

## Smart Objects

### Open Source Hardware

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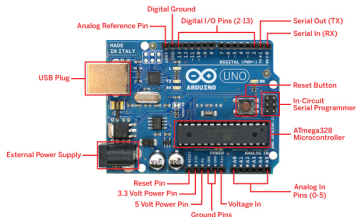
### Lecture 1



## Arduino UNO



## Arduino UNO



## Arduino UNO components

### USB Plug:

1. Power Arduino
2. Exchange Data with PC
3. Receive new program

### External Power Supply:

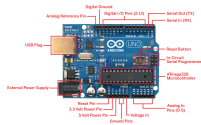
1. Recommended: 7 ... 12 V
2. Limit: 6 ... 20 V

### ATmega328P Microcontroller:

1. 32KBytes FLASH (program)
2. 1KBytes EEPROM
3. 2KBytes Internal SRAM
4. Clock: 16MHz ( $\approx$  20

### Input/Output:

1. 14 Digital I/O
2. 6 PWM Digital
3. 6 Analog Inputs



## Sense-Think-Act Paradigm

**Sense-Think-Act** is a popular interaction paradigm

1. **Sense** – observe the environment
2. **Think** – based on the observation, make a decision
3. **Act** – based on the decision, perform some action(s)



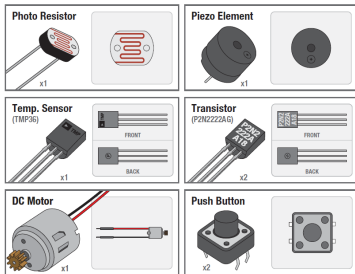
## Sense-Think-Act: Physical Computing

Almost all systems that use physical computing will have a combination of the following

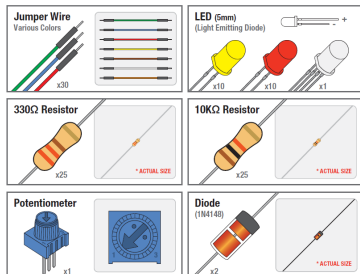
1. **Sense** → **Input** – signal/informing going into the boards
  - ▶ Buttons Switches, Light Sensors, Flex Sensors, Humidity Sensors, Temperature Sensors ...
  - ▶ Internet Services (next semester)
2. **Think** → **Processing** – processing of input, internal processing, decision making
3. **Act** → **Output** – signal/information going out of the boards
  - ▶ LEDs, DC motor, servo motor, a piezo buzzer, relay, an RGB LED ...
  - ▶ Internet Services (next semester)



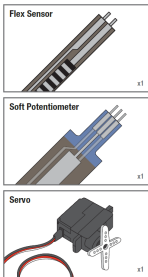
## External Components for Sensing and Acting



## External Components for Sensing and Acting



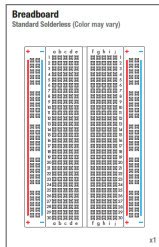
## External Components for Sensing and Acting



## Prototyping Circuits Solderless Breadboard

One of the most useful tool.

- ▶ A breadboard is easier than soldering
- ▶ A lot of those little holes are connected, which ones?
- ▶ Sometimes breadboards break

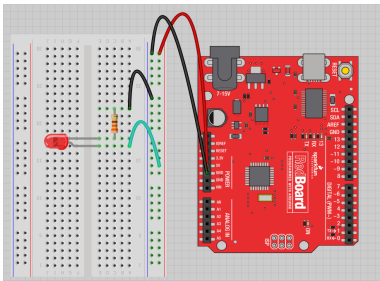


Each row (horiz.) of 5 holes are connected.

Vertical columns – called power bus are connected vertically



## A Simple Example



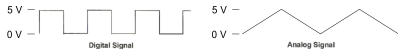
## Type of External Components

Name	Image	Type	Function	Notes
Push Button		Digital Input	Switch - Closes or opens circuit	Polarized, no resistor
Trim potentiometer		Analog Input	Variable resistor	Also called a Trimpot.
Photoresistor		Analog Input	Light Dependent Resistor (LDR)	Resistance varies with light.
Relay		Digital Output	Switch driven by a small signal	Used to control larger voltage
Temp Sensor		Analog Input	Temp Dependent Resistor	
Flex Sensor		Analog Input	Variable resistor	
Soft Trimpot		Analog Input	Variable resistor	Careful of shape
RGB LED		Dig & Analog Output	16,777,216 different colors	Ooh... So pro

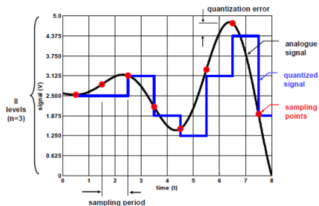
## Analog vs Digital Input/Output

Microcontrollers are digital devices

- ▶ ON or OFF
- ▶ Digital signals are discrete
- ▶ Analog signals are anything that can be a full range of values.
- ▶ Discrete NOT continuous

