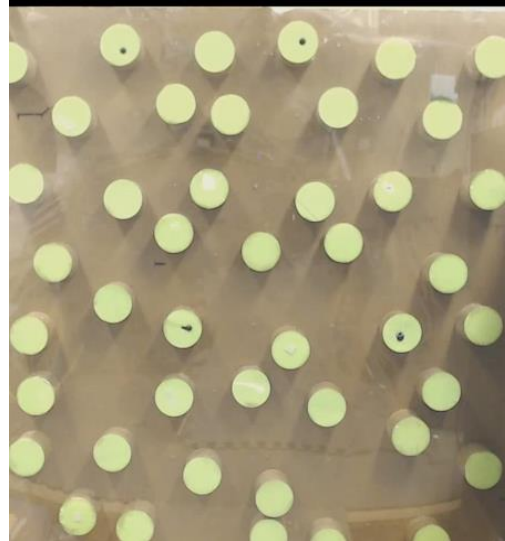# Tutorial: Techniques for building robots
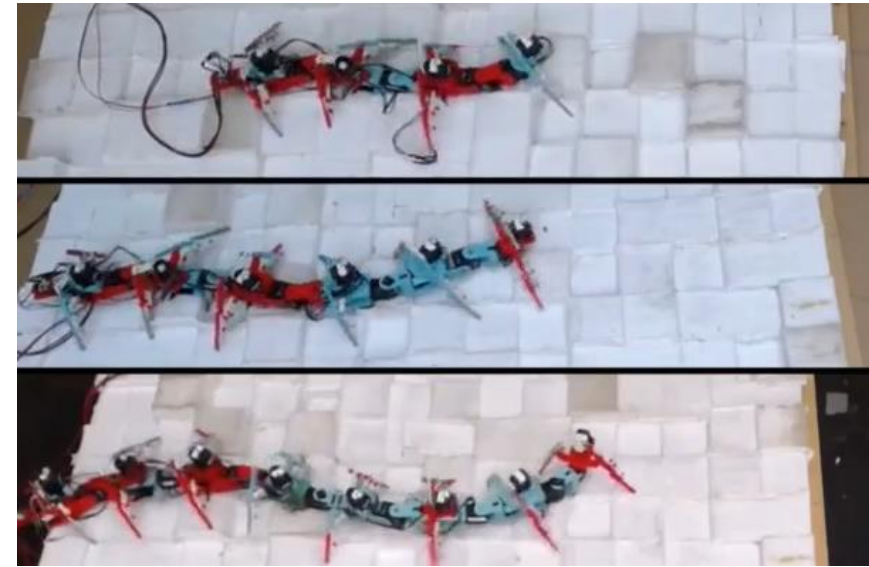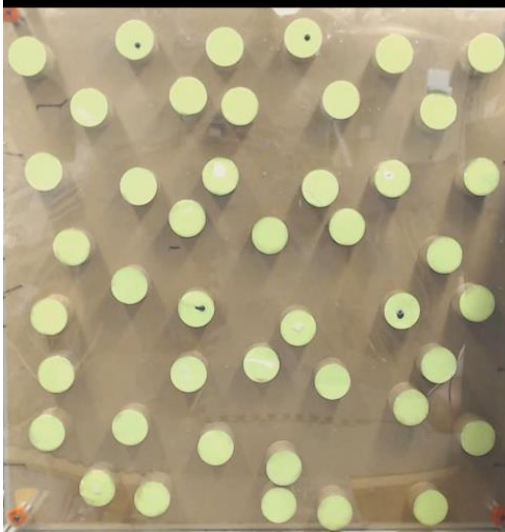
Madison Hales

Robophysics: robots as a tool for understanding locomotion


circumnutating

non-circumnutating

AquaMILR+
Design of an untethered limbless robot for complex aquatic terrain navigation

Matthew Fernandez, Tianyu Wang, Galen Tunnicliffe, Donoven Dortilus,
Peter Gunnarson, John O. Dabiri, Daniel I. Goldman

Nicole Mazouchova, Paul Umbanhowar, and Daniel I. Goldman, 2013

Your directive: the three-link swimmer

- 3 rigid links connected by 2 servo motors
- Simplest possible platform for studying swimming gaits
- Can be used to understand locomotion of microorganisms like *C. elegans*

