Introduction to Art Engineering

Medway High School

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Unlondon Digital Media Assoc.

Goals

Art Engineering

- Science, technology, engineering and maths; in service of Art.
- Allows unprecedented interactivity
- Reach Kids, non-traditional art audiences
- Opens doors to new funding sources, non-traditional gallery space.

Unlondon

- 121Studios: Coworking for Creatives
- Unlab: Hackerspace
- Events: STEAM Outreach & Edu., ExplodeConf, X, Y, Z

Shawn: Day Job

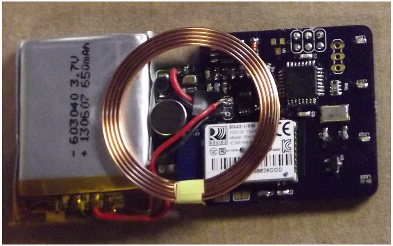
Freelance Engineer, Father

- Indoor location tracking w/ Bluetooth
- Keychain / Fitness Band Widgets
- Joystick for VR
- Remote Controls
- Internet of S*#t

Shawn: The Fun Stuff

Hacker, Church of the Weird Machine, Odd Duck

- Arduino compatible implant
- EEG Games / Toy Hacking
- Brain Stimulation
- Be Weird, Make Weird, Have Fun!
- Bad at "Art"



@scanlime: Micah Elizabeth Scott, Art Engineer

> *". . . she explores the boundaries between technology, society, and creative expression, using her unique perspective to try and help illuminate what makes us human."* [1]

- Eclipse
- Forest
- Zen Photon Garden

[1] Micah's Portfolio Website: misc.name

@kimalpert: Kim Alpert, Aesthetic Engineer

"With a background in fine art, world music, and carpentry, Kim Alpert brings an attention to detail and diverse style to her work." [2]

- Bodyphonic @ National Music Center, Calgary

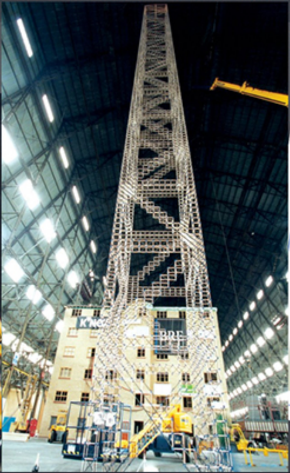
[2] Kim's Portfolio Website: `http://aestheticengineer.com`

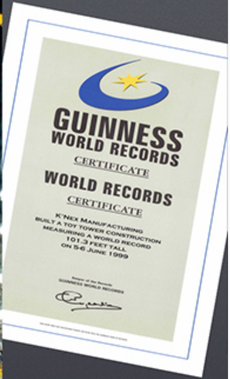
Fred:

Hey Fred, how about a bio? Then your images follow. Seemed like a logical flow... intro shawn; shawn talks about his heros, then switch.

