Innovation Research Lab
Microcontroller Workshop # 1
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Welcome!

Feedback is appreciated.
Feel free to ask questions!
Let’s get started!

Quote of the day

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The corollary of constant change is ignorance. This is not often talked about: we computer experts barely know what we're doing. We're good at fussing and figuring out. We function well in a sea of unknowns. Our experience has only prepared us to deal with confusion. A programmer who denies this is probably lying, or else is densely unaware of himself.

- **Ellen Ullman**

Close to the Machine

Agenda

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- Quick Introduction
- Pacing (We may not get through everything this session -- that's OK)
- Why Should we Care about Microcontrollers?
- A Quick Review: Microprocessors and Computers.
- What is a Microcontroller?
- Some examples for starting with Microcontrollers.
- Questions / Conclusion.

Who Am I?

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Licensed Professional Engineer

Almost 40 years of Embedded System and Digital Signal Processing experience.

Author of 3 books and numerous papers.

Why do We Care?

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- Microcontrollers are the “brains” of a great deal of modern products.
- They are not designed for everyday computational tasks (web browsing, for example). Therefore they tend to get overlooked.
- However, they are the workhorse of the modern technological revolution: Smartphones, small UAVs (“drones”), cars, cameras, radios, TVs, many toys, and even some things like flashlights all make use of microcontrollers.
- Thus, microcontrollers have a direct impact on virtually every aspect of our daily lives -- and yet most people don’t even know what they are!

One Step Back: What is a Microprocessor?

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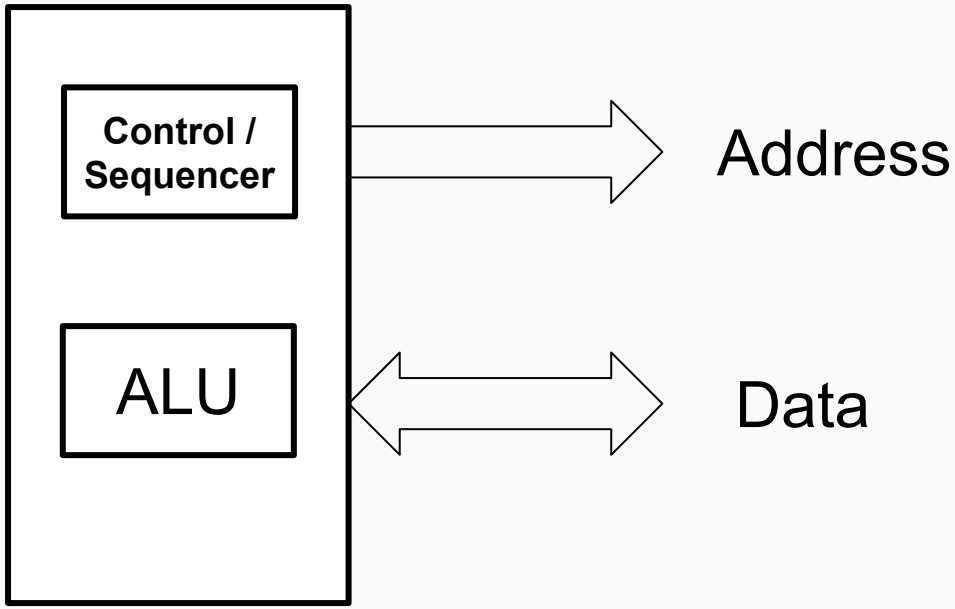
ALU: Arithmetic and Logic Unit.



Central Processing Unit (CPU)

What is a Computer?

