IME-100
Interdisciplinary Design and Manufacturing

Introduction Arduino and Programming

Topics:

1. Introduction to Microprocessors/Microcontrollers

2. Introduction to Arduino

3. Arduino Programming Basics

- Several online Tutorials are also available on the Arduino website

  http://arduino.cc/en/Tutorial/HomePage

- Online Arduino book

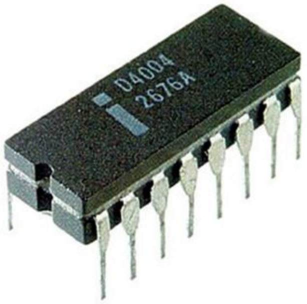
  http://www.introtoarduino.com/downloads/IntroArduinoBook.pdf

- Simulate Arduino online

  http://123d.circuits.io/

Introduction to Microprocessors

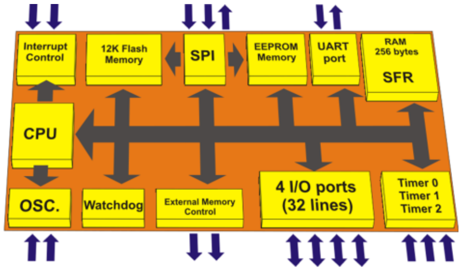
- The earlier processors were implemented in multiple printed circuit boards.
- ***Microprocessor*** is a processor implemented in a single integrated circuit.
- Brief history
    - In 1971, Intel introduced the first microprocessor in a single chip, the Intel 4004, which was a 4-bit processor running at 400 KHz clock



- Disadvantages
    - Does not have on-chip memory.
    - Cannot drive the I/O devices.
    - Does not have peripheral functions such as parallel I/O ports, timers, A/D converter, and so on.