54
über cool stuff
Fringe
unLondon
RETRO ELECTRO
SIDESHOW

WORLD RECORD TOWER



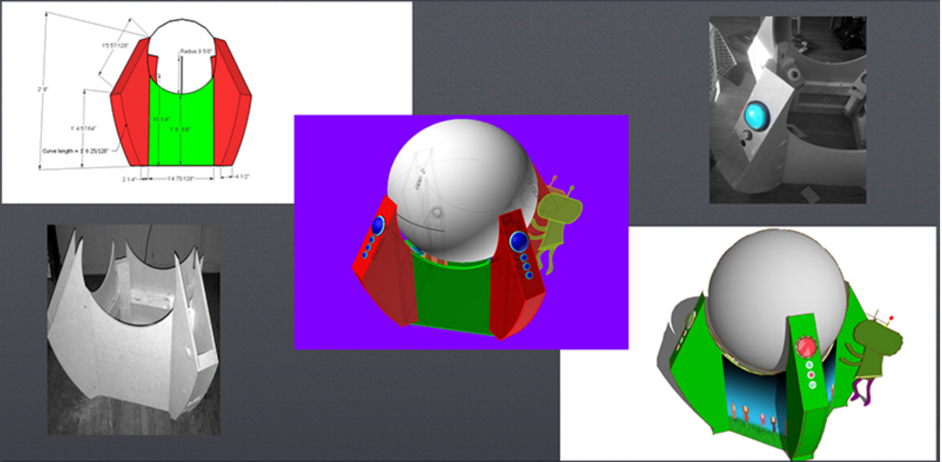

GUINNESS
WORLD RECORDS
CERTIFICATE

WORLD RECORDS
CERTIFICATE

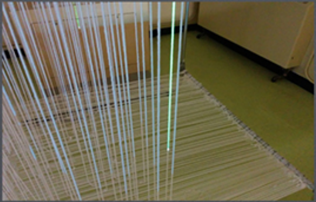
K'NEX MANUFACTURING
BUILT A TOY TOWER CONSTRUCTION
MEASURING A WORLD RECORD
101.3 FEET TALL
ON 5-6 JUNE 1999

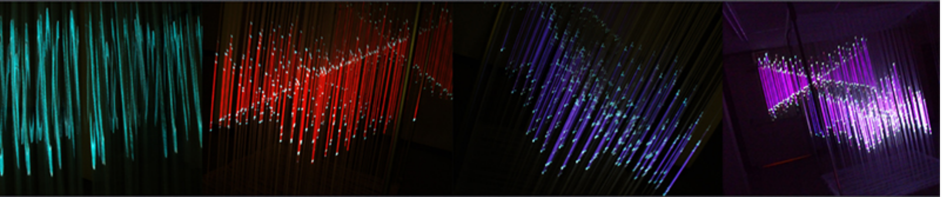
Keeper of the Records
GUINNESS WORLD RECORDS

ROLL UP THE COSMOS



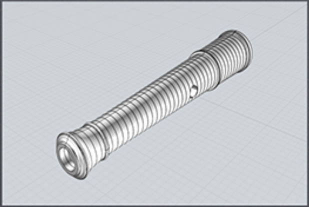
LUMARCA

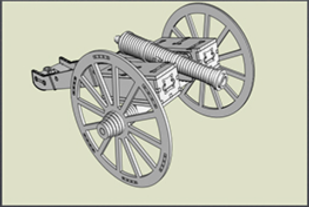


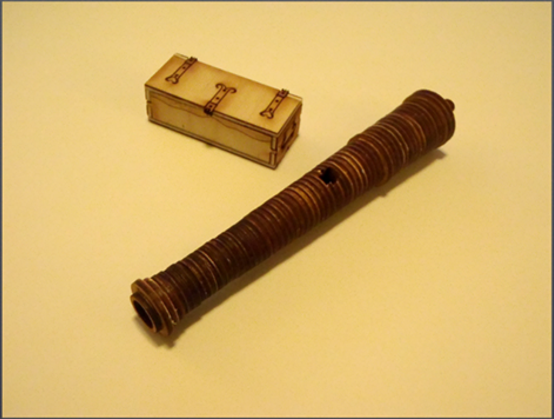


K'NEX EXHIBITIONS

LASER CUT CANNON







What’s in your kit?

Kit Contents

- Arduino Uno R3 Clone
- Solderless Breadboard
- Connecting wires
- LEDs
- Resistors, Potentiometer
- Buzzer
- IR Remote
- IR Receiver

What is Arduino?

μC + reset button + led + USB

It's a kit (on a board) with the bare minimum components to easily use the μC hardware. They do the basic, boring design needed for any board, so users only need to add the neat stuff.

Arduino Software

The Arduino folks also adapted an *Integrated Development Environment* (IDE) to their boards. This IDE allows us to easily write programs for their boards and then write the programs to the μC.

Get the Arduino IDE:

`https://www.arduino.cc/en/Main/Software`

Installation

Get installing

Circuit Basics

Current

Current is the flow of charge through a circuit. Conventionally we think of this as happening from HIGH $(+)$ to LOW $(-)$

Voltage / Potential / Resistance

Voltage is how fast the current can move in the circuit. River metaphor:

- current = flow rate: ($\mathrm{L\,s^{-1}}$)
- voltage = change in height: (m)

Other devices in a circuit can impede / effect current flow. We'll call them resistance(s).

