Intel Innovation Week

University of Johannesburg (23 June – 27 June 2014)

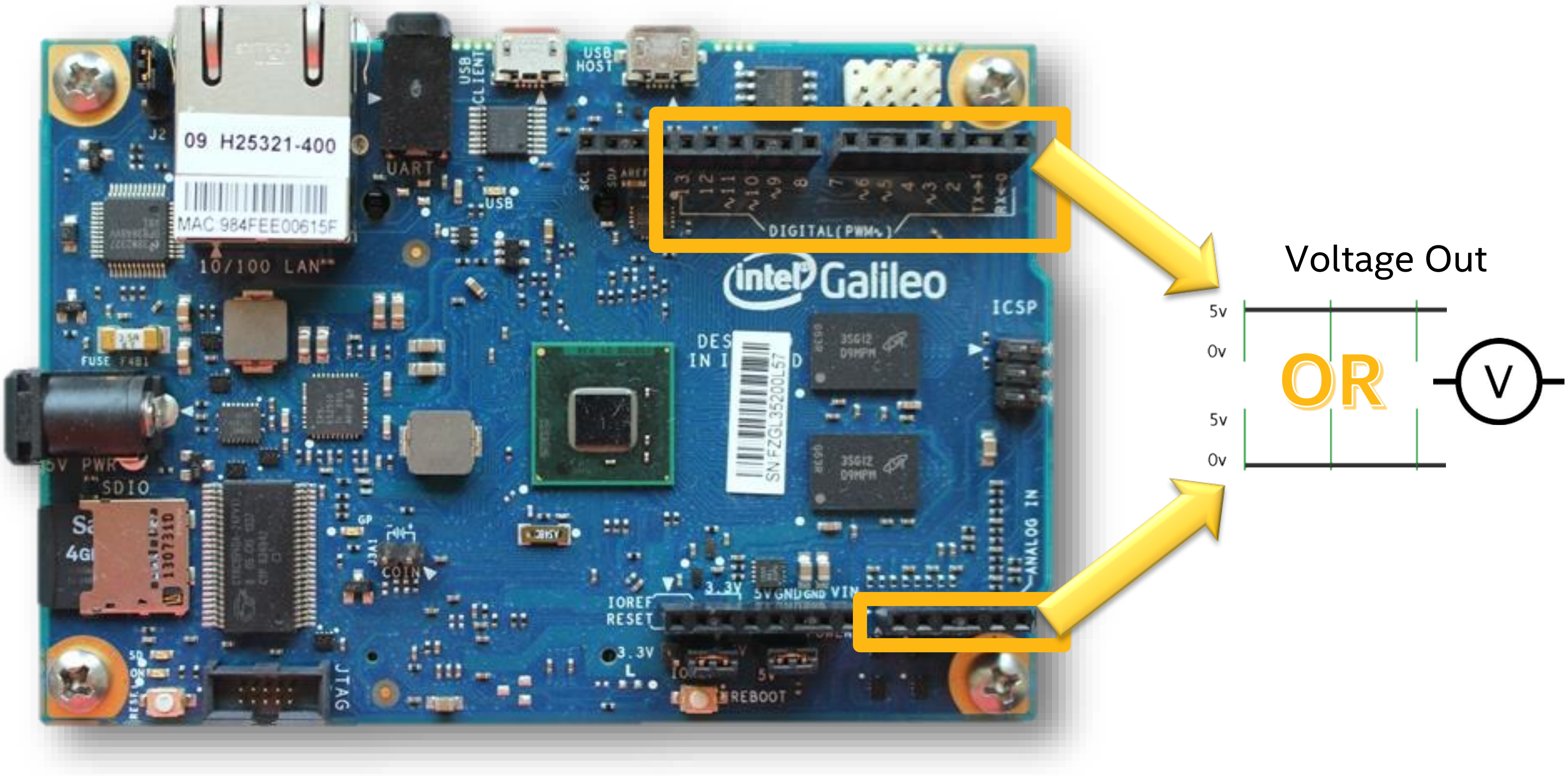
Basic I/O

intel Galileo

What will you make?

Basic I/O - Digital Writes

Digital Write



Voltage Out

5v

0v

OR

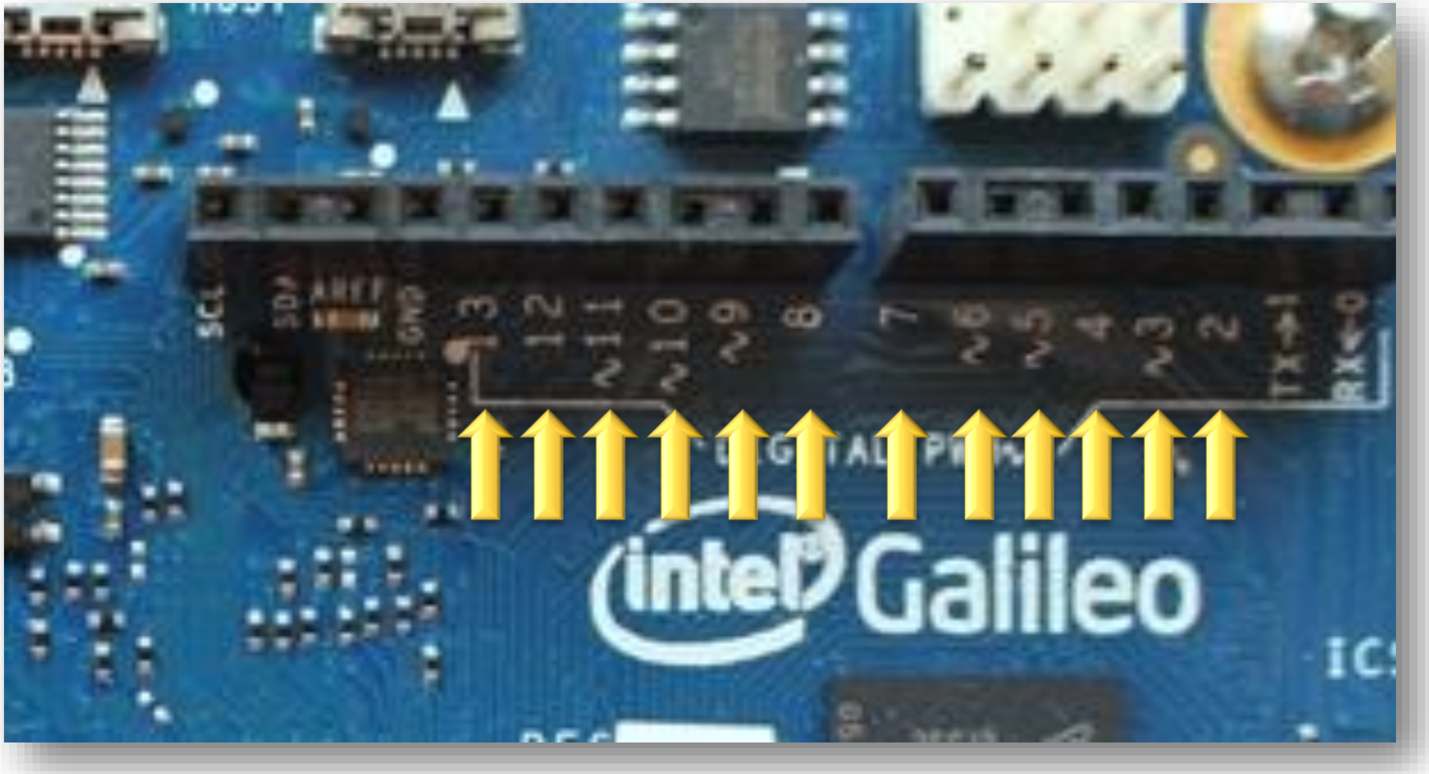
5v

0v

V

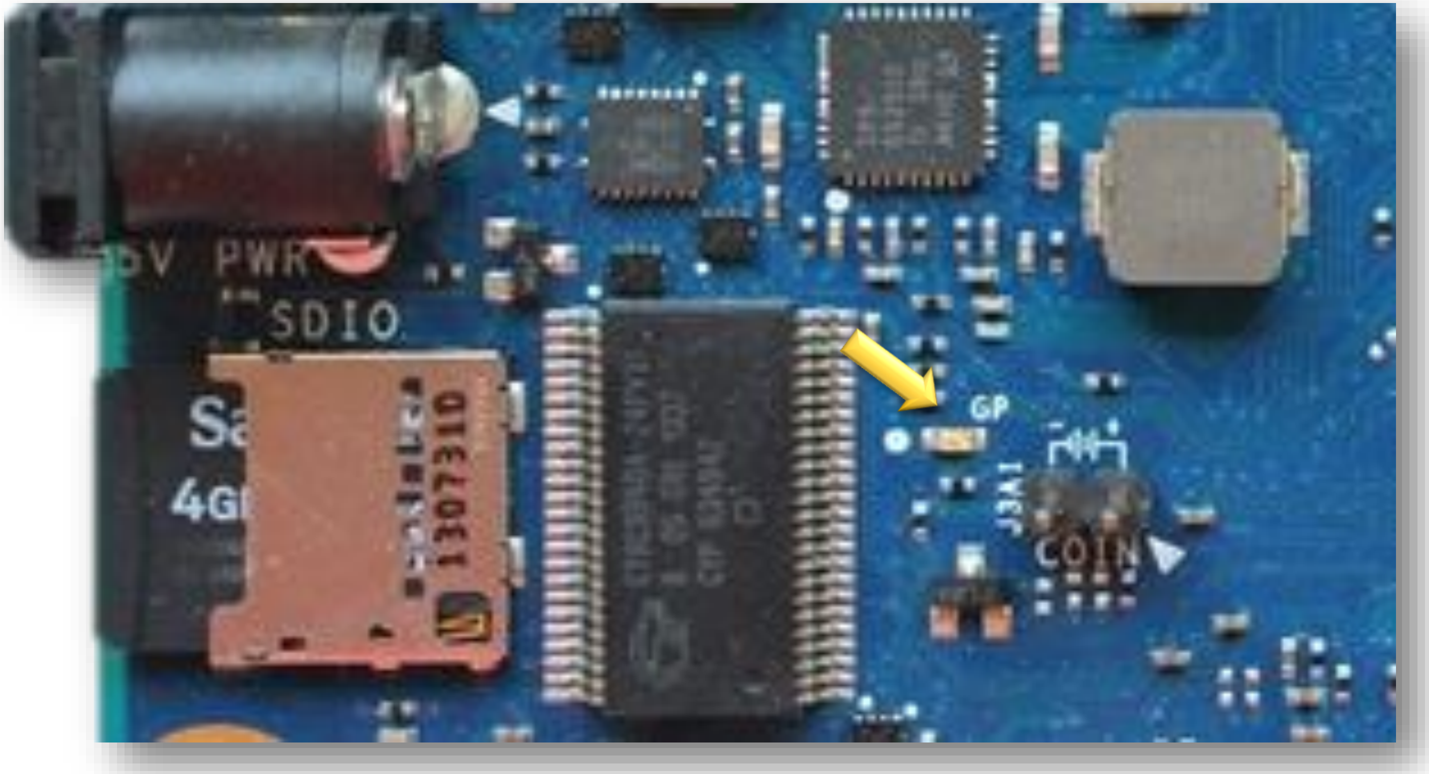
Digital Pins

- General Purpose I/O Pin are 2, 3, 4, 5, 6, 7,8, 9, 10, 11, 12, & 13
- Analog I/O can also be used as digital pings; analog input A0 as digital pin 14 through analog input A5 as digital pin 19



Digital Pins

- Pin 13 has a built-in LED connected to it
- When the pin is HIGH value, the LED is on, when the pin is LOW value, it's off



Digital Write – Key Concepts

pinMode(): Configures the specified pin to behave either as an input or an output

