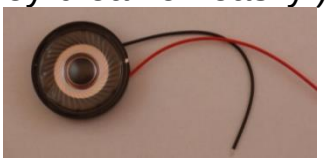
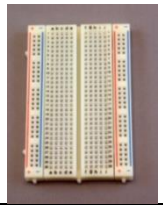
Activity 1: Sound on a Breadboard

Parts List:

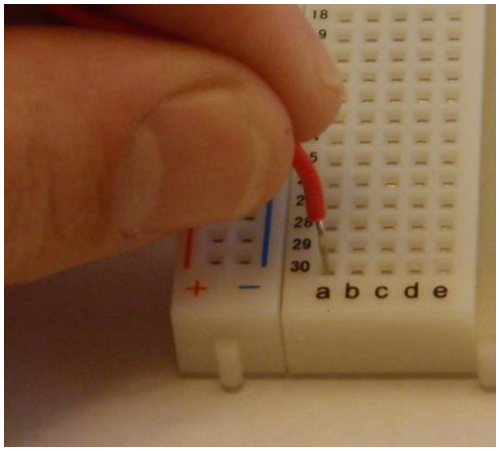
Speaker (Note: Be careful with the wires. They break off easily.) 	Wire with headphone plug 
Music player (MP3 player or radio that uses headphones)	Breadboard 

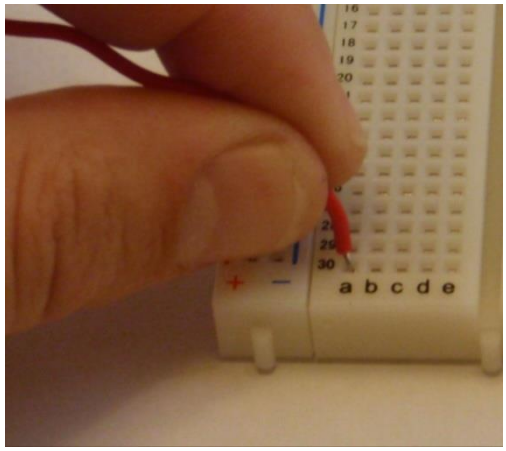
Part I: Playing Music Through a Speaker

Challenge: Can you play sound through the speaker using just these three pieces? Hint: You will use the Music player as the source. When you plug in the headphone plug, the music signal is converted to an electrical signal at the two wires on the end of the wire. You will need to connect the wire from the headphone plug to the speaker using the breadboard.

Part II: Using a Breadboard

You will build your circuits on a **breadboard**, which electrical engineers use to build and test circuits. Wires can be inserted into the holes to connect them to the circuit. Insert wires as shown below.





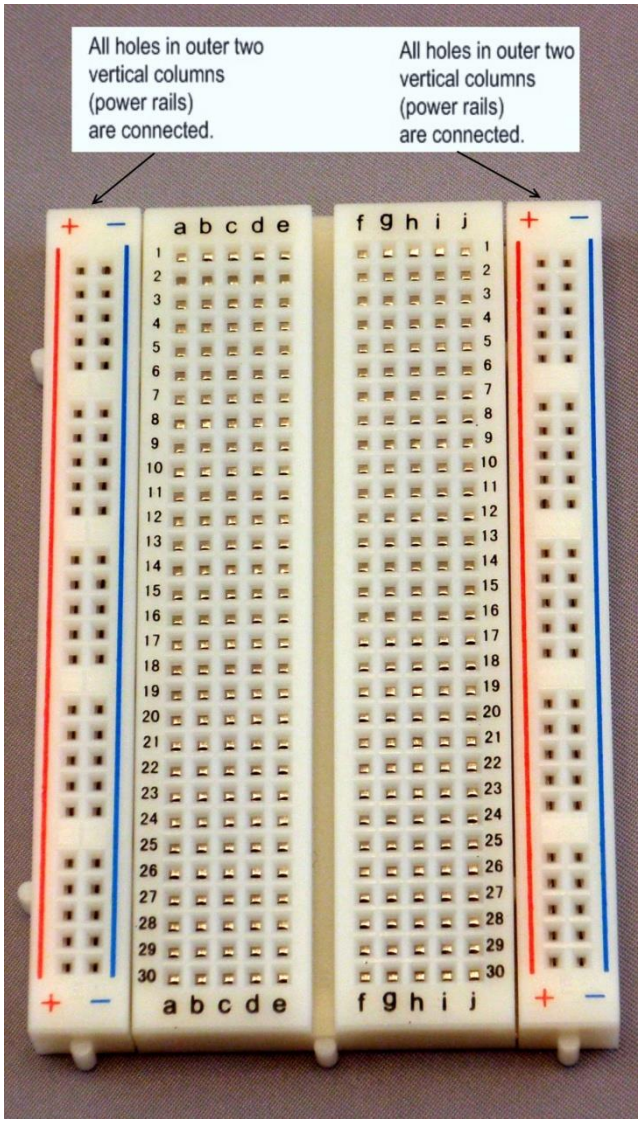
Challenge: Can you connect the music player to the speaker using the breadboard? Once you figure this out, try different connections until you are confident which portions of the breadboard are connected and which are not.

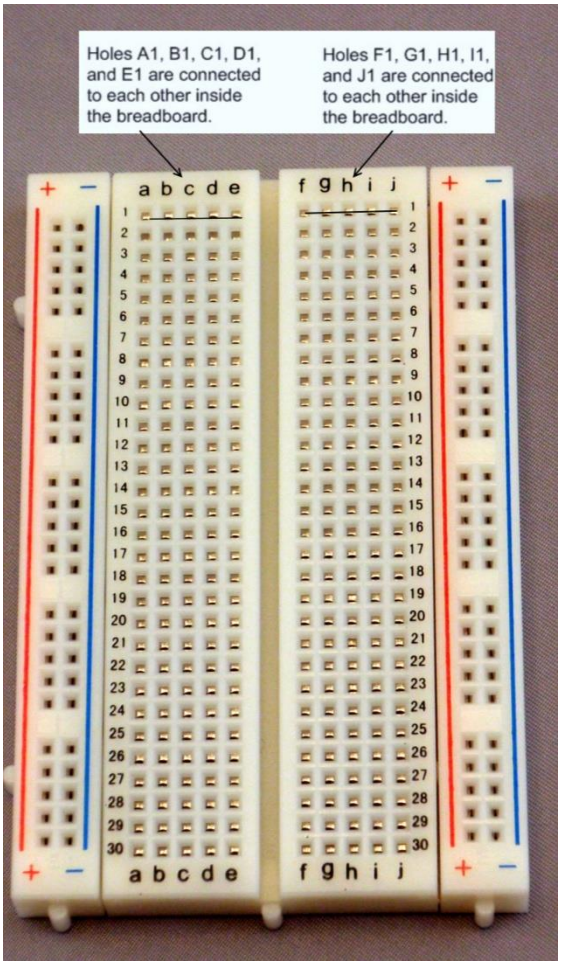
Breadboard Inner Holes

All five holes in a single row are connected inside the breadboard. Opposite halves of the breadboard are not connected.

Examples:

- **A1** is connected to **D1**.





- **A1** is NOT connected to **A2**.
- **E1** is NOT connected to **F1**.

Breadboard Outer Holes (Power Rails)

All 25 holes in a column of a power rail are connected together inside the breadboard. We will use the blue power rail on the left and the red power rail on the right. We will make the blue power rail negative and the red power rail positive.

