Medical Electronics

Arduino

Organization

- Laboratory:
  - 3 exercises
  - Pass/Fail
  - 25% of the final grade
- Project:
  - Arduino-based project + Report
  - 25% of the final grade
- Final test:
  - Single choice test
  - ~15 questions
  - 50% of the final grade

Course schedule - lectures

Date/hour	Topic
13.10. 11:15-13	Arduino (A. Królak)
20.10 11:15-14	Medical Imaging I (A. Materka)
27.10 11:!5-14	Medical Imaging II (A. Materka)
3.11 11:15-13	EOG, EMG, (A. Królak)
10.11 11:15-13	EEG Artifacts and Noise (A. Królak)
17.11 11:15-13	Medical Instrumentation (A. Królak)
24.11 11:15-13	Thermal Imaging (M. Strąkowska)
1.12 11:15-12	Test

Course schedule – laboratory & project

Group I	Group II	Topic
12.10 15:15-17	13.10 13:15-15	Laboratory 1
19.10	20.10	No labs
26.10 15:15-16	27.10 14:15-15	Laboratory 2
2.11	-	No labs – Wednesday plan
9.11 15:15-17	3.11 13:15-15	Laboratory 3
From 10.11		Work on projects Consultations possible on Thursdays 15-17 and Fridays 13-15

Arduino

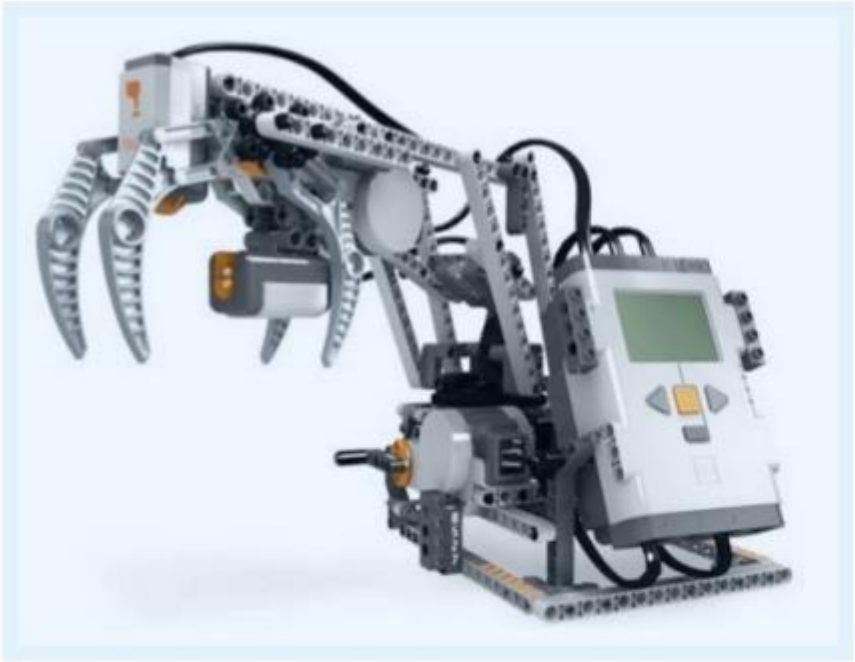
- microcontroller-based kits for building digital devices and interactive objects

- Wikipedia says:

  A micro-controller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals


Expensive but user friendly
+
i-cubeX
Lego Mindstorm
Phidgets
Make Controller
Price
Wiring
BasicStamps
Sufficient for almost all needs
Arduino
Chips and PCBs
Bare / custom
-
easy to use
some knowledge required
advanced
Technological Ability

☆ Lego Mindstorm NXT



Approx.
~€250

☆ Arduino

Approx.
~€25

☆ ATMega168

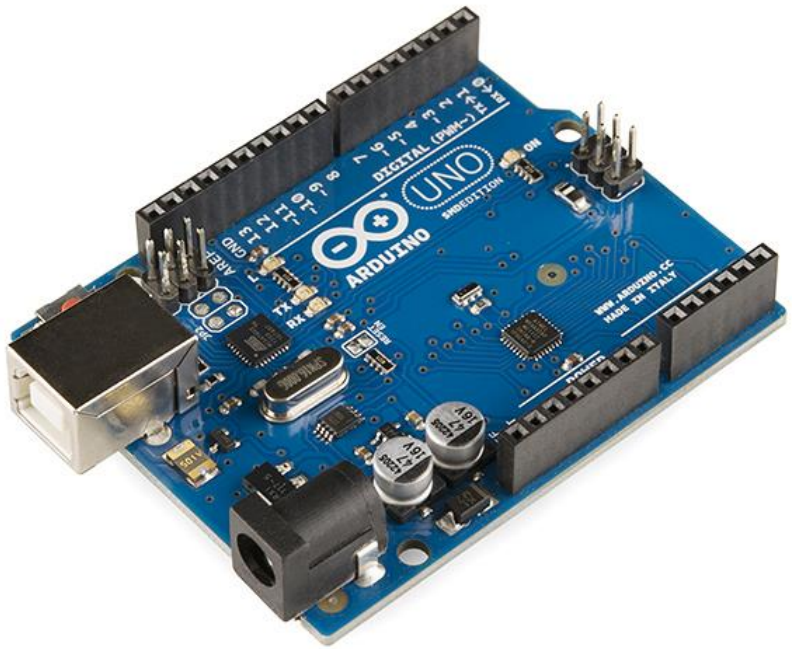
Approx.
~€4

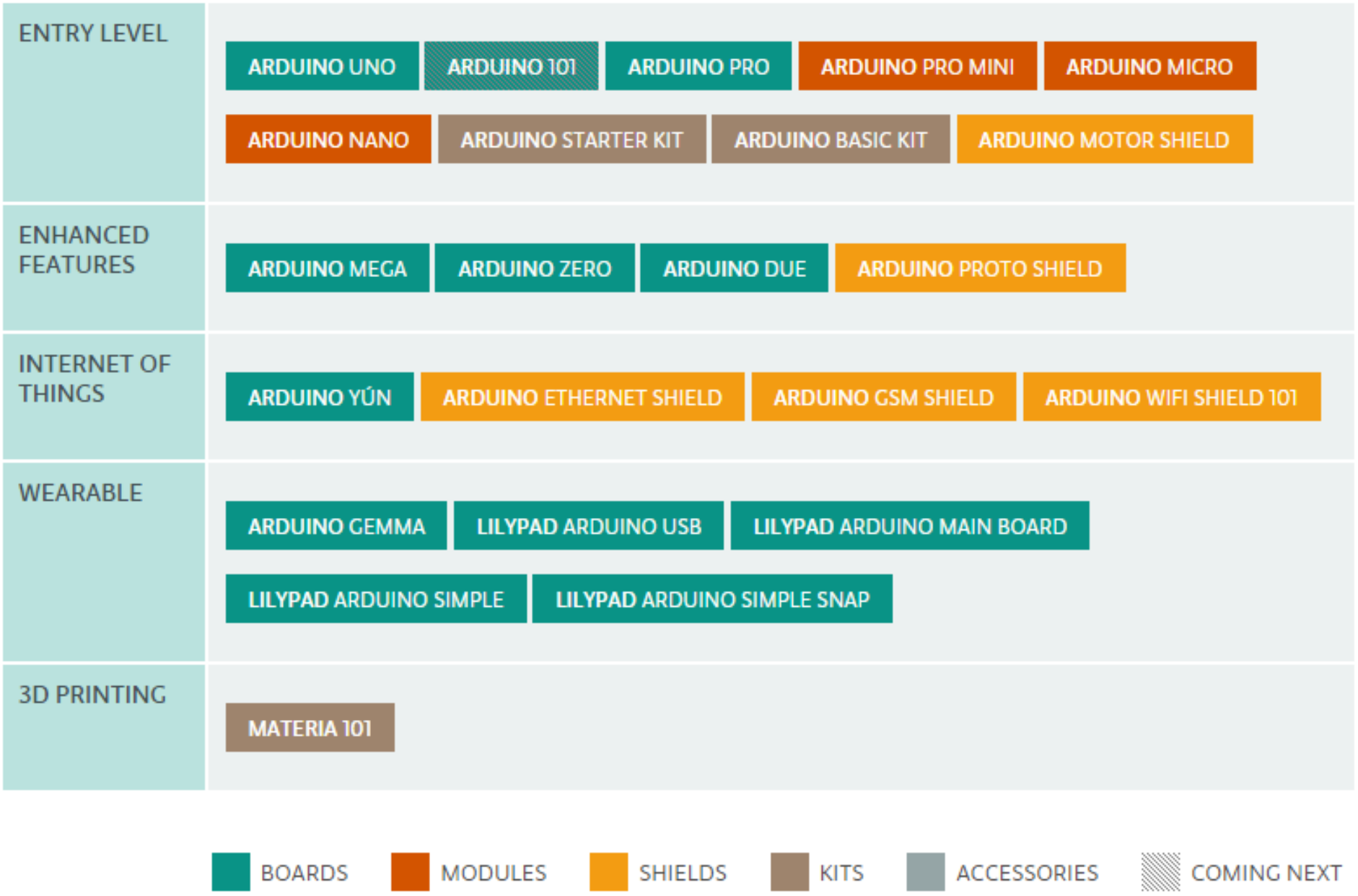
History

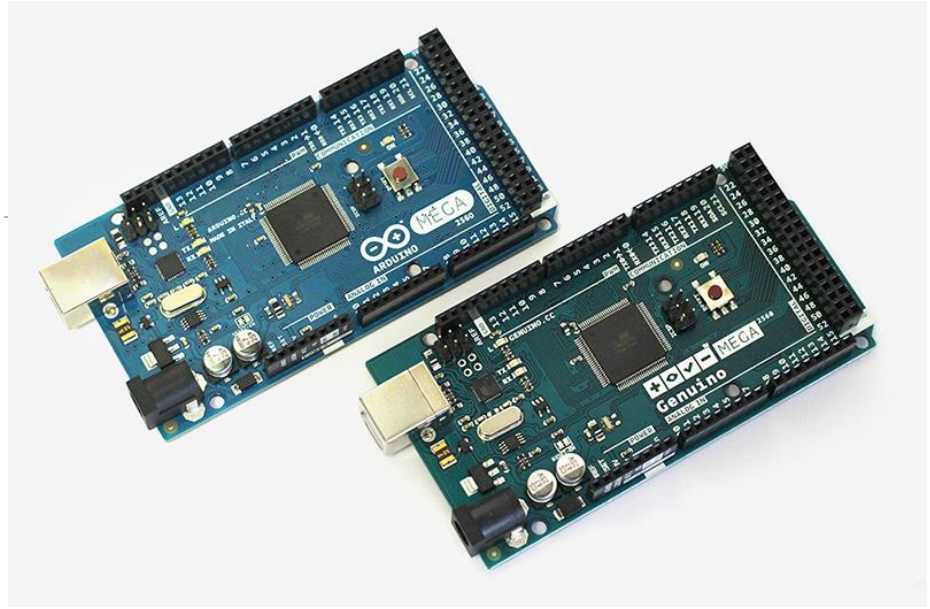
- The Arduino project grew largely out of the "DIY" climate to easily prototype interactive works.
- In 2005, the Arduino team was formed in Ivrea, Italy, consisting of Barragan, Massimo Banzi, David Cuartielles, Dave Mellis, Gianluca Marino, and Nicholas Zambetti
- The Arduino achieved rapid success even within its first two years of existence, selling in a quantity of more than 50,000 boards.
- By 2009, it had spawned over 13 different incarnations, each specialized for different applications
- Adafruit Industries estimated in mid-2011 that over 300,000 official Arduinos had been commercially produced,[3] and in 2013 that 700,000 official boards were in users' hands.

