Spooky Projects

Introduction to Microcontrollers with Arduino

Class 1

7 Oct 2006 - machineproject - Tod E. Kurt

Everyone's had a little programming experience, right?
Who's had any electrical experience?

What's for Today

- Introduction to Arduino
- Building an LED flashlight
- Making some blinky LED eyes

Class Kit

What's in your goodie bag

Class Kit Manifest

- Arduino NG USB board
- Arduino ProtoShield
- Solderless breadboard
- USB cable
- RC servo
- piezo buzzer
- 6m hookup wire in ghastly colors
- potentiometer with knob
- R,G,B and mystery LEDs
- two push switches
- 9V battery and connector
- 220, 330, 10k, and 1M resistors
- light sensitive resistor
- 5.1v zener diode
- square of velcro
- scary eyeballs

And other bits as we progress
Ignore most of the kit for now, just use Arduino board and USB cable
Complete kit manifest with part numbers will be online

A Word on Safety

- Electronics are toxic to you
  - Lead in some of the parts
  - Wash up afterwards
- You are toxic to electronics
  - Static-sensitive: don't shuffle your feet
  - Wires only bend so much

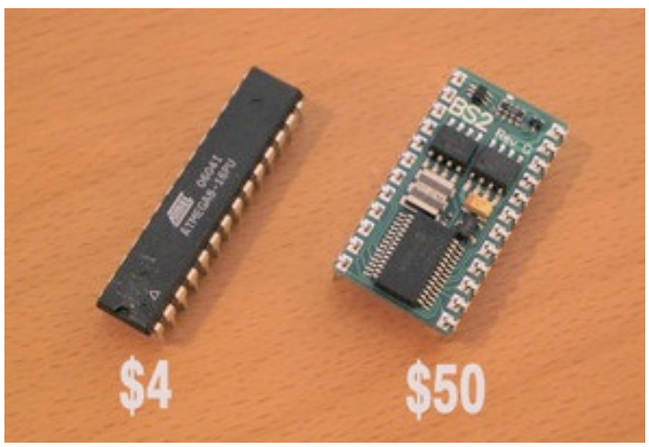
What is Arduino?

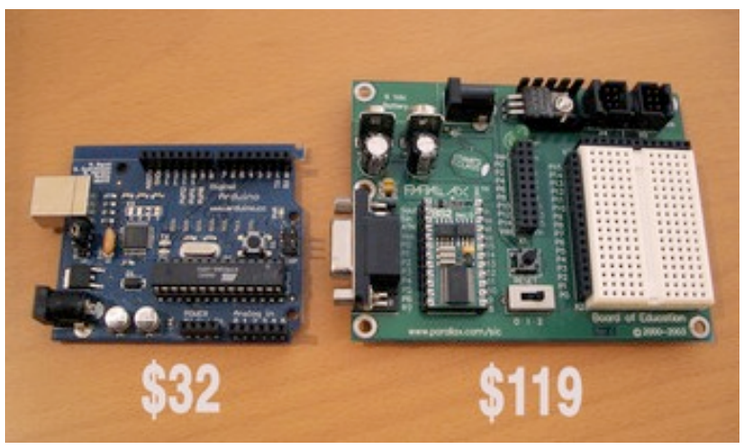
- Open Source Physical Computing Platform
  - open source: free to inspect & modify
  - physical computing. er, what? ubiquitous computing, pervasive computing, ambient intelligence, calm computing, everyware, spimes, blogjects, smart objects...
- A physical board, a programming environment, a development philosophy
- Tiny computer you can program
  - Completely stand-alone, talks to other devices

Physical computing as invisible computing
Can run off a battery
Can talk to other computers, cell phones, etc.

What is Arduino?

- Based on AVR-GCC, avr-libc, AVRlib and Processing (all open source projects)
- Very similar to Basic Stamp (if you know it)
  - but cheaper, faster, & open
- Uses AVR ATmega8 microcontroller chip

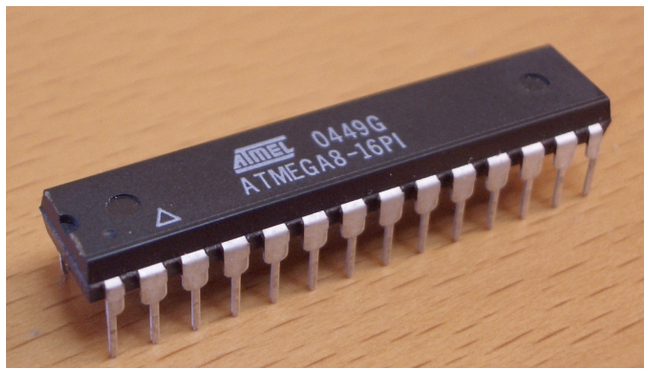




Basic Stamp uses PIC microcontroller chip.
PICs and AVRs are very comparable, one's not necessarily better than the other
AVRs are a little better if you're using a language like C (stack-based)
Don't need to worry about the chip particulars for now

What is Arduino?

- Why not just use a bare AVR ATmega8 chip?



- Arduino is also a standardized "bootloader"
  - A tiny program that loads other programs
  - It's alive during first 5 seconds

A bootloader is akin to an BIOS on a real computer. It handles the startup of the chip
After 5 seconds, your program runs
Don't need special programmer board with a bootloader
Arduino can work with other AVR chips, some are smaller than your fingernail, cost ~ 40 cents

What is Arduino?

- Capabilities
  - 8 kBytes of Flash program memory
  - 1 kByte of RAM
  - 12 MHz (Apple II: 1 MHz)
  - Inputs and Outputs
    - 13 digital input/output pins
    - 5 analog input pins

Digital I/O can read switches and buttons, control LEDs and motors
Analog input can read knobs or other varying sensors
Analog output can be done with PWM

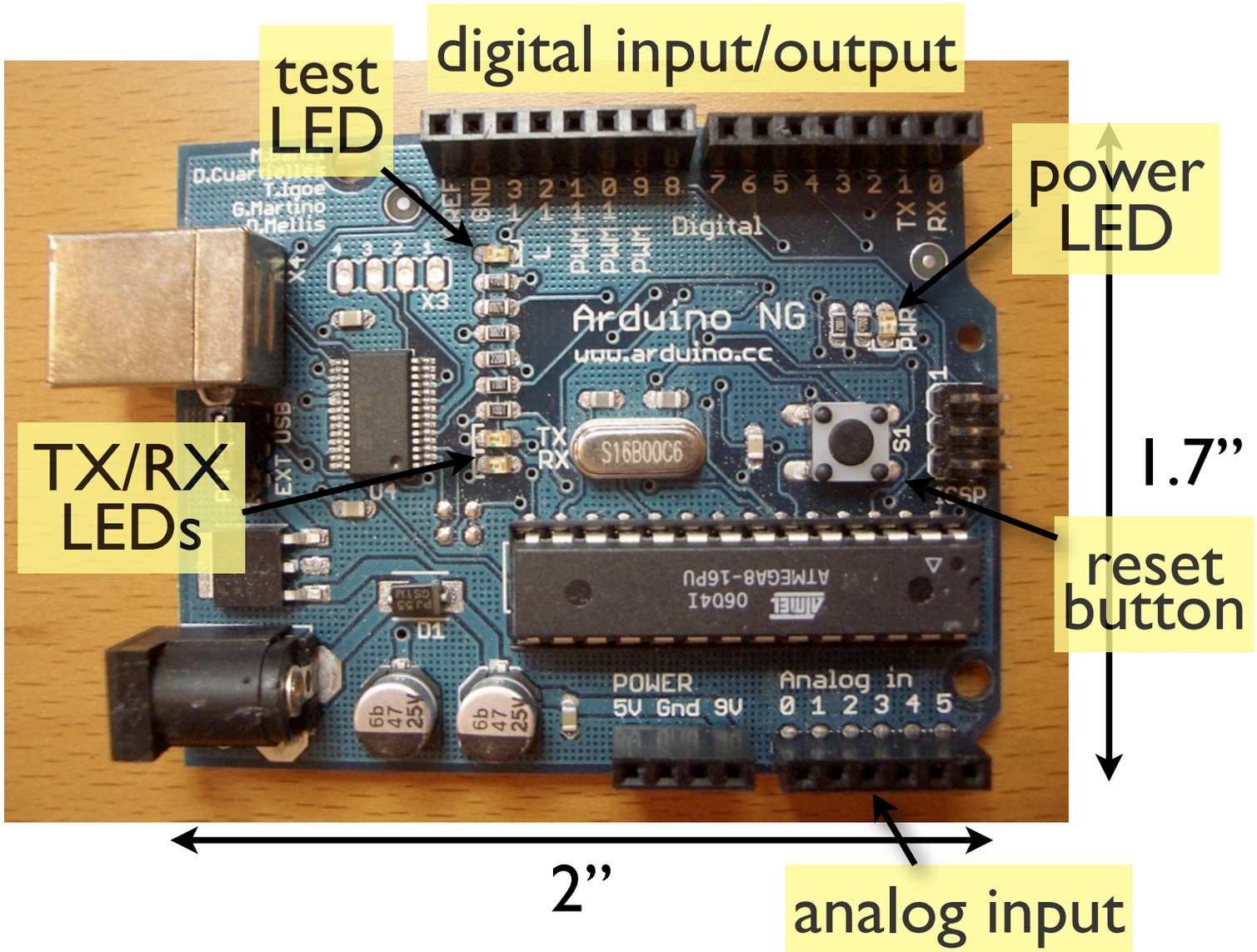
What is Arduino?

