

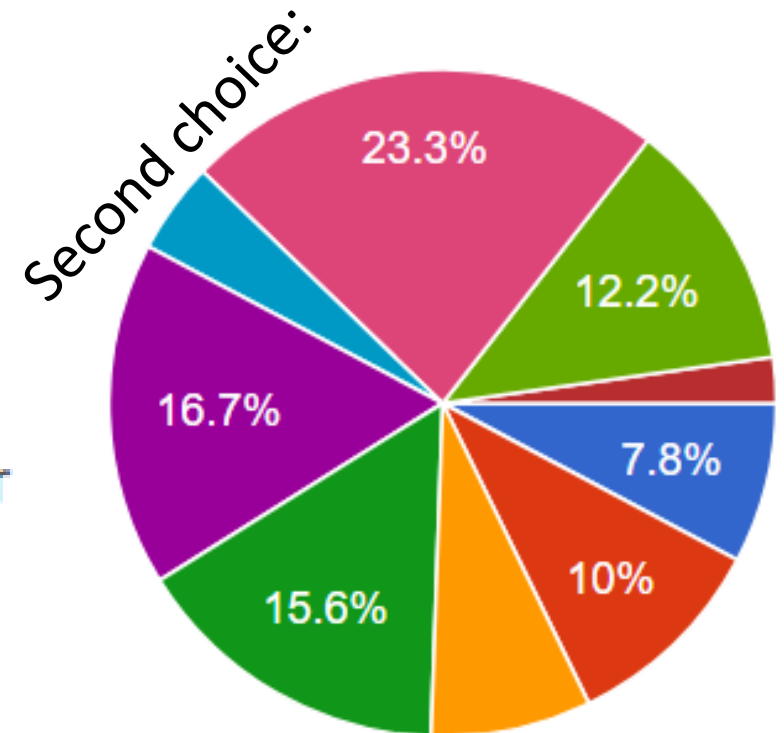
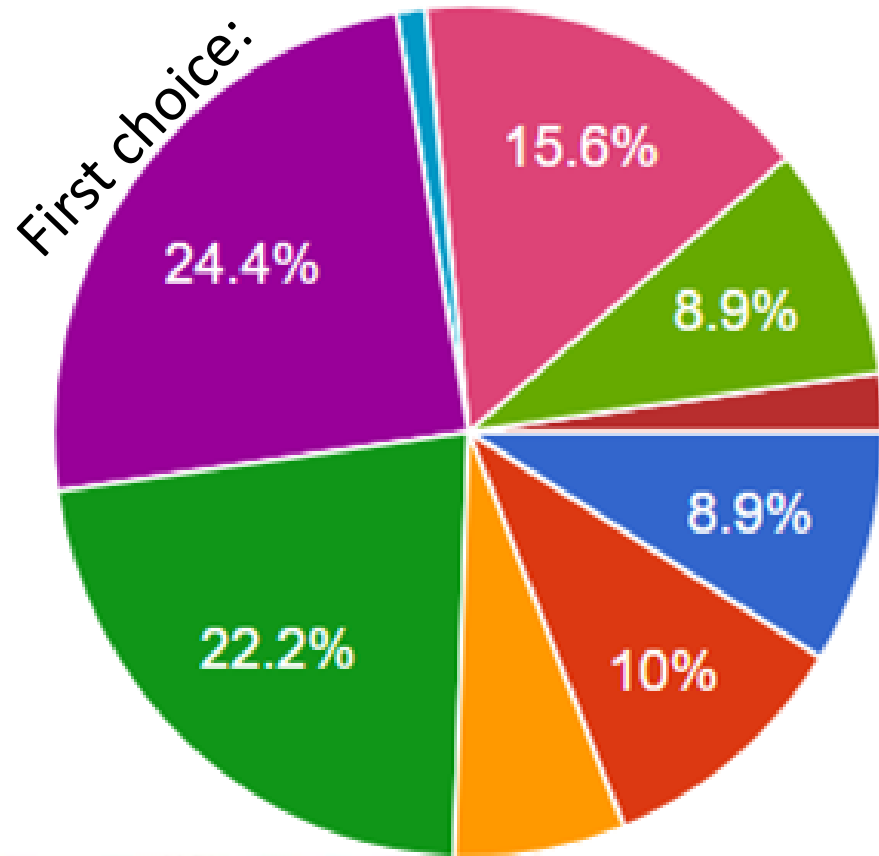
Intelligent Physical Systems

Join Piazza!