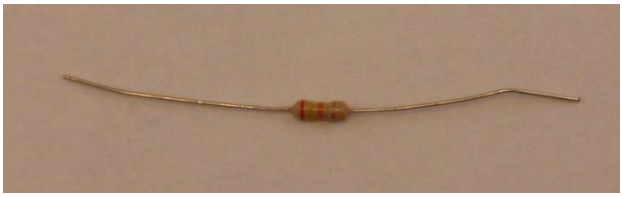
Activity 2: Amplifying Sound

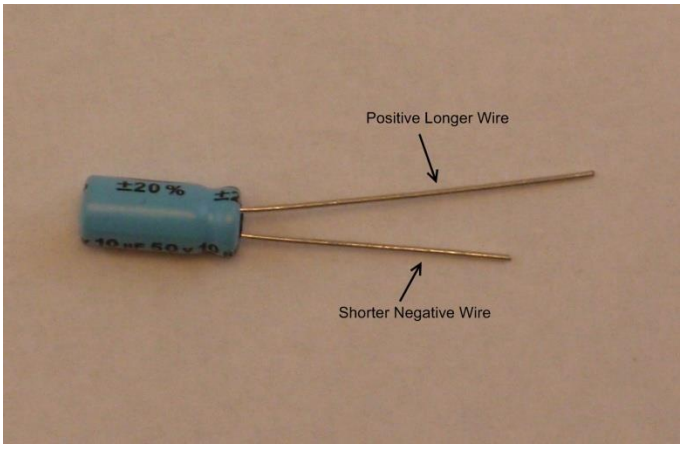
In this activity, you will build a circuit that uses the energy from a battery to make the sound coming out of the speaker louder. When you finish building this circuit, do not take it apart because you will be using it in Activities 3 and 4.

Parts List

- One TechXcite Music Receiver Bag containing:
  - 3 capacitors (10 μF electrolytic)
  - 1 phototransistor (to be used in Activity 3)
  - 1 amplifier chip (LM 386 Integrated Circuit)
  - 1 resistor (red, yellow, orange — 24 kΩ)
  - Speaker
  - Battery snap
- 9V battery
- 2” jumper wires
- Speaker
- Wire with headphone plug
- Music player

A **resistor** converts electrical energy into heat. The colored bands refer to how much resistance each resistor has.

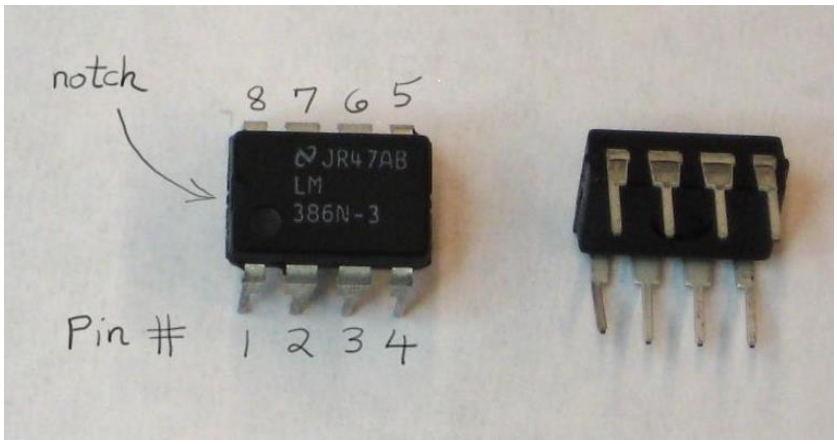




The **capacitors** in this kit have a cylindrical body, as shown in the picture. These capacitors are polarized. This means that there is a positive (+) wire and a negative (**–**) wire. Look at one of the capacitors closely. Notice that one of the wires is shorter than the other. The shorter wire is negative (**-**) and the longer wire is positive (+). Also, there is a black band running down the negative side of the capacitor.

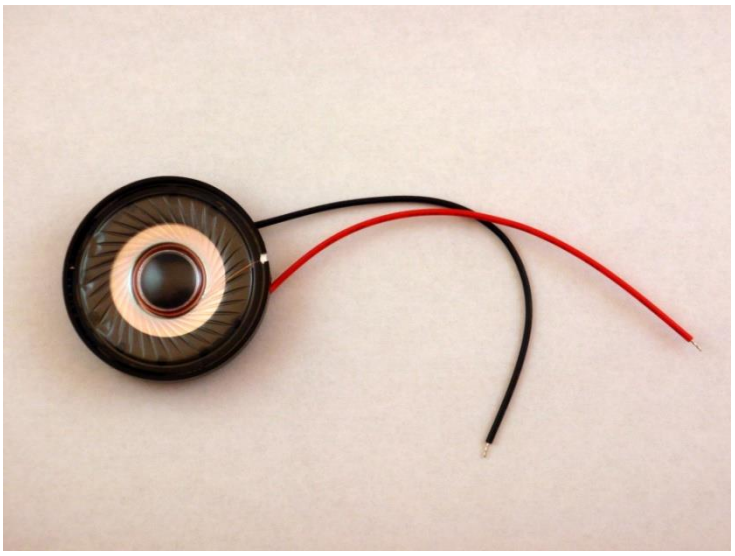
When building the circuit, it is important to insert the positive (+) and negative (-) wires of the capacitor into the correct holes.

The amplifier chip (labeled LM 386) has 8 pins that connect to the breadboard. Each pin connects to a different part of the circuit.



Look closely at the top of the chip. There is a notch on one end. The pin numbers are not written on the chip, but are counted going around the chip, as shown at left.

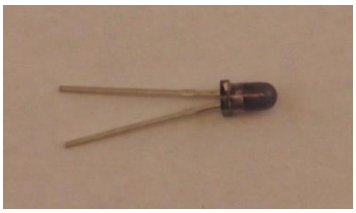
Be careful when you handle the LM 386 to avoid bending the pins.



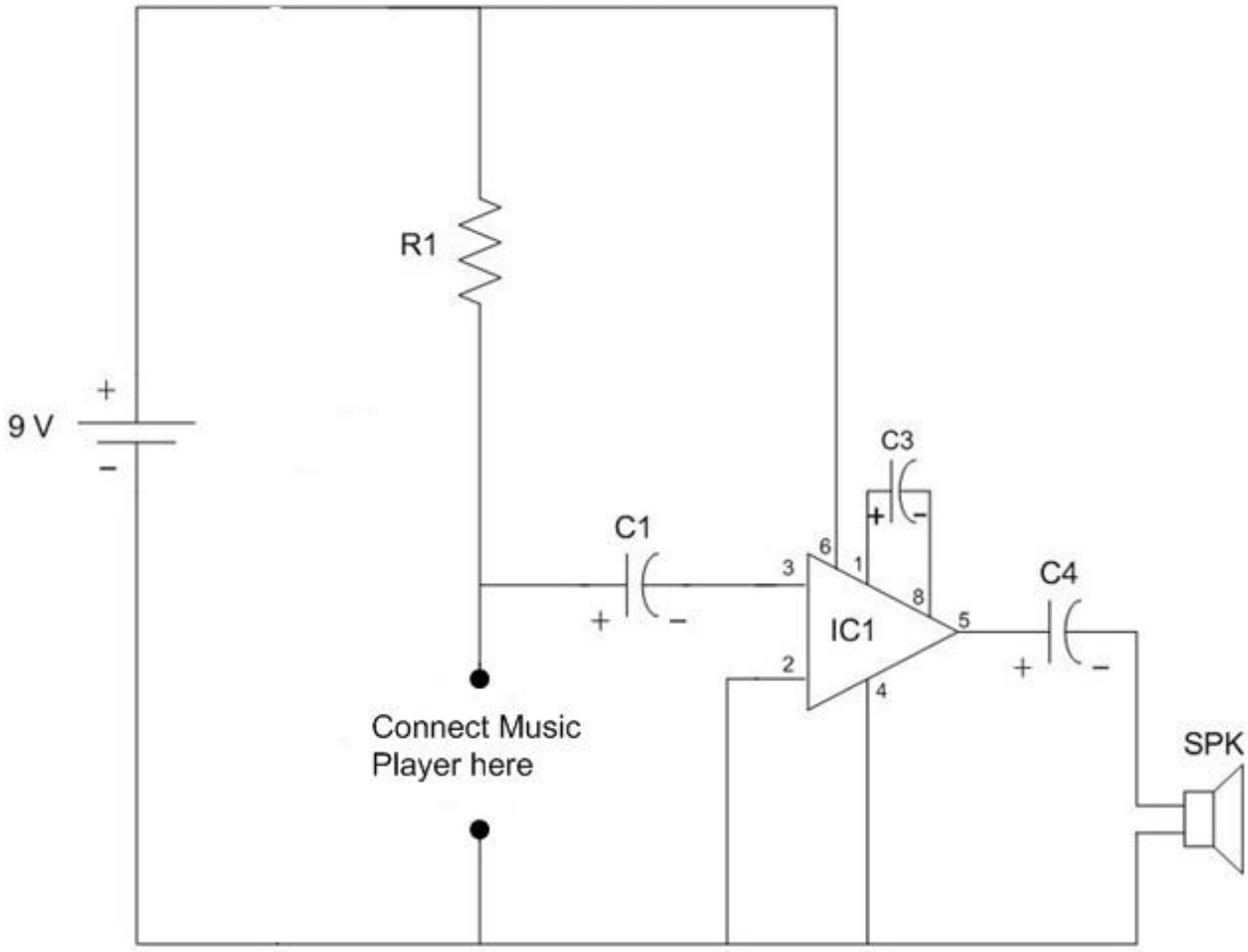
The **speaker** (left) turns electricity into sound.