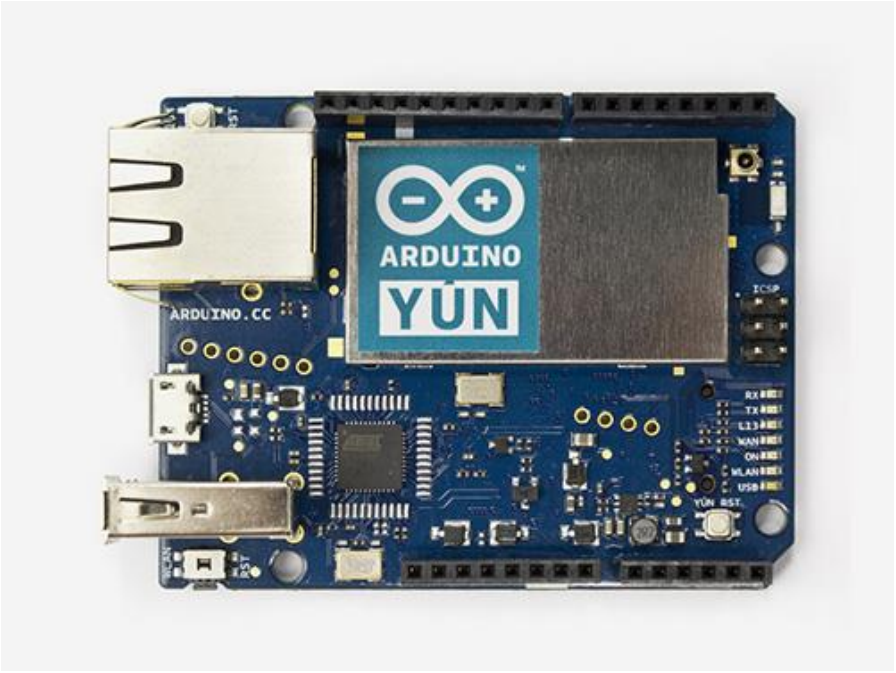
Arduino

- Prototype board
- Development environment

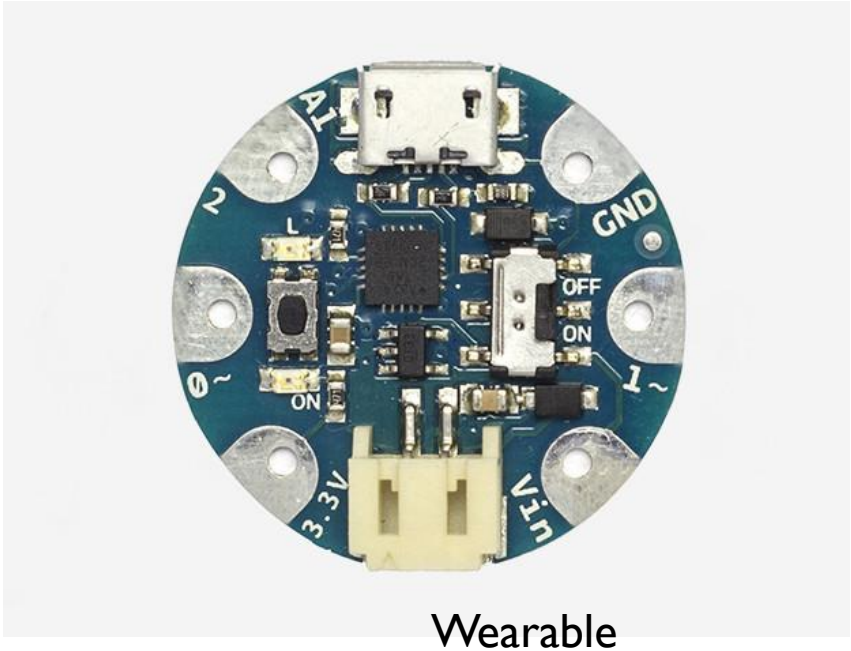



ENTRY LEVEL
ARDUINO UNO
ARDUINO 101
ARDUINO PRO
ARDUINO PRO MINI
ARDUINO MICRO
ARDUINO NANO
ARDUINO STARTER KIT
ARDUINO BASIC KIT
ARDUINO MOTOR SHIELD
ENHANCED FEATURES
ARDUINO MEGA
ARDUINO ZERO
ARDUINO DUE
ARDUINO PROTO SHIELD
INTERNET OF THINGS
ARDUINO YÚN
ARDUINO ETHERNET SHIELD
ARDUINO GSM SHIELD
ARDUINO WIFI SHIELD 101
WEARABLE
ARDUINO GEMMA
LILYPAD ARDUINO USB
LILYPAD ARDUINO MAIN BOARD
LILYPAD ARDUINO SIMPLE
LILYPAD ARDUINO SIMPLE SNAP
3D PRINTING
MATERIA 101
BOARDS
MODULES
SHIELDS
KITS
ACCESSORIES
COMING NEXT





IoT

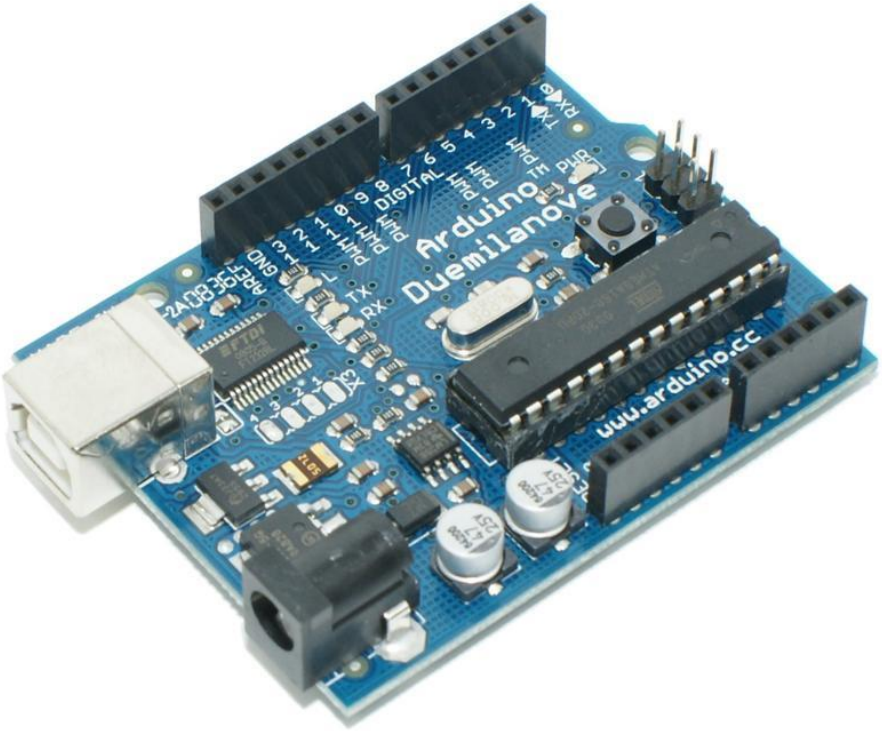


Wearable
D = ~28mm

Capabilities

Intel 286

=

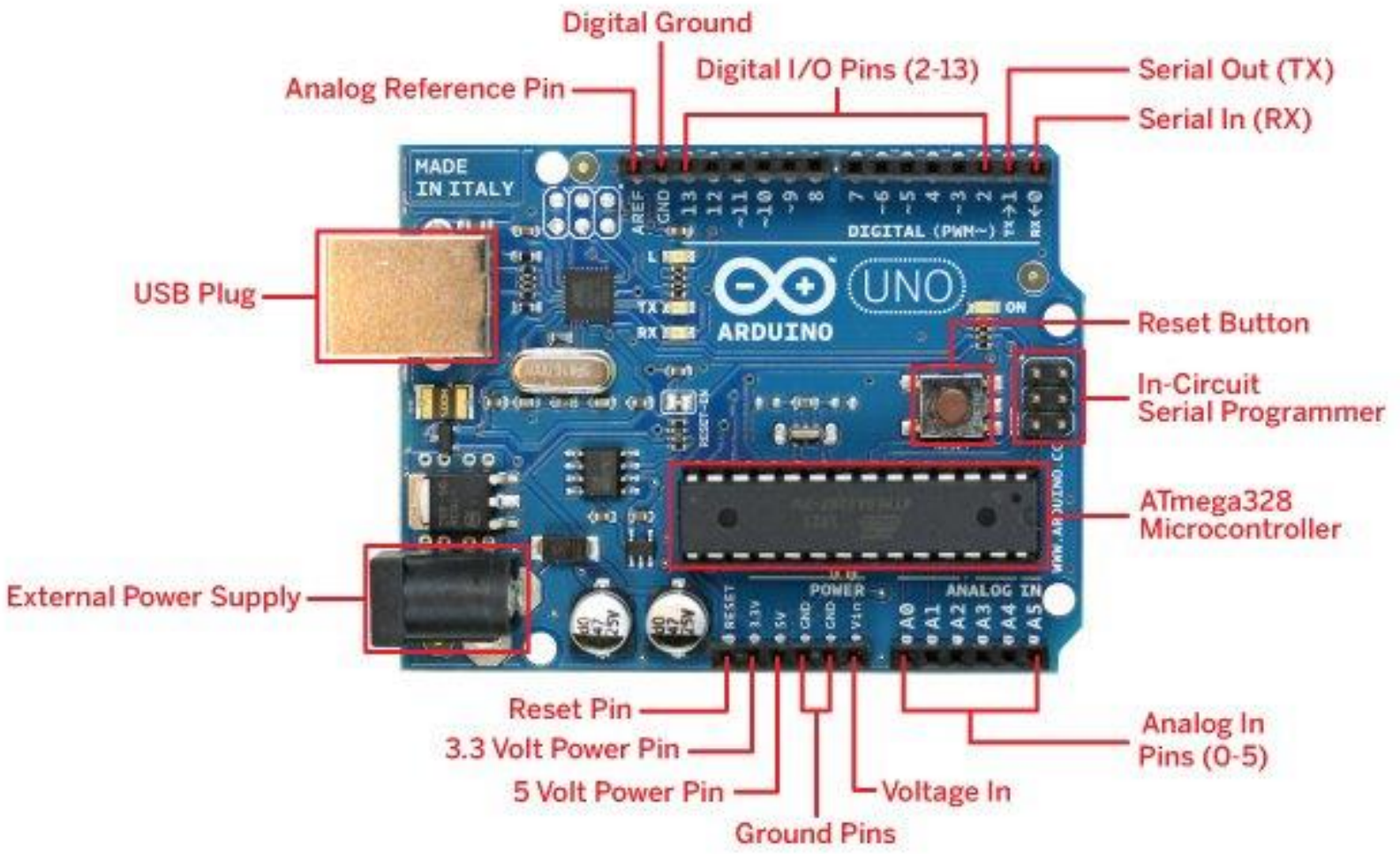


Arduino board

Capabilities

- 16 kB of Flash program memory
- 1kB of RAM
- 16MHz
- 13 digital input/output pins
- 5 analog input pins
- 6 analog input pins (PWM only)