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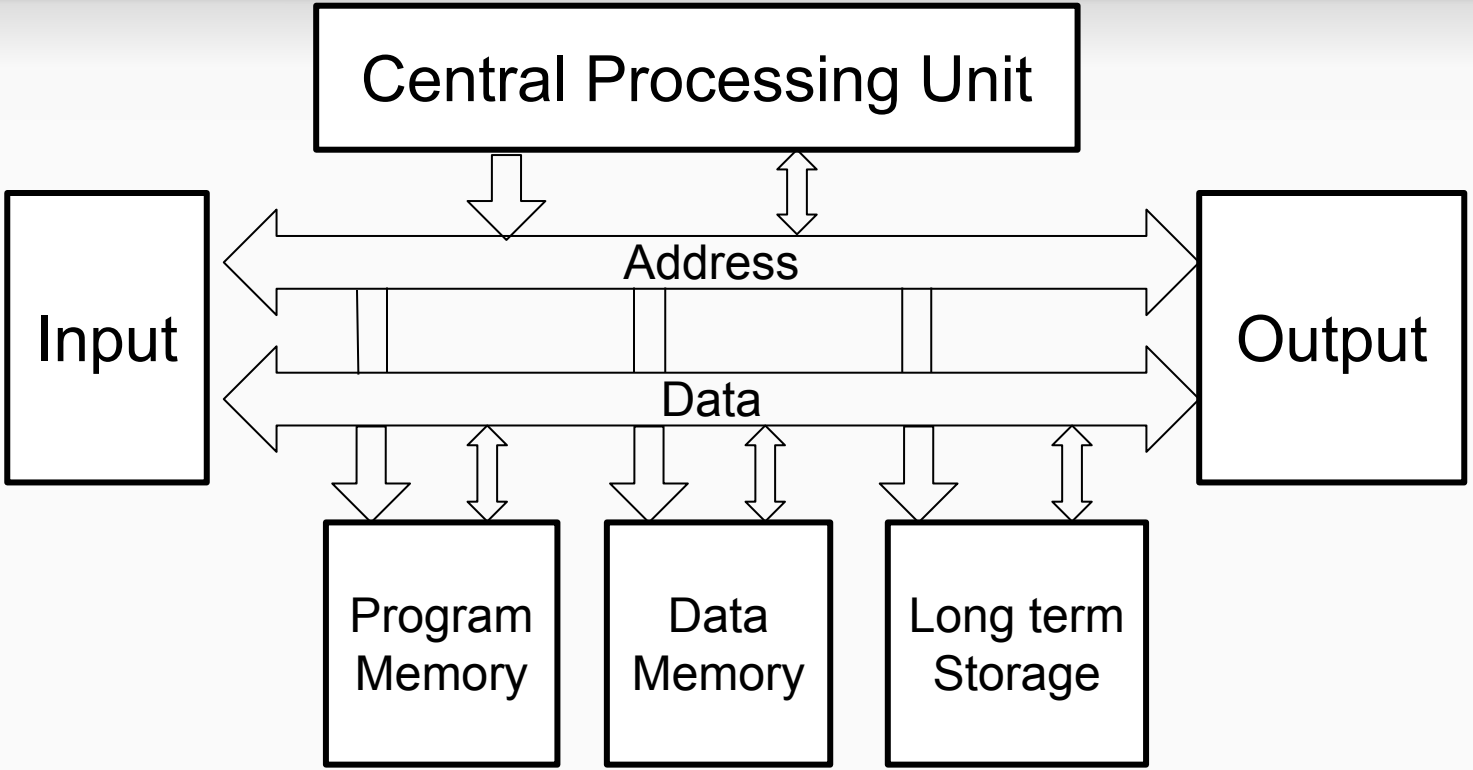

What is a Computer?