Link 1

motor

Link 2

motor

Link 3

Robot experiment (subsurface)

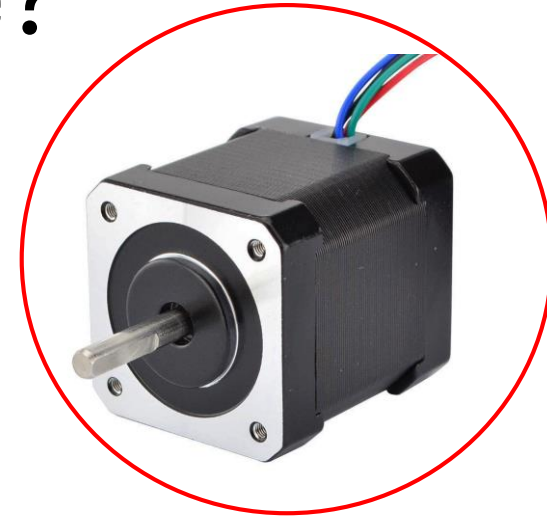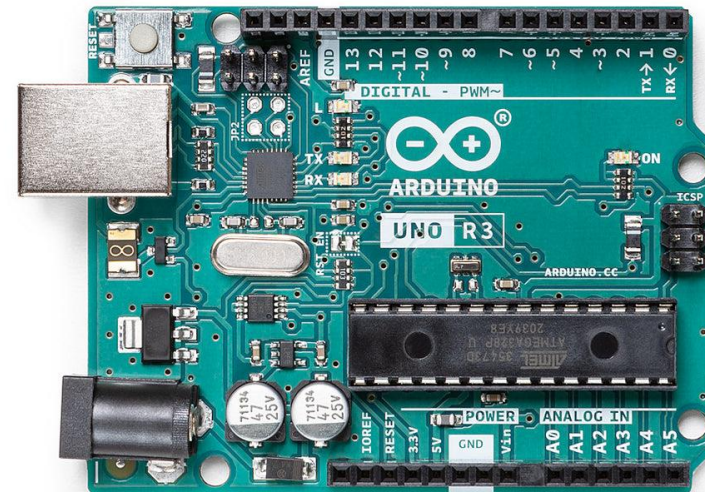Experiment (subsurface)
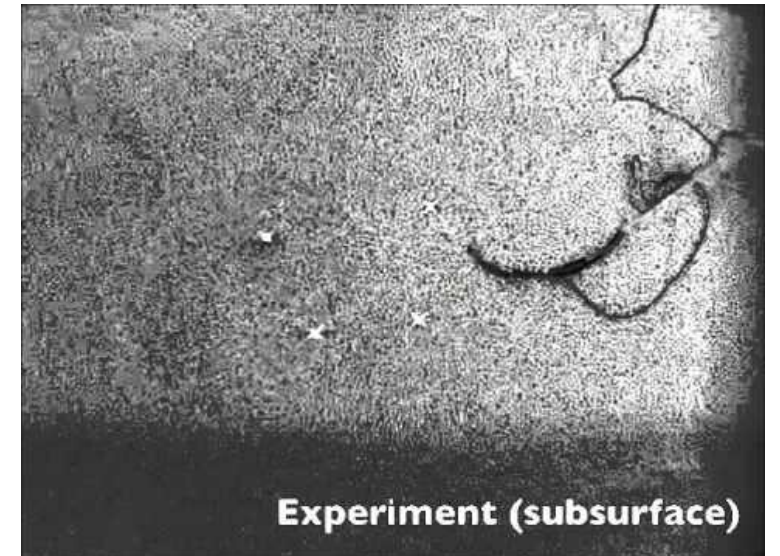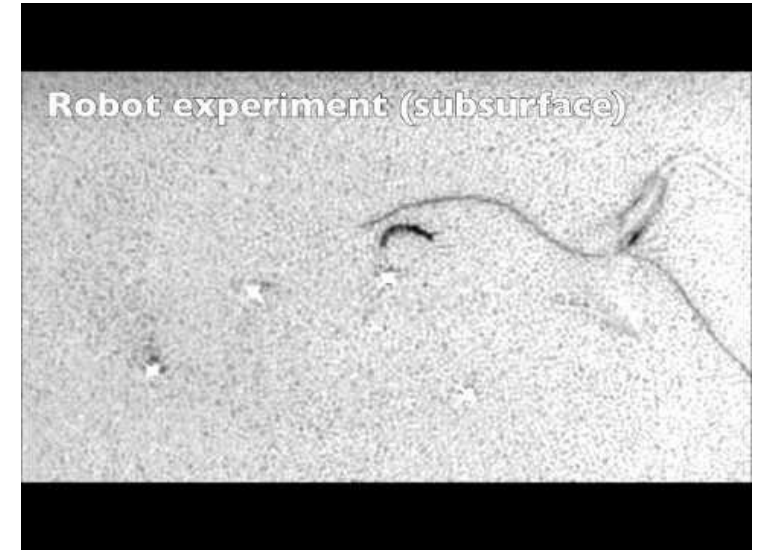
How can we make a robot move?