Find link on: <https://cei-lab.github.io/ece3400/>

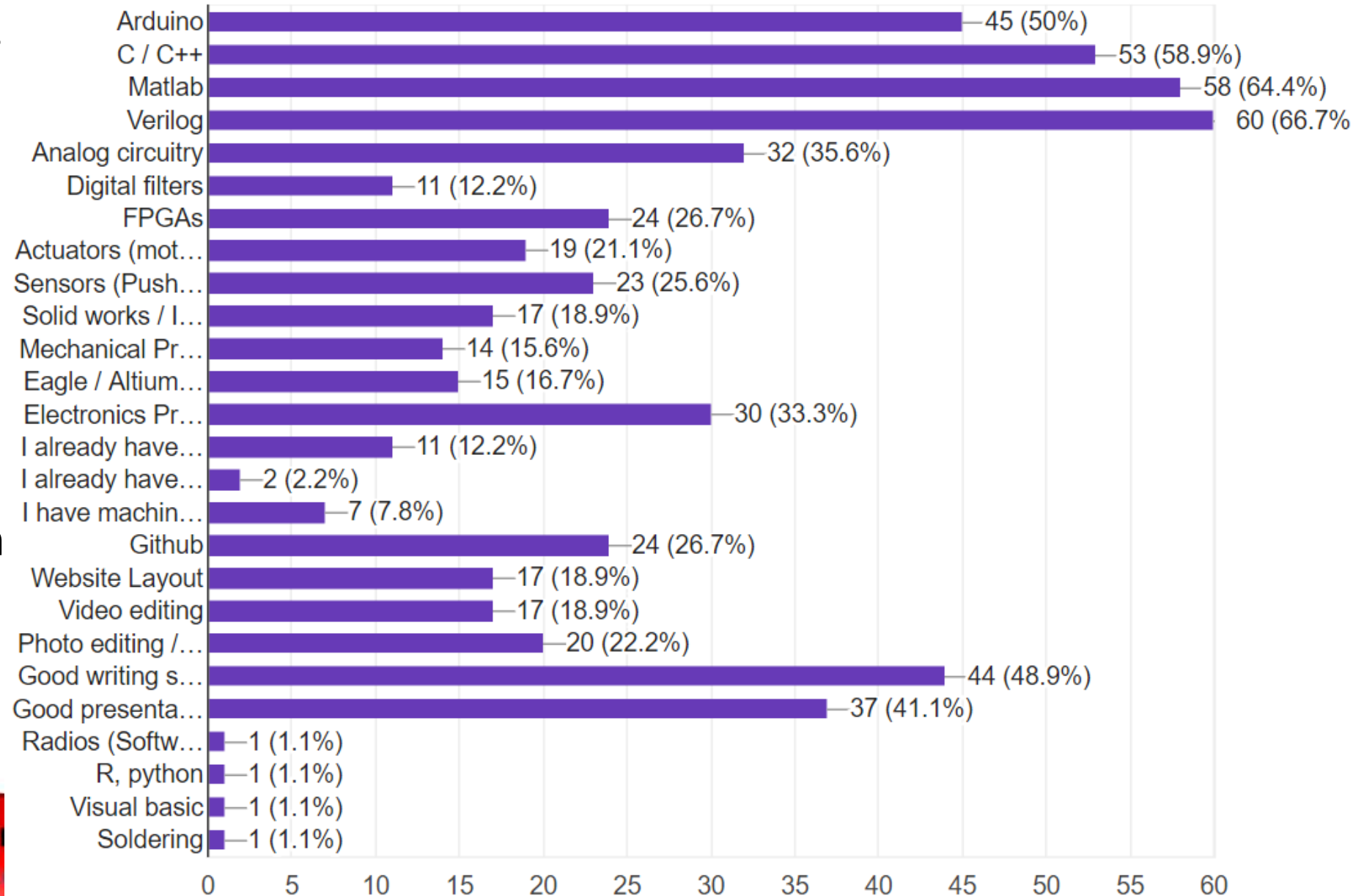
Intelligent Physical Systems

- Team compositions



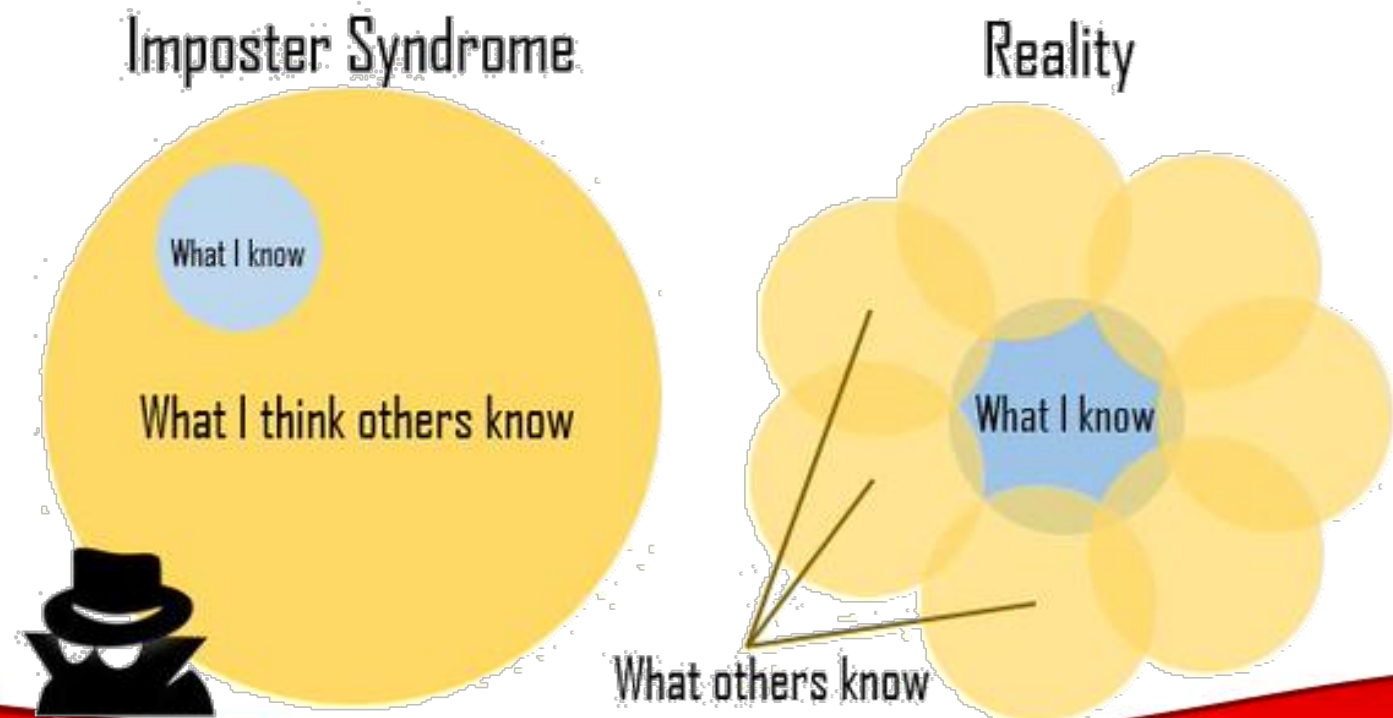
Intelligent Physical Systems

- Team compositions
- Biggest concerns
 - Technical skill
 - Electronics
 - Algorithms
 - Mechanics
 - Presentation



Intelligent Physical Systems

- Team compositions
- Biggest concerns
 - Technical skill (electronics, algorithms, mechanics, presentation)
 - Team
 - Dead weight
 - Not getting to do anything
 - Scheduling/finding time
 - Innovation/creativity
 - Disinterest / Laziness



Intelligent Physical Systems

- Introduction
 - What under the hood?
 - How do you program it?