But how do you program it?

- Write programs on your PC
- Download them into the Arduino board
- Arduino board can then be used by itself

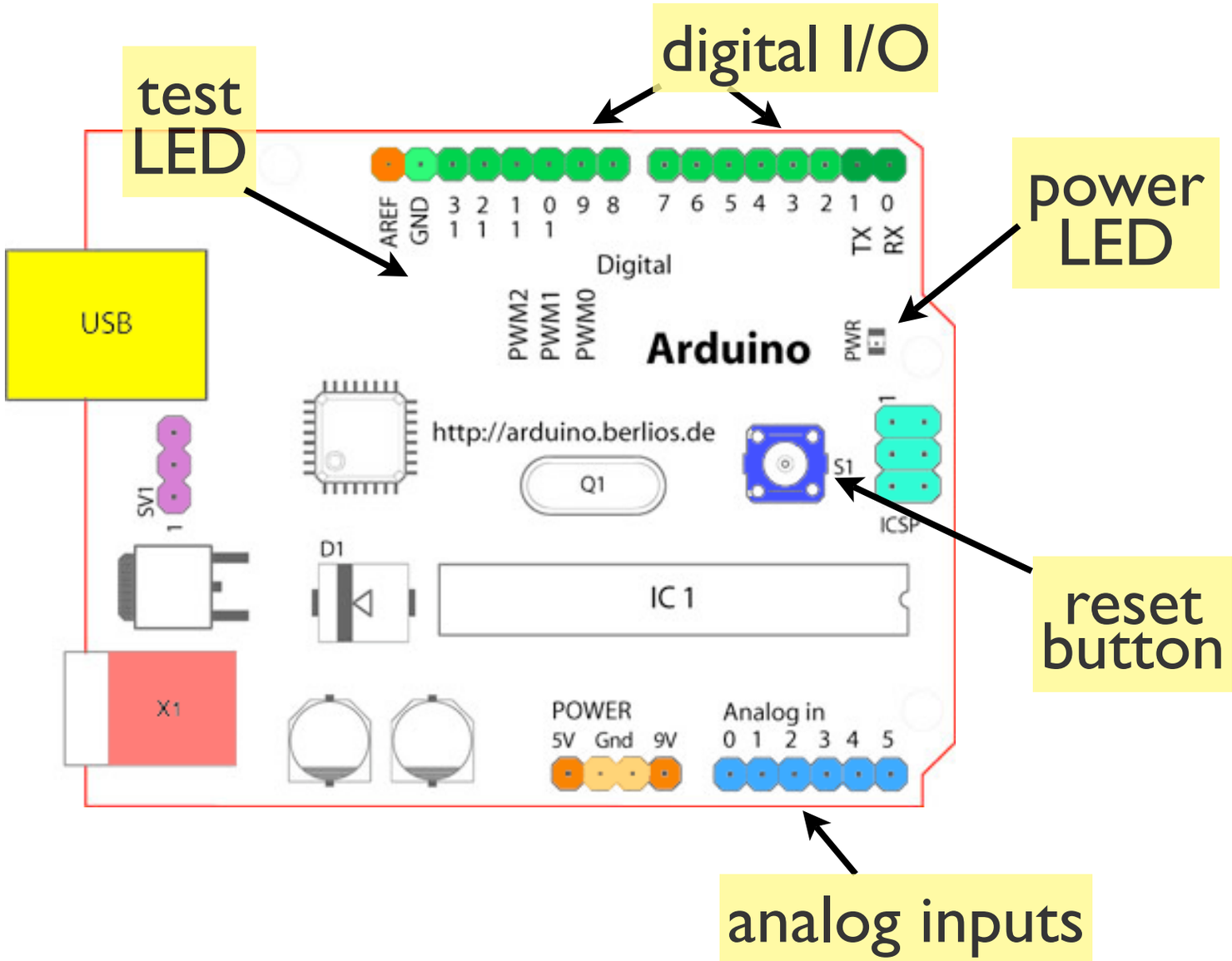
No keyboard, mouse or display
Your PC becomes the “head”

Arduino Board



Also: USB input, power input, ICSP programming header

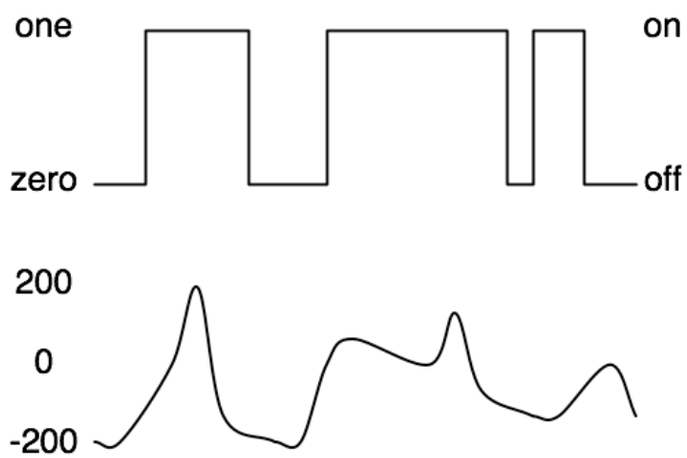
Arduino Board



Diagrammatic version, to simplify
But of a slightly older version of the board

Digital? Analog?

- Digital – only has two values: on/off
- Analog – has many (infinite) values



- Computers don't really do analog
- So they fake it, with *quantization*

Quantization = breaking up the analog range into bins. The number of bins is the resolution.
More bins = higher accuracy, but is more complex
Digital can be thought of as only two bins.