- Syntax: pinMode(pin, mode)
- Example: pinMode(13, OUTPUT) set pin 13 to output mode
- Example: pinMode(13, INPUT) set pin 13 to input mode

digitalWrite(): Write a HIGH or a LOW value to a digital pin

- If set to OUTPUT with pinMode(), 5V (or 3.3V on 3.3V boards) for HIGH, 0V (ground) for LOW.
- Syntax: pinWrite(pin, value)
- Example 1: digitalWrite(13, HIGH) is 5 volts to pin 13
- Example 2: digitalWrite(13, LOW) is 0 volts to pin 13

Digital Write – Blink LED

LAB

Project Name: Blink LED *(Instructor Lead)*

Objective: Turns LED on for one second, then off for one second, repeatedly

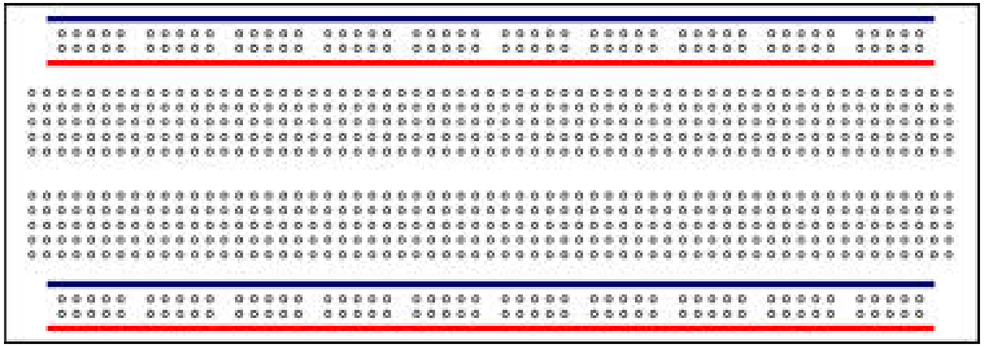
Software Elements

- pinMode()
- digitalWrite()
- delay()

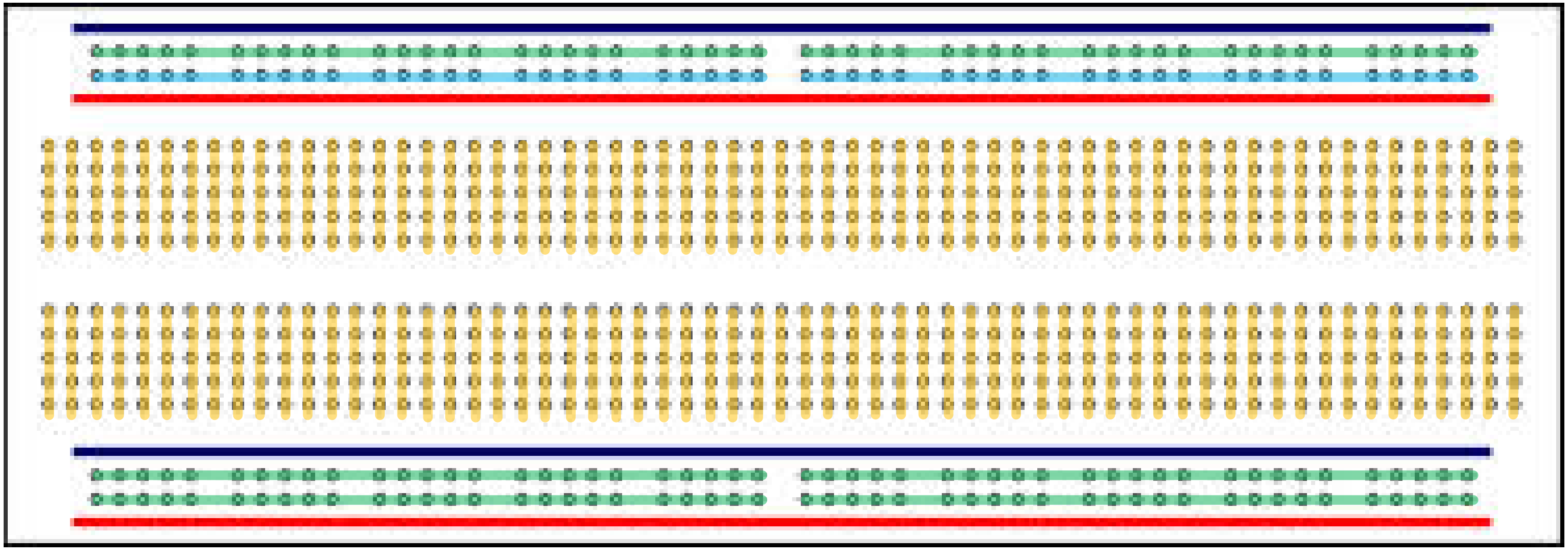
Components

- Intel Galileo Board (Qty 1)
- Breadboard (QTY1)
- Jumper Wires
- 5mm LED (Qty 1)
- 220 Ohm Resister (Qty1)

Breadboard Layout



Connected dots
represent connectivity



Digital Write – Blink LED

LAB

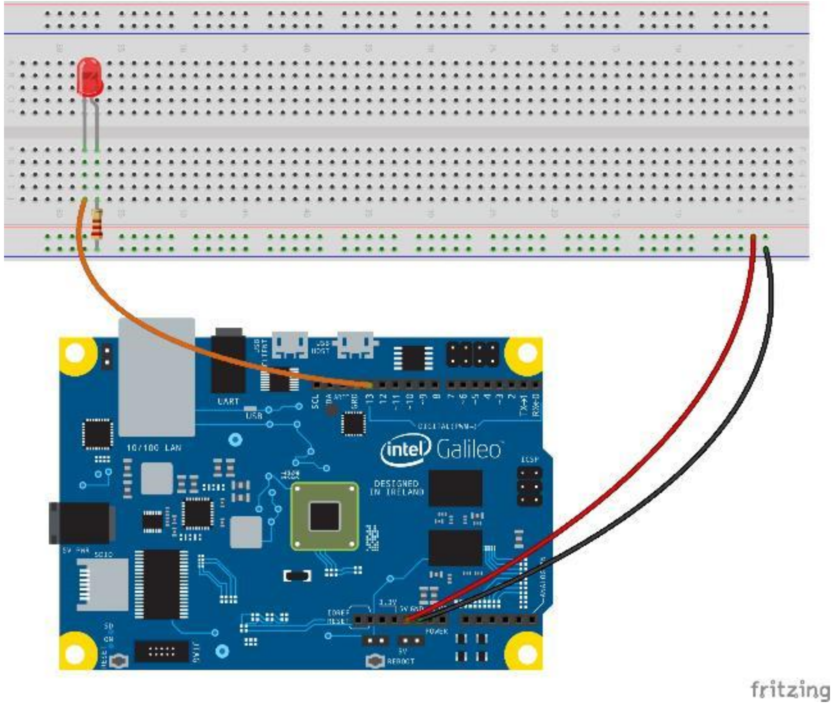
```
/*
  Blink
  Turns on an LED on for one second, then off for one second, repeatedly.

  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;

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led, OUTPUT);
}

// the loop routine runs over and over again forever:
void loop() {
  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
}
```

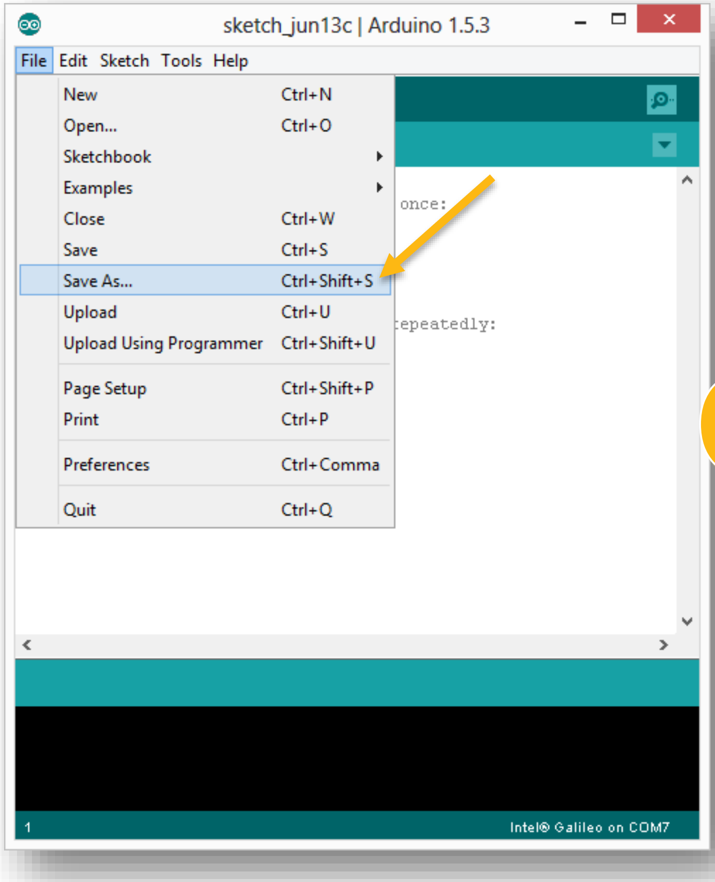


* Other names and brands may be claimed as the property of others

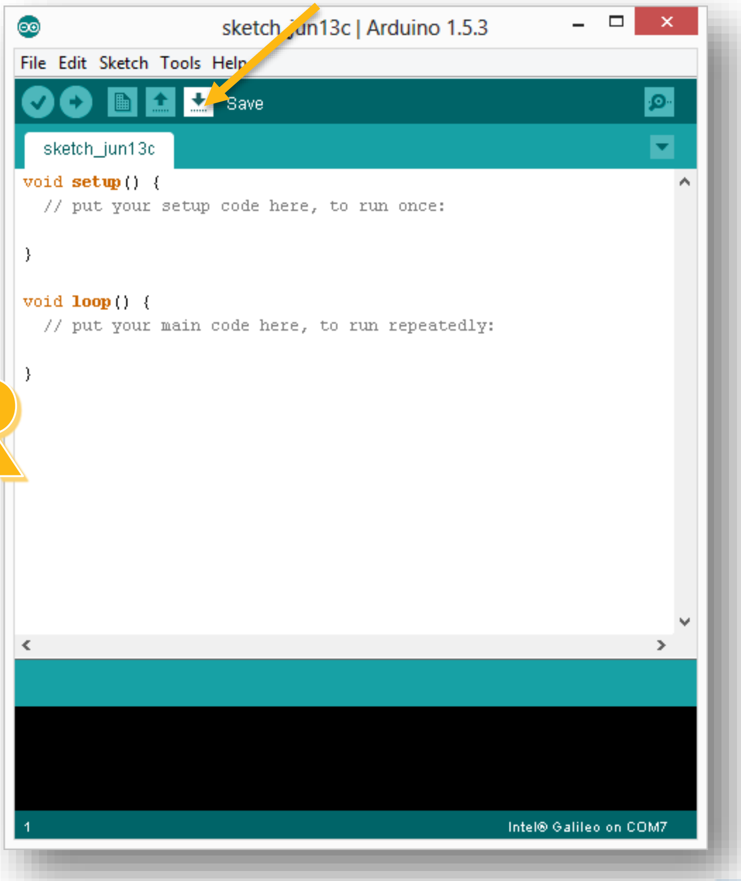
Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section1-DigitalWrite\Blink