Circuits

A circuit is a completed loop from HIGH potential (voltage) to LOW, which causes current to flow through some other components along the way.

Transducers

Often these *other* components are *transducers*, which convert electrical energy into another sort of energy:

Speaker	Electrical → Sound
Microphone	Sound → Electrical
LED	Electrical → Light
LED	Light → Electrical
Piezoelectric	Electrical → Motion

Power

The power supply provides the energy to drive the system.

Can be a:

- Voltage Regulator (converts one potential to another)
- Batteries
- Solar Panel

In our circuits, your laptop is converting it's power source to 5 V and delivering power to our circuit via USB. You also have a battery pack for computer-free shenanigans (6 V).

μController

Microcontroller (μC) is a *processor*, *memory* and a few *peripherals* on a standalone chip.

Processor is a group of transistors that understands a dozen or so commands (ADD, SUB, JUMP..)

Memory a circuit that can hold values.

Peripherals Vary chip to chip, but often include timers, communications and ADC, DAC.

Seems complicated, but really simple. They read a command from the start of memory, then execute the command. At the end of the command, read the next command from the next memory cell and repeat[3]

[3] some commands change the address of the next fetched command

Digital Signals

- Vcc: The power supply of the circuit elements
- GND: The reference voltage (usually 0 V)
- Connecting a part to Vcc = Logical 1
- Connecting to GND = Logical 0
- Connecting to Vcc & Ground is all the μC can do to talk to the world [4]

[4] w/o fancy peripherals

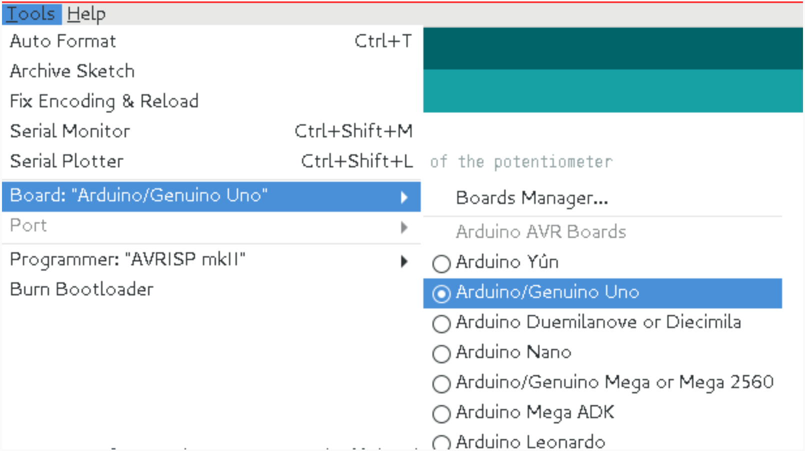
μC + Digital Signals as Switches

If one end of an LED is connected to ground, and the other end is connected to a pin on a μController, then:

- If the μC sets the pin HIGH (Vcc, 5 V) then current will flow from the pin through the LED and turn it on.
- If μC sets the pin LOW (GND, $0 V) then the current will not flow and the LED is off.

Let’s start programming

Configure Arduino

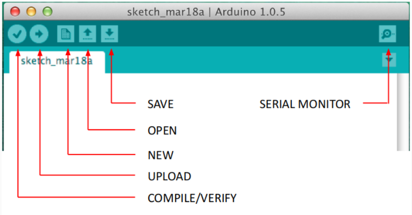


- Board: Arduino/Genuino UNO
- Port: . . .

Fetch the Class Code

- Download and extract: `https://nocko.se/assets/arduino-medway.zip`
- File→Preferences
- Browse for sketchbook
- Point it at the `sketchbook` subfolder of the extracted download
- You should now see a list of projects in the File→Sketchbook menu.