Arduino Software

compile (*verify*)

upload to board

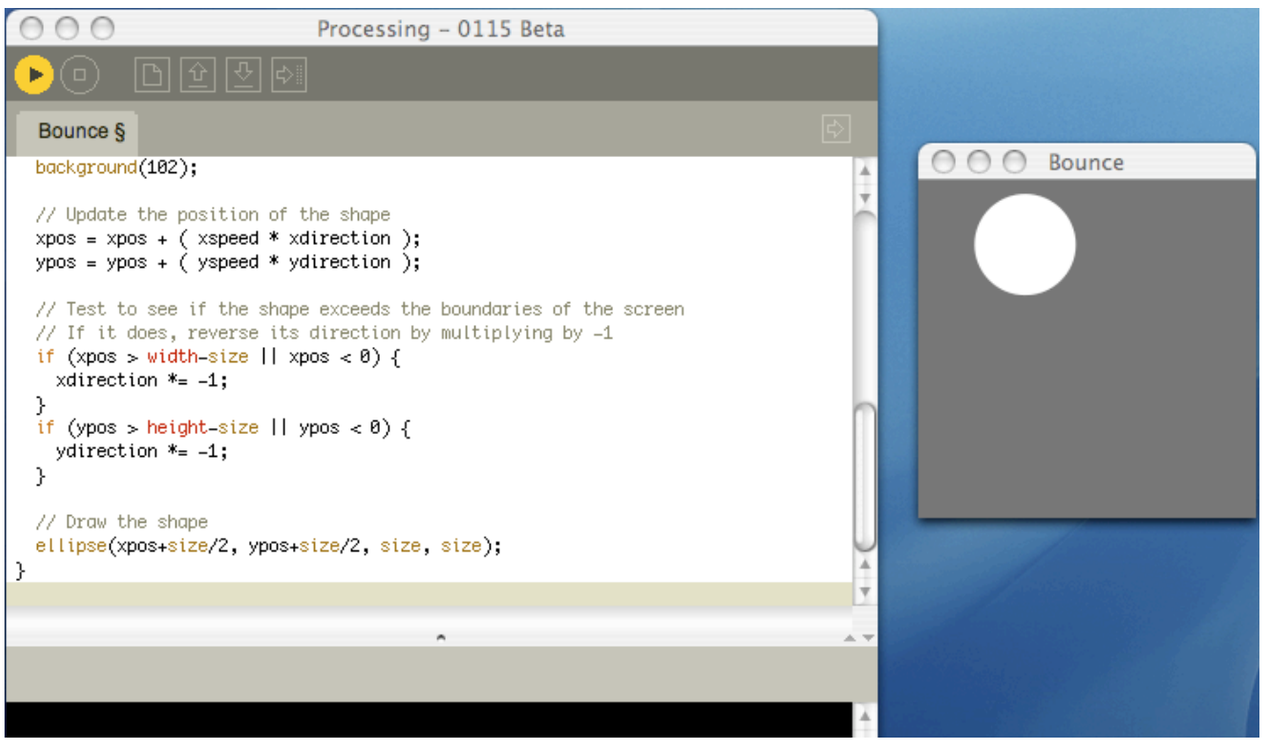
status area

That's the full code for blinking an LED, btw.
Arduino defines several useful functions like digitalWrite() and delay(). more on that later
Processing and Wiring not needed

Arduino & Processing

http://processing.org/

build generative art or other applets easily
not needed for Arduino, but can work with it



Arduino has essentially the same GUI as Processing
Easier than Arduino, since all software
Though similar UI and philosophy, Arduino is a different language
We'll use Processing later in the class to let the computer control Arduino & vice-versa

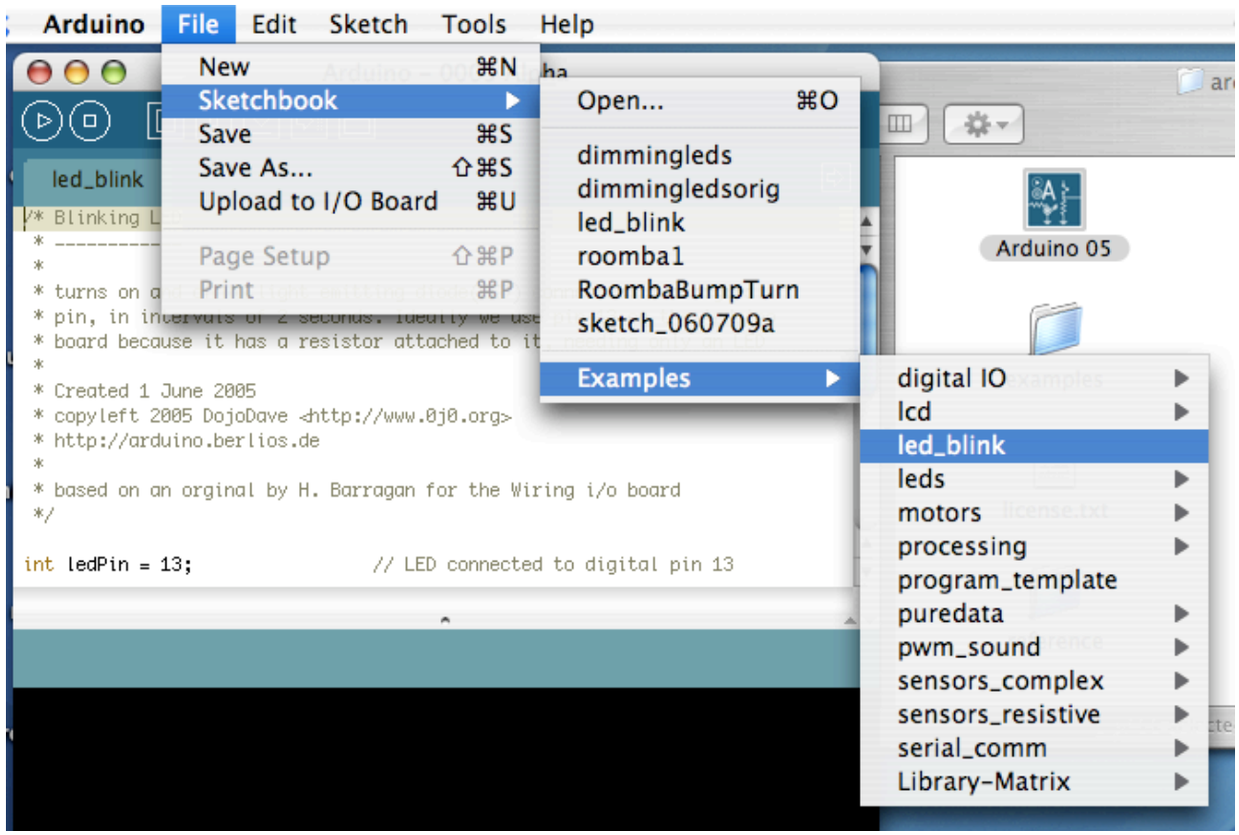
Installing Arduino

- Download software: http://arduino.cc/
  - Mac OS X PPC or Intel (must pick)
  - Windows 2000/XP
- Install drivers
  - In “drivers” folder, pick appropriate one
  - Windows: unzip driver, plug in board, setup
  - “macosx-setup-command” for Mac folk
- Reboot

Different Arduino downloads for each operating system
Different drivers for each OS too
“macosx-setup-command” must be run before reboot,
but, it will go away in next version