Actuators!

Linear actuator

Rotary actuator (motor)

How do we tell our motors to do what we want them to?

A microcontroller!

About Arduinos: hardware

Reset button
- Press this to restart program uploaded to board

USB Jack
- Program here
- Power board here (with laptop)

Power Jack
- Power board here (without laptop, after programming)

Digital I/O pins
- Supply voltage when programmed to
- HIGH (5V) or LOW (0V), nothing in between
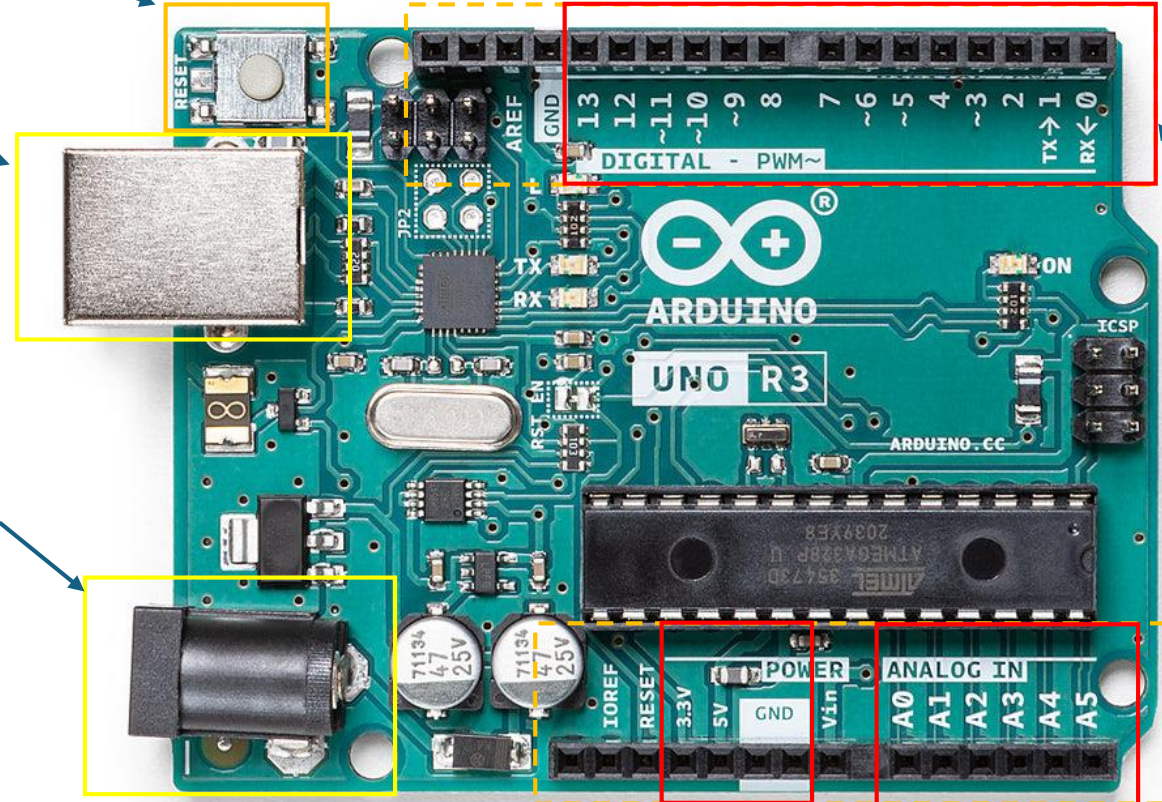- Read voltage from a sensor (high or low)

Pin 13 is an LED

Pins!