Saving a Sketch

1. To Save Sketch, Use “File” -> “Save” or “Save As…”
   Be careful not to over write Sketches you want to keep



OR



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

}

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

}
```

Digital Write - Engineering Challenge LAB

Using your own circuit design and Arduino sketch, design a solution that solves the following challenges.

Use previous Lab example as needed for reference

Challenge 1a: Add a Second LED to the circuit and make them Blink together. 1b: Then make them Blink alternating on and off.

Challenge 2: Add a Third LED to circuit and make them Blink in series and then repeat.

Engineering Challenge Review

Challenge Review

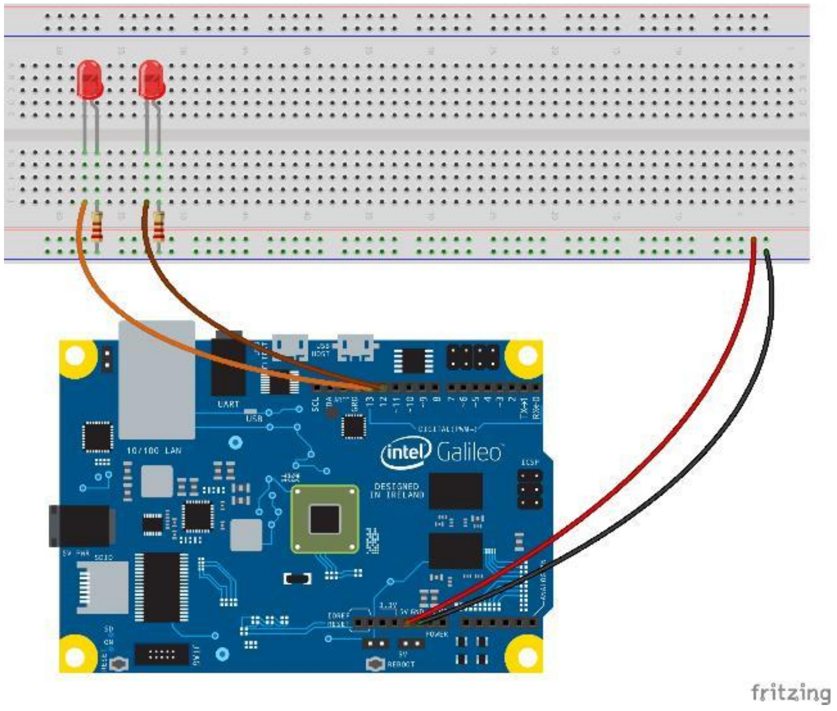
Challenge 1a: Add a Second LED to the circuit and make them Blink together

```
/*
  Blink two LEDs together
  Created by Matt Royer May 5, 2014
 */

// Pin 13 has an LED connected on most Arduino boards.
// give it a name:
int led1 = 13;
int led2 = 12; // Additional LED Pin

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led1, OUTPUT);
  pinMode(led2, OUTPUT); // Additional LED Pinmode
}

// the loop routine runs over and over again forever:
void loop() {
  digitalWrite(led1, HIGH);   // turn the LED on (HIGH is the voltage level)
  digitalWrite(led2, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(1000);                // wait for a second
  digitalWrite(led1, LOW);    // turn the LED off by making the voltage LOW
  digitalWrite(led2, LOW);    // turn the LED off by making the voltage LOW
  delay(1000);                // wait for a second
}
```



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Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section1-DigitalWrite\Blink2Together

Engineering Challenge Review

Challenge Review

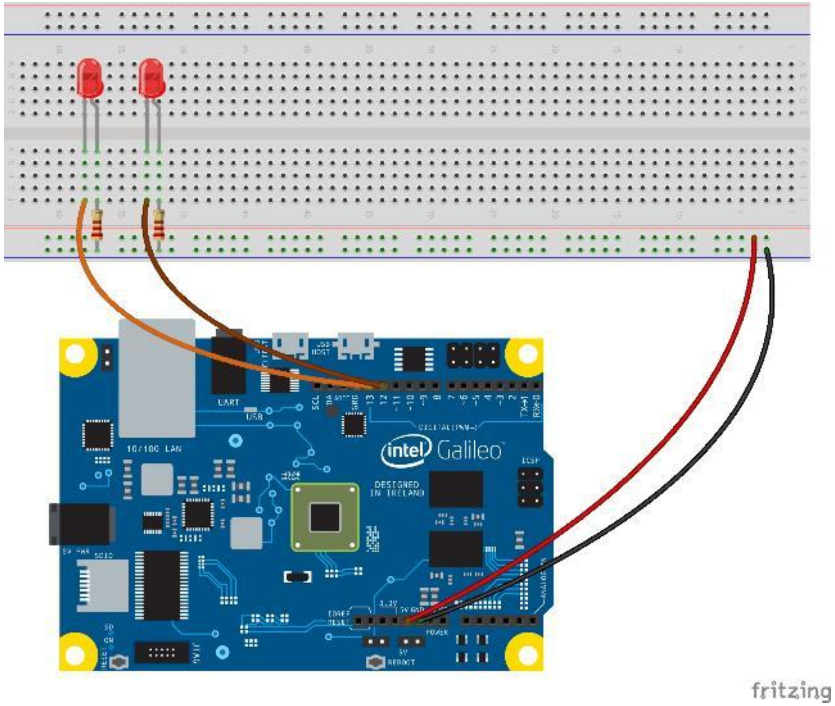
Challenge 1b: Make them Blink Alternating on and off.

```
/*
  Blink two LEDs together
  Modified by Matt Royer May 5, 2014
*/

// Pin 13 has an LED connected on most Arduino boards.
// give it a name:
int led1 = 13;
int led2 = 12; // Additional LED Pin

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led1, OUTPUT);
  pinMode(led2, OUTPUT);  // Additional LED Pinmode
}

// the loop routine runs over and over again forever:
void loop() {
  digitalWrite(led1, HIGH);   // turn the LED on (HIGH is the voltage level)
  digitalWrite(led2, LOW);   // turn the LED on (HIGH is the voltage level)
  delay(1000);               // wait for a second
  digitalWrite(led1, LOW);    // turn the LED off by making the voltage LOW
  digitalWrite(led2, HIGH);    // turn the LED off by making the voltage LOW
  delay(1000);               // wait for a second
}
```



* Other names and brands may be claimed as the property of others

Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section1-DigitalWrite\Blink2Alternating

Engineering Challenge Review

Challenge Review

Challenge 3: Add a Third LED to circuit and make them Blink in series and then repeat.

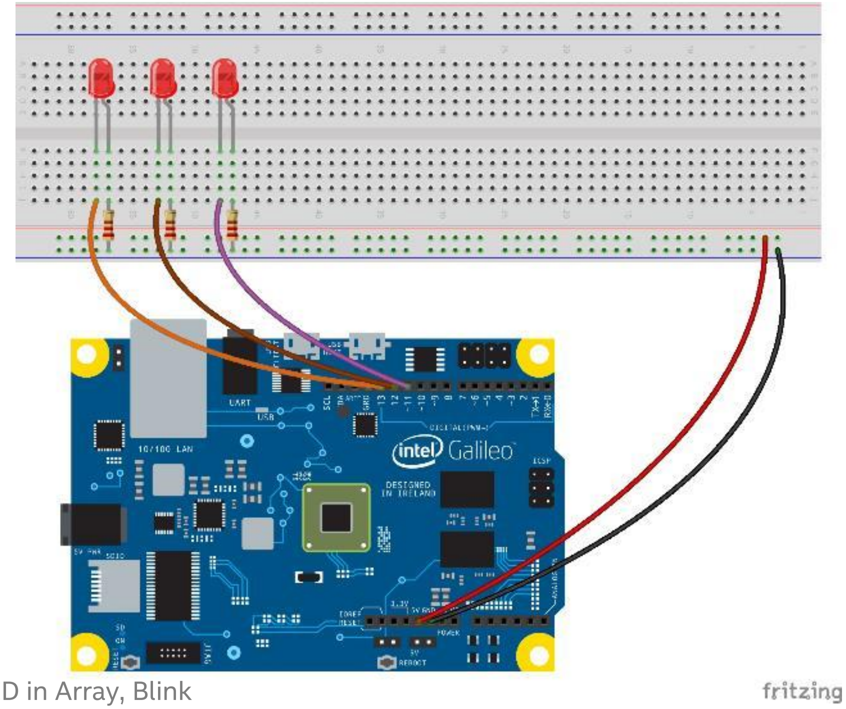
```
/*
 Blink
 Cycle through Array list of LEDs.  For each LED in Array turns it on for 1 second.

 Modified by Matt Royer May 5, 2014
*/

const int numberOfLED = 3; // Number of LED in Array
const int lEDToBlink[numberOfLED] = { // Array to store LED Pins
  13,
  12,
  11
};

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output
  // For each LED in Array, initialize
  for (int initalizeLED = 0; initalizeLED < numberOfLED; initalizeLED++){
    pinMode(lEDToBlink[initalizeLED], OUTPUT);
  }
}

