P524: Survey of Instrumentation and Laboratory Techniques

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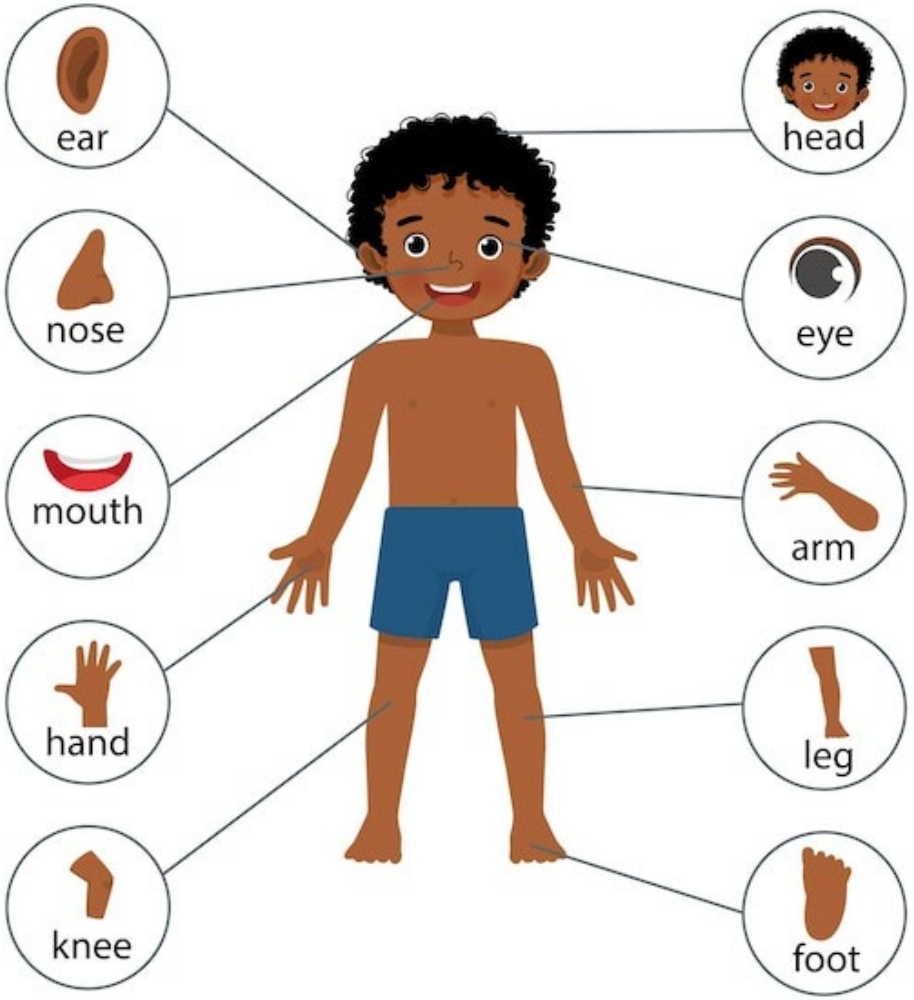
Guest lecturers: Aaron Pearlman, Chris Morris

Course designer: George Gollin

Human Anatomy



Instrumentation, or building your project (could be a robot)

We will need the following:

1. A brain:

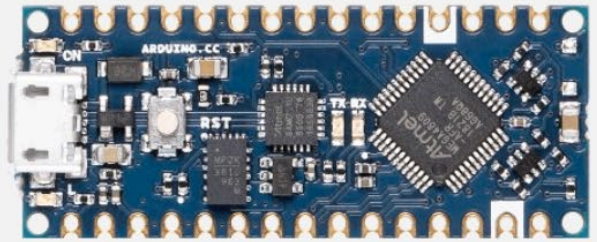
   Microprocessors (with CPU: Central Processing Unit)

   - Personal computer (running windows, mac, or linux OS)
   - Raspberry Pi (small computer, running linux OS)
   - Arduino board (microprocessor)
   - Other boards similar to Arduino boards

https://www.sparkfun.com/standard_arduino_comparison_guide

	PC	Raspberry Pi	Arduino Uno	Arduino Mega	Feather M0	Feather M4
Processor make	Intel, AMD, Apple	ARM Cortex-A72	Atmega328P	ATmega2560	ATSAMD21G18	ATSAMD51
cores	1 to 64 (standard)	4	1	1	1	1
Speed	Up to 3.8 GHz	Up to 1.8 GHz	16 MHz	16 MHz	48 MHz	120 MHz