The Code Environment



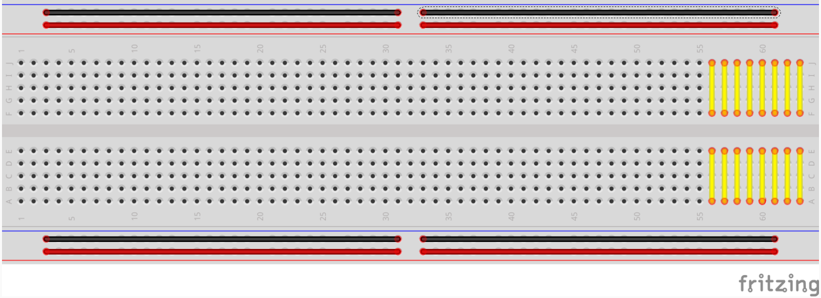
Your first Program

```
/* the setup function runs once on reset / power */
void setup() {
  /* set pin 13 as an output */
  pinMode(13, OUTPUT);
}

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

Add Some Parts

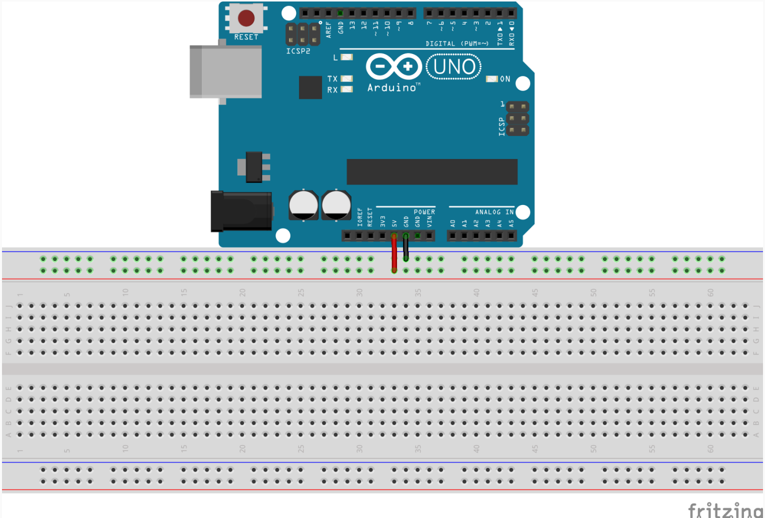
Breadboard



- Connectors gently pinch component leads, wires.
- Have internal connections

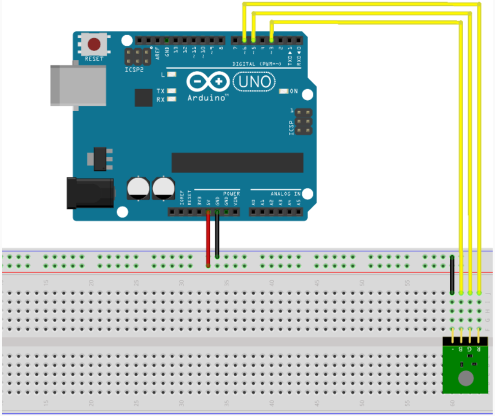
Power Up the Rails

We use the long rows to distribute power. The Arduino outputs 5 V on the pin marked `5V`, the reference (GND) is marked `GND`.



RGB LED

- Three LEDs in the same package.
- LEDs share the same GND (−) pin, one (+) side of each LED
- Connect – to negative rail, R, G, & B to pins 3,5, & 6 on Arduino



RGB Blink, pt. 1

```
#define RED 6
...
#define DELAY_MS 1000

void setup() {
  /* initialize digital pin functions */
  pinMode(RED, OUTPUT);
  ...
```

RGB Blink, pt. 2

