Spooky Projects

Introduction to Microcontrollers with Arduino

Class 2

14 Oct 2006 - machineproject - Tod E. Kurt

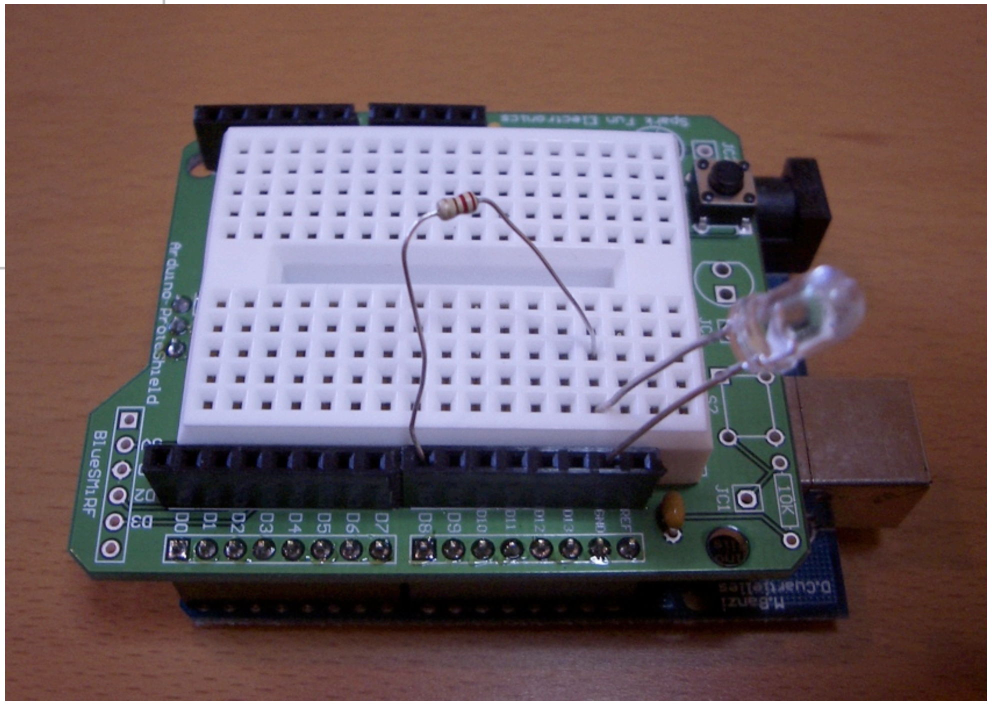
What’s for Today

- Reading buttons
- Reading analog values (knobs and photocells)
- Detecting the dark
- More complex LED circuits

Also, any questions about last week?
Or about stuff on the Arduino site?

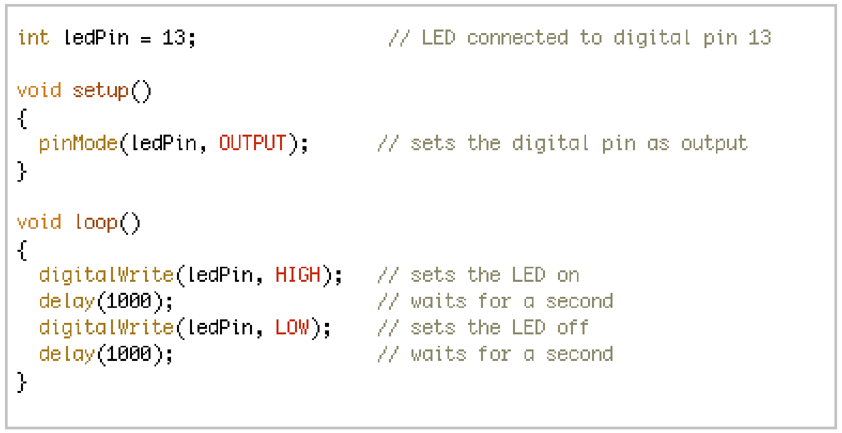
Recap: Blinky LED

```
int ledPin = 13;                  // LED connected to digital pin 13

void setup()
{
  pinMode(ledPin, OUTPUT);       // sets the digital pin as output
}

void loop()
{
  digitalWrite(ledPin, HIGH);    // sets the LED on
  delay(1000);                   // waits for a second
  digitalWrite(ledPin, LOW);     // sets the LED off
  delay(1000);                   // waits for a second
}
```



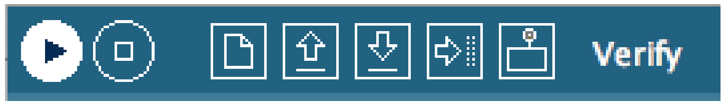
Recap: Programming

Edit

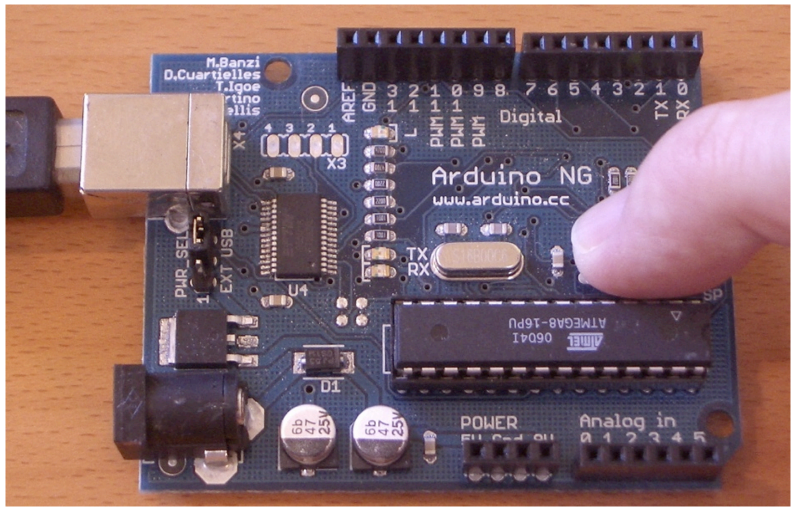


```
int ledPin = 13;                 // LED connected to digital pin 13

void setup()
{
  pinMode(ledPin, OUTPUT);      // sets the digital pin as output
}

void loop()
{
  digitalWrite(ledPin, HIGH);   // sets the LED on
  delay(1000);                  // waits for a second
  digitalWrite(ledPin, LOW);    // sets the LED off
  delay(1000);                  // waits for a second
}
```

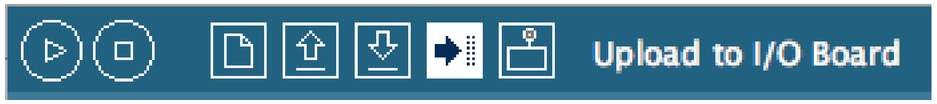
Compile



Reset



Upload



Known Good Configuration

Rule #1 of experimenting:

Before trying anything new,

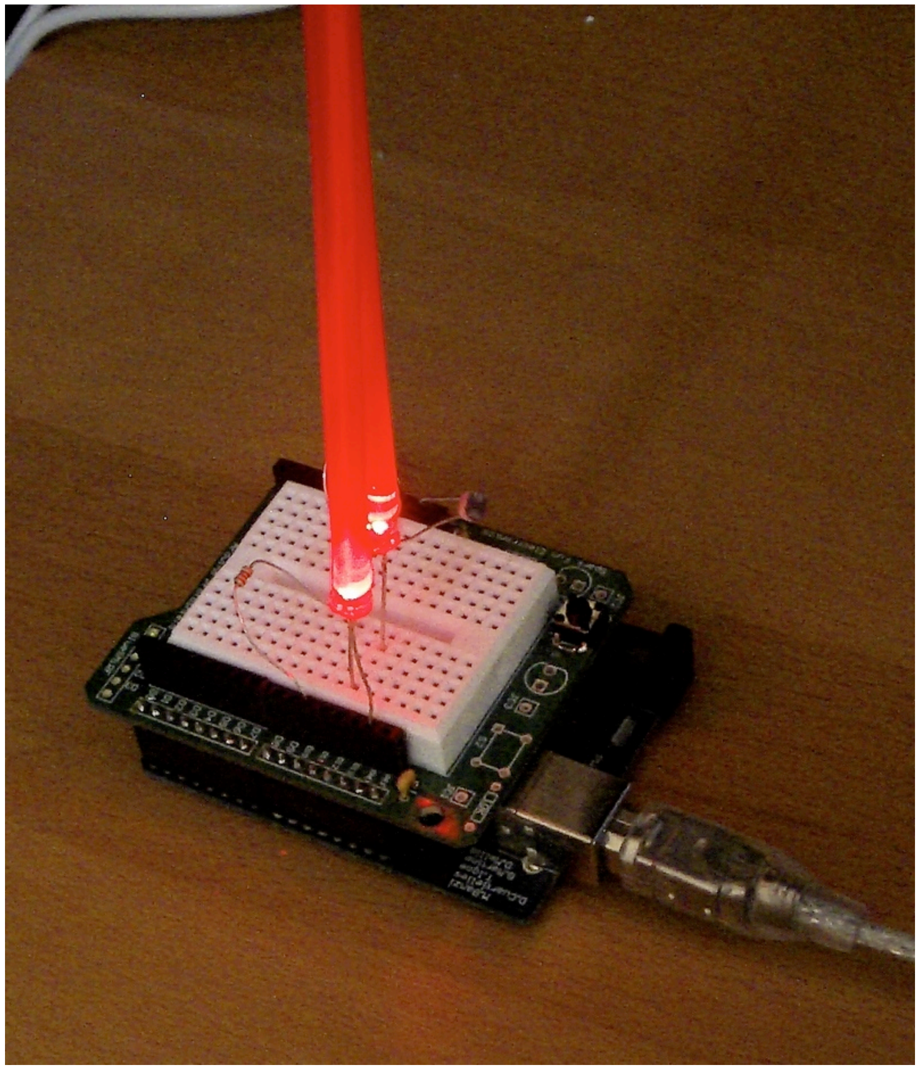
Get back to a known working state

So let's spend a few minutes & get "led_blink" working again

Get your entire edit->compile->upload->run working
Even if it becomes so second nature to you that you feel you shouldn't need to, do it anyway.
Especially when mysterious problems arise, revert to a known state