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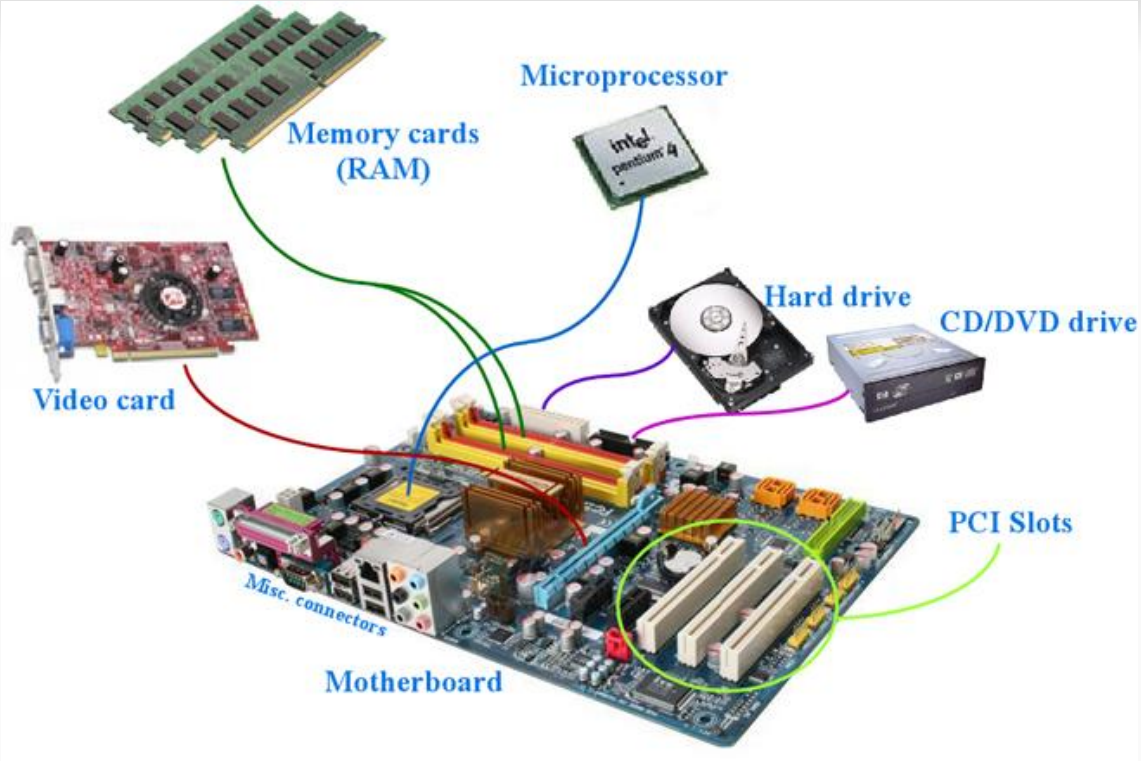

So, What is a Microcontroller?

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- Microcontrollers, or MCUs, are self-contained chips that feature everything from a processor (CPU) to memory to input/output peripherals ***on a single die*** (piece of silicon.)
- In addition to the uses mentioned above, microcontroller units are widely used in office machinery, vending machines, medical equipment, engine control systems, home appliances and other ***embedded systems*** to perform specific tasks.
- Modern microcontrollers are generally 8-bit, 16-bit and 32-bit. This refers to the number of bits the MCU can operate on at one time (more-or-less).

A Microcontroller Integrated Circuit

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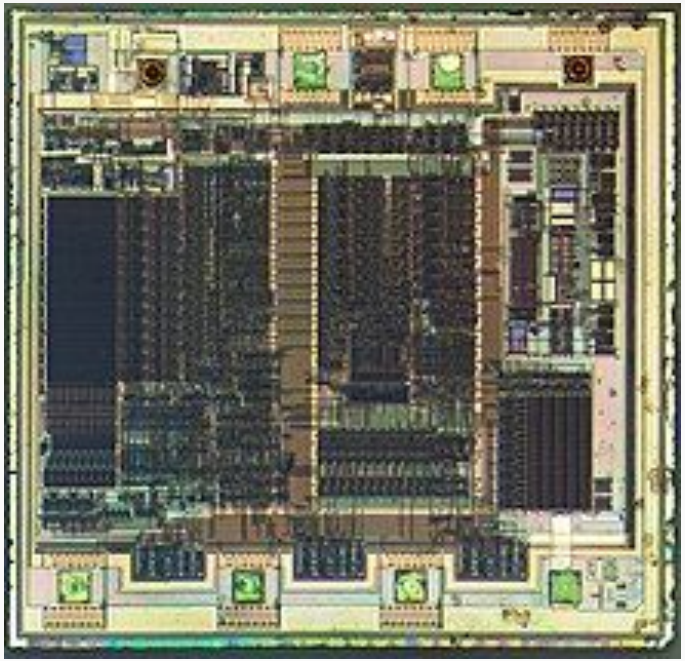