Using Arduino

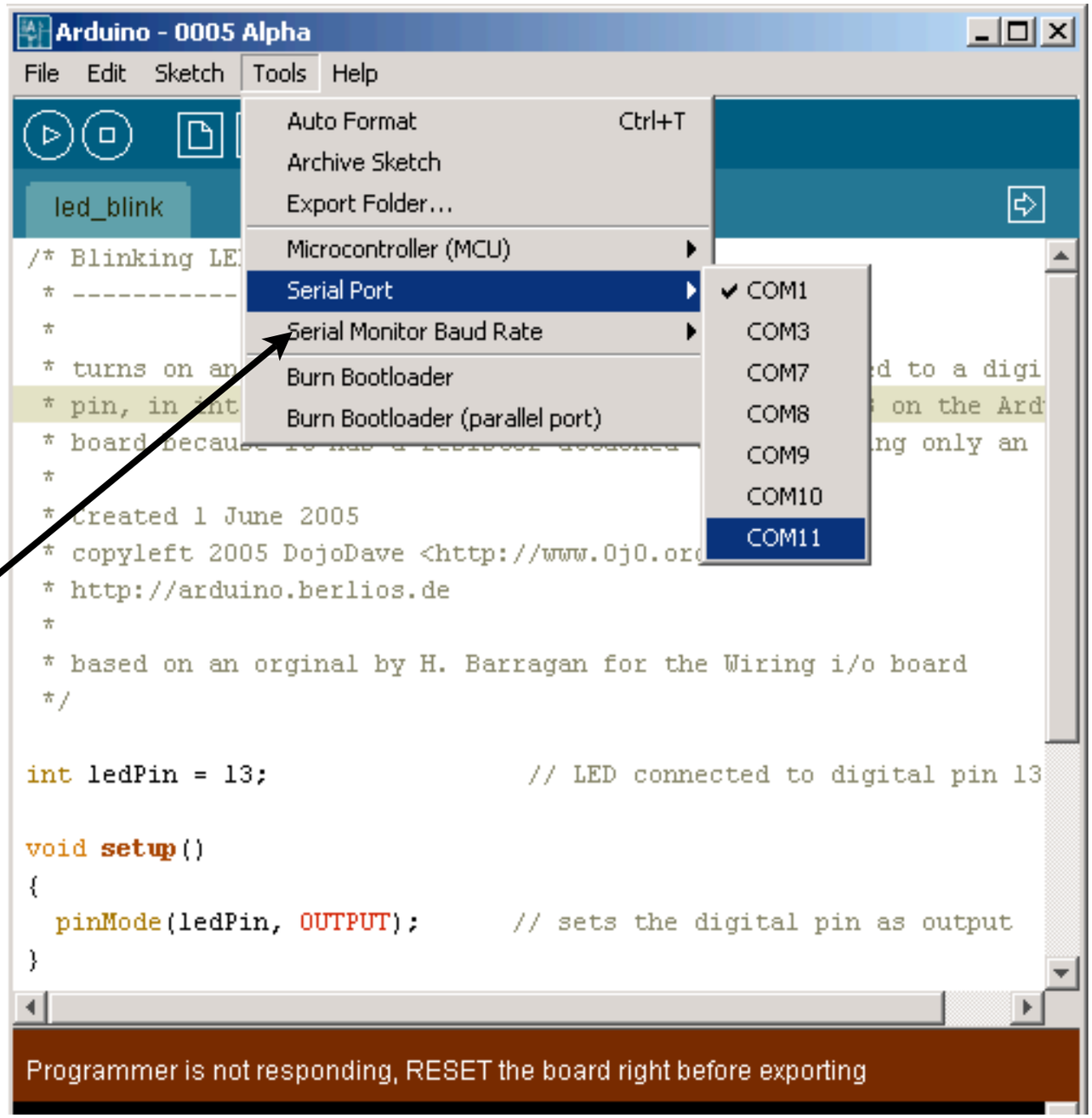
- Programs are called “sketches”
- Load up example sketch “led_blink”



Errors

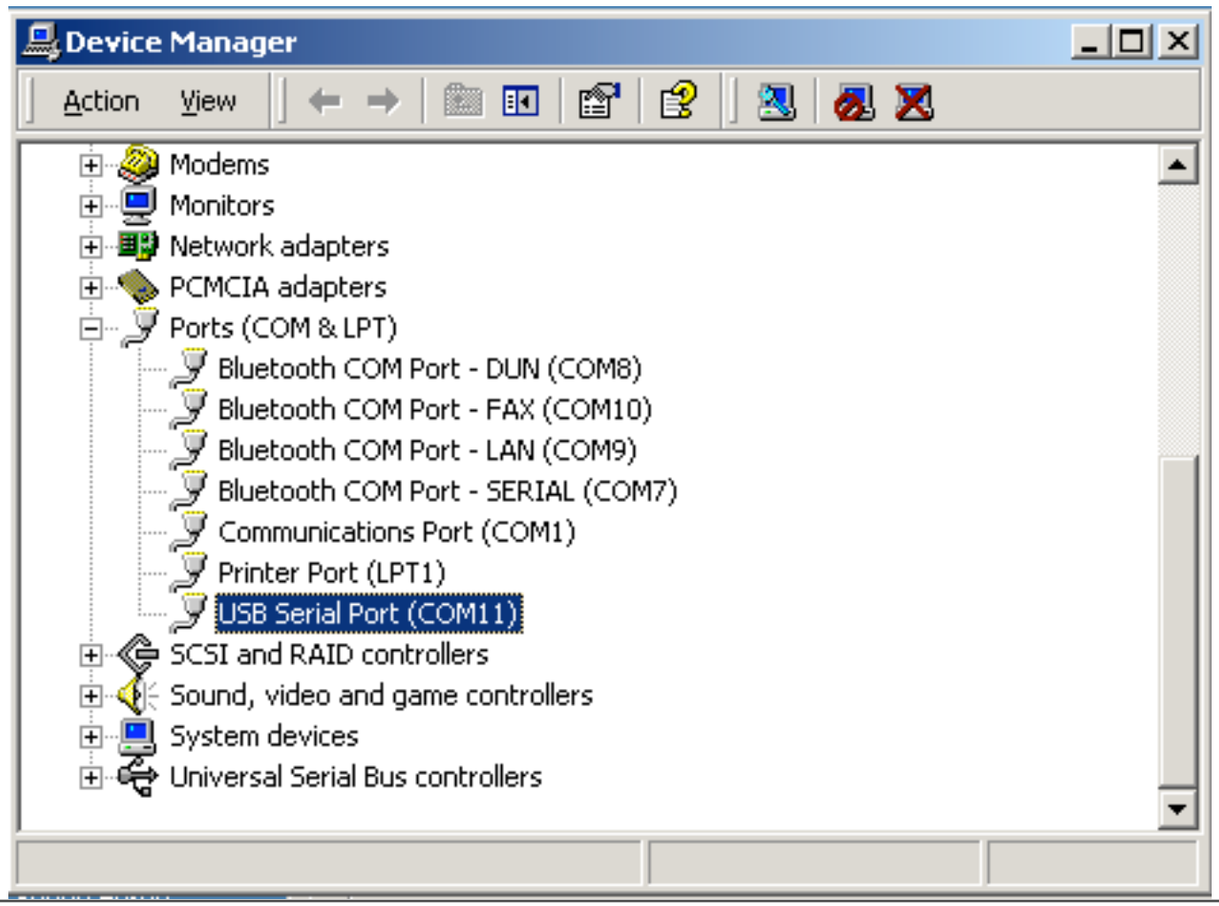
"Programmer is not responding"

Must select serial port



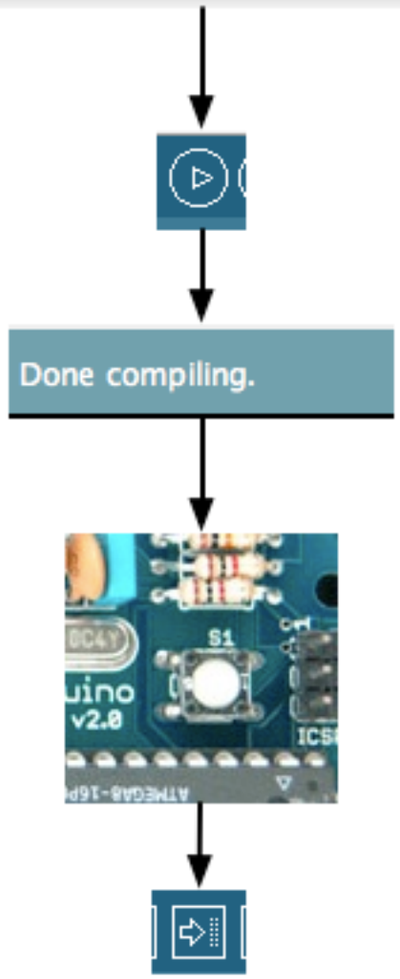
What's my serial port?

