# IAT 884 – Week 3 – Workshop 3

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# Microcontrollers

Basics

An **I/O board** is a device that acts as a conduit between various electronic devices. I/O boards generally utilize a microprocessor to analyze and transmit data packets between the attached devices.

A **microprocessor** is a silicon chip that contains a CPU. Microprocessors control the logic of almost all digital devices, from clock radios to fuelinjection systems for automobiles.

A **microcontroller** is a low power consumption, self sufficient microprocessor. They typically integrate read/write memory, ROM memory, and EEPROM for permanent data storage.



Arduino

Arduino is a cheap, robust I/O board based on the ATmega328P chip.

The Arduino board can function connected to a computer (in Serial communication mode) or as a stand-alone CPU that can drive a hardware application.

#### Arduino Uno Rev3 – Tech specs:

Microcontroller: Atmega 328P Operating Voltage: 5V Input Voltage (recommended): 7-12 V Digital I/O Pins: 14 (of which 6 provide PWM output) Analog Input Pins: 6 DC Current per I/O Pin: 20 mA Flash Memory: 32KB (of which 0.5 KB used by bootloader) Clock Speed: 16 MHz







Output

Output from the Arduino can replace the use of a battery for powering electronic circuits.

Unlike a battery which has a preset output, the Arduino can be **programmed** to send out a specific amount of voltage.

The Arduino can output from 0-5 V



### Microcontrollers

Arduino IDE



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<pre>// the loop function runs over /oid loop() {\$ digitalWrite(LED_BUILTIN, HI delay(1000); digitalWrite(LED_BUILTIN, L0/ delay(1000);</pre>	and over again forever GH); // turn the LED on (HIGH is the voltage level) // wait for a second W); // turn the LED off by making the voltage LOW // wait for a second	
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# Digital & Analog Output

Differences

Analog allows for setting the amount of voltage as a specific value from 0-5 volts (continuous)

### ANALOG SIGNAL



Digital works like a switch. It is either: **ON** (sending voltage) or **OFF** (not sending voltage)

# **Digital & Analog**

Information

This is an important distinction since it affects the way that information will be displayed to your user.

Digital output is good for alerts: Is something on? Is there danger?

Analog Output is good for conveying continuous and subtle information: How much? Volume, Speed of rotation, levels.





Digital Out

Binary is 0 or 1 For digital signals we use **high** or **low**.

High = 5v Low = 0v

When you set a digital pin to high it will begin sending out 5 volts until it has its state changed to low.

When you set a digital pin to low it will stop sending voltage until it has its state changed to high.

There are 14 dedicated digital out pins on the Arduino Uno. You can additionally use the 6 analog in pins as digital output pins if necessary. These are referenced as digital pins 14-19.



#### Structure of an Arduino program

#### Global variables;

#### void setup(){

Setup environment variables; Setup Pins for digital/analog input/output;

#### }

#### void loop(){

This is the stuff that creates the interaction; Generally, you will either be checking the state of a sensor Or changing the state of an attached device (LED, Motor, etc) This is also where you call other functions;

### void function(var 1, var 2){ Do something;

}



Digital output

#### int ledPin = 2;

void setup(){

}

void loop(){

digitalWrite(ledPin, HIGH); delay(1000); digitalWrite(ledPin. LOW); delay(1000);

pinMode(ledPin, OUTPUT);

#### Give a name to the pins you will be using

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<pre>// the setup function runs once wh void setup() {     // initialize digital pin LED_BU     pinMode(LED_BUILTIN, OUTPUT); }</pre>	en you press reset or power the board ILTIN as an output.	
<pre>// the loop function runs over and void loop() {\$ digitalWrite(LED_BUILTIN, HIGH); delay(1000); digitalWrite(LED_BUILTIN, LOW); delay(1000); }</pre>	over again forever // turn the LED on (HIGH is the voltage level // wait for a second // turn the LED off by making the voltage LOW // wait for a second	)
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Digital output

int ledPin = 2; void setup(){ pinMode(ledPin, OUTPUT); } void loop(){ digitalWrite(ledPin, HIGH); delay(1000); digitalWrite(ledPin. LOW); delay(1000); }

#### Tell the program whether you will use this pin as an output or input pin

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Digital output

int ledPin = 2; void setup(){ pinMode(ledPin, OUTPUT); } void loop(){ digitalWrite(ledPin, HIGH); delay(1000); digitalWrite(ledPin. LOW); delay(1000); }

The command digitalWrite allows you to change the amount of voltage being sent to the pin

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<pre>// the setup function runs once // initialize digital pin LED_ pinMode(LED_BUILTIN, OUTPUT);</pre>	when you press reset or power the board BUILTIN as an output.	
<pre>// the loop function runs over a void loop() {\$ digitalWrite(LED_BUILTIN, HIGH delay(1000); digitalWrite(LED_BUILTIN, LOW) delay(1000);</pre>	nd over again forever ); // turn the LED on (HIGH is the voltage leve // wait for a second ; // turn the LED off by making the voltage LOU // wait for a second	L) N
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Digital output

int ledPin = 2;	
void setup(){ }	pinMode(ledPin, OUTPUT);
void loop(){ }	digitalWrite(ledPin, <b>HIGH</b> ); delay(1000); digitalWrite(ledPin. <b>LOW</b> ); delay(1000);

#### HIGH = 5V **LOW = 0V**

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Digital output

int ledPin = 2; void setup(){ pinMode(ledPin, OUTPUT); } void loop(){ digitalWrite(ledPin, HIGH); delay(1000); digitalWrite(ledPin. LOW); delay(1000); }

Between turning the ledPin (pin 2) high and low, we wait 1000ms (1s)

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<pre>// 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 } } 22 Arduino/Genuino Uno on COM1</pre>	<pre>// 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); }</pre>		
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Analog output: PWM

The Arduino Analog Output pins **do not generate a true analog output** in the sense that the microcontroller does not have a resistive diver to create the voltage.