A Packaged Microcontroller

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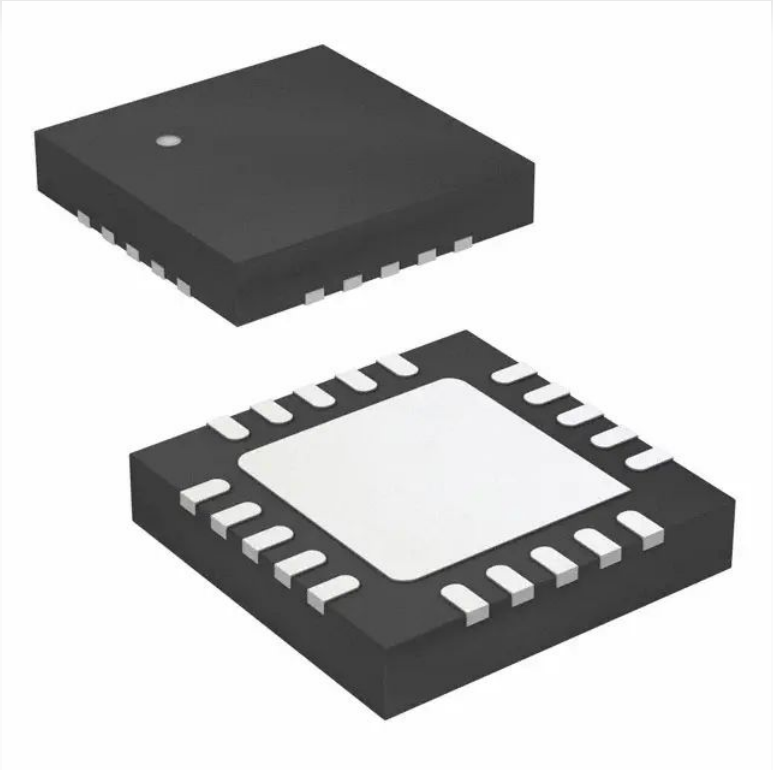
Size: 3mm x 3mm



A Microcontroller Board

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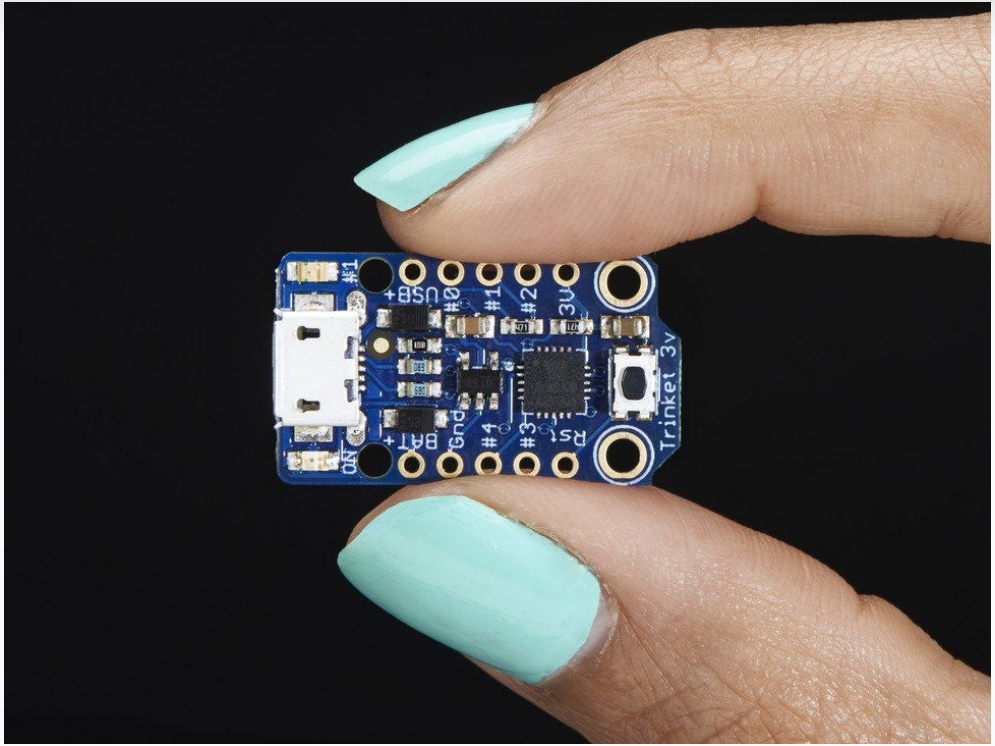