// the loop routine runs over and over again forever:
void loop() {
  for (int lightLED = 0; lightLED < numberOfLED; lightLED++){ // For each LED in Array, Blink
    digitalWrite(lEDToBlink[lightLED], HIGH);   // turn the LED on (HIGH is the voltage level)
    delay(1000);
    digitalWrite(lEDToBlink[lightLED], LOW);   // turn the LED on (HIGH is the voltage level)
  }
}
```



Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section1-DigitalWrite\Blink3Serially

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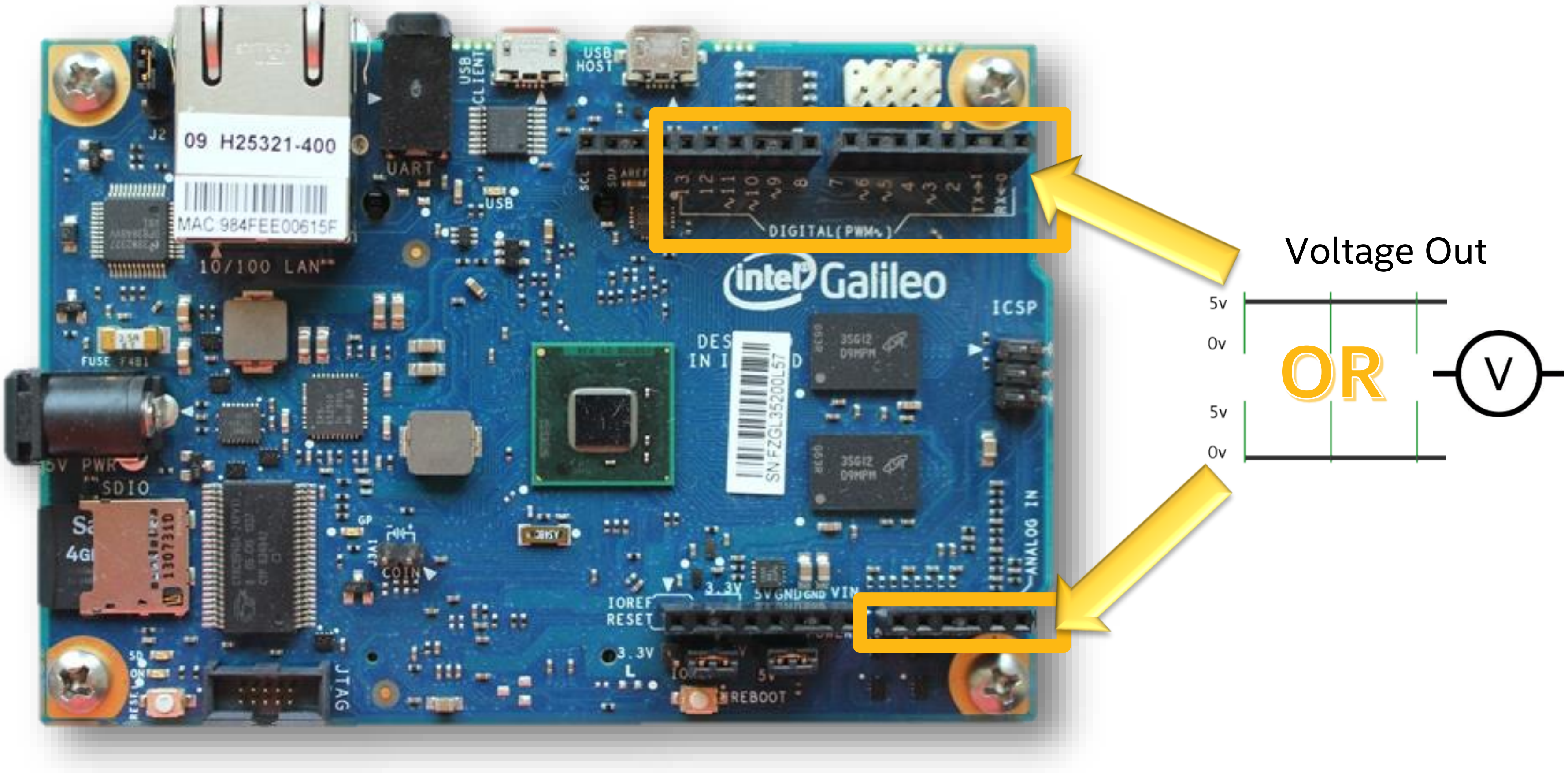
Basic I/O - Digital Reads

Digital Read



Voltage Out

5v

0v

OR

5v

0v

Digital Read – Key Concepts

Reminder pinMode(): Configures the specified pin to behave either as an input or an output

- Syntax: pinMode(pin, mode)
- Example: pinMode(2, OUTPUT) set pin 2 to output mode
- **Example: pinMode(2, INPUT)** set pin 2 to input mode

digitalRead(): Reads the value from a specified digital pin, either HIGH or LOW

- Syntax: pinMode(pin)
- Example 1: digitalRead(2) reads High or Low from pin 2

Digital Read – LED Button Press

LAB

Project Name: LED Button Press*(Instructor Lead)*

Objective: Illuminate LED when button is pressed

Software Elements

- pinMode()
- digitalWrite()
- digitalRead()
- if / else

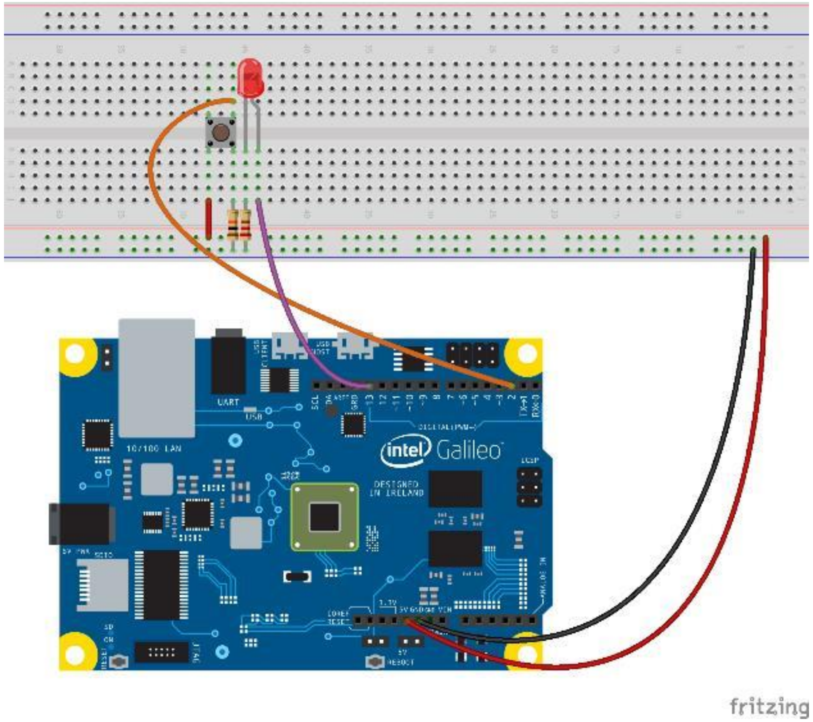
Components

- Intel Galileo Board (Qty 1)
- Breadboard (QTY1)
- Jumper Wires
- 5mm LED (Qty 1)
- Momentary Switch (Qty 1)
- 220 Ohm Resister (Qty1)
- 10k Ohm Resister (Qty1)

Digital Write – LED Button Press

LAB

```
// 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);
  }
}
```



Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section2-DigitalRead\ButtonPush

* Other names and brands may be claimed as the property of others

Digital Write - Engineering Challenge

LAB

Using your own circuit design and Arduino sketch, design a solution that solves the following challenges.

Use previous Lab example as needed for reference

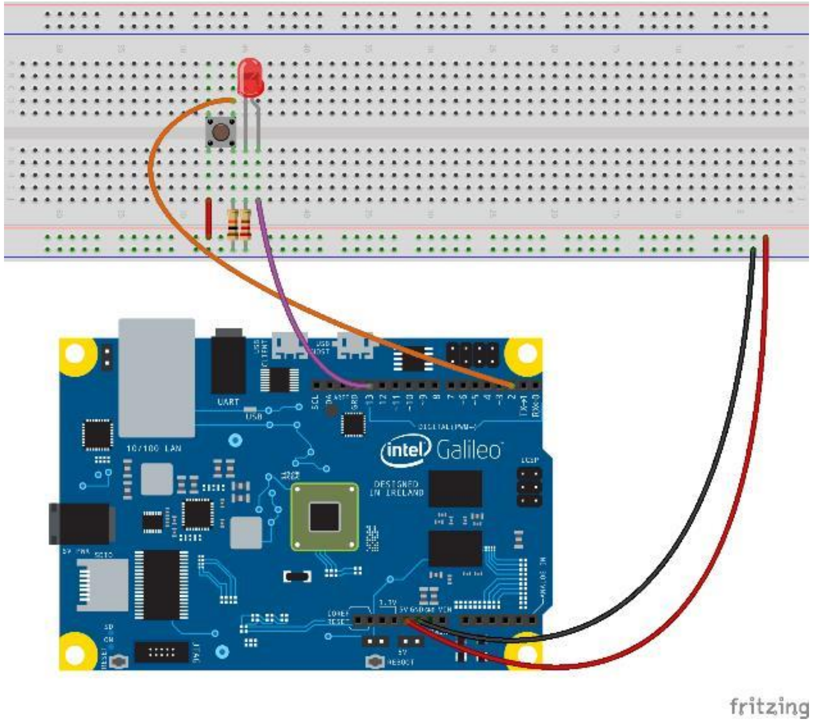
Challenge 1: Blink LED continuously while button is pressed

Engineering Challenge Review

Challenge Review

Challenge 1: Blink LED continuously while button is pressed.

```
// 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) {
    digitalWrite(ledPin, HIGH);
    delay(500);
    digitalWrite(ledPin, LOW);
    delay(500);
  }
  digitalWrite(ledPin, LOW);
}
```



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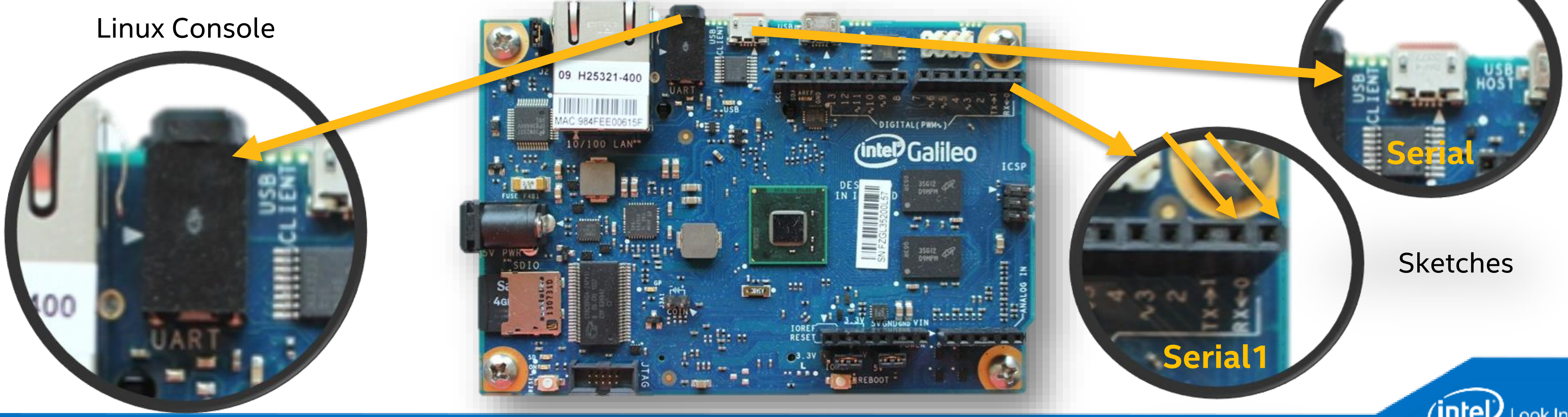
Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section2-DigitalRead\ButtonPushBlink

Basic I/O - Serial Writes

Refresher: Galileo Serial Interfaces

- Used for communication between the Arduino board and a computer or other devices.
- Arduino platforms have at least one serial port (also known as a UART or Universal Asynchronous Receiver/Transmitter)
- Serial Communicates through digital pins 0 (RX) & 1 (TX) and via USB to Computer for Sketches
- Serial Communicates through UART for Linux Console
- Supported baud rates: 300, 600, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, or 115200.



Serial Write – Key Concepts

Serial.begin(): Sets the data rate in bits per second (baud) for serial data transmission

- Syntax: Serial.begin(baud)
- Example: Serial.begin(9600) sets serial baud rate to 9600 bits per second

Serial.print(): Prints data to the serial port as human-readable ASCII text without carriage return / Newline Feed character

- Syntax: Serial.print(val) or Serial.print(val, format)
- Parameters:
  - val: the value to print - any data type
  - format: specifies the number base or number of decimal places
- Example: Serial.print(”Hello world.“) gives "Hello world.“
- Example: Serial.print(1.23456, 2) gives “1.23”

Serial Write – Key Concepts

Serial.println(): Prints data to the serial port as human-readable ASCII text *followed by a carriage return and a newline character*

- Syntax: Serial.println(val) or Serial.print(val, format)
- Parameters:
  - val: the value to print - any data type
  - format: specifies the number base or number of decimal places
- Example: Serial.println(”Hello world.“) gives "Hello world.“
- Example: Serial.println(1.23456, 2) gives “1.23”

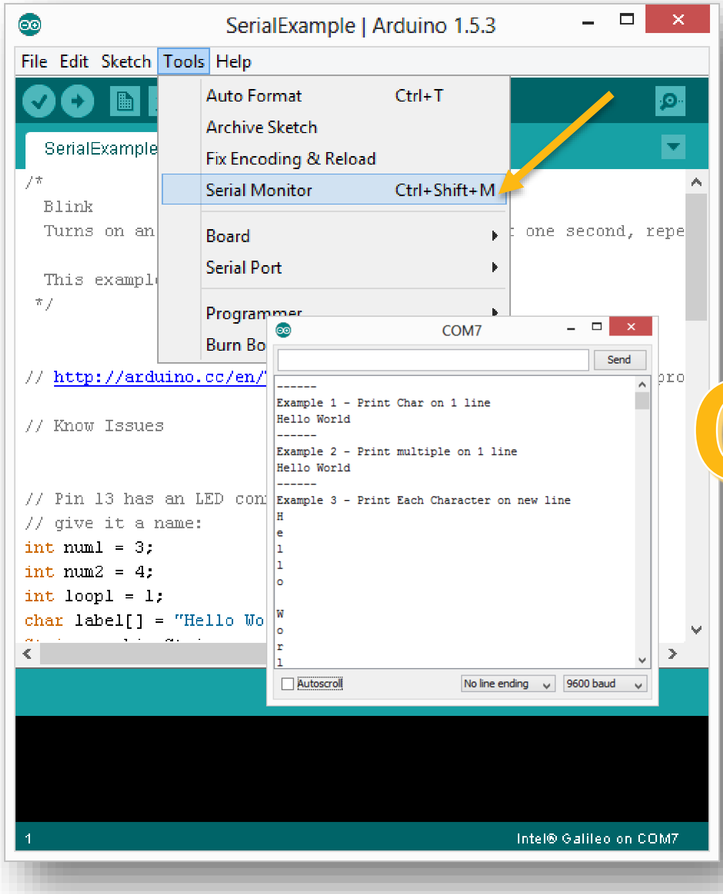
Serial.write(): Writes binary data to the serial port. This data is sent as a byte or series of bytes

- Syntax: Serial.write(val)
- Example: Serial.wrtie(”Hello world“) writes "Hello world“

Bring up Serial Monitor

- Select “Tools” -> “Serial Monitor” or click Serial Monitor Icon

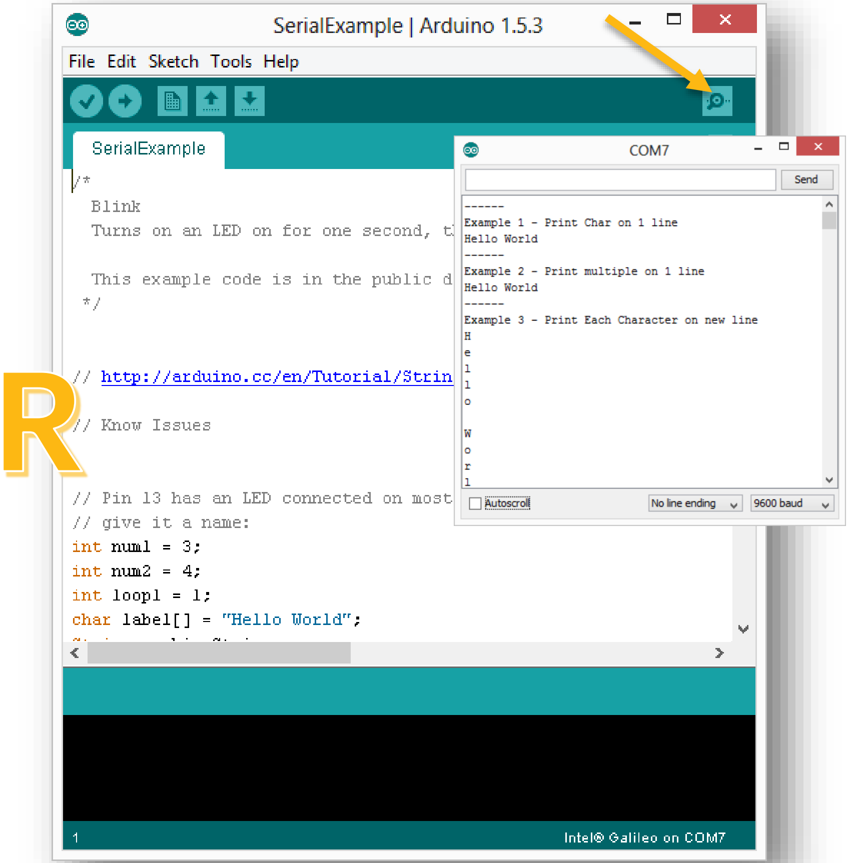
Note: Sketch must be loaded first; else, Serial Monitor will close on Sketch upload