```
/* turn the RED LED */
digitalWrite(RED, HIGH);
/* Do nothing for a while */
delay(DELAY_MS);
/* turn the LED off */
digitalWrite(RED, LOW);
delay(DELAY_MS);
/* Continue on to green LED */
digitalWrite(GREEN, HIGH);
...
```

More Parts

Potentiometer

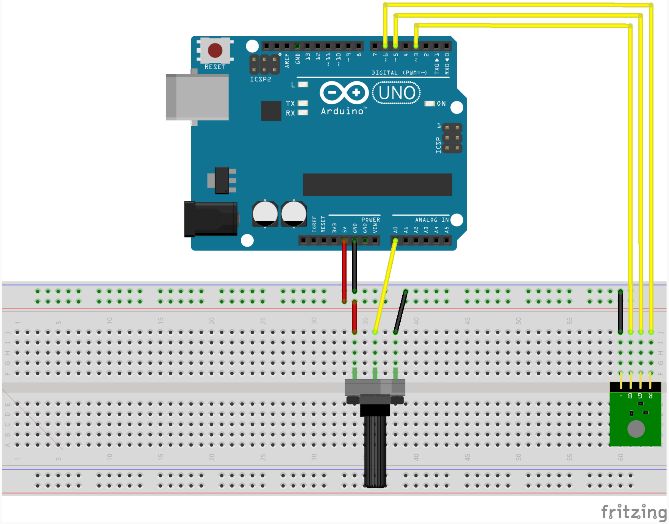
Puh - ten - she - ometer

- *Pot* for short
- A Voltage Divider
- Potential at *Wiper* varies between the two terminals

ADC: Analog to Digital Converter

- A peripheral of the μController
- Measures Potential, outputs a number
- In our case, $0\,\mathrm{V} \rightarrow 0$ and $5\,\mathrm{V} \rightarrow 1023$
- A0-A5 pins on Arduino can be used
- Fun uses: Reading pot position, sampling audio, reading from sensors

The Pot Hookup



Connect center pin to A0, outer pins to (+) and (−) rails

Pot Code, pt. 1: Variable

Declare a variable:

```
int delay_ms = 1000;
```

`<type> <name> [= <initial value>];` (value optional)

It's a name, like a preprocessor `#define`, but the value can change at *runtime*

Pot Code, pt. 2: ADC

`analogRead(`*pin*`)` returns the current state of the pin (0–1023), it can be assigned to a variable.

```
void loop() {
  delay_ms = analogRead(A0);
  digitalWrite(RED, HIGH);
  delay(delay_ms);
  ...
```

Each time through the loop, a new `delay_ms` value is read. Since the subsequent delay calls use `delay_ms`, the blink rate changes.

What else can you do with a light?

Dimmer Code, pt. 1

New variable:

```
int brightness = 0;
```

Dimmer Code, pt. 2

`analogWrite(`*pin*, <*0–255*>`)`, sets the *average* voltage to 0 V @ 0 to 5 V @ 255.

