Arduino

AS220 Workshop

Part II – *Interactive Design with advanced Transducers*

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How we see the computer

Image source: “Considering the Body”, Kate Hartman, 2008.

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How the computer sees us

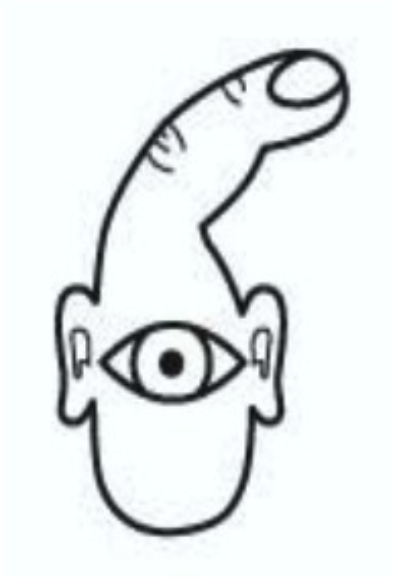

Image source: “Physical Computing”, O'Sullivan and Igoe, Thomson, 2004.

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Principles of Interactive Design

- The “Conversation Loop”
  - Listening (Sensing)
  - Thinking (Processing)
  - Speaking (Acting)

Principles of Interactive Design

- Examples of the “Loop”
  - Sensing
    - read photoresistor value
    - read potentiometer value
  - Processing
    - convert to sound wave period
    - compute PWM duty cycle
  - Acting
    - output sound wave to speaker
    - output PWM signal to LED

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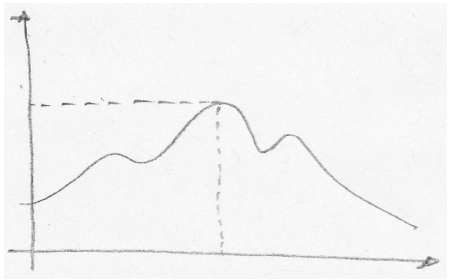
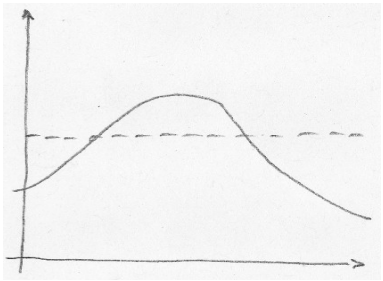
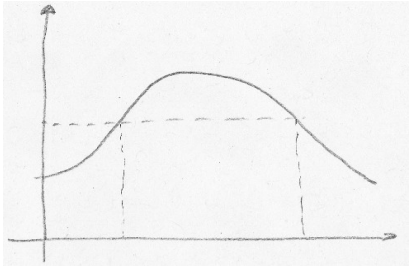
Principles of Interactive Design



Peak Detection



Threshold Setting



Edge Detection

- Sensing
  - Intensity
    - peak detection
    - threshold setting
  - Duration
    - edge detection

Note: Pulse edge detection is achieved on the Arduino with the 'pulseIn(pin, value)' function.

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Principles of Interactive Design

- Sensing
  - Presence
    - foot switches
    - beam breaking
    - motion detection
    - ultrasonic sensors
  - Attention
    - pushbuttons
    - potentiometers
    - flexsensors

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Principles of Interactive Design