LED Light Tubes

Snug-fit straws on the end of your LEDs to make them glow more visibly

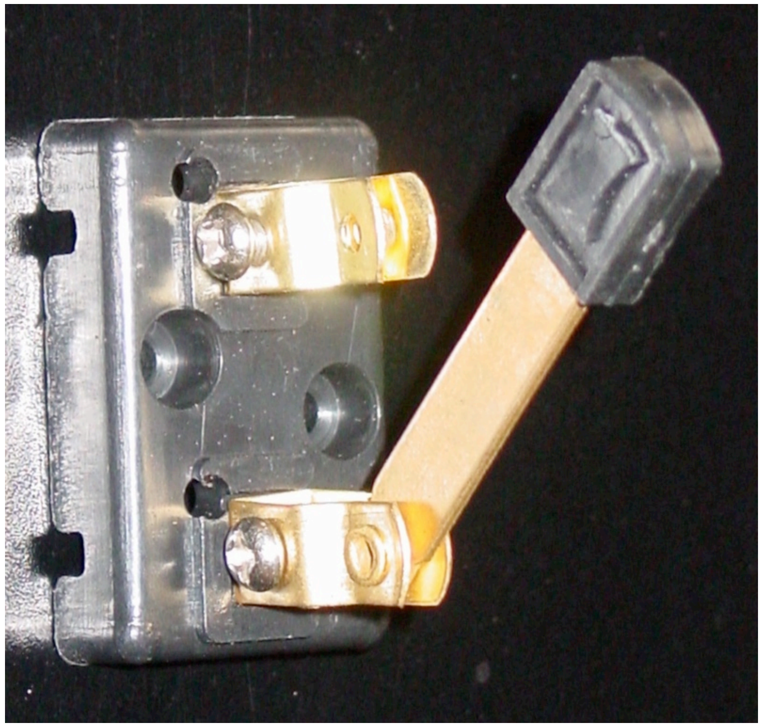


I have a box of multi-colored straws for whatever color LED you like

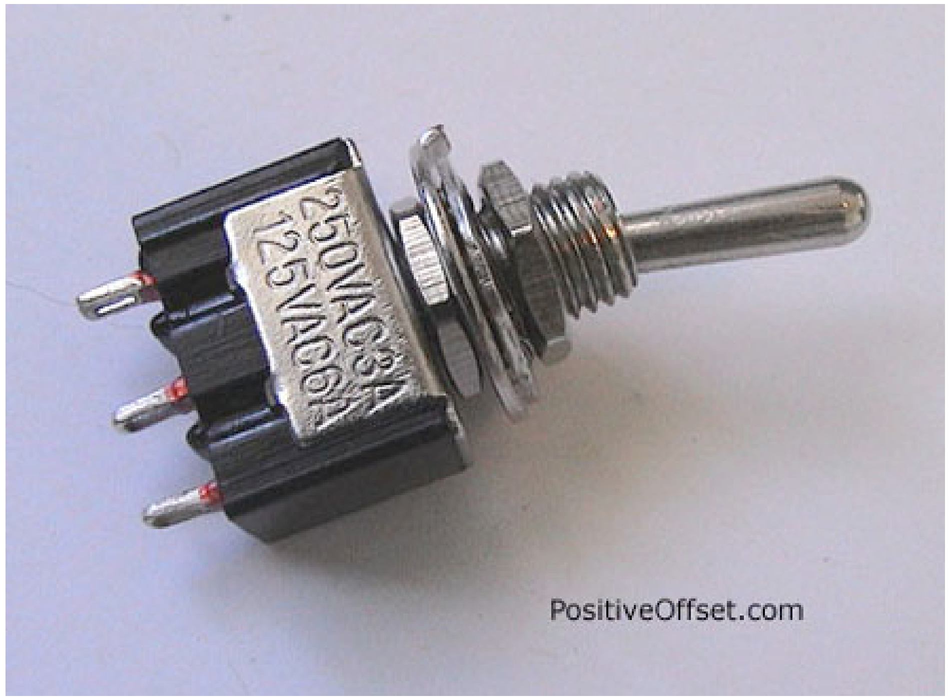
Digital Input

Most inputs you'll use are variations on switches

Switches make or break a connection



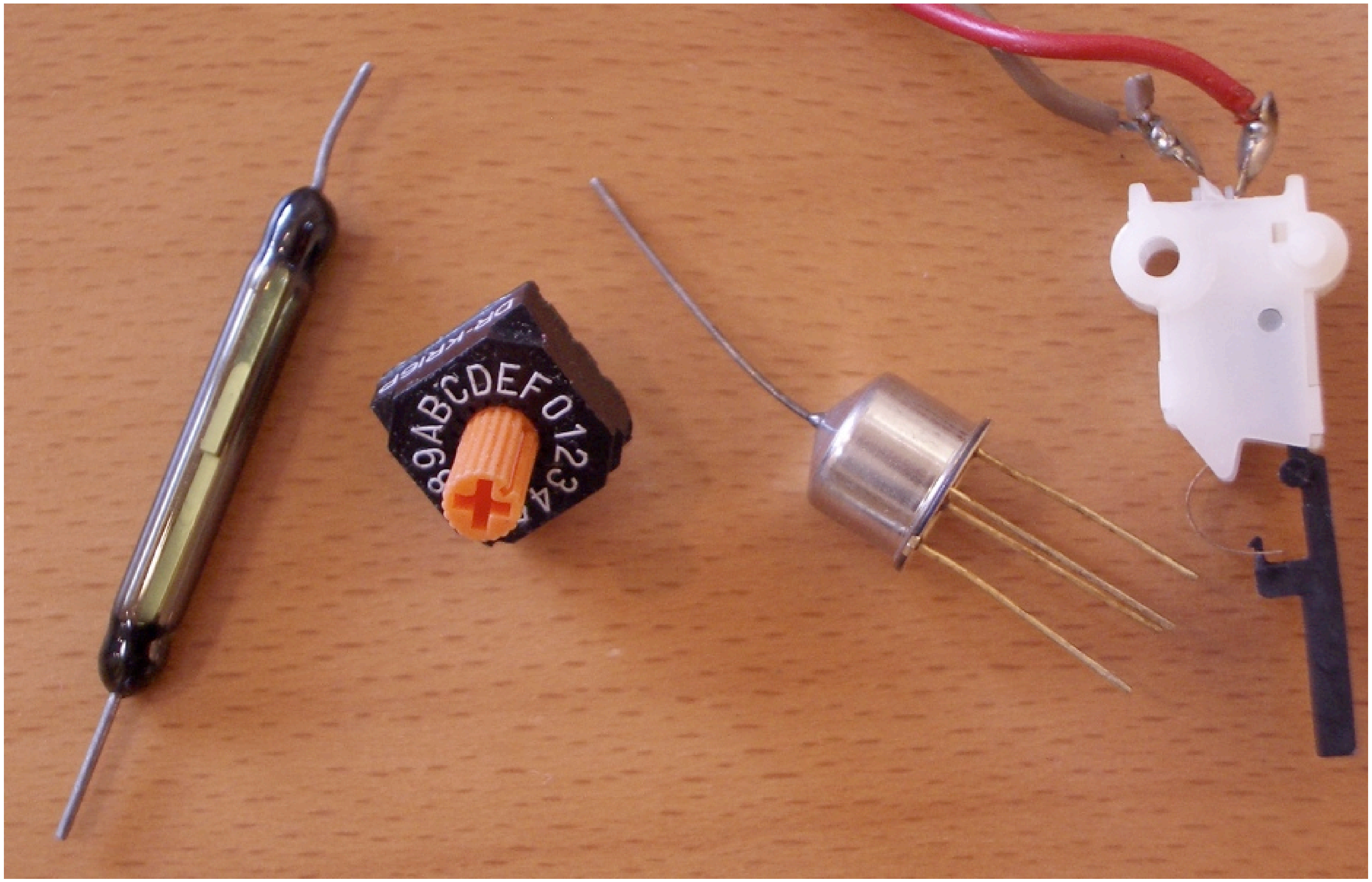
knife switch
(SPST)



toggle switch
(SPDT)

Fundamentally, they're all like the simple knife switch
Single pole = only one circuit is being controlled
Double pole = two circuits are being controlled at once
Single throw = only one path for circuit
Double throw = two potential paths for circuit

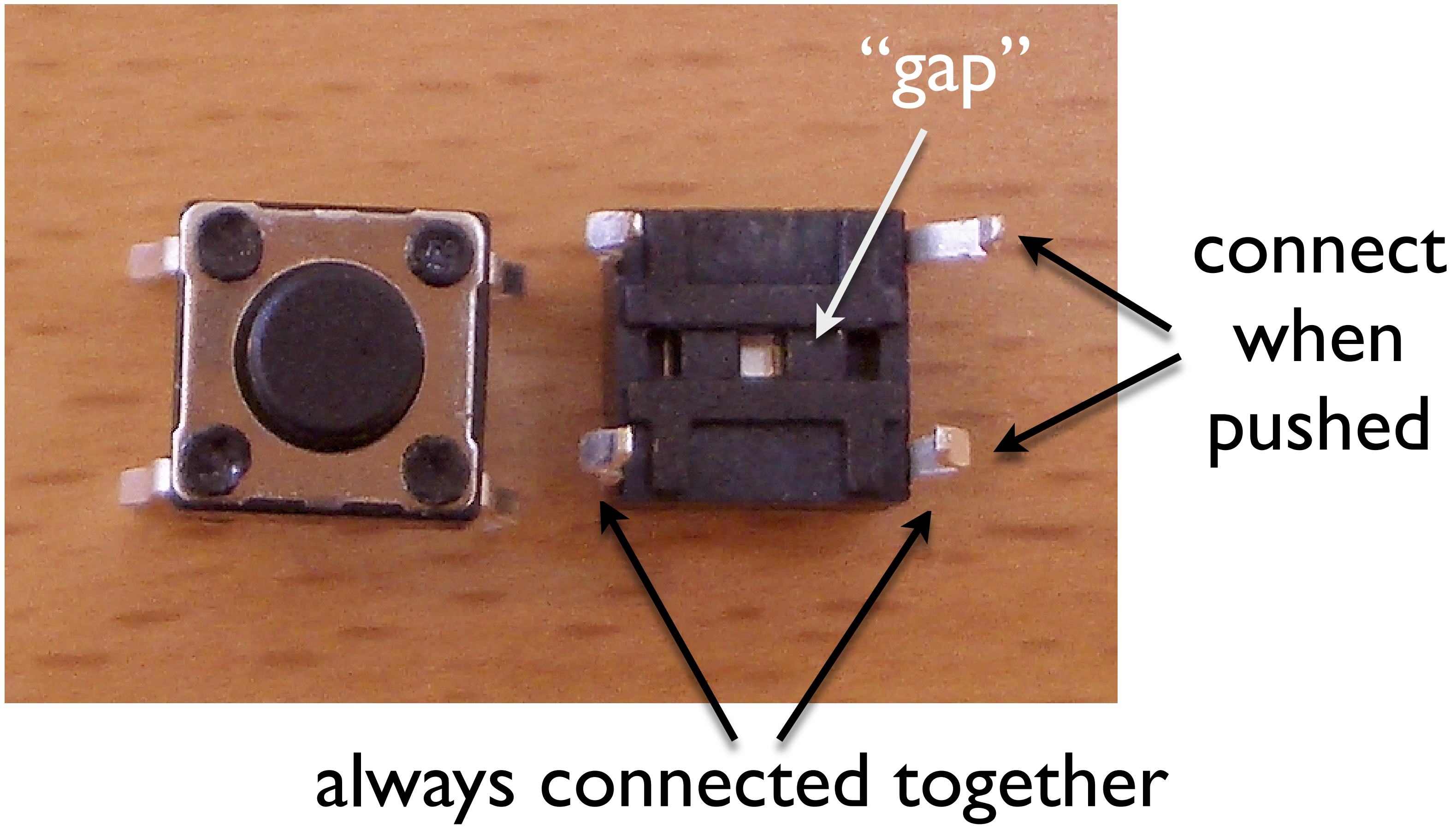
Many Kinds of Switches



magnetic hexidecimal tilt lever

Tilt sensor has a little ball inside you can hear.
Used to have mercury switches, with real metallic mercury inside. Not so much now tho'.
Magnetic reed switches are cool, but delicate.
The hex switch is actually many switches in one, and outputs 4 signals

Tiny Switches



Pressing the button, "closes the gap"

These are the switches in your kit. One should have a slightly different button on it than the other.

Make Your Own Switches

- Anything that makes a connection
- Wires, tin foil, tinfoil balls, ball bearings
- Pennies!
- Nails, bolts, screws

- Or repurpose these tiny switches as bump detectors or closure detectors

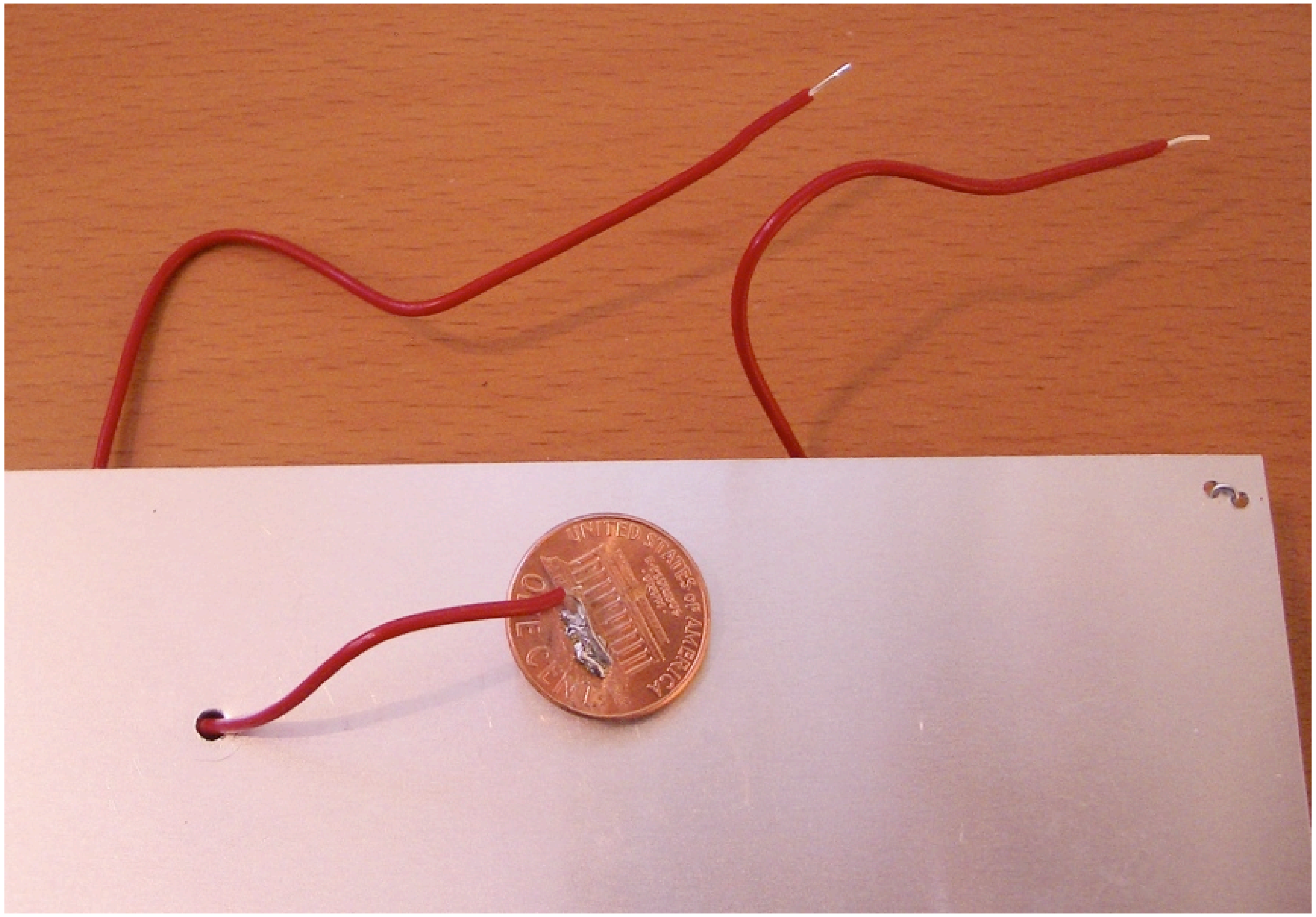
Homemade Switches

"Trick Penny"

Penny on a surface.
When the penny is lifted, alarms go off

Homemade Switches

"Trick Penny"

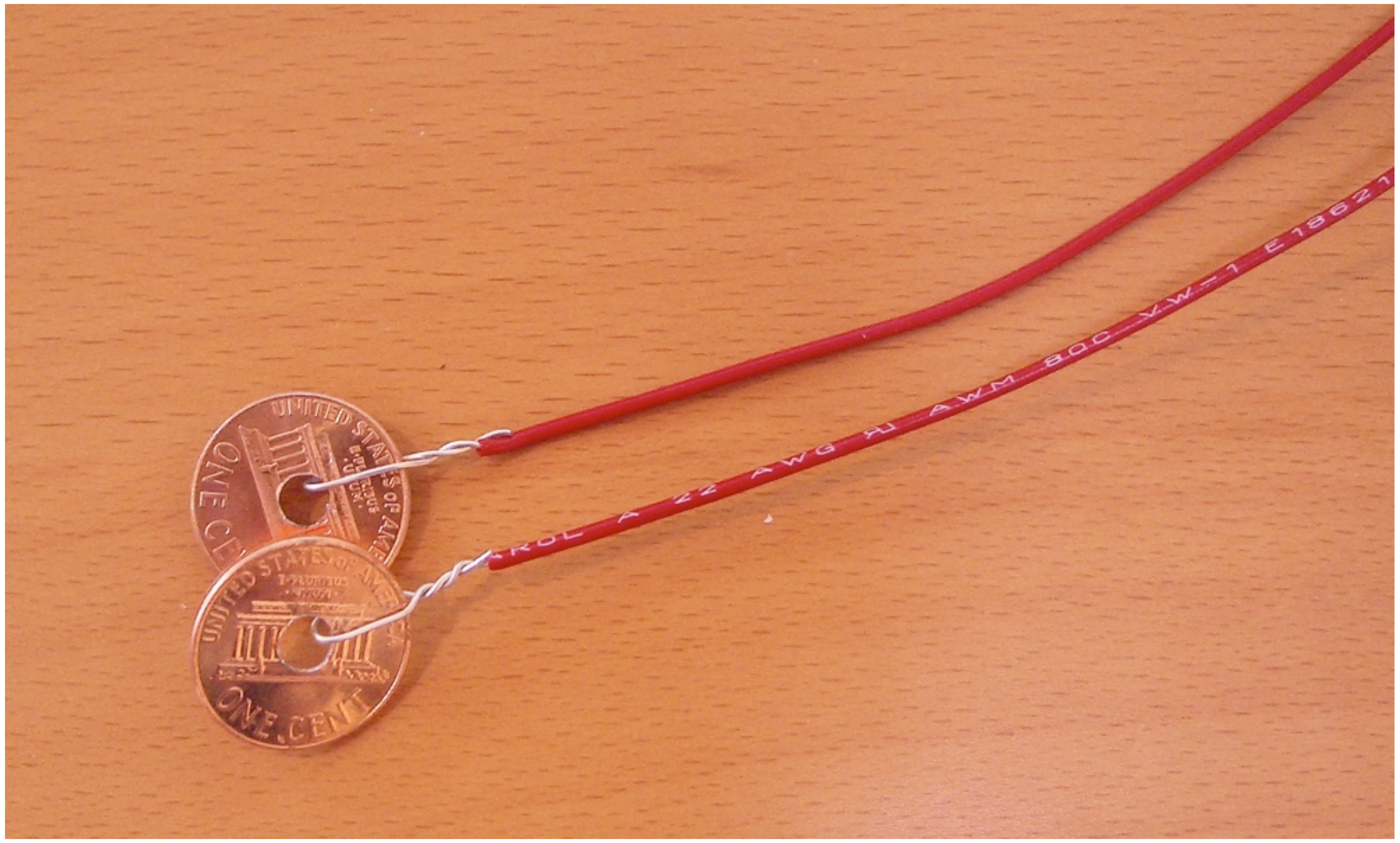


Wire soldered to penny.
Wire looped or crimped to aluminum sheet.

Homemade Switches

"Smart Wind Chimes"

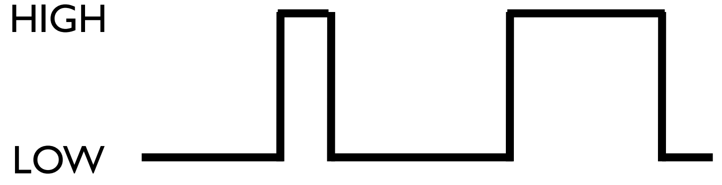
When the wind blows hard enough, you're sent email



Should use stranded wire, not solid.
Code analyzes series of on/off/on/off pulses to determine wind.