What Do Microcontrollers Do?

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- Microcontrollers are excellent time keepers -- they have special hardware for keeping accurate time. Thus they are often used in clocks, monitoring systems, light control, etc.
- Microcontrollers are excellent communicators. They often have 6 or more channels for communicating with other devices -- WiFi, BT, etc. Connecting these devices is what the Internet-of-Things (IoT) is all about.
- They are stand alone devices: this makes them useful for things like thermostats, light control, and appliances.

Arduinos

The Good:

- Open source hardware and software.
- Clones are available for around $10 on Amazon and other sites.
- Coding is done with a free IDE.
- Both desktop and web IDEs are available.
- Uses a cross compiler model: code is written on a desktop but executed on the Arduino.
- Can be used independent of the desktop computer.
- Uses a very C++ like language.
- Direct access to registers and peripherals is possible.
- Numerous libraries are available for a wide variety of applications.
- A variety of microprocessors are available with good code compatibility between them.
- Relatively easy to use for people unfamiliar with hardware.

Arduinos

The Bad:

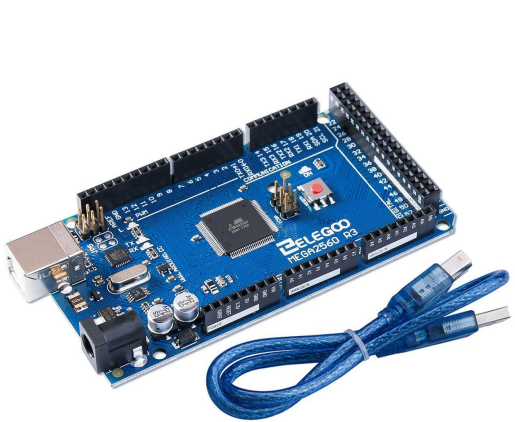
- No debugger -- though you can use print statements.
- Libraries are often incompatible.
- Pins and peripheral functions are often emulated -- not necessarily connected directly to the peripherals.
- The “analog output”, for example, is actually a digital PWM output.
- Generaly an amature level experience.

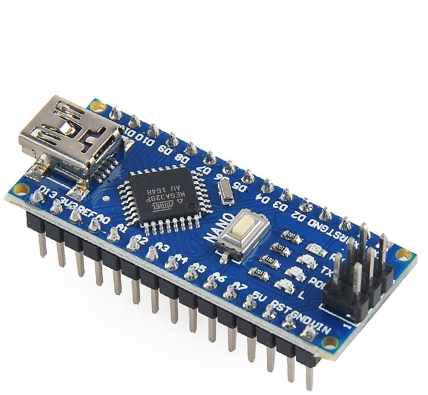
Variations

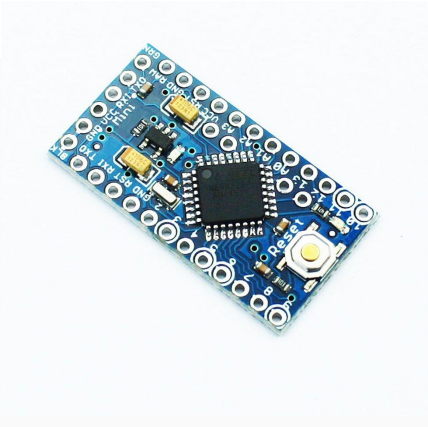
There are a wide range of physical variations on the basic Arduino.