Expressive Interfaces

Arduino

Principles of Interactive Design

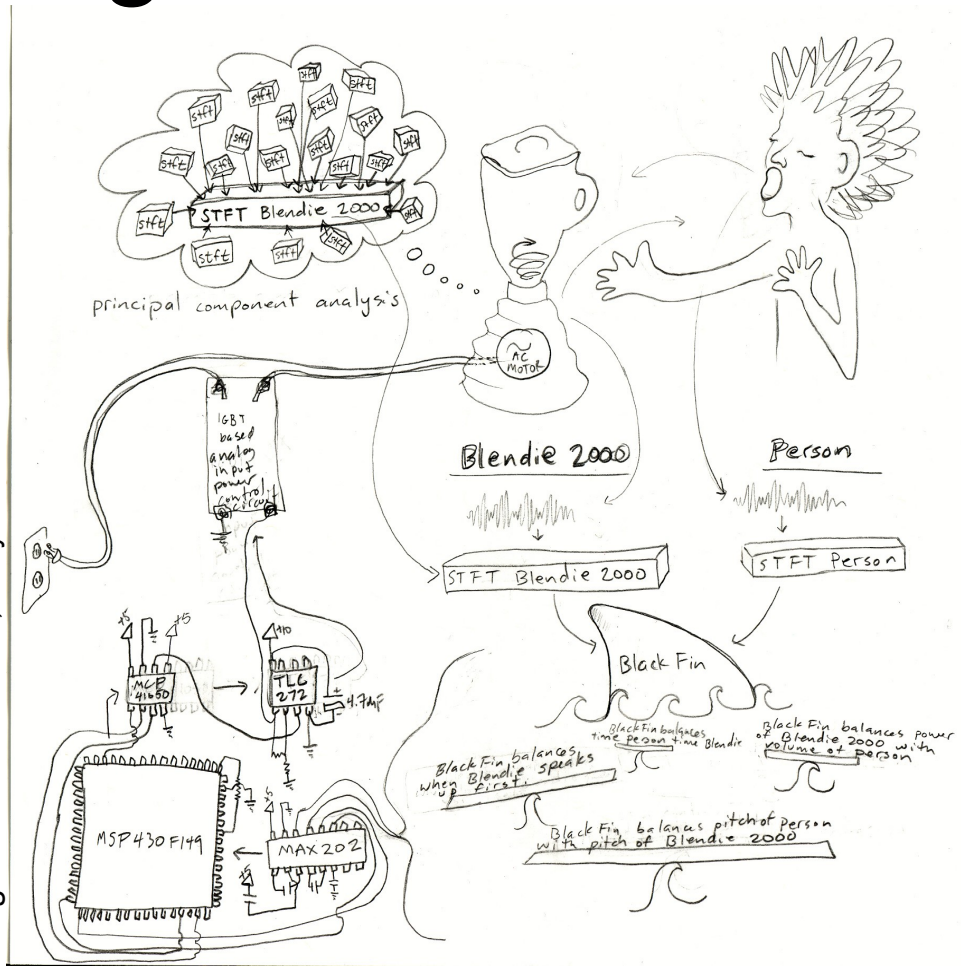

Image source: "Blendie", Kelly Dobson

Expressive Interfaces

Arduino

Principles of Interactive Design

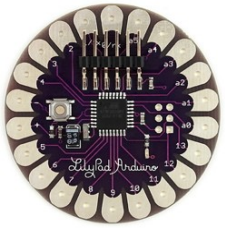

Image source: “turn signal biking jacket”, Leah Buechley

Expressive Interfaces

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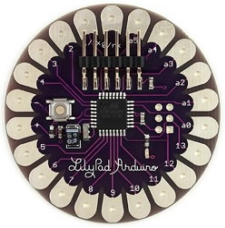
Principles of Interactive Design



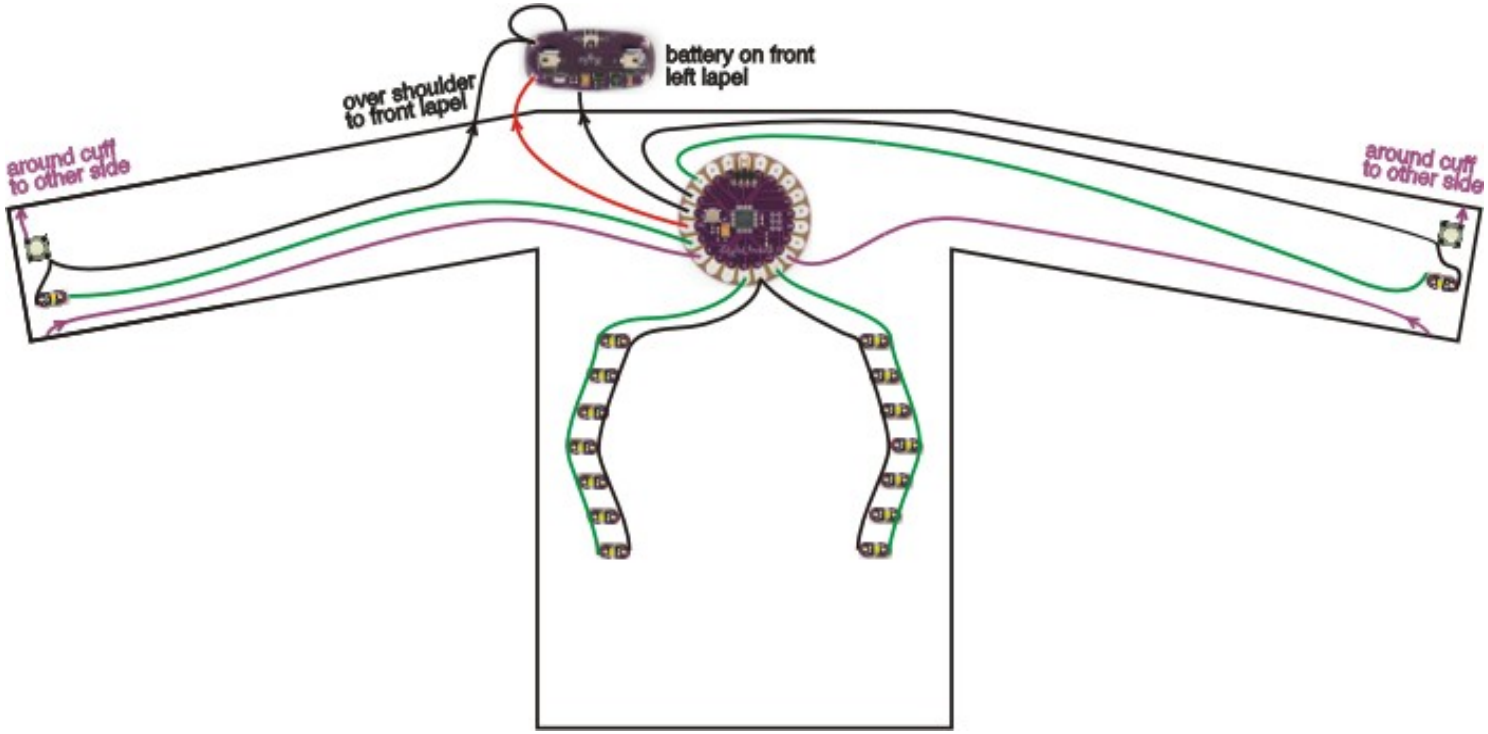


Image source: "turn signal biking jacket", Leah Buechley

Expressive Interfaces

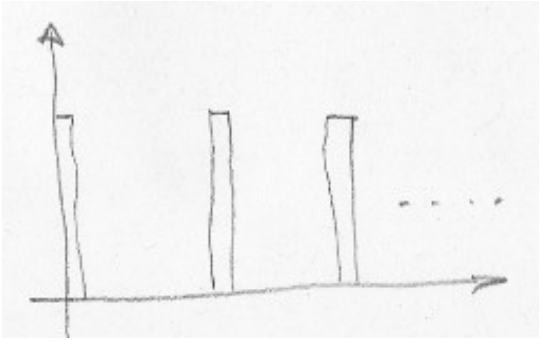
Acting - Motors

- The actuators we have seen so far provided us with *information*
- Motors allow us to act on the world in a more immediate fashion by creating *movement*
- Motors come in many different sizes and functionalities, we discuss two types of motors: *RC servos* and *DC motors*