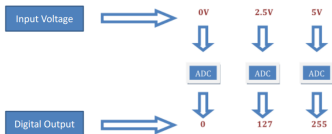


## Converting Analog value to Digital



## ADC – Analog to Digital Converter

1. contains 6 pins for ADC
2. 10-bit analog to digital converter
3. Maps input voltages 0 ... 5 volts → number between 0 ... 1023

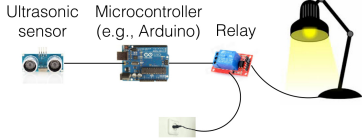


## A Smart Dekstop Lamp

- ▶ Motion-controlled Lamp
- ▶ User is approaching – turn on lights.
- ▶ No user present – turn off lights.
- ▶ How do we sense if user is present?
  - ▶ Multiple ways
  - ▶ One possible way: Ultrasonic Sensor (Cost: 4 €)
- ▶ How do we switch on/off the lamp?
  - ▶ Multiple ways
  - ▶ One possible way: Relay (Cost: 2 €)



## A Smart Desktop Lamp: A simplified schema

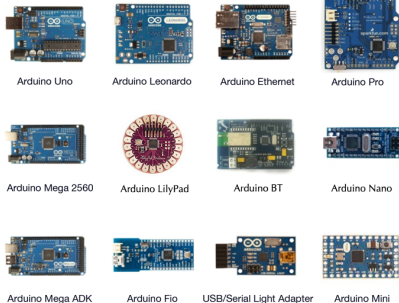


- ▶ The ultrasonic sensor measures the distance to the closest object
- ▶ Arduino reads the measurement
- ▶ If the distance is small enough, Arduino switches the relay on
- ▶ The relay lets the current flow and the lamp switch on
- ▶ If the distance is large, Arduino switches the relay off
- ▶ The relay interrupts the current flow and the lamp switches off

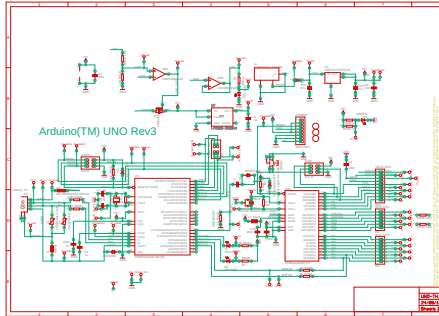
## Many possibilities

- ▶ Change Relay → Servo
- ▶ Multiple Relays
- ▶ Multiple Ultrasonic Sensors
- ▶ ...

## Different Arduino Boards



## Open Source Hardware



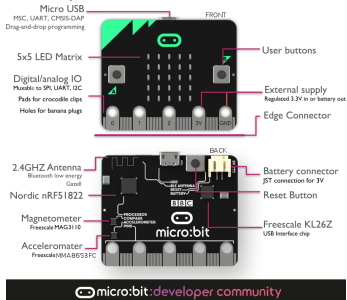
## MicroBit



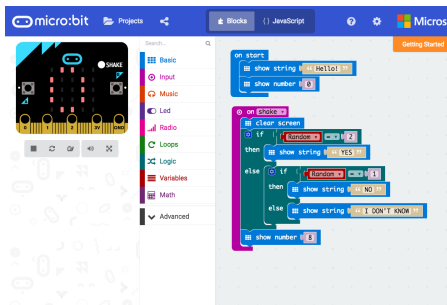
- ▶ designed by the BBC for use in computer education in the UK
- ▶ teach broad audience how to program
- ▶ targeting schools & K-12



## MicroBit - Components



## MicroBit - Micro Code Environment



## MicroBit – Details

### Micro USB Plug

- ▶ Power
- ▶ Program



### nRF51822 ARM Cortex-M0:

1. 256KBytes FLASH (program)
2. 16KBytes Internal SRAM
3. Clock: 16MHz
4. Bluetooth LE

### Input/Output:

1. 17 Digital I/O
2. 3 PWM Digital
3. 6 Analog Inputs
4. SPI
5. I2C
6. 2 Buttons

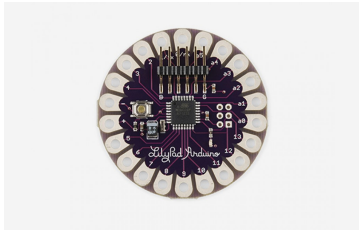
### 3-axis accelerometer sensor

### 25 LEDs in a 5x5 array

Cost: 27 €

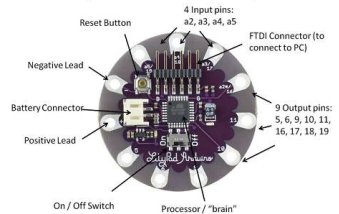


## LilyPad Arduino



## LilyPad Arduino – Components

### The LilyPad Arduino “Simple” Board



## LilyPad Arduino – Details

FTDI connector

- ▶ USB Plug

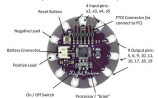
LiPo charger/power Supply

ATmega168 Microcontroller:

1. 16KBytes FLASH (program)
2. 1KBytes Internal SRAM
3. Clock: 32MHz

Cost: 18 €

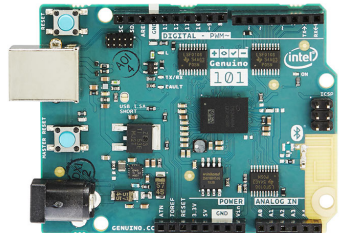
The LilyPad Arduino “Simple” Board



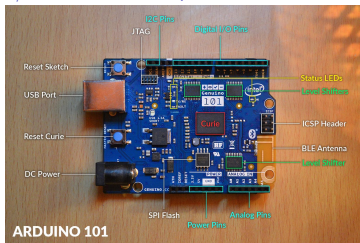
Input/Output:

1. 14 Digital I/O
2. 6 PWM Digital
3. 6 Analog Inputs

## Arduino/Genuino 101



## Arduino/Genuino 101 – Components



## Arduino/Genuino 101 – Details

USB Plug

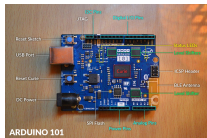
External Power Supply:

- ▶ Similar to Arduino Uno

Intel Curie Microcontroller:

1. 196KBytes FLASH (program)
2. 24KBytes Internal SRAM
3. Clock: 32MHz
4. Bluetooth LE
5. 6-axis accelerometer/gyro
6. Neural Network Pattern Matching Engine

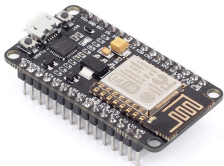
Cost: 40\$



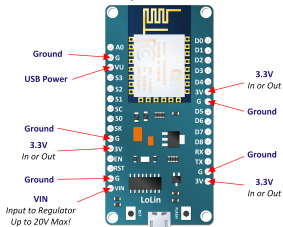
Input/Output:

1. 14 Digital I/O
2. 4 PWM Digital
3. 6 Analog Inputs

## NodeMCU ESP8266



## NodeMCU ESP8266 – Components





## NodeMCU ESP8266 – Details

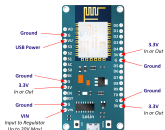
Micro USB Plug

LiPo charger/power supply

Tensilica L106 32-bit RISC  
Microcontroller:

- 32KBytes FLASH (program)
- 128KBytes Internal SRAM
- Clock: 80MHz
- 802.11 b/g/n WiFi

Cost: 2\$



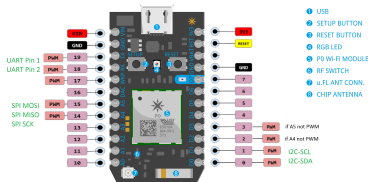
Input/Output:

- 16 Digital I/O
- SPI
- I2C

## Spark Core/Photon



## Spark Core/Photon – Components



## Spark Core/Photon – Details

Micro USB Plug

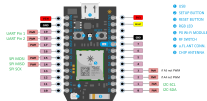
STM32F205 120Mhz ARM  
Cortex M3:

- 1MBytes FLASH (program)
- 128KBytes Internal SRAM
- Clock: 120Mhz
- 802.11 b/g/n WiFi

Device Cloud

- Over the Air Update
- Device Management
- Fully Managed Connectivity

Cost: 19\$



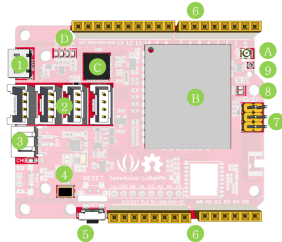
Input/Output:

- 18 Digital I/O
- 9 PWM Digital
- 8 Analog Input
- SPI
- I2C

## Seeeduino LoraWAN



## Seeeduino LoraWAN – Components



## Seeeduino LoraWAN – Details

Micro USB Plug

JST.2.0 Lipo battery input

ATSAMD21G18 32-Bit ARM

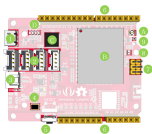
Cortex M0+:

1. 256KBytes FLASH (program)
2. 32KBytes Internal SRAM
3. Clock: 48Mhz

LoRaWAN

GPS Receiver

Cost: 49\$



Input/Output:

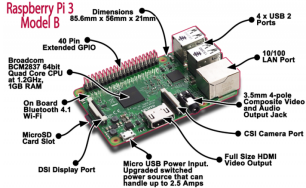
1. 20 Digital I/O
2. 1 PWM Digital
3. 6 Analog Input
4. 4 Grove Connectors

## Raspberry Pi



## Raspberry Pi – Components

### Raspberry Pi 3 Model B



## Raspberry Pi – Details

Broadcom BCM2837

4 × ARM Cortex-A53:

1. 1GB SDRAM
2. Clock: 1.2GHz

Storage: microSD

Networking

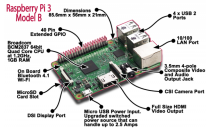
1. 10/100 Ethernet
2. 2.4GHz 802.11n
3. Bluetooth LE

GPU: Broadcom VideoCore

IV @ 400 MHz

Cost: 36€

### Raspberry Pi 3 Model B



Input/Output:

1. 40 GPIO
2. HDMI
3. Audio
4. 4 USB