Mac: It's called "/dev/tty.usbserial-*something*"
Windows: Use Device Manager to find COM port



Using Arduino

```
void setup() {
  pinMode(ledPin, OUTPUT);      // sets t
}
void loop() {
  digitalWrite(ledPin, HIGH);   // sets t
  delay(1000);                  // waits
  digitalWrite(ledPin, LOW);    // sets t
  delay(1000);                  // waits
}
```

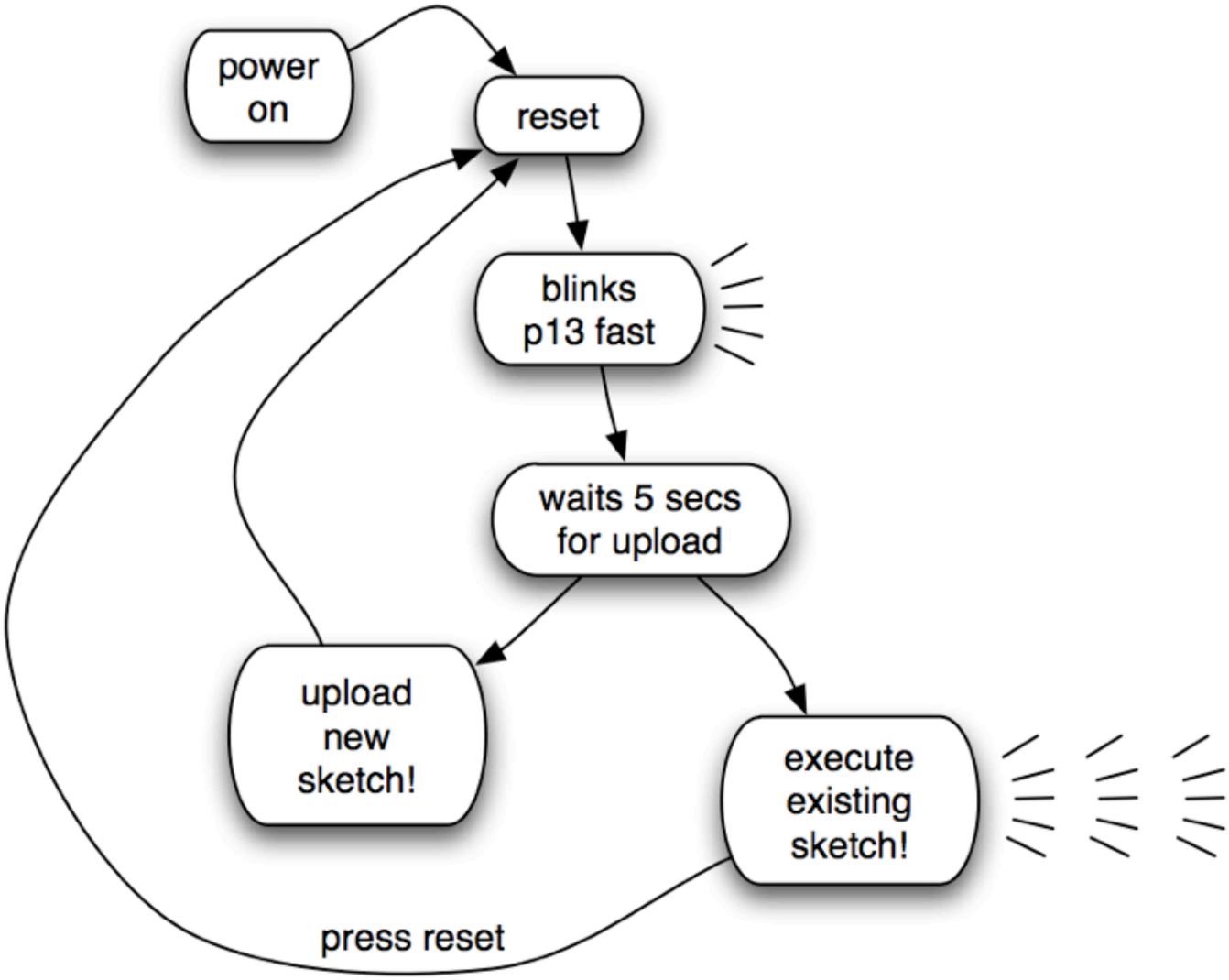


- Write program
- Compile (check for errors)
- Reset board
- Upload to board

Try it out with “led_blink”!

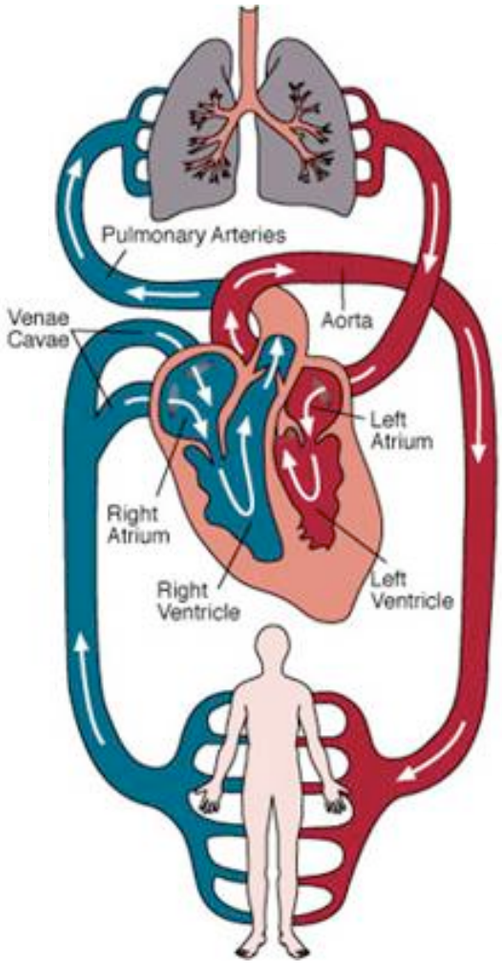
On reset, board will flash on-board pin 13 LED really fast for a split-second to indicate bootloader exists
When uploading, TX/RX lights will flash as data is transferred
Then the board resets, pin 13 will flash fast again
Finally, your program will run

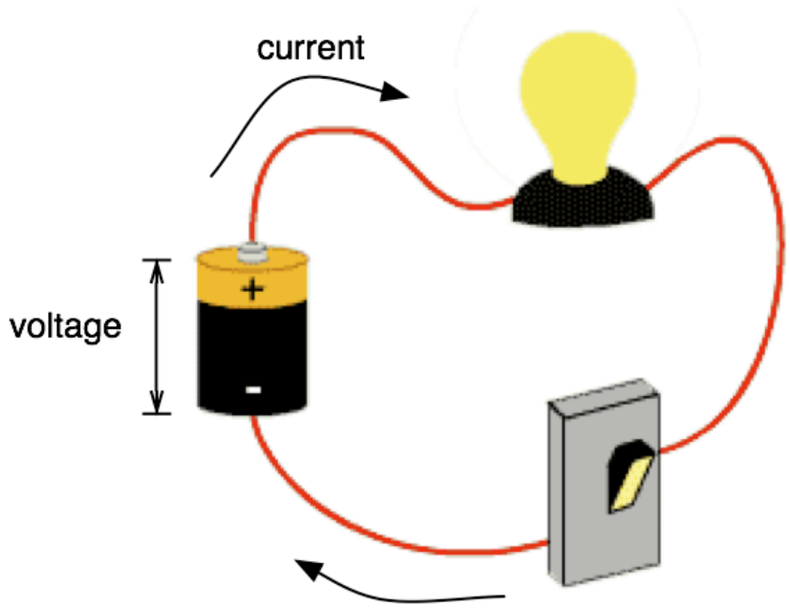
Arduino Board Lifecycle



Take a Break

Making Circuits



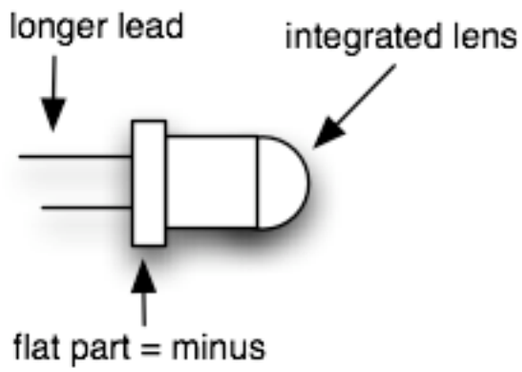


heart pumps, blood flows

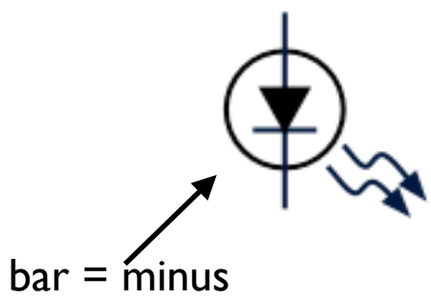
voltage pushes, current flows

LEDs

- LED = Light-Emitting Diode
  - electricity only flows one way in a diode
- Needs a "current limiting" resistor, or burns out