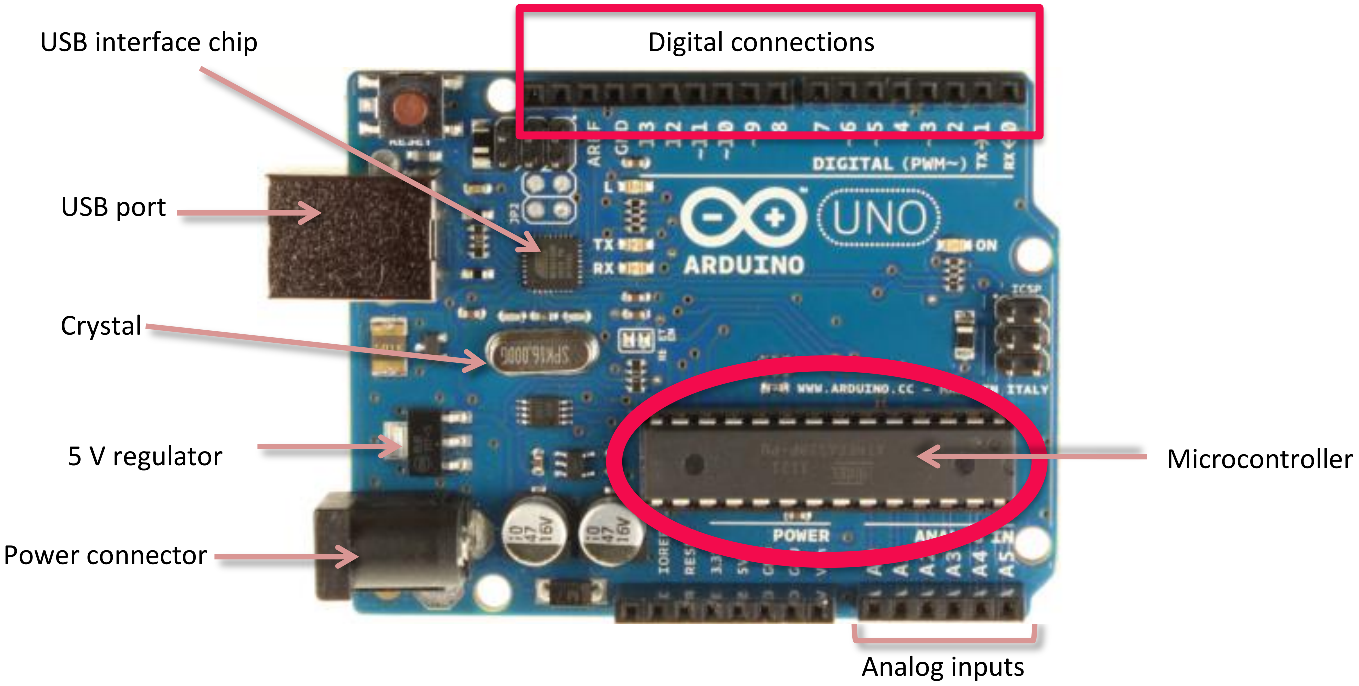
Microcontroller

- A computer on a chip. The chip contains:
    - Processor
    - RAM for holding data
    - EPROM/Flash for holding the programs
    - Input and output pins (link the microcontroller to the rest of the world).



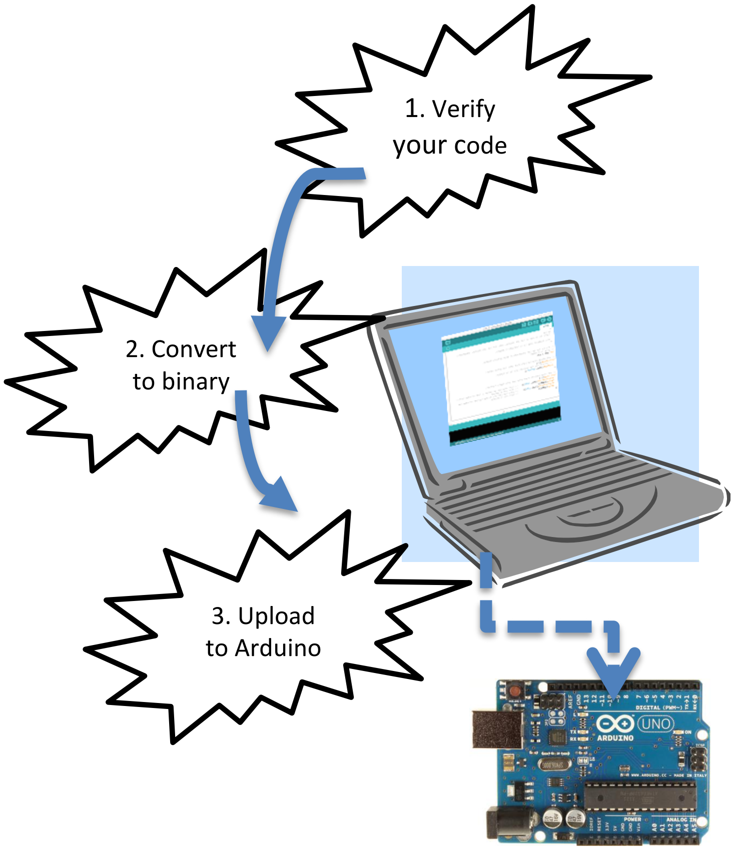
Introduction to Arduino

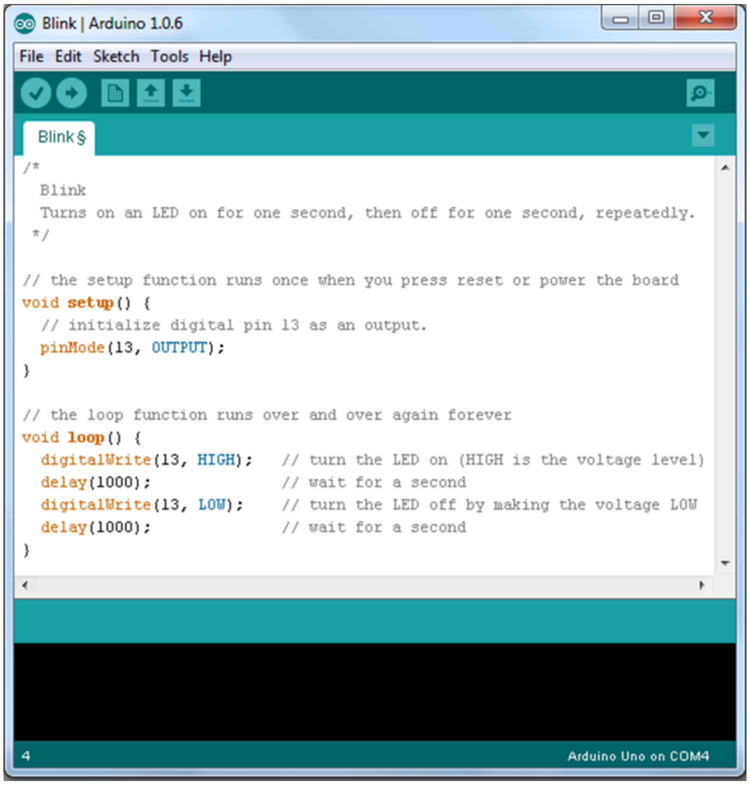
- Arduino is an open-source physical computing platform based on a simple microcontroller board
- It has development environment for writing software for the board.
- Its programming language: Simplified version of C/C++. (Easy to learn)
- Why Arduino?
    - Inexpensive: ATmega328p: $2.50, Pre-assembled Arduino Uno board < $30
    - Cross-platform
    - Simple and clear programming environment
    - Open source and extensible software
        - C++ libraries and AVR-C code can be added
    - Open source and extensible hardware
        - Hardware design is also open
        - Users can extend it