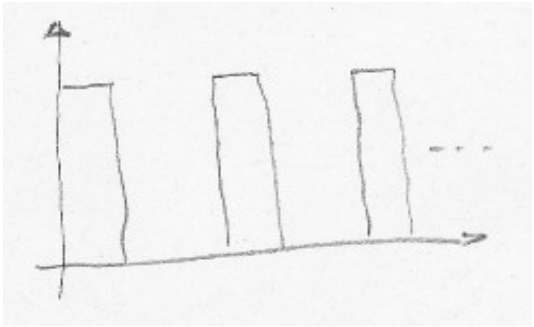
RC Servo Motors

- Remote Control (RC) Motors are DC motors that have control circuitry built-in
- These motors can be controlled in such a way that you can rotate the spindle between 0° and 180°
- You guessed it, we use *pulse widths* to do so

RC Servo Motors



Rotation = 0°



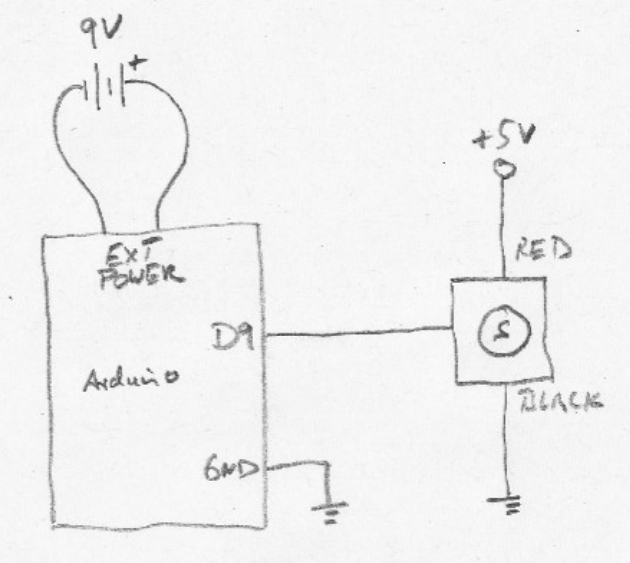
Rotation = 180°

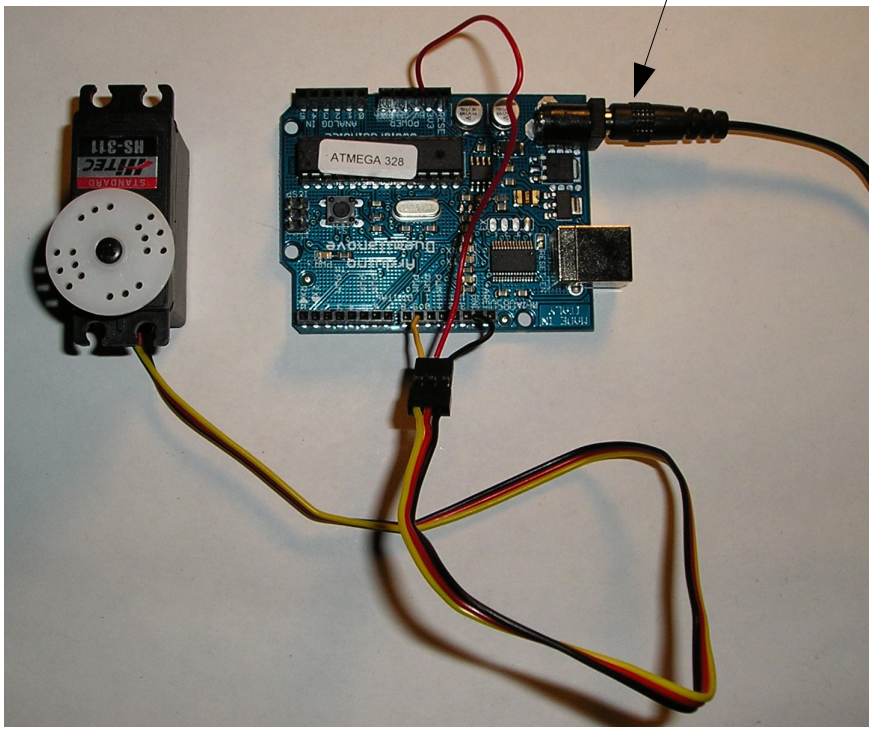
- A pulse every 20msec
- Pulse width of 1msec ⇒ 0°
- Pulse width of 2msec ⇒ 180°
- Good News: we have a library that does that for us!

RC Servo Motors

- Idea:
  - Write a sketch that sweeps the motor back and forth through its 180 degrees of rotation.