Arduino Boards



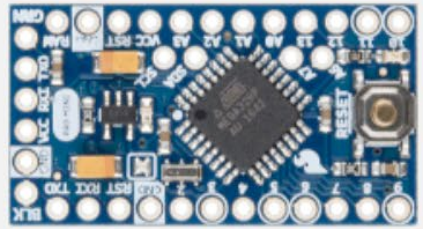
Arduino Nano Every

Arduino Uno Rev3

Arduino Mega 2560 Rev3

Arduino Nano 33 BLE Sense

Arduino Zero

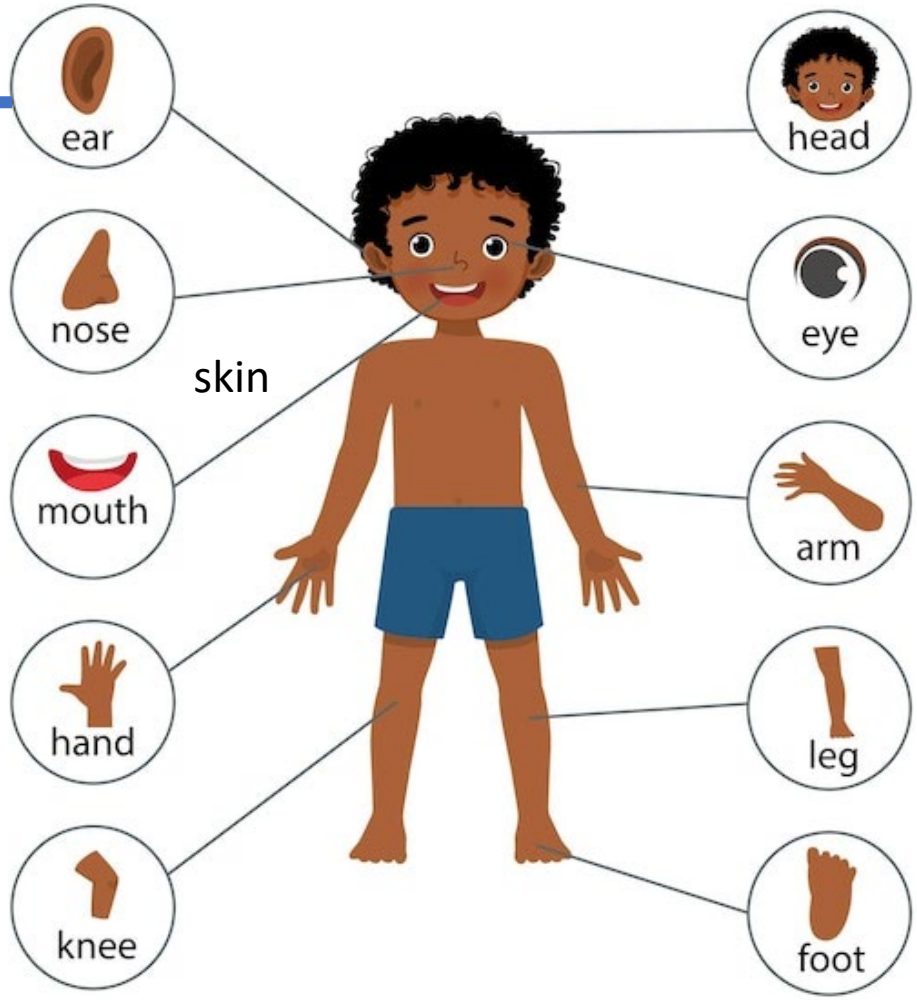


Arduino Pro Mini