Arduino Programming Process

- Arduino IDE is an Integrated development environment
  - Used for writing and downloading program to Arduino chip
- Setup process
  - Select a board type (the IDE supports several types of Arduino compatible boards)
  - Select a serial port (the communication interface between the Arduino board and your PC)
- Program structure – All Arduino programs (sketches) contain:
  - void setup()
  - void loop()
- Uploading a sketch





```
/*
  Blink
  Turns on an LED on for one second, then off for one second, repeatedly.
 */

// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin 13 as an output.
  pinMode(13, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(13, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(1000);              // wait for a second
  digitalWrite(13, LOW);    // turn the LED off by making the voltage LOW
  delay(1000);              // wait for a second
}
```

Arduino Prep

- This should have already been done on your lab PCs. No need to do it again.
- Follow the following steps if you want to set up the Arduino programming environment on your own computer.
- Video tutorial is available on youtube, check out the following: http://www.youtube.com/watch?v=fCxzA9_kg6s

1. Install the Arduino IDE software

2. Install a USB driver to let your computer recognize an Arduino board. This will install a serial port device through which the computer can talk to the Arduino.

Installing the Arduino IDE Software

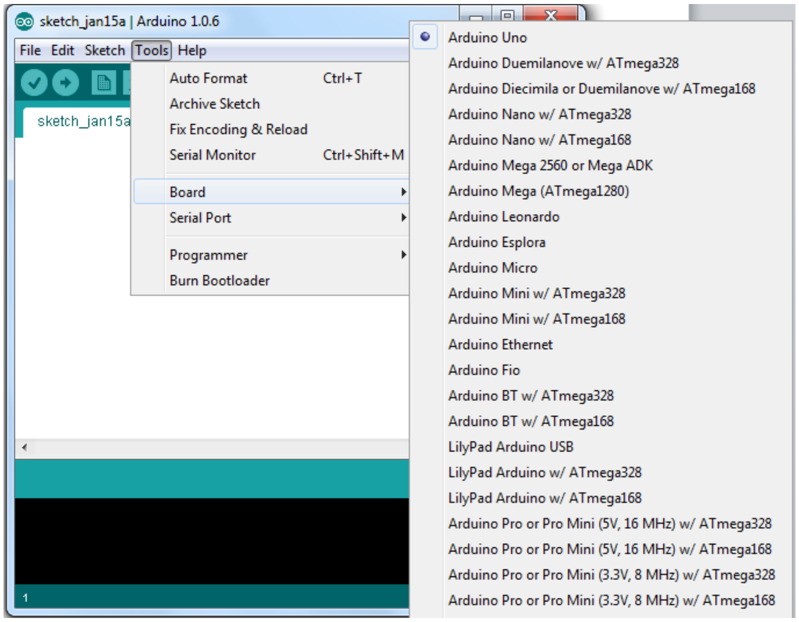
- Go to http://arduino.cc/en/Main/Software
- Download the latest version of Arduino for your system.
    - For the computers in the lab we the Windows version of the Arduino IDE software, but it is also available for other operating systems.
    - You can download the Windows installer which gets an executable file that automatically installs the software or get a zip file.
- If you get the zip file, you need to unzip it and you will see a folder named after the zip filename.
    - Open the folder. Finally you will see 'arduino-1.x.x' folder (where x represents the version number). This is the folder where the Arduino software is installed in.
- There is no fancy installation tool or setup the software.
    - You can just copy the folder to anywhere on your disk drive.