```
/*
  Blink
  Turns on an                              one second, repe

  This exampl
 */


// http://arduino.cc/en/                                pro

// Know Issues


// Pin 13 has an LED con
// give it a name:
int num1 = 3;
int num2 = 4;
int loop1 = 1;
char label[] = "Hello Wo
```

```
------
Example 1 - Print Char on 1 line
Hello World
------
Example 2 - Print multiple on 1 line
Hello World
------
Example 3 - Print Each Character on new line
H
e
l
l
o

W
o
r
l
```

OR



```
/*
  Blink
  Turns on an LED on for one second, t

  This example code is in the public d
 */


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

// Know Issues


// Pin 13 has an LED connected on most
// give it a name:
int num1 = 3;
int num2 = 4;
int loop1 = 1;
char label[] = "Hello World";
```

```
------
Example 1 - Print Char on 1 line
Hello World
------
Example 2 - Print multiple on 1 line
Hello World
------
Example 3 - Print Each Character on new line
H
e
l
l
o

W
o
r
l
```

Serial Write – Printing to Serial Monitor LAB

Project Name: Printing to Serial Monitor *(Instructor Lead)*

Objective: Demonstrate different means to print to Serial monitoring

Software Elements

- Serial.Begin()
- Serial.print()
- Serial.println()
- concat()
- delay()

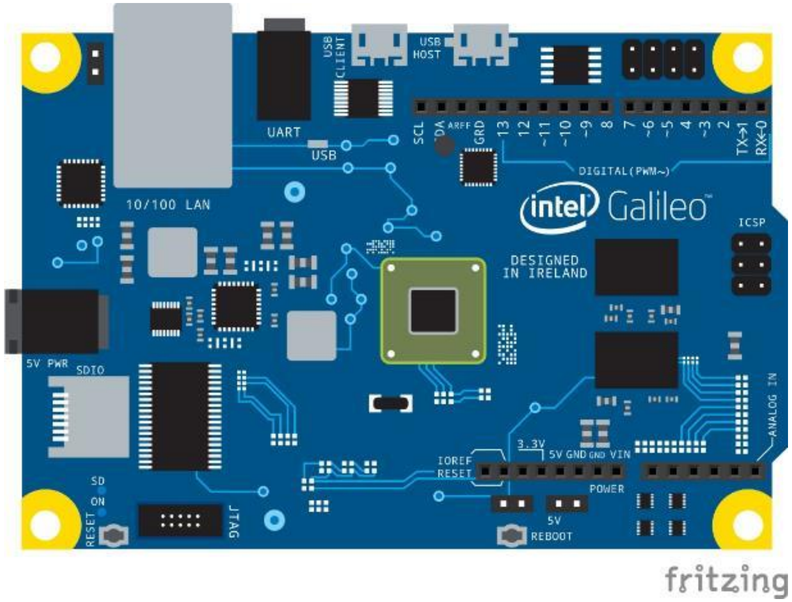
Components

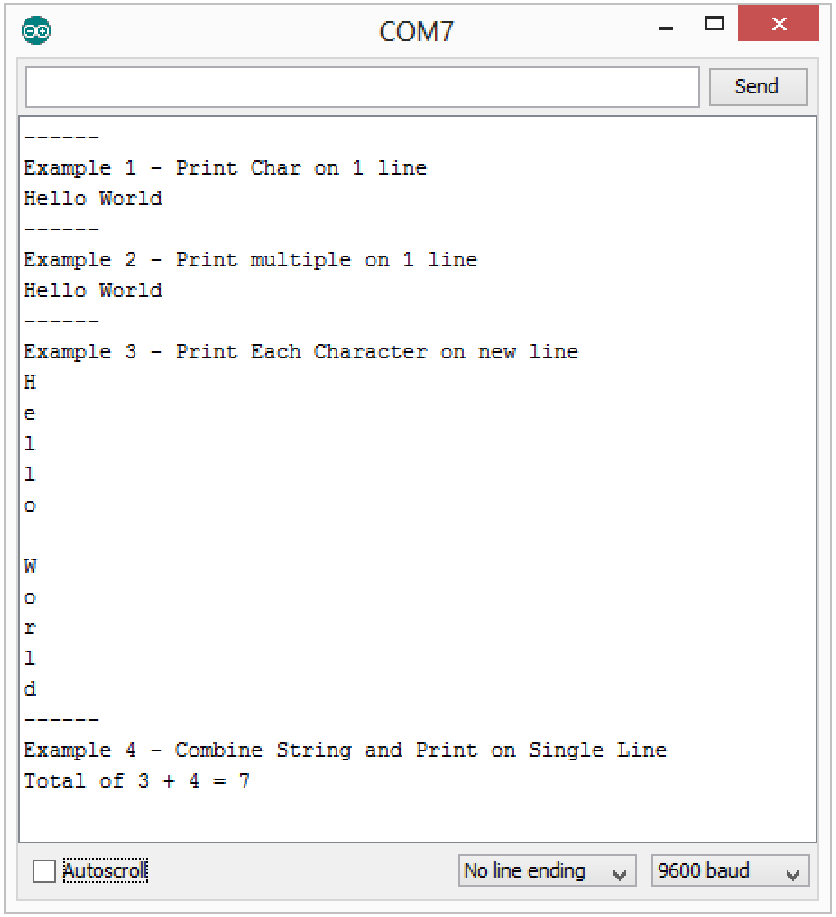
- Intel Galileo Board (Qty 1)

Serial Write – Printing to Serial Monitor

LAB

Source Code: *Lesson2-BasicIO\Section3-SerialWrite\SerialExample*





```
------
Example 1 - Print Char on 1 line
Hello World
------
Example 2 - Print multiple on 1 line
Hello World
------
Example 3 - Print Each Character on new line
H
e
l
l
o

W
o
r
l
d
------
Example 4 - Combine String and Print on Single Line
Total of 3 + 4 = 7
```

□ Autoscroll   No line ending   9600 baud

* Other names and brands may be claimed as the property of others

Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section3-SerialWrite\SerialExample

Serial Write - Engineering Challenge

LAB

Using your own circuit design and Arduino sketch, design a solution that solves the following challenges.

Use previous Lab example as needed for reference

Challenge 1: Store your Name in a variable and write it to serial interface

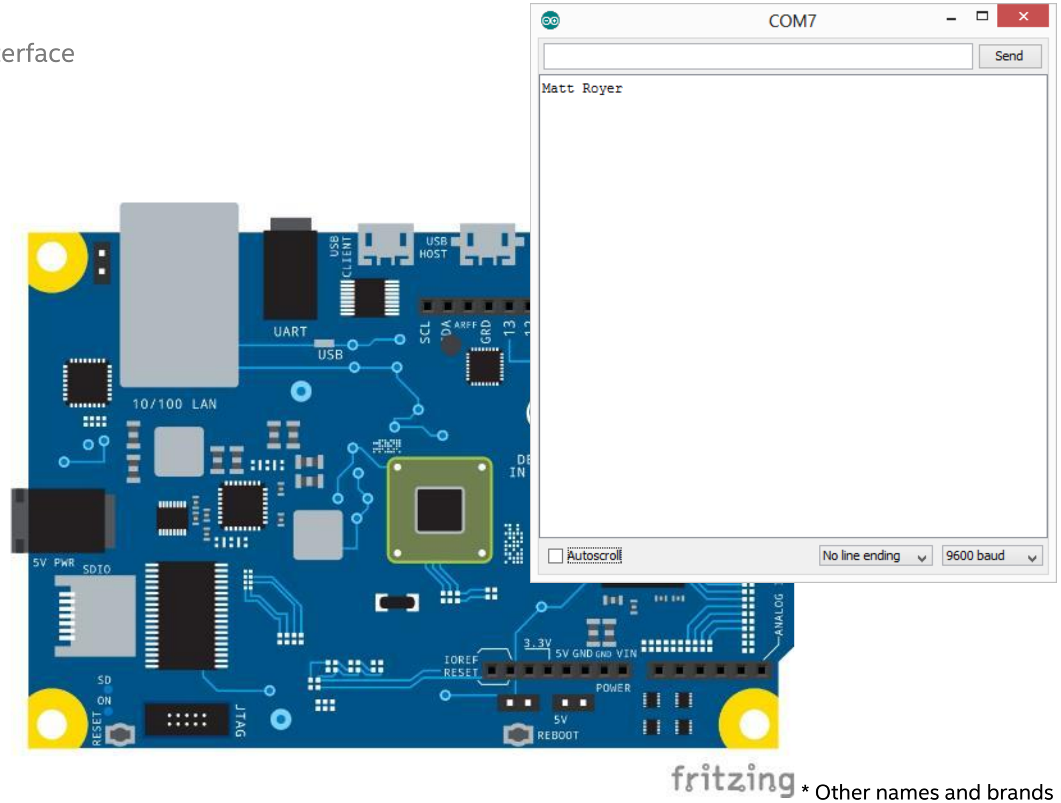
Challenge 2: Write every number from 0-100 to Serial interface

Engineering Challenge Review

Challenge Review

Challenge 1: Store your Name in a variable and write it to serial interface