2. To sense the environment, we will add various sensors

MAX9814

- Microphone with an built-in amplifier
- Measures sound waves



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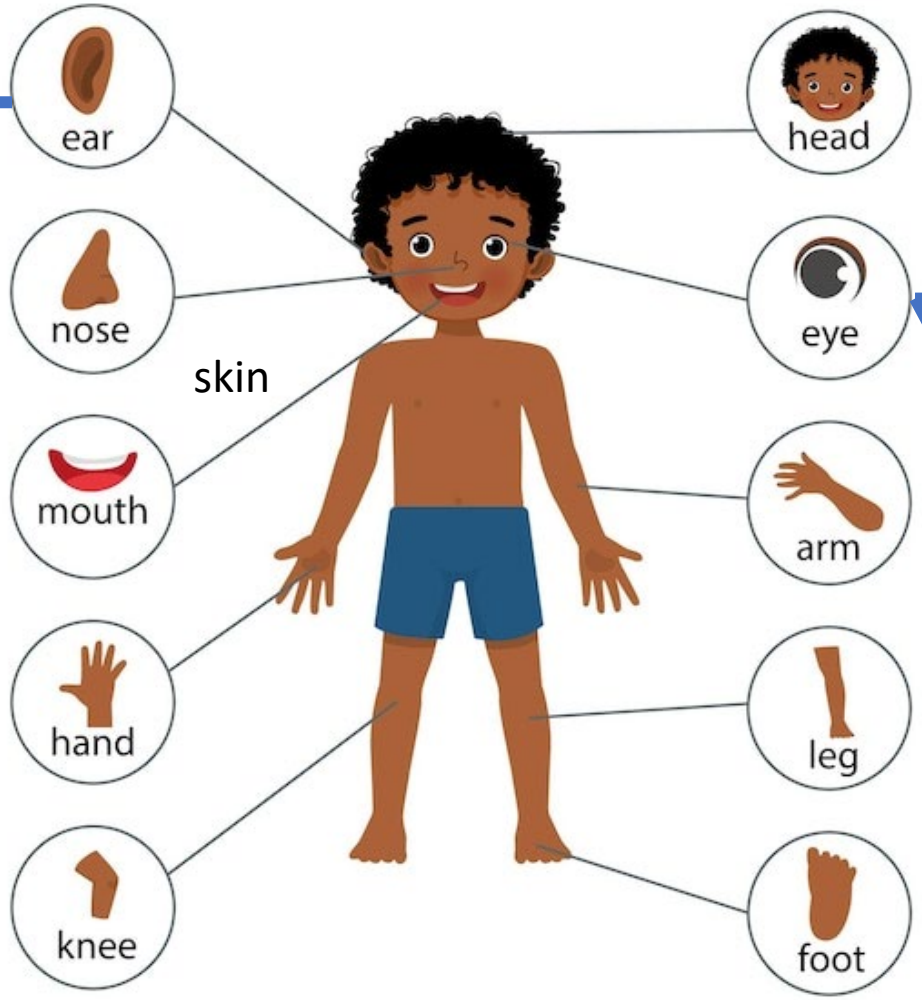
MAX4466