Arduino Uno Layout

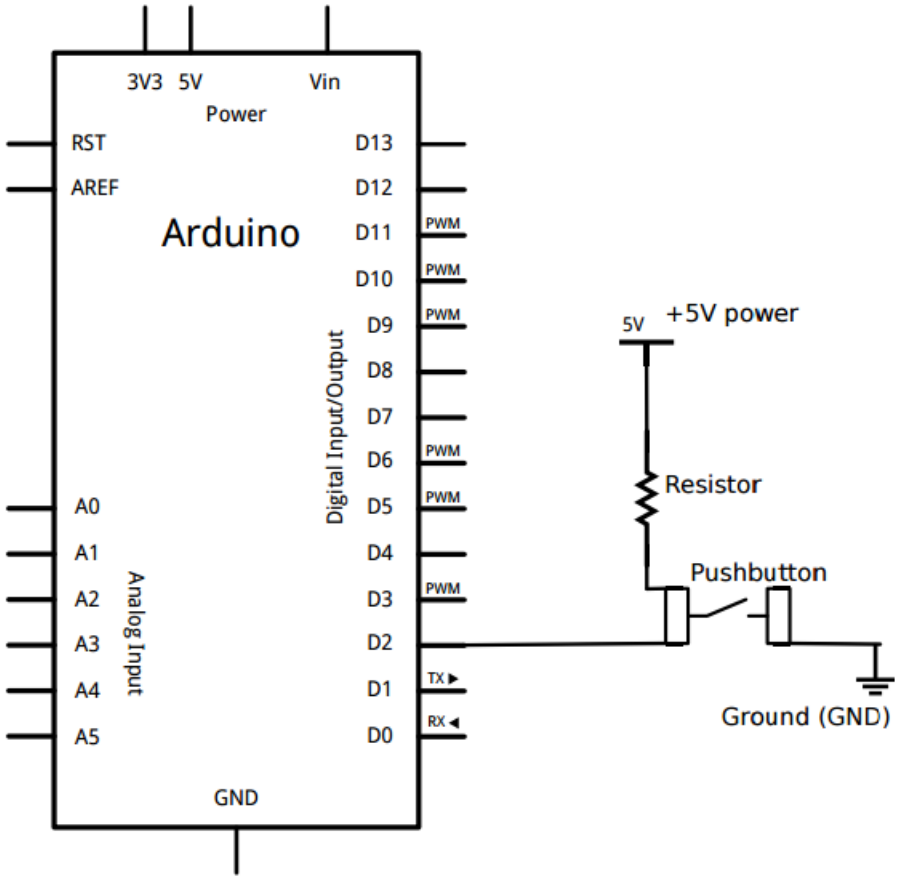


Glossary

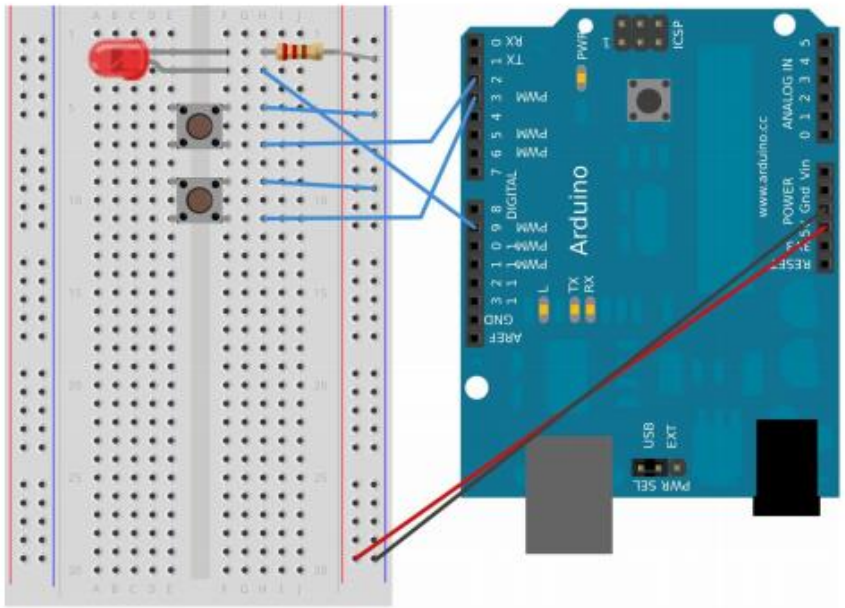
- **Sketch** – program that runs on the board
- **Pin** – input or output connected to sth.
- **Digital** – 0-1 value (OFF-ON)
- **Analog** – range (typically 255)
- **Wiring drawing** – physical layout (interconnection) of all devices and components
- **Schematic drawing** – shows underlying logic, may not link to physical layout

Diagrams

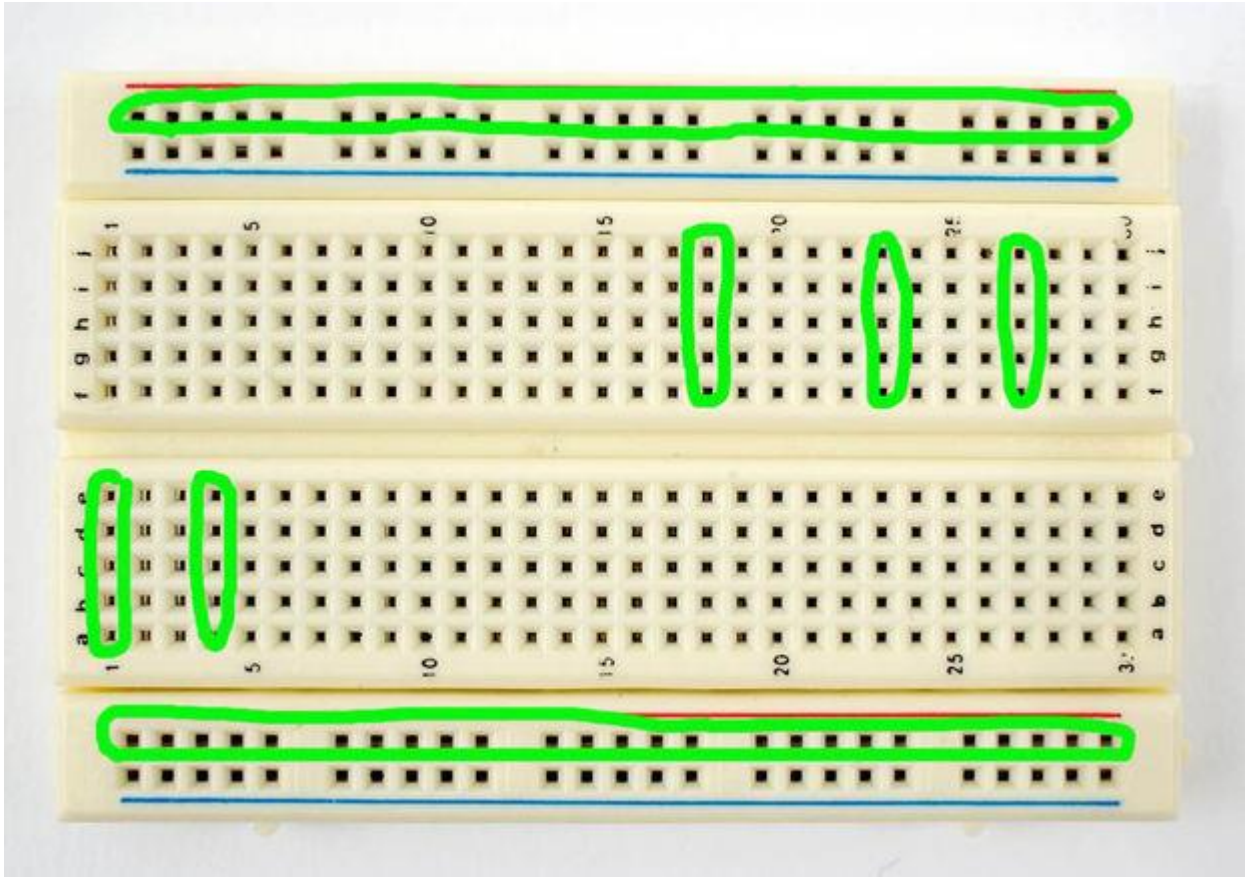
Schematic drawing



Wiring drawing



Solderless breadboard



Arduino UNO

Technical specs

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Structure of Arduino Program

```
int  ledPin = 13;
```