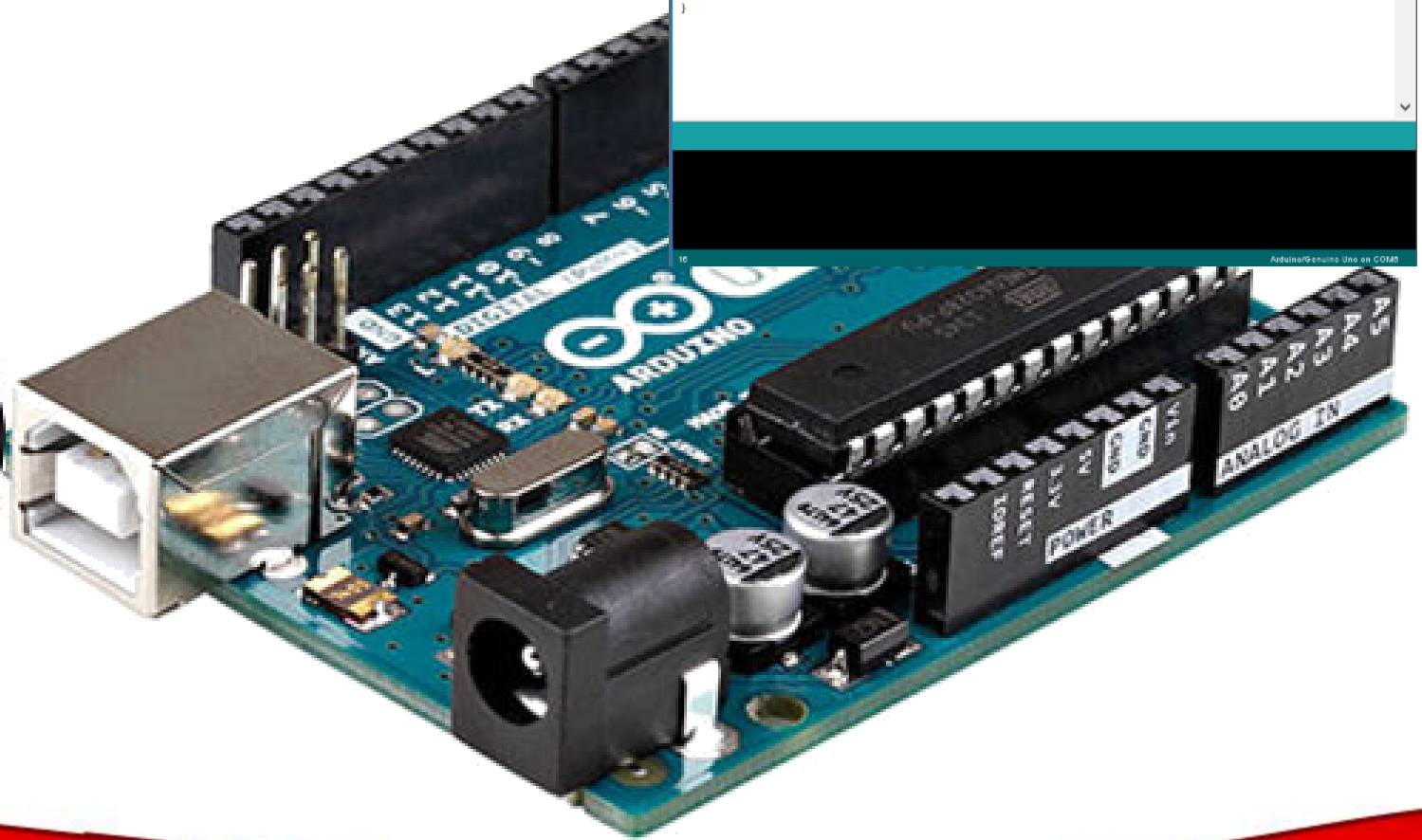
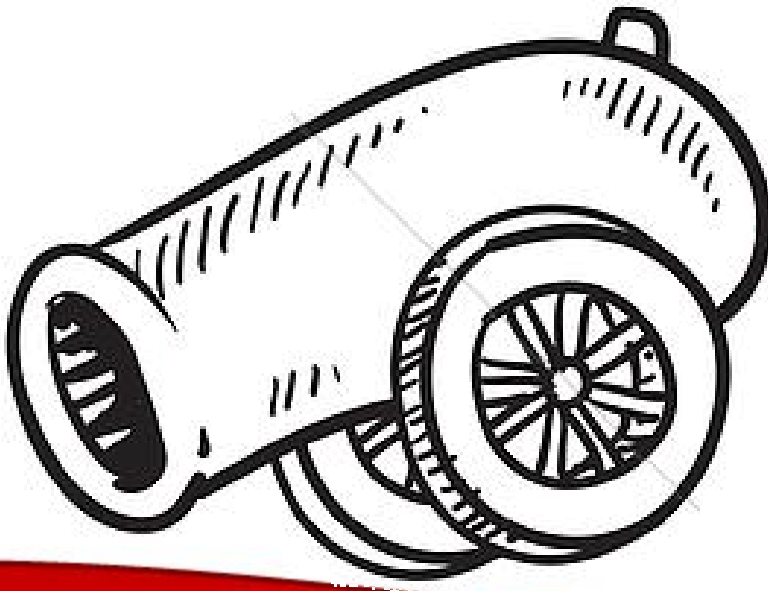
Arduino Uno

```
Blink | Arduino 1.6.12
File Edit Sketch Tools Help

Blink §

// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

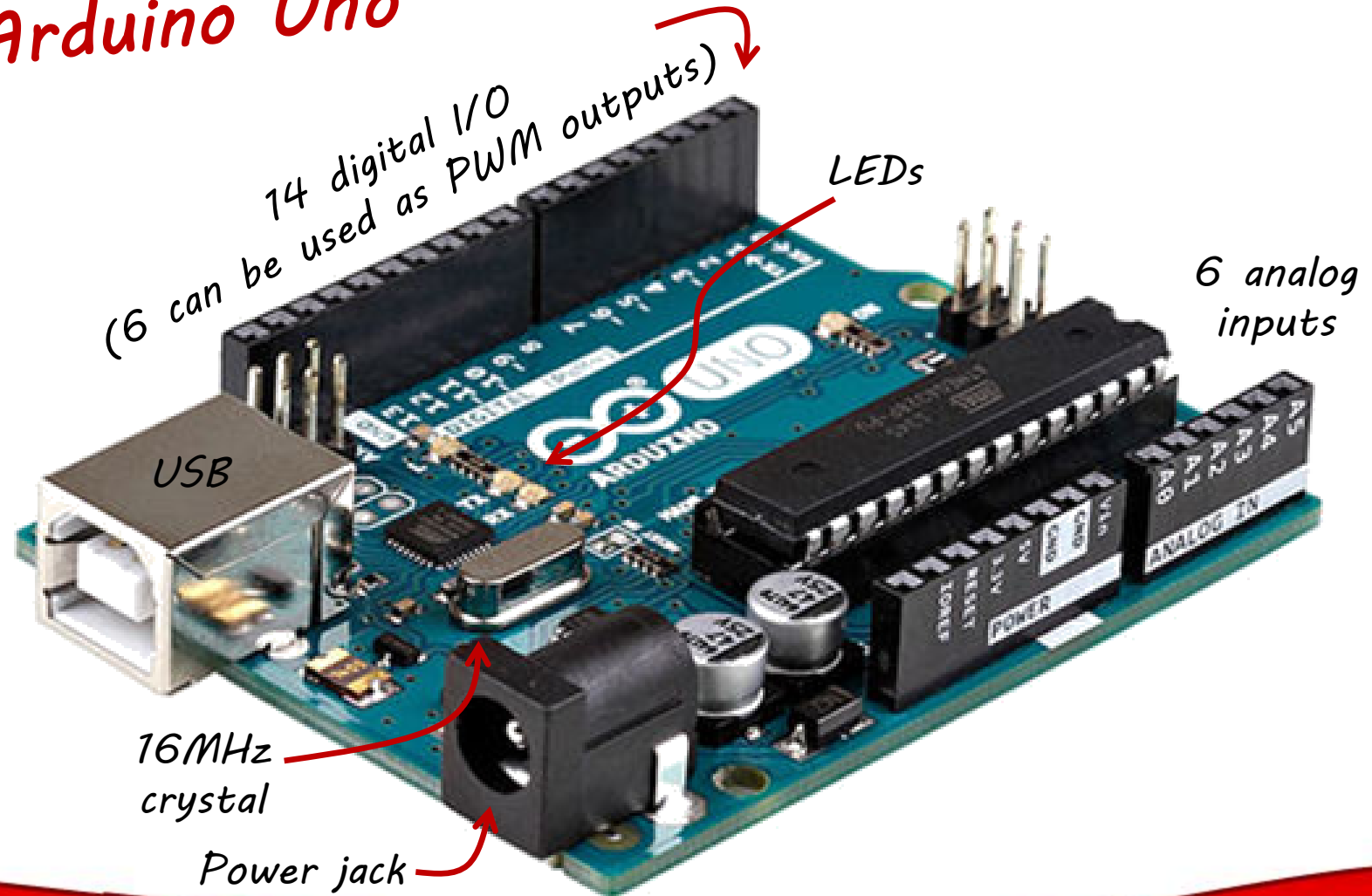
// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH); // turn the LED on (HIGH is the voltage level)
  delay(1000); // wait for a second
  digitalWrite(LED_BUILTIN, LOW); // turn the LED off by making the voltage LOW
  delay(1000); // wait for a second
}
```