```
/*
  Store your Name in a variable and write it to serial interface

  Created by Matt Royer
*/

String myName = "Matt Royer";

// the setup routine runs once when you press reset:
void setup() {
  // initialize the Serial Interface
  Serial.begin(9600);

}

// the loop routine runs over and over again forever:
void loop() {

  Serial.println(myName);

  delay(2000);

}
```



```
Matt Royer
```

fritzing

* Other names and brands may be claimed as the property of others

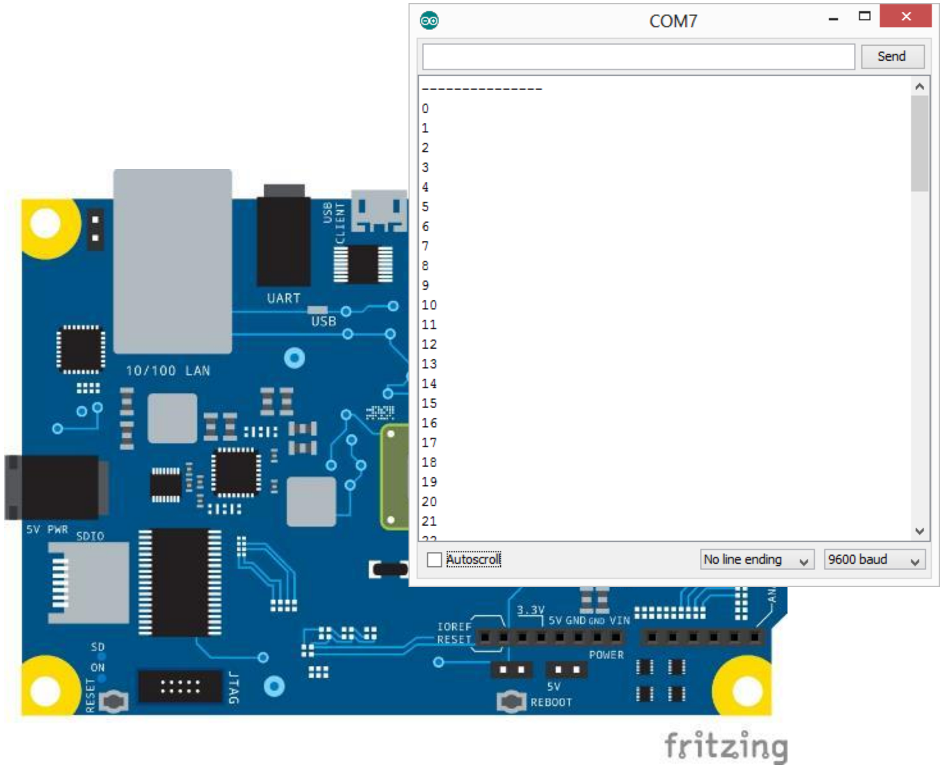
Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section3-SerialWrite\SerialName

Engineering Challenge Review

Challenge Review

Challenge 2: Write every number from 0-100 to Serial interface

```
/*
  Write every number from 0-100 to Serial interface

  Created by Matt Royer
*/

int maxNum = 100;

// the setup routine runs once when you press reset:
void setup() {
  // initialize the Serial Interface
  Serial.begin(9600);

}

// the loop routine runs over and over again forever:
void loop() {
  Serial.println("---------------");
  for (int numIndex = 0; numIndex <=  maxNum; numIndex++){
    Serial.println(numIndex);
  }
  Serial.println("---------------");
  delay(10000);
}
```



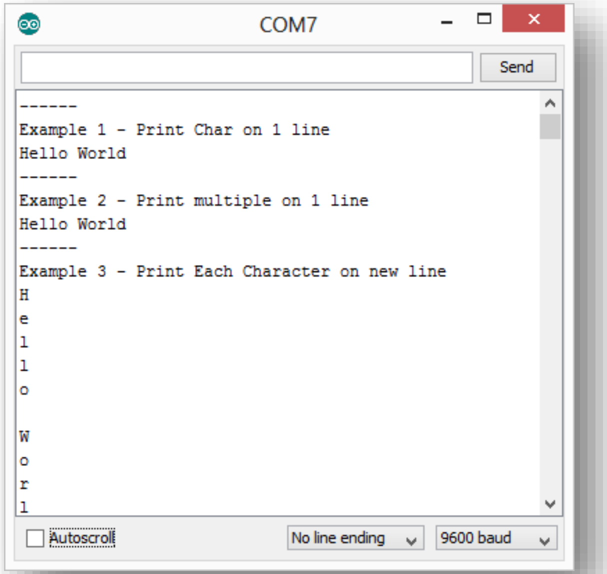
```
---------------
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
```

* Other names and brands may be claimed as the property of others

Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section3-SerialWrite\Serial0to100

Using Alternative Terminals

- Although nicely integrated into Arduino IDE, you are not required to use the integrated Serial Monitor.
- Use any Terminal connecting to the proper COM port at the correct baud rate
- Simultaneous use (multiple sessions to COM port), not viable



```
------
Example 1 - Print Char on 1 line
Hello World
------
Example 2 - Print multiple on 1 line
Hello World
------
Example 3 - Print Each Character on new line
H
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W
o
r
l
```
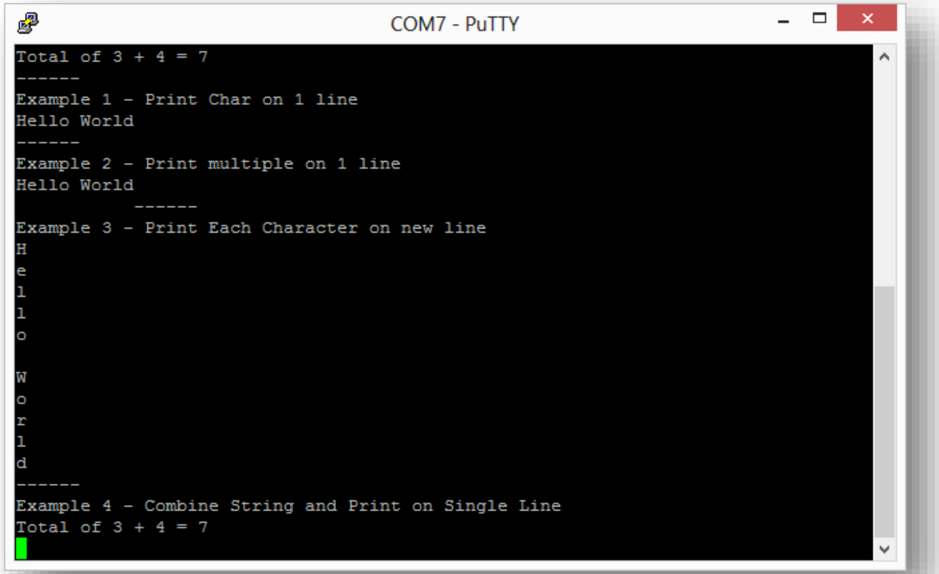

□ Autoscroll   No line ending   9600 baud

Arduino Serial Monitor



```
Total of 3 + 4 = 7
------
Example 1 - Print Char on 1 line
Hello World
------
Example 2 - Print multiple on 1 line
Hello World
           ------
Example 3 - Print Each Character on new line
H
e
l
l
o

W
o
r
l
d
------
Example 4 - Combine String and Print on Single Line
Total of 3 + 4 = 7
```

PuTTY

Basic I/O - Serial Reads

Serial Read – Key Concepts

Reminder Serial.begin(): Sets the data rate in bits per second (baud) for serial data transmission

- Syntax: Serial.begin(baud)
- Example: Serial.begin(9600) sets serial baud rate to 9600 bits per second

Serial.availible(): Get the number of bytes that have already arrived and been stored in the serial receive buffer (which holds 64 bytes).

- Syntax: Serial.availible()

Serial.read(): Reads incoming serial data. Removes data from serial buffer

- Syntax: Serial.read()

Serial Read – Read Input

LAB

Project Name: Read Input *(Instructor Lead)*

Objective: Read input from Serial Monitor input and write it back out

Software Elements

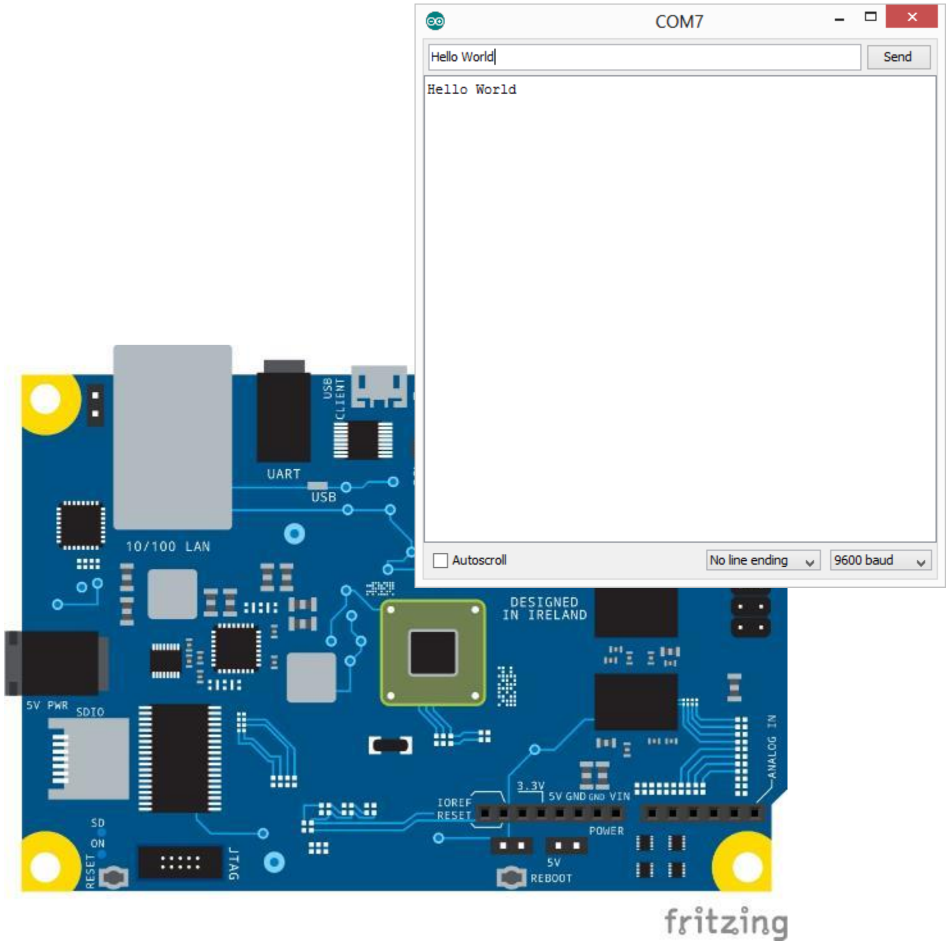
- Serial.begin()
- Serial.availible()
- Serial.read()
- Serial.print()
- Serial.write()
- Serial.println()

Components

- Intel Galileo Board (Qty 1)

Serial Read– Read Input

```
/* Simple Serial ECHO script : Written by ScottC 03/07/2012 */

/* Use a variable called byteRead to temporarily store
   the data coming from the computer */
byte incomingByte;

void setup() {
// Turn the Serial Protocol ON
  Serial.begin(9600);
}

void loop() {
   /*  check if data has been sent from the computer: */
  if (Serial.available()) {
    /* read the most recent byte */
    incomingByte = Serial.read();
    /*ECHO the value that was read, back to the serial port. */
    Serial.write(incomingByte);
  }
}
```



COM7

Hello World | Send

