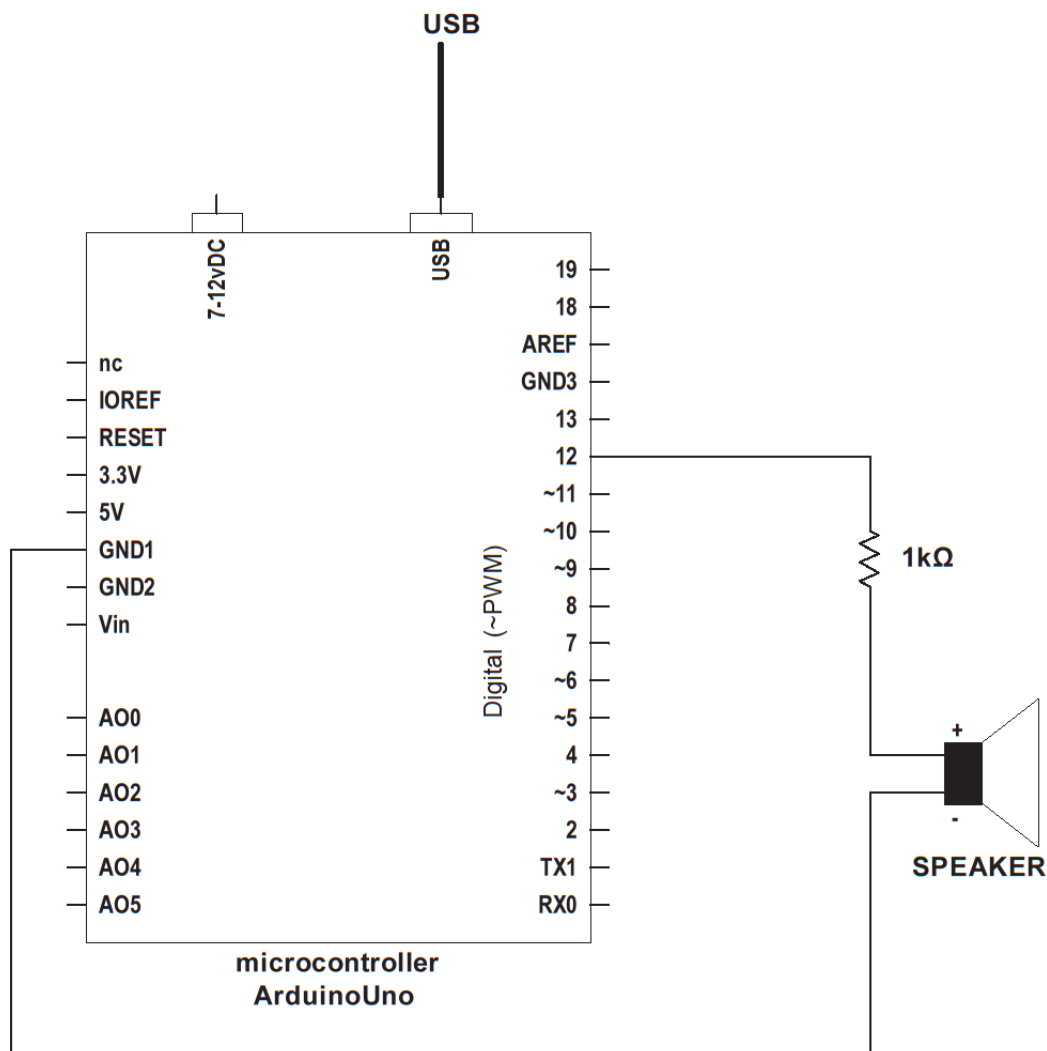You can build an electronic system to play simple melodies using these components:

- Arduino microcontroller
- Breadboard and wires
- 1kΩ resistor
- Piezoelectric speaker
- USB cable (standard A to B)
- Computer with USB port and Arduino-compatible software