Be careful when you handle the speaker because the wires break off easily.

The **phototransistor** (right) converts light into electricity. It will not be used until the next activity.



Sound Amplifier Circuit Diagram

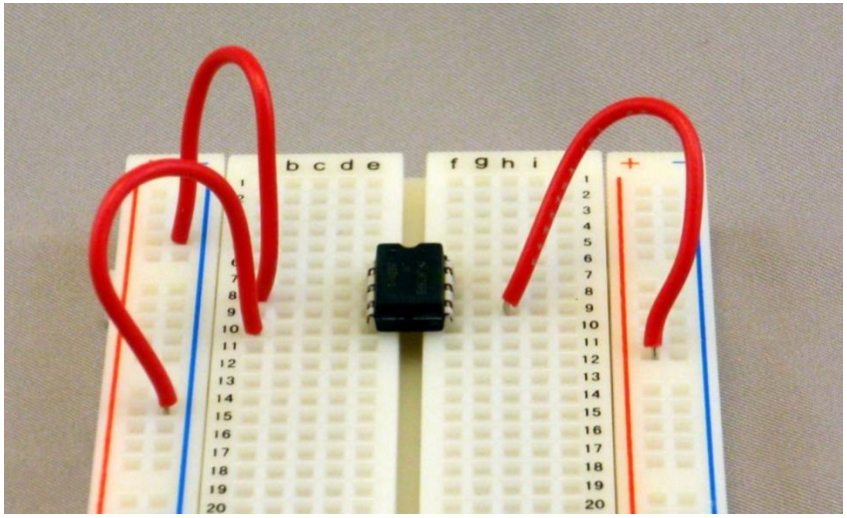


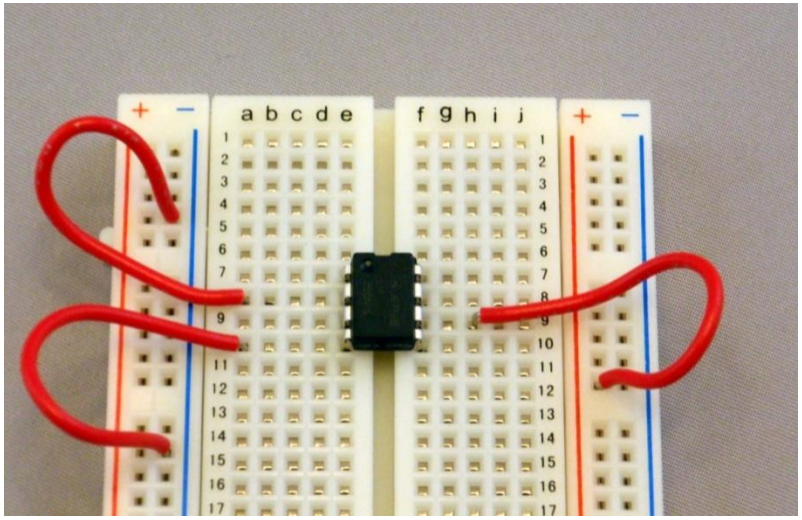
Above is a picture of the amplifier circuit called a **circuit diagram**. A circuit diagram is a plan that electrical engineers use to represent how electrical components are connected together. The music player is connected to the speaker through an amplifier circuit. The lines represent wires and any connections to the breadboard.

The numbers shown by the connections to IC1 are LM 386 pin numbers. For example, pin 6 is connected to the +9V power supply rail, and pin 4 is connected to the negative power rail. All three capacitors (C1, C3, C4) are polarized. This means that you have to be careful when you plug the capacitors into the breadboard to make sure that the positive and negative leads are in the right place.

Step-by-step instructions follow, guiding you through the circuit-building process. When you've gone through all the steps, your instructor will give you a 9V battery so you can connect and test your circuit.

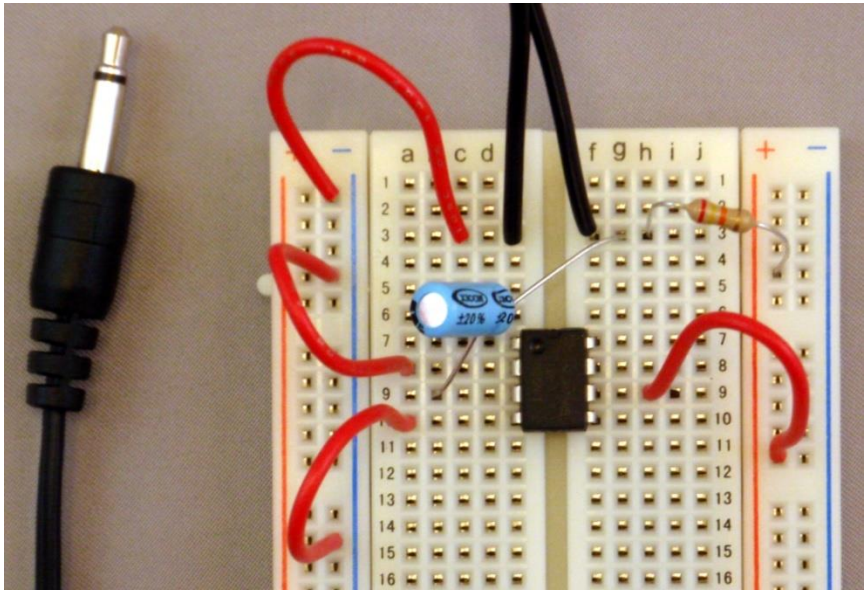
Step	Component	Placement Location	Why did I just do that?
1	Amplifier chip	• Place chip across middle of breadboard as shown below. • Notch should face the top of the board. • Bottom pins should be in row 10.	• The chip needs to split the middle of the board so that each of the 8 pins is connected to a separate row.
2	2” jumper	• Connect **A8** to anywhere on **left blue** power rail (using a wire called a ‘2” jumper’).	• This connects pin 2 of the chip to negative. • This provides power to the amplifier.
3	2” jumper	• Connect **A10** to anywhere on **left blue** power rail (using a wire).	• This connects pin 4 of the chip to negative. • This provides power to the amplifier.
4	2” jumper	• Connect **H9** to anywhere on **right red** power rail.	• This connects pin 6 of the chip to positive. • This provides power to the amplifier.