```
Hello World
```

□ Autoscroll | No line ending | 9600 baud

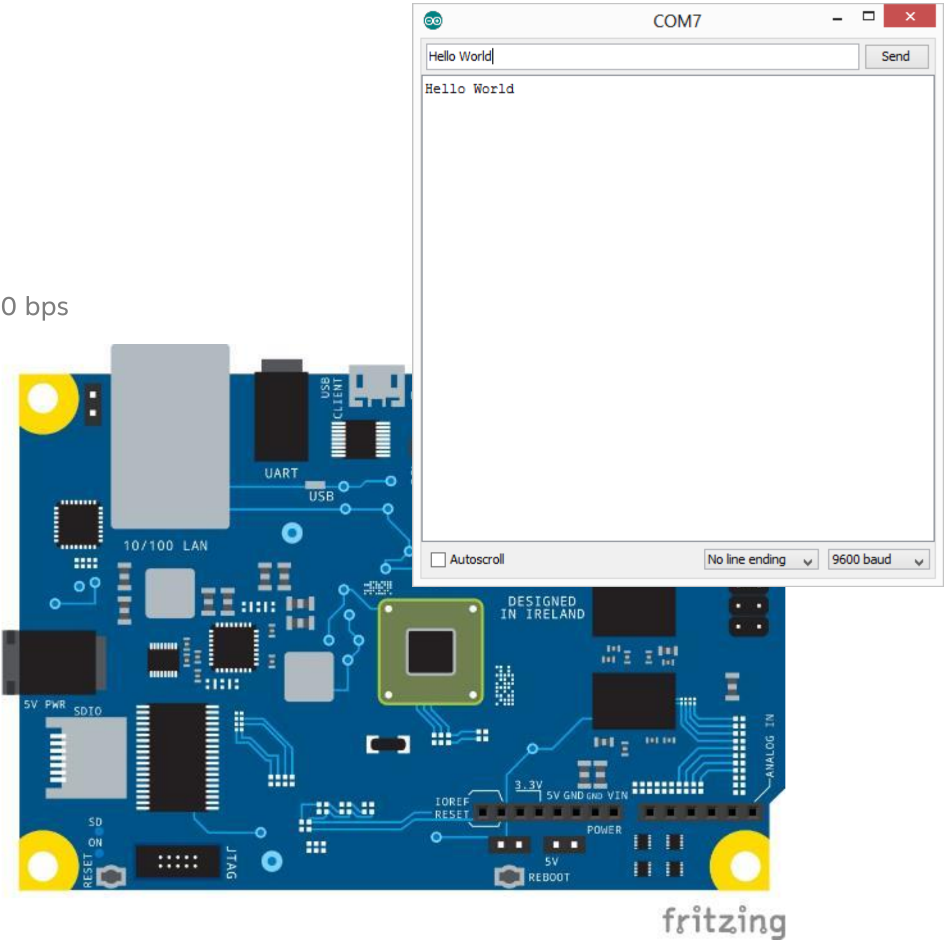
* Other names and brands may be claimed as the property of others

Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section4-SerialRead\SerialReadWrite

Serial Read– Read Entire Buffer

LAB

```
/*
 Read entire input from Serial Monitor input buffer, then write it back out

 Create by Matt Royer
 */


char character;
String content = "";

void setup() {
 Serial.begin(9600);     // opens serial port, sets data rate to 9600 bps
}

void loop() {

 while(Serial.available()) {

   character = Serial.read();
   content.concat(character); //Concatenate to existing string

 }

 if (content != "") {

   Serial.println(content); //Print string to serial
   content = ""; //Empty string

 }

}
```



COM7

Hello World

Send

```
Hello World
```

□ Autoscroll

No line ending

9600 baud

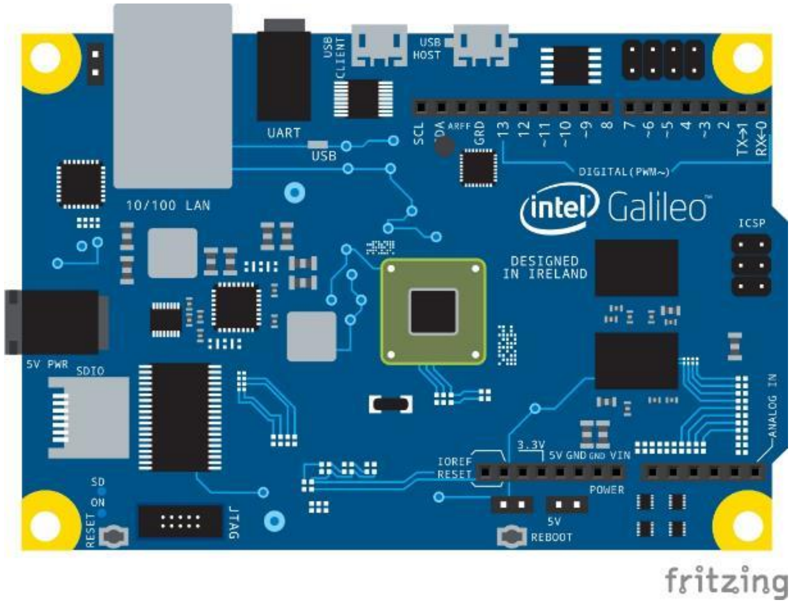
* Other names and brands may be claimed as the property of others

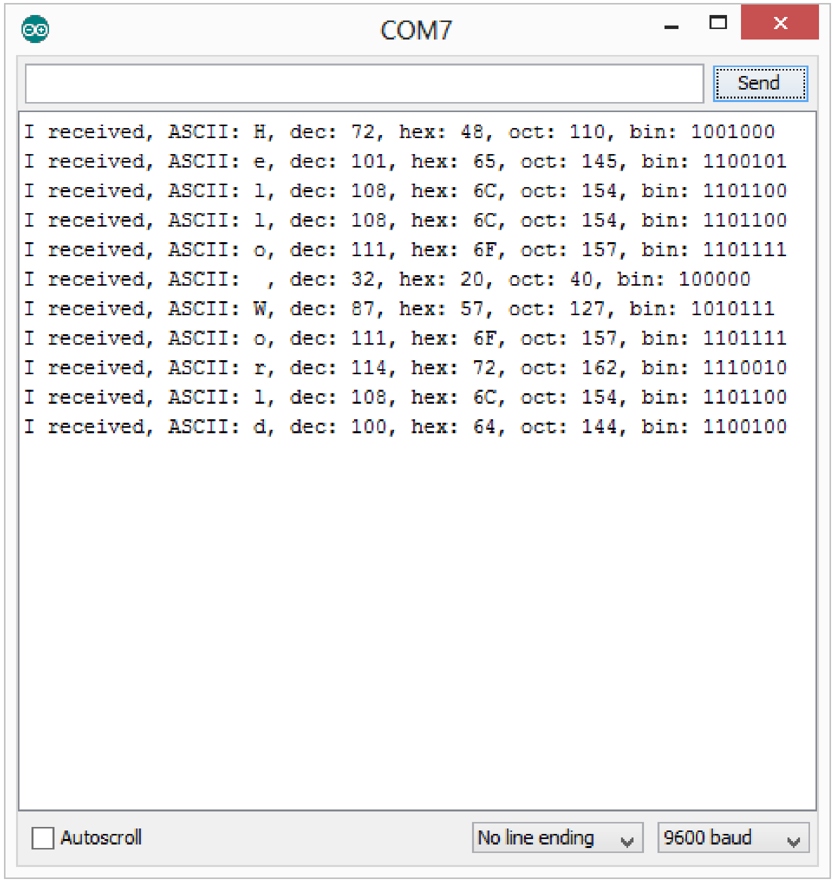
Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section4-SerialRead\Serial_ReadEntireBuffer

Serial Write – Read Input and Format

LAB

Source Code: *Lessons\Lesson2-BasicIO\Section4-SerialRead\Serial_ReadWriteFormates*





```
I received, ASCII: H, dec: 72, hex: 48, oct: 110, bin: 1001000
I received, ASCII: e, dec: 101, hex: 65, oct: 145, bin: 1100101
I received, ASCII: l, dec: 108, hex: 6C, oct: 154, bin: 1101100
I received, ASCII: l, dec: 108, hex: 6C, oct: 154, bin: 1101100
I received, ASCII: o, dec: 111, hex: 6F, oct: 157, bin: 1101111
I received, ASCII:  , dec: 32, hex: 20, oct: 40, bin: 100000
I received, ASCII: W, dec: 87, hex: 57, oct: 127, bin: 1010111
I received, ASCII: o, dec: 111, hex: 6F, oct: 157, bin: 1101111
I received, ASCII: r, dec: 114, hex: 72, oct: 162, bin: 1110010
I received, ASCII: l, dec: 108, hex: 6C, oct: 154, bin: 1101100
I received, ASCII: d, dec: 100, hex: 64, oct: 144, bin: 1100100
```

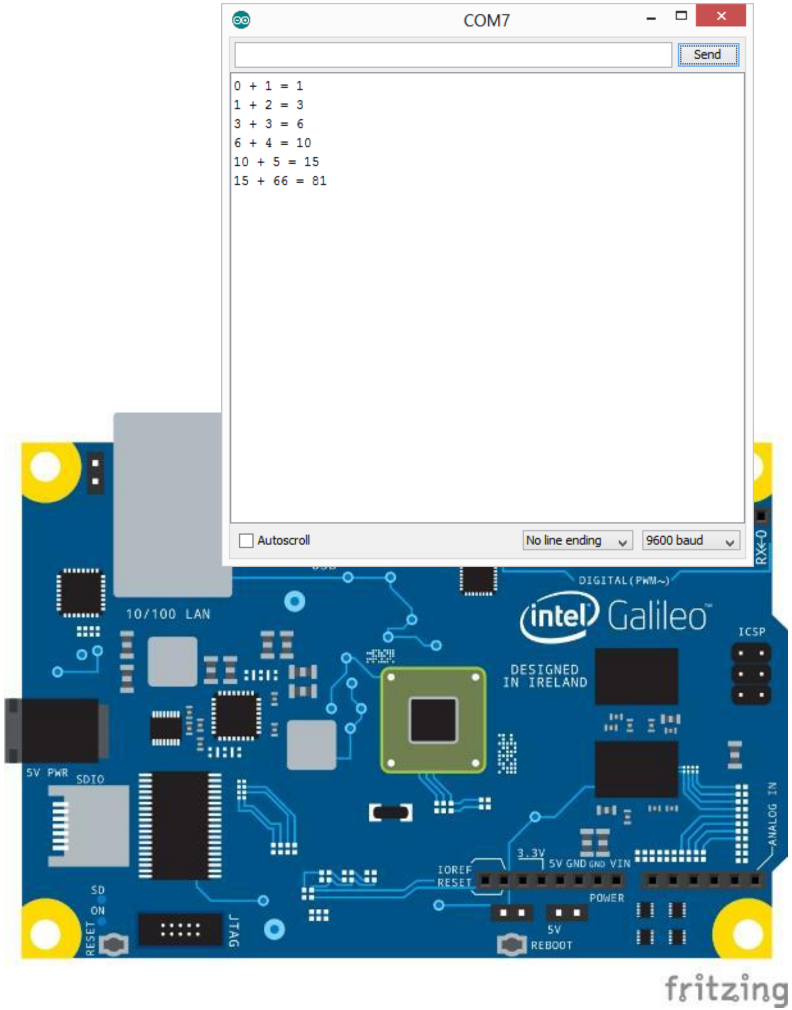
☐ Autoscroll | No line ending | 9600 baud

* Other names and brands may be claimed as the property of others

Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section4-SerialRead\Serial_ReadWriteFormates

Serial Read – Read Convert to int, then Add