```
void loop() {
  brightness = analogRead(A0) >> 2;
  analogWrite(RED, brightness);
  ...
```

Bitwise Shift

Then number 100 is the number 4 in binary.

$0c100 << 1 = 0b1000 = 8$

$0b100 >> 1 = 0b10 = 2$

$0b10 >> 1 = 0b1 = 1$

Many μC do no have multiplication/division hardware, and they take a lot of time and power to fake it. For powers of two, shifting is faster/better.

PWM

If μC can only output 0 and 1, how does "analogWrite" work?

We can turn the pin on and off very quickly and vary the *duty cycle* (the percentage of time the pin is HIGH).

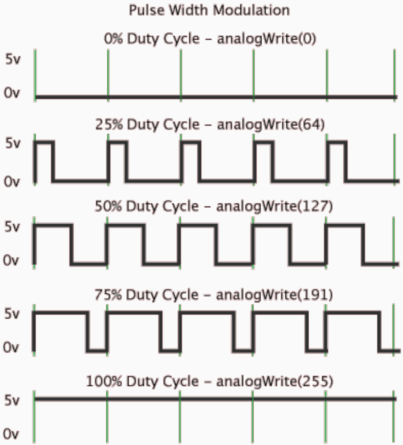
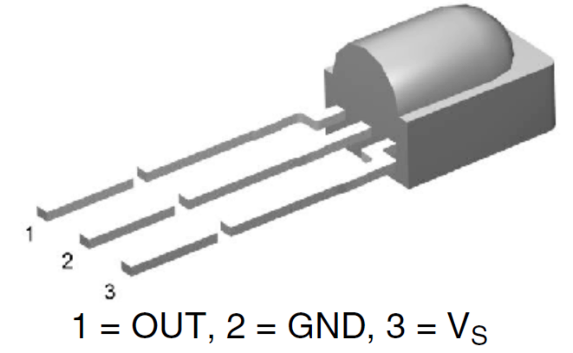

Pulse Width Modulation
0% Duty Cycle – analogWrite(0)
25% Duty Cycle – analogWrite(64)
50% Duty Cycle – analogWrite(127)
75% Duty Cycle – analogWrite(191)
100% Duty Cycle – analogWrite(255)
5v
0v

Image courtesy of Arduino.cc

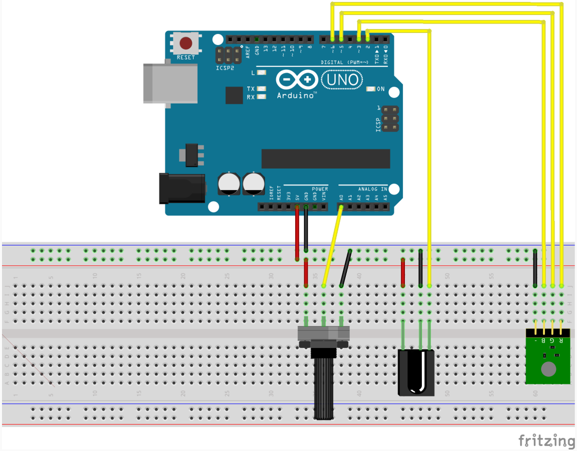
Remote Control

IR Receiver



Neat piece of kit. Internally demodulates IR signal @ 38 kHz and outputs 16 bit code (unique to each button).

Remote Control: Hardware Setup



OUT of IR Receiver connects to pin 2 of Arduino, GND (middle) GND rail, remaining pin to Vcc rail.

Remote Control: Code, pt. 1

Imports and libraries. You can include code from other files using `#include`. These are often used to include library code, for example below the `IRremote.h` file includes declarations that allow us to use objects / methods from the IRremote library.

```
#include <IRremote.h>
#include "medway-remote.h"
```

Remote Control: Code, pt. 2

```
bool power = false;

/* Initialize the irrecv part of the IRremote  library */
IRrecv irrecv(IR_PIN);
decode_results results;

void setup() {
  ...
  irrecv.enableIRIn();
}
```

Bitwise AND

A function that compares the bit-by-bit two numbers. For each bit, it returns 1 if both input bits are 1, else 0. Examples

- 5 & 1 = 1; 0b101 & 0b001 = 0b001
- 241 & 133 = 129; 0b11110001 & 0b10000101 = 0b10000001

Why use this? Setting or clearing ranges of bits.

0xF = 0b00001111, so anything & 0xF will clear any bits *left* of the last four.

Remote Control: Code, pt. 3

```
void loop() {
  if (irrecv.decode(&results)) {
    uint16_t resultCode = (results.value & 0xFFFF);
    switch (resultCode) {
      ...
      case ONE:
        digitalWrite(RED, !digitalRead(RED));
        break;
      case TWO:
        digitalWrite(GREEN, !digitalRead(GREEN));
        break;
```

Remote Control: Code, pt. 4

```
irrecv.resume();
```

This tells the IR Receiver library that we've processed the current code, and it can provide (or wait) for the next one.

Where to go next?

Light Painting

Program a blink / fade (see Fade example in sketchbook) / colour pattern into your led(s). Take a long exposure / multiple exposure photograph as you move the project around the room.

Buzzer

Hook up one end of the Piezo buzzer (black cylinder) to `GND` rail and the other to a μController pin (sample code in remote sketch). Turn on the buzzer and watch Fred and I squirm.

Other sensors

Your kit also contains a photoresistor, try hooking it up to an ADC pin. Your kit also has a modified LED that can act as a *flame sensor*, it may be fun to play with. . . .

The End?

Let's build some cool stuff!