//global variables

```
void setup()
{
      statements;
}
```

//preparation

```
void loop()
{
      statements;
}
```

//execution

Global variables - example

```
int ledPin = 13;  //LED connected to
  control pin 13

int aSensor = 0; //setup sensor
  'aSensor' on analog pin 0

int statePin = LOW; //holds state of a
  pin
```

void setup() - example

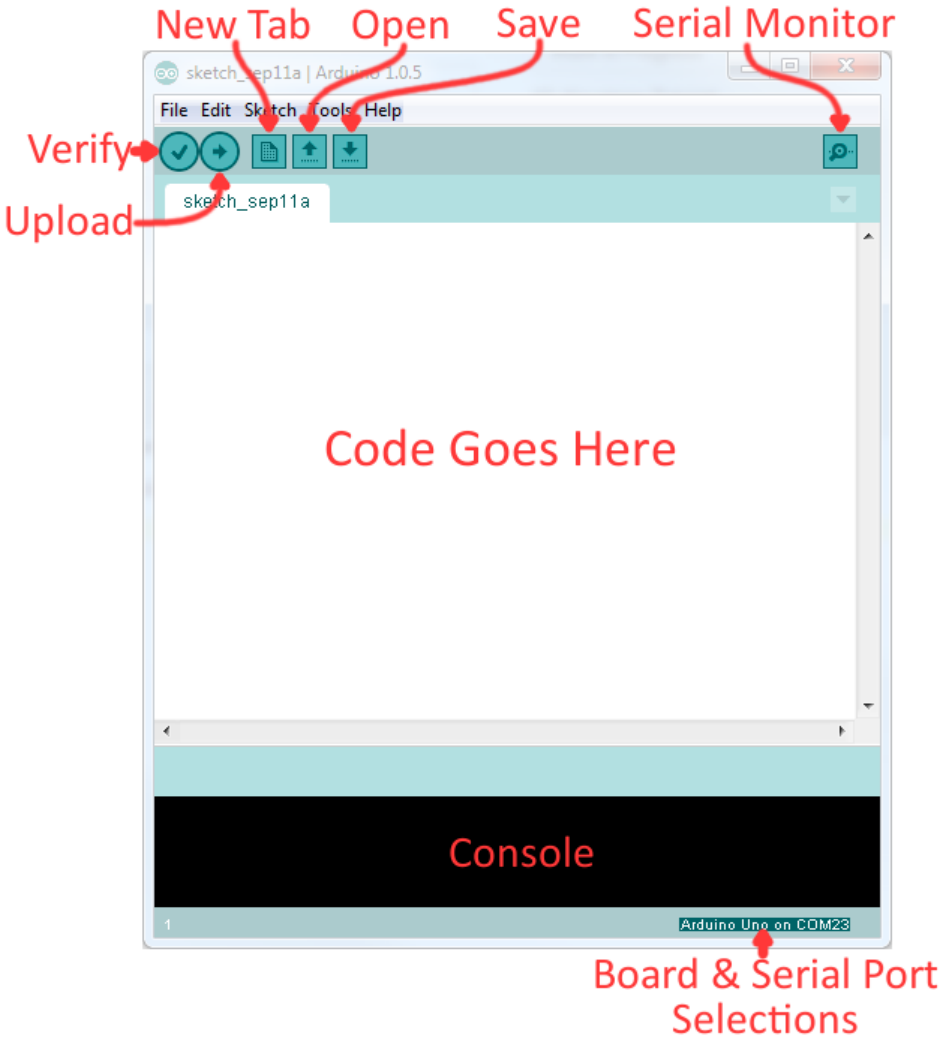
```
pinMode(ledPin, Output); //set ledPin as
  output

serial.Begin(9600); //talk to the
  computer at 9600 bit rate
```

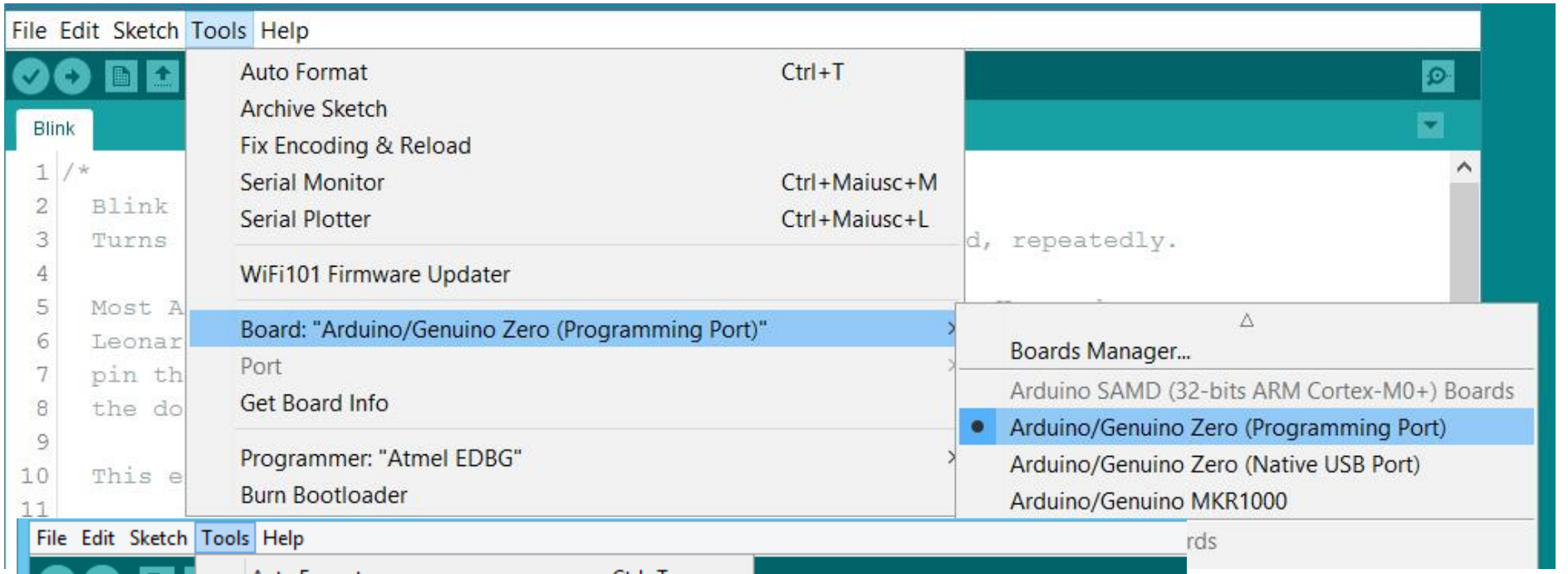
void loop() - example

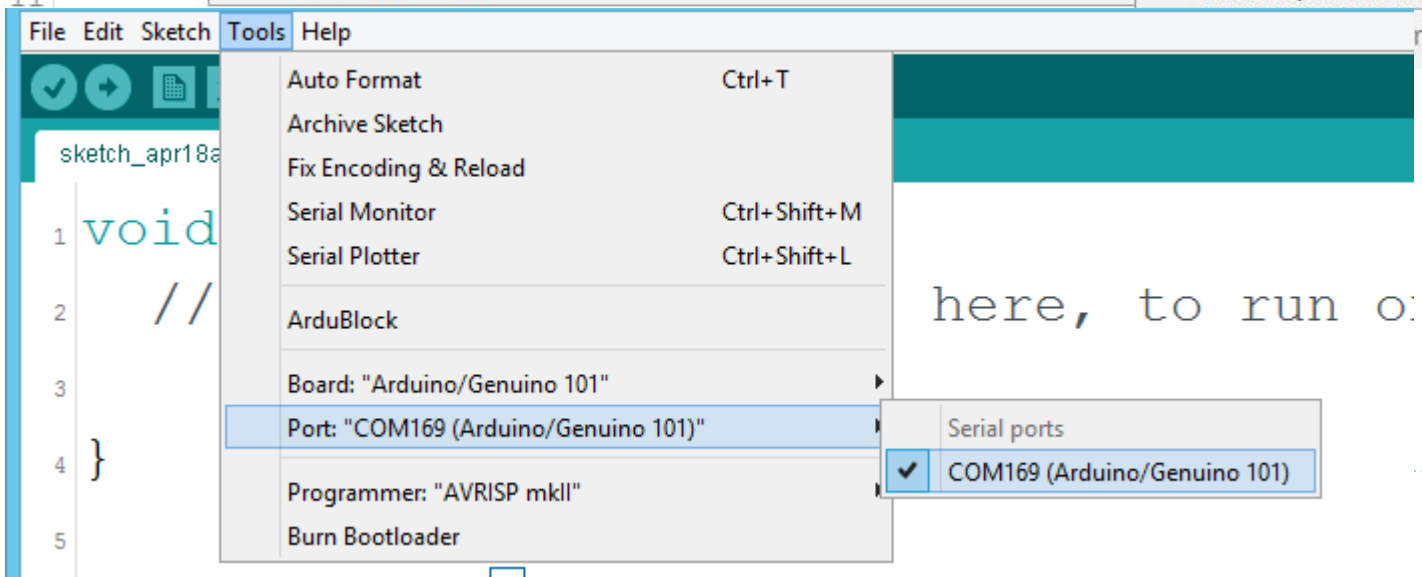
```
digitalWrite() //set digital pin to HIGH
  or to LOW
digitalRead() //read digital pin state
analogWrite() //write „analog” PWM value
analogRead() // read analog pin value
delay() //wait given amount of time
millis() //get current time
```