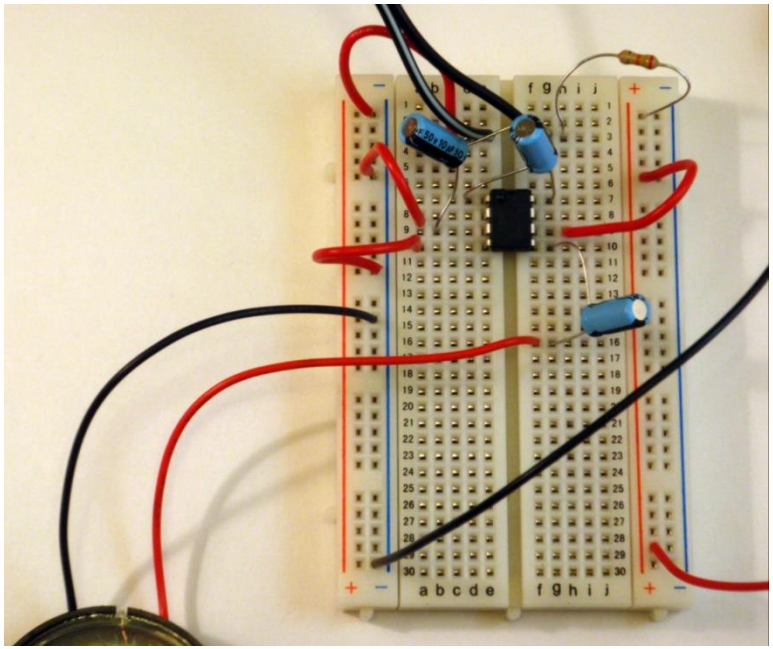


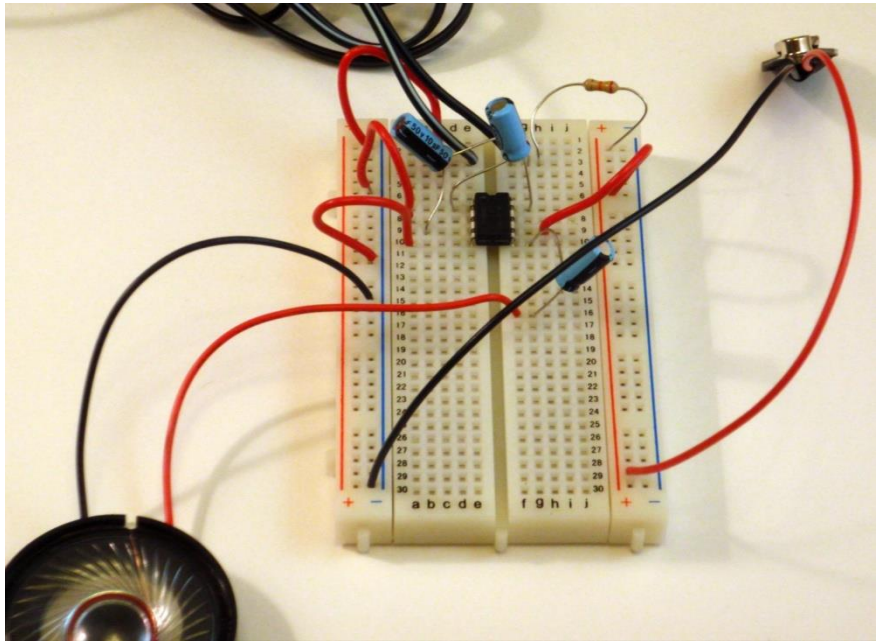
The following instructions refer to the diagram below.

5	Wire with headphone plug	• Connect these two wires to **E3** and **F3**.	• This is how the music player connects to the amplifier circuit. The sound signal (as electricity) enters and returns through this pair of wires.
6	2” jumper	• Connect **C3** to anywhere on **left blue** power rail.	• These connect the signal to the positive and negative power supply rails.
7	Resistor (R1)	• Connect resistor from H**3** to anywhere on **right red** power rail.	
8	Capacitor (C1)	• Insert long wire of capacitor into **G3** and short wire of capacitor into **B9**.	• The shorter, negative wire on the side of the capacitor with the stripe connects the weak signal to the input of the amplifier chip. • The longer wire of the capacitor connects the music player to the capacitor.

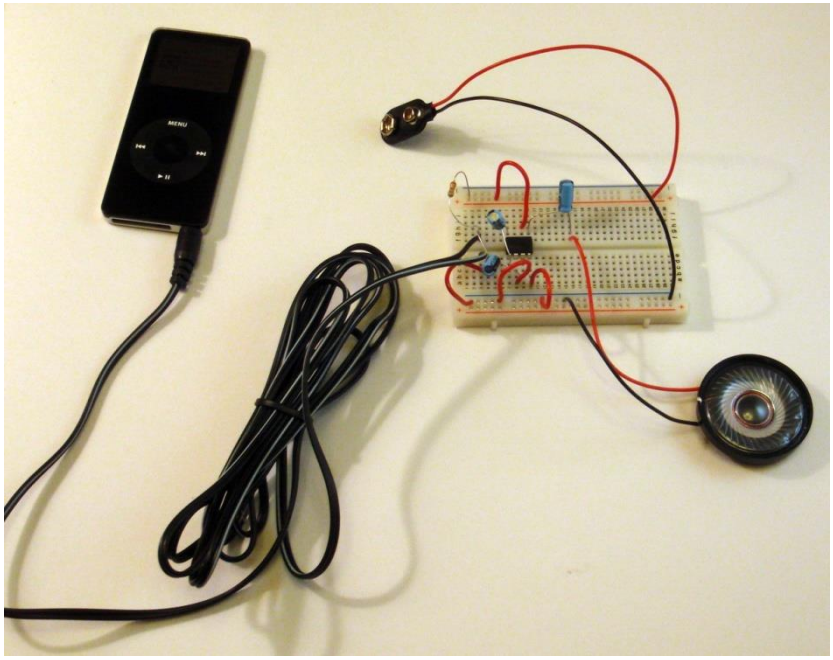


9	Capacitor (C3)	• Insert long wire of capacitor into **D7** and short wire of capacitor into **G7**. • Be sure that the wires do not touch other components on the board.	• The longer, positive wire connects to pin 1 of the amplifier chip. • The shorter, negative wire on the side of the capacitor with the stripe connects to pin 8 of the amplifier chip.
10	Capacitor (C4)	• Insert long wire of capacitor into **G10** and short wire of capacitor into **G16**.	• This connects the speaker to pin 5 (the output) of the amplifier chip.
11	Speaker	• Connect red speaker wire to **F16** and black speaker wire to **left blue** power rail.	• The speaker changes the electrical signal into sound.
12	Battery snap	• Connect red battery snap wire to **right red** power rail and black battery snap wire to **left blue** power rail.	• This connects the battery to power the circuit.
13	9V battery	• Ask your instructor for a 9V battery to connect and test the circuit.	• The 9V battery provides power to the amplifier chip, which increases the volume of the sound.





Testing the Circuit



To test the circuit, plug the music player in and turn it on. You should hear sound and it should be louder than in the last activity when the music player was connected directly to the speaker. If you do not hear any sound from the speaker, you will need to **troubleshoot** your circuit.

Connect a 9V battery to the battery snap. If your circuit does not work, immediately disconnect one of the battery snap wires from the breadboard. A wiring error has occurred and you don't want to drain the battery!

Troubleshooting **(Go through this process if your circuit fails to operate.)**

Troubleshooting is the process of figuring out why a circuit does not work.

1) The most common problem is a wiring error. Check to make sure that every wire and component leads are going into the correct holes.
2) The second most common error is a polarity mistake. Check the direction of each capacitor to make sure the short negative wire is in the correct hole.