Here's an example of such a system. This diagram shows one way to connect different *components* together with wires to make sounds. Note that the speaker has *polarity*; or in other words, it has a positive and a negative pin. Also the USB cable connects to a computer, not shown in this diagram.
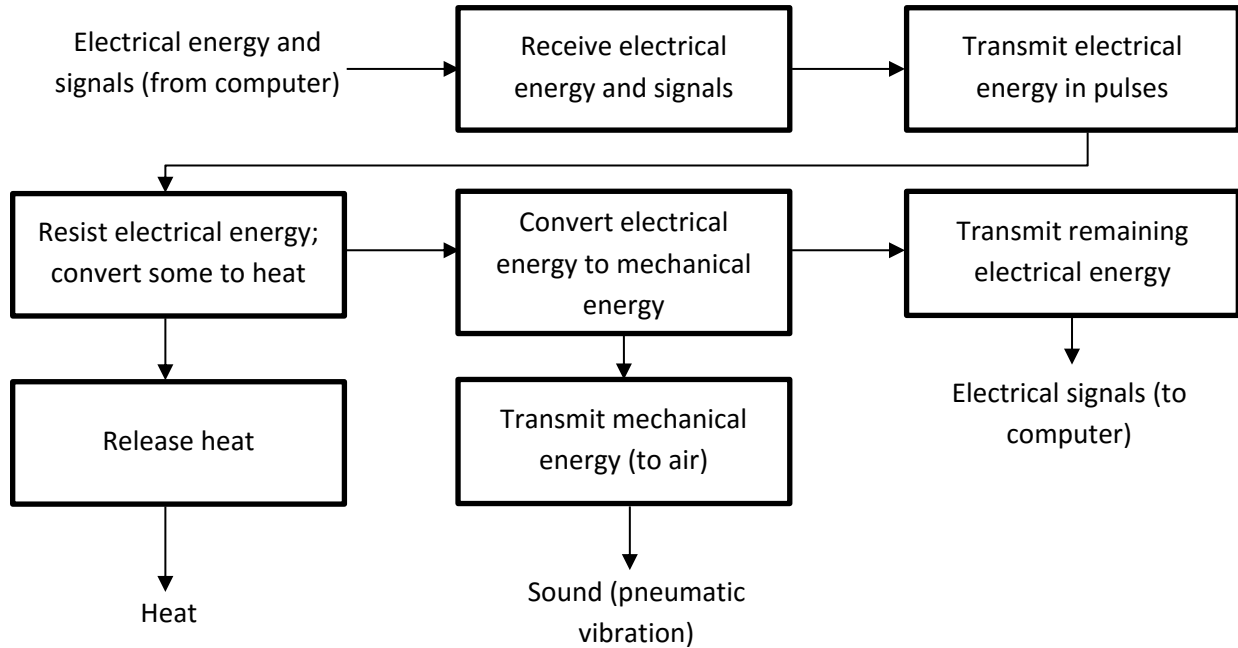
After it is built, it may look something like this photo. Again, the USB cable connects to a computer, which is not shown here.
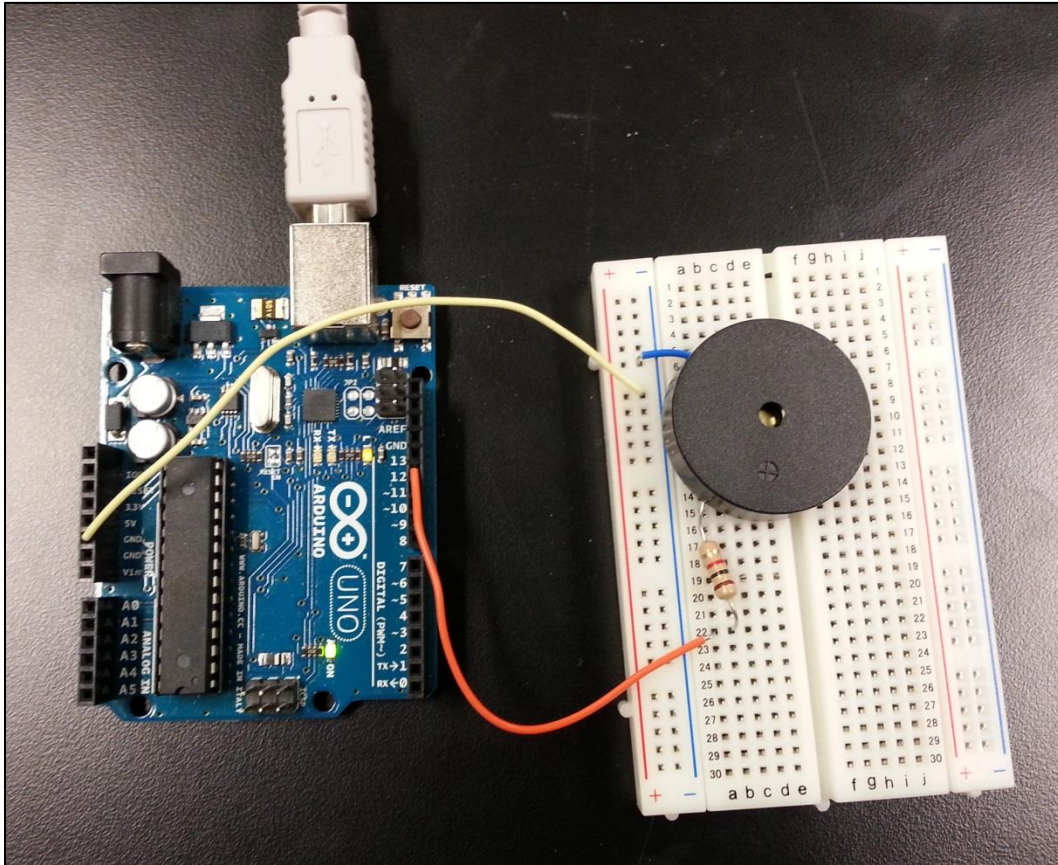
To verify your circuit, continue to the next lesson and program your system to beep.