Power and ground pins
- Supply power for attachments (such as a motor)
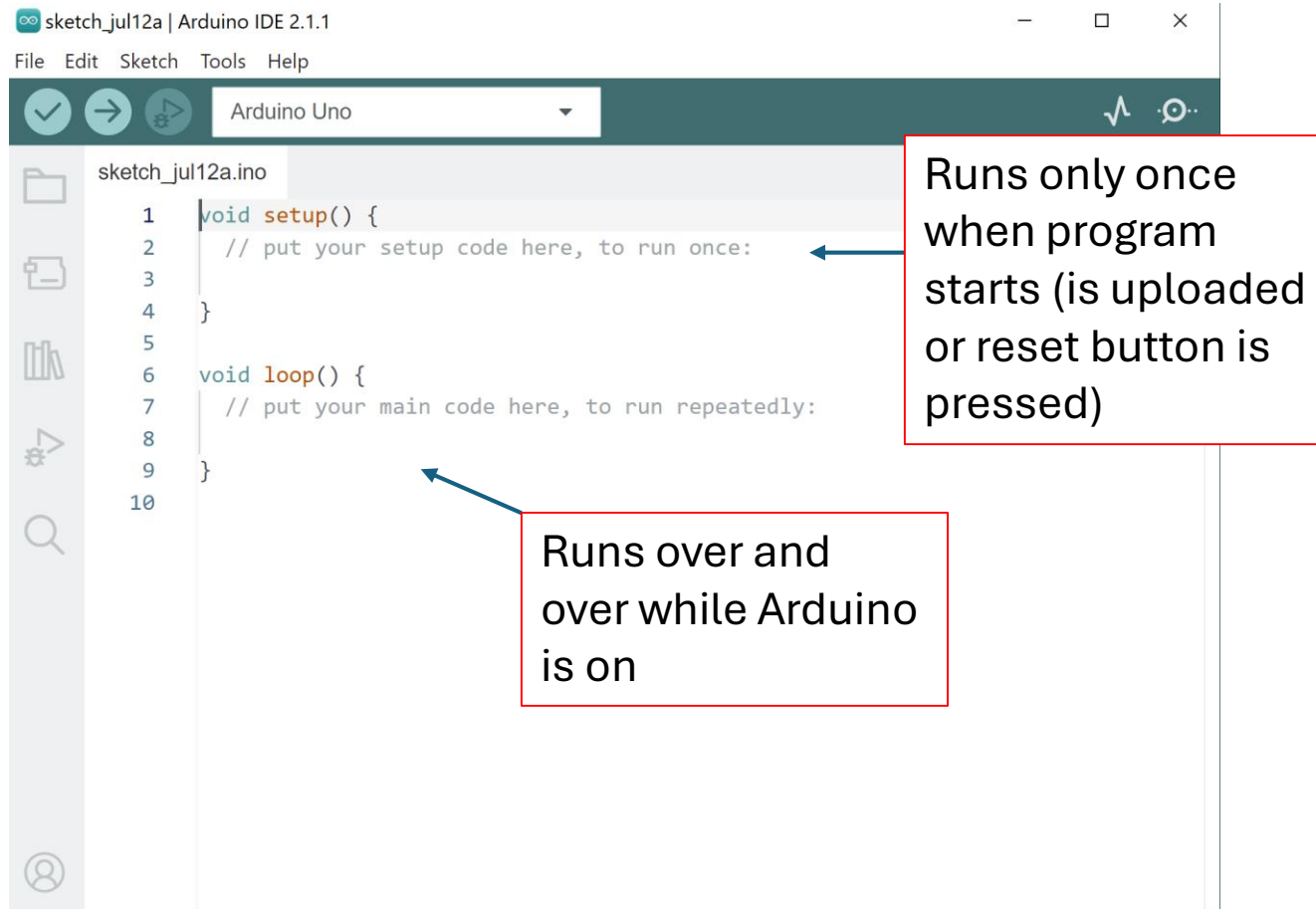- Make sure all grounds are connected

