Piezoelectrics

- Big word – *piezein* is greek for “squeeze”
- Some crystals, when squeezed, make a spark
- Turns out the process goes the other way too
- Spark a quartz crystal, and it flexes
- Piezo buzzers use this to make sound
  (flex something back and forth, it moves air)

Piezo buzzers don’t have quartz crystals, but instead a kind of ceramic that also exhibits piezoelectric properties.
I pronounce it “pie–zoh”. Or sometimes “pee–ay–zoh”.
Piezo Buzzers

- Two wires, red & black. Polarity matters: black = ground
- Apply an oscillating voltage to make a noise
- The buzzer case supports the piezo element and has resonant cavity for sound

Oscillating voltage alternately squeezes and releases the piezo element. Must apply fluctuating voltage, a steady HIGH or LOW won’t work.

diagrams from: http://www.maxim-ic.com/appnotes.cfm/appnote_number/988
What's in a Piezo Buzzer?

You can get at the piezo element pretty easily.

Be careful not to crack the white disc that is the actual piezo

Only take it out of its case to use it as a sensor

Of course, you usually destroy the enclosure to get at the element. And it’s the enclosure that has the proper support and resonant cavity to make a loud sound
Piezo leads are very thin. The breadboard holes grab them better than the header sockets, which is why the jumper leads are used.
Play a Melody

“sound_serial”

Play the piezo beeper with the Serial Monitor

Type multiple letters from “cdefgabC” to make melodies

This sketch is in the handout, and is based on “Examples/pwm_sound/keyboard_serial”

Notice the problem with this sketch?
Different notes play for different amounts of time.
50 cycles of low C isn’t the same amount of time as 50 cycles of high B
Making it Quieter

Easiest way: add a resistor

Like most things in electronics, if you want less of something, add a resistor. A better value would probably be 1k, but we don’t have that on hand. This may not seem important now, but wait for the next project.
Play a Stored Melody

“play_melody”

Plays a melody stored in the Arduino

```c
/*
 int ledPin = 13;
 int speakerOut = 7;
 byte names[] = {'c', 'd', 'e', 'f', 'g', 'a', 'b', 'C'};
 int tones[] = {1915, 1700, 1519, 1432, 1275, 1136, 1014, 956};
 byte melody[] = "2d2a1f2c2d2a2d2c2f2d2a2c2d2a1f2c2d2a2a2g2p8p8p8p";
 // count length: 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6
 //
 int count = 0;
 int count2 = 0;
 int count3 = 0;
 int MAX_COUNT = 24;
 int statePin = LOW;

 void setup()
 {
  pinMode(ledPin, OUTPUT);
  pinMode(speakerOut, OUTPUT);
```
Make a Theremin

“ooo-weee-ooooo”

The original spooky sound machine

Works by measuring your body’s electric field

No touching needed!

We’ll use light in lieu of RF

Leon Theremin

As heard on Star Trek, Beach Boys, horror movies, Mars Attacks!, and bad New Age songs. Works sorta like those touch switches, but no touching here. That is, your body becomes a variable capacitor.
Make a Theremin

Take photocell circuit from before, bolt it on

This is a light-to-sound converter, if you will.
Make a Theremin

“theremin”

Move hand over photocell to change pitch

Play with val processing & cycles count to alter sensitivity, pitch and timbre

This is frequency modulation, since you’re changing the frequency

Okay so maybe it sounds more like a bad video game than a spooky movie
The glitchy sound is cause because of the time it takes to read the sensor
There are ways around such stuff, but requires more complex programming using timers & interrupts
The sound can get annoying quick
Piezo Buzzer as Sensor

- Piezo buzzers exhibit the reverse piezoelectric effect.
- The normal piezoelectric effect is generating electricity from squeezing a crystal.
- Can get several thousand volts, makes a spark.
- You probably have seen a big example of this already:

![Fireplace lighter](image)

I have a demo piezo igniter from one of these lighters. It’s fun to shock yourself. Puts out several thousand volts. (ionization voltage of air \(\approx 30\text{kV/cm}\))
Piezo Read

- To read a piezo you can just hook it into an analog input, but:
- You need to drain off any voltage with a resistor, or it just builds up
- You should have a protection diode to limit big voltages, else fry your inputs

Note polarity of piezo still matters.
The protection diode is a special kind of diode called a “zener diode”. It acts invisible until the voltage gets over its designed value (5.1 volts in this case), then it acts like a short circuit.
Create two little busses for GND and A0, and hook components across it. Black bar on diode indicates “bar” of diode.
Piezo Read

“piezo_read”

Whack the piezo to generate a number based on force of whack

Waits for input to go over threshold, then to drop below threshold

Number is “t”, the number of times it looped waiting for the value to drop below THRESHOLD/2.
How Does that Work?

- When a piezo is struck, it “rings” like a bell
- But instead of sound, it outputs voltage
- The sketch measures time above a certain voltage, hoping to catch largest ring

Depending on how fast you can watch the input, this technique works either really well or not that well. There are much faster ways of watching inputs that loops with analogRead(). But for now it works okay.
Custom Piezo Sensors

Can mount the element on anything (floor mat, door, your body, etc.)

Here’s one glued to a larger brass disc for a drum trigger