- Microphone with a built-in amplifier
- Measures sound waves



TSL2591

- Light sensor (LUX)
- Infrared & full-spectrum

VL6180: Time-of-flight distance sensor

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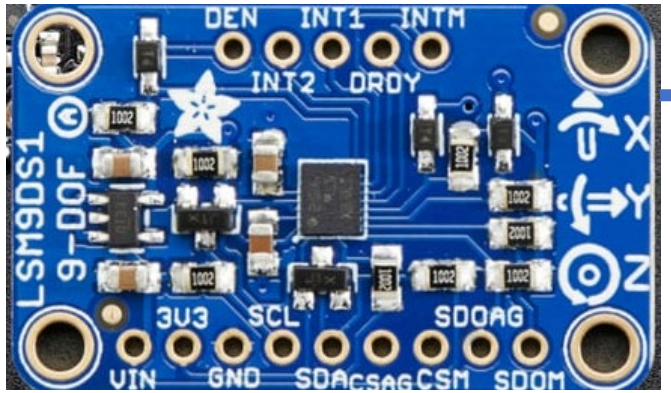
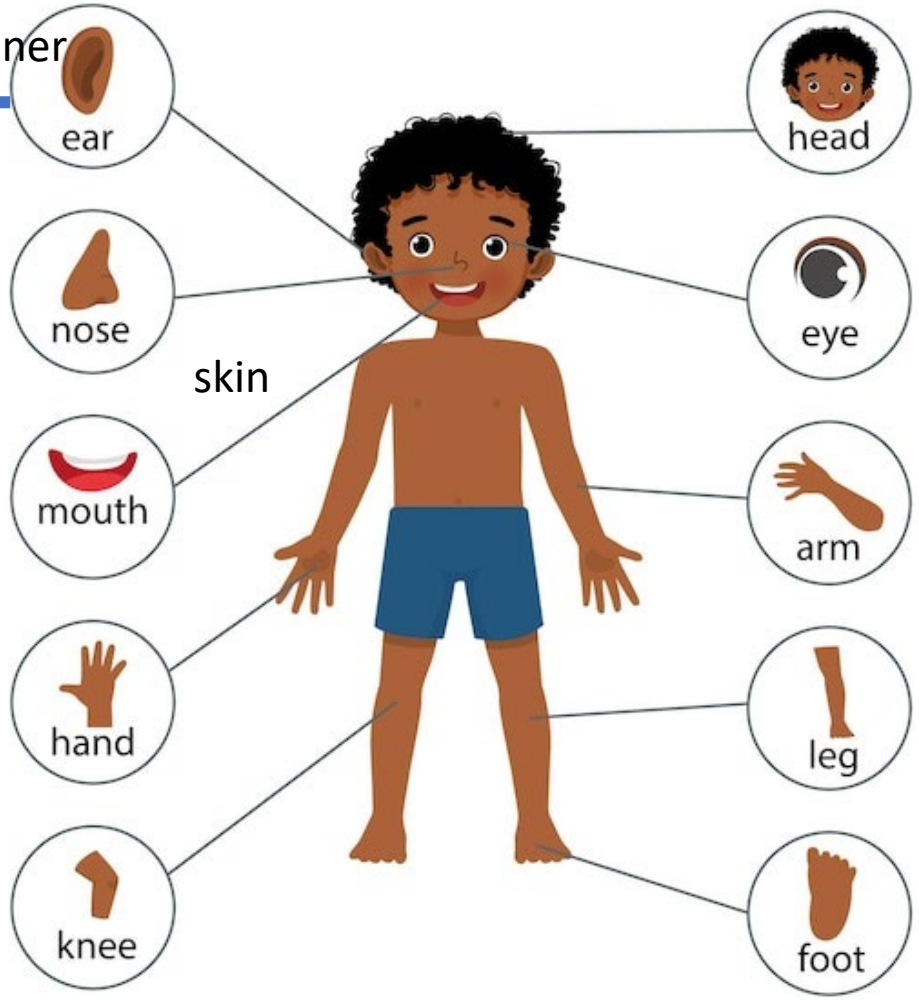


LSM9DS1 (9-DOF)