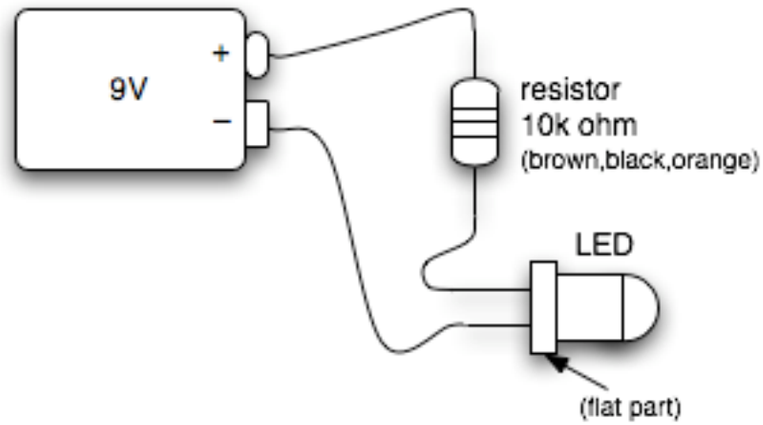
physical characteristics



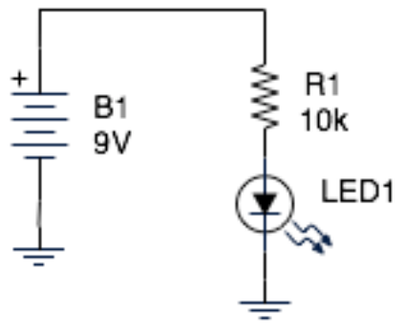
schematic symbol

Many types of integrated lenses.
Some project a narrow beam (like the ones in this class), some project a very wide beam

LED flashlight



wiring diagram



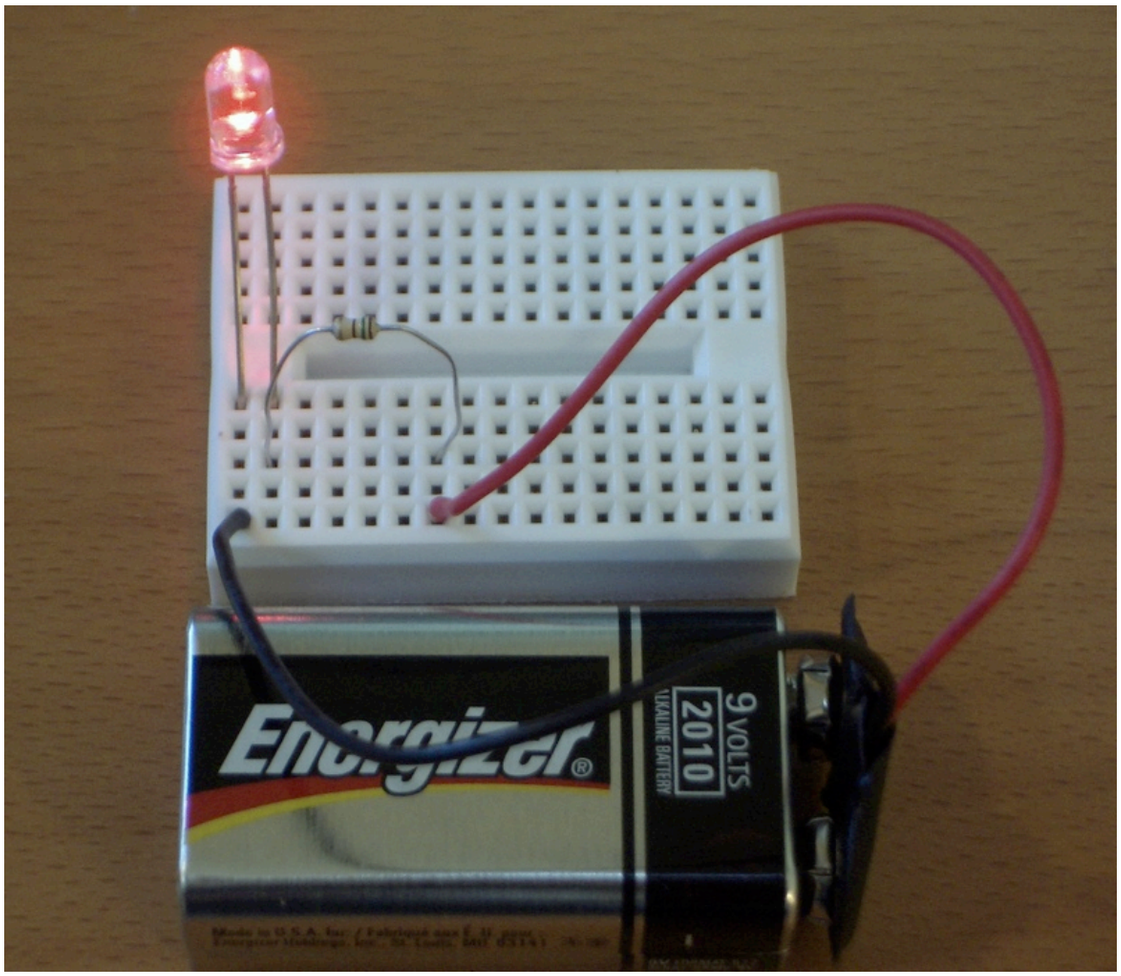
schematic

All LED circuits are essentially this: power source, current limiter, LED

Flat part of LED goes to negative, like bar in schematic

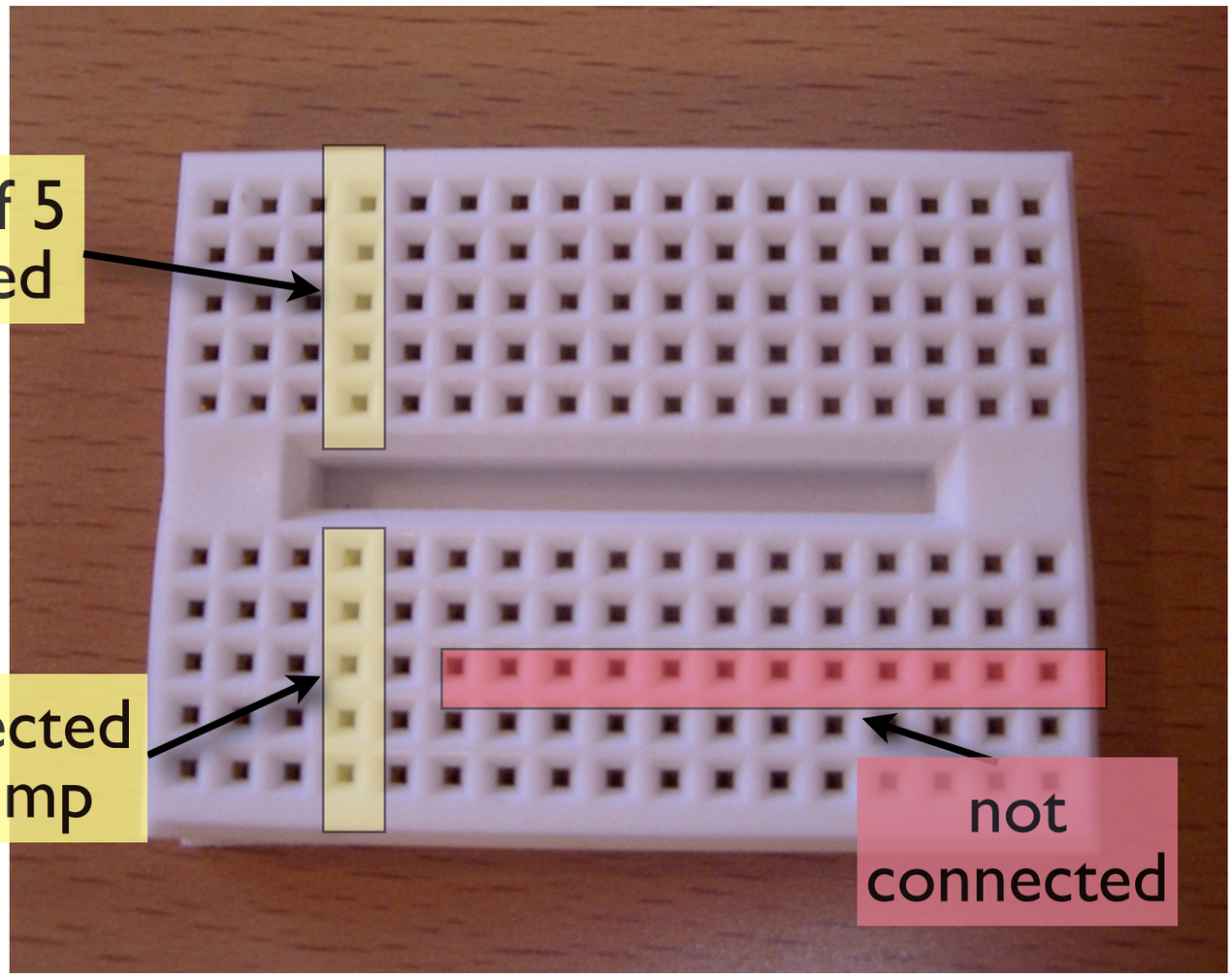
The higher the resistance, the dimmer the LED; the lower, the brighter