Intelligent Physical Systems

- Introduction
 - What under the hood?
 - How do you program it?

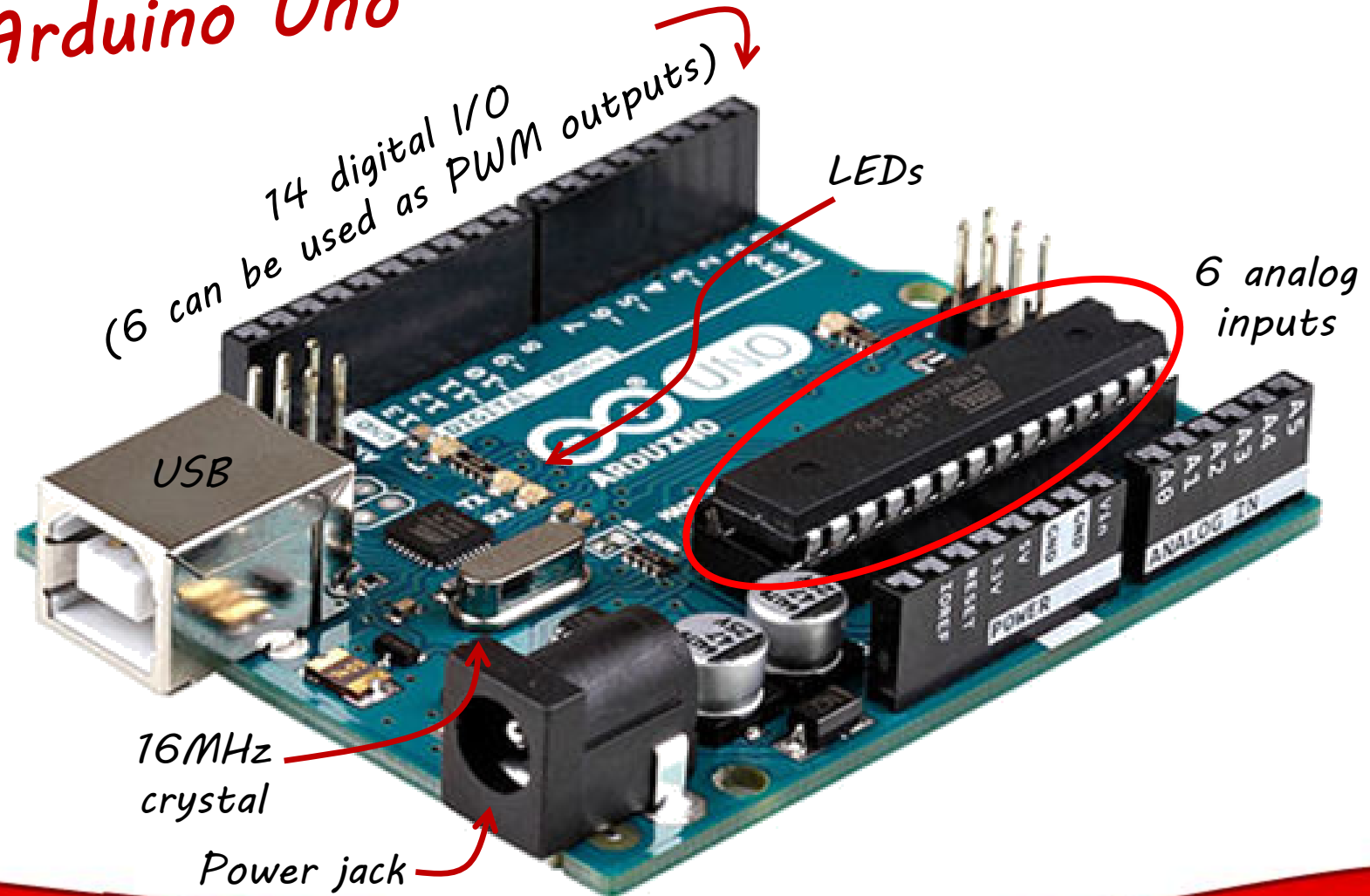
Arduino Uno



Intelligent Physical Systems

- Microcontroller (ATmega328)
- No operating system
- 32KB Flash
- 2KB SRAM
- 1KB EEPROM
- But it can do real-time control, sequential processing, timers, and interrupts!

Arduino Uno



ATmega328

(Arduino Uno Microcontroller)

http://www.atmel.com/Images/Atmel-42735-8-bit-AVR-Microcontroller-ATmega328-328P_Datasheet.pdf

ATmega328/P

1 / 442

Atmel

8-bit AVR Microcontrollers

[ATmega328/P](#)

DATASHEET COMPLETE

Introduction

The Atmel® *picoPower*® ATmega328/P is a low-power CMOS 8-bit microcontroller based on the AVR® enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328/P achieves throughputs close to 1MIPS per MHz. This empowers system designer to optimize the device for power consumption versus processing speed.

Feature