RC Servo Motors





Notes:

- You will need an *external* power supply.
- The Arduino servo library only supports servos on D9 and D10 (see documentation)

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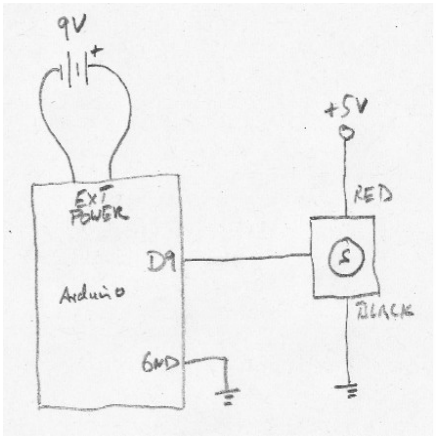
RC Servo Motors




```
// Sweep
// by BARRAGAN <http://barraganstudio.com>

#include <Servo.h>

Servo myservo;  // create servo object to control a servo
                // a maximum of eight servo objects can be created

int pos = 0;    // variable to store the servo position

void setup()
{
  myservo.attach(9);  // attaches the servo on digital pin 9 to the servo object
}


void loop()
{
  for(pos = 0; pos < 180; pos += 1) // goes from 0 degrees to 180 degrees
  {                                 // in steps of 1 degree
    myservo.write(pos);             // tell servo to go to position in variable 'pos'
    delay(15);                      // waits 15ms for the servo to reach the position
  }
  for(pos = 180; pos>=1; pos-=1)    // goes from 180 degrees to 0 degrees
  {
    myservo.write(pos);             // tell servo to go to position in variable 'pos'
    delay(15);                      // waits 15ms for the servo to reach the position
  }
}
```

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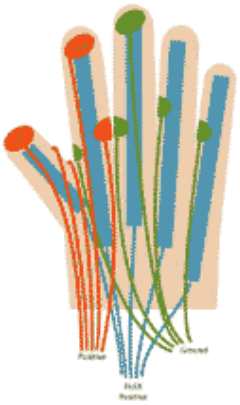
RC Servo Motors

- Idea: Use a *flex sensor* to control the rotation of the servo.



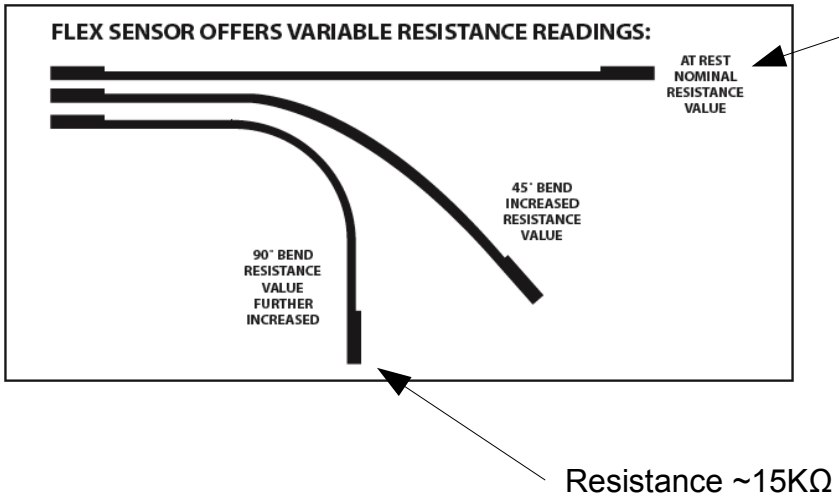
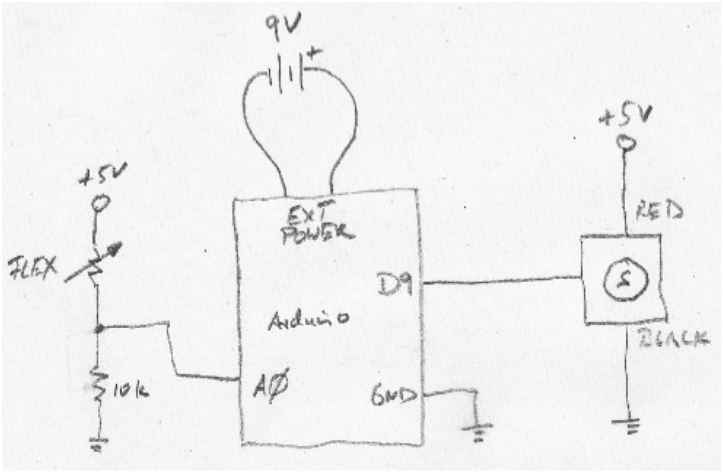
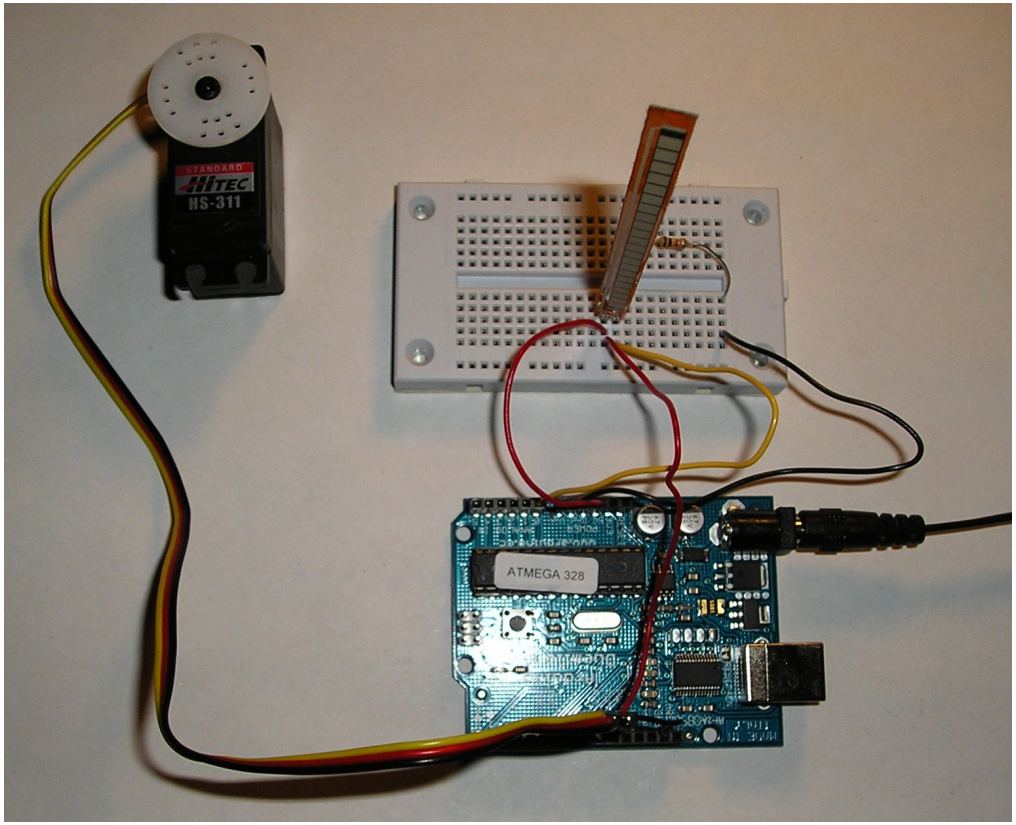