Digital Input

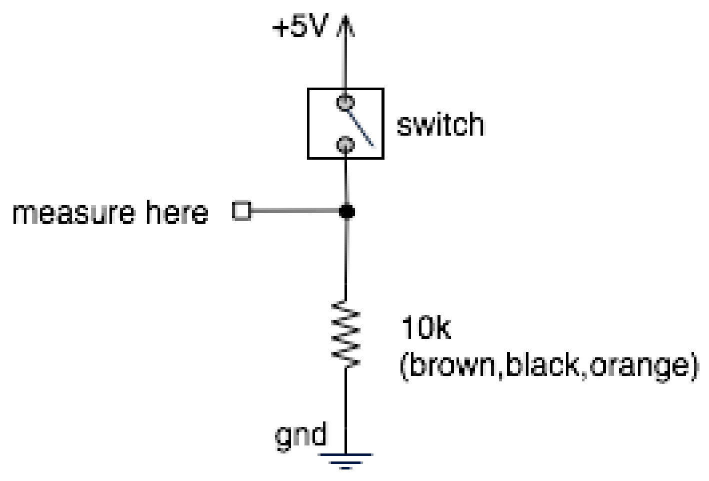
- Switches make or break a connection
- But Arduino wants to see a voltage
  - Specifically, a “HIGH” (5 volts)
  - or a “LOW” (0 volts)



How do you go from make/break to high/low?

Switch to Volts: Positive Logic

- Digital inputs can “float” between 0 and 5 volts
- Resistor “pulls down” input to ground (0 volts)
- Pressing switch sets input to 5 volts
- Press is HIGH
  Release is LOW

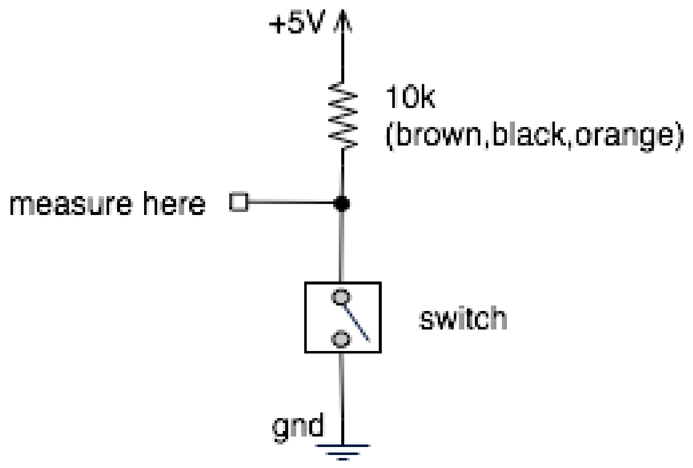


“pull-down”

Don’t want “pull-down” to be too small, or it uses a lot of current

Switch to Volts: Inverted Logic

- Resistor pulls up input to 5 volts
- Switch sets input to 0 volts
- But now the sense is inverted
    - Press is LOW
    - Release is HIGH

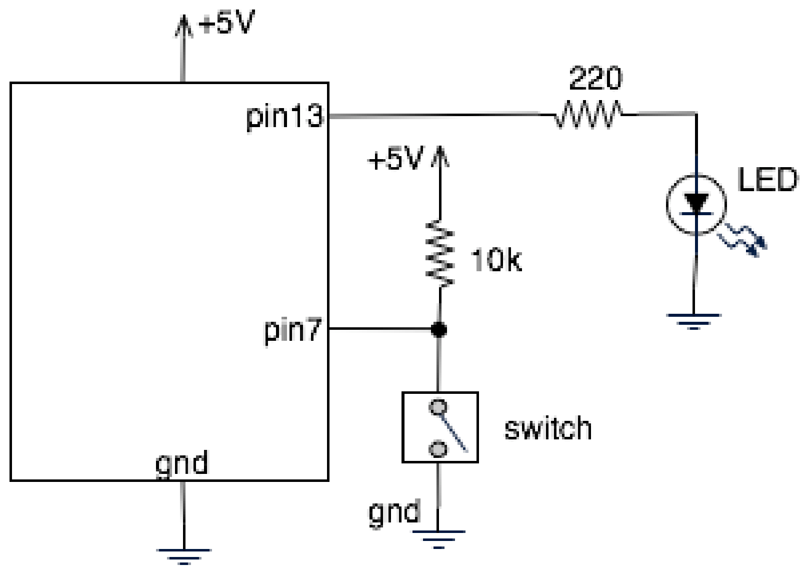


"pull-up"

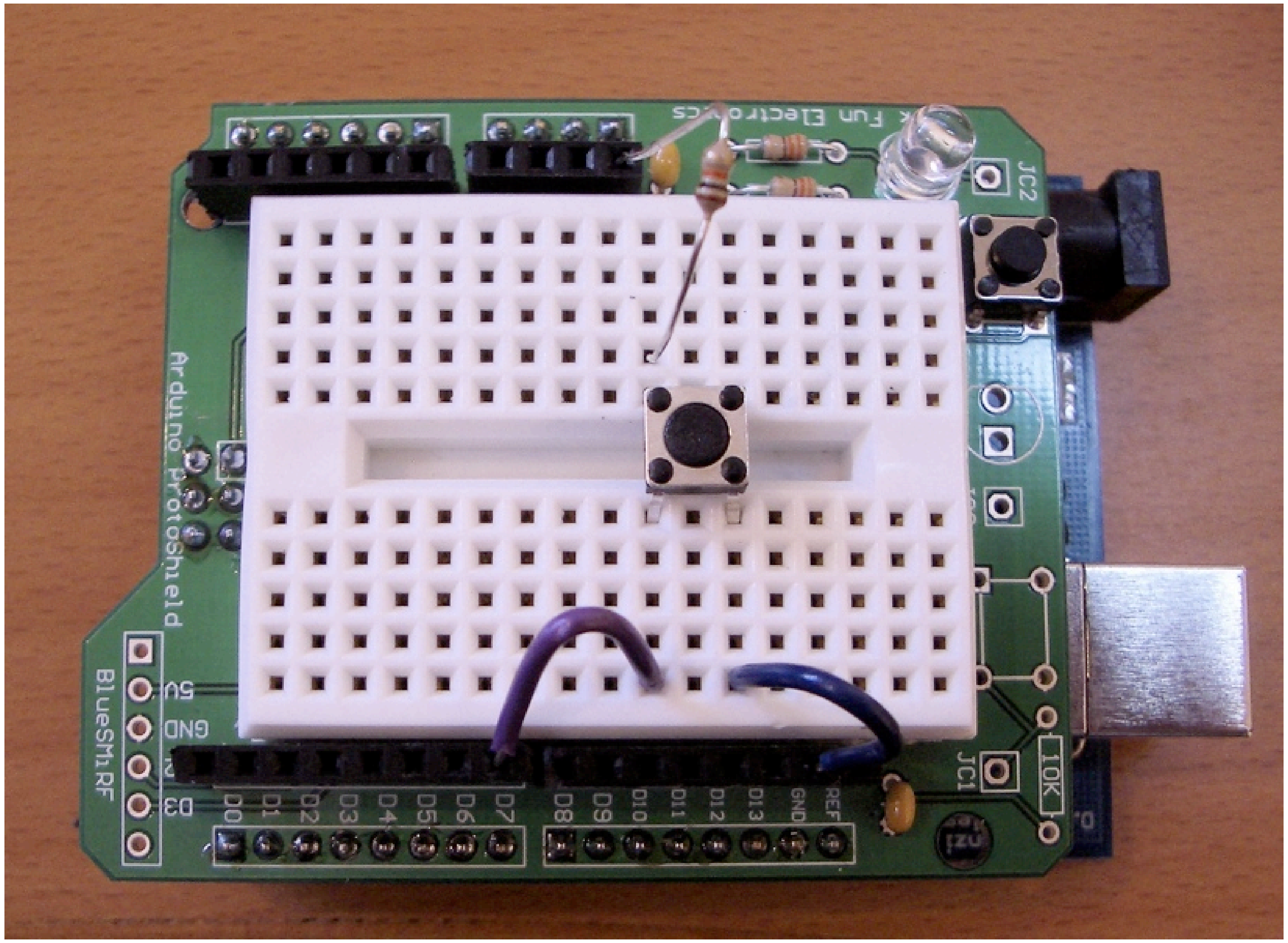
Inverted logic like this is common in microcontrollers

Arduino Digital Input

- Add switch circuit to any digital input (except pin 13)
- For output, use either existing pin 13 LED or wire up your own



Arduino Digital Input

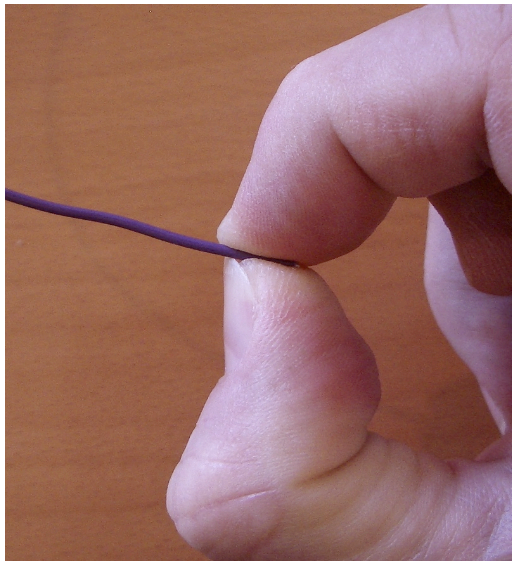
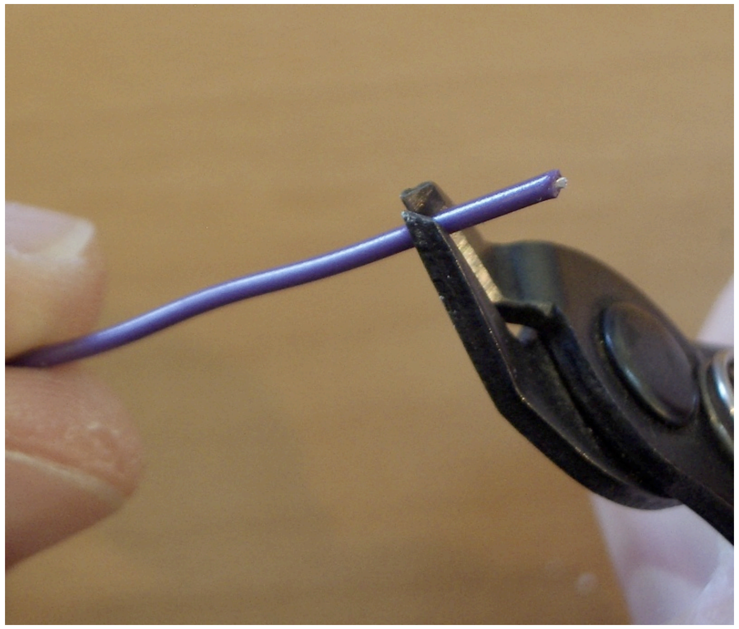
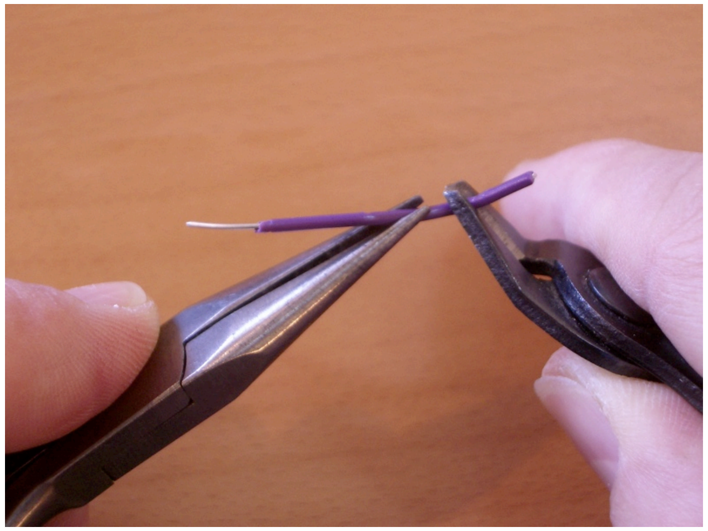


Output is on-board pin 13 LED for now

Using the fact that two of the switch leads are connected.
Also, notice color coding. Blue is ground, purple is signal
But pin 13 LED is underneath! So gotta take a peak.

Making Jumper Wires

- strip off about 1/2” of insulation
- Can use wire strippers, cutters, or fingers
- Can be a pain, so I have some pre-cut wires

Making Jumper Wires

The end result

Or buy pre-cut

One of these "how much is your time worth?" situations.
If you do a lot of breadboarding, pre-cut jumpers can save a lot of time.

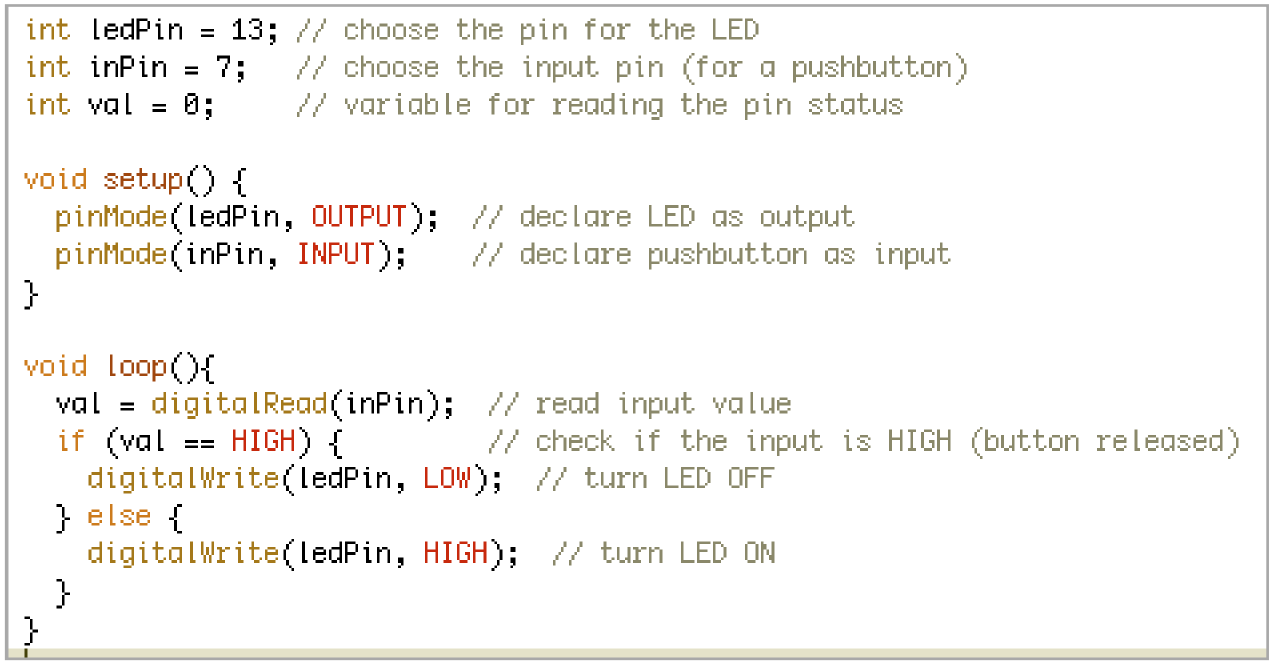
Using digitalRead()