High Performance, Low Power Atmel® AVR® 8-Bit Microcontroller Family

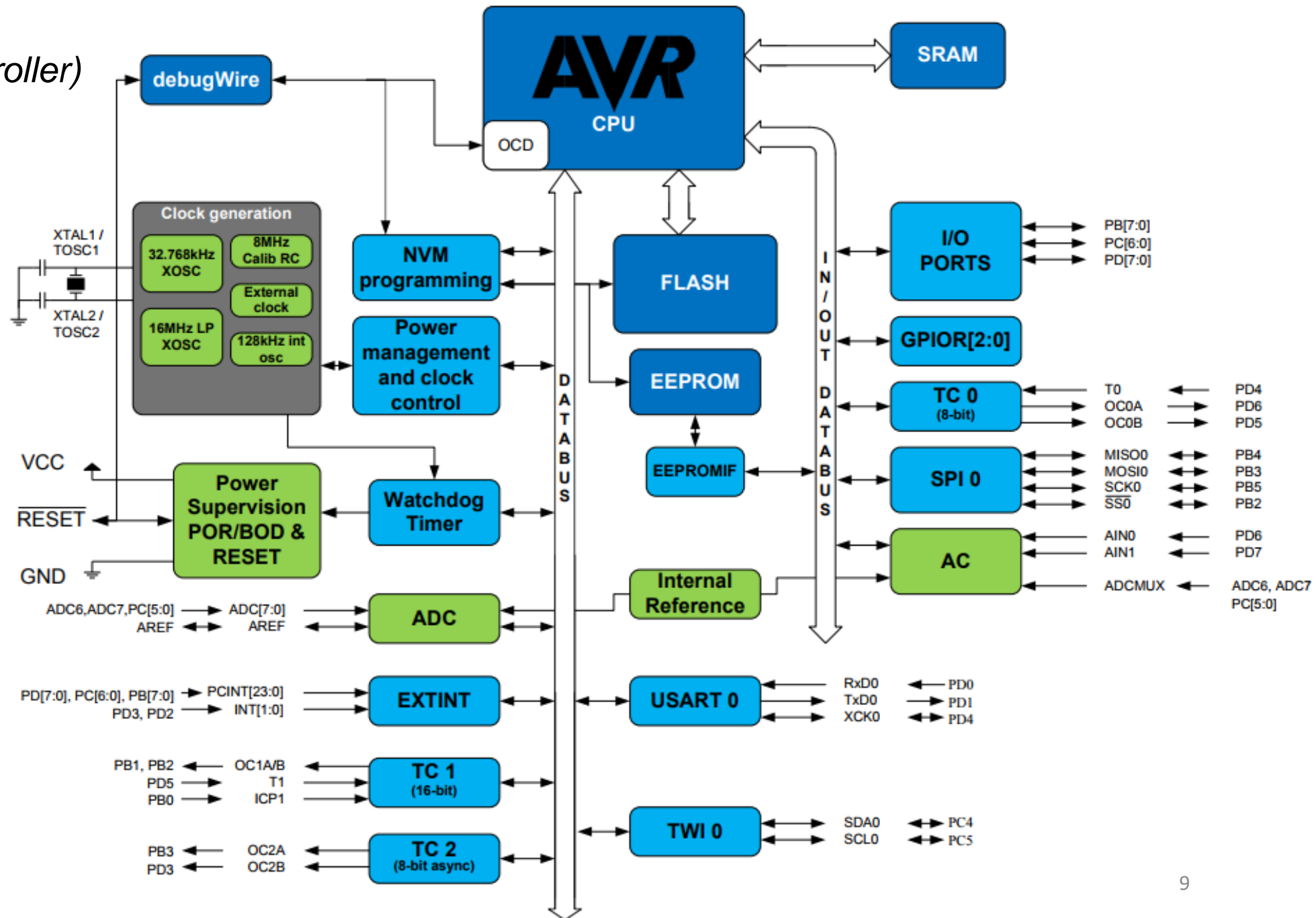
- Advanced RISC Architecture
 - 131 Powerful Instructions
 - Most Single Clock Cycle Execution
 - 32 x 8 General Purpose Working Registers
 - Fully Static Operation
 - Up to 20 MIPS Throughput at 20MHz
 - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory Segments
 - 32KBytes of In-System Self-Programmable Flash program Memory
 - 1KBytes EEPROM
 - 2KBytes Internal SRAM
 - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
 - Data Retention: 20 years at 85°C/100 years at 25°C⁽¹⁾
 - Optional Boot Code Section with Independent Lock Bits
 - In-System Programming by On-chip Boot Program
 - True Read-While-Write Operation
 - Programming Lock for Software Security
- Atmel® QTouch® Library Support
 - Capacitive Touch Buttons, Sliders and Wheels
 - QTouch and QMatrix® Acquisition
 - Up to 64 sense channels

