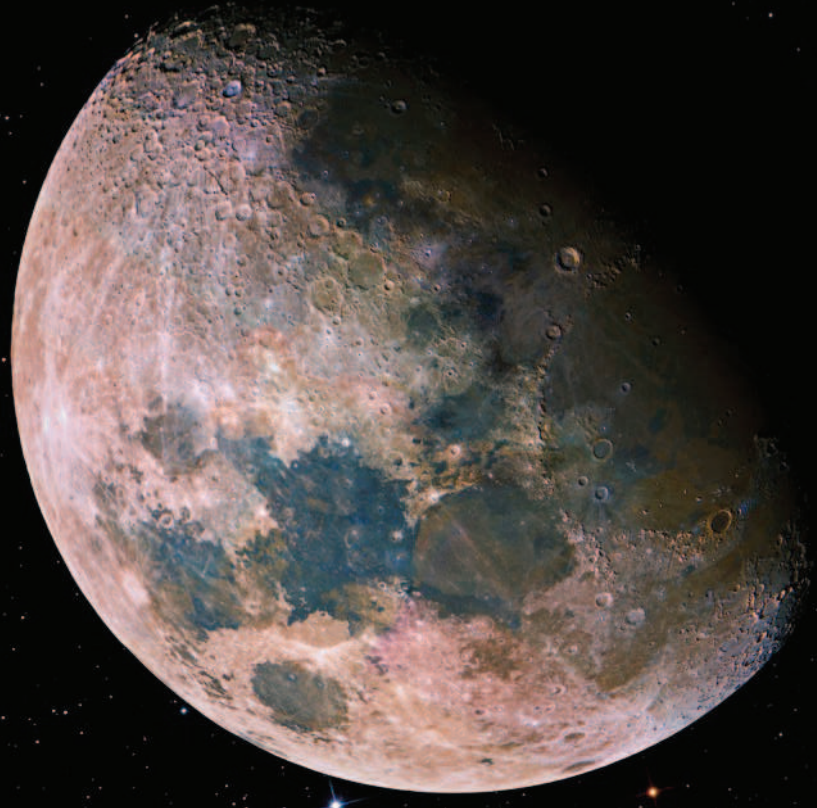


Arduino Part 1: Type and Blink

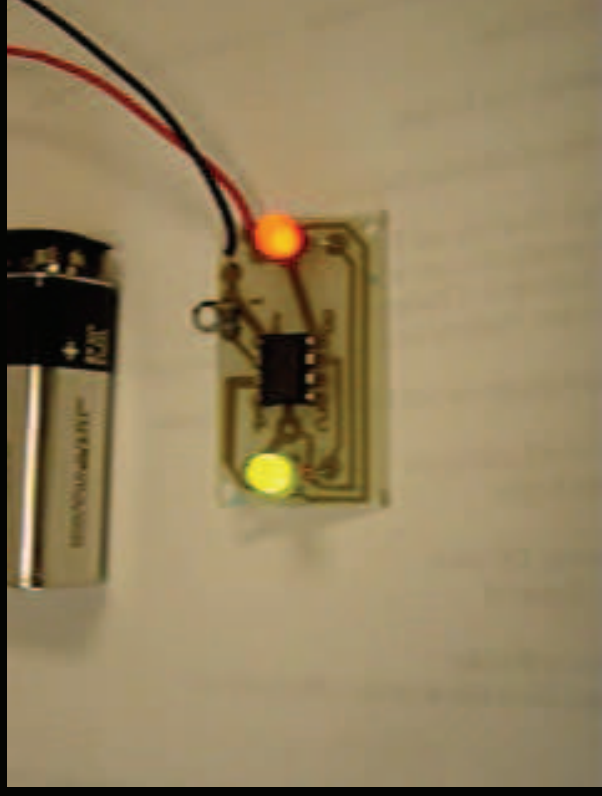


Colorado Space Grant Consortium



Arduino Overview:

- Last class, solder and blink



But...

- **How do you change it?**
- **How can you really use this?**
- **What could you use?**

Arduino Overview:



"TI's Home Computer. This is the one."

A lot of computers offer the "Oh, we're in the price range of the one." The TI Home Computer.

Learn to expand. Our expanded Expert System gives you a split card for memory expansion, 16 color capabilities, and dual timer channels and the RS232C interface. You can do all this in slow, speed.

Learn to expand. Our expanded Expert System gives you a split card for memory expansion, 16 color capabilities, and dual timer channels and the RS232C interface. You can do all this in slow, speed.

performance, data drive and 300,000 instructions per year.

Programming flexibility. TI BASIC's built-in real-time Compiler Baritan also handles TI's own TI BASIC, UCSD PASCAL, Version IV, TIL, COOL, TMS 9900 Assembly Language and TILLOT. Programs can be written in the optional Mini-Macro Compiler Cartridge.

High-Speed 68000 address processor. 10K bytes RAM (expandable to 32K), 20K bytes internal ROM, up to 10K bytes external ROM, 2 timer channels (100KHz/100KHz).

2271E to 40,000/1E. High resolution video. U.S.A. Single line available for 240 lines. Great in function too. 200 lines program with 40000 bytes.

Speedy response. Compare a TI Home Computer with the competition and you'll be impressed. You won't need a second computer to help you do it.

TEXAS INSTRUMENTS

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Arduino Overview:

IT'S A SMALL MIRACLE HOW HEWLETT-PACKARD
PUT 656K OF MEMORY, LOTUS 1-2-3, WORD
PROCESSING, A TELECOMMUNICATIONS MODEM
AND COMPLETE IBM CONNECTABILITY INTO

A 9-POUND COMPUTER.

HP-PORTABLE

THE PORTABLE.

For years business people had to choose between the power of a desktop computer and the limited capabilities of the first portables. That problem was solved when Hewlett-Packard introduced The Portable.

The Portable is designed with more total memory than most leading desktop personal computers...656K in fact, that includes 322K of user memory. So, The Portable's built-in business software can work with enormous amounts of data.

1.28" "Brain Lotus" American most popular spreadsheet, file management and business graphics programs, is permanently built into The Portable. So is Hewlett-Packard's word processing program, MicroMaker. Just press the key and you're ready to work.

The Portable even has a built-in modem and easy-to-use telecommunications software to send

or receive data using a standard telephone jack. If you use a Hewlett-Packard Transcrypter PC, IBM PC, XT or an IBM compatible you'll be glad to know that your desktop and The Portable can talk to each other with the simple addition of the Hewlett-Packard Portable Desktop Link.

The Portable's rechargeable battery gives you 16 hours of continuous usage in every charge. Finally, you can work comfortably on a full size keyboard and an easy-to-read 19-line by 80-column screen. And at all odds that to turn The Portable into a simple nine-pound book.

The Portable. A small miracle...perhaps.

But then consider where it came from. See The Portable and the entire family of personal computers, software and peripherals at your authorized Hewlett-Packard dealer. Call (800) F0R-HP-PC for the dealer nearest you.

Setting You Free



HP-PORTABLE 100-A

HP is a registered trademark of Hewlett-Packard Business Machines Corporation. 1-2-3 and Lotus are trademarks of Lotus Development Corporation.

Arduino Overview:

"Designing a revolutionary concept in software demanded a computer with extraordinary performance. The Tandy 2000 delivered."

Bill Gates
Chairman of the Board,
Microsoft

Bill Gates has been at the leading edge of personal computing from the very beginning. His company is a leading producer of personal computer software.

One recent software product, MSWindows, is an integrated windowing environment. It will let personal computer users combine individual programs into a powerful, integrated system.

When we set out to design MSWindows in color, we knew that the Tandy 2000 computer would let us turn an extraordinary product into a work of art. The graphics are sharp and crisp, and give us a degree of spontaneity like nothing before.

Our engineers were quite impressed with the processing speed of the Tandy 2000's state-of-the-art microprocessor too. And while the finished product will utilize the 2000's Ega-Memory, the software we developed has helped us speed through the design stage.

We're proud of our work. So when we want to show customers' how great MSWindows really is, we give them a demonstration. On the Tandy 2000.

Just imagine you enjoyed peak performance from a



personal computer! Go ahead, watch how much faster today's most sophisticated programs run on the high technology Tandy 2000.

You can choose from the latest programs (word, tax, and more exclusive Expert-Driver Software) or use

Tandy 2000 systems start at \$2999, and even for leased-line (only \$500 per month)*. Come in today and see what you've been missing.

Our new 10th computer, enabling 6 years for the asking at any Radio Shack Computer Center or participating Radio Shack store or dealer. Check out our complete line of microcomputers—from pocket models to laptop portables, from powerful desktop computers to multi-user office systems. We have it all. That's why we're so important!

Member since 1980
Radio Shack Computer Centers
are a division of Radio Shack Computer Centers, Inc.
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Radio Shack
COMPUTER CENTERS

Engineered for Excellence!

We've introduced the latest technology in our systems. The Tandy 2000 offers faster file speed, graphics capability and disk storage of over 100 MB (100 megabytes).