Storing Your Sound Amplifier Circuit

You will need to store your receiver for use during the next two activities. Disconnect your battery from the breadboard and remove the battery snap. This will maximize the life of your battery. Your instructor will collect the batteries.

Activity 3: Music Receiver

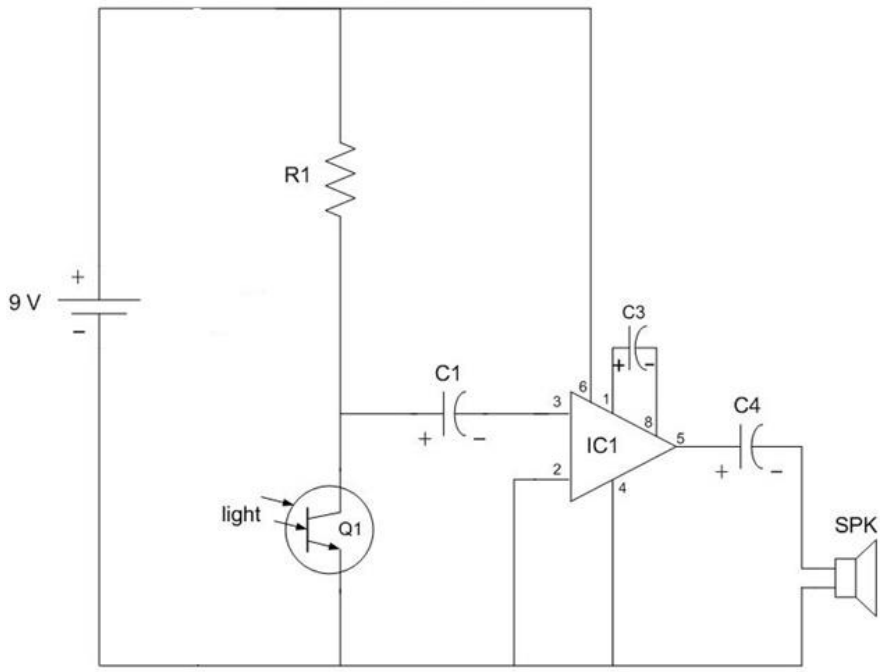
In this activity, you will build a sound receiver that converts light signals into sound. At the end of the activity, you will test your receiver by pointing a TV remote at the input and hearing the signal that your TV responds to when you press a button on the remote. When you finish building this circuit, do not take it apart because you will be using it in the next activity.

Parts List

- Sound amplifier circuit from Activity 2.
- Phototransistor
- 9V battery
- Tape measure

A **phototransistor** converts light into electricity and looks like a small light. The phototransistor has a flat side by one of the wires that indicates positive (+).

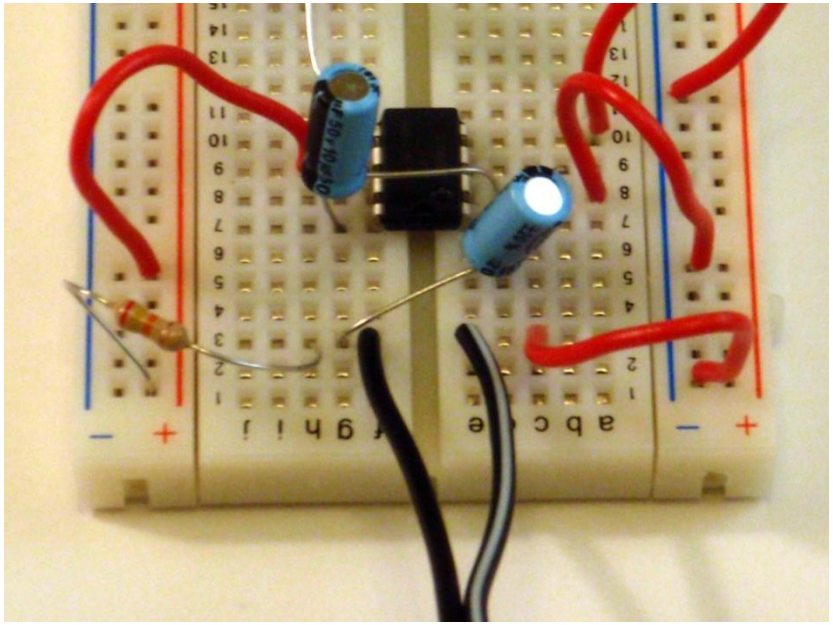
Music Receiver Circuit Diagram



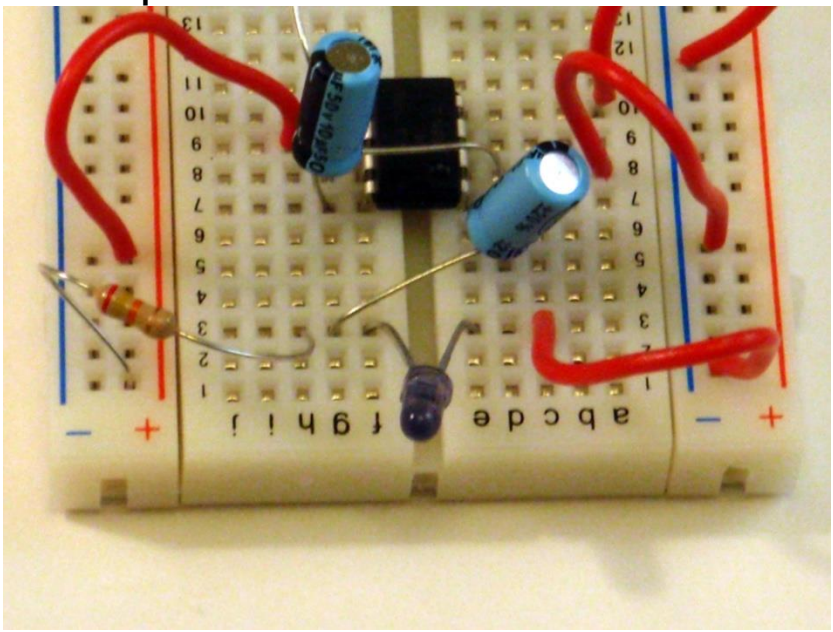
Converting the Sound Amplifier to a Music Receiver

Step	Component	Placement Location	Why did I just do that?
1	Wire with headphone plug	• Remove these two wires from **E3** and **F3**. (See picture, below left.)	• This is where the electrical sound signal entered the circuit.
2	Phototransistor	• Connect the phototransistor to **E3** and **F3** with wire coming out of the flat side in **F3**. (See picture, below right.) Bend the phototransistor down so that it points along the table.	• Now the light signal is received by the phototransistor and converted into an electrical signal.

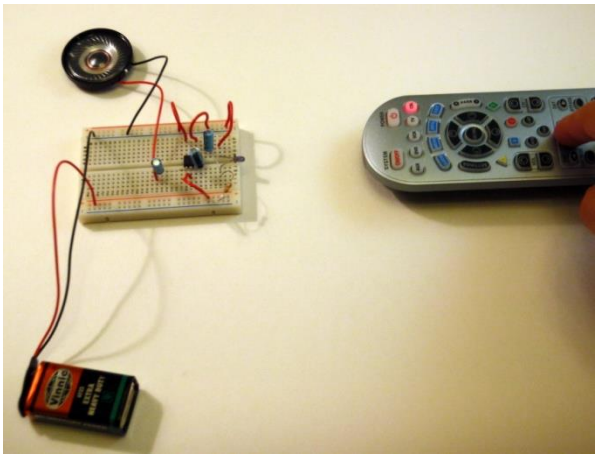
Before Step 1



After Step 2



Exploring the Music Receiver Circuit



Infrared (IR) light is invisible. You cannot see the IR light that is emitted from the TV remote. But you know that the TV remote is emitting IR light because when you fire it at the sound receiver, you can hear the signal coming out of the speaker.