- In `setup()`: use `pinMode(myPin,INPUT)` to make pin an input
- In `loop()`: use `digitalRead(myPin)` to get switch position
  - If doing many tests, use a variable to hold the output value of `digitalRead()`.
  - `e.g. val = digitalRead(myPin)`

Enough with the atoms, back to the bits

Digital Input Sketch

Load "examples/digital IO/digital_read"



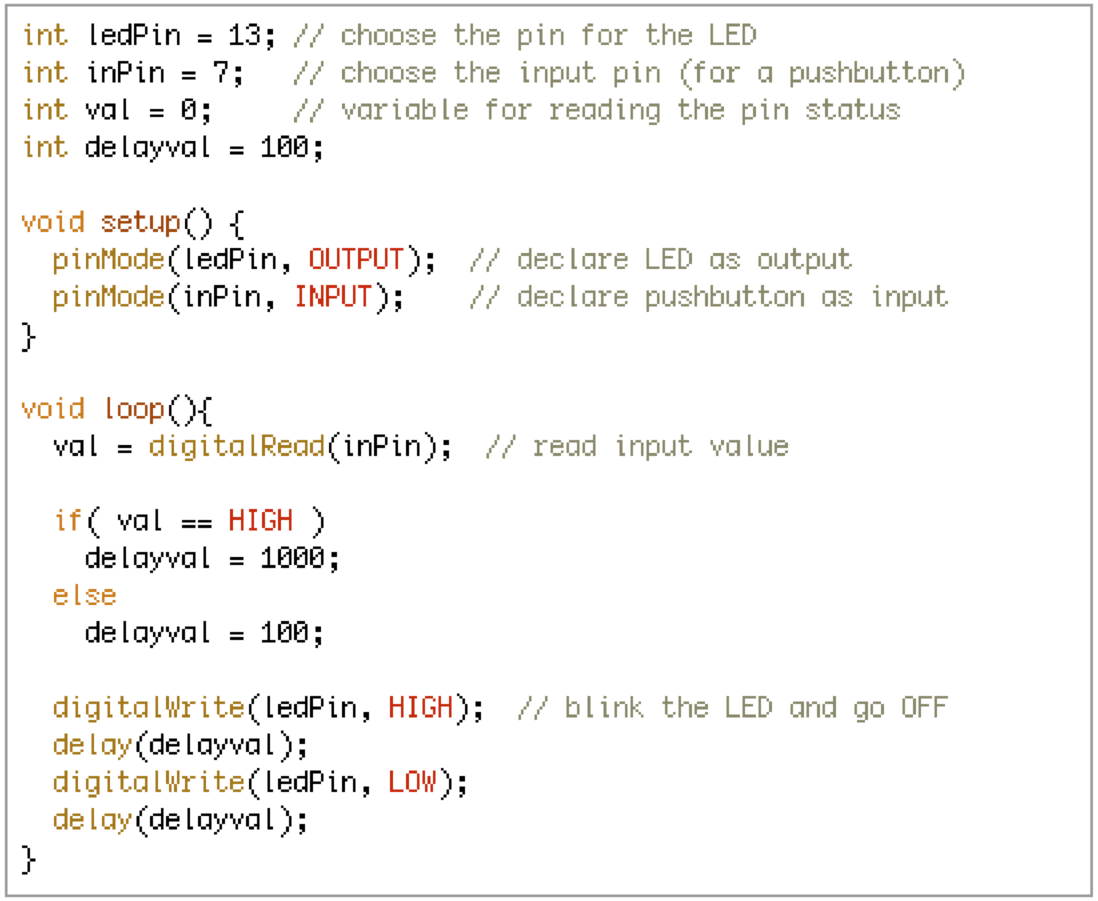
```
int ledPin = 13; // choose the pin for the LED
int inPin = 7;   // choose the input pin (for a pushbutton)
int val = 0;     // variable for reading the pin status

void setup() {
  pinMode(ledPin, OUTPUT);  // declare LED as output
  pinMode(inPin, INPUT);    // declare pushbutton as input
}

void loop(){
  val = digitalRead(inPin);  // read input value
  if (val == HIGH) {         // check if the input is HIGH (button released)
    digitalWrite(ledPin, LOW);  // turn LED OFF
  } else {
    digitalWrite(ledPin, HIGH);  // turn LED ON
  }
}
```

Now <u>you</u> control the blinking

Press to turn on, release to turn off.

Changing Blink Rate

Or, combine “led_blink” with “digital_read”

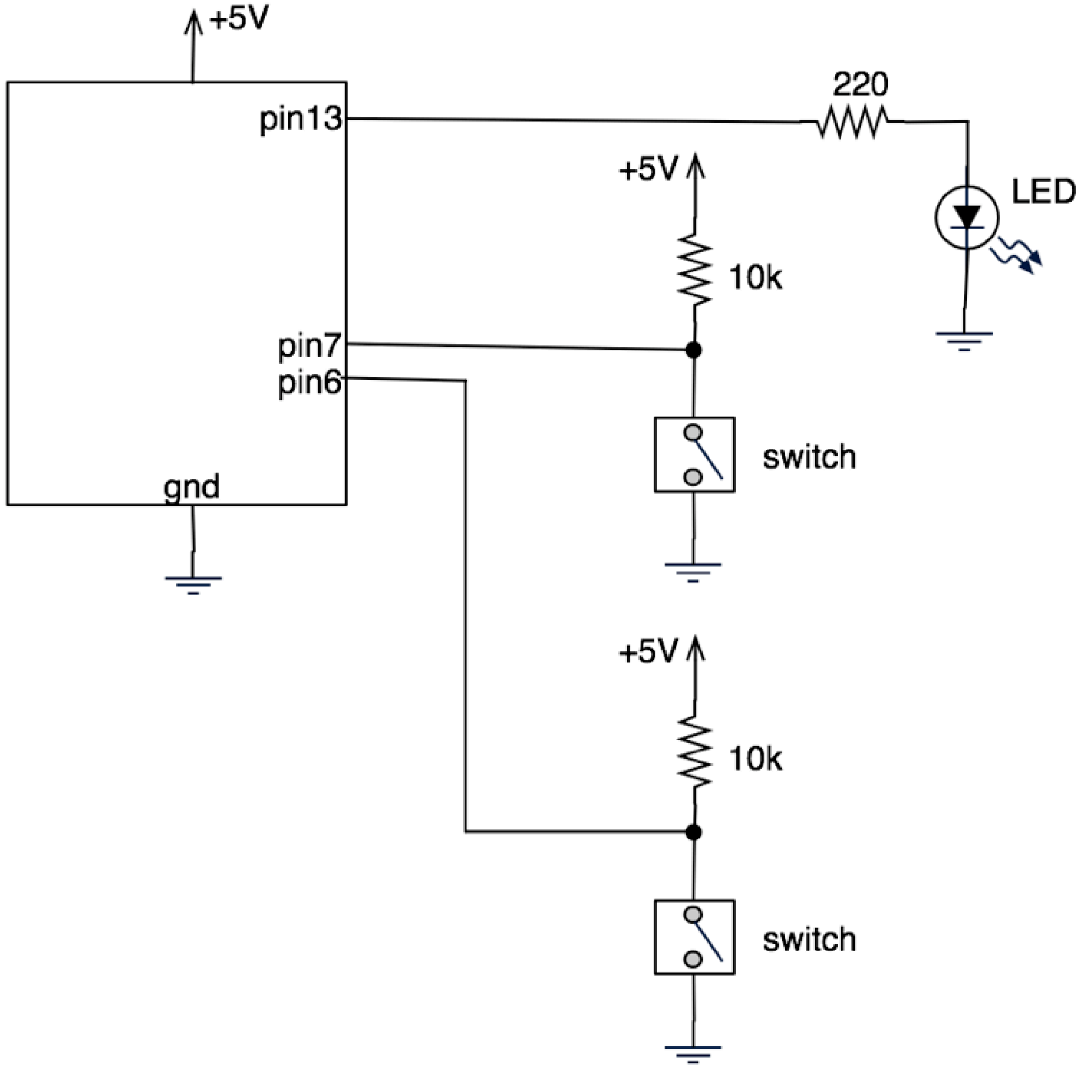


```
int ledPin = 13; // choose the pin for the LED
int inPin = 7;   // choose the input pin (for a pushbutton)
int val = 0;     // variable for reading the pin status
int delayval = 100;

void setup() {
  pinMode(ledPin, OUTPUT);  // declare LED as output
  pinMode(inPin, INPUT);    // declare pushbutton as input
}

void loop(){
  val = digitalRead(inPin);  // read input value

  if( val == HIGH )
    delayval = 1000;
  else
    delayval = 100;

  digitalWrite(ledPin, HIGH);  // blink the LED and go OFF
  delay(delayval);
  digitalWrite(ledPin, LOW);
  delay(delayval);
}
```

Built up of pieces you’ve seen before. Sorta like Lego.
Not an example in the “Examples” folder, but just something I made up.

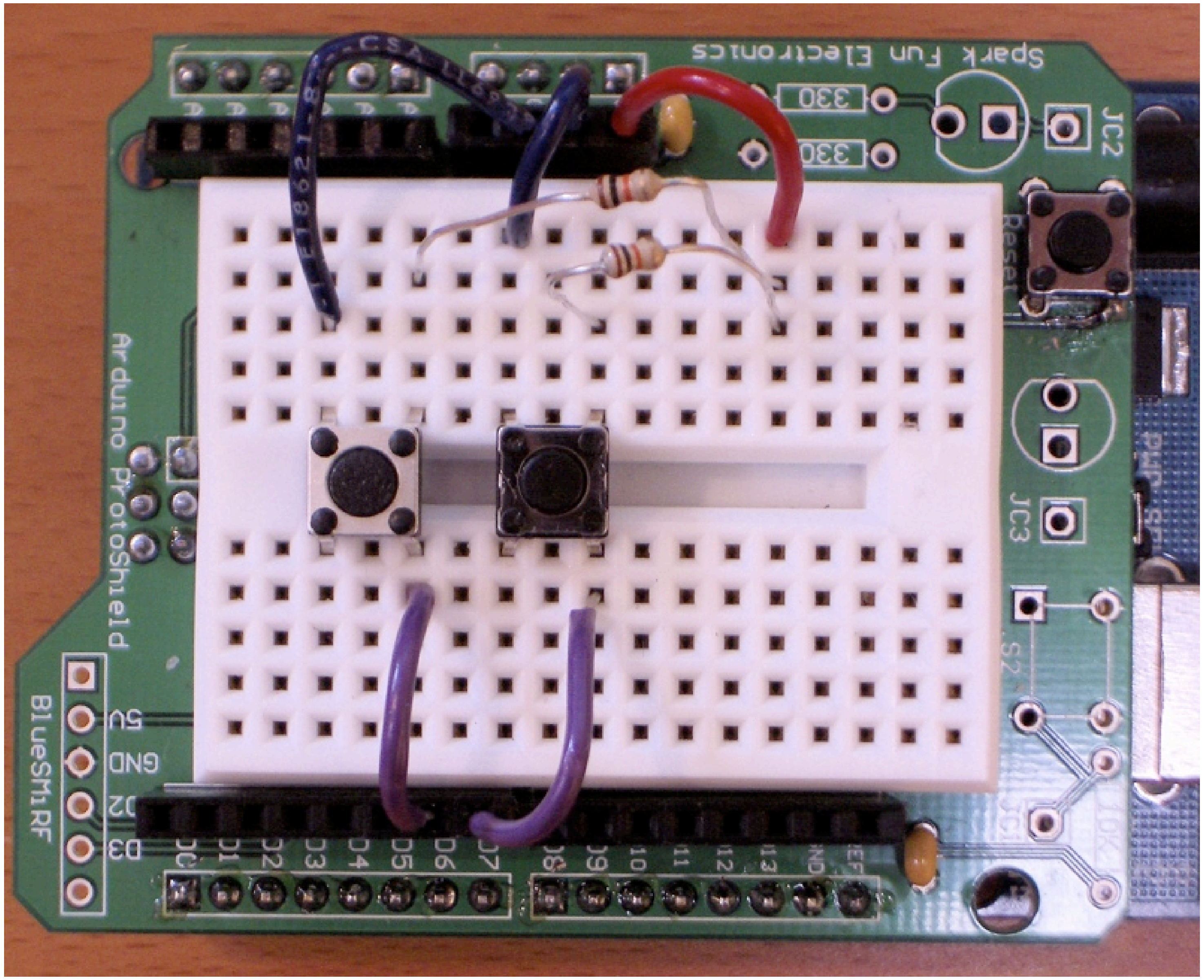
Multiple Switches

Same sub-circuit, just duplicate



Can do lots of switches this way.

Multiple Switches



An example of how to lay it out. Don’t have to do it here. Try at home.
I have extra 10k resistors.

Digital Input Uses

- spooky, remember?

Take a Break

Analog Input

To computers, analog is chunky

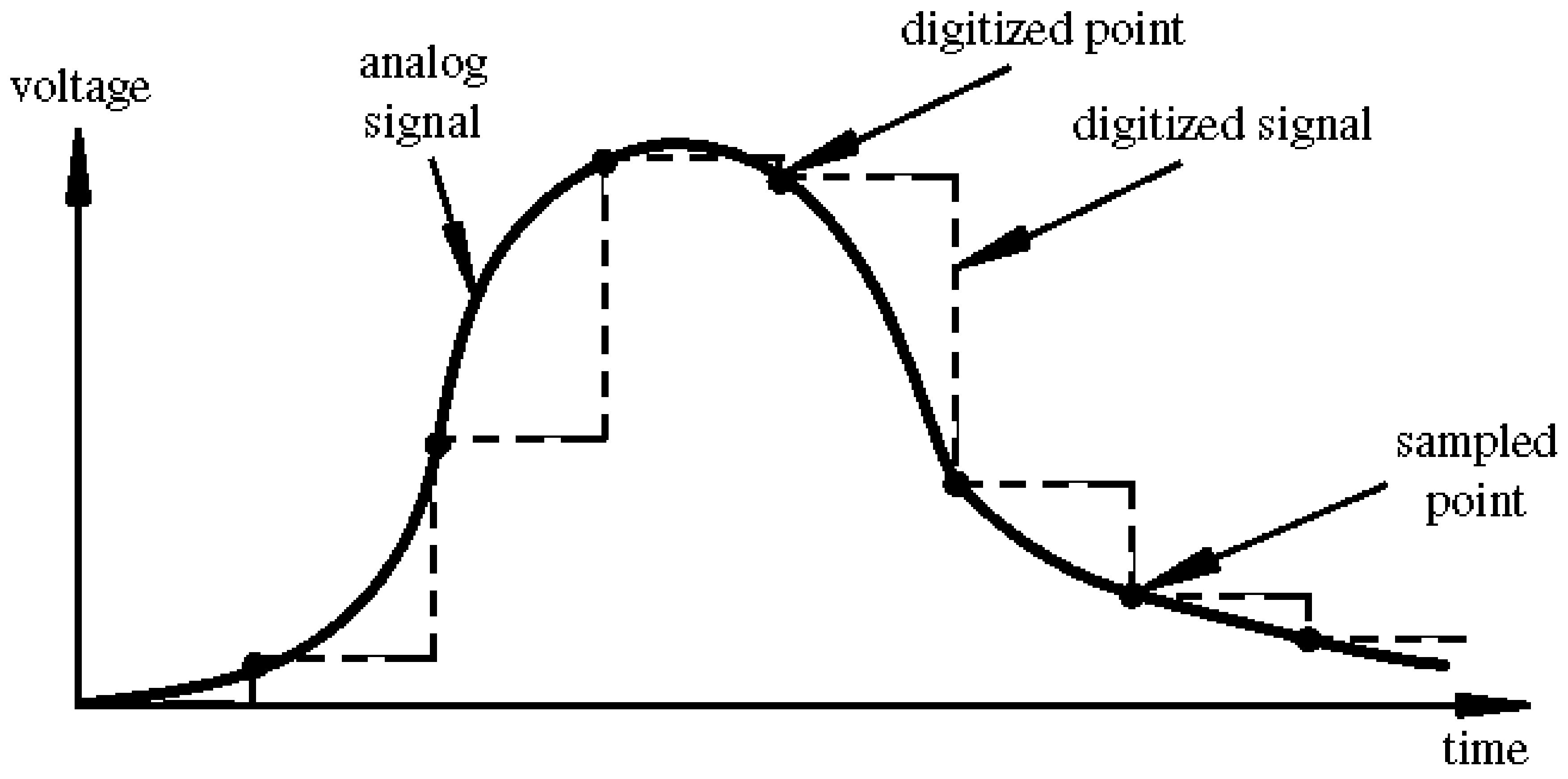
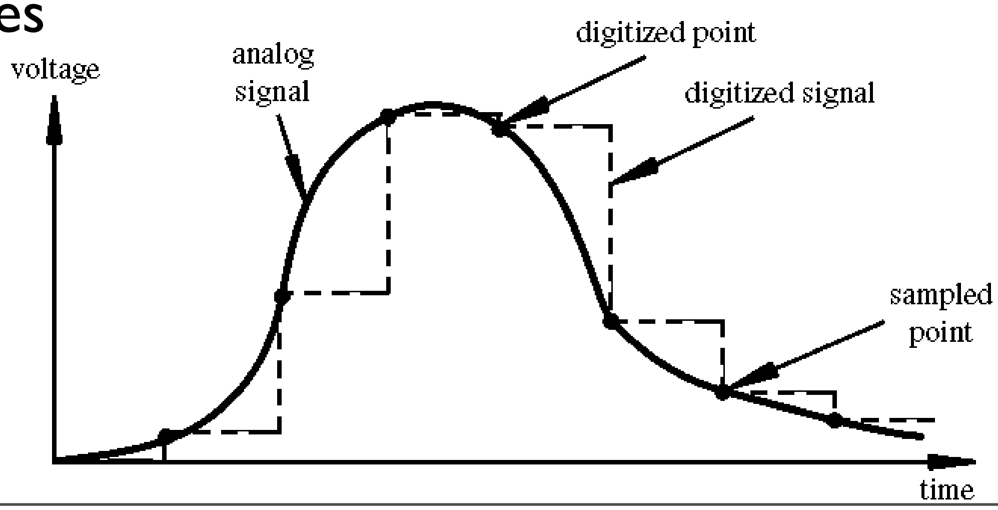