Arduino development environment

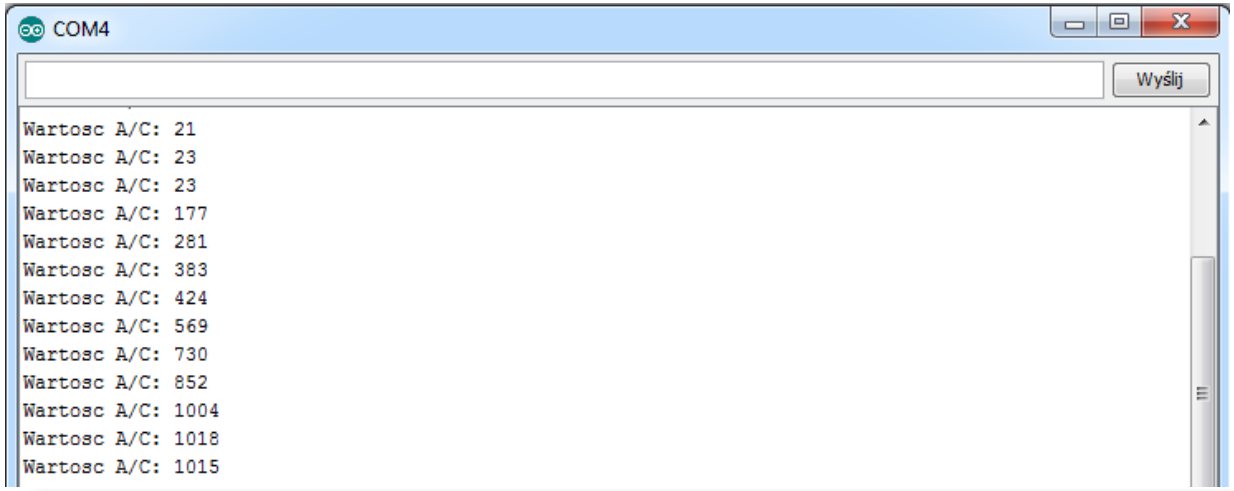


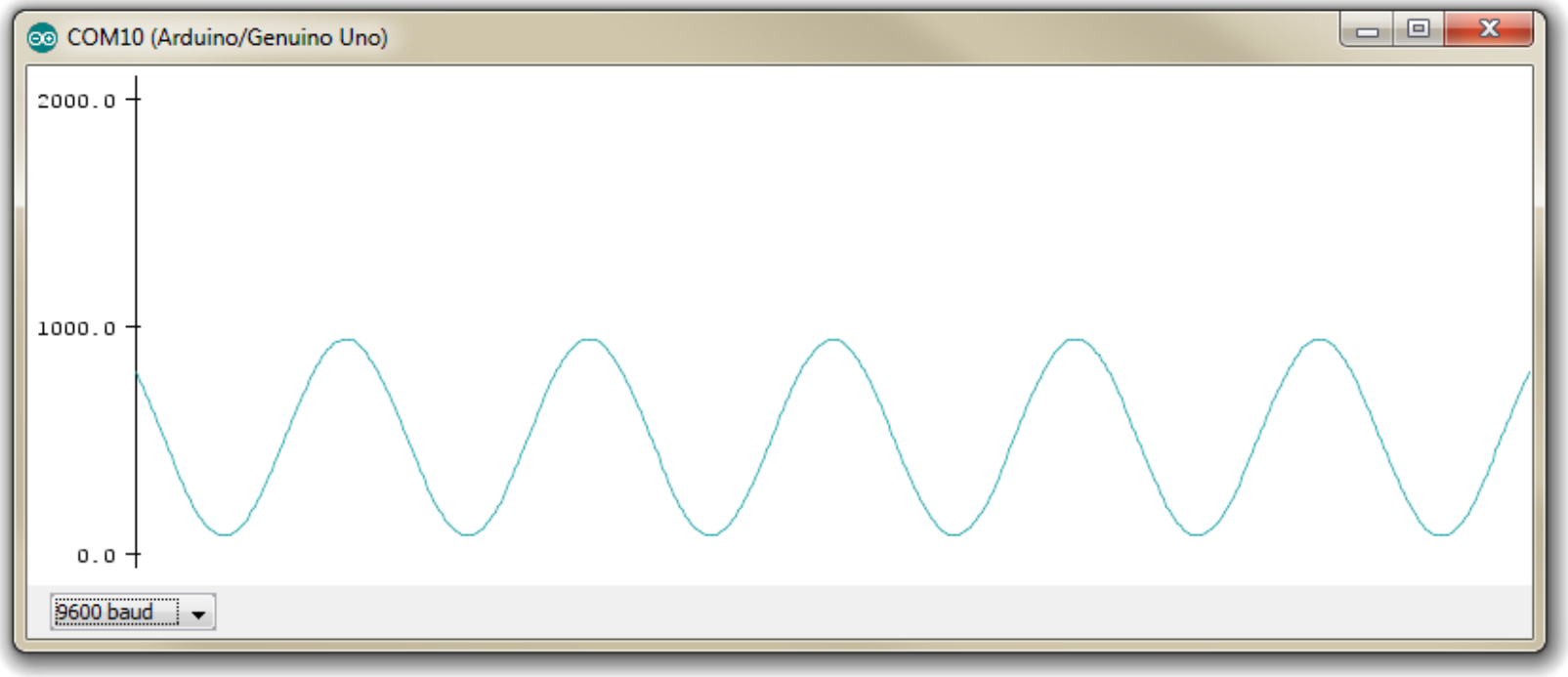
Arduino IDE - Settings





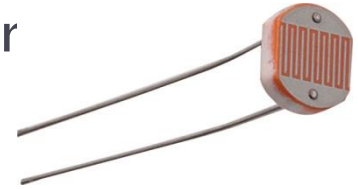
Serial Monitor & Serial Plotter

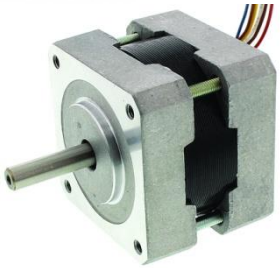




Typical Input & Output Elements

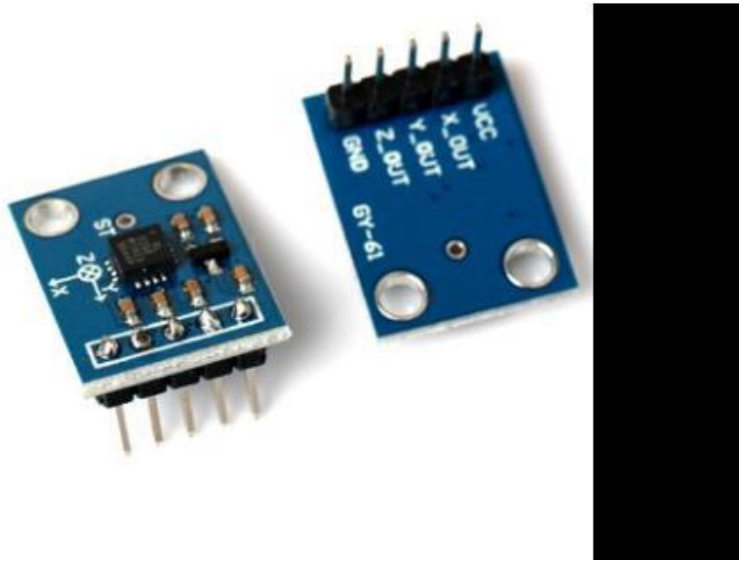
- Sensors
  - Light Dependent Resistor (LDR) = Photoresistor
  - IR (InfraRed)
  - Switch
  - Joystick
  - Ultrasonic
- Indicators
  - LED
  - Buzzer
- Actuators
  - Solenoid
  - Stepper Motor



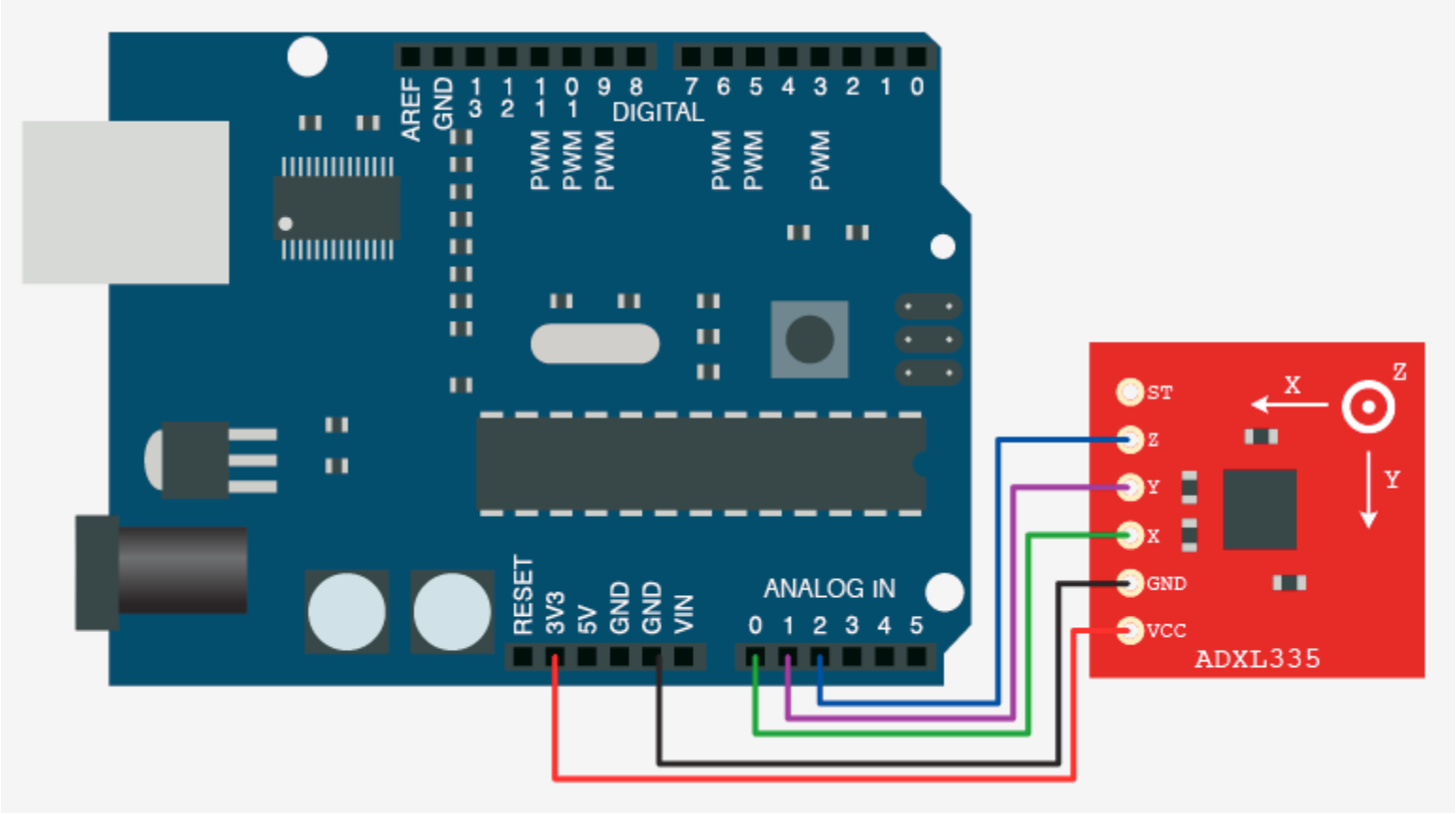


Accelerometer ADXL335

- Analog 0: test pin
- Analog 1: z axis
- Analog 2: y axis
- Analog 3: x axis
- Analog 4: GND
- Analog 5:VCC



Pedometer


AREF
GND
13 12 11 10 9 8 7 6 5 4 3 2 1 0
DIGITAL
PWM
PWM
PWM
PWM
PWM
PWM
RESET
3V3
5V
GND
GND
VIN
ANALOG IN
0 1 2 3 4 5
ST
Z
Y
X
GND
VCC
X
Z
Y
ADXL335

Pedometer – pseudo-code

- Read data from accelerometer from all axes (x, z, y):

  analogRead(axis);

- Calculate acceleration vector:

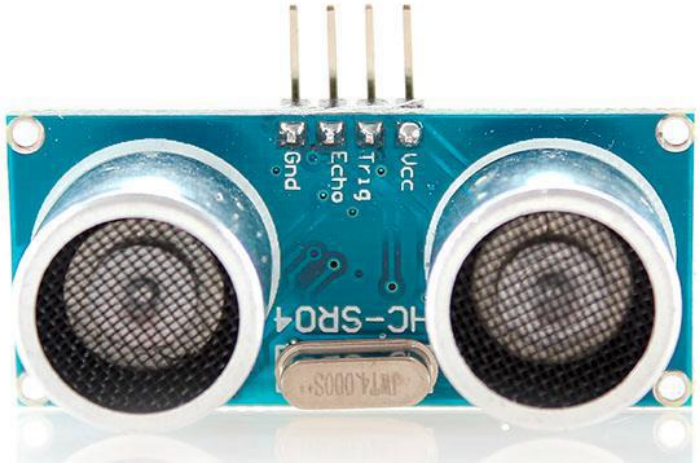
  AccVec = sqrt($x^2+y^2+z^2$);