Exploration 1: Take turns with your partner firing the TV remote at the phototransistor from different distances and angles. What happens if you put something (like a piece of paper) between the remote and phototransistor? Discuss with your partner what you observe and what you think causes the system to respond the way it does. What is the purpose of the phototransistor in the circuit?

Write down what you observe and possible explanations below:

Exploration 2: Work with your partner to use the tape measure to determine the farthest distance the TV remote can be fired and still trigger a sound in the sound receiver. Compare your results with other teams' results. Discuss why your results are different.

What is the farthest distance the TV remote can be fired and still trigger a sound in the sound receiver? Explain how you would change the system to increase the trigger distance.

Answer:

Storing Your Music Receiver

You will need to store your music receiver for use during the next activity. Disconnect your battery from the breadboard and remove the battery snap. This will maximize the life of your battery. Your instructor will collect the batteries.

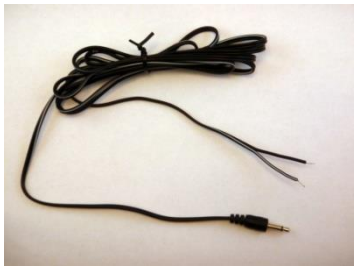
Activity 4: Infrared Music Transmitter

In this activity, you will build an infrared (IR) music transmitter. The signal from any music player can be "jacked in" to the input of the transmitter.

Parts List

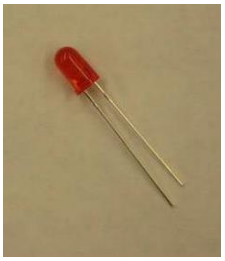
- Music Receiver Circuit from Activity 3
- One TechXcite Music Transmitter Bag containing:
  - 5 resistors (brown, black, black — 100 Ω)
  - IR LED (Light Emitting Diode)
  - Red LED (Light Emitting Diode)
  - Transistor (2N3904)
  - Potentiometer (50 kΩ variable resistor)
  - Capacitor (47 μF Electrolytic)
  - Wire with headphone plug
  - Battery snap
- 9V battery
- Breadboard
- 2" jumper wires

The **transistor** has a black body with a flat front and three leads coming out of the bottom.



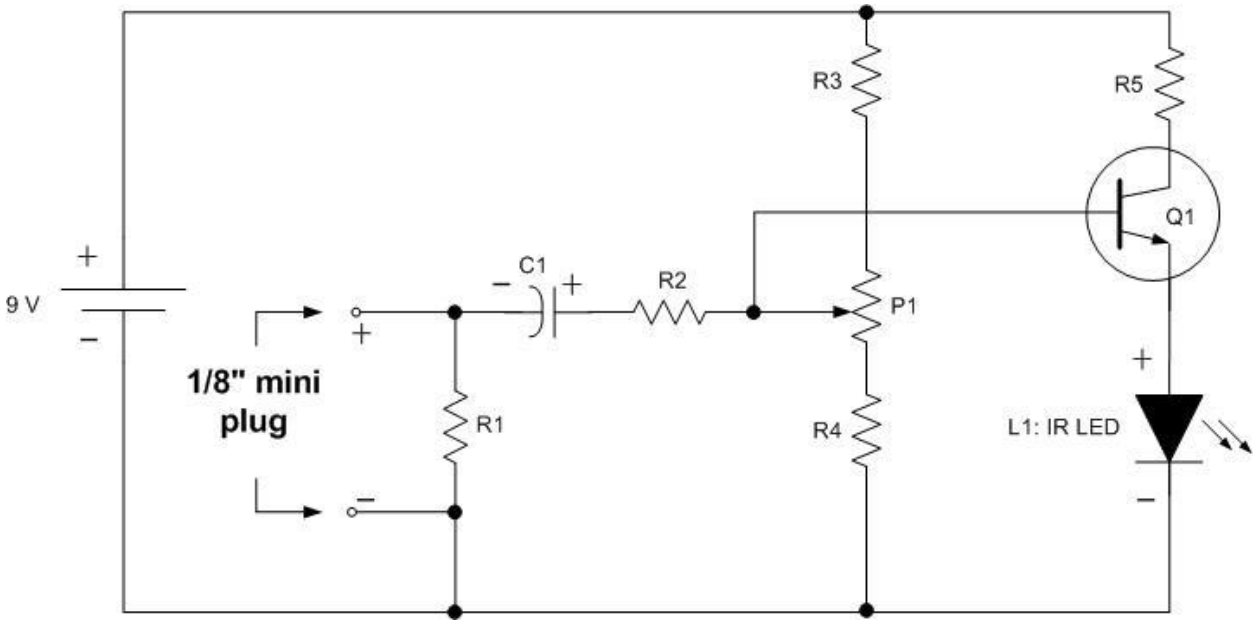
The headphone plug is a standard 1/8-inch mini plug that fits most portable music players. The other end of the cable has two wires that can be inserted into a breadboard.

The 50 kΩ **potentiometer** (variable resistor) has a rotatable dial and three metal connections. Rotating the dial changes the resistance between the center lead and the leads on the outside. A potentiometer allows you to rotate a dial to control the electricity through it.



A **light emitting diode**, or **LED**, converts electrical energy into light of a single color. It has two metal wires. The longer lead is positive (**+**) and the shorter lead is negative (**-**).

Music Transmitter Circuit Diagram

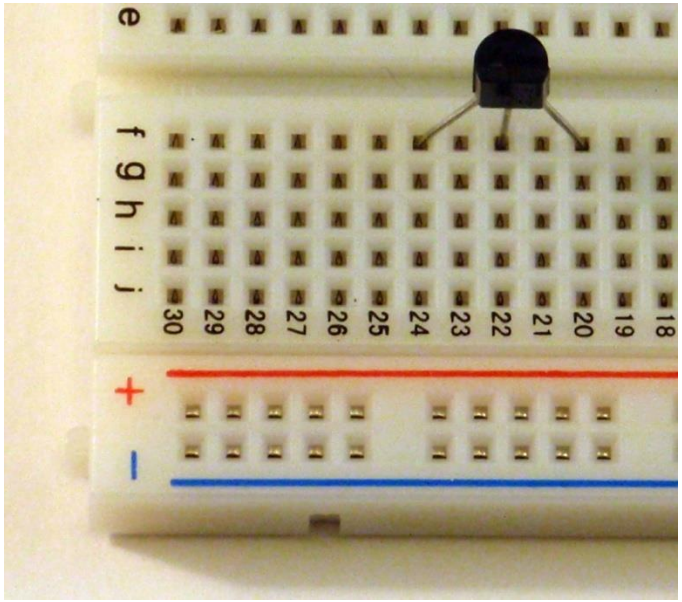


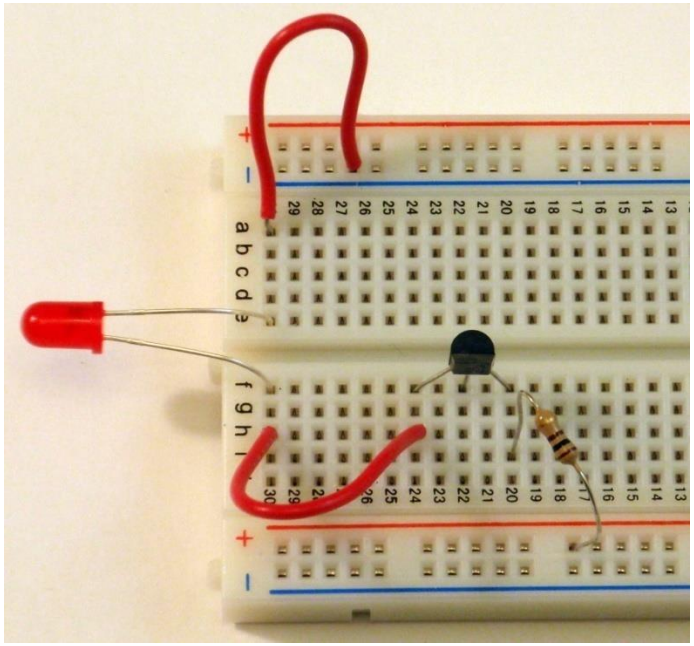
Note: The black dots emphasize that a physical connection is made. The wire that goes from the middle pin on the potentiometer (P1) to the middle pin on the transistor (Q1) does **not** connect to the wire between R3 and P1, even though the wires cross, because there is **no black dot at the cross point.**

Step-by-step instructions are on the next page. As you build the circuit on your breadboard, you can refer back to the circuit diagram to relate the schematic drawing to your breadboard circuit. When you've gone through all the steps, your instructor will give you a 9V battery so you can connect and test your circuit.