Image source: ITP/NYU

RC Servo Motors





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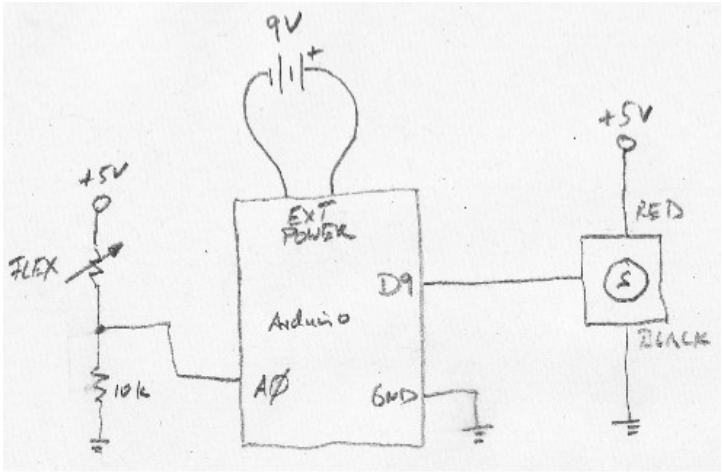
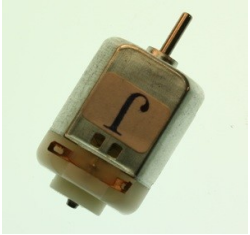
RC Servo Motors



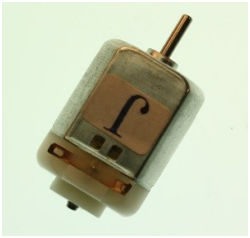

```
// Controlling a servo position using a flex sensor
// based on a sketch by Michal Rinott

#include <Servo.h>

Servo myservo;

int flexpin = 0;
int val;

void setup()
{
  myservo.attach(9);
}

void loop()
{
  // reads value between 0 and 1023
  val = analogRead(flexpin);
  // scale it to a value between 0 and 180
  val = map(val, 500, 400, 0, 180);
  myservo.write(val);
  delay(15);
}
```

DC Motors



- A *DC motor* works by converting electric power into mechanical work
- This is accomplished by forcing current through a coil and producing a magnetic field that spins the motor
- Able to run forward and backwards, depending of the orientation of the voltage source

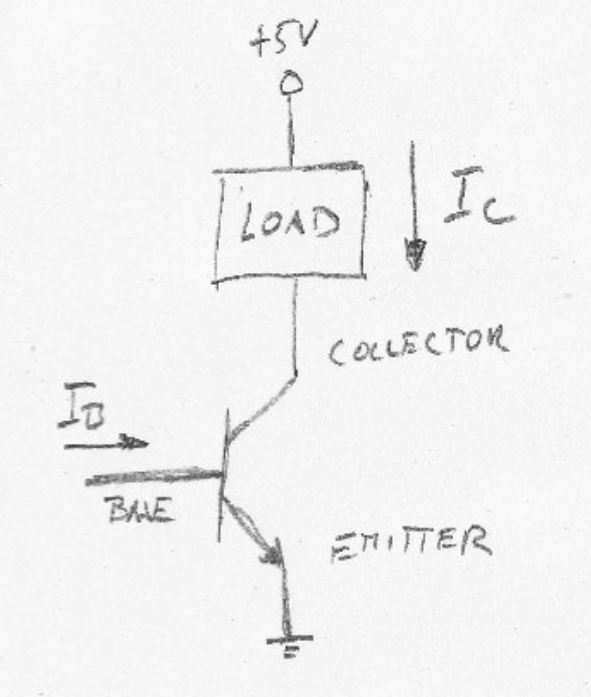
DC Motors



- Idea:
  - Control the speed of the rotation of a DC motor using PWM
  - We read an analog signal from a pot and output the appropriate PWM signal to the motor

- Caveat:
  - DC motors draw too much current to directly hook up to an IO port
  - Use *transistor* circuitry to drive the motor

Transistors



- Transistors act like switches:
  - $I_B \ll I_c$
  - If $I_B = 0$ then $I_c = 0$
  - If $I_B \neq 0$ then $I_c \neq 0$