Arduino Sketch

- Open the folder 'arduino-1.x.x'
- Create a short cut on the Desktop
  for the executable, arduino.exe.
  - Right click on the exe and select Send to – Desktop.
- Execute arduino.exe.
  - Ignore Security Warning and click the Run button.
  - "Sketchbook folder disappeared" message will be shown.
  - Do not worry. Just click 'OK'
- You can find the 'Arduino' folder is newly created.
  - This is your Sketchbook folder that is a kind of workspace where your source code will be saved.
  - Saving your source code into this folder is strongly recommended for later uses.

Arduino Board Type

- Several options are available
- In this lab you will be using an Arduino Uno board
  - See http://arduino.cc/en/Main/Products for details
  - Select 'Arduino Uno' from the Tools – Board menu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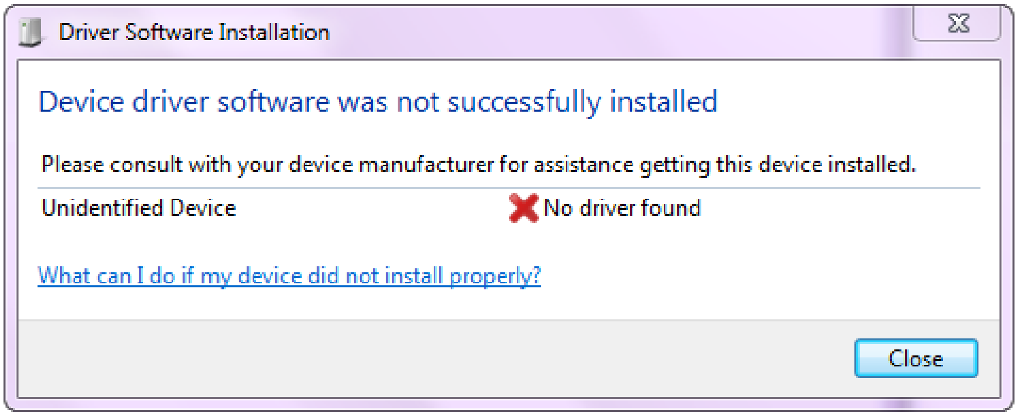
Auto Format Ctrl+T
Archive Sketch
Fix Encoding & Reload
Serial Monitor Ctrl+Shift+M
Board
Serial Port
Programmer
Burn Bootloader
Arduino Uno
Arduino Duemilanove w/ ATmega328
Arduino Diecimila or Duemilanove w/ ATmega168
Arduino Nano w/ ATmega328
Arduino Nano w/ ATmega168
Arduino Mega 2560 or Mega ADK
Arduino Mega (ATmega1280)
Arduino Leonardo
Arduino Esplora
Arduino Micro
Arduino Mini w/ ATmega328
Arduino Mini w/ ATmega168
Arduino Ethernet
Arduino Fio
Arduino BT w/ ATmega328
Arduino BT w/ ATmega168
LilyPad Arduino USB
LilyPad Arduino w/ ATmega328
LilyPad Arduino w/ ATmega168
Arduino Pro or Pro Mini (5V, 16 MHz) w/ ATmega328
Arduino Pro or Pro Mini (5V, 16 MHz) w/ ATmega168
Arduino Pro or Pro Mini (3.3V, 8 MHz) w/ ATmega328
Arduino Pro or Pro Mini (3.3V, 8 MHz) w/ ATmega168
1

Serial Port

- Serial Port is an entry or exit door through which you can send or receive data between the Arduino and your PC
- Modern laptops do not have serial ports anymore
- Do not worry! We can create a virtual serial port from a USB port
  - This means that the USB port connected to a cable will be considered as a serial port
- A virtual serial port should be installed for your computer to communicate with an Arduino board
  - The latest versions of the Arduino IDE handle this automatically
  - However, if the driver is not installed on your computer you need to follow the step-by-step instructions given below
- Please remember you have to select a serial port in Sketch after completing the instructions

USB Driver Install

- This step is optional. It is needed only if the USB driver was not automatically installed as part of the Arduino IDE installation through the Windows installer.
- Connect an Arduino board to your computer using a USB cable
  - The Driver Software Installation message box will appear
  - Sooner or later it will fail
  - No need to worry, we are on the right track