- Analyze obtained values for threshold value
- If AccVec > Threshold count step:

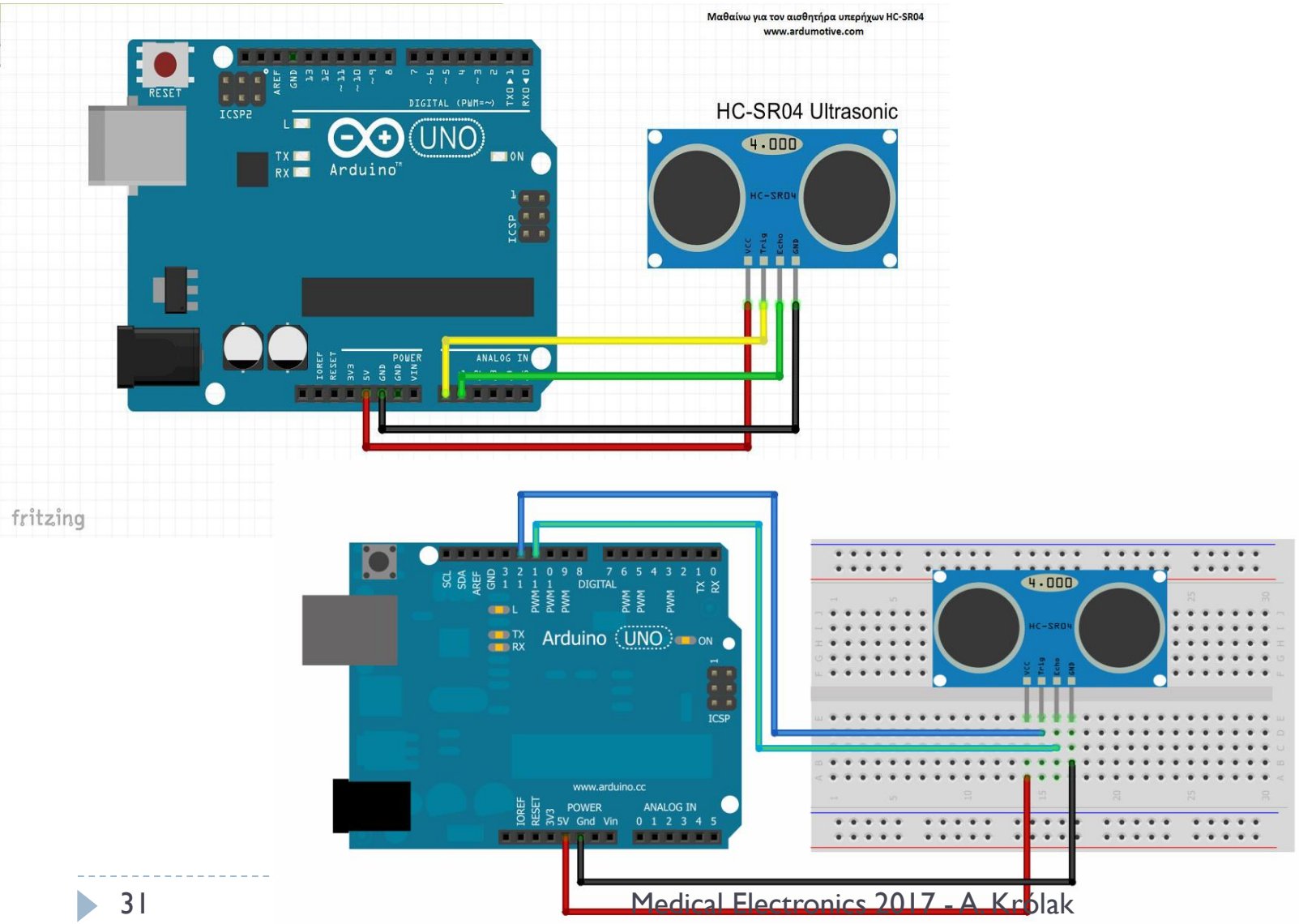
  step++;

HC-SR04

- Utrasonic ranging sensor
- Pins:
  - Trig
  - Echo
  - GND
  - VCC
- Supply 5V
- Ranging accuracy up to 3mm
- Measure angle: 15°
- Ranging distance: 2cm-4m



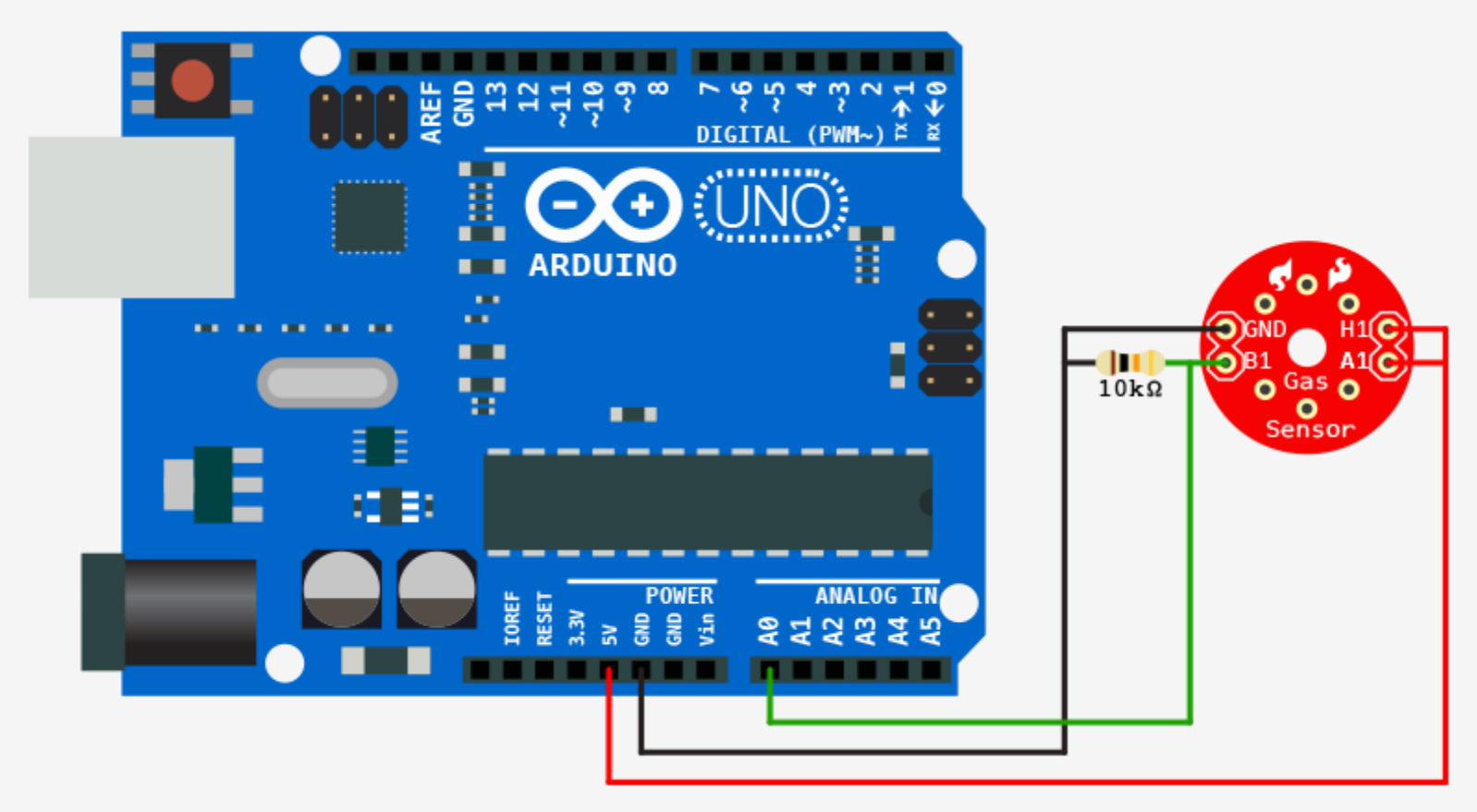
Obstacle detector



MQ-3

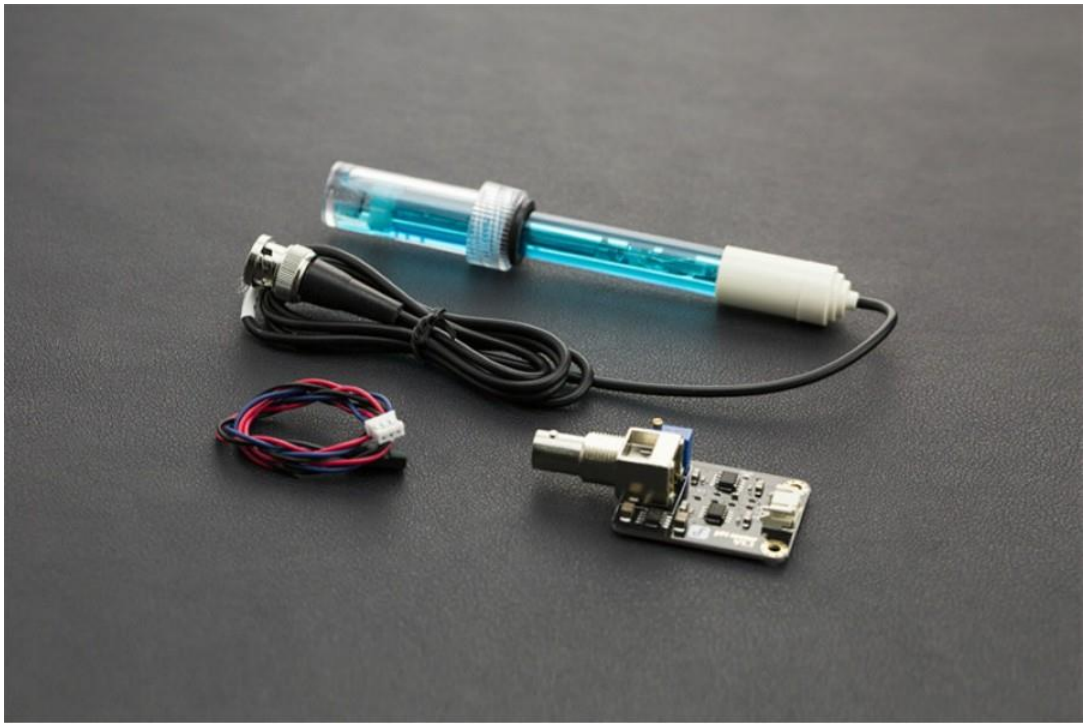
- Alcohol Gas Sensor
- Pins:
  - DOUT (digital output)
  - AOUT (analog output)
  - VCC
  - GND
- Supply: 5V