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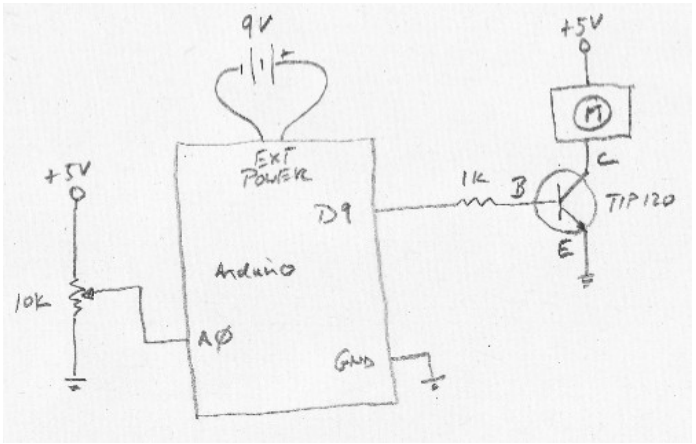
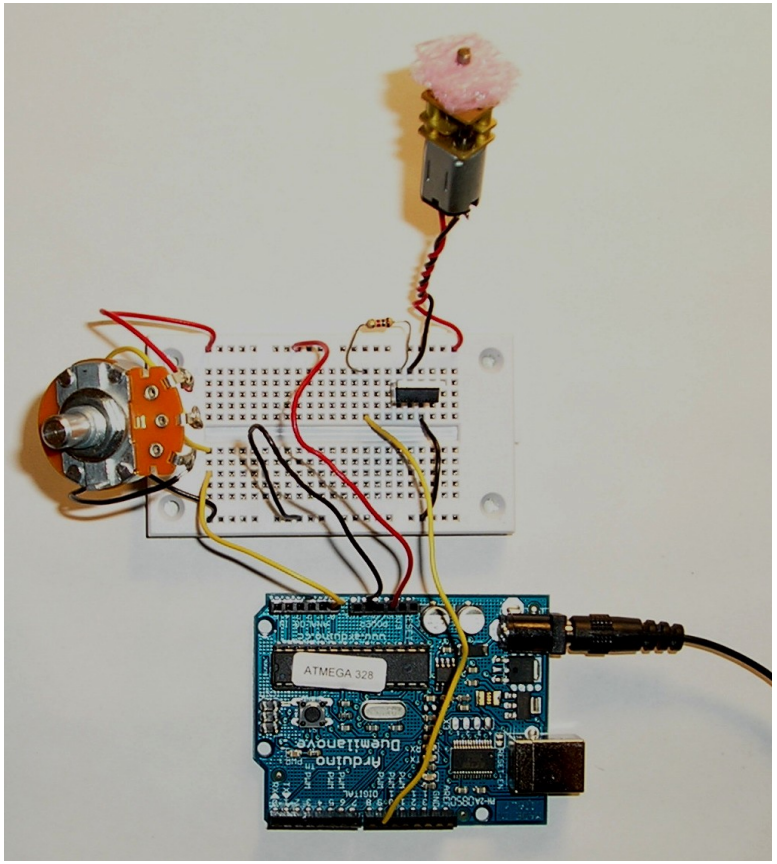
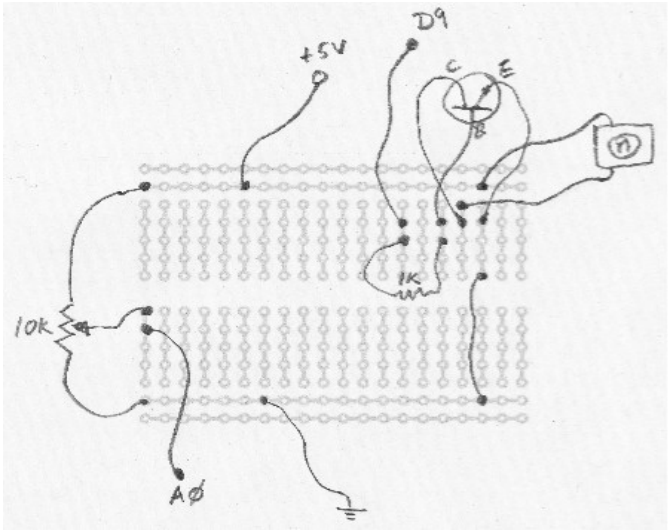
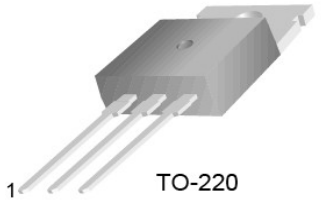
DC Motors









TO-220

1.Base 2.Collector 3.Emitter

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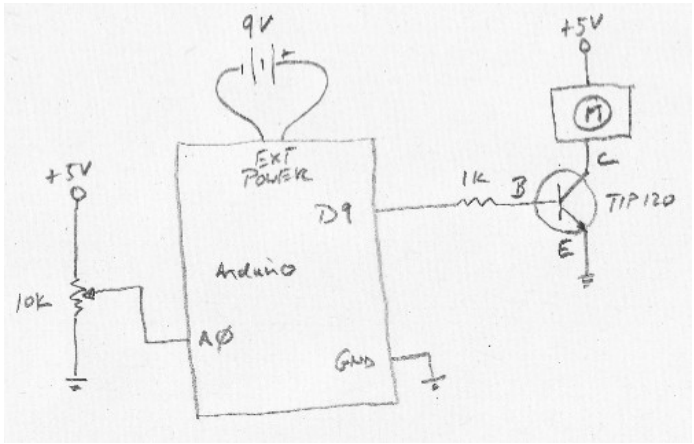
DC Motors




```
// PWM control of a DC motor

int motorPin = 9;   // motor connected to digital pin 9 (PWM)
int potPin = 0;     // pot connected to analog pin 0
int val = 0;

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

void loop()
{
  val = analogRead(potPin);
  val = map(val,0,1023,0,254);
  analogWrite(motorPin,val);
  delay(100);
}
```

H-Bridge

- Idea:
  - Use a digital control signal to let a motor spin forwards and backwards
  - We use an *H-bridge* to accomplish this
  - An H-bridge is an integrated circuit (IC) that is able to interpret digital commands and spin the motor in the appropriate direction