Driver Software Installation

Device driver software was not successfully installed

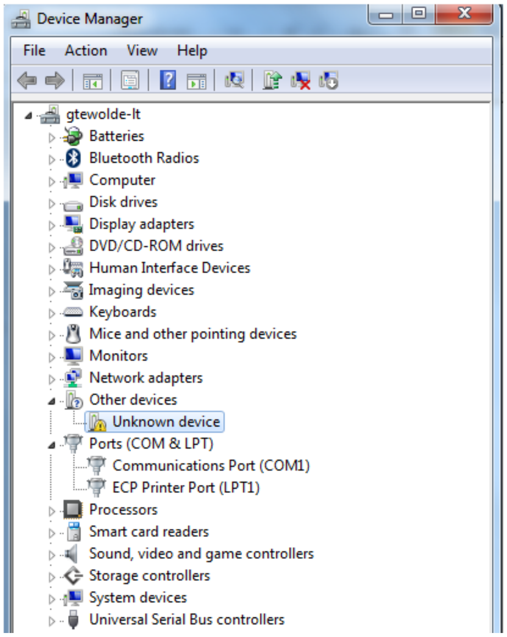
Please consult with your device manufacturer for assistance getting this device installed.

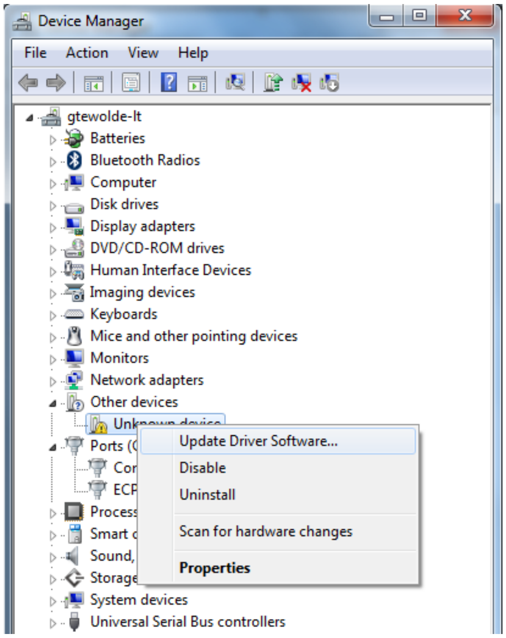
Unidentified Device ❌ No driver found

What can I do if my device did not install properly?

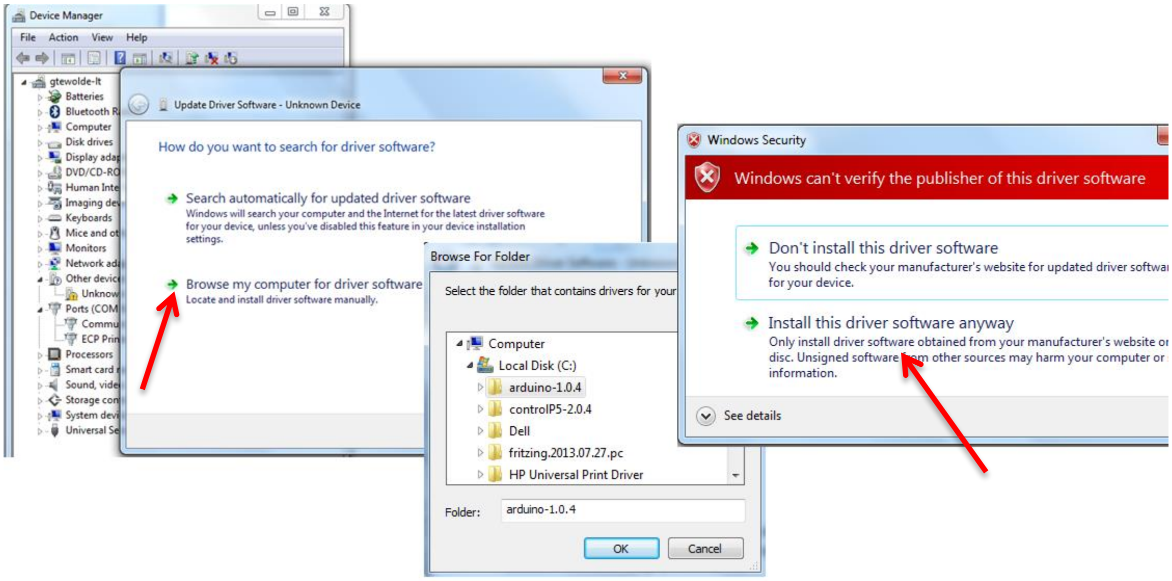
USB Driver Install …

- Open Device Manager from [Control Panel -- System and Security]
- Locate "Other devices" – Unknown device





- Click Update Driver Software…
- Select 'Browse my computer for device software.'
- Find the drivers folder inside the arduino-1.x.x folder.
- Ignore this warning. Select 'Install this driver software anyway.'