www.atmel.com/Images/Atmel-42735-8-bit-AVR-Microcontroller-ATmega328-328P_Datasheet_Complete-110816

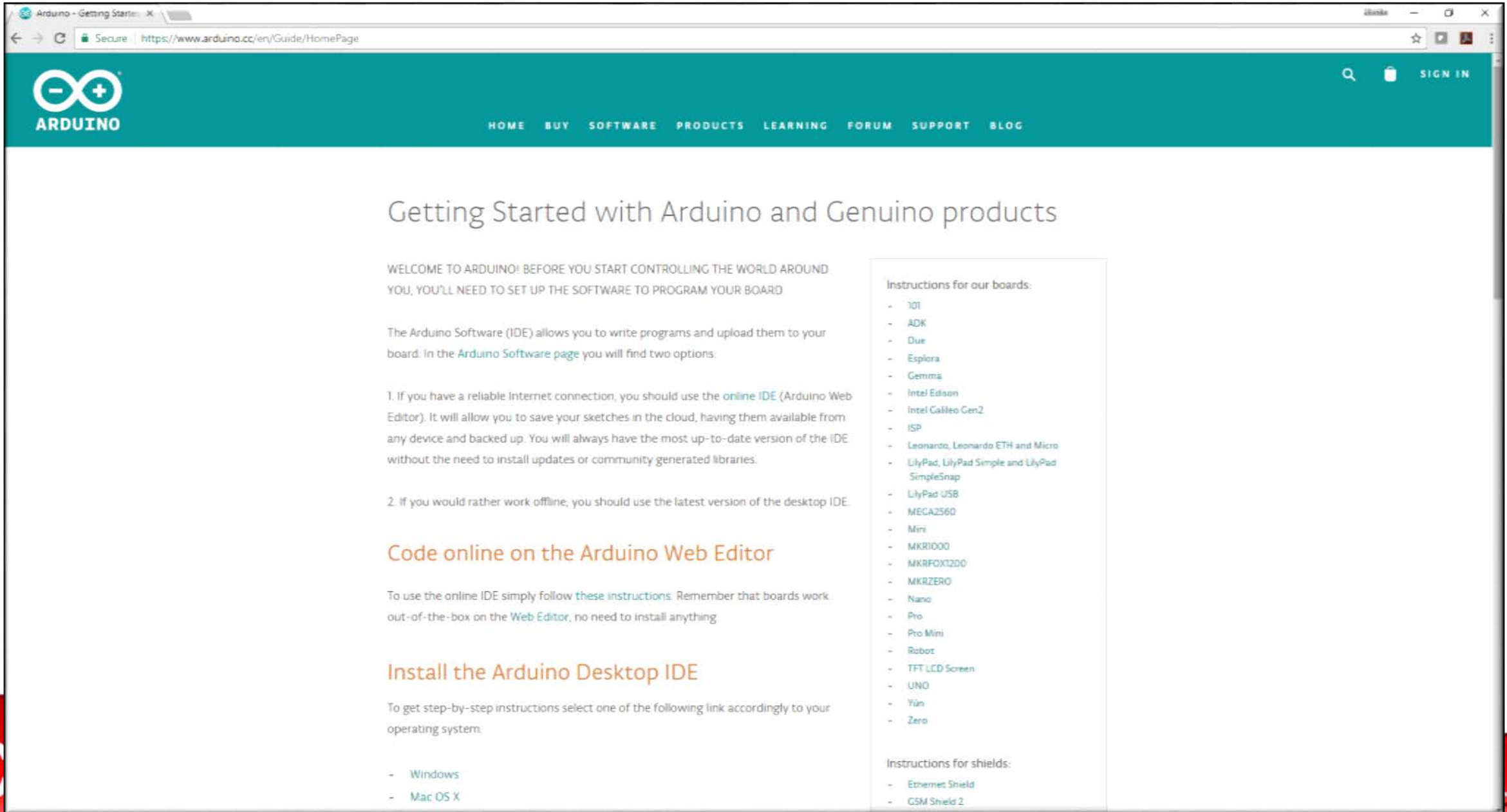
EC

ATmega328

(Arduino Uno Microcontroller)