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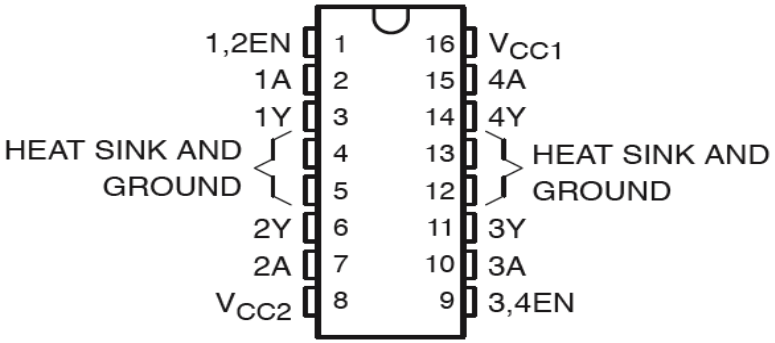
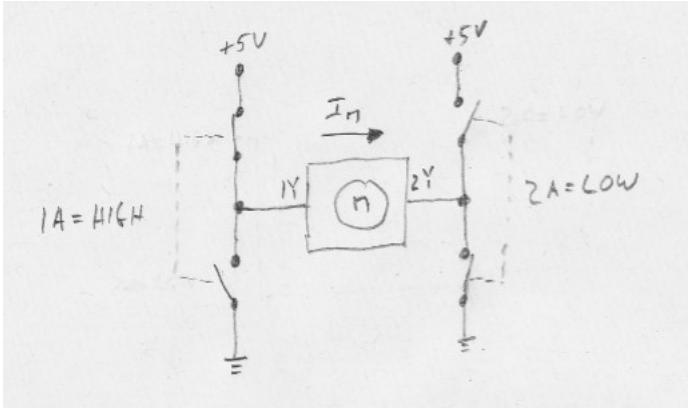
H-Bridge

SN754410

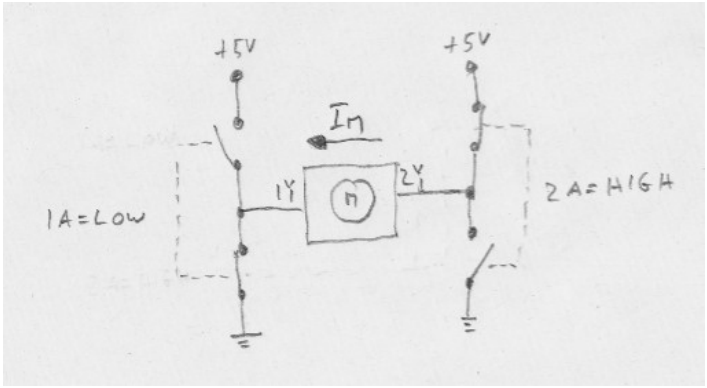


Command Interpretation

Inputs		Outputs	
1A	2A	1Y	2Y
High	Low	High	Low
Low	High	Low	High



Motor spins in one direction



Motor spins in the other direction

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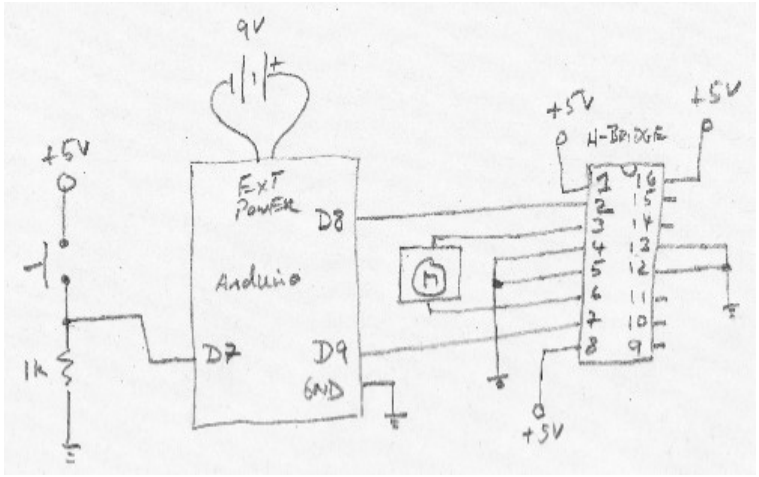
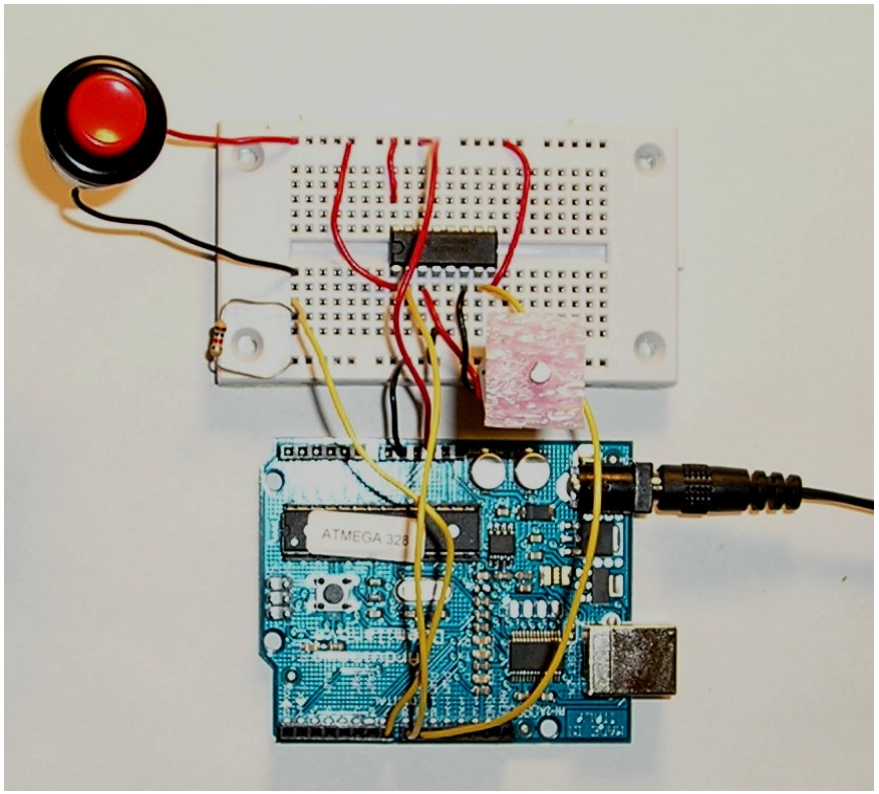
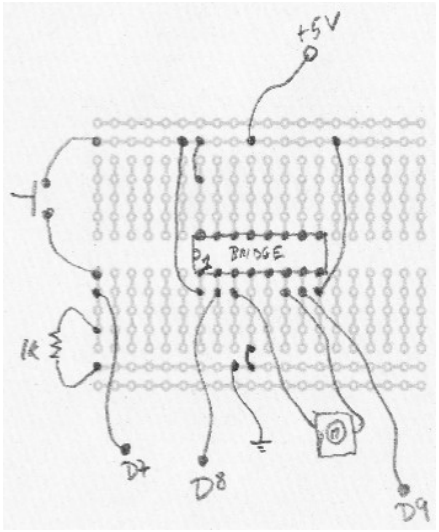
H-Bridge







