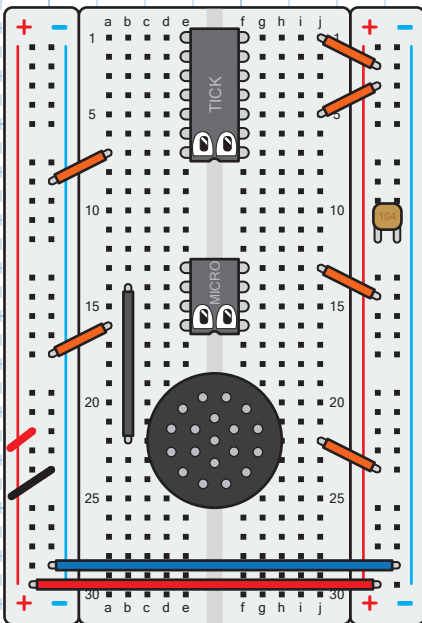


Let's think about what's going on. Right now, I'm connected to a speaker, a battery, and a capacitor. The battery gives me power, and the capacitor stores extra energy for when I need it most.

With this power, I create an electrical signal that I send to the speaker. When the signal changes, the magnet inside the speaker moves. This creates sound that you can hear. I'm only playing a single note now, so let's add parts to build a real theremin!

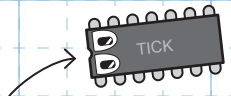


Stage 2: Pitch Control



16

- Turn power **"OFF"** while building the circuit.

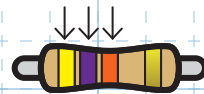


- Place Tick in rows 1 to 7 and column E & F, with eyes pointed down. **Direction matters!**
- Connect A7 to the **"-"** strip with an orange wire.
- Connect J1 to the **"+"** strip with an orange wire.
- Connect J5 to the **"+"** strip with an orange wire.

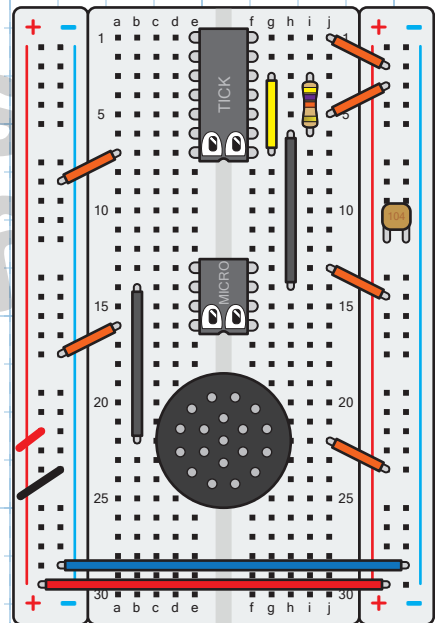
- Connect G3 to G7 with a yellow wire.

- Connect H6 to H14 with a gray wire.

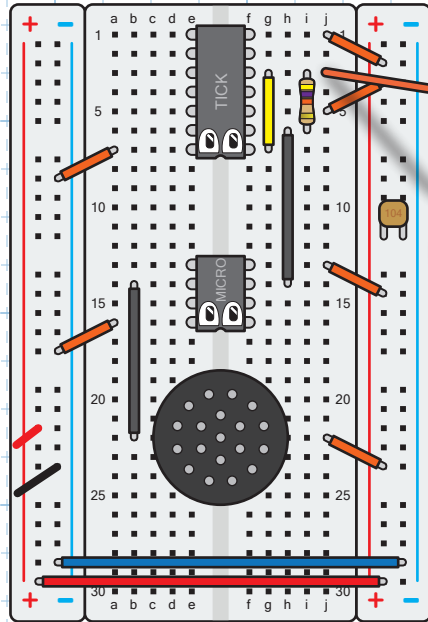
- Find the resistor with the following bands: Yellow Purple Orange. Place it in I3 and I6 (either direction will work).



The colors show the value of the resistor.
This one is 47,000 Ohms.

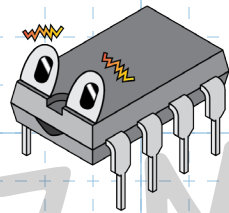


17



This antenna is a big capacitor!

- Place one of the two long copper wires in J3. The wire should stick straight up and away from the board, but other than that you can bend it however you want. This will act as our pitch antenna.



Give your circuit one more check, and when you're ready, turn it **"ON"**! What happens when you reach toward the antenna? If nothing changes and the note stays constant, turn **"OFF"** the power and troubleshoot like before.