LED flashlight



Take out solderless breadboard, resistor, LED, and battery and make a circuit
LEDs have been marked a little as to what color they are, but color doesn't matter here

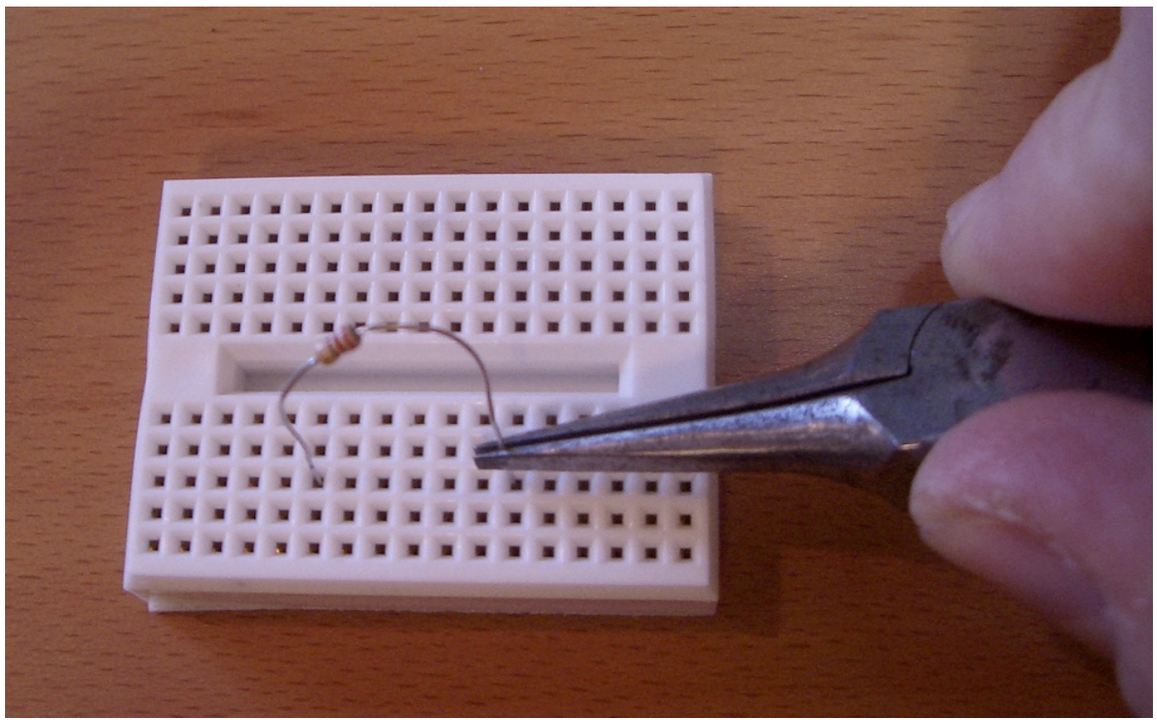
Solderless Breadboards



Insert wires into holes to make a connection.
Much easier, quicker than soldering
But, they wear out, are expensive ($8 for this little one)

Using Solderless Breadboards

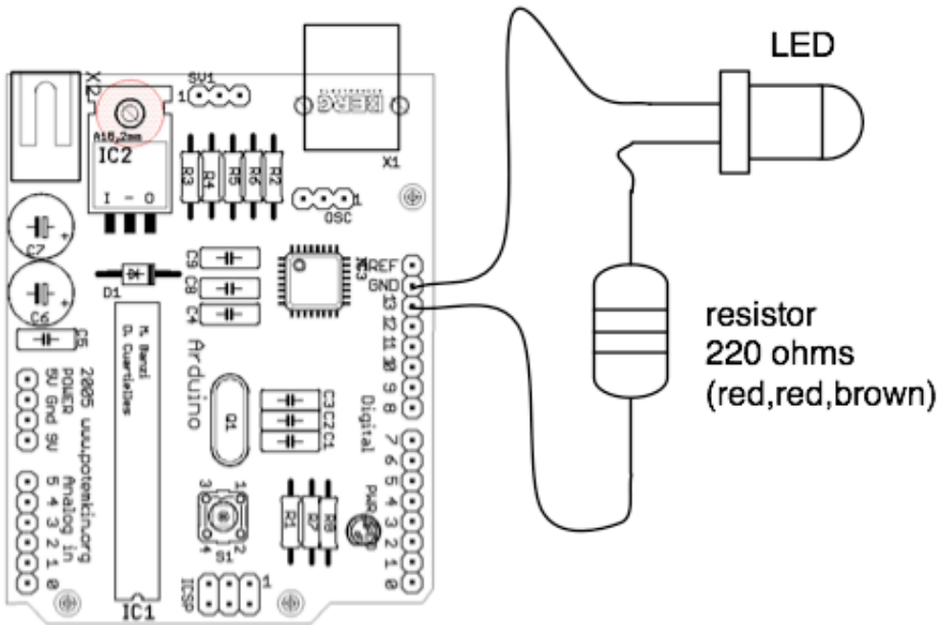
Using needle nose pliers can help



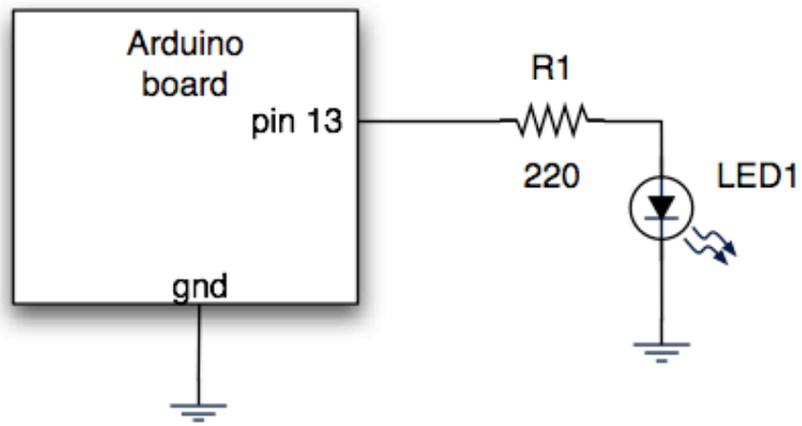
Grab wire or lead toward end and push into hole