- Accelerometer
- Gyro
- Magnetometer



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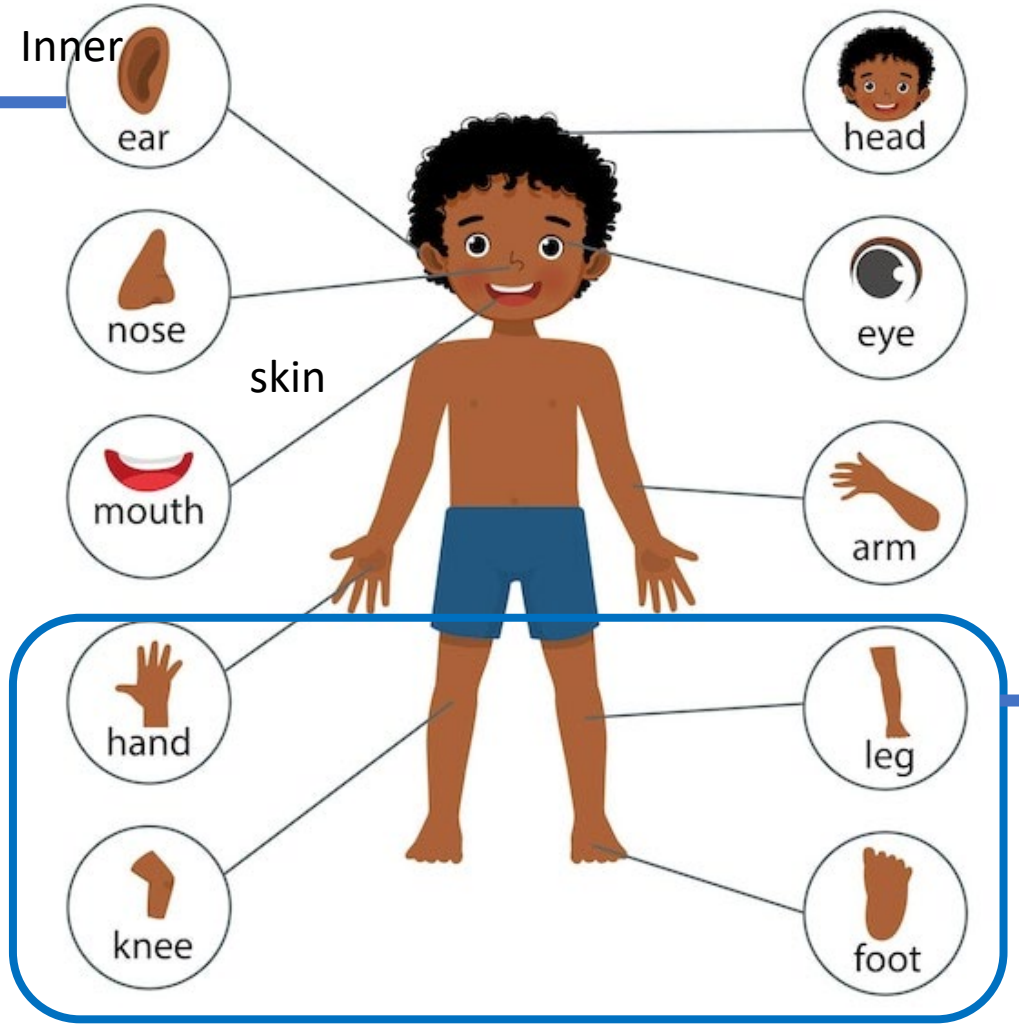
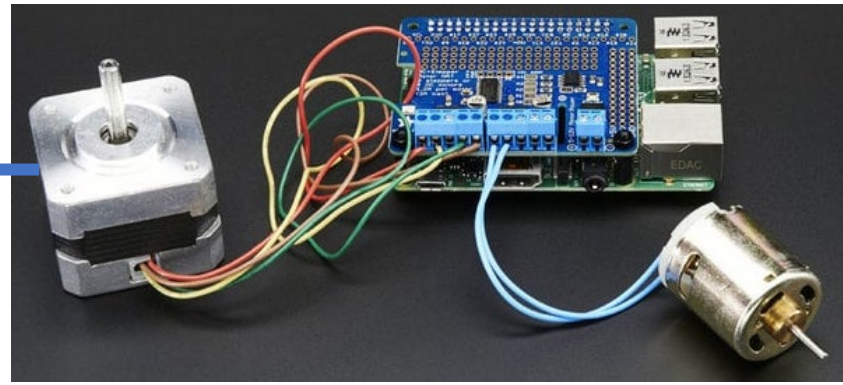
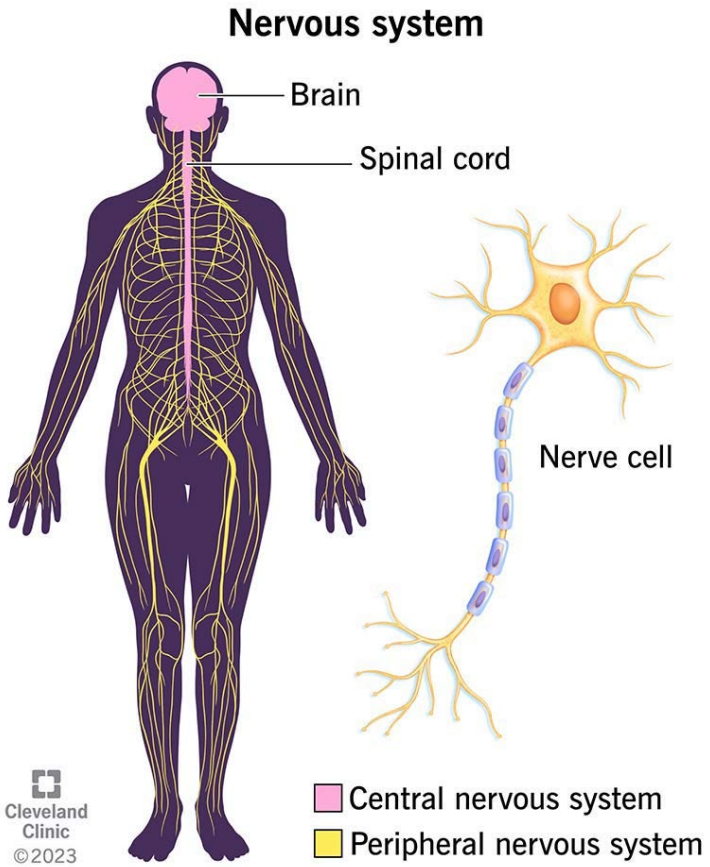