image from: http://www.engr.colostate.edu/~dga/me307/lectures.html

Analog Input

- Many states, not just two (HIGH/LOW)
- Number of states (or “bins”) is *resolution*
- Common computer resolutions:
  - 8-bit = 256 states
  - 16-bit = 65,536 states
  - 32-bit = 4,294,967,296 states



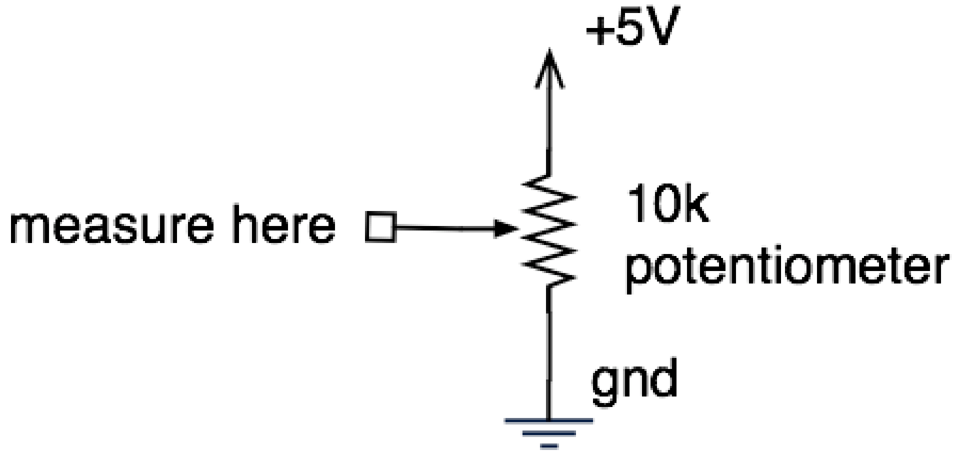
Analog Input

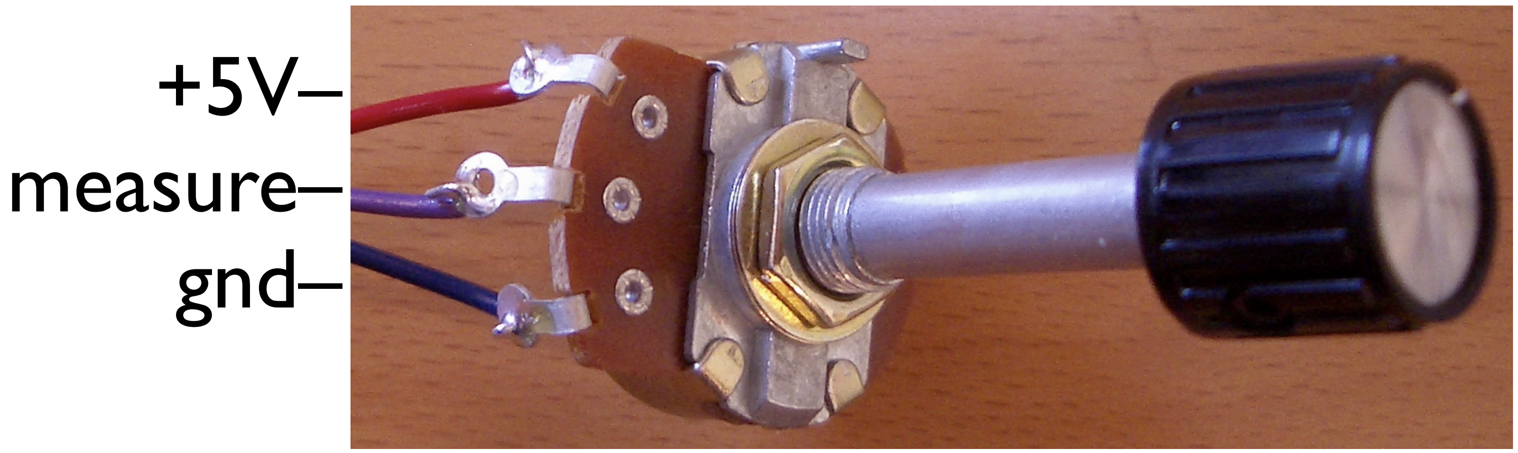
- Arduino (ATmega8) has six ADC inputs
- (ADC = Analog to Digital Converter)
- Reads voltage between 0 to 5 volts
- Resolution is 10-bit (1024 states)
- In other words, 5/1024 = 4.8 mV smallest voltage change you can measure

Analog Input

Sure sure, but how to make a varying voltage?

With a *potentiometer*. Or just *pot*.

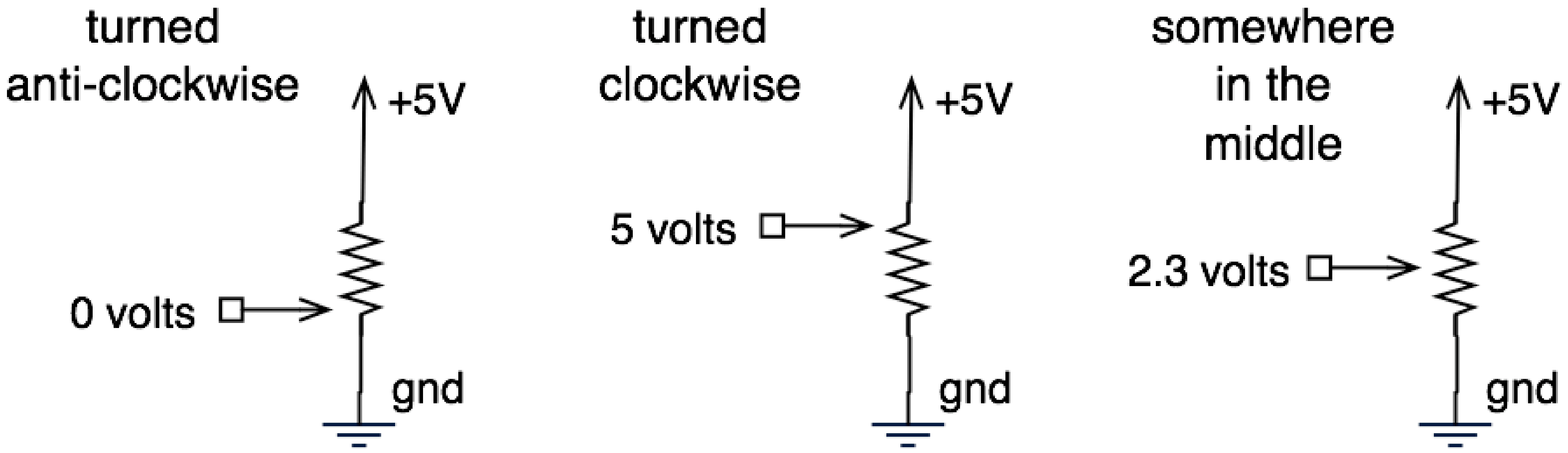




Color coding: red goes to power, blue to ground, purple to ‘measure here’ (it’s a mix, see?)

Potentiometers

Moving the knob is like moving
where the arrow taps the voltage on the resistor



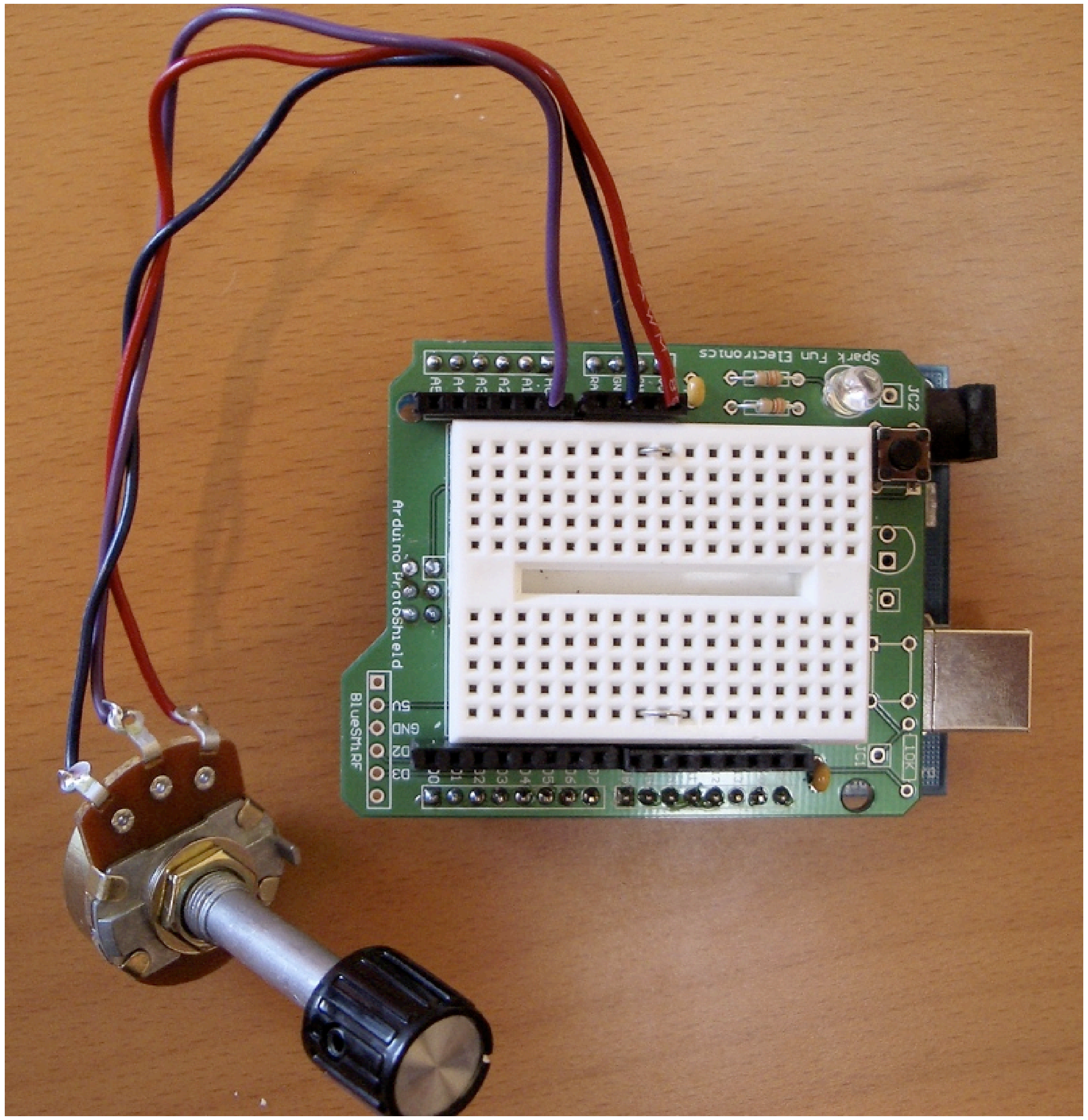
And that's actually how it works, btw, if you take apart a pot.
But I might have the directions reversed (clockwise vs. anti-clockwise).