Arduino Overview:

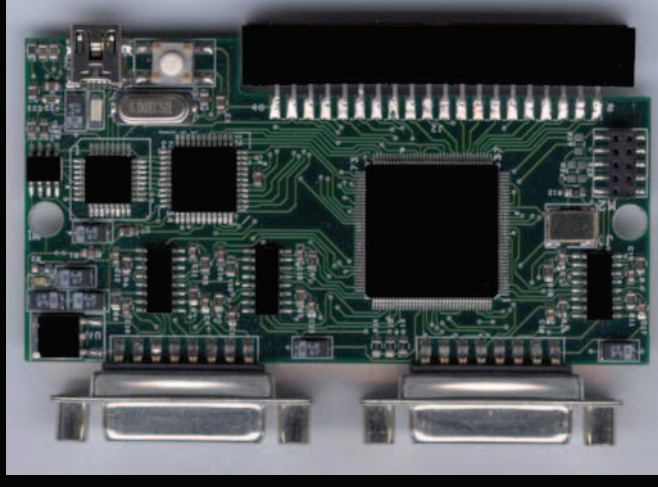
General Purpose computer

- Usually has a human in the loop
- Can be reconfigured to do any number of tasks (excel, email, music)



Embedded Systems

- Human input not required all the time
- Takes specific inputs and computes outputs for a very specific application
- Meets real-time goals
 - Heart monitor
 - Automatic braking systems (ABS)





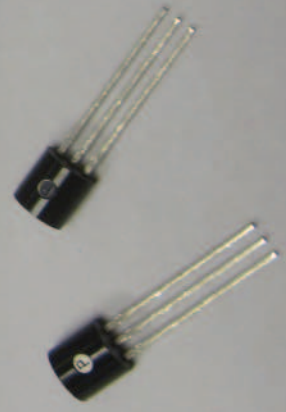
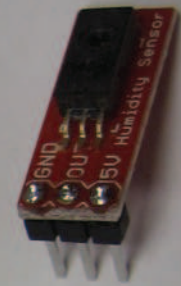
ARDUINO

UNO

Arduino Uno R3
B06H06TVG

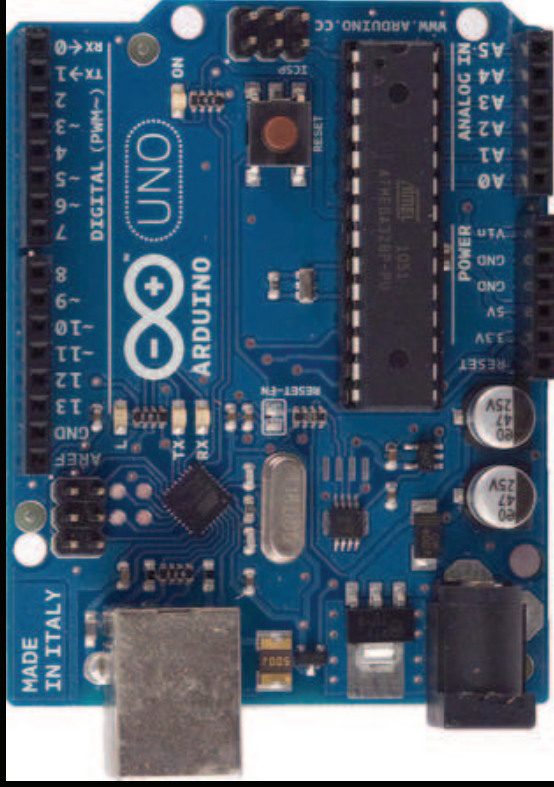
New

00939281



Arduino Overview:

Bit nervous how this might go...



Arduino Overview:

What's under the hood?

External Interrupts

14 Digital
Input/Outputs

GND

Serial I/O

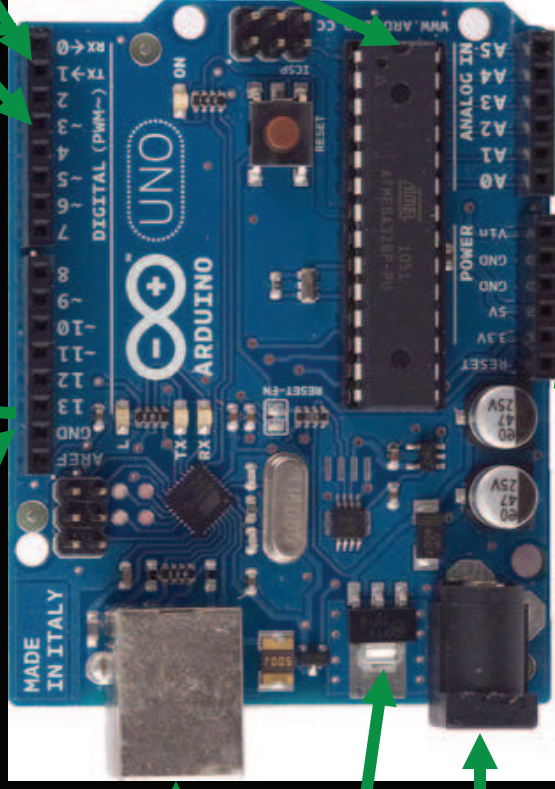
USB

5.0 V

Regulator

9V DC

Power In



- ATmega328
- 10 Bit ADC
- 16 MHz
- 32 KB Flash
- I2C & SPI
- 40 to +85C

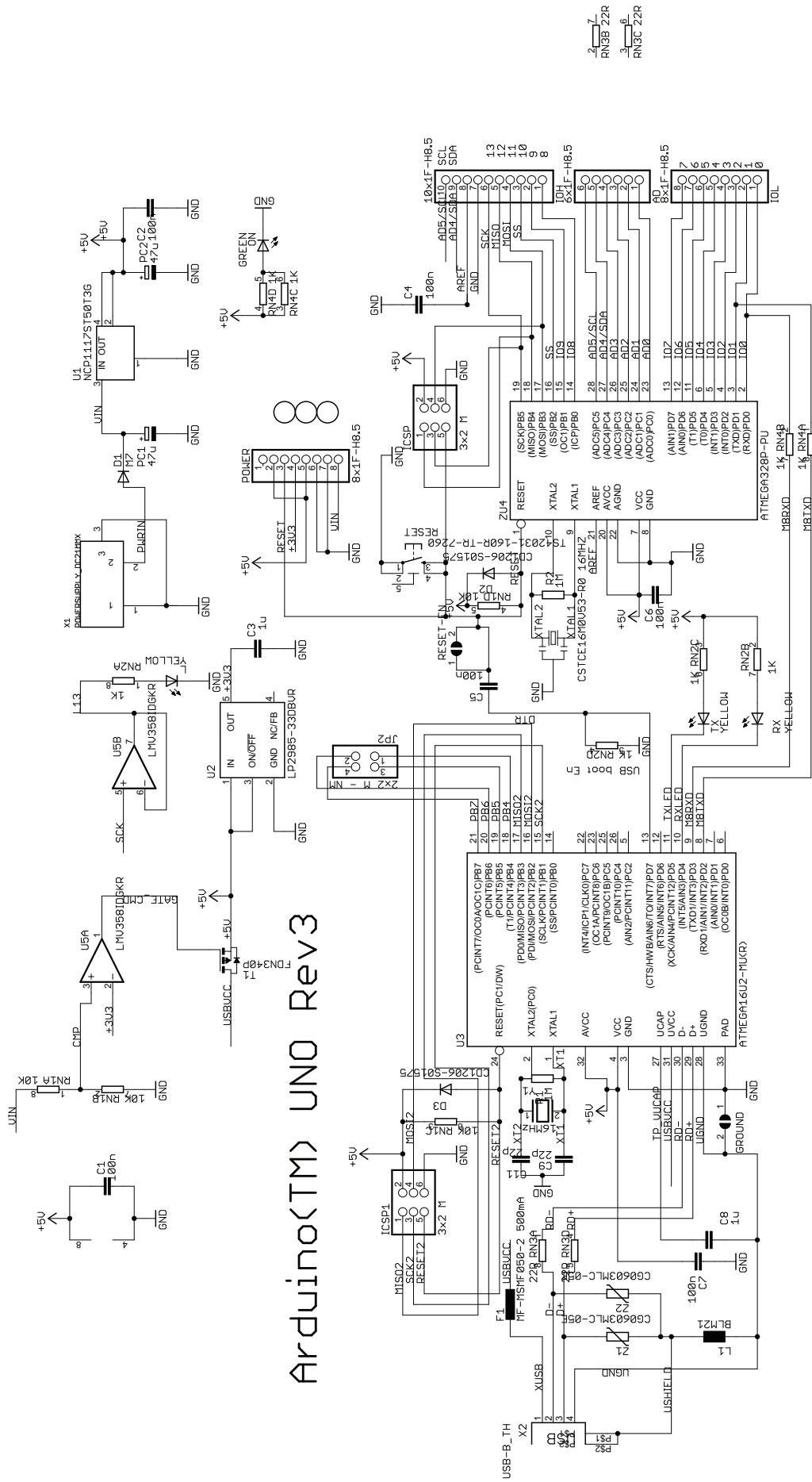
3.3 V

5.0 V

GND

6 Analog Inputs

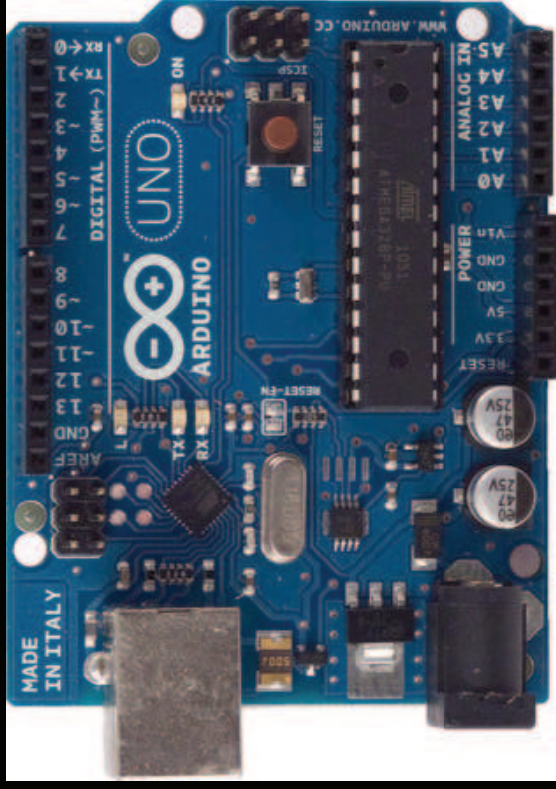
Arduino Overview:



Arduino™ UNO Rev3

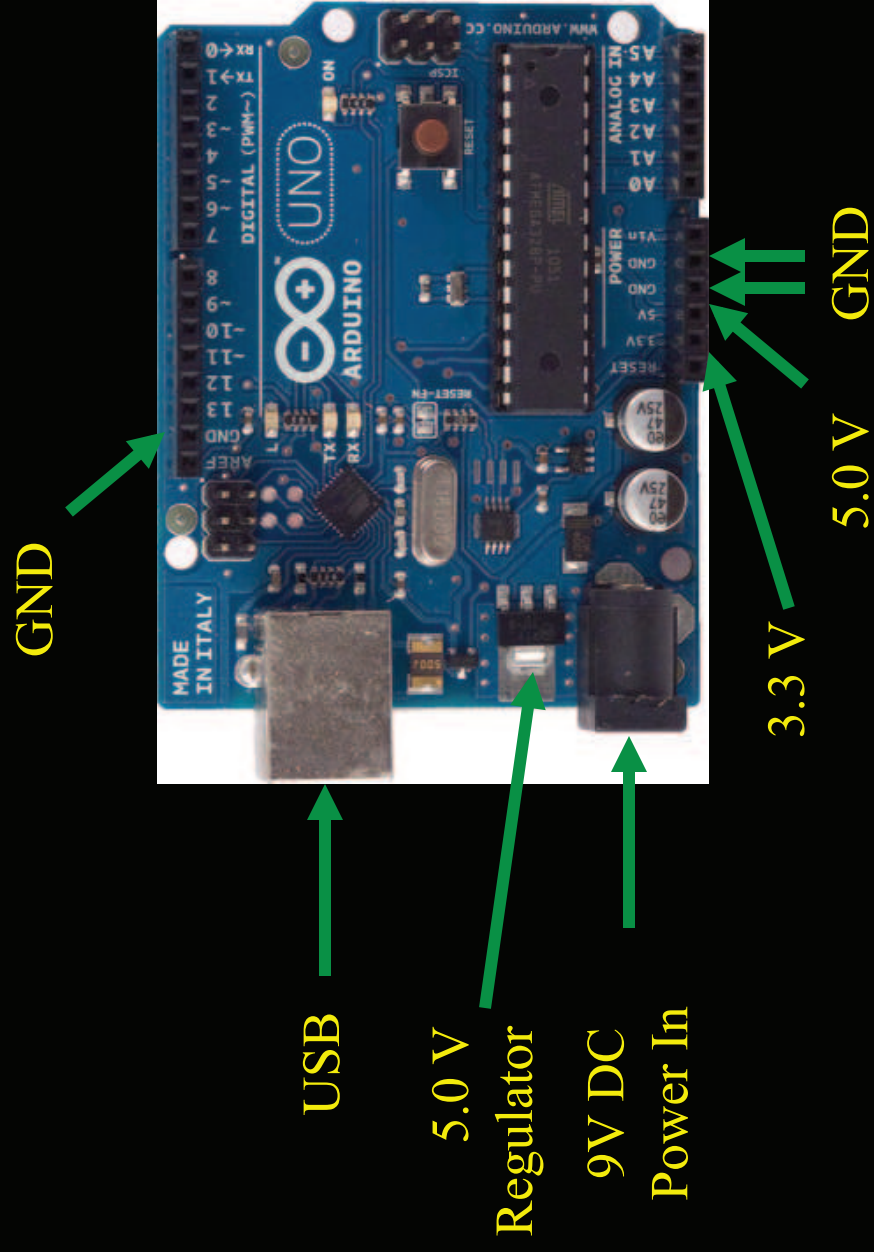
Arduino Overview:

- So what does all that mean?

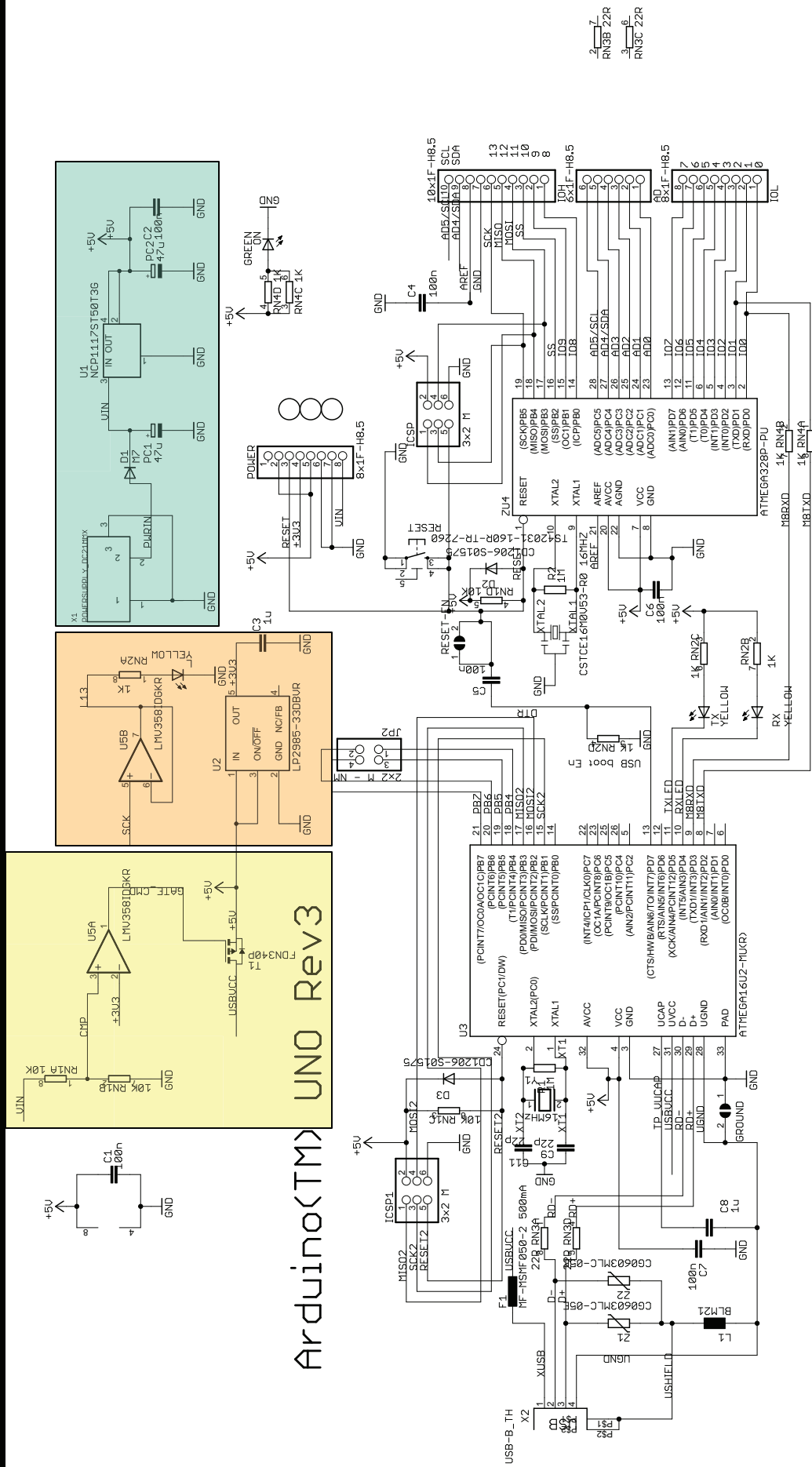


Arduino Overview:

The Easy Stuff...

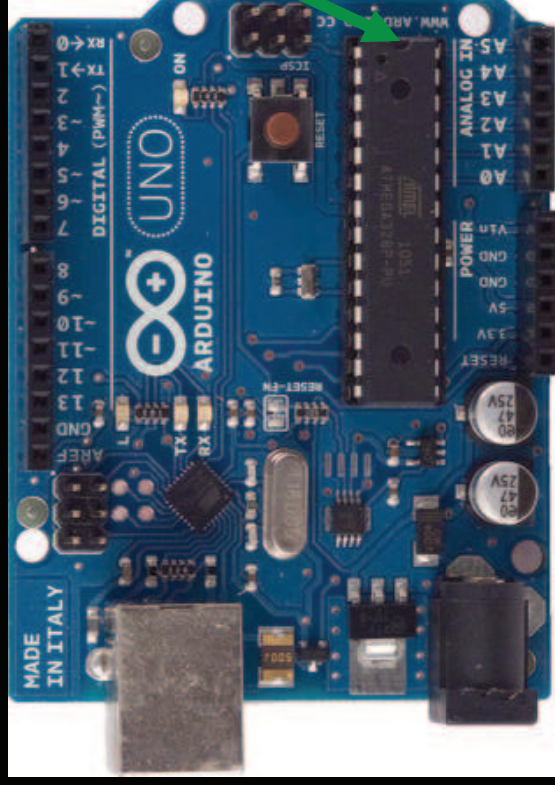


Arduino Overview:



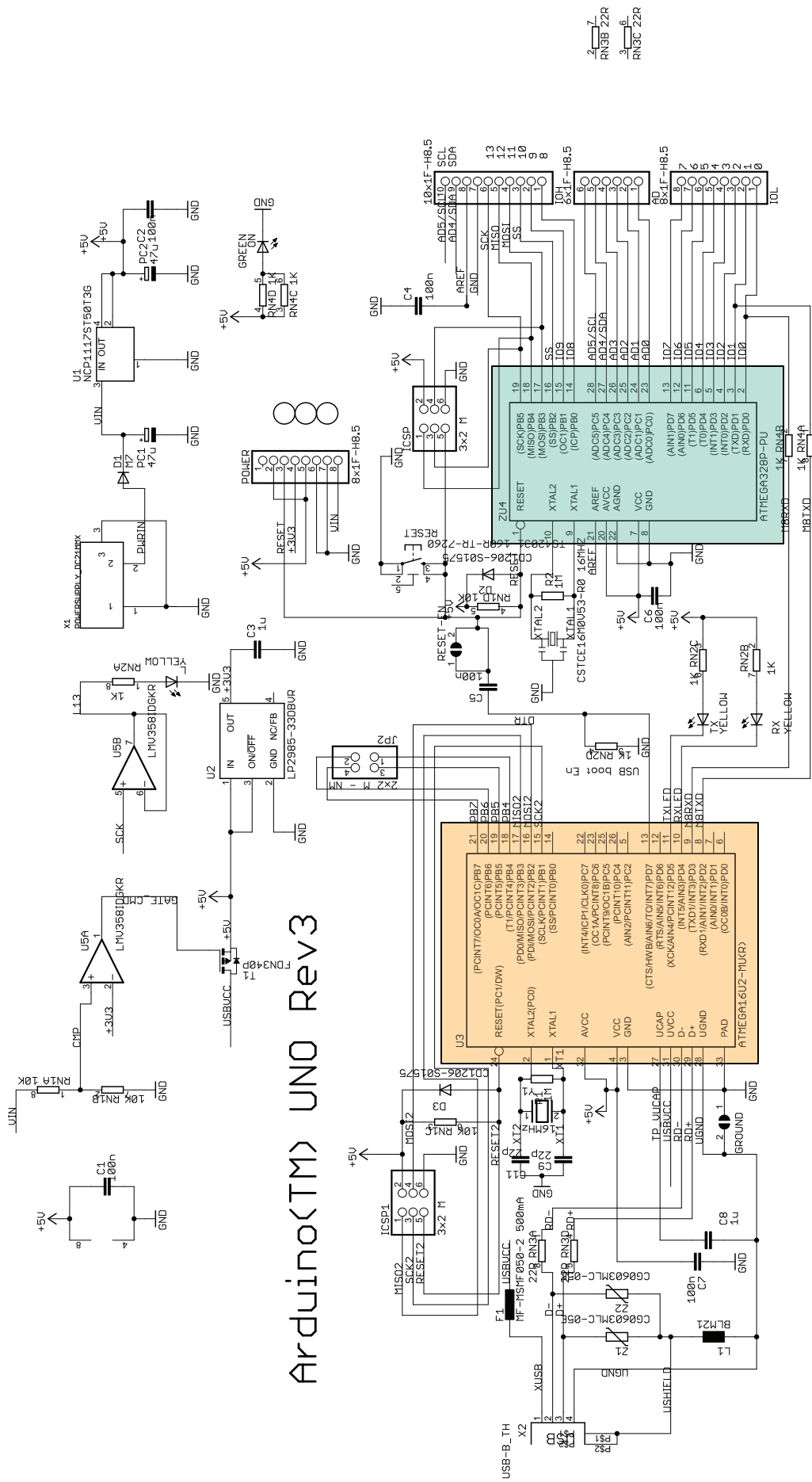
Arduino Overview:

The Chip....