3. Output and control:



Stepper Motors and Control Board

4. The sensor signals will need to be sent to the processor via communication buses



Within the boards, we have communication bus & protocol

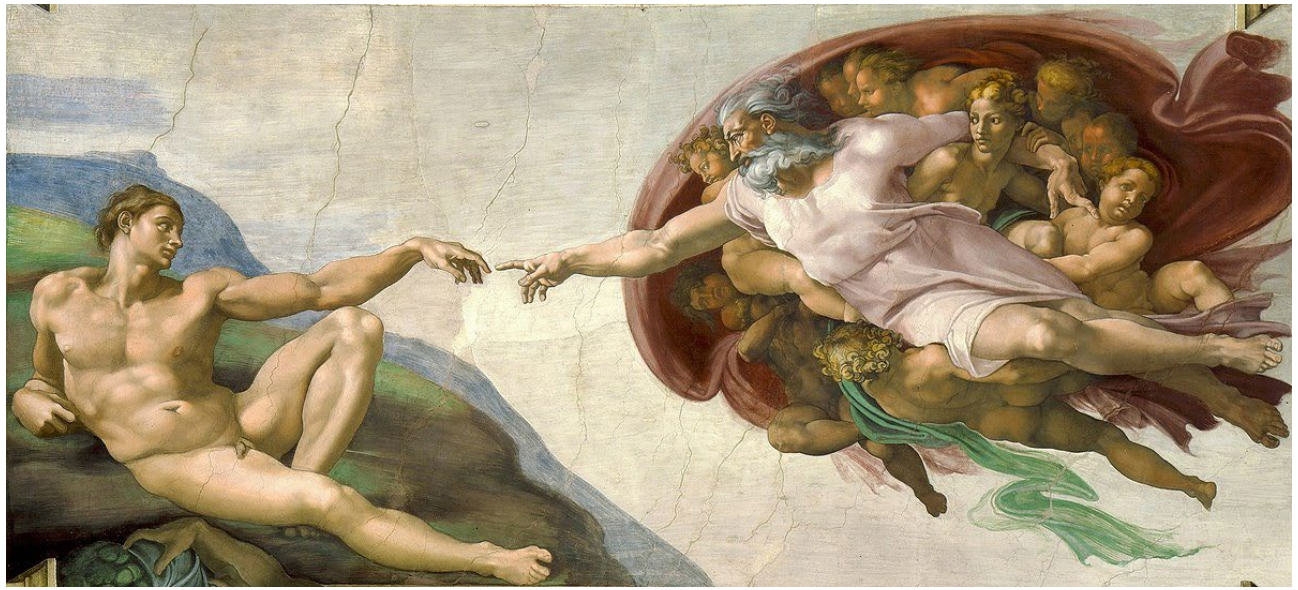
- Serial communication (UART, Universal Asynchronous Receiver/Transmitter)
- I2C (Inter-integrated Circuit)
- SPI (Serial Peripheral Interface)

There are also wireless communication available:

TECHNOLOGY	APPLICATION	SUCCESS METRICS	DATA RATE	RANGE
Wi-Fi	LAN, Internet	Speed, Flexibility	.1-7 Gbps	100m
Li-Fi	LAN, Internet	Security, Speed, Cost	1-3.5 Gbps	10m
Bluetooth	PAN, Mobile Credentials	Cost, Convenience	48 Mbps	<300m
ZigBee	Sensor Networks	Reliability, Power, Scalability, Cost	.250 Mbps	70-300m

II (or B) Software: Finally, you need to "program" how the brain process the signals

- You will write programs and download to the microprocessor:



  - Arduino: C++ (in Arduino IDE), or python (circuit python)
  - Python: to process the recorded data (on your PC) to make sense of the data
  - *Modify examples*

PHYS 523: Projects

- Muon Tomography for commercial and security applications
- Radiation Monitoring for extreme environments
- Cryogenic Technologies for quantum industries

Equipment box

- Please return at end of spring term
- Small components are easy to lose; be careful
  - replenish from cabinets and shelves if possible (not other kits)
- Wash hands after handling metal parts of included hardware (some contain lead)
- Tweezers have sharp tips; be careful

In-class assignment and Homework (due 9/2)

- Download and install ARDUINO IDE
- Connect ARDUINO MEGA 2560
- Load and run the Blink program
- Blink your name in Morse code