Most are very similar to the basic Uno.

However, there can be differences that may trip you up on some projects.



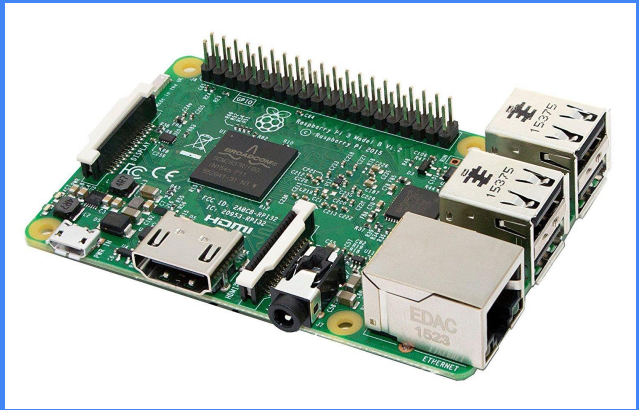




Breakout Boards and Shields

There are a large number of breakout boards and shields to make working with the Arduino Even easier.

Raspberry PI 3



Linux based System on a Chip.

Wide range of languages:

- Python
- C
- C++

Best used for high level projects. (Calculators, display based applications, etc.)

The PI can be used for control applications.

However, the SoC is not optimized for control and the documentation is limited.

Raspberry Pi System

The Raspberry PI (unlike the Arduino) is typically designed to be used with as a complete system with a display and keyboard.

It is typically used in a “stand alone” configuration.

Microstick II

Free design tools

Comes with a variety of processors

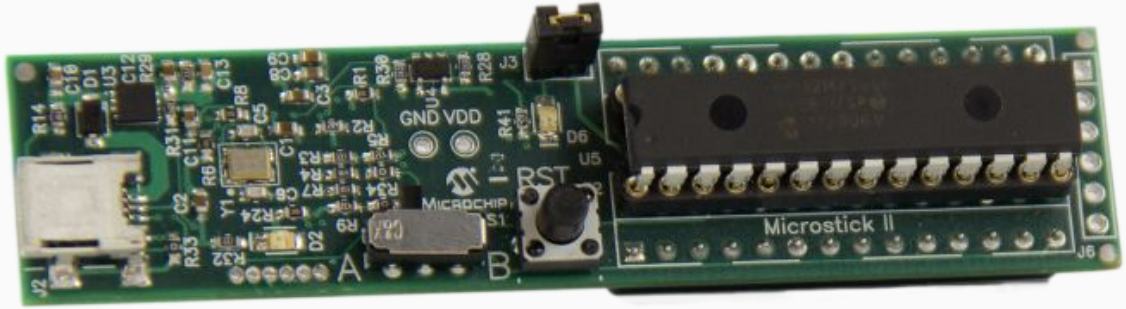
Built in debugger.

Good choice for “close to the machine” projects.

Relatively large learning curve.

Programmable in C (C++ for the 32 bit processor).

Professional Development tool.



Microchip Xpres

8 Bit microcontroller.

Built in debugger.

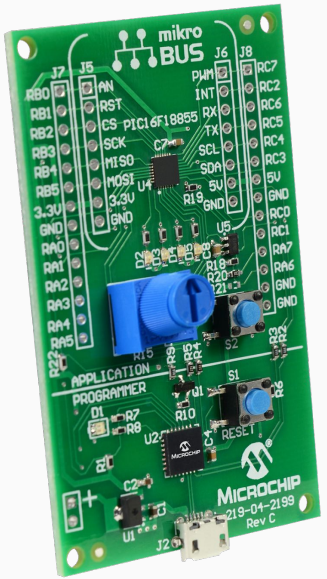
Free web based programming.

Relatively simple to use.

Low cost: ~ $10.00

Only programmable in C.

Professional level tool.



Complete Kits

Complete kits are available for robot arms, remote controlled vehicles, camera pan and tilts, etc.

Prices range from around $50 to $150