# **CS578: Internet of Things**



#### **Introduction to Arduino**

#### **Arduino UNO Board & IDE**



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"The soil of India is my highest heaven, the good of India is my good." - Swami Vivekananda

## What is Arduino?



- Arduino is an open-source electronics platform
  - based on easy-to-use hardware and software.
- It was born at Interaction Design Institute Ivrea, Italy
  - an easy tool for fast prototyping
  - aimed at students without any background in electronics and programming.
- These boards are incorporated with microcontrollers
  - To execute a small program, to receive input, to apply action on real world
- It has the capability to act as an interface for electrical and electronic systems
- These boards are used extensively because:
  - Inexpensive
  - Cross-platform runs on Windows, Mac OS, and Linux OS.
  - Easy-to-use hardware and software environment
  - Open source hardware and software IDE
  - Capable to interact with other boards and computers
  - Can interact with sensors and actuators
  - Facilitate serial communication

#### **Types of Arduino Boards**

- Entry Level easy to use and ready to power your first creative projects.
  - Arduino UNO
  - Arduino Nano
  - Arduino Micro
- Enhanced Features boards with advanced functionalities, or faster performances
  - Arduino Zero
  - Arduino Mega 2560
  - Arduino Motor Shield
  - Internet of Things Make connected devices easily with one of these IoT products
    - Arduino Nano 33 IoT
    - Arduino Nano 22 BLE
    - UNO WiFi REV2



Arduino UNO



Arduino Mega 2560



Arduino Nano 33 IoT



#### **Arduino UNO**



- Arduino UNO is a Single board Microcontroller based on ATmega328P Processor
  - a product of Atmel (now Microchip)
  - 32 represents it's flash memory capacity that is 32KB
  - 8 represents it's CPU type that is of 8 bit
  - p simply denotes picoPower (i.e. very low power).



# Pins/Jacks in Arduino UNO R3

- It has the following major pins/jacks:
  - $\checkmark$  14 digital input/output pins (of which 6 can be used as PWM outputs),
  - ✓ 6 analog inputs,
  - $\checkmark$  6 pins related to energy/power
  - ✓ a reset pin
  - $\checkmark$  an analog reference pin
  - $\checkmark$  a reset button
  - ✓ a USB connection,
  - $\checkmark$  a power jack,
  - ✓ a 16 MHz ceramic resonator,
  - ✓ two ICSP header
  - ✓ Atmel ATmega328 IC pins



#### Source: https://docs.arduino.cc/hardware/uno-rev3

## **Detailed Pin Diagram**





## **Pin Description**



Pin category	Pin Name	Details
Power Pins	Vin, 3.3V, 5V, GND, RESET	Vin : Input voltage to Arduino when using an external power source.
		<b>5V</b> : Regulated power supply used to power microcontroller and other components on the board.
		<b>3.3V</b> : 3.3V supply generated by on-board voltage regulator. Maximum current draw is 50mA.
		GND : ground pins.
		Reset: Reset the microcontroller
ICSP: In-Circuit Serial Programming	ICSP pins: MISO, VCC, SCK, MOSI, RESET, GND	Used to code and boot an Arduino from an external source. Allow inter workings of two or more Arduino boards. Allow you to upload your firmware.

#### Cont...



Pin category	Pin No / name	Details		
Analog pin	A0 - A5	Used to provide analog input in the range 0-5V.		
Digital Input/output pin	Digital Pins 2 - 13	Can be used as input or output pins.		
Serial Communication	0(Rx),1(Tx)	Used to receive and transmit TTL serial data.		
External Interrupts	2, 3	To trigger an interrupt.		
PWM: Pulse Width Modulation	3, 5, 6, 9, 10, 11	Provides 8-bit PWM output.		
SPI: Serial Peripheral Interface	10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK)	Used for SPI communication.		
Inbuilt LED	13	To turn on the inbuilt LED.		
I2C: Inter-IC, or TWI: Two Wire Interface	A4 (SDA: Serial Data), A5 (SCL: Serial Clock)	Used for TWI / I2C communication.		
AREF	AREF : Analog Reference Voltage	To provide reference voltage from an external power supply for analog-to-digital conversion of inputs to the analog pins. E.g. if AREF is 4V – the analogRead() range of 0~1023 will relate to 0~4V and not 0~5V.		

## Arduino in IoT

And the of Technology

- Arduinos are used to create IoT projects.
- But, it requires either a specialized Arduino or shields to provide network capabilities
- The network interface could be Ethernet / WiFi / Cellular



EtherTen







Arduino Ethernet Shield

#### Arduino + Ethernet Shield

Arduino UNO WiFi Rev2

## **Configure Arduino IDE**

- the indemnity of the of Technology
- Download and Install Arduino IDE <a href="https://www.arduino.cc/en/Main/Software">https://www.arduino.cc/en/Main/Software</a>
- The Arduino Software (IDE) allows you to write programs and upload them to your board.
- When the Arduino IDE first opens, this is what you should see:



#### **Built-in Examples**





- Launch the Arduino application
- Programs written using Arduino IDE are called **sketches**.
- There are many built-in examples / sketches.
- To open built-in examples: select File
  -> examples.
- These simple programs demonstrate all the basic Arduino commands.

#### **Set Arduino Board**





- Plug in your board through cable
- Select the type of Arduino board you're using:
  - ✓ Tools -> Board -> (your board type)
    - ✓ e.g. Arduino UNO

#### **Set Serial Port**





- Select the serial/COM port that your Arduino is attached to:
  - ✓ Tools > Port > COMxx

Note: If you're not sure in which serial port your Arduino is connected, take a look at the available ports, then unplug your Arduino and look again. The one that disappeared is your Arduino.

#### **Code Compilation**





Compilation successful message at the bottom left corner.

## **Code Uploading**



#### local\_server | Arduino 1.8.9 Ø local serv 1 #include SP8266WiFi.h> //Including ESP8266 library 2 #include<ESP266WebServer.h> //Including ESP8266WebServer library for web serv //Including ThingSpeak library 3 #include<Thing Upload Button 5 IPAddress IP(192,160,4 (15), //State C IP address of local server 6 IPAddress gateway(192,168,4,1); //Gateway of the network 7 IPAddress mask(255, 255, 255, 0); //Subnet mask of the network 9 WiFiClient client: 10 WiFiServer server(80); 11 12 unsigned long myChannelNumber = 814887; //Replace with channelID of ThingSpeak 13 const char \* myWriteAPIKey = "EK4LTPHWU4GGEOVP"; //Replace with WriteAPIKey of 14 15 const char\* softAPssid = "ESP8266": //SSID of the hotspot of ESP8266 acting 16 const char\* password = "12345678";//Password of the hotspot of ESP8266 act 17 18 const char\* wifissia = "Tenda\_8060A0": //Replace with SSID of WIF router provi 19 const char\* pass = "12345678"; //Password of WIFI router providing inte Done uploading

RACE +0.000 Received full packet: 011202000

ard resetting via RTS pin...

NodeMCU 1.0 (ESP-12E Module) on /dev/cu.SLAB\_USBtoUART

- With your Arduino board connected, and the Blink sketch open, press the 'Upload' button
- After a second, you should see some LEDs flashing on your Arduino, followed by the message
   'Done Uploading' in the status bar of the Blink sketch.
- If everything worked, the on-board LED on your Arduino should now be blinking!

## **Serial Monitor**



- The serial monitor is the 'tether' between the computer and your Arduino it lets you send and receive text messages.
- First **select the port** (go to Tools -> Port: ) to which the board is connected then click the icon of **Serial Monitor** on the top right side of the Arduino IDE



		/dev/cu.SLAB_USBtoUART	
		Sen	d
Serial Monitor output	14:39:43.602 -> Sta 14:39:44.864 -> Vib 14:39:59.873 -> Sta 14:39:59.9873 -> Sta 14:39:59.9873 -> Sta 14:39:59.945 -> Sta 14:40:32.597 -> Sta 14:40:32.630 -> Sta 14:40:32.630 -> Sta 14:40:32.665 -> Sta 14:40:32.702 -> Sta 14:40:32.770 -> Sta 14:40:32.770 -> Sta 14:40:32.770 -> Sta 14:40:32.770 -> Sta 14:40:32.770 -> Sta 14:40:34.148 -> LDR 14:40:34.148 -> Sen	Ations connected = 4 pration Sensor data: 29 Sent to ThingSpeak server ations connected = 4 ations connected = 4 ations connected = 4 mperature: 23.30 degree celcius, Humidity: 70.00%. Sent to ThingSpeak Server ations connected = 4 ations connected = 4 Sensor data value: 1024 ht to ThingSpeak Server Show timestamp	ıt

#### **Serial Plotter**



PWMGenerationSineTriangularWave | Arduino 1.8.19 (Windows Store 1.8.57.0)



- Can use Serial Plotter to plot the output signal
- See the below image for example



#### **How to Install Sensor Libraries**



- Let we will use DHT11 sensor for which we need DHT.h header file
- So, this header file needs to be installed first.
- Install Using the Library Manager
  - click to Sketch menu -> Include Library -> Manage Libraries
  - Search for "**DHT**" on the Search box and install the DHT library from **Adafruit**.

• •	Library Manager
Туре	All O Topic All O DHT
EduIntr Library basic con Arduino <u>More inf</u>	ro by Arduino LLC v used for super-fast introduction workshops Is intended to be used with Arduino UNO / MICRO / MEGA / NANO / MKR and a set of pomponents (led, button, piezo, LM35, thermistor, LDR, PIR, DHT11, and servo) as a way to introduce people to the basic aspects of during short workshops. fo
	Version 0.0.7 🗘 Install
DHT ser Arduing More inf	o library by Adafruit Version 1.3.4 INSTALLED o library for DHT11, DHT22, etc Temp & Humidity Sensors Arduino library for DHT11, DHT22, etc Temp & Humidity Sensors fo
DHT ser Arduinc correct f <u>More inf</u>	o ESP library for ESPx by beegee_tokyo o ESP library for DHT11, DHT22, etc Temp & Humidity Sensors Optimized libray to match ESP32 requirements. Last changes: Use field separator in keywords.txt. fo
Grove T	Temperature And Humidity Sensor by Seeed Studio
	Close

#### Cont...



• After installing the DHT library from Adafruit, install "Adafruit Unified Sensor" libraries.

dafruit TSL2561 by Adafruit Inified sensor driver for Adafruit's TSL2561 breakouts Unified sensor driver for Adafruit's TSL2561 breakouts Iore info				
Version 1.0.3 🗘 Insta	all			
Adafruit Unified Sensor by Adafruit Version 1.0.3 INSTALLED Required for all Adafruit Unified Sensor based libraries. A unified sensor abstraction layer used by many Adafruit sensor libraries. More info				
	Close			

- There exist other methods for installing libraries
  - Importing a .zip Library
    - Sketch --> Include Library --> Add .Zip Library
  - Manual Installation of Library
    - Download the library as .Zip --> extract it
    - Place the files in File --> Preferences --> Sketchbook location
    - Restart Arduino IDE



- See the Demo using Arduino UNO circuit board
- 1) Blink the in-built LED of Arduino Board
- 2) Blink the additionally attached LEDs

# **Blink In-built LED Continuously**



- First upload the bare minimum example:
  - ✓ Files -> Examples -> Basics -> BareMinimum
- Output:
  - ✓ In-built LED will glow continuously



# **Blink In-built LED Periodically**



- First upload the bare minimum example:
  - ✓ Files -> Examples -> Basics -> BareMinimum
- Output:
  - ✓ In-built LED will glow continuously
- Then, upload the blink example:
  - Files -> Examples -> Basics -> Blink
- Output:
  - In-built LED will glow periodically

New	Ctrl+N				
Open	Ctrl+O				
Open Recent	:				
Sketchbook					
Examples	1	Δ			
Close	Ctrl+W	Built-in Examples			
Save	Ctrl+S	01.Basics	2	AnalogRead	Jerial
Save As	Ctrl+Snift+S	02.Digital	;	BareMinimu	m
D	Chill Children D	03,Analog		Blink	
Page Setup	Ctrl+Shift+P	04.Communication		DigitalReadS	erial
Print	Ctrl+P	05.Control	2	Fade	
Preferences	Ctrl+Comma	06.Sensors	2	ReadAnalog	Voltage
0	Chillio O	07.Display	>		
Quit	Ctil+Q	08.Strings	>		
		09.USB	>		
		10.StarterKit_BasicKit	>		
		11.ArduinoISP	>		
		Examples for any board			
		Adafruit Circuit Playground	>		
		Bridge	>		
		Esplora	>		
		Ethernet	>		
		Firmata	>		
		GSM	>		
		LiquidCrystal	>		
		Robot Control	>		
		Robot Motor	>		
		SD	>		
		Servo	>		
		•			

#### **Blink External LED**





#### **Demo on LED Blink**





#### **Lessons Learned**



- ✓ What is Arduino
- ✓ Types of Arduino Board
- ✓ Arduino UNO pin diagram
- ✓ Arduino in IoT
- ✓ Arduino IDE
- ✓ Built-in Sketch in IDE
- ✓ Compiling and Uploading a sketch using IDE
- ✓ LED blink program and system setup



# Thanks!



#### Which is better? ATmega328P vs STM32 vs MSP430



	ATmega328P	STM32	MSP430
Brand	ATmel (now MicroChip)	Cortex (STMicroelectronics)	Texas Instruments
Cost	Low	High	Low
Architecture	Advanced RISC architecture	Power Architecture technology designed for embedded applications	Older, von-Neumann architecture
Power Consumption	Low	Medium	Low
Performance	Medium, suitable for complex projects	High, fast processing speed, Running 32 bit ARM processor core with sufficient RAM	Low, more suitable for only simple projects
Ease of Usage	Easy to use, 8 bit and high compatibility with Arduino boards	Complicated due to its nature of being a 32 bit microcontroller	Complex relative to Arduino boards