Update Driver Software - Unknown Device

How do you want to search for driver software?

→ Search automatically for updated driver software
Windows will search your computer and the Internet for the latest driver software for your device, unless you've disabled this feature in your device installation settings.

→ Browse my computer for driver software
Locate and install driver software manually.

Browse For Folder

Select the folder that contains drivers for your

Folder: arduino-1.0.4

Windows Security

Windows can't verify the publisher of this driver software

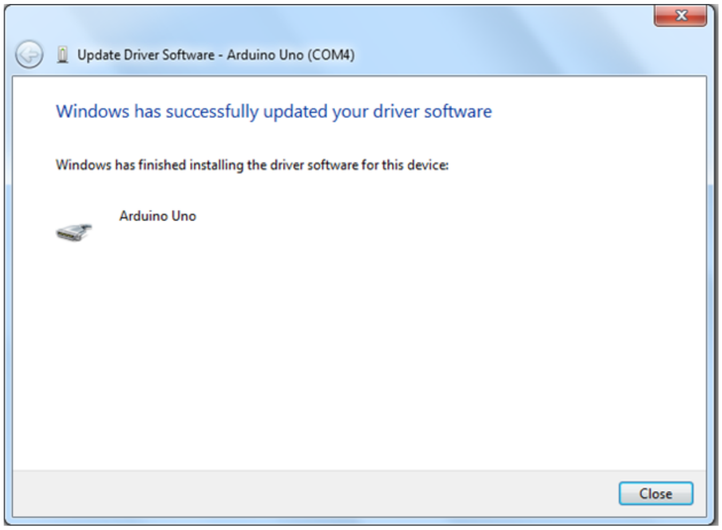
→ Don't install this driver software
You should check your manufacturer's website for updated driver softwa
for your device.

→ Install this driver software anyway
Only install driver software obtained from your manufacturer's website or
disc. Unsigned software from other sources may harm your computer or
information.

USB Driver Install …

To verify that the USB Driver is successfully installed:

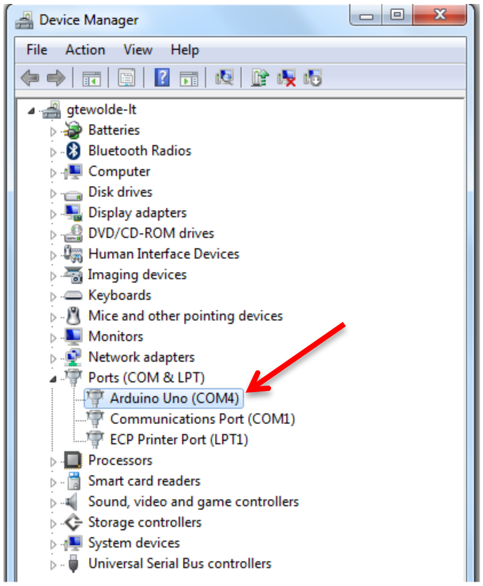
- Make sure that Arduino UNO R3 is installed in the Ports (COM & LPT)
- Anytime when you connect the Arduino board to the PC, the port will be shown under the ports list
- Your computer can now talk to the Arduino through the serial port



Windows has successfully updated your driver software

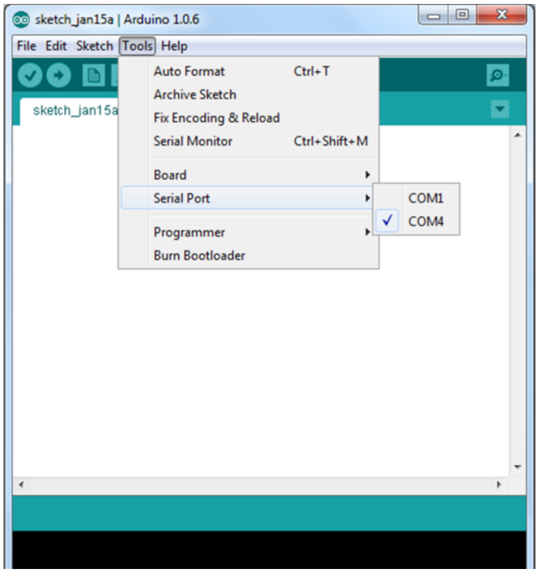
Windows has finished installing the driver software for this device:

Arduino Uno



Selecting the Arduino Serial Port

- The final and important step is to select a serial port for your Arduino Sketch.
- Now your PC is ready to talk the Arduino via the serial port.



Arduino Programming Basics

Refer to the Arduino Language Reference: http://arduino.cc/en/Reference/HomePage

- Sketch
    - That is what a program called in Arduino lingo
    - It is code that is uploaded to and run on the Arduino board
- Comments – used to enhance program readability and documentation
    - Multiline comments
        - /* comments start with the slash and * sign
          it can be multilines
          should end with * and the slash just like the line below
          */
        - Everything between /* and */ is comment and will be ignored by the processor
    - Single line comments
        - // two slashes are an indicator of starting comments.
- Variable
    - A place for storing a piece of data
    - It has a Name, a Type, a Value
        - Example: int ledPin = 13;
            - ledPin is the variable Name, int the Type, 13 is value
    - Whenever you use the variable name in the code, the value will be retrieved
    - The value can be changed while your program is running
        - This is why we call it a *variable*
- Data type
    - boolean: true/false
    - *char*: -128 ~ 127 *byte*: 0 ~ 255
    - *int*: -32,768 ~ 32,767 *unsigned int*: 0 ~ 65,535
    - *long*: 32-bits integer *unsigned long*: 32-bits
    - *float*: 32-bits real number *double*: (= *float* in Arduino Uno)

Function

- A named piece of code with a specific task and that can be called/used as many times as needed form elsewhere in your program
- Example

```
void setup()                          // return type, name of the function, parameters
{
    pinMode(ledPin, OUTPUT);   // call pinMode function with two parameters
}
```

- Two special functions that you should include in your Arduino sketch:

  setup()

  - This is called once when your program starts
  - Good place to initialize anything

  loop()

  - This is called over and over, indefinitely

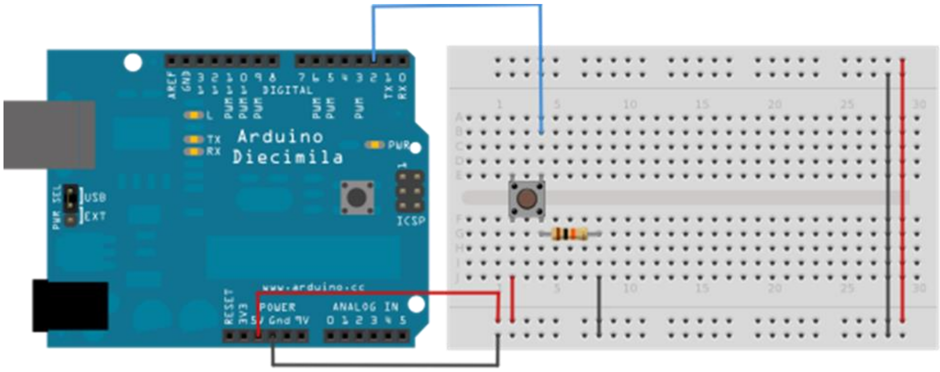
Digital vs. Analog Signals

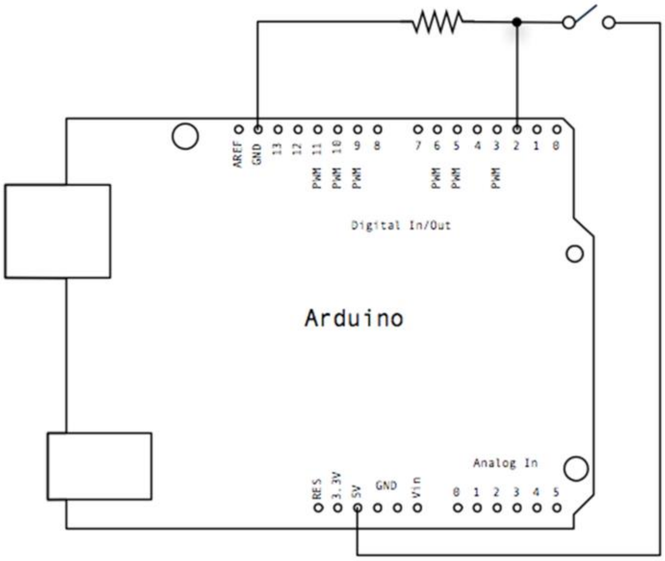
- Digital: Only two values are allowed
  - 1 or 0
  - True or False
  - HIGH or LOW
- Analog: Continuous range of values
  - 0~1023
- The pins on the Arduino
  - They can be configured as either *inputs* or *outputs*
- Sneak peek of basic functions to know
  - *pinMode*: Configure the specified pin to either an input or output
  - *digitalWrite*: Write a HIGH or LOW to a digital PIN
  - *digitalRead*: Read a value from the specified digital pin. Returns HIGH or LOW
  - *analogRead*: Read analog value from the specified analog pin. Returns 0~1023
  - *analogWrite*: Write analog value to the specified pin
  - *delay*: Pauses the program for the amount of the specified time (in milliseconds)

Arduino Programming Example

You can find helpful tutorials and examples at the Arduino website: http://arduino.cc/en/Tutorial/HomePage

The following example shows how to work with an Arduino connected to a 10 KΩ resistor, a pushbutton switch and an on-board LED. A program is implemented to control the on-board LED (attached to pin 13) based on the external switch input. So if the button is pressed the LED is on and when the button is released the LED is off.





```
/*
 Button -
 Turns on and off a light emitting diode (LED) connected to digital
 pin 13, when pressing a pushbutton attached to pin 2.

 The circuit:
 * LED attached from pin 13 to ground
 * pushbutton attached to pin 2 from +5V
 * 10K resistor attached to pin 2 from ground
  created 2005
 by DojoDave <http://www.0j0.org>
 modified 30 Aug 2011
 by Tom Igoe

 This example code is in the public domain.

http://www.arduino.cc/en/Tutorial/Button
 */

// constants won't change. They're used here to
// set pin numbers:
const int buttonPin = 2;     // the number of the pushbutton pin
const int ledPin =  13;      // the number of the LED pin

// variables will change:
int buttonState = 0;         // variable for reading the pushbutton status

void setup() {
  // initialize the LED pin as an output:
  pinMode(ledPin, OUTPUT);
  // initialize the pushbutton pin as an input:
  pinMode(buttonPin, INPUT);
}

void loop(){
  // read the state of the pushbutton value:
  buttonState = digitalRead(buttonPin);

  // check if the pushbutton is pressed.
  // if it is, the buttonState is HIGH:
  if (buttonState == HIGH) {
     // turn LED on:
     digitalWrite(ledPin, HIGH);
  }
  else {
     // turn LED off:
     digitalWrite(ledPin, LOW);
  }
}
```

Exercise: Modify your program so that when the button is pressed the LED is turned on, stays on for 3 seconds and then turns itself off. When the button is not pressed the LED remains off. Hint: use the Arduino *delay(….)* function.

Exercise: Traffic Lights Controller

1. Build the traffic lights circuit

First build the traffic lights circuit by wiring three LEDs (green, yellow, red) in series to 120Ω resistors each to three digital pins of the Arduino. To control the operating mode of the traffic lights connect a switch to a digital pin using a 10KΩ resistor in a configuration similar to that shown in the schematic diagram in page 19.

2. Write Arduino program to control the traffic lights

Write a program that implements the behavior for a proper operation of the traffic lights similar to what you find at an intersection on a street. The traffic lights will be controlled by the switch. When the program starts, it checks the status of the switch and if the switch is ON the lights behave as follows:

a) Green LED is on for 5 seconds (yellow and red are off)
b) Yellow LED is on for 2 seconds (green and red are off)
c) Red LED is on for 3 seconds (green and yellow are off)
d) Red LED goes off for 1 second before returning back to the first step a)
e) The program repeats the above steps a) to d) as long as the switch stays on

When the control switch is turned OFF, the traffic lights switch to flashing red light mode. In this mode the red LED turns on for 1 second and turns off for 1 second. It repeats this mode as long as the control switch stays off.

The program continues indefinitely, running in either of the two operating modes based on the status of the switch.