Arduino IDE



Arduino - Getting Started: X

Secure | <https://www.arduino.cc/en/Guide/HomePage>

ARDUINO

HOME BUY SOFTWARE PRODUCTS LEARNING FORUM SUPPORT BLOG

Getting Started with Arduino and Genuino products

WELCOME TO ARDUINO! BEFORE YOU START CONTROLLING THE WORLD AROUND YOU, YOU'LL NEED TO SET UP THE SOFTWARE TO PROGRAM YOUR BOARD

The Arduino Software (IDE) allows you to write programs and upload them to your board. In the [Arduino Software](#) page you will find two options:

1. If you have a reliable Internet connection, you should use the [online IDE](#) (Arduino Web Editor). It will allow you to save your sketches in the cloud, having them available from any device and backed up. You will always have the most up-to-date version of the IDE without the need to install updates or community generated libraries.
2. If you would rather work offline, you should use the latest version of the desktop IDE.

Code online on the Arduino Web Editor

To use the online IDE simply follow [these instructions](#). Remember that boards work out-of-the-box on the [Web Editor](#), no need to install anything

Install the Arduino Desktop IDE

To get step-by-step instructions select one of the following link accordingly to your operating system.

- Windows
- Mac OS X

Instructions for our boards:

- 101
- ADK
- Due
- Esplora
- Gemma
- Intel Edison
- Intel Galileo Gen2
- ISP
- Leonardo, Leonardo ETH and Micro
- LilyPad, LilyPad Simple and LilyPad SimpleSnap
- LilyPad USB
- MEGA2560
- Mini
- MKR1000
- MKRFOX1200
- MKRZERO
- Nano
- Pro
- Pro Mini
- Robot
- TFT LCD Screen
- UNO
- Yún
- Zero

Instructions for shields:

- Ethernet Shield
- GSM Shield 2

Programming

COMPUTER

Libraries

Arduino IDE

Source code → Preprocessing

C++ → AVR compiler (avr-gcc)

machine readable instructions

AVR linker (avr-id)

*.hex executable

AVR programmer

USB

ARDUINO BOARD

USB-to-Serial

TX/RX

ATmega328

Arduino bootloader → On-chip flash memory (32KB)

Input/Output Ports

DDxn	PORTxn	PINxn	Setup
1	0	X	Output low
1	1	X	Output high
1	X	1	Toggle output
0	1	X	Input
0	0/1	X	Tri-state

Input/Output Ports

Variable	Memory	Max (unsigned) value	Max signed value
Boolean	8 bits / 1 byte	-	-
Char	8 bits / 1 byte	2^8	2^7
Int	16 bits / 2 bytes	2^{16}	2^{15}
Double	32 bits / 4 bytes	2^{32}	2^{31}
Float	32 bits / 4 bytes	-	2^{31}