- ATmega328
- 10 Bit ADC
- 16 MHz
- 32 KB Flash
- I2C & SPI
- 40 to +85C

Arduino Overview:



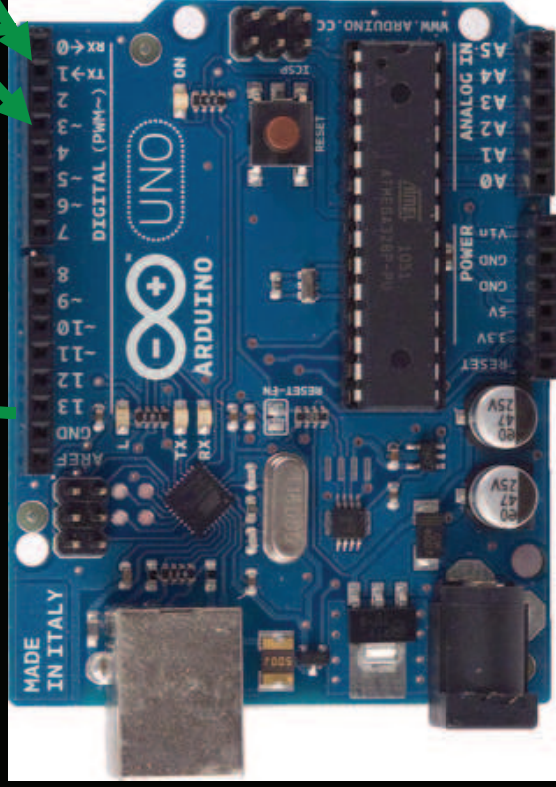
Arduino Overview:

Other...

External Interrupts

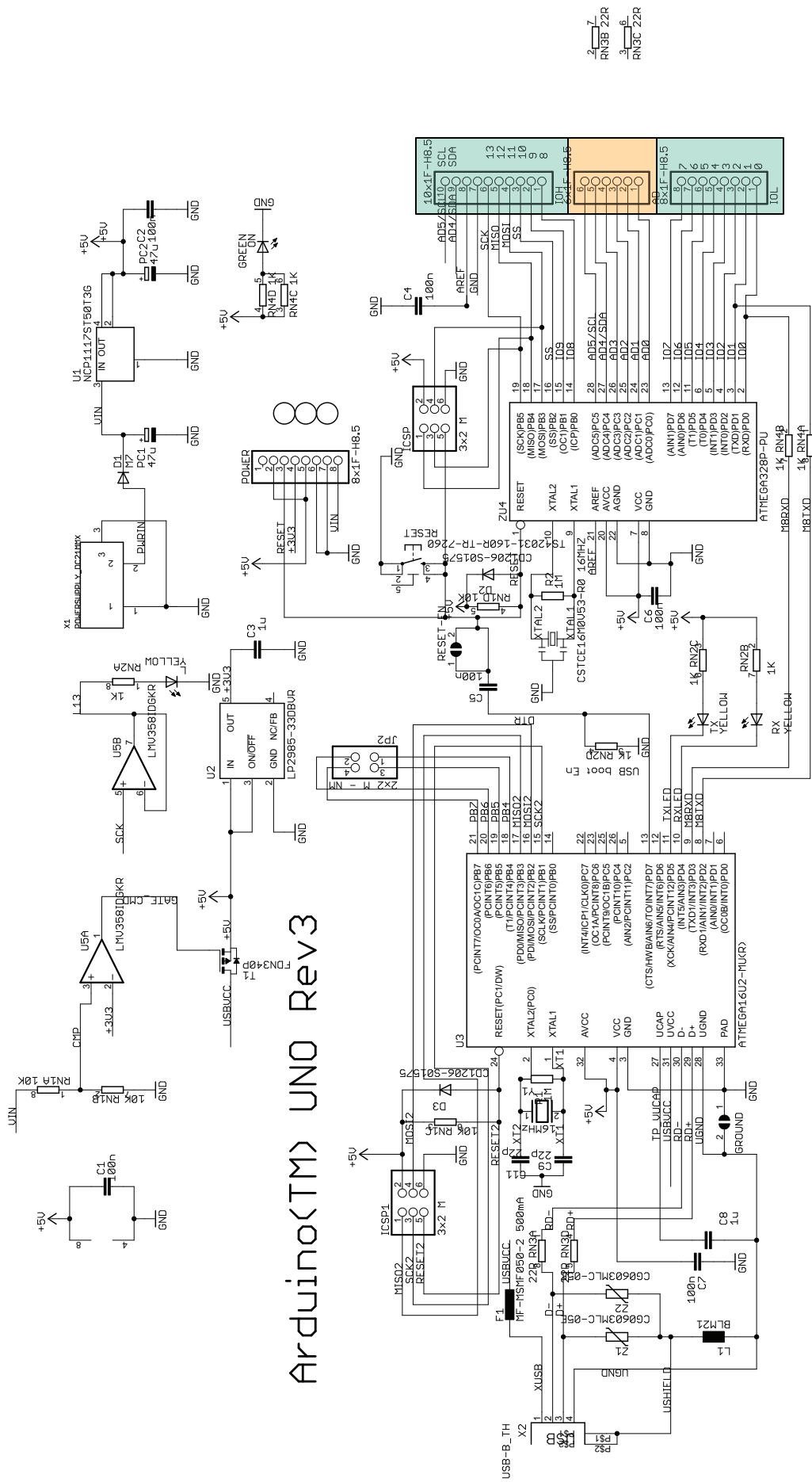
14 Digital
Input/Outputs

Serial I/O



6 Analog Inputs

Arduino Overview:



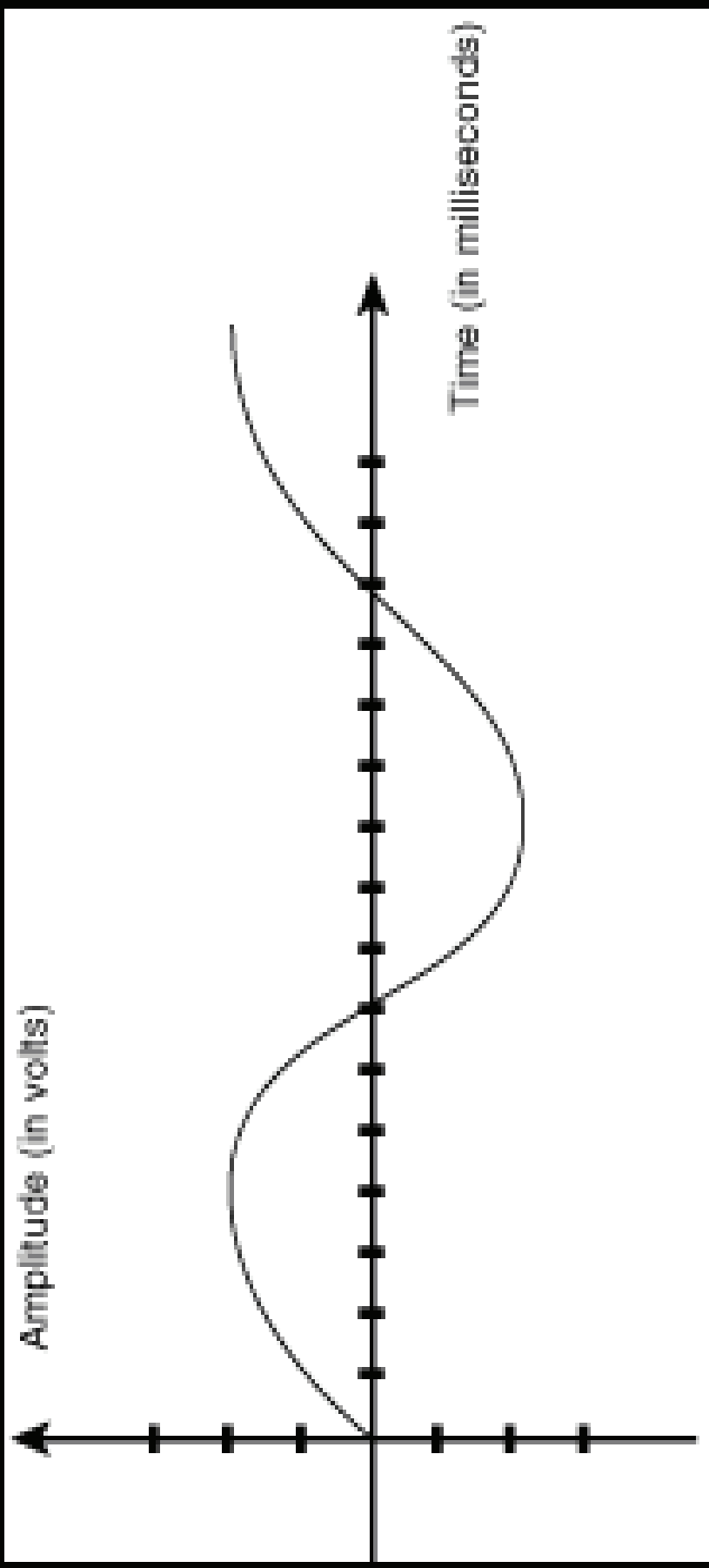
Arduino(TM) UNO Rev3

Analog vs. Digital



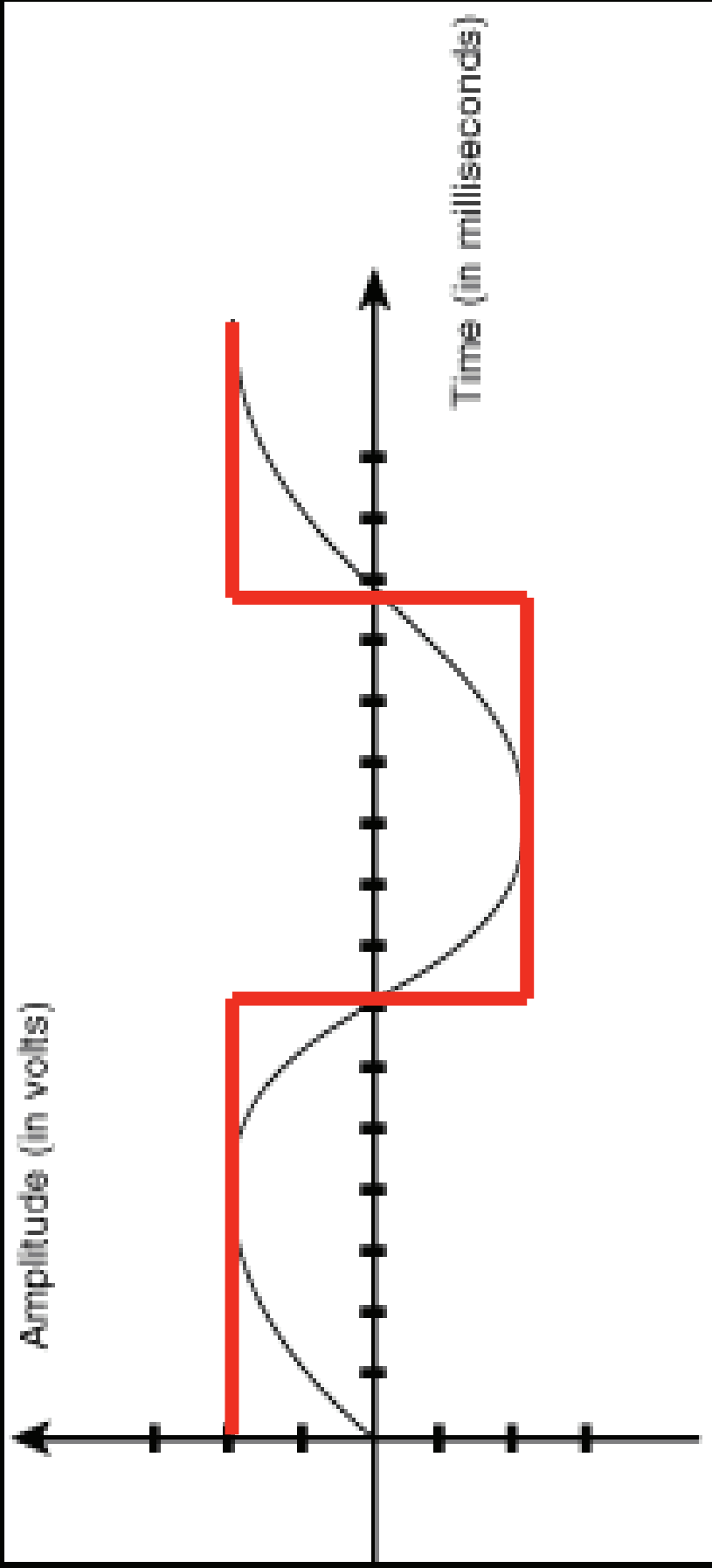
Analog:

- Voltage, continuous, real-world



Digital:

- Bits and Bytes, On/Off, 1 or 0, high or low, non-continuous

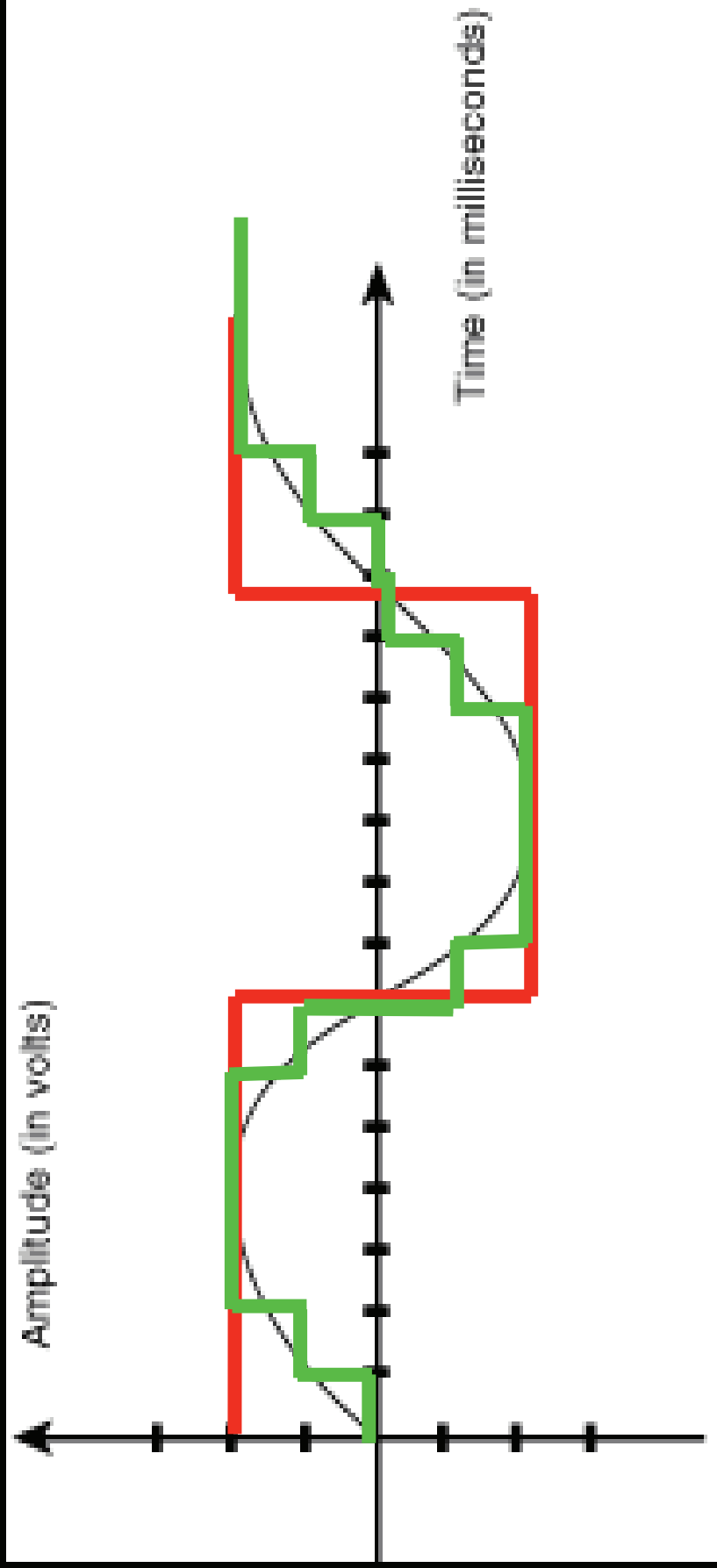


Digital:

- A state is one unique combination of bits
 - 1 bit – 0 or 1 = 2 states = 2^1
 - 2 bits – 00, 01, 10, 11 = 4 states = 2^2
 - 4 bits – 0000, 0001...1111 = 16 States = 2^4
 - 8 bits = 00000000...11111111 = 256 states = 2^8
 - 16 bits = 0000000000000000...1111111111111111
= 65,536 states = 2^{16}
- More bits provides more precision over a given voltage range
- If it is necessary to record small changes, more precision (bits), is required
- 8 bits is a byte
- **10 bits is how many bytes?**

Digital:

- Bits and Bytes, On/Off, 1 or 0, high or low, non-continuous



Red line – 2 bits = less info

Green line – 4 bits = more info

Analog vs. Digital

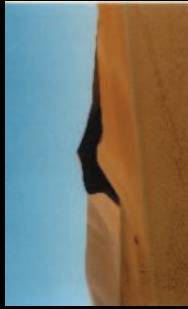
- What is the difference between 8-bit and 10-bit conversions?
 - An 8-bit conversion has 2^8 (0 to 255) possible values,
 - Resolution is $1/(2^8 - 1) * 5V = 1/255 * 5V = 0.0196 V$

Analog vs. Digital

- **A 10-bit conversion has 2^{10} (0 to 1024) possible values**
- **Resolution is $1/(2^{10} - 1) * 5V = 1/1023 * 5V = 0.00489 V$**
- **For a device that is very precise, a 10-bit conversion allows for a higher resolution on the data (high-range accelerometers)**

Analog vs. Digital

42.0 C temp
Real World



Real World to
Analog Voltage



4.20V = 42.0 C

2 bit ADC

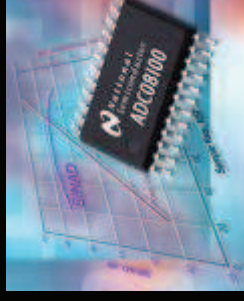
0C = 0V 50C = 5V

3 =
11 binary

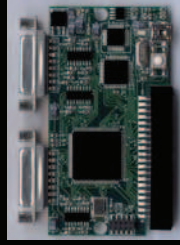
4.20V = 4

$$\begin{aligned} & (4.20V / 5.0V * 4) \\ & = 3.36 \\ & = 3 \end{aligned}$$

5V = 3



0V = 0



Storage for
later use

ADC = Analog to Digital Converter
= Voltage to Binary

Sensor & Storage

42.0 C temp
Real World



Real World to
Analog Voltage



4.20V = 42.0 C

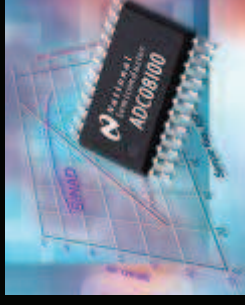


10 bit ADC



0C = 0V 50C = 5V

5V = 1023



0V = 0

860 =
1101011100 binary



4.20V = 860

$$\begin{aligned} & (4.20\text{V} / 5.0\text{V} * \\ & 1024) \\ & = 860.14 \\ & = 860 \end{aligned}$$