Arduino Analog Input

Red to Vcc

Purple to A0

Blue to Gnd

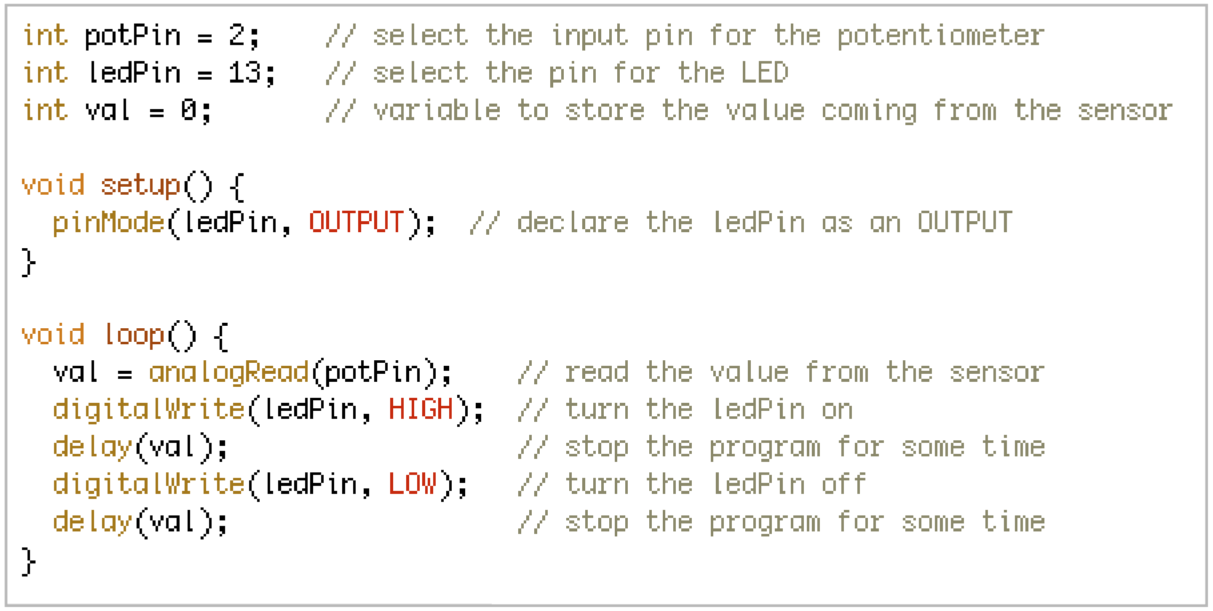


Hook it up, plug in the wires in directly
"Vcc" is alias for +5V.
"Raw" is alias for external power (approx 9V)

Analog Input Sketch

Sketch “Examples/sensors_resistive/analog_read_led”

Change to 0



```
int potPin = 2;    // select the input pin for the potentiometer
int ledPin = 13;   // select the pin for the LED
int val = 0;       // variable to store the value coming from the sensor

void setup() {
  pinMode(ledPin, OUTPUT);  // declare the ledPin as an OUTPUT
}

void loop() {
  val = analogRead(potPin);    // read the value from the sensor
  digitalWrite(ledPin, HIGH);  // turn the ledPin on
  delay(val);                  // stop the program for some time
  digitalWrite(ledPin, LOW);   // turn the ledPin off
  delay(val);                  // stop the program for some time
}
```

Turn knob to vary blink rate of the LED

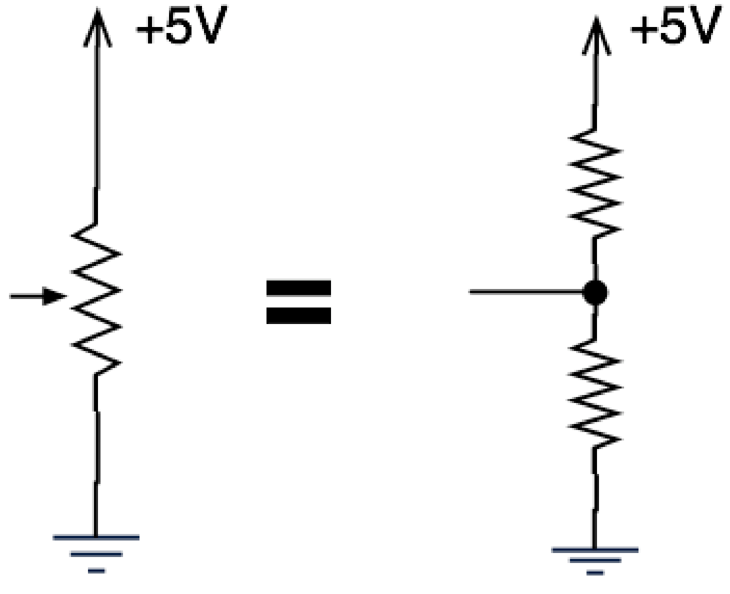
Notice no `pinMode()` for analog inputs

What good are pots?

- Anytime you need a ranged input
  - (we're used to knobs)
- Measure rotational position
  - steering wheel, etc.
- But more importantly for us, potentiometers are a good example of a *resistive sensor*

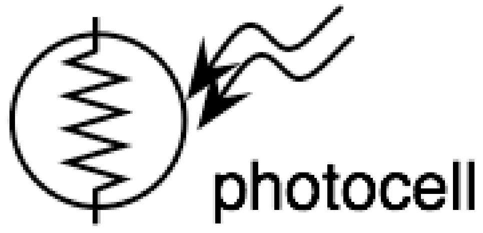
Sensing the Dark

- Pots are example of a *voltage divider*
- Voltage divider splits a voltage in two
- Same as two resistors, but you can vary them

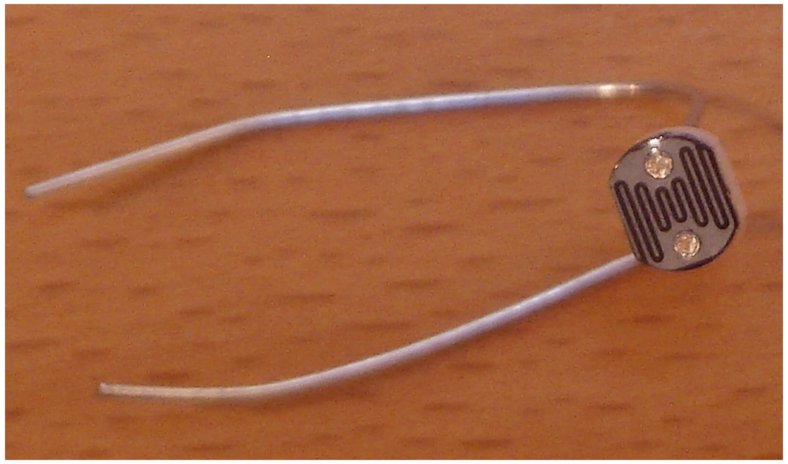


Sensing the Dark: Photocells

- aka. photoresistor, light-dependent resistor
- A *variable* resistor
- Brighter light == lower resistance
- Photocells you have range approx. 0-10k

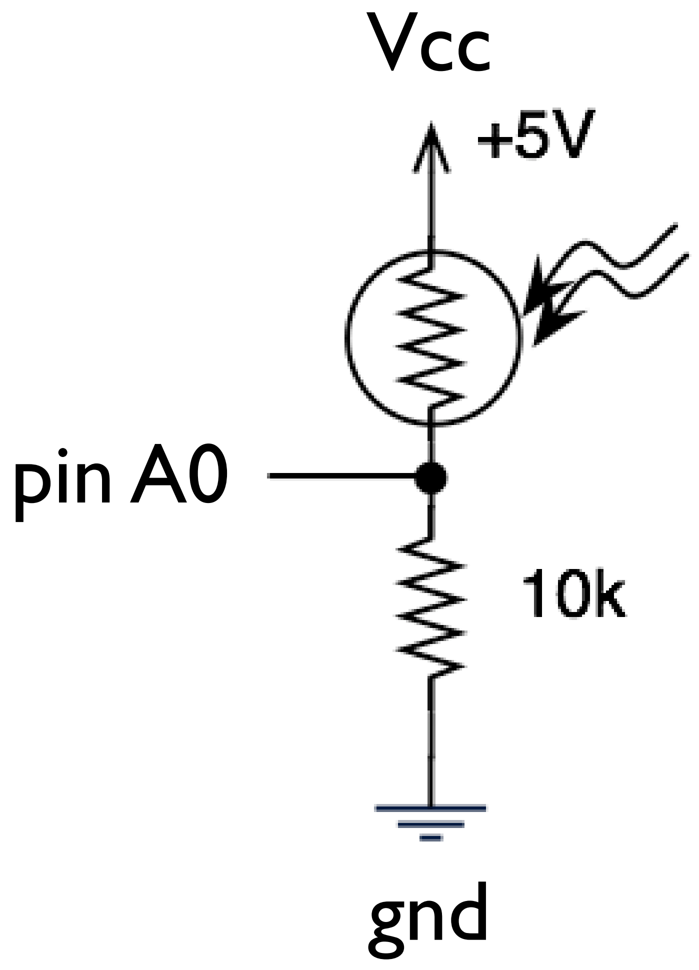


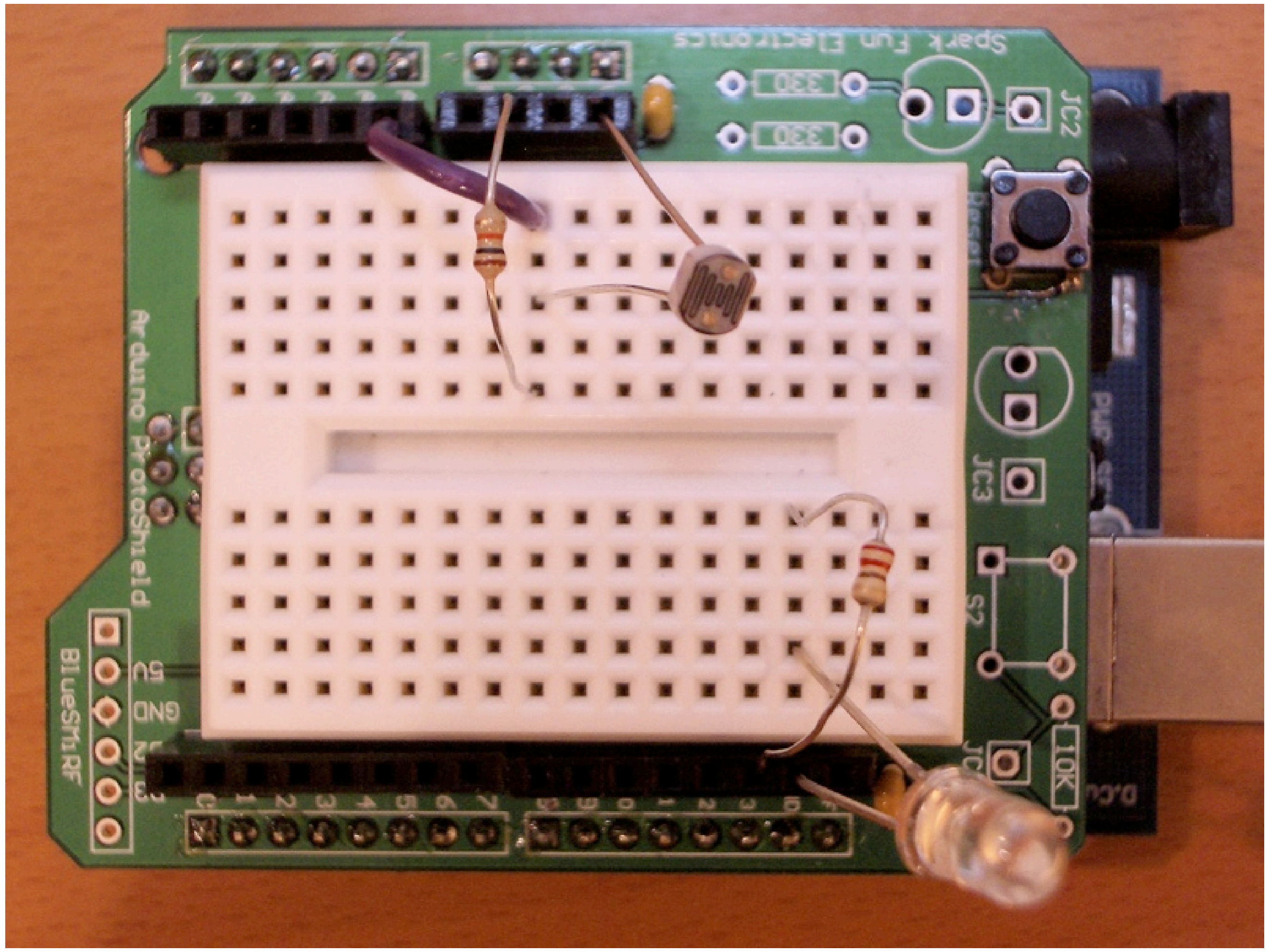
schematic symbol



Pretty cheap too. Can get a grab bag of 100 misc from Jameco for $20

Photocell Circuit



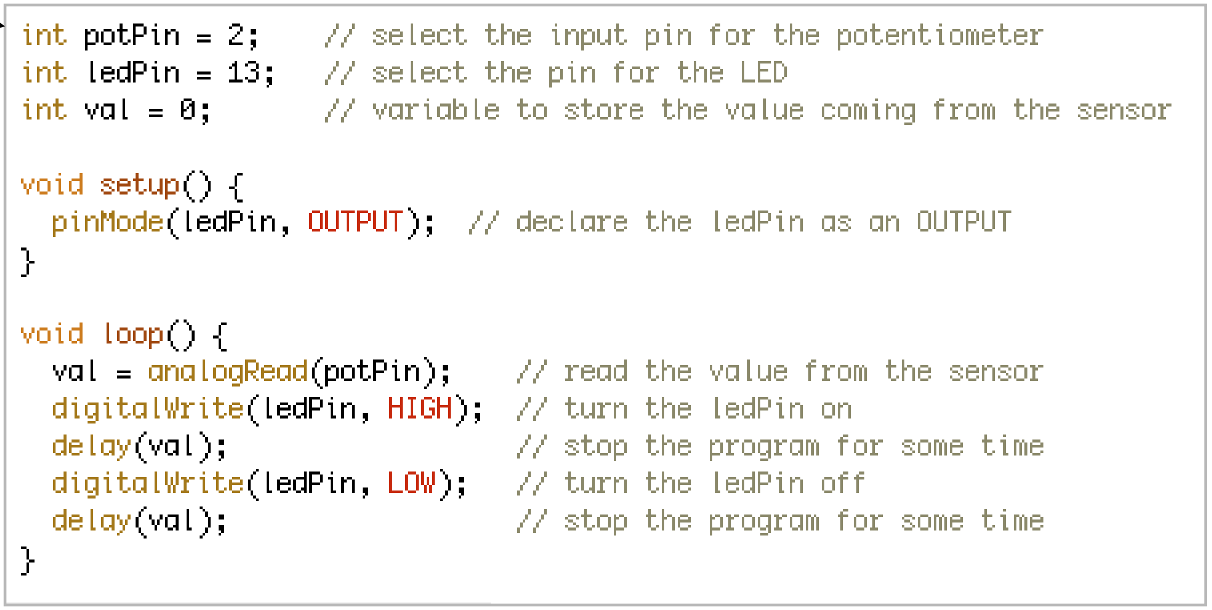


Looks a lot like the pot circuit, doesn't it?

Photocell Arduino Sketch

Can use as before, sketch “analog_read_led”

Change to 0



```
int potPin = 2;    // select the input pin for the potentiometer
int ledPin = 13;   // select the pin for the LED
int val = 0;       // variable to store the value coming from the sensor

void setup() {
  pinMode(ledPin, OUTPUT);  // declare the ledPin as an OUTPUT
}

void loop() {
  val = analogRead(potPin);    // read the value from the sensor
  digitalWrite(ledPin, HIGH);  // turn the ledPin on
  delay(val);                  // stop the program for some time
  digitalWrite(ledPin, LOW);   // turn the ledPin off
  delay(val);                  // stop the program for some time
}
```

Wave your hand over it = blink faster
Point it towards the light = blink slower

Just like magic!
If circuit was configured the other way (photocell on bottom), then darkness would make it blink slower.

More Spooky, Please

All this blinking is okay, but...

Okay, so the googly-eyeness of it makes it more Simpsonesque than spooky.