How does it work?

To help explain what this system does, a simple *functional model* of the system is shown below, not including the computer.

```
Electrical energy and          ┌──────────────────┐        ┌──────────────────┐
signals (from computer)   ───► │ Receive electrical│  ───►  │ Transmit electrical│
                               │ energy and signals│        │ energy in pulses  │
                               └──────────────────┘        └──────────────────┘

┌──────────────────┐        ┌──────────────────┐        ┌──────────────────┐
│ Resist electrical │        │ Convert electrical│        │ Transmit remaining│
│ energy;           │  ───►  │ energy to         │  ───►  │ electrical energy │
│ convert some to   │        │ mechanical        │        │                   │
│ heat              │        │ energy            │        │                   │
└──────────────────┘        └──────────────────┘        └──────────────────┘
         │                           │                            │
         ▼                           ▼                            ▼
┌──────────────────┐        ┌──────────────────┐          Electrical signals (to
│   Release heat    │        │ Transmit mechanical│              computer)
│                   │        │ energy (to air)    │
└──────────────────┘        └──────────────────┘
         │                           │
         ▼                           ▼
        Heat                  Sound (pneumatic
                                 vibration)
```

The USB port receives 5V of power from the computer. It also both receives and sends electrical signals between the Arduino system and the computer.

The Arduino microcontroller then transmits this electrical energy in pulses to the resistor, through wires and the breadboard.

The resistor resists flow of electrons. It converts some of the electrical energy to heat, which is released into the air. This decreases the voltage of energy flowing into the piezoelectric speaker. That helps protect the speaker, and it also will decrease the speaker volume.

The speaker converts the remaining electrical energy to mechanical energy. As the electrons flow through the piezoelectric material in pulses, the speaker expands and contracts in pulses, too. This also makes the air around it expand and contract in waves. Our ears hear these waves as sound.

The remaining electrical energy is essentially used up after going through the speaker. The electrons flow back to the Arduino and back into the computer.

Reference: "Getting Started with Arduino". Arduino SA. http://arduino.cc/en/Guide/HomePage. Feb 2014.