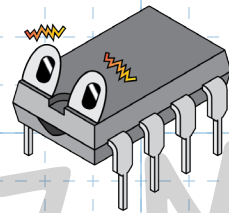
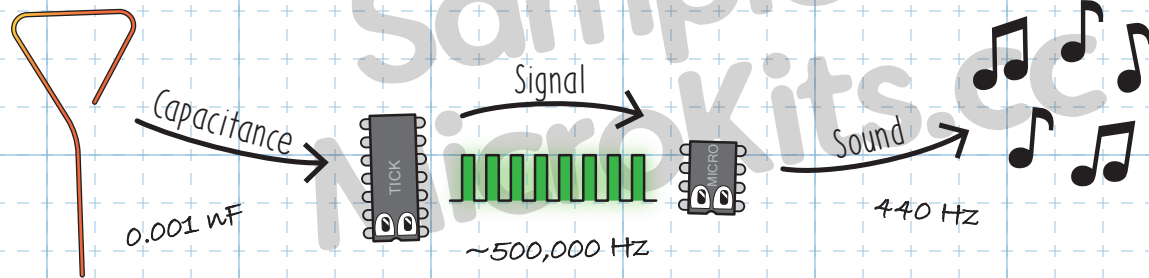
If the pitch **increases** as you approach, congratulations! Your theremin is working. You can now create three octaves worth of notes just by waving your hand.

We're not done yet, though. We still need to add the volume antenna to create a fully functional theremin.

But before we do that, let's learn a bit more about the circuit we just built!

So how does a theremin work, anyway? It's all about turning one kind of signal into another kind of signal. First, your hand adds electric fields to the antenna. This adds capacitance. Tick creates a high frequency signal based on this capacitance.

Then, I, Micro, read the signal from Tick. I do math to turn Tick's high frequency signal into a signal you can hear. Then, the speaker turns my signal into sound.

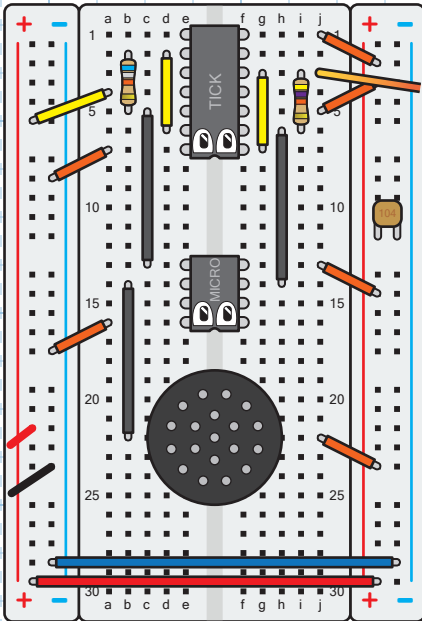


I bet you're wondering how Tick turns capacitance into a signal. Tick contains a timer circuit, a kind of clock. This clock is based on the amount of time it takes to build up a tiny amount of charge. In this case, the theremin antenna is what is building up the charge.

Moving your hand toward the antenna adds capacitance, and Tick needs extra time to charge. The resistor you added also changes Tick's frequency. The whole equation is:

$$f = 0.72 / R \times C$$

Where R is resistance, C is capacitance, and F is output frequency. F is proportional to the inverse of R and C. This just means that the more resistance and capacitance, the lower the frequency.

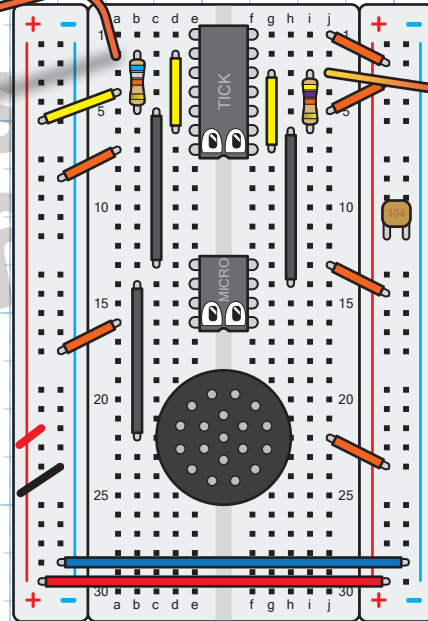
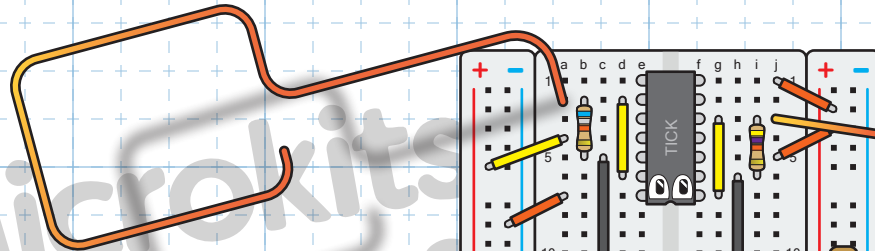


Stage 3: Volume Control

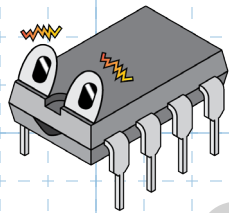
- Turn power **"OFF"** while building the circuit.
- Connect A4 to the **"+"** strip using a yellow wire
- Connect C5 to C13 using a gray wire
- Connect D2 to D6 using a yellow wire
- Place the resistor with Blue Grey Orange bands in B2 and B5.



- Place the second long copper wire in A2. Bend it up and away from the circuit board, and off to the side. Make sure to keep this antenna away from the pitch antenna. This is our volume antenna.



Your theremin is now complete. Turn it "**ON**" and see if volume **decreases** when you move your hand toward the second antenna. If not, you know how to troubleshoot!



What did you learn from this project?

- How to connect different parts to build a circuit.
- What kind of parts are needed for a circuit and what they do.
- How to troubleshoot mistakes and check your work as you go.
- How electric fields and capacitance work, and are turned into electrical signals.

Playing the theremin is challenging, but here are some tips!

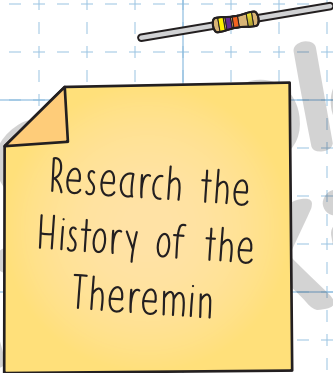
- Use your left hand to control the volume antenna, and your right for pitch.
- More surface area means more capacitance. Move your whole hand toward the instrument and focus on the middle of the antenna, not the end.
- Bend the two antennas away from each other, so that they don't interfere.
- Your theremin automatically adjusts to the environment. If you move the antennas or the tuning seems wrong, just turn it off and back on again.
- Turn the battery holder "**OFF**" when not in use.

Congratulations on building your theremin! But this is only the start. Now you can learn more about electronics, experiment with music, and investigate physics. What will you do next?

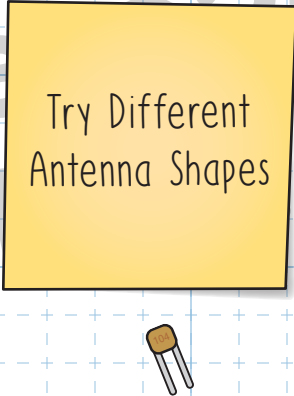
Impress Your
Friends with
Science



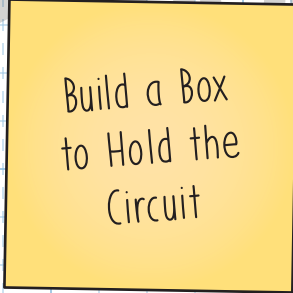
Research the
History of the
Theremin




Try Different
Antenna Shapes



Build a Box
to Hold the
Circuit



Learn to
Play a Melody



Test the
Capacitance of
Different Things



Build More
Electronic Kits



Find Out More
at [MicroKits.cc!](http://MicroKits.cc)



See Ya
Later!



Antenna: a conductor that can send or receive electromagnetic waves • **Capacitance:** the ability to hold an electric charge • **Circuit:** a path for electrical current to flow, made up of different electrical parts • **Frequency:** the number of times a wave repeats in a unit time • **Integrated Circuit:** also called a chip, a miniaturized circuit created on a thin semiconductor wafer • **Pitch:** the frequency of a sound • **Resistance:** the ability to resist the flow of electrical current • **Timer:** an integrated circuit which changed frequency based on resistance and capacitance • **Troubleshooting:** finding and solving problems in a system • **Volume:** the loudness of a sound

⚠ WARNING

- Small parts. DO NOT allow children under 3 years old to play with or near this product.
- NEVER connect any part of the kit or circuit to any AC electrical outlet.
- Discontinue use of any kits that malfunction, become damaged or broken.
- Components are subject to damage by static electricity. Handle with care.
- Keep conductive materials (such as paper clips, aluminum foil, etc.) away from the circuit and battery.
- Always turn OFF the battery pack when not in use, when left unattended, or when disconnected from the rest of the circuit.
- Incorrect connections can cause damage or overheating to system or batteries. Always ensure proper connections before turning on.
- Never use the kit in or near any liquid, or in any extreme environments such as extreme hot or cold, high humidity, or sand.

Safety First!