Alternatives



ARDUINO UNO



ARDUINO LEONARDO



ARDUINO 101



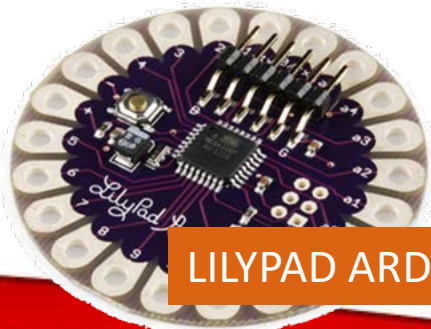
ARDUINO ESPLORA



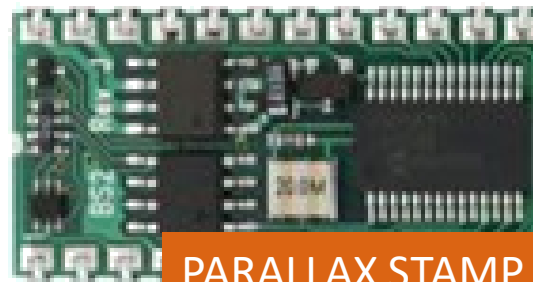
ARDUINO MICRO



ARDUINO NANO



LILYPAD ARDUINO



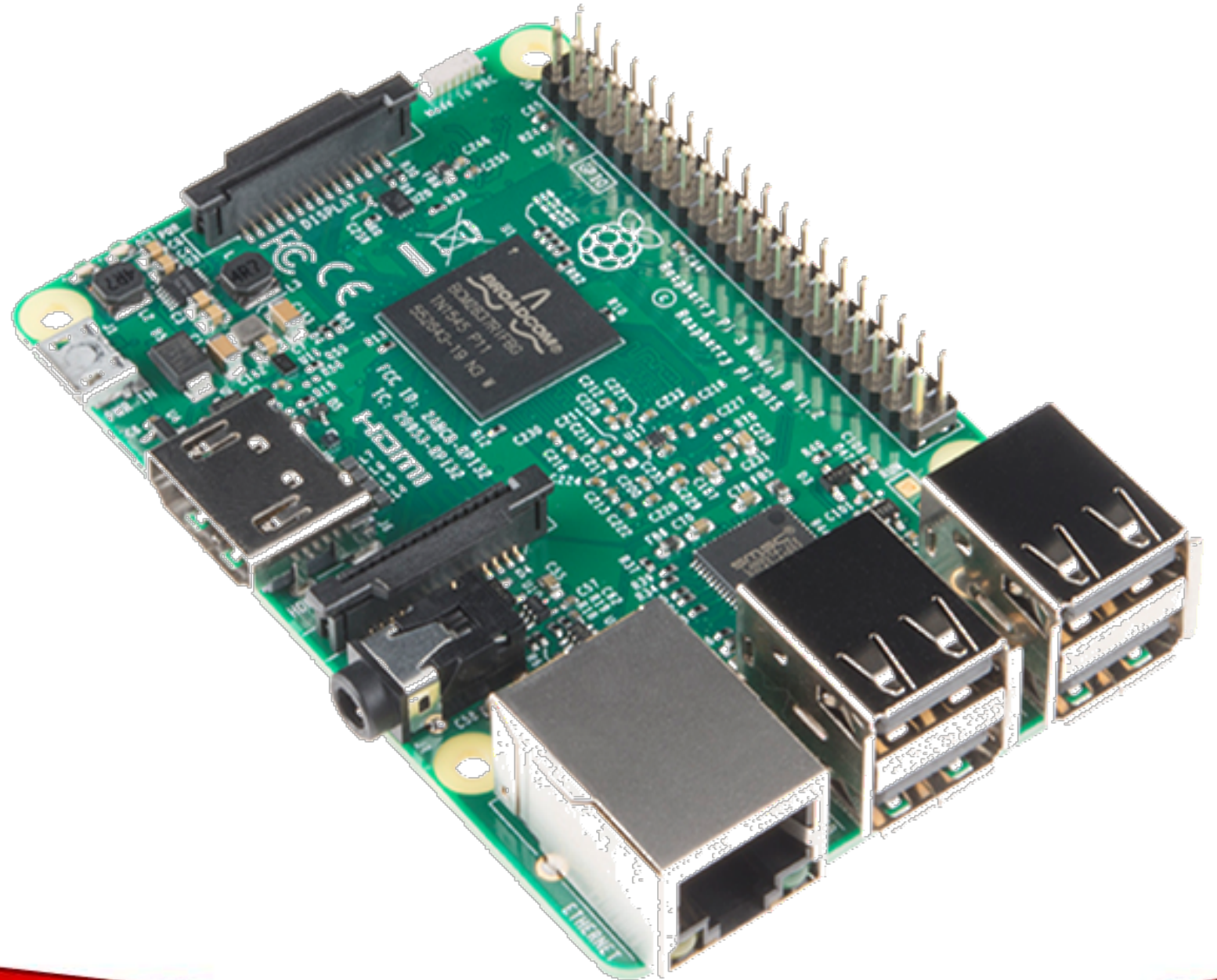
PARALLAX STAMP



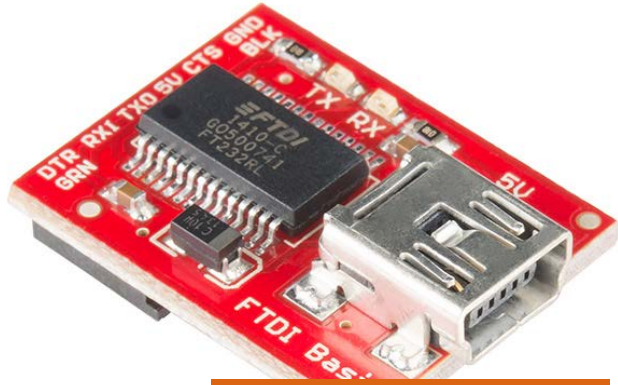
ARDUINO MINI

Alternatives

*Raspberry Pi's and other
mini computers*



Add-Ons



FTDI CONVERTERS



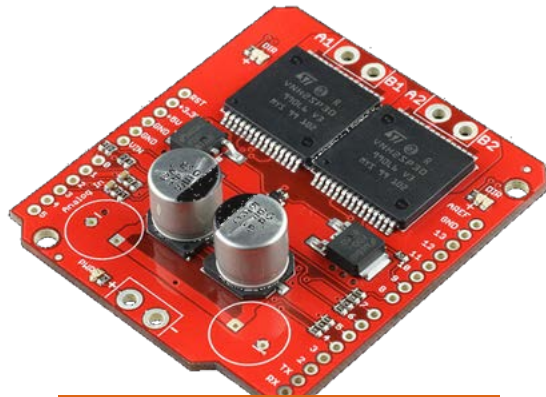
BLUETOOTH



WIRELESS MODULE



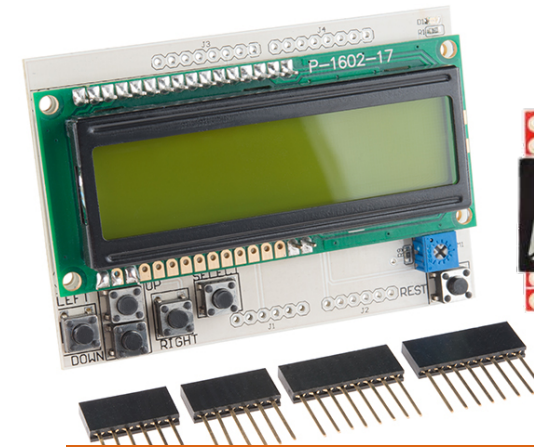
DATA LOGGER (SD CARD)



MOTOR DRIVERS



SENSORS



LCD SHIELD / 7-segment LED displays



Commercial Vendors

- **Components:** Digikey, Allied, Mouser, Newark, Circuit Specialists
- **Robotics:** Parallax, Lynxmotion, Tower Hobbies, Hobbyking, Sparkfun, Polulu, Jameco, Phidgets
- **Mechanics:** McMaster, Stock Drive Products

Pololu Robotics & Electronics

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Playstation 4 VR rigs for adults!
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All Phidgets

Go Build Robots!



Class website: <https://cei-lab.github.io/ece3400/>

Piazza: <https://piazza.com/cornell/fall2017/ece3400/home>