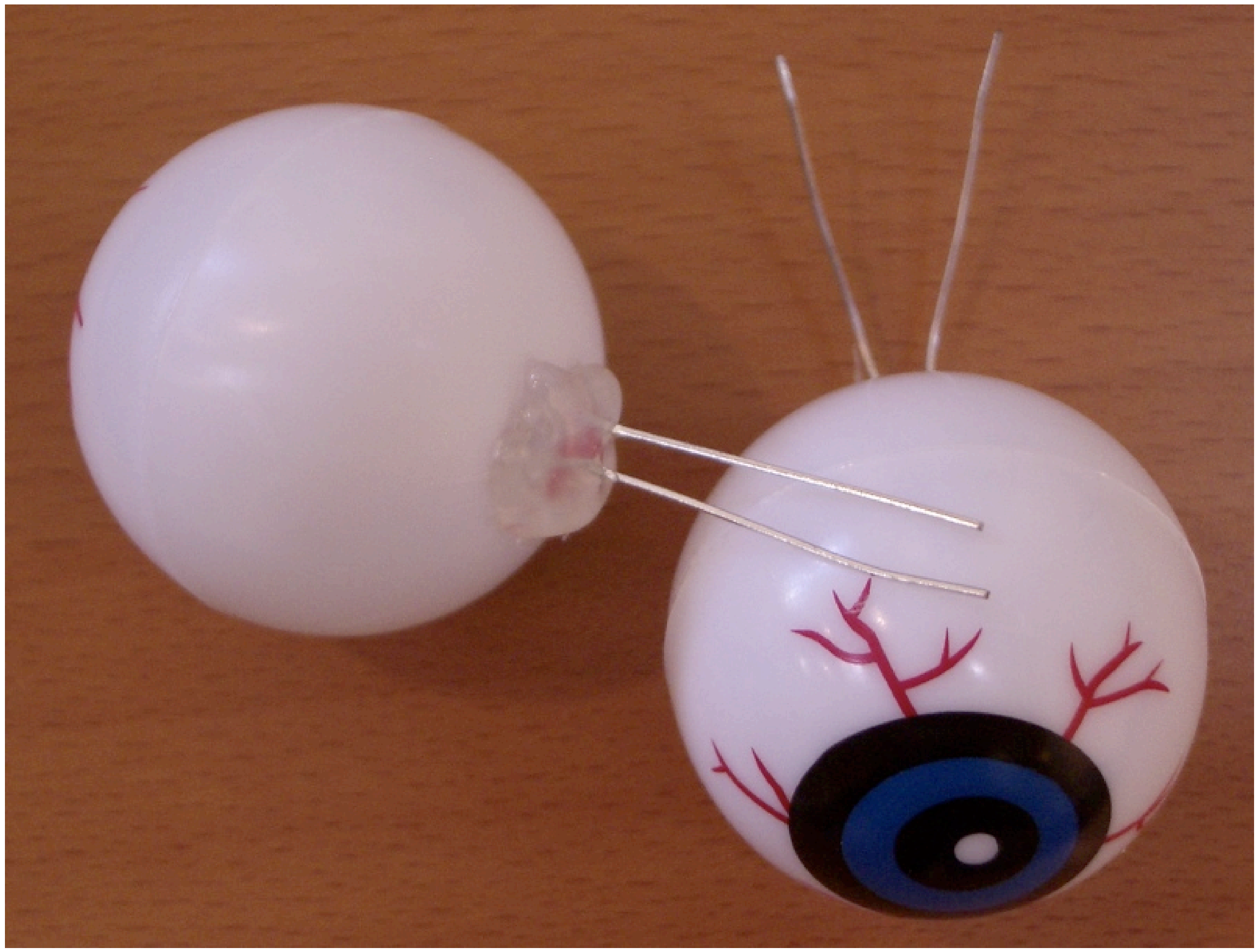
Evil Glowing Eyes

Almost as cool as Roy Batty

LED Eyeballs

Use your two orange LEDs

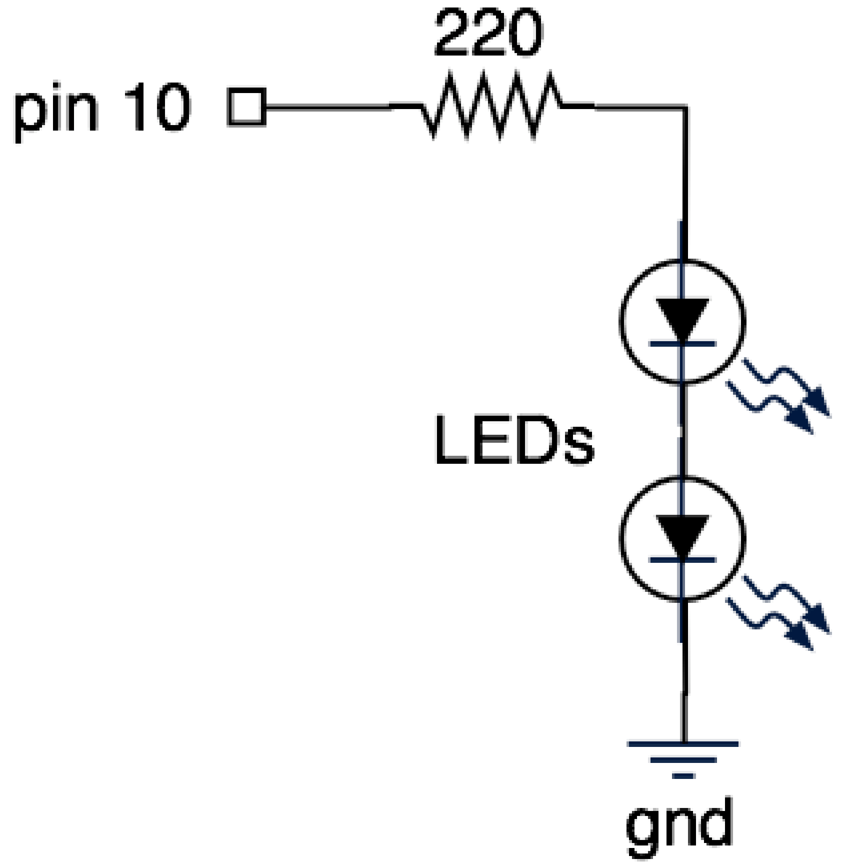
Little bit of hot glue and you're set



Use the two orange LEDs.
Save the R,G,B LEDs for next week.
Hot glue is the best thing in the world.
I brought my hot glue gun if you want to do this right now

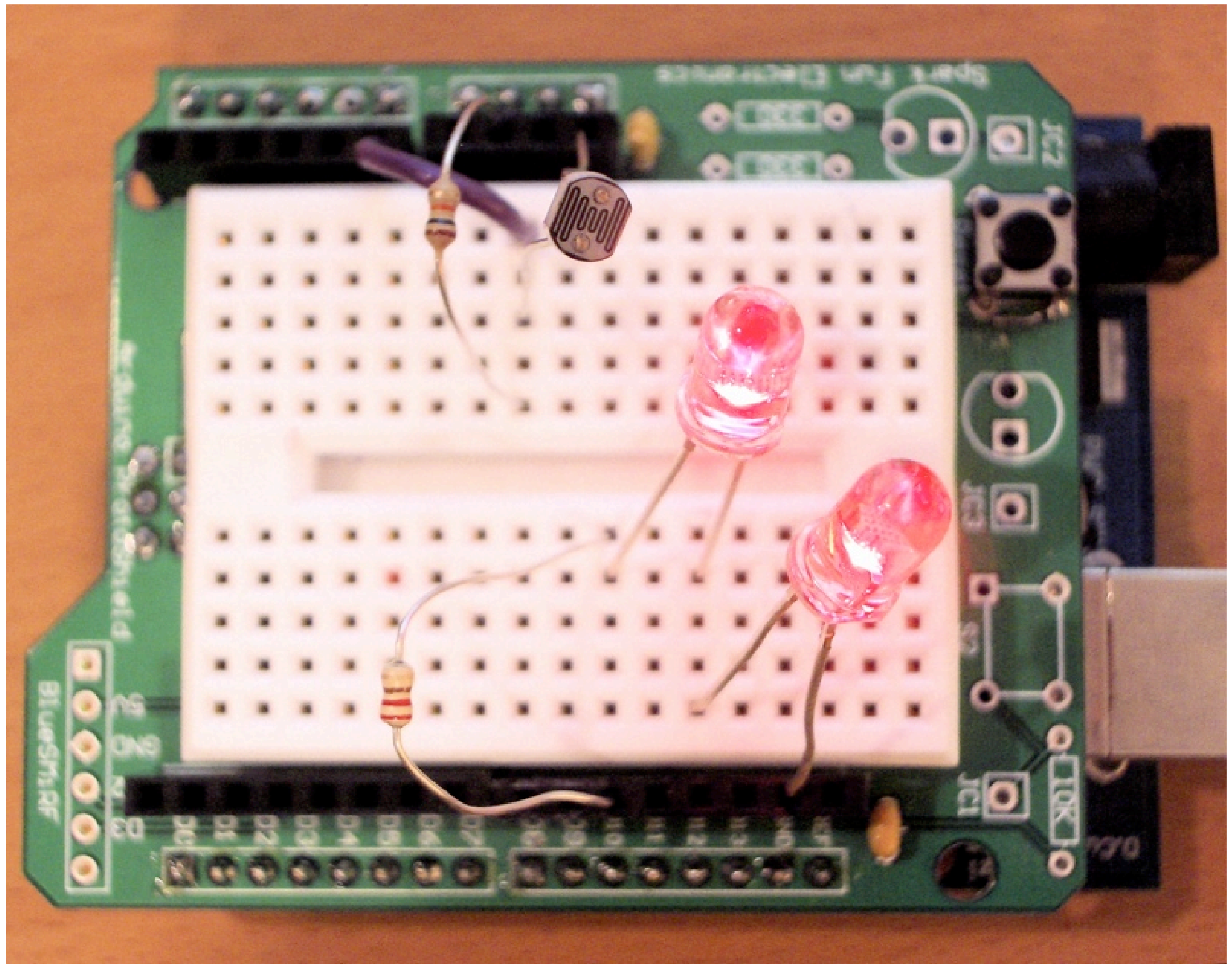
Driving Two LEDs

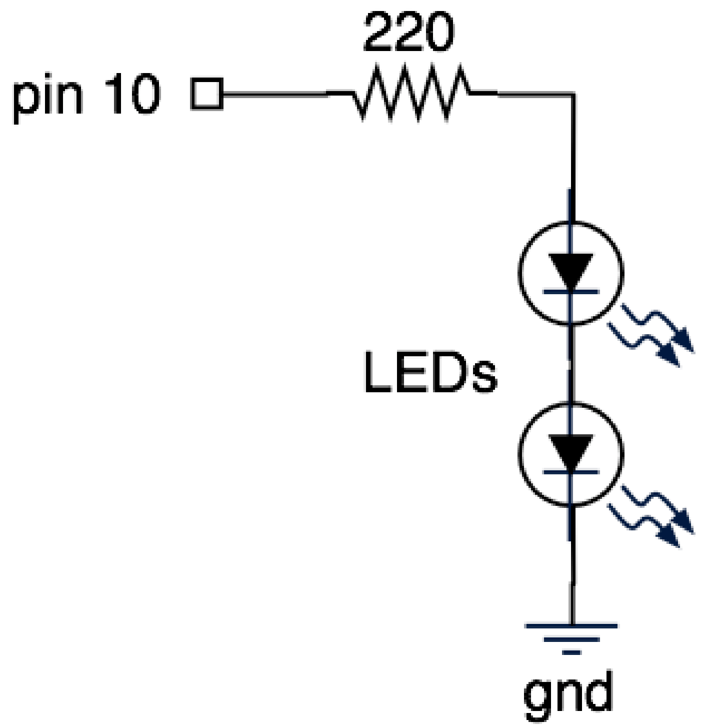
- Could use two Arduino pins. But wasteful.
- Instead, put two in series
- Doesn't work for blue LEDs
  (and white, and some green)



Blue LEDs have a voltage drop of ~3.4V, two in series makes ~6.8V which is greater than the 5V the Arduino puts out.
Don't put LEDs in parallel. http://members.misty.com/don/ledd.html
Notice pin 10. That's important.

LED Eyes





photocell circuit is as before

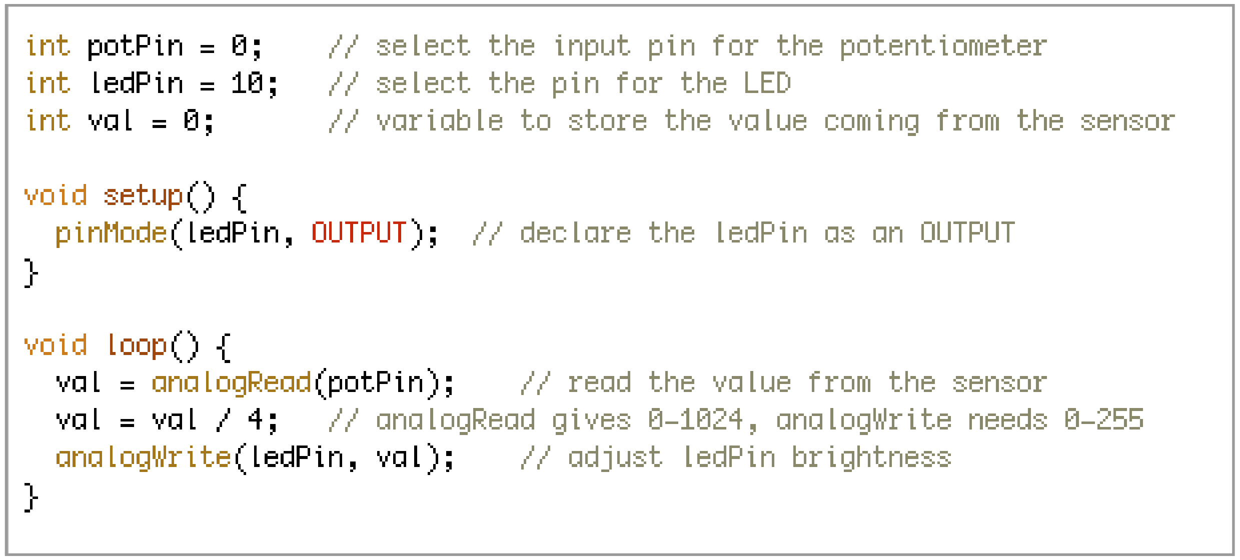
Notice, pin 10. This will become important later.

LED Eyes Brightness

- To complement `analogRead()`, there is `analogWrite()`.
- Only available on digital pins 9,10,11.
  (yes, a little confusing)
- More next week about how it works.
- Can use it to set <u>brightness</u> of LEDs

LED Eyes Sketch

Sketch “analog_brightness”



```
int potPin = 0;    // select the input pin for the potentiometer
int ledPin = 10;   // select the pin for the LED
int val = 0;       // variable to store the value coming from the sensor

void setup() {
  pinMode(ledPin, OUTPUT);  // declare the ledPin as an OUTPUT
}

void loop() {
  val = analogRead(potPin);    // read the value from the sensor
  val = val / 4;   // analogRead gives 0-1024, analogWrite needs 0-255
  analogWrite(ledPin, val);    // adjust ledPin brightness
}
```

As it gets darker, the LEDs get less bright

You just built an auto-dimmer

This is cool, but still not spooky enough.

Making Eyes Glow

(where "glow" is the throbbing of brightness)

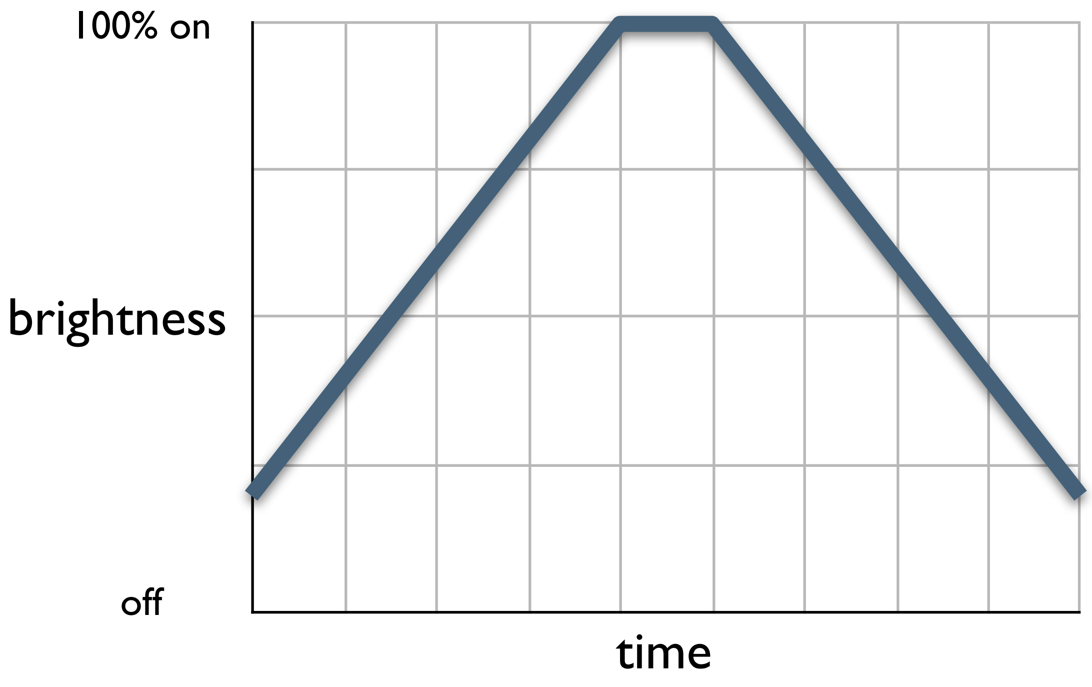
How does that glow throbbing work?

Sleeping laptops do something similar

Need to describe how brightness changes over time

LED Brightness Functions

Brightness over time can be described as a graph

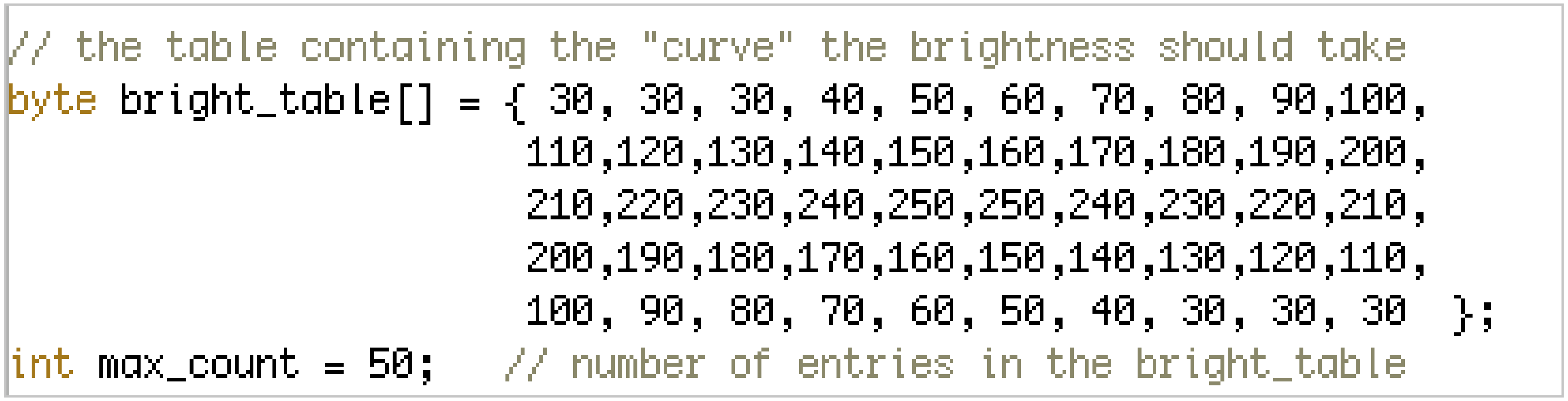


Draw your graph, use the resulting numbers

Doesn’t matter which numbers you choose right now

LED Brightness Functions

Then turn those numbers into an array



```
// the table containing the "curve" the brightness should take
byte bright_table[] = { 30, 30, 30, 40, 50, 60, 70, 80, 90,100,
                       110,120,130,140,150,160,170,180,190,200,
                       210,220,230,240,250,250,240,230,220,210,
                       200,190,180,170,160,150,140,130,120,110,
                       100, 90, 80, 70, 60, 50, 40, 30, 30, 30  };
int max_count = 50;   // number of entries in the bright_table
```

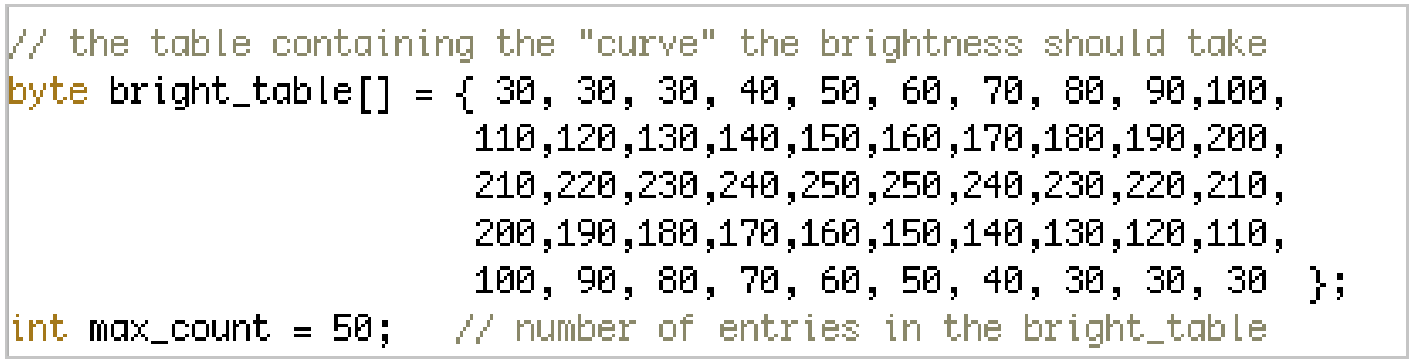
Use any pattern of numbers you like
but they must range between 0-255

```
  0 = full off
127 = half on
255 = full on
```

Make sure max_count is not too large!

LED Brightness Functions

Once you have your table...



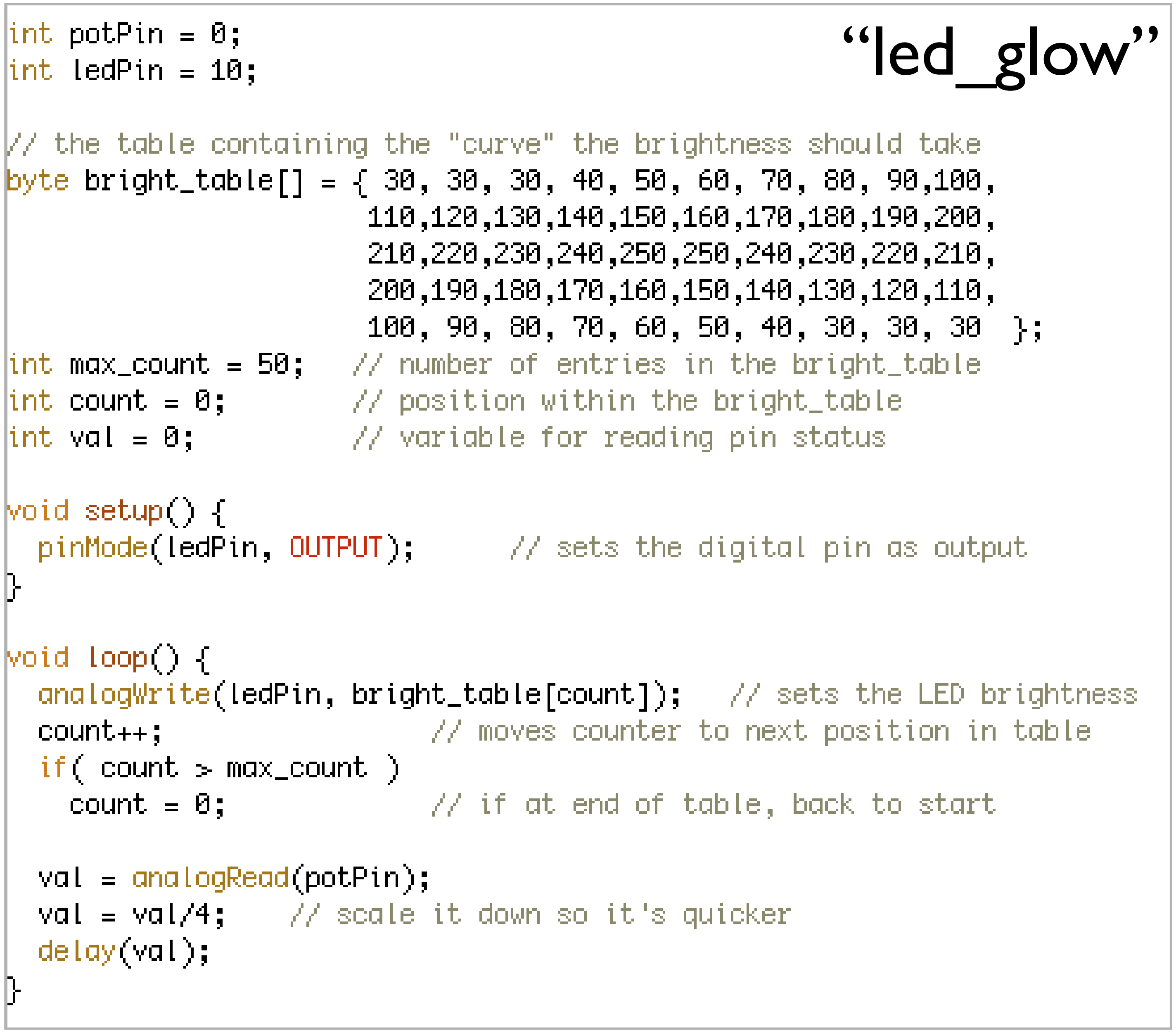
```
// the table containing the "curve" the brightness should take
byte bright_table[] = { 30, 30, 30, 40, 50, 60, 70, 80, 90,100,
                       110,120,130,140,150,160,170,180,190,200,
                       210,220,230,240,250,250,240,230,220,210,
                       200,190,180,170,160,150,140,130,120,110,
                       100, 90, 80, 70, 60, 50, 40, 30, 30, 30  };
int max_count = 50;   // number of entries in the bright_table
```

...the rest is just programming

1. Get a `bright_table` value
2. Send it out with `analogWrite()`
3. Advance counter into `bright_table`
4. Wait a bit
5. Repeat

Glowing Eyes Sketch

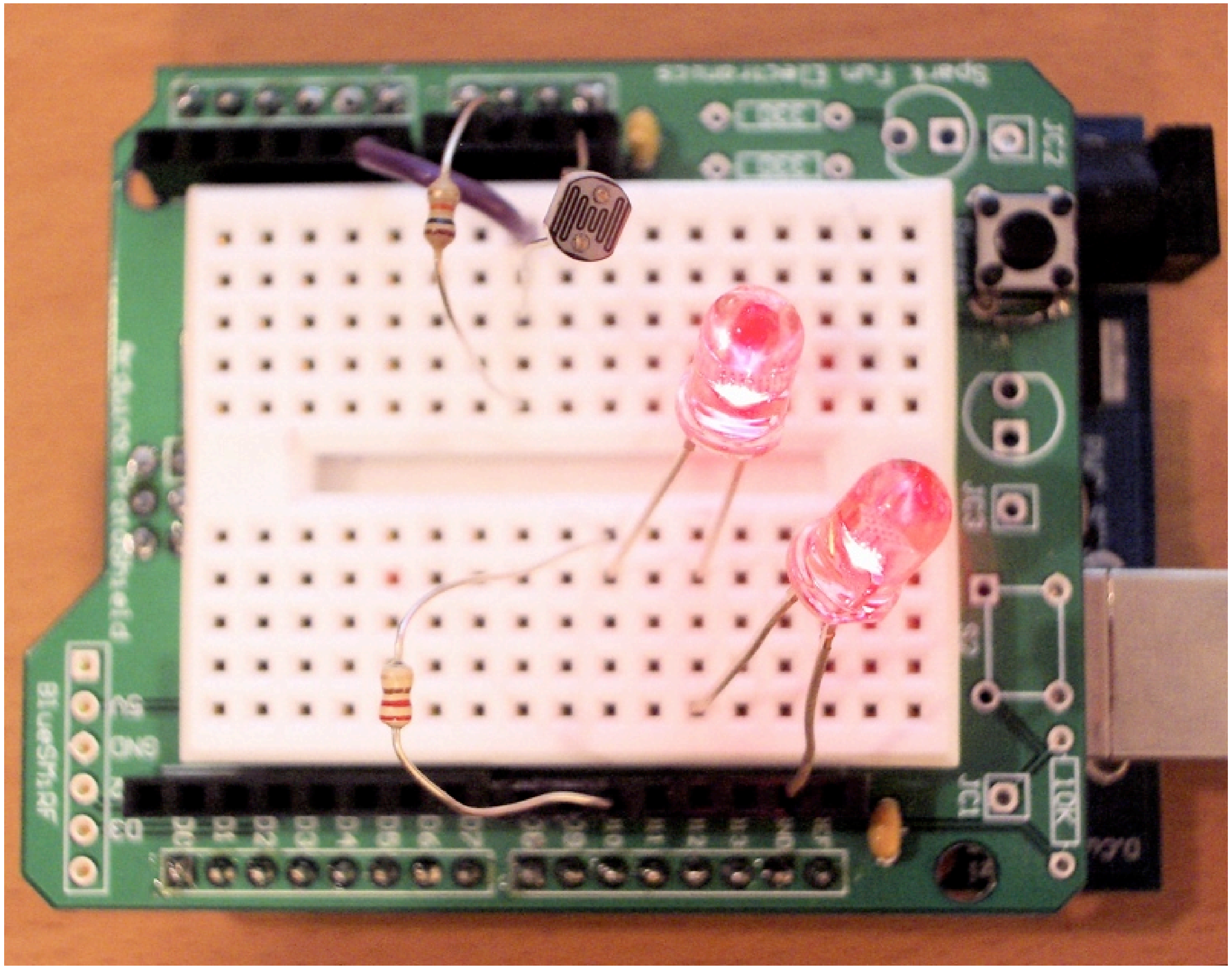
“led_glow”



```
int potPin = 0;
int ledPin = 10;

// the table containing the "curve" the brightness should take
byte bright_table[] = { 30, 30, 30, 40, 50, 60, 70, 80, 90,100,
                       110,120,130,140,150,160,170,180,190,200,
                       210,220,230,240,250,250,240,230,220,210,
                       200,190,180,170,160,150,140,130,120,110,
                       100, 90, 80, 70, 60, 50, 40, 30, 30, 30  };
int max_count = 50;    // number of entries in the bright_table
int count = 0;         // position within the bright_table
int val = 0;           // variable for reading pin status

void setup() {
  pinMode(ledPin, OUTPUT);      // sets the digital pin as output
}

void loop() {
  analogWrite(ledPin, bright_table[count]);   // sets the LED brightness
  count++;                    // moves counter to next position in table
  if( count > max_count )
    count = 0;                // if at end of table, back to start

  val = analogRead(potPin);
  val = val/4;    // scale it down so it's quicker
  delay(val);
}
```

I can

Glowing Eyes



Going Further

- Glowing LEDs
  - The last sketch is *data driven*
  - So you can plug in any brightness function
  - Make a flickering candle or a bad neon light

Going Further

- Photocells
  - Think of some interesting uses
  - What about *multiple* photocells?
- Homemade Sensors
  - Make some of your own!

Next Week

- Motion with Servos
- R,G,B color mixing for mood lighting
- Controlling Arduino from a computer
- Controlling a computer from Arduino

END Class 2

http://todbot.com/blog/spookyarduino

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