Blinky LED circuit

“hello world” of microcontrollers



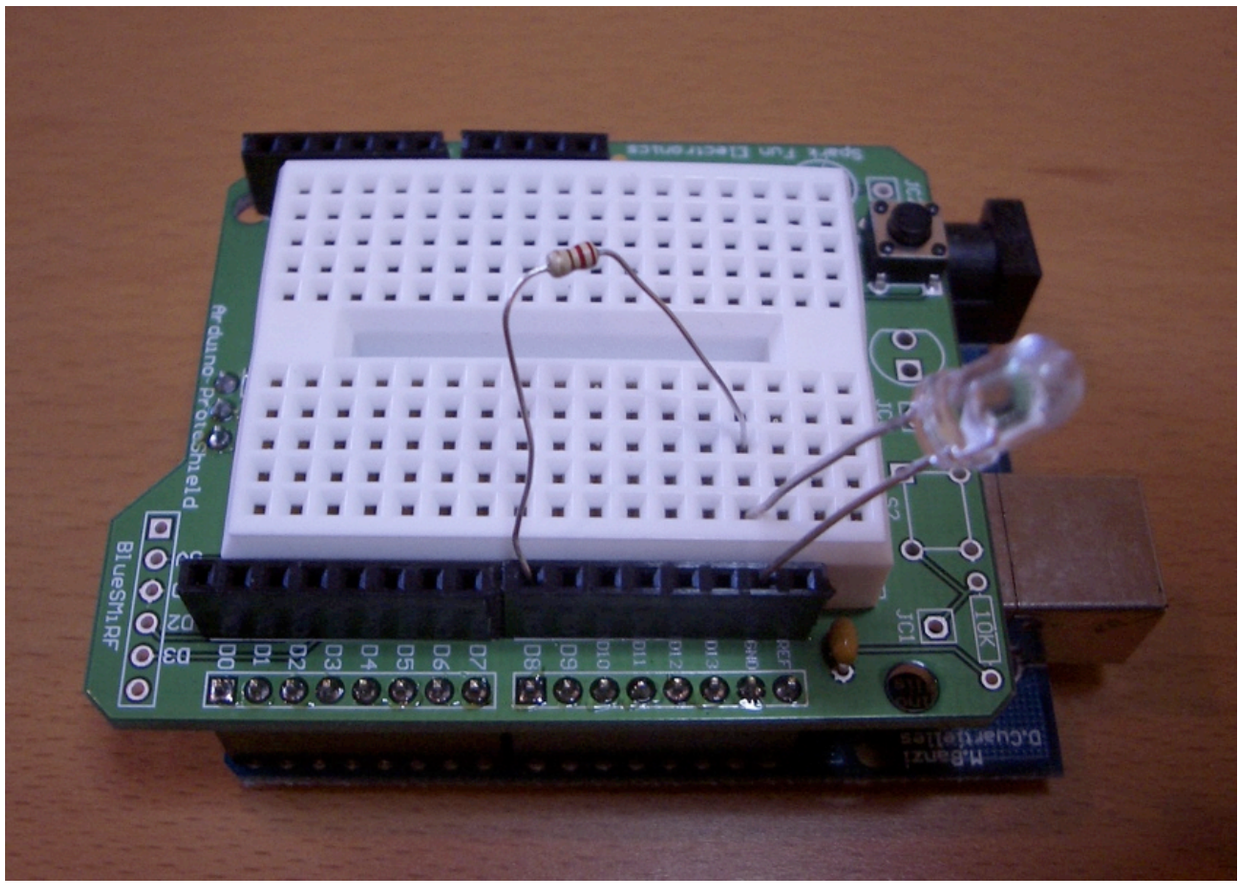
wiring diagram



schematic

In schematics signals often flow from top-left to bottom-right
Common nodes like “gnd” are given their own symbol
Pick any digital pin to hook up to, doesn’t matter which

Blinky LED circuit



- Plug shield on top of Arduino board
- Stick breadboard to shield

Blinky LED Software

You've already seen it.

```
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
}
```

Arduino Sketch Structure

- Declare variables at top
- Initialize
  - `setup()` – run once at beginning, set pins
- Running
  - `loop()` – run repeatedly, after `setup()`

Pins can be changed in loop() too, but conceptually easier in setup()

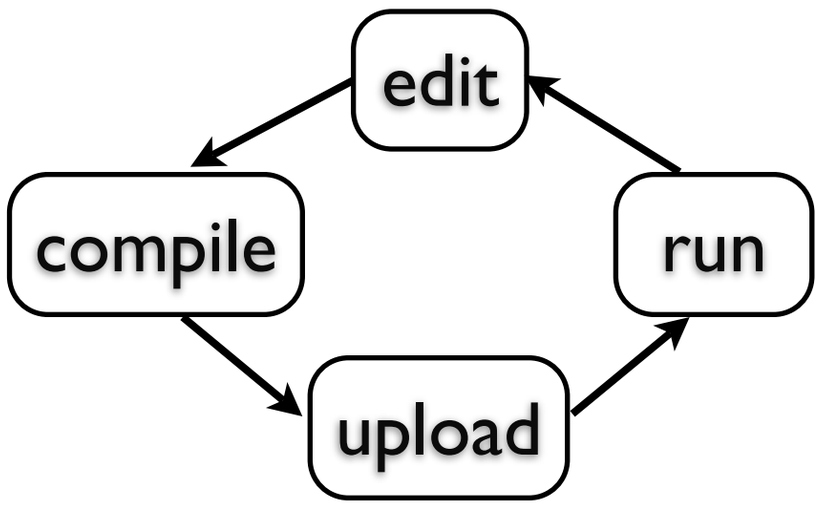
Arduino "Language"

- Language is standard C (but made easy)
- Lots of useful functions
  - `pinMode()` – set a pin as input or output
  - `digitalWrite()` – set a digital pin high/low
  - `digitalRead()` – read a digital pin's state
  - `analogRead()` – read an analog pin
  - `analogWrite()` – write an "analog" PWM value
  - `delay()` – wait an amount of time
  - `millis()` – get the current time
- And many others. And libraries. And examples!

Also: serial library, LCD library, servo examples

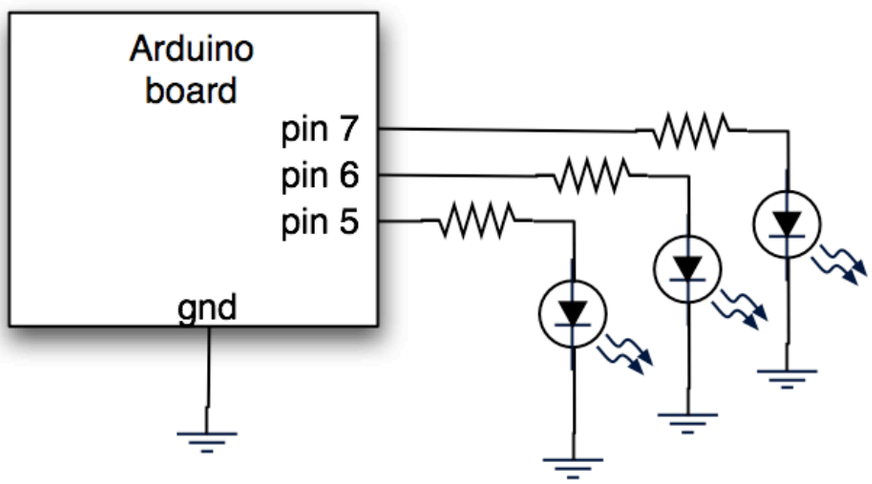
Development Cycle

- Make as many changes as you want
- Not like most web programming: edit → run
- Edit → compile → upload → run



More Blinky Madness

Add LEDs




```
int ledAPin = 7;
int ledBPin = 6;
int ledCPin = 5;

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

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

  digitalWrite(ledCPin, HIGH);   // sets the LED on
  delay(100);                    // waits for a second
  digitalWrite(ledCPin, LOW);    // sets the LED off
  delay(100);                    // waits for a second
  digitalWrite(ledCPin, HIGH);   // sets the LED on
  delay(100);                    // waits for a second
  digitalWrite(ledCPin, LOW);    // sets the LED off
  delay(100);                    // waits for a second
}
```

Next Week

- Reading buttons
- Reading analog values (knobs)
- Detecting the dark
- More complex LED circuits
- Stand-alone Arduino

END Class 1

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ATmega8 & Arduino

Arduino Pin Mapping

www.arduino.cc