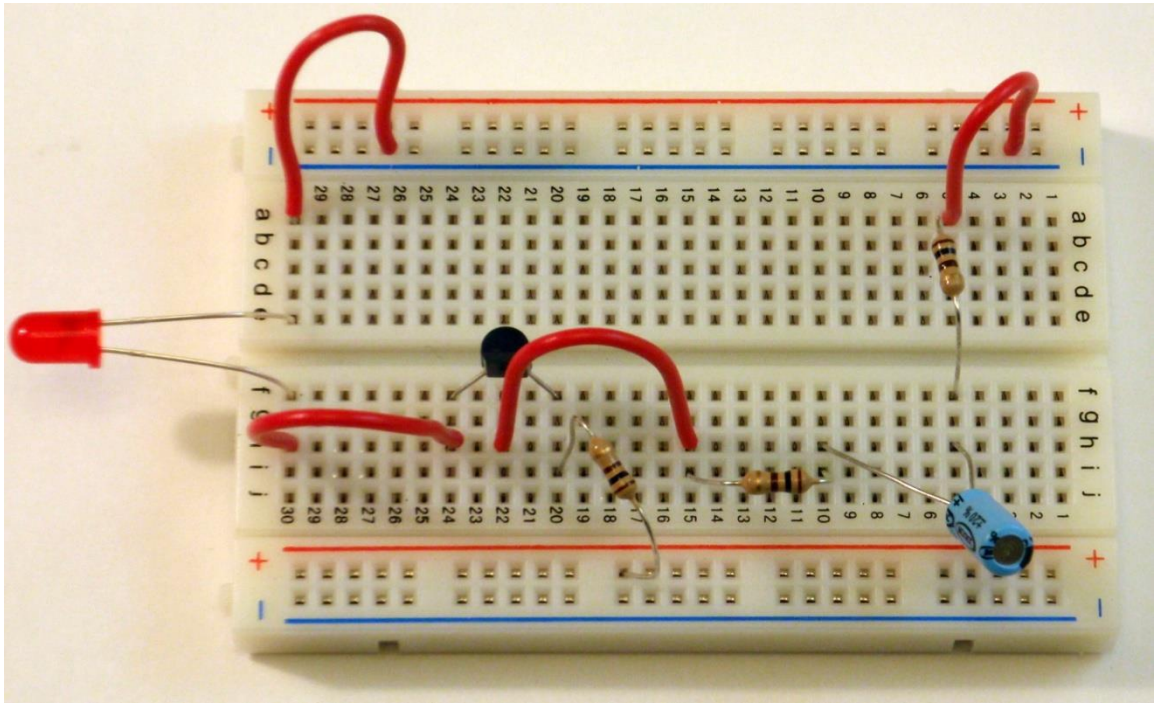
Building the IR Music Transmitter Circuit

Step	Component	Placement Location	Why did I just do that?
1	Transistor	• With flat side of transistor facing you, insert left wire into **F24**, middle lead into **F22** and right wire into **F20**.	• The direction of the transistor is important, which is why the flat side is facing you. • This will amplify the signal for the LED.
2	Resistor (brown, black, brown)	• Connect resistor to **I20** and **bottom red** power rail.	• This connects the resistor between the right lead of the transistor and the bottom positive red power supply rail.
3	2” jumper	• Connect to **H24** and to **H30**.	• This will connect to the LED.
4	Red LED	• Connect longer wire (+) to **F30** and shorter wire (-) to **E30**.	• This converts the electrical signal to a light signal.
5	2” jumper	• Connect to **A30** and to **top blue** power rail.	• This connects the LED to the negative.