Breathalyzer



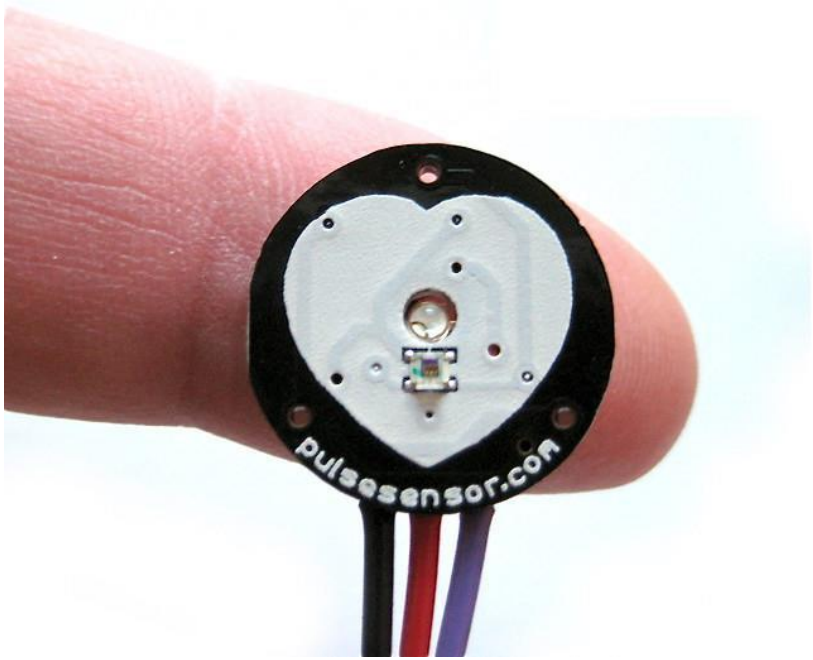
Gravity: Analog pH Sensor

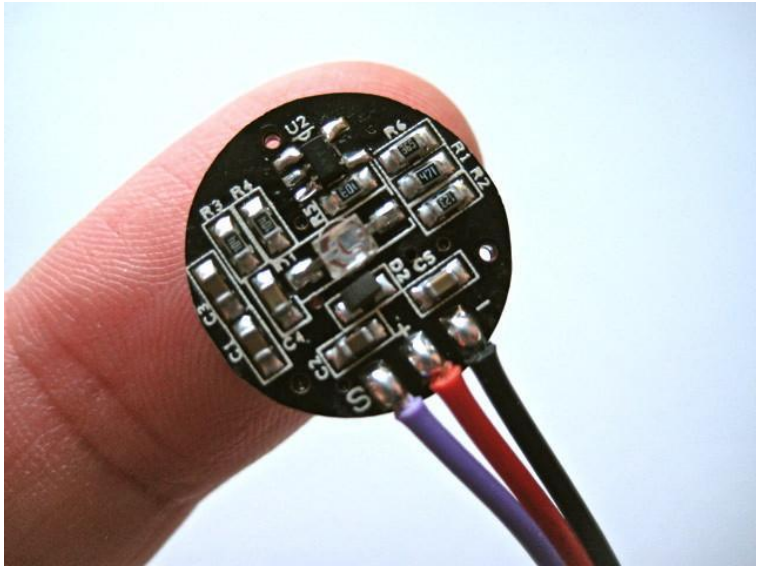
- Water quality testing
- Aquaculture
- Module Power : 5.00V
- Module Size : 43 x 32mm(1.69x1.26")
- Measuring Range :0 - 14PH
- Measuring Temperature: 0 - 60 ℃
- Accuracy : ± 0.1pH (25 ℃)
- Response Time : ≤ 1min



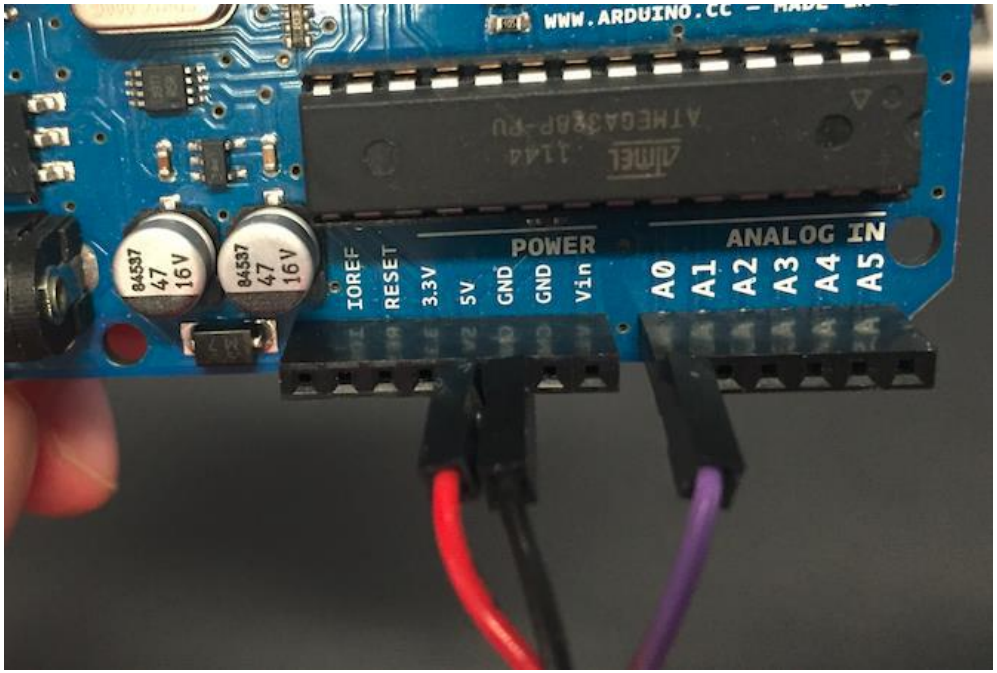
Amped

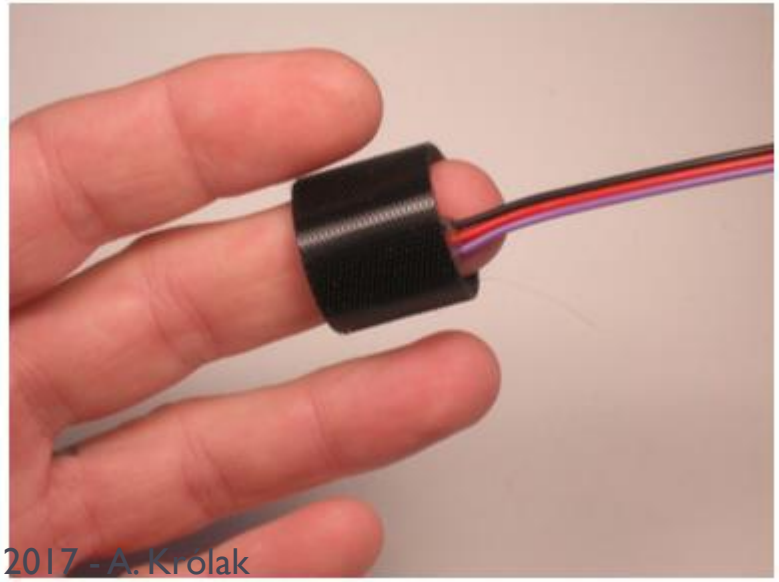
- Pulsemeter
- (+) VCC
- (-) GND
- S (analog signal)