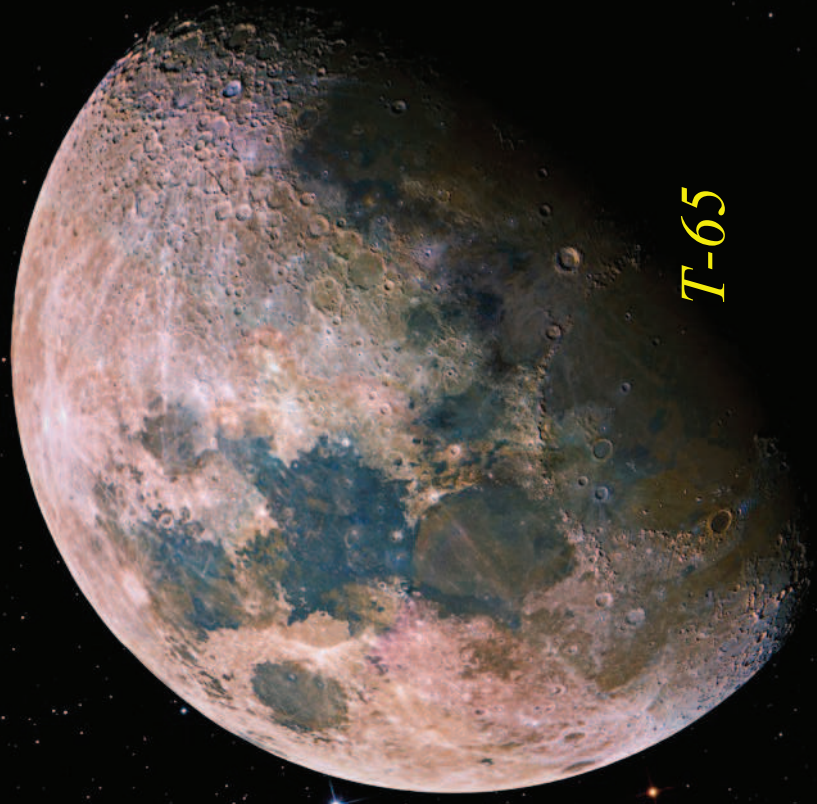
Storage for
later use

ADC = Analog to Digital Converter
= Voltage to Binary

Questions?



Colorado Space Grant Consortium



T-65

Arduino Overview:

Let's take it for a drive...

External Interrupts

14 Digital
Input/Outputs

GND

Serial I/O

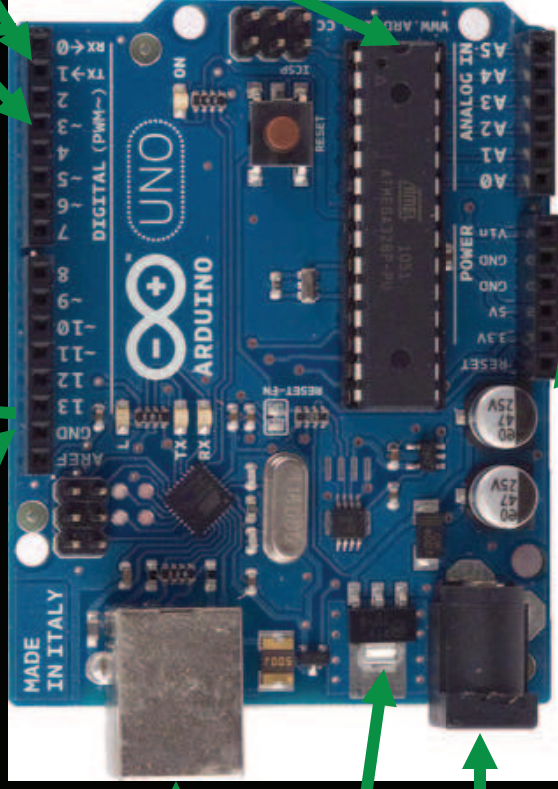
USB

5 V

Regulator

9V DC

Power In



- ATmega328
- 10 Bit ADC
- 16 MHz
- 32 KB Flash
- I2C & SPI
- 40 to +85C

3.3 V

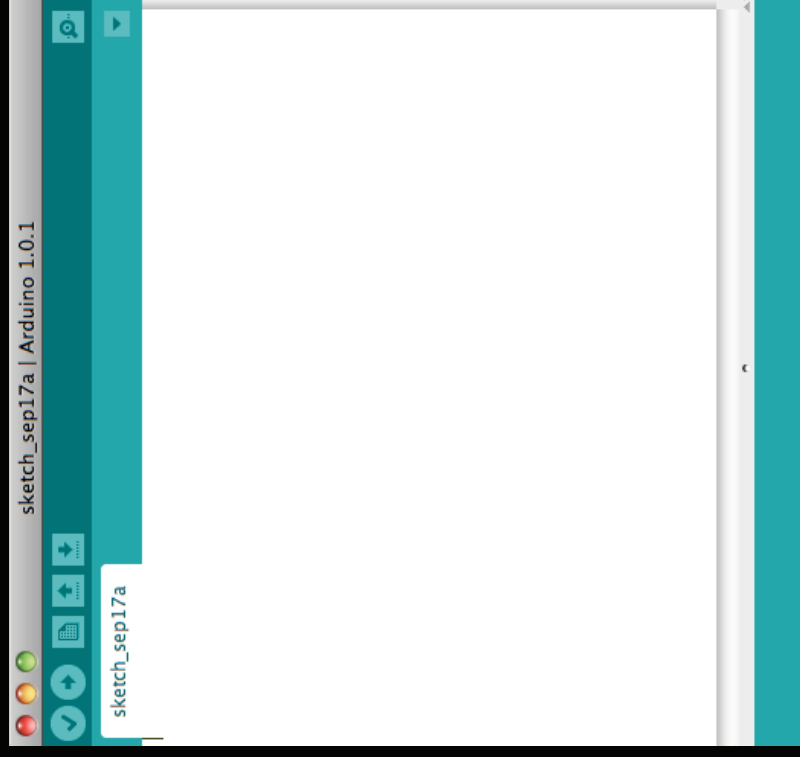
5.0 V

GND

6 Analog Inputs

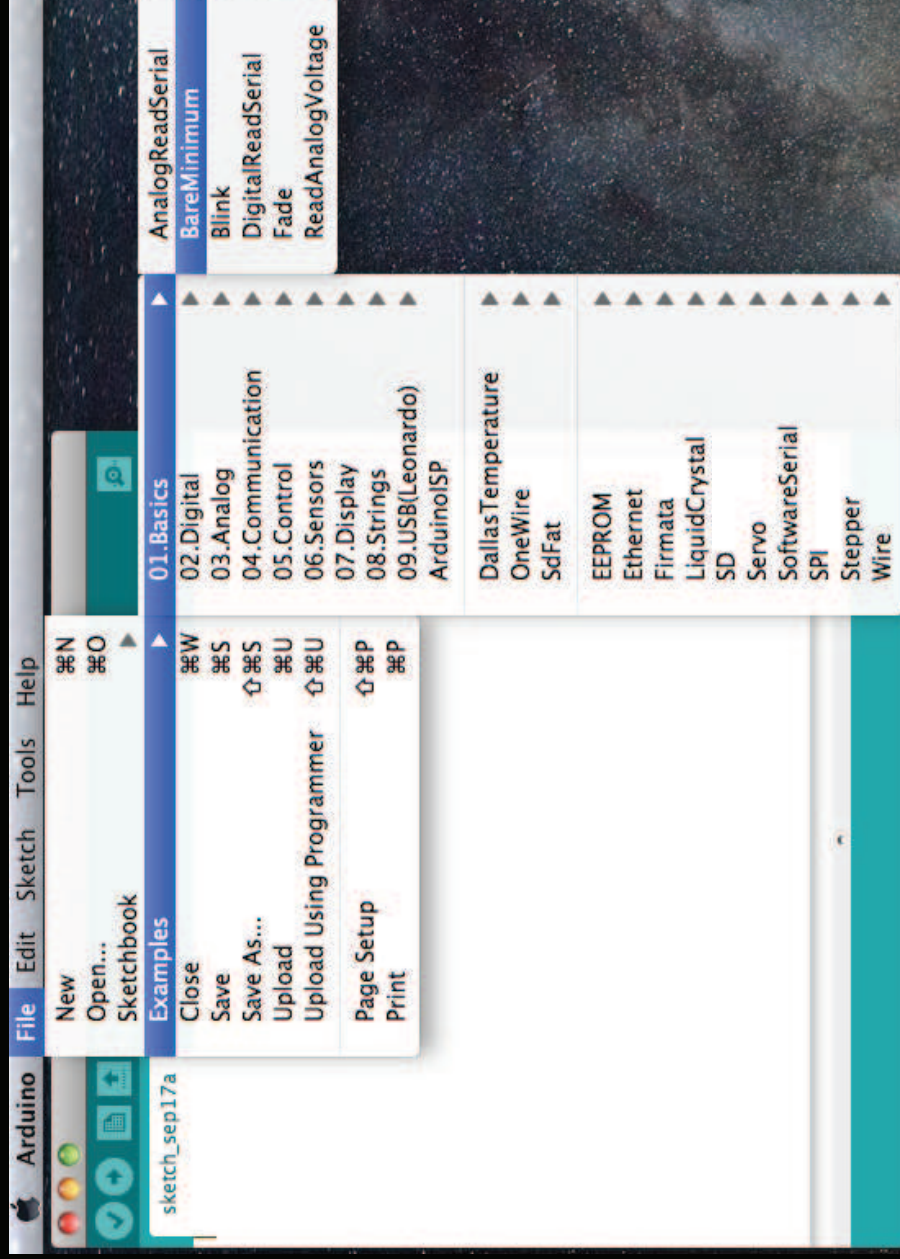
Arduino Overview:

- Launch the Arduino Software **1.0.1**
- Sketch

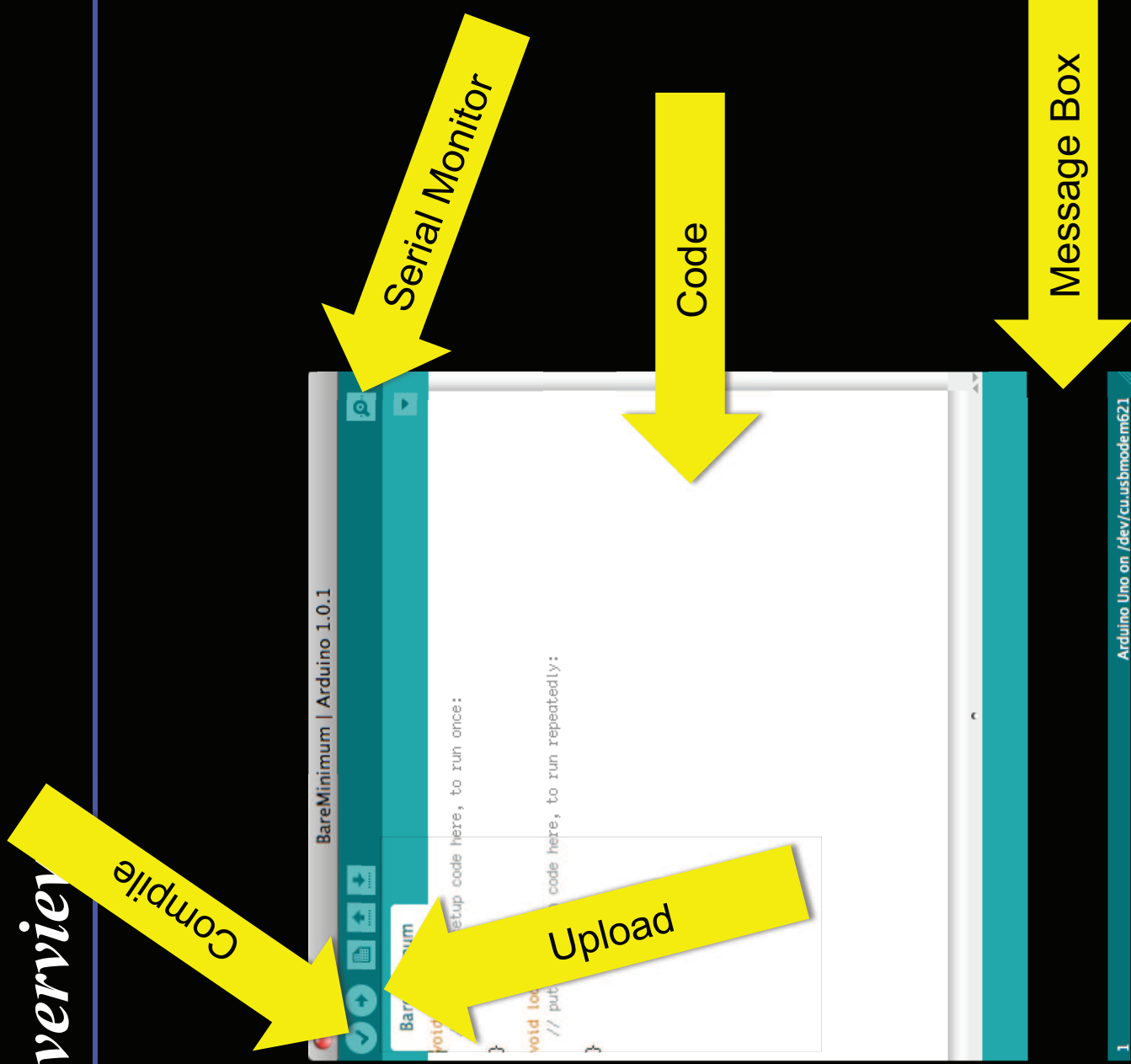


Arduino Overview:

- File/Examples/01.Basics/BareMinimum



Arduino Overview



Message Box

Arduino Overview:

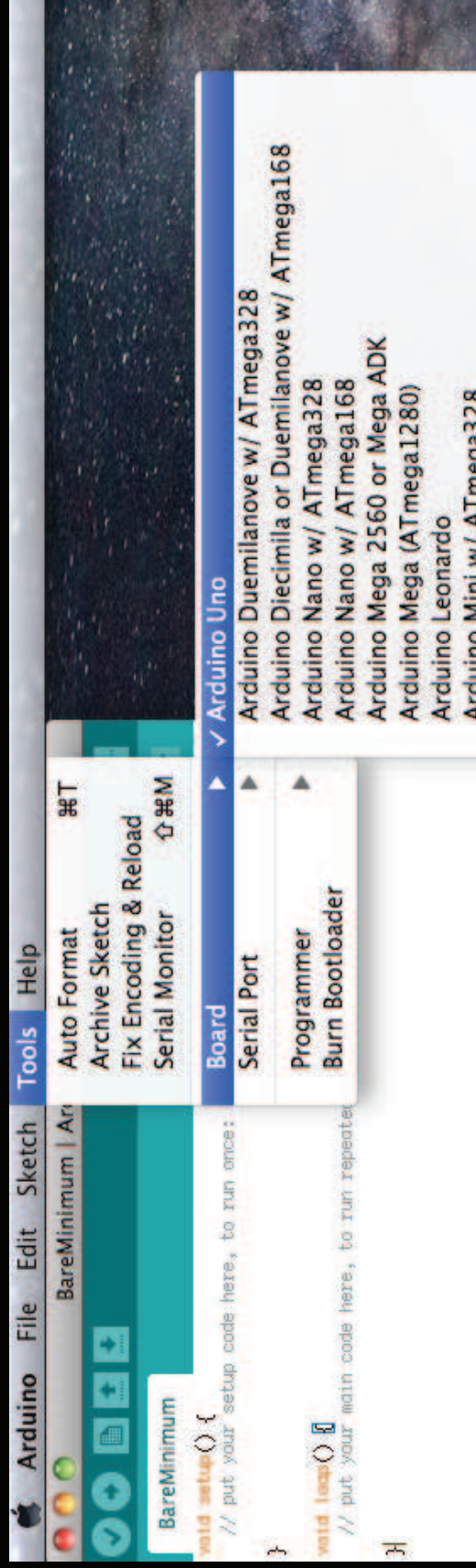
Code



```
void setup() {  
  // put your setup code here, to run once:  
}  
  
void loop() {  
  // put your main code here, to run repeatedly:  
}
```

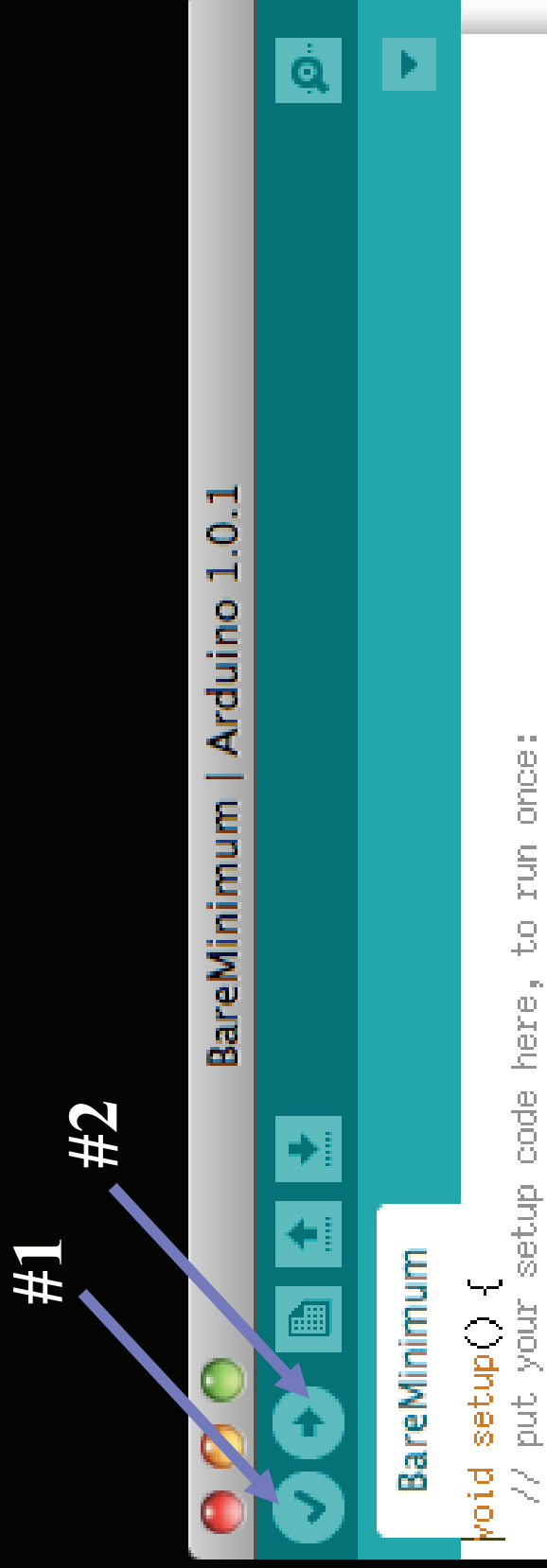
Arduino Overview:

- Connect your Arduino Uno to your laptop via the USB cable
- Select right board = **Tools/Board/Arduino Uno**



Arduino Overview:

1. Compile code and check for messages
2. Upload code to Arduino (checking communication with board)



Arduino Overview:

- Any problems?
- Everyone, please wait until this has been completed

Arduino Overview:

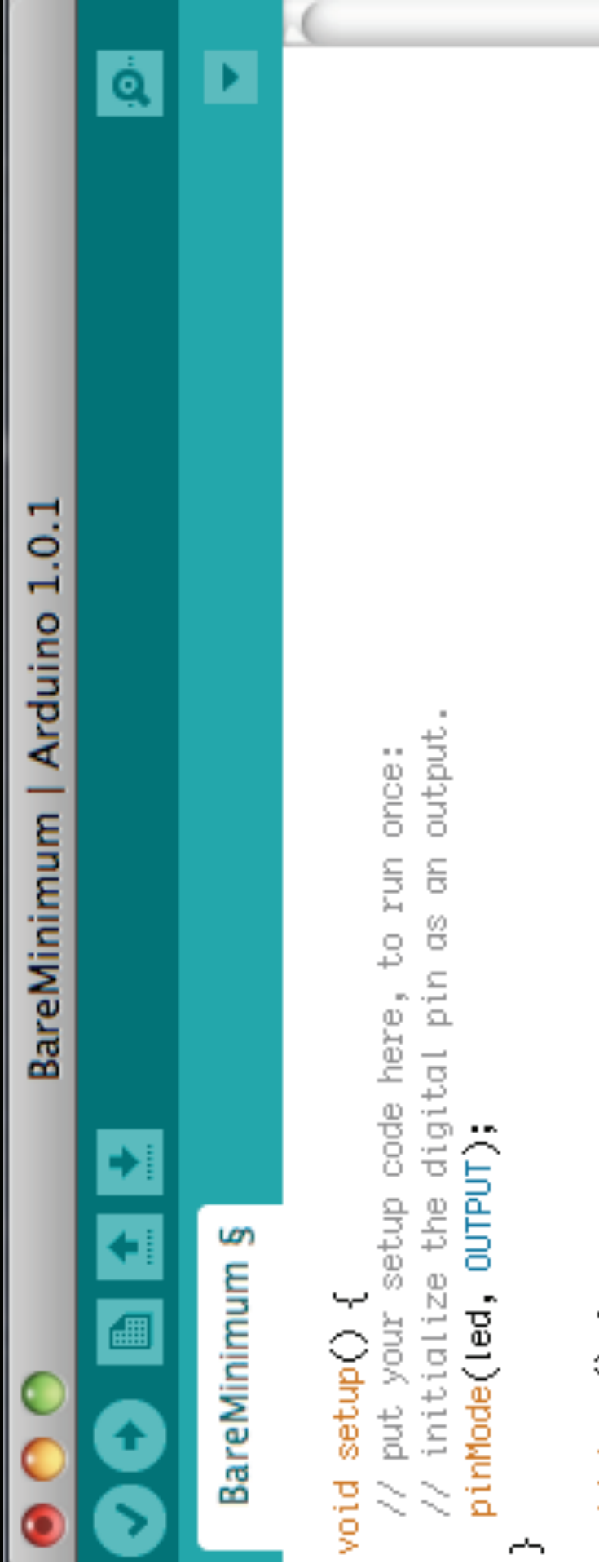
- Add the following to the sketch...



```
/*  
  Blink  
  Turns on an LED on for one second, then off for one second, repeatedly.  
  
  This example code is in the public domain.  
  */  
  
// Pin 13 has an LED connected on most Arduino boards.  
// give it a name:  
int led = 13;
```

Arduino Overview:

- Add the following to the sketch...

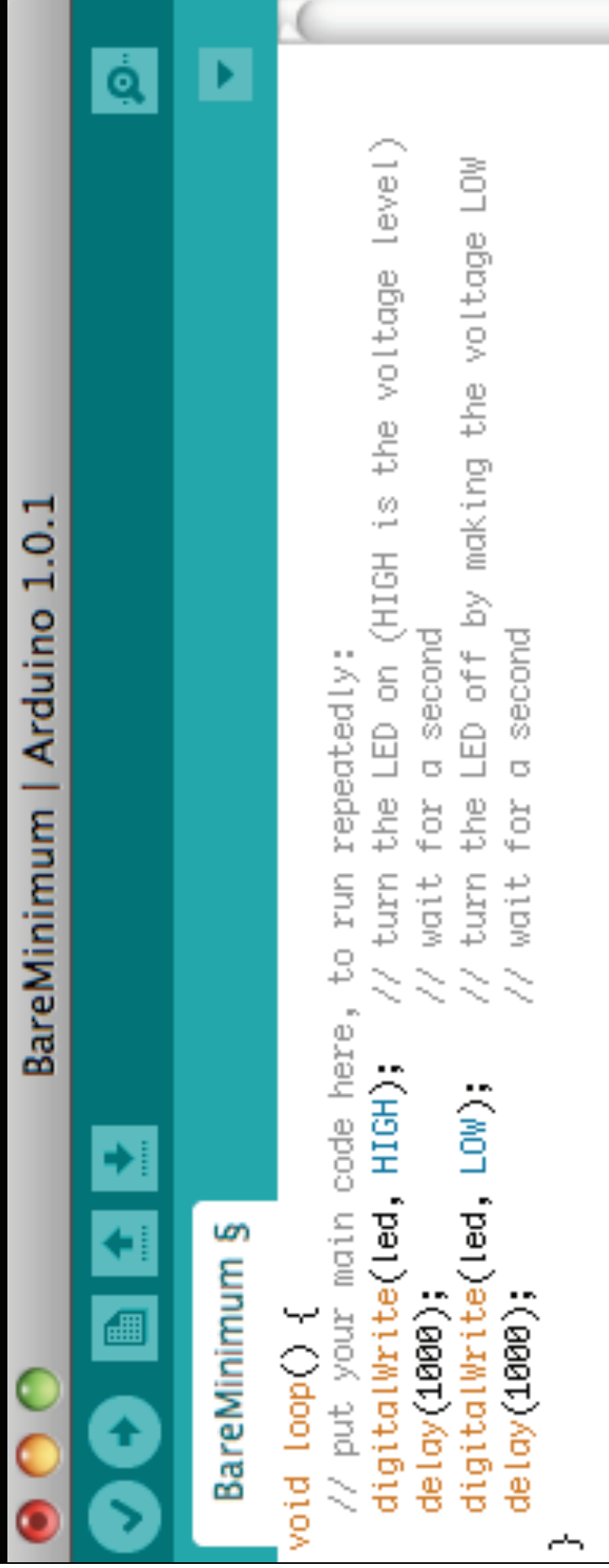


The screenshot shows the Arduino IDE interface. The title bar reads "BareMinimum | Arduino 1.0.1". The toolbar includes icons for a checkmark, a keyboard, a mouse, and a search icon. The code editor displays the following C++ code:

```
void setup() {  
  // put your setup code here, to run once:  
  // initialize the digital pin as an output.  
  pinMode(led, OUTPUT);  
}
```

Arduino Overview:

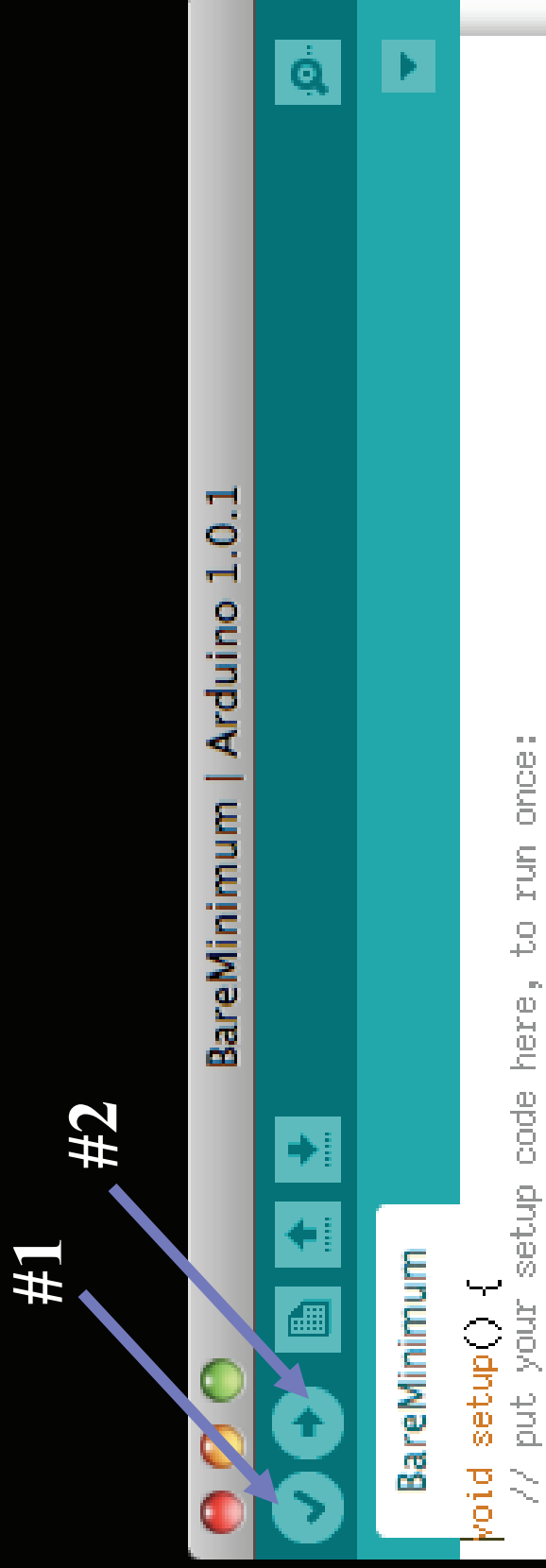
- Add the following to the sketch...



```
void loop() {  
  // put your main code here, to run repeatedly:  
  digitalWrite(led, HIGH); // turn the LED on (HIGH is the voltage level)  
  delay(1000); // wait for a second  
  digitalWrite(led, LOW); // turn the LED off by making the voltage LOW  
  delay(1000); // wait for a second  
}
```

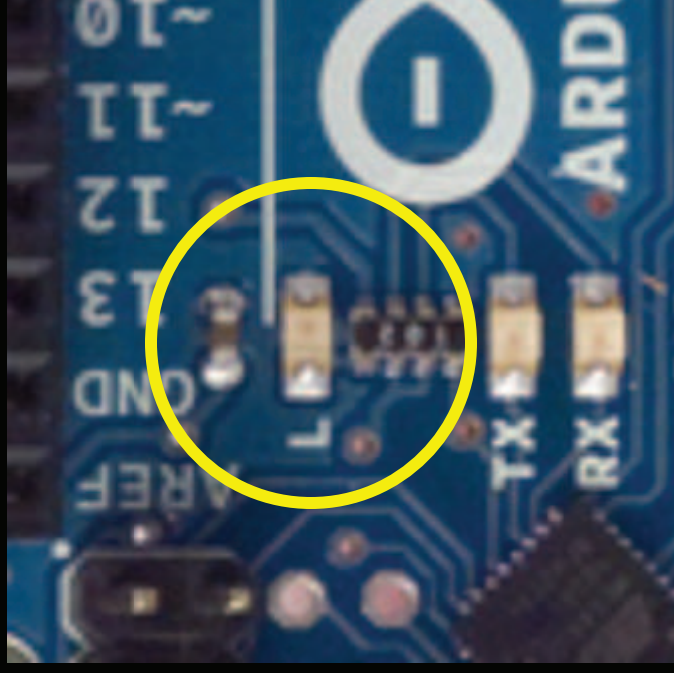
Arduino Overview:

1. Compile code and check for messages
2. Upload code to Arduino (checking communication with board)



Arduino Overview:

- Does LED blink?
- Change the delay in the sketch and try again
- Do you see a change?



Arduino Overview:

- If you can Blink an LED, you can do anything
- Why?