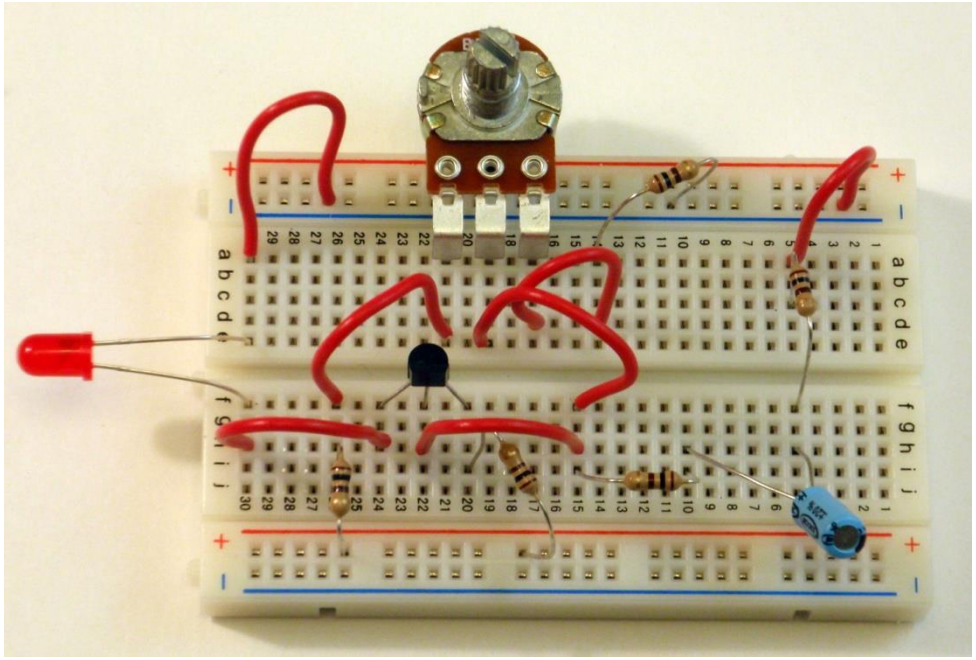




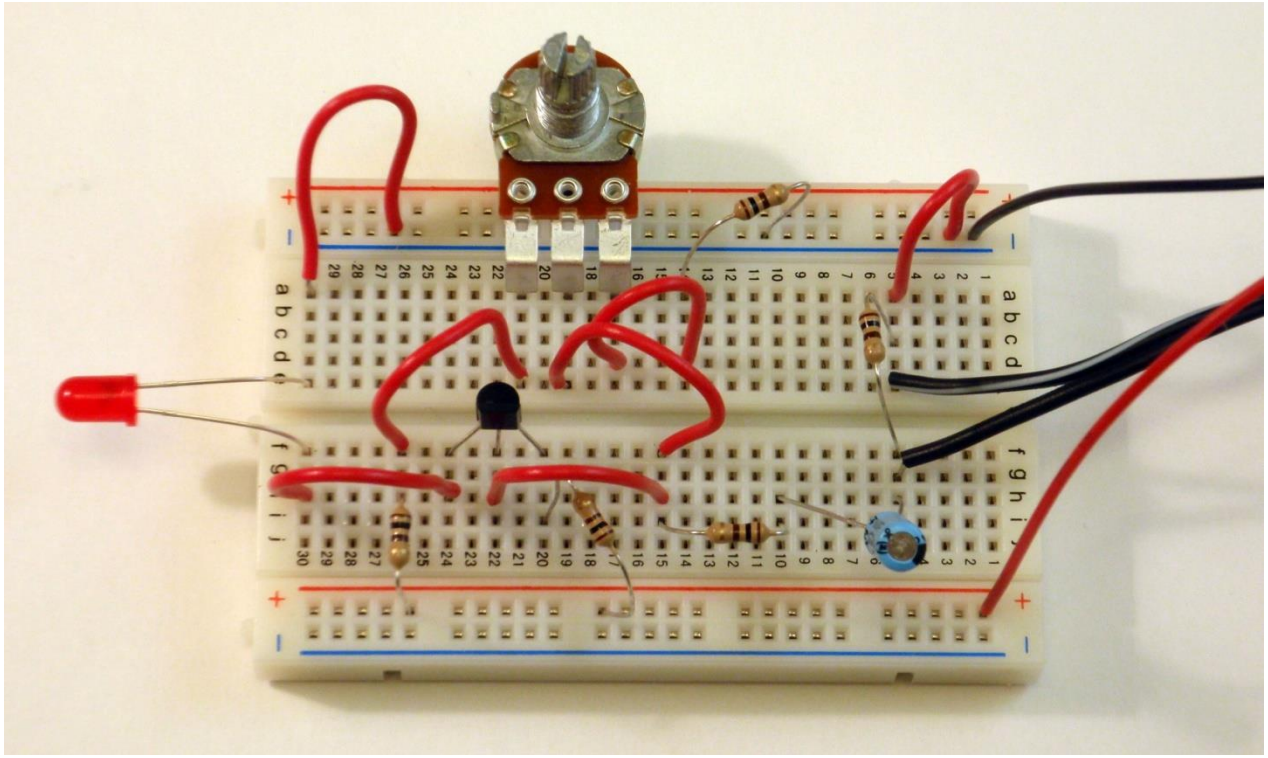
Step	Component	Placement Location	Why did I just do that?
6	2” jumper	• Connect to **H22** and to **H15**.	• These components connect the signal to the middle pin of the transistor and to the negative blue power rail.
7	2” jumper	• Connect to **A5** and to **top blue** power rail.	
8	Resistor (brown, black, brown)	• Connect to **G15** and to **G10**.	
9	Capacitor	• Connect short negative lead to **H5** and long positive lead to **H10**.	
10	Resistor (brown, black, brown)	• Connect to **F5** and to **C5**.	



Step	Component	Placement Location	Why did I just do that?
11	Potentiometer	• Insert potentiometer's metal tabs into **A21**, **A19** and **A17**.	• The potentiometer is a variable resistor and turning it varies the amplification of the transistor.
12	Resistor (brown, black, brown)	• Connect resistor between **J26** and **bottom red** power rail.	• This connects the potentiometer to the red positive power rail.
13	2" jumper	• Connect to **F26** and to **E21**.	
14	2" jumper	• Connect to **F15** and to **E19**.	• This connects the middle pin of the potentiometer to the middle pin of the transistor.
15	2" jumper	• Connect to **D17** and to **D14**.	• This connects the potentiometer to the blue negative power rail.
16	Resistor (brown, black, brown)	• Connect to **A14** and to **top blue** power rail.	



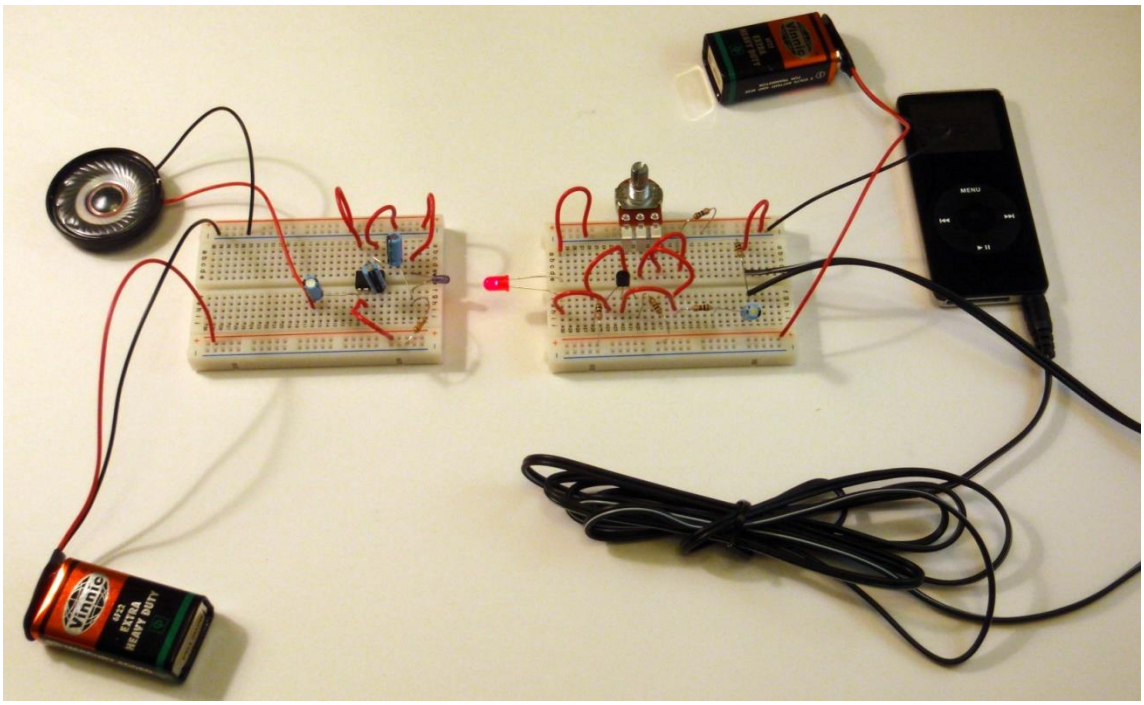
Step	Component	Placement Location	Why did I just do that?
17	Wire with headphone plug	• Connect these two wires to **G5** and **E5.**	• This is how the music player is connected to the circuit. The sound signal enters through this wire.
18	Battery snap	• Connect the red battery snap wire to **right red** power rail and the black battery snap wire to **left blue** power rail.	• This connects the battery to power the circuit.
19	9V battery	• Ask your instructor for a 9V battery to connect and test the circuit.	• The 9V battery provides power for the circuit. • The transistor uses this to amplify the electrical signal to increase the brightness of the LED.



Test the Circuit

To test the circuit, aim the red LED at the phototransistor of the music receiver that you built in the last activity. Position the music transmitter so that the LED is ½ inch from the phototransistor.

Get a portable music player from your instructor or use one of your own, such as an iPod. Listen to it through headphones and make sure it is producing loud and clear music or speech.



Connect the music player to your IR music transmitter by connecting the earphone plug to the headphone jack of your music player. Turn up the volume on your music player. Rotate the stem of the potentiometer on your transmitter circuit. The red LED should be on. You should hear music coming out of the speaker in the receiver. If you do not hear any sound from the speaker, you will need to troubleshoot your IR music transmitter-receiver system.

If your circuit does not work, immediately disconnect one of the battery snap leads from the breadboard of both the transmitter **AND** the receiver. A wiring error has occurred and you don't want to drain the batteries!

Now try infrared.
Try using the clear infrared (IR) LED instead of the red LED.

System Operation, Exploration and Description

Twist the potentiometer stem in the music transmitter circuit until the sound from the speaker is as clear as possible.

1) Explain how the music goes from the music player to the speaker. Try to address as many of the electronic components as possible.

Answer:

2) What do you think rotating the stem of the potentiometer in the transmitter does?

Answer: