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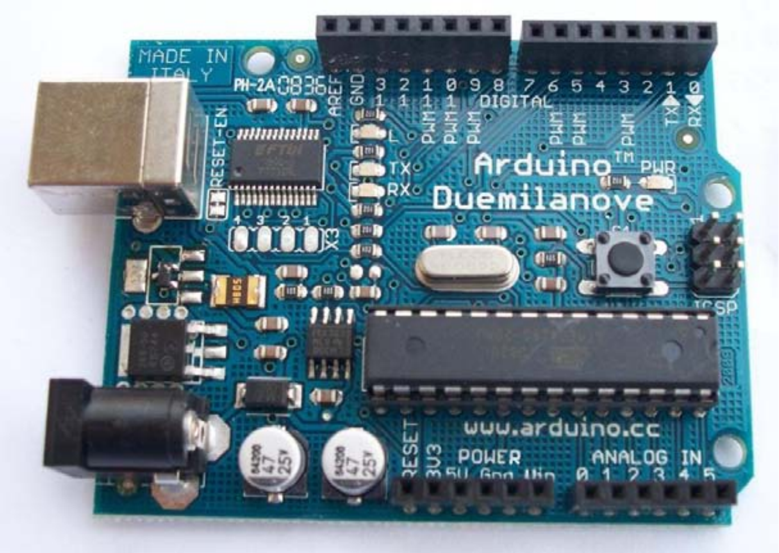
SIGGRAPH2013

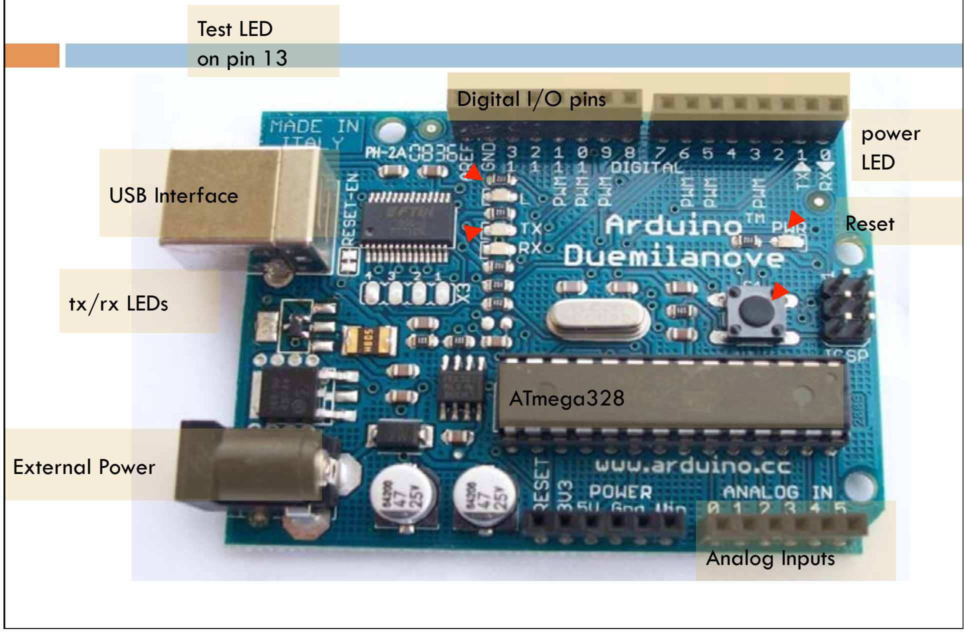
INTRODUCTION TO ARDUINO AND LEDS

Activity one: Make sure everybody is up and running

Arduino



Arduino



Physical Computing Essentials

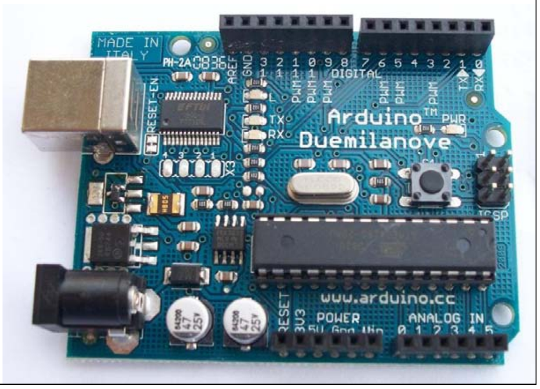
- □ pinMode(pinNumber, mode); // declare a pin INPUT or OUTPUT
- □ digitalRead(pinNumber); // read the HIGH/LOW status of pin
- □ digitalWrite(pinNumber, value); // force HIGH/LOW voltage
- □ analogWrite(pinNumber, value); // PWM for intermediate vals
- □ analogRead(pinNumber); // read analog pin through ADC

Physical Computing Helpers

- delay(ms); // delay for ms milliseconds
- millis(); // return total milliseconds since program start
- Serial.begin(baud); // set up serial communication to host
- Serial.print(val); // print on monitor (number, char, or string)
- Serial.println(val); // print with line feed
- random(min, max); // return random between min, max-1
- map(val, fromLo, fromHi, toLo, toHi); // interpolate to range
- constrain(val, lo, hi); // constrain value to a range

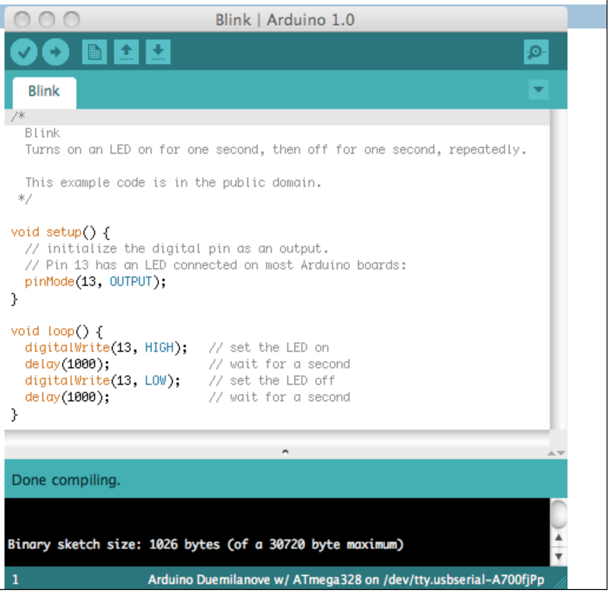
Digital Pins

- Each of the digital pins can be set to one of two values
  - High and Low (logic 1 (+5v) and logic 0 (0v))
  - digitalWrite(<pin-number>, <value>);
  - digitalWrite(13, HIGH);
    digitalWrite(13, 1);
  - digitalWrite(13, LOW);
    digitalWrite(13, 0);



Arduino Programming

Load Examples - Basics - Blink



```
/*
  Blink
  Turns on an LED on for one second, then off for one second, repeatedly.

  This example code is in the public domain.
 */

void setup() {
  // initialize the digital pin as an output.
  // Pin 13 has an LED connected on most Arduino boards:
  pinMode(13, OUTPUT);
}

void loop() {
  digitalWrite(13, HIGH);   // set the LED on
  delay(1000);              // wait for a second
  digitalWrite(13, LOW);    // set the LED off
  delay(1000);              // wait for a second
}
```

Done compiling.

```
Binary sketch size: 1026 bytes (of a 30720 byte maximum)
```

1 Arduino Duemilanove w/ ATmega328 on /dev/tty.usbserial-A700fjPp

Arduino SW system

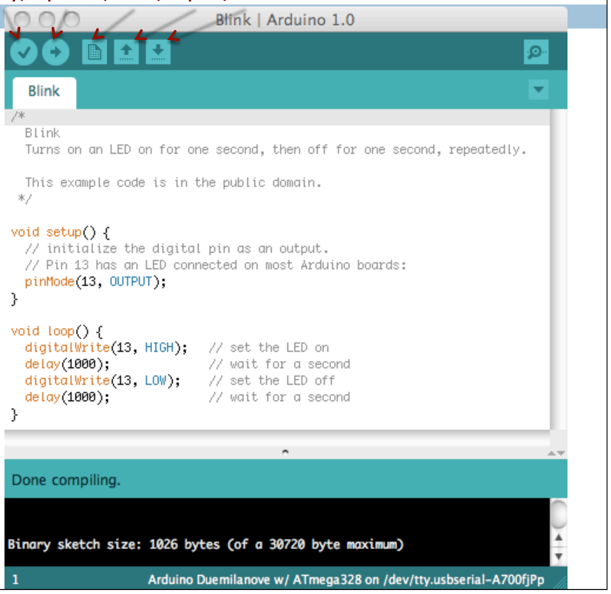
- Two required functions
  - void setup(){…} // runs once at init time
  - void loop(){…} // loops forever after init

Arduino Programming

Verify, Upload, New, Open, Save

Programming area

Notification area



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void loop() {
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  delay(1000);              // wait for a second
  digitalWrite(13, LOW);    // set the LED off
  delay(1000);              // wait for a second
}
```

Done compiling.

```
Binary sketch size: 1026 bytes (of a 30720 byte maximum)
```

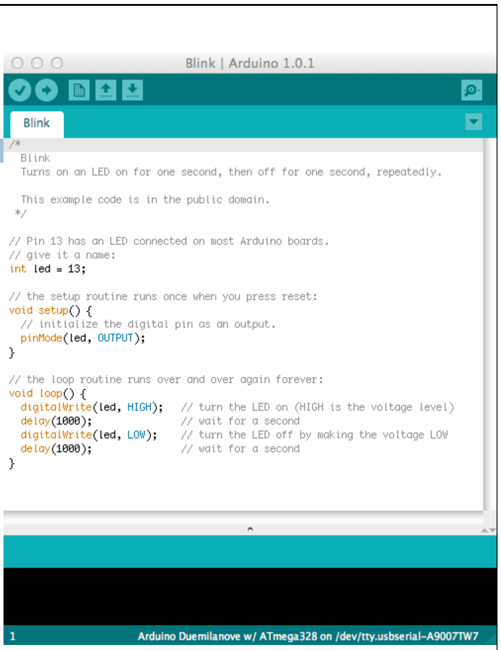
1 Arduino Duemilanove w/ ATmega328 on /dev/tty.usbserial-A700fjPp

Blink Example

```
int led = 13;

void setup() {
    pinMode(led, OUTPUT);
  }

void loop() {
     digitalWrite(led, HIGH);
     delay(1000);
     digitalWrite(led, LOW);
     delay(1000);
  }
```



```
/*
  Blink
  Turns on an LED on for one second, then off for one second, repeatedly.

  This example code is in the public domain.
 */

// Pin 13 has an LED connected on most Arduino boards.
// give it a name:
int led = 13;

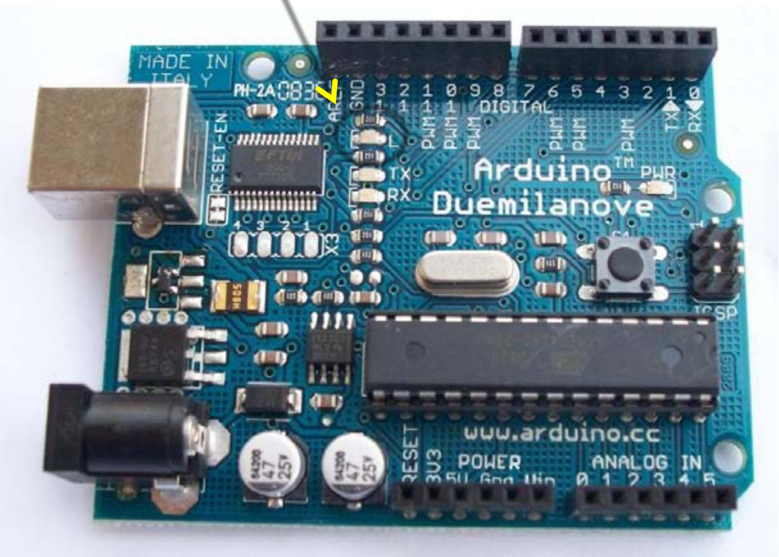
// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led, OUTPUT);
}

// the loop routine runs over and over again forever:
void loop() {
  digitalWrite(led, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(1000);               // wait for a second
  digitalWrite(led, LOW);    // turn the LED off by making the voltage LOW
  delay(1000);               // wait for a second
}
```

1 Arduino Duemilanove w/ ATmega328 on /dev/tty.usbserial-A9007TW7

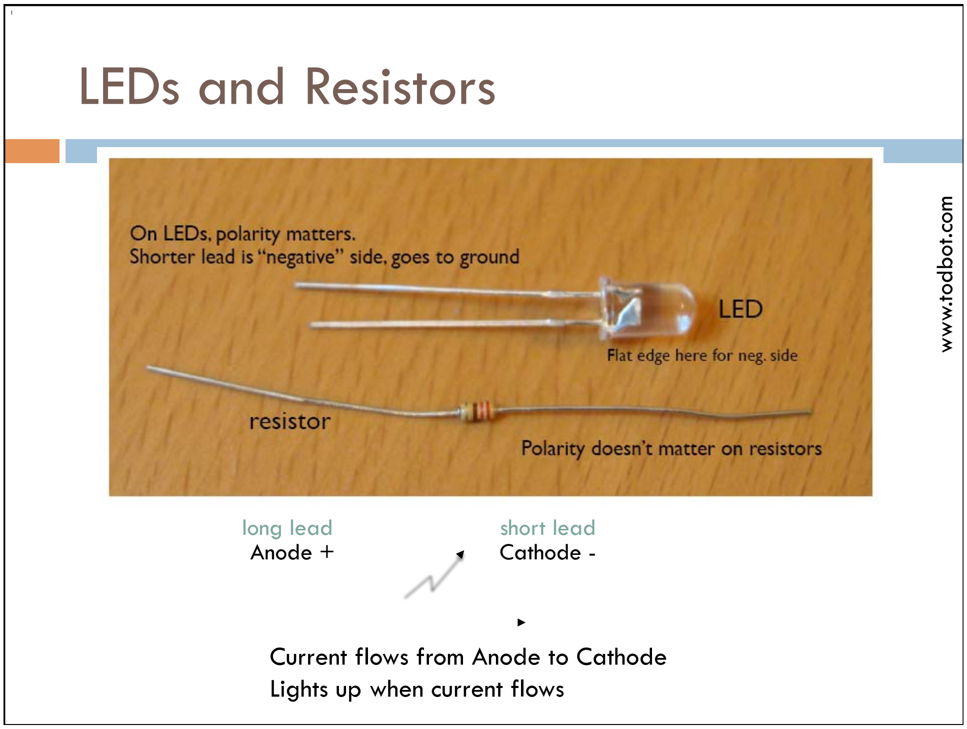
Arduino

LED already connected to pin 13



Upload Blink to your Arduino

- Load Basics -> Blink into IDE
- Make sure you select the correct board
  - Tools -> Board -> (Uno or Duemilanove)
- Make sure you select the correct serial port
  - Not the bluetooth ports…
- Click on the upload button
  - Watch for blinky lights during upload



LEDs and Resistors

On LEDs, polarity matters.
Shorter lead is "negative" side, goes to ground

LED

Flat edge here for neg. side

resistor

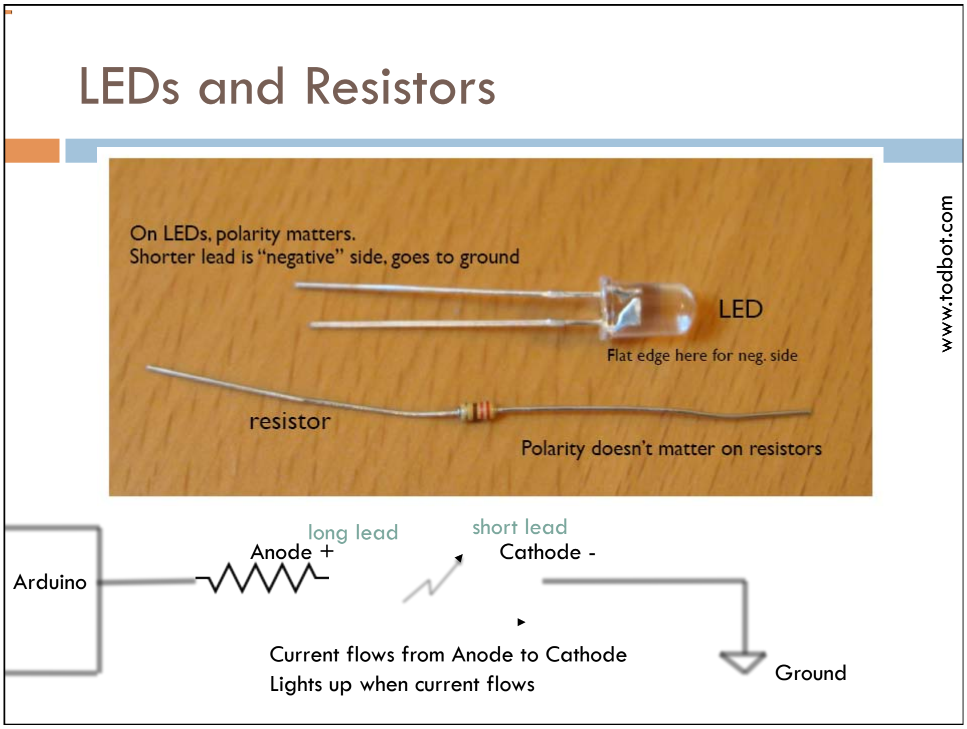
Polarity doesn't matter on resistors

www.todbot.com

long lead
Anode +

short lead
Cathode -

Current flows from Anode to Cathode
Lights up when current flows



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Flat edge here for neg. side

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Arduino

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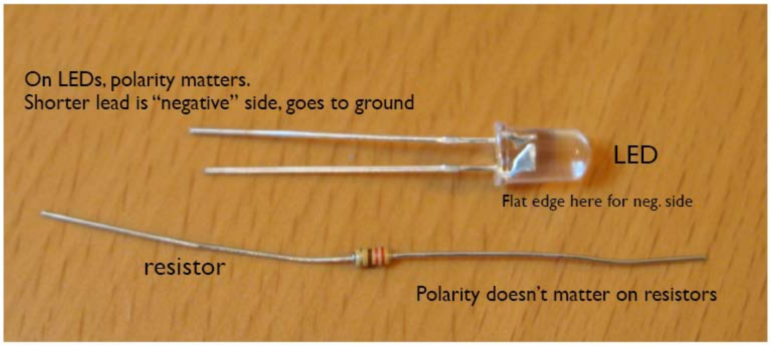
Current flows from Anode to Cathode
Lights up when current flows

Ground

LEDs and Resistors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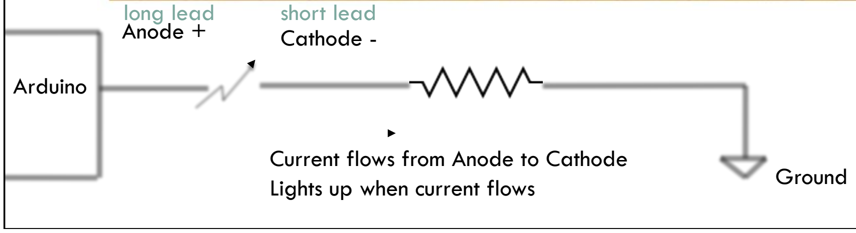


Current flows from Anode to Cathode
Lights up when current flows

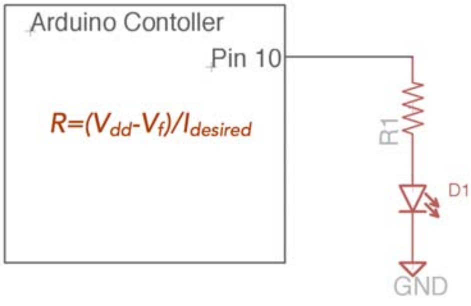
Current Limiting Resistor

- Diodes have a *"forward voltage" or "diode drop"*
  - *Typically V_f is around 0.7v for a diode, and 1.5v to 3.0v for an LED*
- Diodes also have a current limit
  - *Typically 20mA for an LED*
  - *If you don't limit the current, they'll burn out*

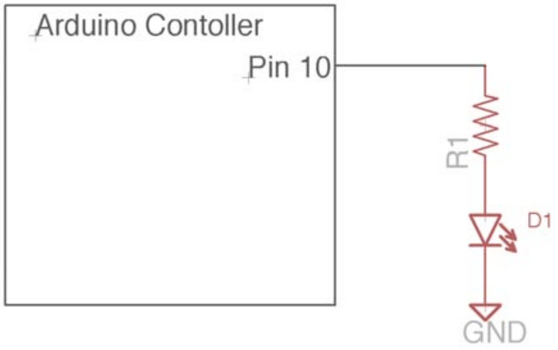
Current-Limiting Resistor

Ohm's Law: $V = IR$

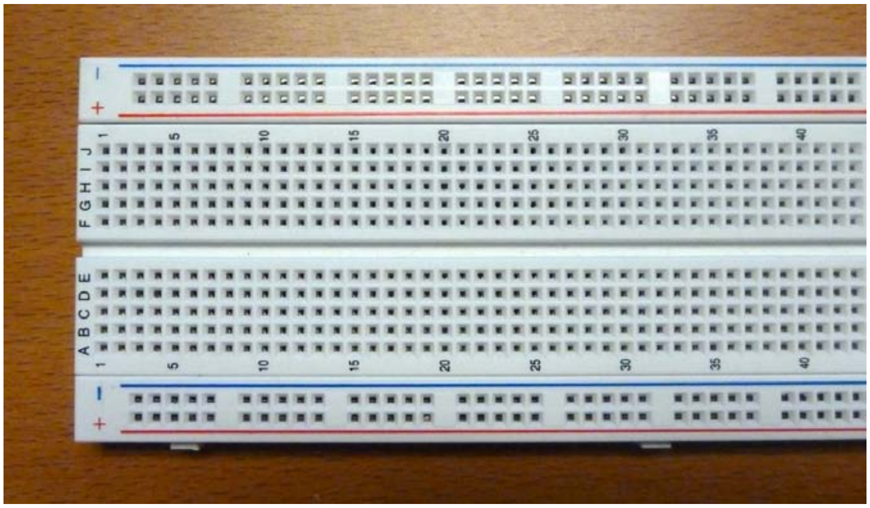
- Assume Pin10 can supply 5v
- Assume LED V_f *is 2.0v*
- *(5v - 2v) = 3v remaining for R1*
- *We want 20mA*
- *R = V/I = 3v / .020A*
- *R = 150 Ω*
- *In practice,*
  220 Ω - 470 Ω will work



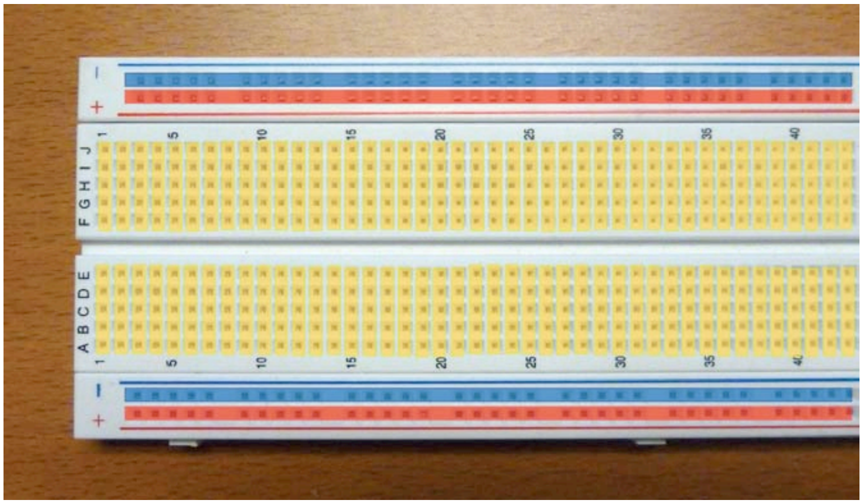
Wiring an external LED



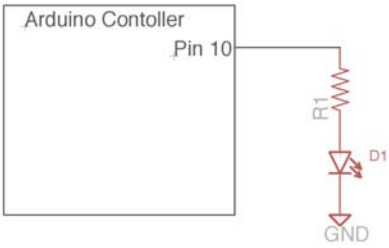
Solderless Breadboad

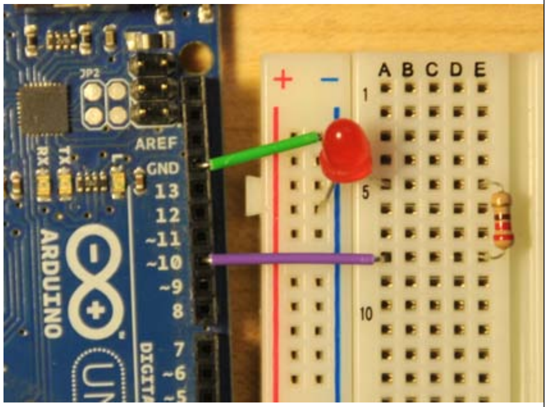


Solderless Breadboard

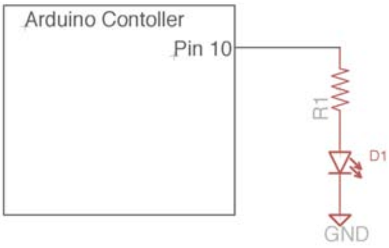


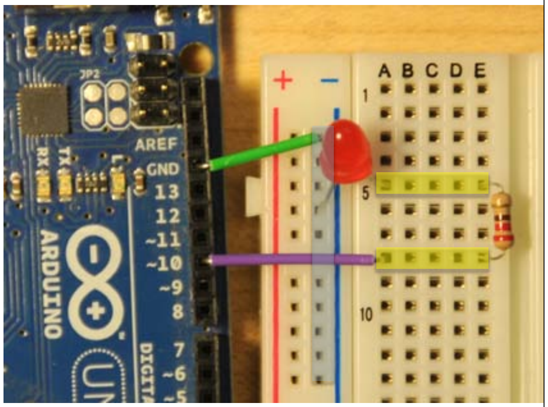
Wiring up an External LED





Wiring up an External LED

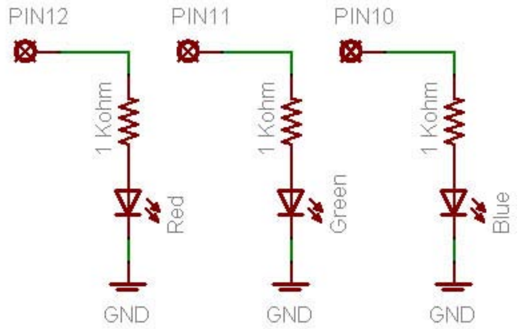




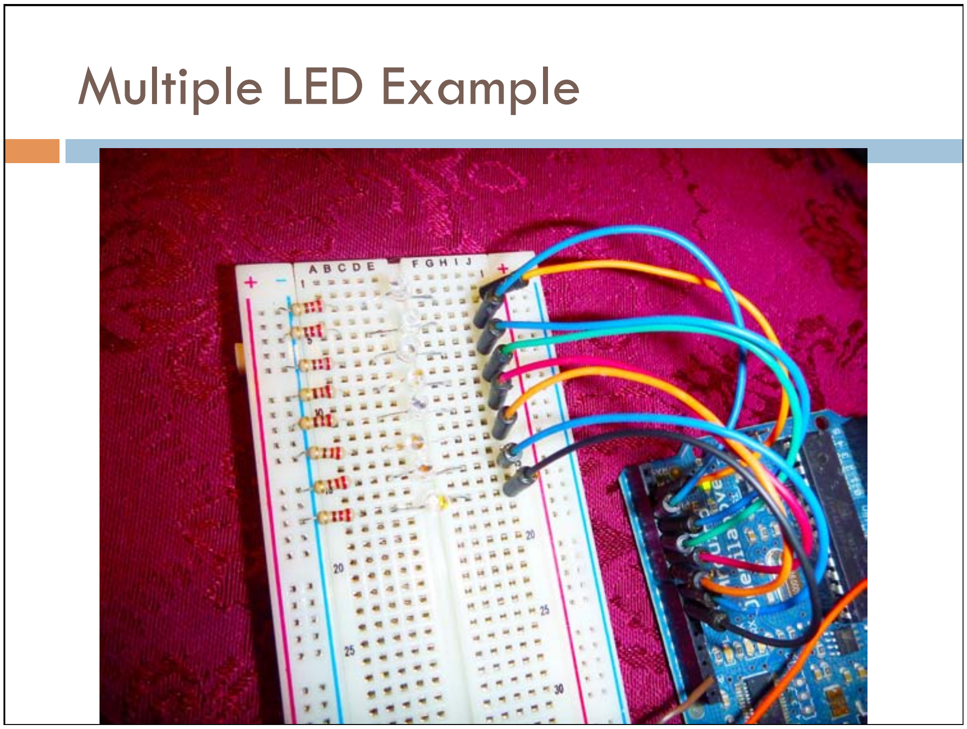
Blink Modifications

- Change numbers in the code
  - Then "upload" to Arduino – watch for blinky lights
- Change so that blink is on for 500msec and off for 100msec
  - What happens?
- Change so that blink is on for 50msec and off for 50msec
  - What happens?
- Change so that blink is on for 10ms and off for 10ms
  - What happens?

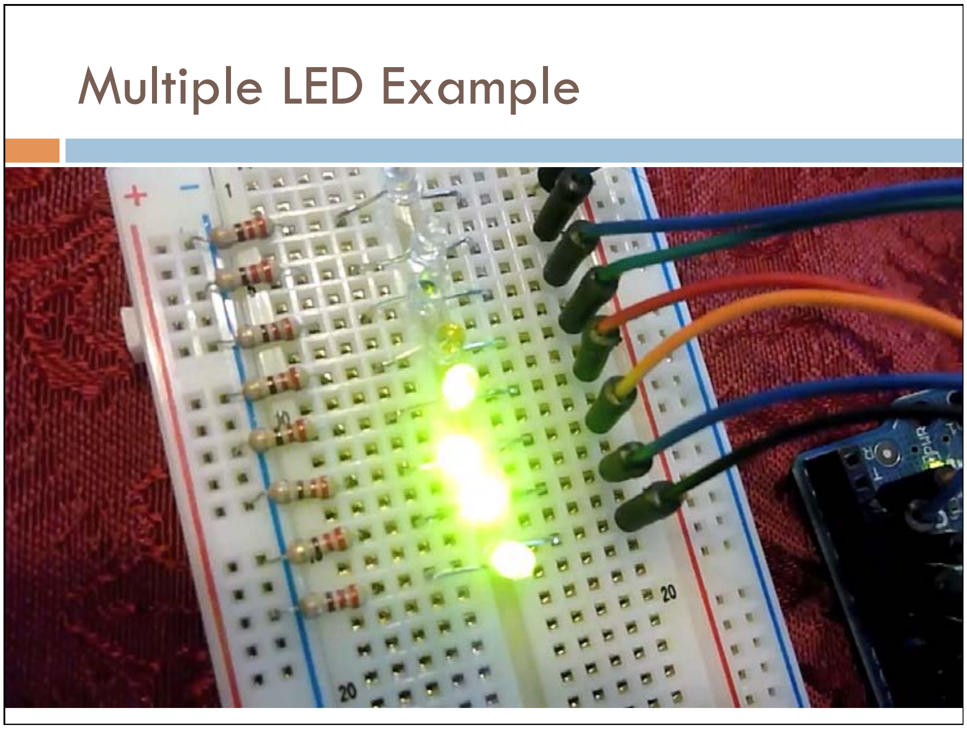
Aside: Multiple LEDs



Each LED needs its own resistor! You can't share…



Multiple LED Example

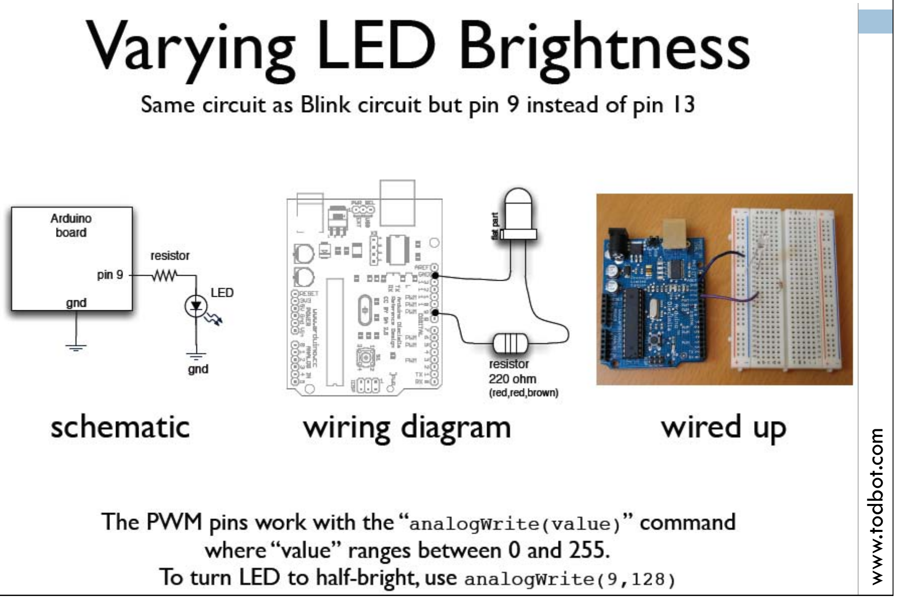


Multiple LED Example

We just made LEDs blink…Big Deal?

- Most actuators are switched on and off with a digital output
  - The digitalWrite(pin,value); function is the software command that lets you control almost anything
- LEDs are easy!
  - Motors, servos, etc. are a little trickier, but not much
  - More on that later…
- Arduino has 14 digital pins (inputs or outputs)
  - can easily add more with external helper chips
  - More on that later…

Moving on…



Varying LED Brightness

Same circuit as Blink circuit but pin 9 instead of pin 13

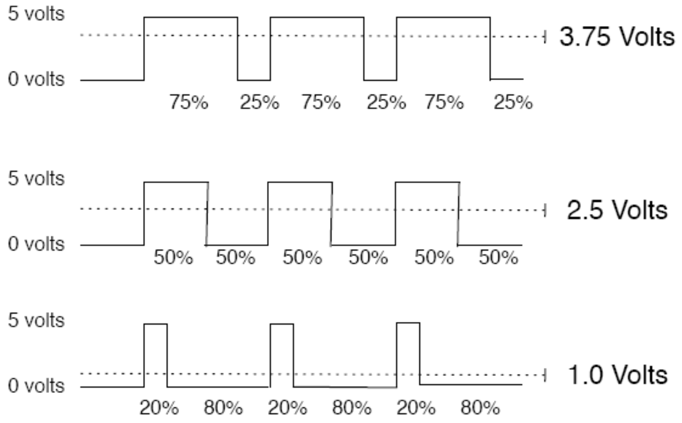
schematic	wiring diagram	wired up

The PWM pins work with the "`analogWrite(value)`" command where "value" ranges between 0 and 255.
To turn LED to half-bright, use `analogWrite(9,128)`

PWM

Output voltage is averaged from on *vs.* off time

output_voltage = (on_time / off_time) * max_voltage



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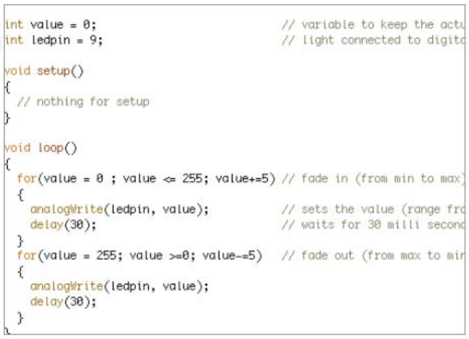
load Examples – Analog - Fading

Pulse Width Modulation

- analogWrite(pin, value);
  - value can be 0 to 255
  - Must be one of the “PWM pins” : pins 3, 5, 6, 9, 10, 11

note →



```
int value = 0;                          // variable to keep the actu
int ledpin = 9;                         // light connected to digitc

void setup()
{
  // nothing for setup
}

void loop()
{
  for(value = 0 ; value <= 255; value+=5) // fade in (from min to max)
  {
    analogWrite(ledpin, value);           // sets the value (range frc
    delay(30);                            // waits for 30 milli second
  }
  for(value = 255; value >=0; value-=5)   // fade out (from max to mir
  {
    analogWrite(ledpin, value);
    delay(30);
  }
```

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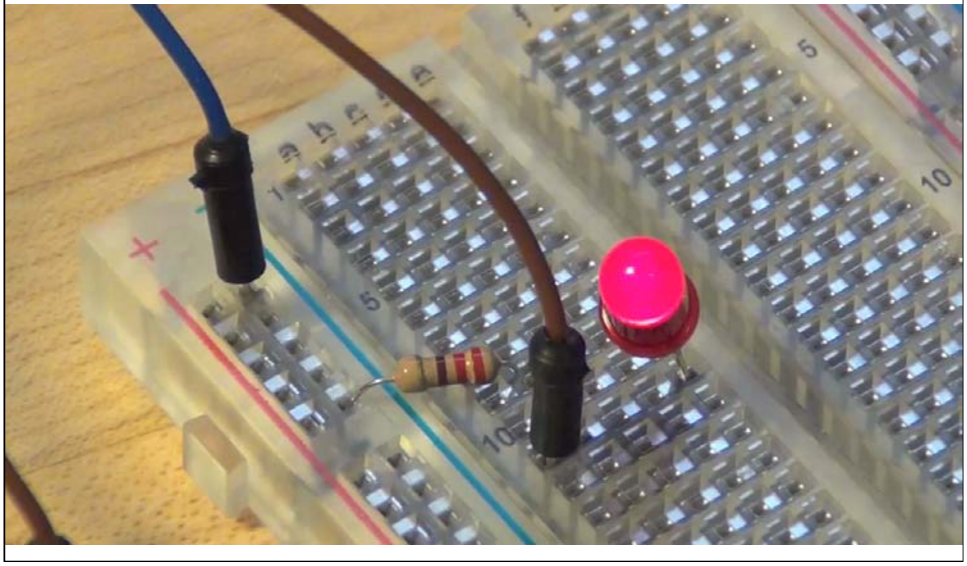
load Examples – Analog - Fading

Fading Program

```
int ledPin = 9;    // LED connected to digital pin 9
void setup()  {
     // nothing happens in setup (Why not?)
    // Answer: Pins default to being OUTPUT. You must define any that you want to use
    // as INPUT, but if you are using them as OUTPUT you can just assume the default.
    // Typically, though, it's good practice to define the OUTPUT pins anyway…
}
void loop()  {
    // fade in from min to max in increments of 5 points:
    for (int fadeValue = 0 ; fadeValue <= 255; fadeValue +=5) {
     analogWrite(ledPin, fadeValue);  // sets the value (range from 0 to 255):
    delay(30);                        // wait for 30 milliseconds between brightness steps
    }

     // fade out from max to min in increments of 5 points:
     for (int fadeValue = 255 ; fadeValue >= 0; fadeValue -=5) {
    analogWrite(ledPin, fadeValue); // sets the value (range from 0 to 255):
    delay(30);                      // wait for 30 milliseconds between dimming steps
     }
}
```

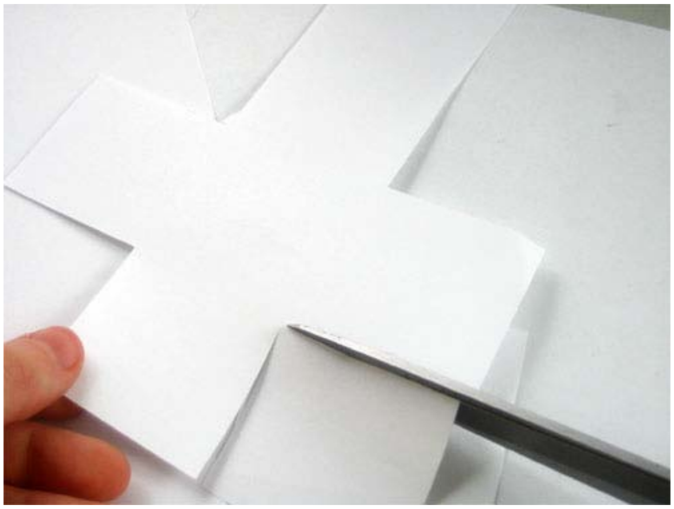
Fading Example



End of Activity One

- There are some additional slides that you can look at later
- There's a summary at the end of the handout

Add a diffuser

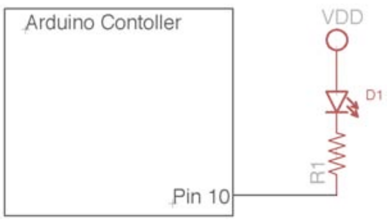


Add a diffuser

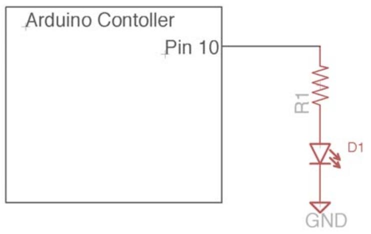
video…. ladyada.net

- □ http://www.ladyada.net/learn/arduino/lesson3.html

Source vs. Sink for current



Sink means pull to ground
LED is on when Pin 10 is LOW

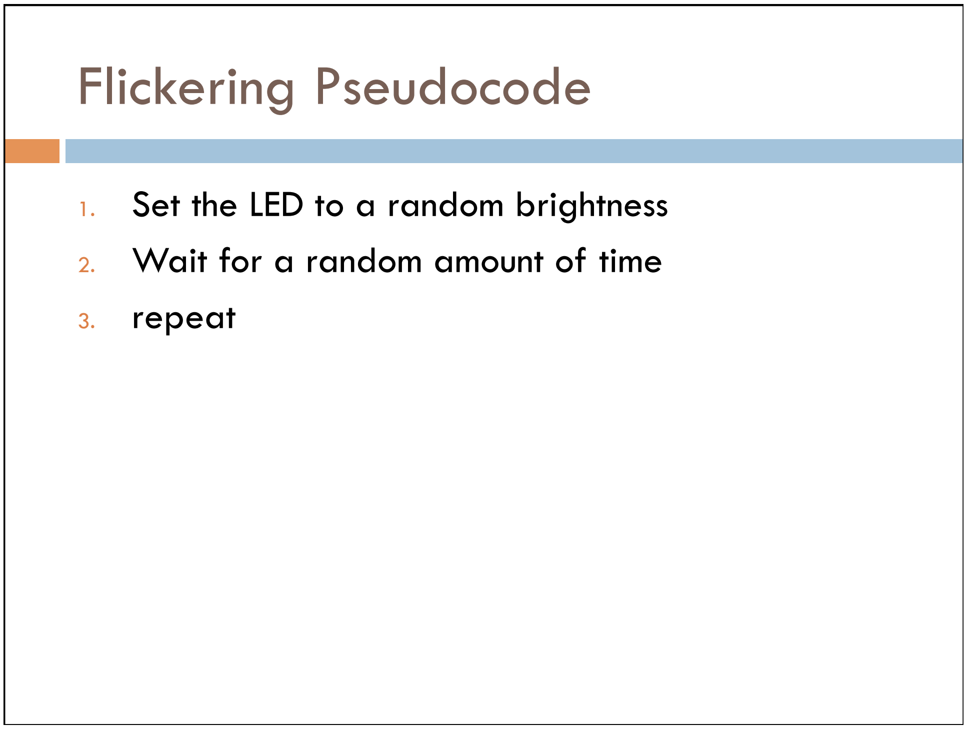


Source means pull to Vdd
LED is on when Pin 10 is HIGH

- Arduino pins: source/sink a max of 40mA/pin
- Also 250mA total for ALL pins

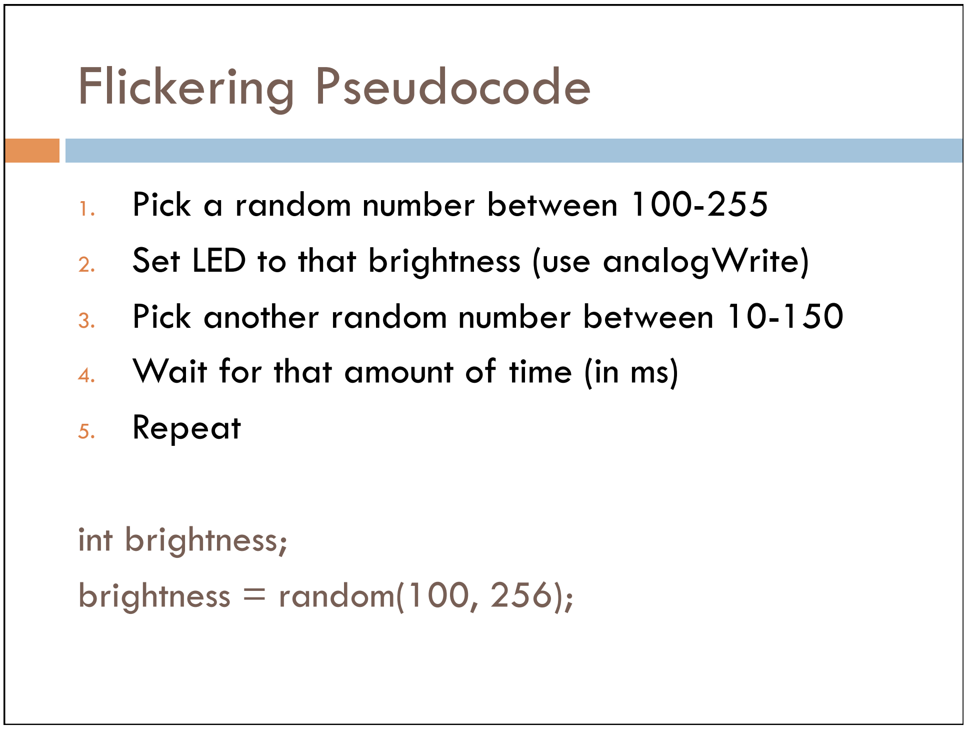
Random Brightness

- Write a program to make the LED flicker like a flame
  - Choose a random intensity
  - For a random amount of time
- Use analogWrite(ledPin, val) to change brightness
- Main loop repeats itself forever…
  - Set the value of the brightness to a random value
  - Wait for a random amount of time
  - repeat
- The effect looks like flickering…



Flickering Pseudocode

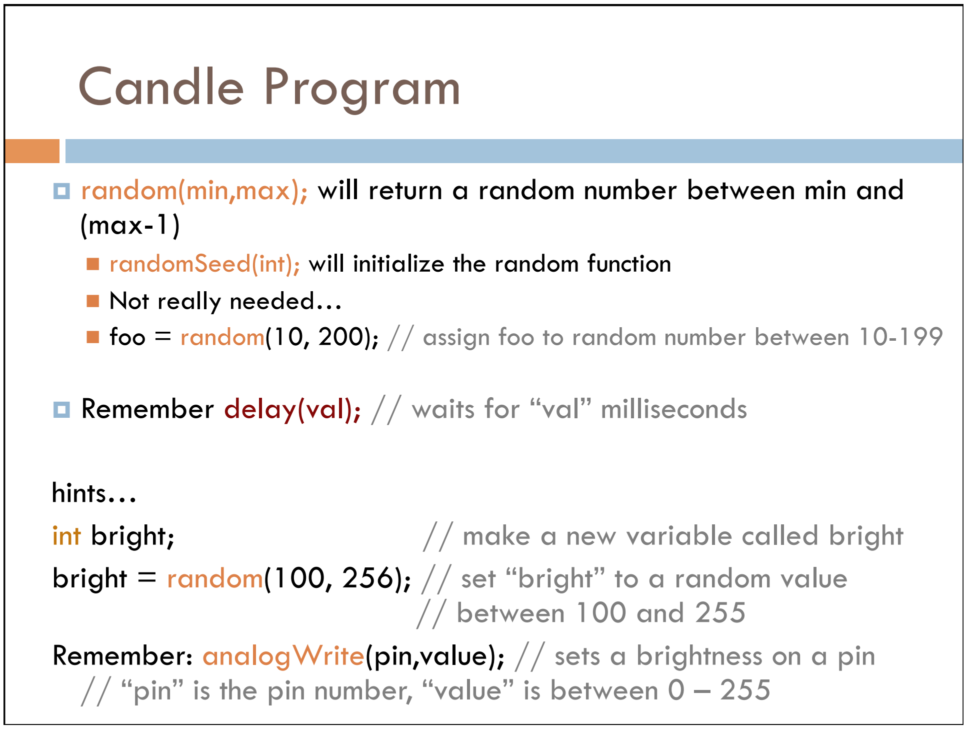
1. Set the LED to a random brightness
2. Wait for a random amount of time
3. repeat



Flickering Pseudocode

1. Pick a random number between 100-255
2. Set LED to that brightness (use analogWrite)
3. Pick another random number between 10-150
4. Wait for that amount of time (in ms)
5. Repeat

```
int brightness;
brightness = random(100, 256);
```



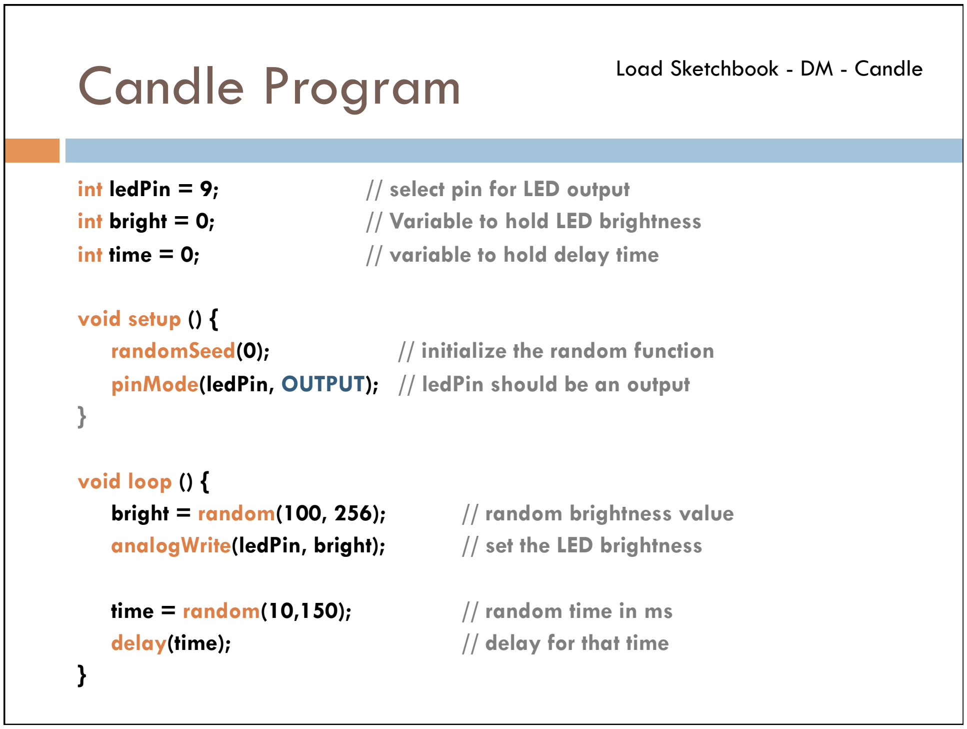
Candle Program

- random(min,max); will return a random number between min and (max-1)
  - randomSeed(int); will initialize the random function
  - Not really needed…
  - foo = random(10, 200); // assign foo to random number between 10-199
- Remember delay(val); // waits for "val" milliseconds

hints…

```
int bright;                      // make a new variable called bright
bright = random(100, 256); // set "bright" to a random value
                                 // between 100 and 255
```

Remember: analogWrite(pin,value); // sets a brightness on a pin
   // "pin" is the pin number, "value" is between 0 – 255



Candle Program

Load Sketchbook - DM - Candle

```
int ledPin = 9;                 // select pin for LED output
int bright = 0;                 // Variable to hold LED brightness
int time = 0;                   // variable to hold delay time

void setup () {
    randomSeed(0);              // initialize the random function
    pinMode(ledPin, OUTPUT);    // ledPin should be an output
}

void loop () {
    bright = random(100, 256);        // random brightness value
    analogWrite(ledPin, bright);      // set the LED brightness

    time = random(10,150);            // random time in ms
    delay(time);                      // delay for that time
}
```

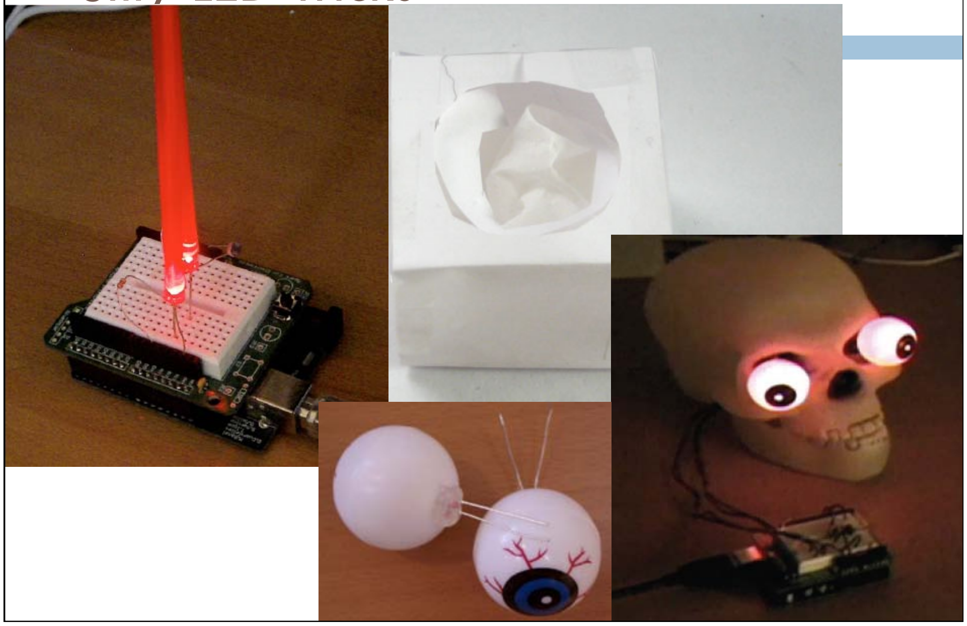
Load Sketchbook - CandleSmall

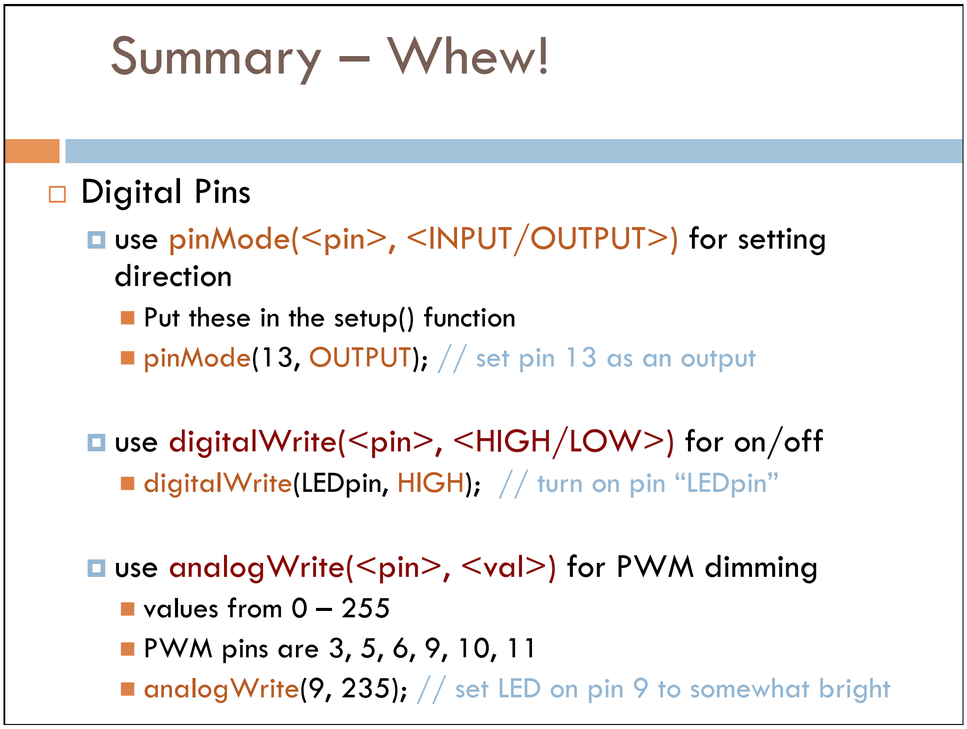
Candle Program (smaller)

```
int ledPin = 9;               // select pin for LED output
void setup () {
   pinMode(ledPin, OUTPUT);   // ledPin should be output
}

void loop () {
   analogWrite(ledPin, random(100, 256));  // LED brightness
   delay(random(10,150)); // delay for random time
}
```

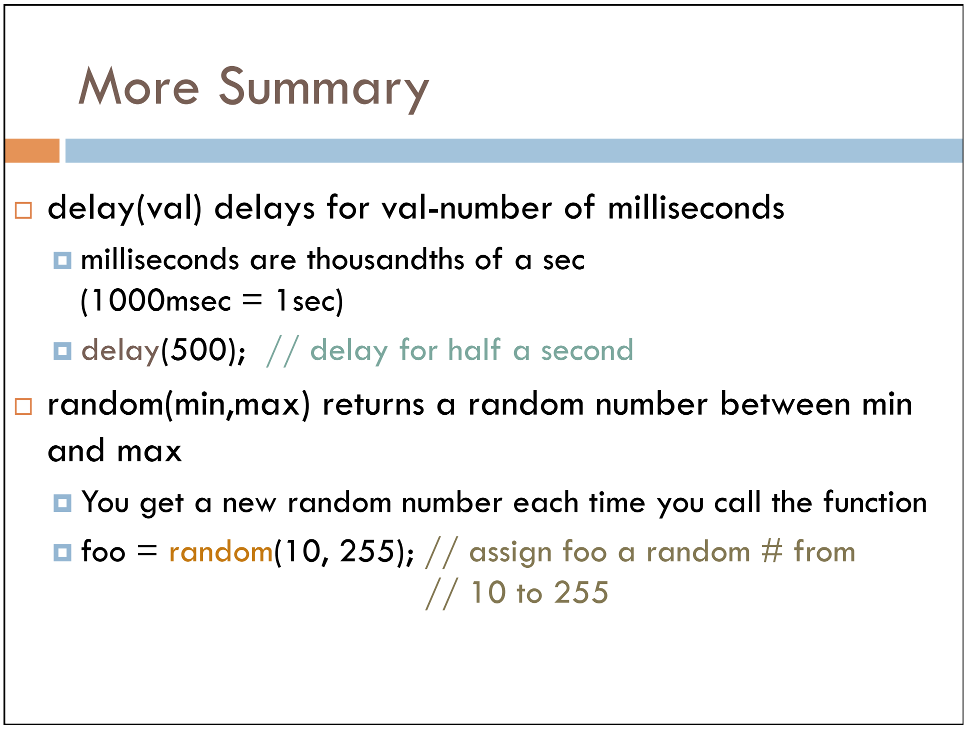
Silly LED Tricks





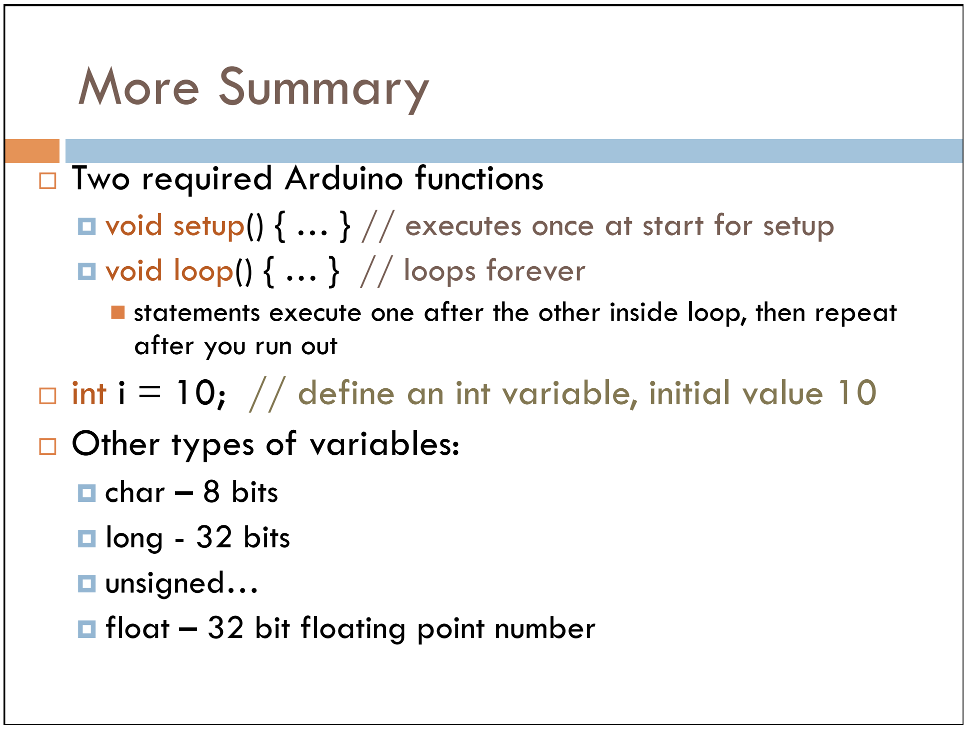
Summary – Whew!

- Digital Pins
  - use pinMode(<pin>, <INPUT/OUTPUT>) for setting direction
    - Put these in the setup() function
    - pinMode(13, OUTPUT); // set pin 13 as an output
  - use digitalWrite(<pin>, <HIGH/LOW>) for on/off
    - digitalWrite(LEDpin, HIGH); // turn on pin “LEDpin”
  - use analogWrite(<pin>, <val>) for PWM dimming
    - values from 0 – 255
    - PWM pins are 3, 5, 6, 9, 10, 11
    - analogWrite(9, 235); // set LED on pin 9 to somewhat bright



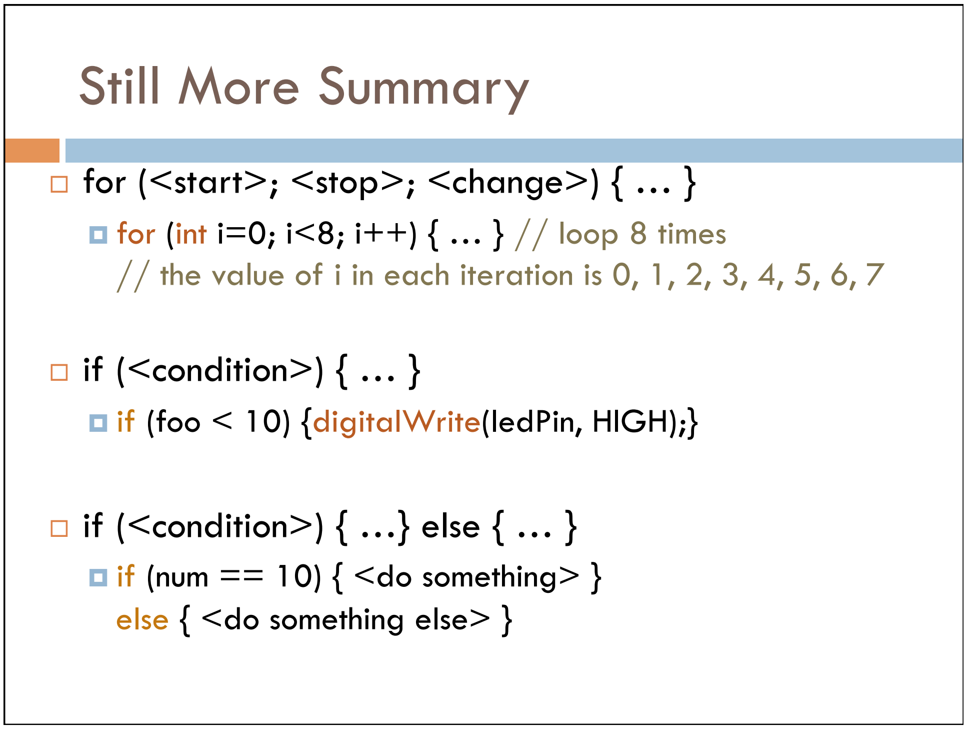
More Summary

- delay(val) delays for val-number of milliseconds
  - milliseconds are thousandths of a sec (1000msec = 1sec)
  - delay(500); // delay for half a second
- random(min,max) returns a random number between min and max
  - You get a new random number each time you call the function
  - foo = random(10, 255); // assign foo a random # from
    // 10 to 255



More Summary

- Two required Arduino functions
  - void setup() { … } // executes once at start for setup
  - void loop() { … } // loops forever
    - statements execute one after the other inside loop, then repeat after you run out
- int i = 10; // define an int variable, initial value 10
- Other types of variables:
  - char – 8 bits
  - long - 32 bits
  - unsigned…
  - float – 32 bit floating point number

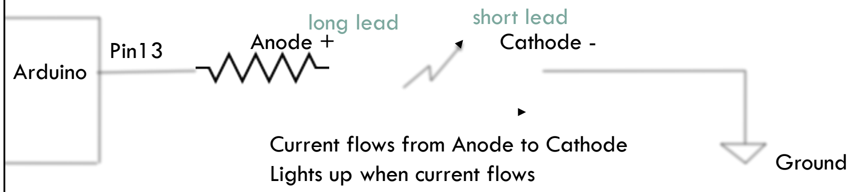


Still More Summary

- for (<start>; <stop>; <change>) { … }
  - for (int i=0; i<8; i++) { … } // loop 8 times
    // the value of i in each iteration is 0, 1, 2, 3, 4, 5, 6, 7
- if (<condition>) { … }
  - if (foo < 10) {digitalWrite(ledPin, HIGH);}
- if (<condition>) { …} else { … }
  - if (num == 10) { <do something> }
    else { <do something else> }

Last Summary (for now)

- LEDs – turn on when current flows from anode to cathode
  - Always use a current-limiting resistor!
  - Remember your resistor color codes
  - 220-470 ohm are good, general-purpose values for LEDs
  - Drive from Arduino on digital pins
  - Use PWM pins if you want to use analogWrite for dimming



Arduino

Pin13

long lead

Anode +

short lead

Cathode -

Current flows from Anode to Cathode

Lights up when current flows

Ground

Resources

- http://arduino.cc/en/Tutorial/HomePage
- http://www.ladyada.net/learn/arduino/index.html
- http://todbot.com/blog/bionicarduino/
- http://todbot.com/blog/spookyarduino/
- http://sheepdogguides.com/arduino/aht0led.htm

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