Instead, it uses **a digital PWM signal** that can be smoothed to create an average voltage, which does result in an "analog output".

Pulse Width Modulation (PWM) modulates the duty cycle of a square wave to control the amount of power sent out to a load.



# **Digital & Analog**

#### Analog output

You do not nee	You do not need to set PINMODE for analog output pins		
	analogWrite(pinNumber, value);		
PinNumber m <b>Value is betwo</b> (The maximum va	ust be one of the PWM pins (3, 5, 6, 9, 10, 11) <b>een 0 - 255 (0v – 5v)</b> Iue is 255 since the PWM register is 8 bits wide (2 in the power of 8 is 255)).		
int ledPin = 9;			
void setup(){	//nothing needs to be here		

}

void loop(){

//send out ~2.5v on Pin 9 **analogWrite** (ledPin, 150);

}

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dimmer		
<pre>int ledPin = 3; //set output pin to write to int val = 0; //variable to store the current value to write boolean up = true; //tracks weather the count is up or down</pre>		^
void setup() (		- 11
}		- 11
<pre>void loop() {     if (up) { //if the count is upward     val+; //increase the value of val     if (val == 255) { //if we have reached the max then     up = false; // start counting downward     }     else { //if we are not counting upwards     val; //decrease the value of val     if (val == 0) { //if val is at its minimum value         up = true; //start counting upwards     }     analogWrite(ledPin, val); //write the value to the output pin     delay(10); }</pre>		v
Done Saving.		
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# **Digital & Analog**

Analog output

```
int ledPin = 3;
void setup(){
```

```
}
```

void loop(){

```
for(int i = 0; i < 255; i++){
analogWrite(ledPin, i);
delay(10);
}
```

//nothing needs to be here

💿 dimmer | Arduino 1.8.16  $\times$ \_ File Edit Sketch Tools Help 🗈 🔝 🔛 New Ø / ] + dimmer int ledPin = 3; //Set output pin to write to int val = 0; //variable to store the current value to write boolean up = true; //tracks weather the count is up or down void setup() { } void loop() { if (up) { //if the count is upward val++; //increase the value of val if (val == 255) { //if we have reached the max then ... up = false; // start counting downward } ł else { //if we are not counting upwards val--; //decrease the value of val if (val == 0) { //if val is at its minimum value up = true; //start counting upwards } } analogWrite(ledPin, val); //write the value to the output pin delay(10); 1 Done Saving

# **Digital & Analog**

Analog output

int ledPin = 3; int val = 0; boolean up = tr	rue;		
void setup(){ }			
void loop(){	if(up){ } else { }	val++; if(val == 255){ } val; if(val == 0){ }	up = false; up = true;
,	analogWrite(le delay(10);	dPin, val);	

#### 💿 dimmer | Arduino 1.8.16 × \_ File Edit Sketch Tools Help 🗈 💽 New Q / [ + ] dimmer int ledPin = 3; //Set output pin to write to int val = 0; //variable to store the current value to write boolean up = true; //tracks weather the count is up or down void setup() { 3 void loop() { if (up) { //if the count is upward val++; //increase the value of val if (val == 255) { //if we have reached the max then ... up = false; // start counting downward ł ł else { //if we are not counting upwards val--; //decrease the value of val if (val == 0) { //if val is at its minimum value up = true; //start counting upwards } } analogWrite(ledPin, val); //write the value to the output pin delay(10); 1 Done Saving.

# Debugging

Serial monitor

#### Serial.print() and Serial.println()

Send data out over the serial communication channel. This is the primary way to send characters and numbers out from the Arduino board.

Because serial communication is used, the data sent is available to any application capable of retrieving serial data communications. So, this also works as a way of sharing data between the Arduino board and Max/MSP, Processing, and other programming environments.

Serial.println() is the same as Serial.print() except it appends both a carriage return character(ASCII 13) and a newline character (ASCII 10).







Step 1: Initialize in Setup

// initialize serial communication at 9600 bits per second:
 Serial.begin(9600);

### **Debugging** Serial monitor

Step 2: Print text and values in Loop

Serial.print("Integer Value: ");
Serial.println(value);

Serial monitor

Step 3: Run code

Step 4: open the Serial Monitor



Serial monitor

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	Send
String: my_name	^
Integer Value: 25	
String: my_name	
Integer Value: 25	
String: my_name	
Integer Value: 25	
String: my_name	
Integer Value: 25	
String: my_name	
Integer Value: 25	
String: my_name	
Integer Value: 25	
String: my_name	
Integer Value: 25	
String: my_name	
	~
Autoscroll Show timestamp	Newline v 9600 baud v Clear output

```
int ledPin = 3;
void setup(){
    Serial.begin(9600);
}
void loop(){
    for(int i = 0; i < 255; i++){
        analogWrite(ledPin, i);
        Serial.println(i);
        delay(10);
    }
}
```

**Output?** 

# **Exercises**

### Exercises

Download the Week 3 Handout on the <u>wiki</u>.

Get as far as possible with the exercises during the lecture time. Complete them at home if you can't finish.

During remote learning: create the circuits through <u>Tinkercad</u> <u>circuits</u>.

Send a document with your name, screenshots of your circuits, and answers to the questions to <u>ahv1@sfu.ca</u>. **Deadline: Sunday 11.59pm**