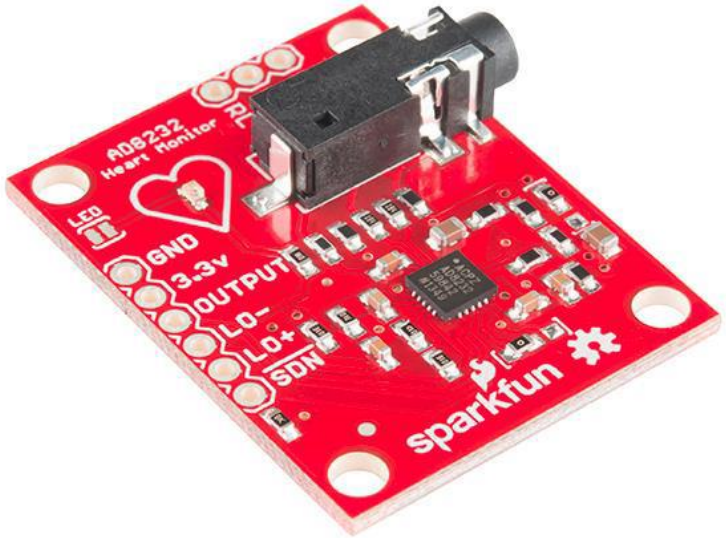
Amped


WWW.ARDUINO.CC
POWER
ANALOG IN
IOREF
RESET
3.3V
5V
GND
GND
Vin
A0
A1
A2
A3
A4
A5

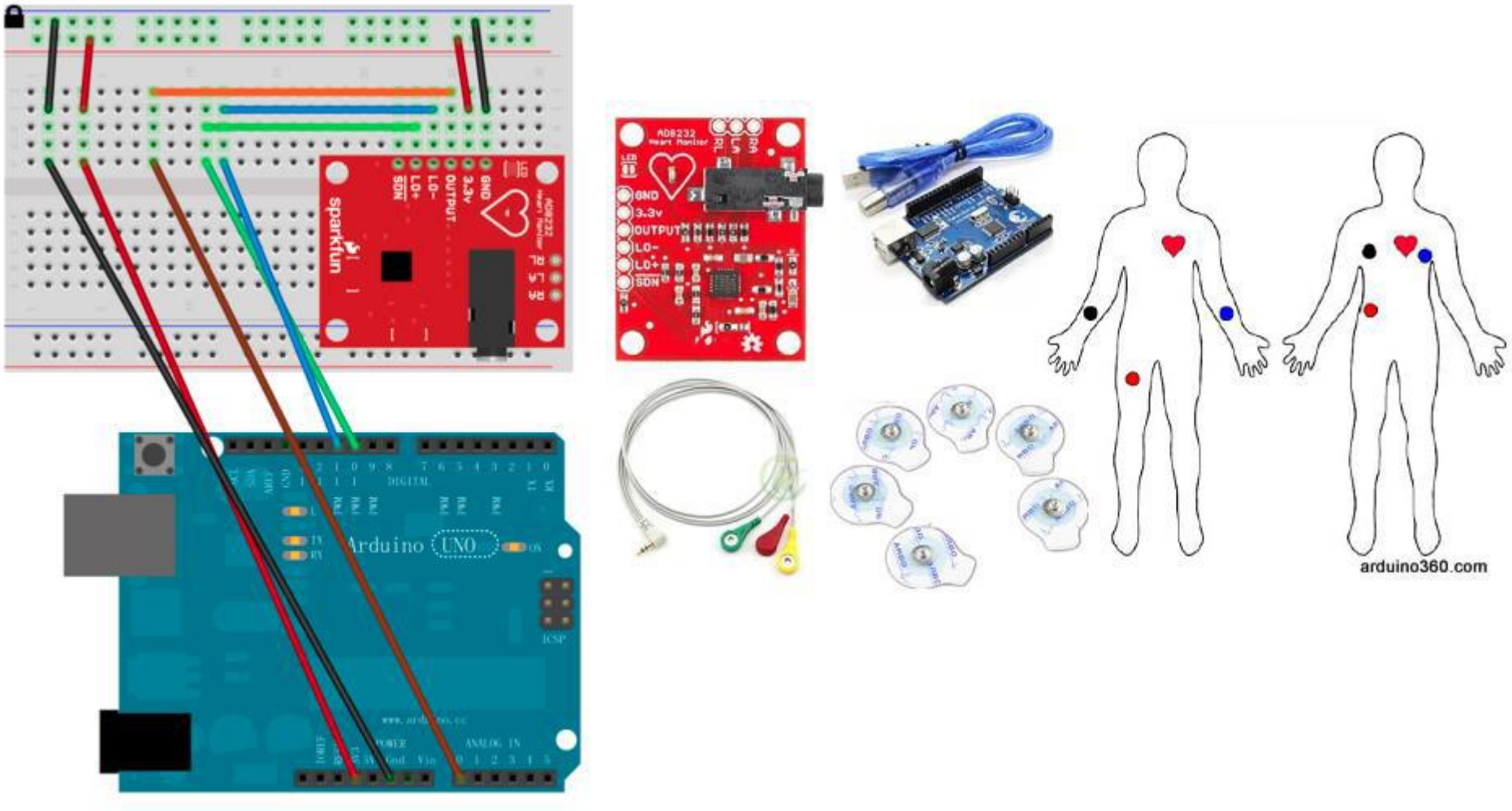


AD8232

- Single Lead Heart Rate Monitor
- Operating Voltage - 3.3V
- Analog Output
- Leads-Off Detection
- Shutdown Pin
- LED Indicator
- 3.5mm Jack for Biomedical Pad Connection

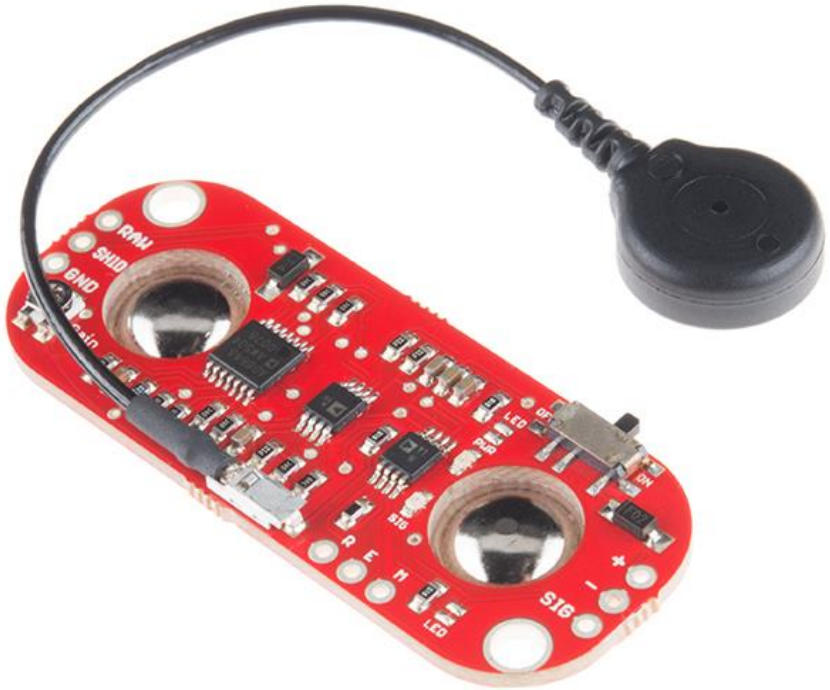


ECG monitor


sparkfun
AD8232
GND
3.3v
OUTPUT
LO-
LO+
SDN
Arduino
UNO
arduino360.com

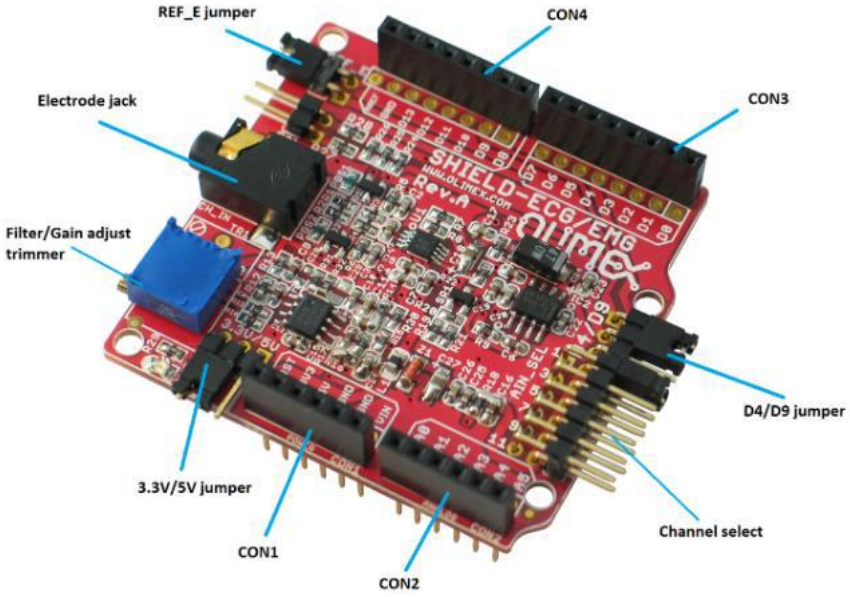
MyoWare Muscle Sensor

- Electromyography (EMG) sensor
- Wearable Design
- Single Supply
  - +2.9V to +5.7V
  - Polarity reversal protection
- Two Output Modes
  - EMG Envelope
  - Raw EMG

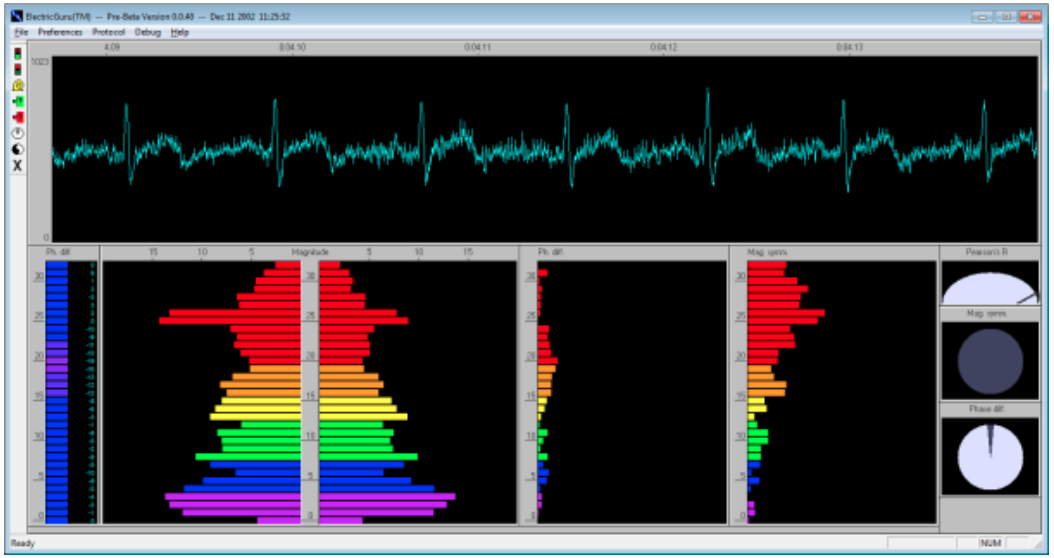


Olimex ECG/EMG shield

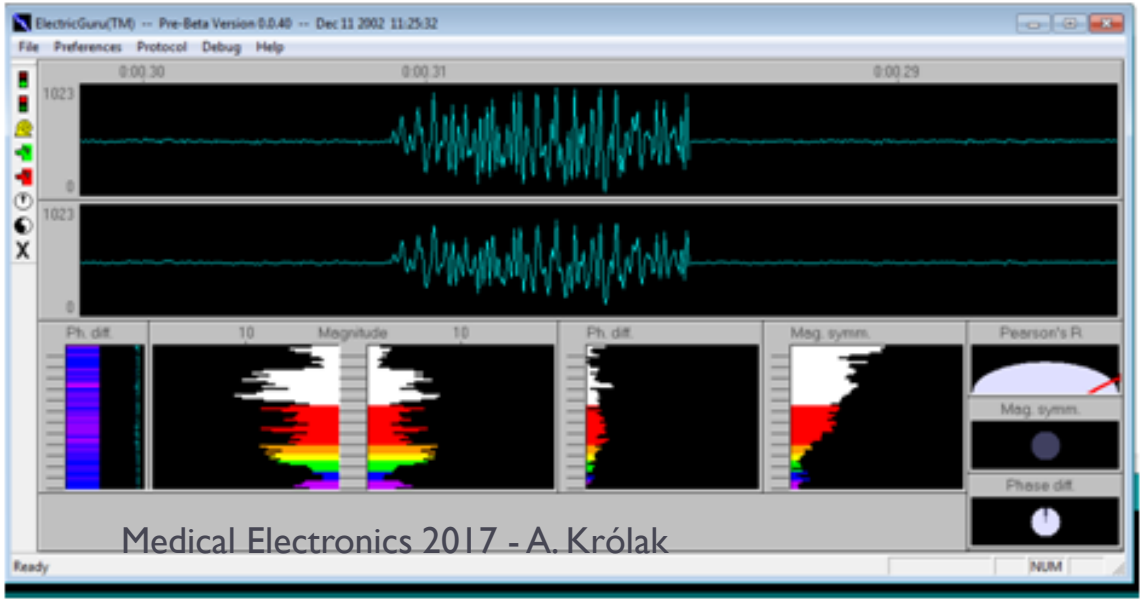
- ECG and EMG signal acquisition
- Up to 6 channels
- Supply: 3.3V or 5V



Olimex ECG/EMG shield



https://www.olimex.com/Products/EEG/OpenEEG/EEG-SMT/resources/ElecGuru40.zip



Polar Wireless Sensor

- wireless heart rate band
- Polar T34 Non-Coded Heart Rate Transmitter monitors and then wirelessly transmits your heart rate data from the chest strap
- Polar WearLink+ compatible receiver allows to monitor wearer's heart rate
- Water resistant up to 30 meters
- ECG accuracy
- Up to 2,500 hours of usage
- Non-user replaceable battery