Analog in pins
- Can read continuous voltage 0-5V from a sensor

About Arduinos: software

Arduino IDE

Runs only once when program starts (is uploaded or reset button is pressed)

Runs over and over while Arduino is on

- Coded in ArduinoC (a simplified version of C/C++)
- Setup is typically where you initialize pins
- Loop is where you execute your main processes (like running a motor or collecting data from a sensor)
- Before running your program, go to 'Tools' in the toolbar above the terminal
  - designate your board as an 'Arduino Uno' under Board
  - Set your COM port under Port

Checkpoint #1: blinking an LED

- Important concepts
  - Initializing a pin
  - Writing to a pin
  - Time delays

- <u>Pseudocode</u>
  - Set up
    - Initialize LED pin 13 as an output
  - Loop
    - Blink on
    - Delay for blink duration
    - Blink off
    - Delay for off curation

<u>Code Dictionary</u>
- Initialize a digital pin as an output
  - pinMode(Pin, OUTPUT)
- Write a digital pin to 5 Volts
  - digitalWrite(Pin name, HIGH);
- Write a digital pin to 0 Volts
  - digitalWrite(Pin name, LOW);
- Delay program for a set length of time
  - delay(Length of time in milliseconds);

Types of motors

- DC Motor
  - Motor torque and speed are related to applied current and voltage
  - No position or speed control
  - 2 wires: power and ground
- Stepper Motor
  - Motor takes 'steps' through discrete positions (usually 1.8° per step)
  - Allows for open-loop position control
  - Requires a driver
  - 4 wires (or more)
- Servo Motor

The basics of servo motors

Duty Cycle = Pulse / Cycle * 100
Frequency = Cycles / Second

- Closed-loop position control
  - Signal wire sends a PWM signal
  - The duty cycle of the PWM corresponds to a certain location for the motor shaft
  - Motor uses internal potentiometer to rotate to desired position
- 3 wires: power (red), ground (grey/black), signal (yellow)
- Usually limited to 180 degrees of rotation
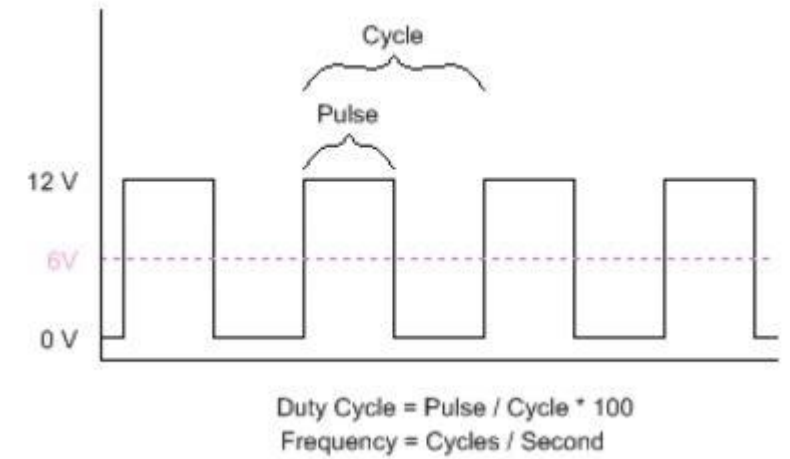
Checkpoint #2: rotate servo motor

- Important concepts
  - Including code libraries
  - Controlling a servo motor

- <u>Pseudocode</u>
  - Set up
    - Include servo library
    - Create servo object
    - Attach servo to a pin
  - Loop
    - Send servo to position 1
    - Delay
    - Send servo to position 2
    - Delay

<u>Code Dictionary</u>
- Create servo object
  - Servo servo_name;
- Attach servo to a pin
  - servo_name.attach (pin number);
- Send servo to a specified angle
  - myservo.write(angle 0-180 in degrees);