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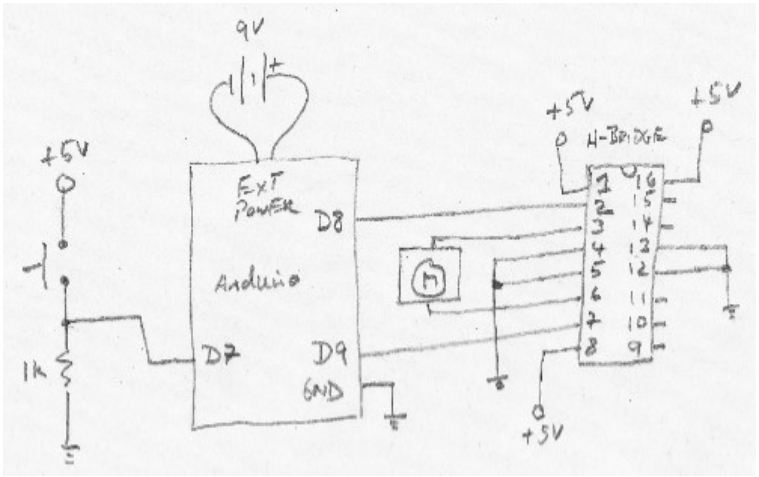
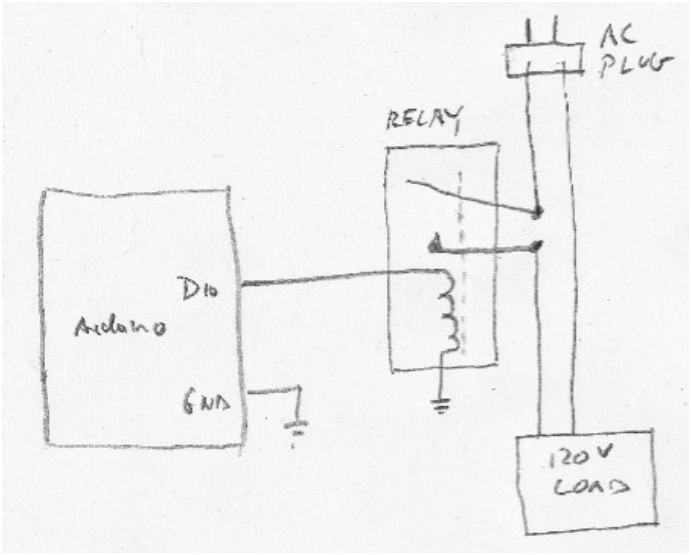
H-Bridge




```
// digital directional control of a DC motor
// using an H-bridge

int inputPin = 7;   // read digital pin 7
int outputPin1 = 8; // output pin 1a to bridge digital pin 8
int outputPin2 = 9; // output pin 2a to bridge digital pin 9
int val = 0;

void setup()
{
  pinMode(inputPin, INPUT);
  pinMode(outputPin1, OUTPUT);
  pinMode(outputPin2, OUTPUT);
}

void loop()
{
  val = digitalRead(inputPin);

  if (val == HIGH) {
    digitalWrite(outputPin1, HIGH);
    digitalWrite(outputPin2, LOW);
  }
  else {
    digitalWrite(outputPin1, LOW);
    digitalWrite(outputPin2, HIGH);
  }
  delay(100); // wait 100ms
}
```

Driving AC Loads



- We can drive 120V AC loads using *relays*
- Relays are mechanical switches that can be switch by applying power to a secondary circuit

WARNING ☠: 120V AC current can kill! If you have not done this before consult with somebody who has experience!

Building Your Objects

- A great way to explore the mechanical side of your objects are construction sets like
  - LEGO
  - Erector/Meccano sets
- Another way is to hack old toys
- Ebay is a great place to shop for these things

Things to do for next Week

- Design your interactive Object(s)
  - Briefly describe the behavior
    - input/output
    - “Conversation Loop”
  - Sketch your overall design
  - Layout the hardware
  - Design the Arduino Sketch
- Bring this all to the next Workshop