```
char character;
String content = "";
int additionSum = 0;


void setup() {
 Serial.begin(9600);     // opens serial port, sets data rate to 9600 bps

}

void loop() {

 //Read Input Buffer
 while(Serial.available()) {
   character = Serial.read();
   content.concat(character);
 }

 if (content != "") {
   if (content.toInt() > 0) { //Make sure input is a number greater than zero

     Serial.print(additionSum);
     Serial.print(" + ");
     Serial.print(content);
     Serial.print(" = ");
     additionSum = additionSum + content.toInt(); // Perform Addition
     Serial.println(additionSum);

   } else {

     Serial.println("Input my be a number greater than 0");
   }
   content = ""; //Empty string
 }
}
```



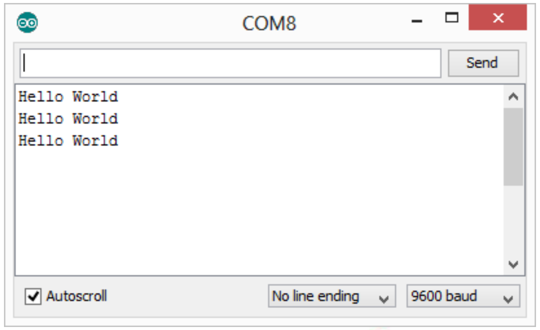
```
0 + 1 = 1
1 + 2 = 3
3 + 3 = 6
6 + 4 = 10
10 + 5 = 15
15 + 66 = 81
```

* Other names and brands may be claimed as the property of others

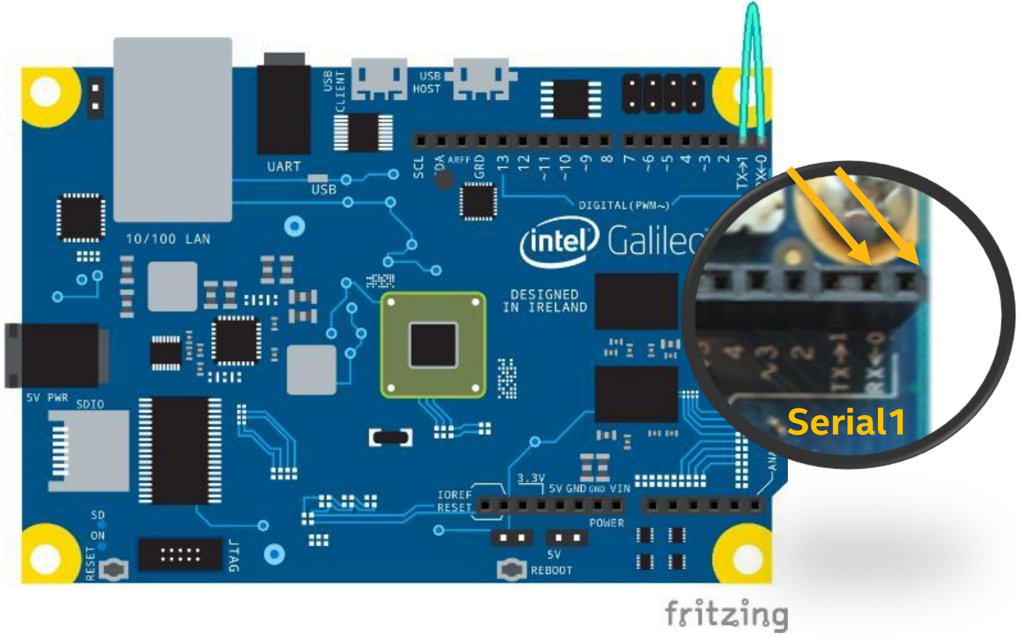
Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section4-SerialRead\Serial_ReadAdd

Serial1 – Reading and Writing

```
char character;
String content = "";

void setup() {
  Serial.begin(115200);     // opens serial port, sets data rate to 115200 bps
  Serial1.begin(115200);     // opens serial port, sets data rate to 115200 bps
}

void loop() {

  Serial1.write("Hello World"); // Write content to Serial1 interface

  while(Serial1.available()) {

    character = Serial1.read();
    content.concat(character); //Concatenate to existing string

  }

  if (content != "") {

    Serial.println(content); //Print string to serial
    content = ""; //Empty string

  }

  delay(2000);

}
```



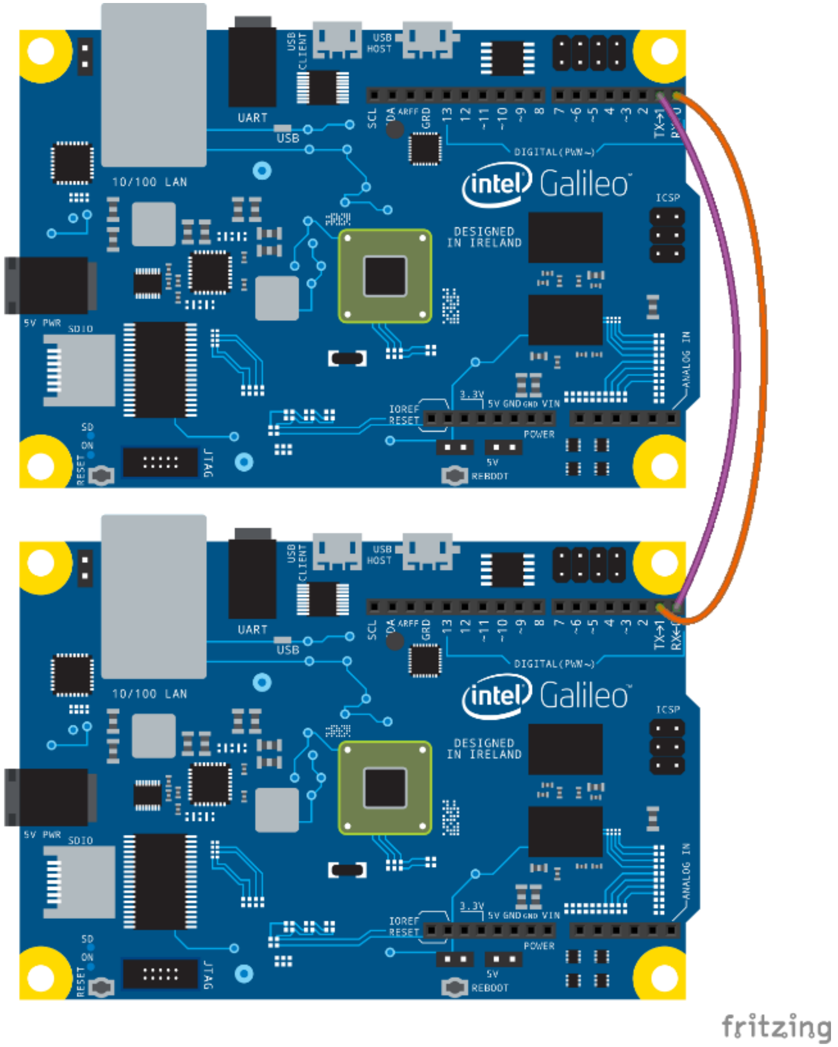
```
Hello World
Hello World
Hello World
```

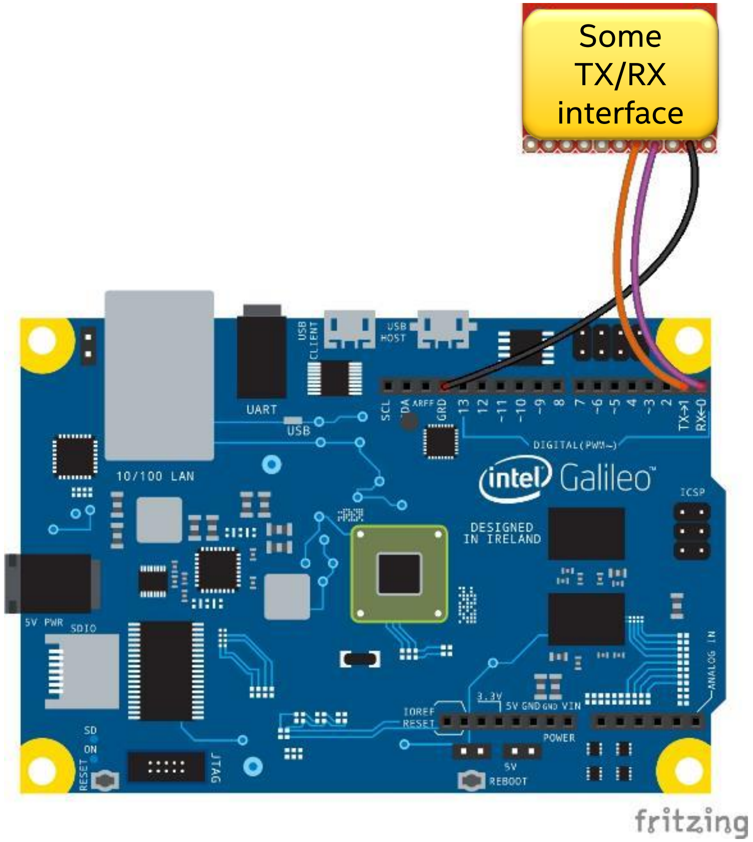


* Other names and brands may be claimed as the property of others

Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section4-SerialRead\Serial1ToSerial

Other Serial1 Possibilities





* Other names and brands may be claimed as the property of others

Serial Write - Engineering Challenge

LAB

Using your own circuit design and Arduino sketch, design a solution that solves the following challenges.

Use previous Lab example as needed for reference

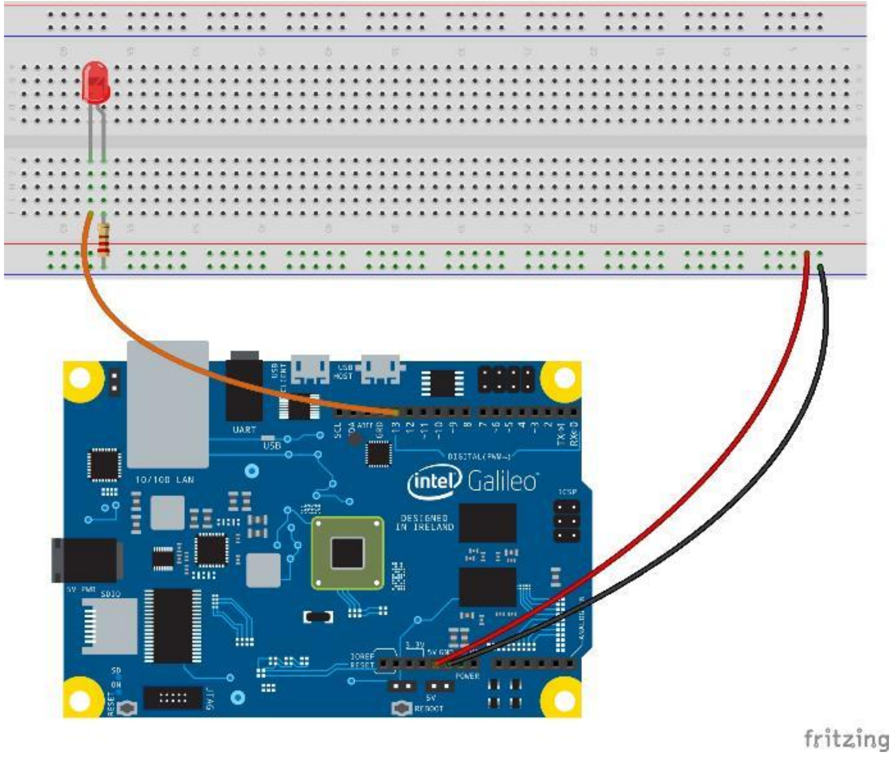
Challenge 1: Type in the number of times to blink an LED

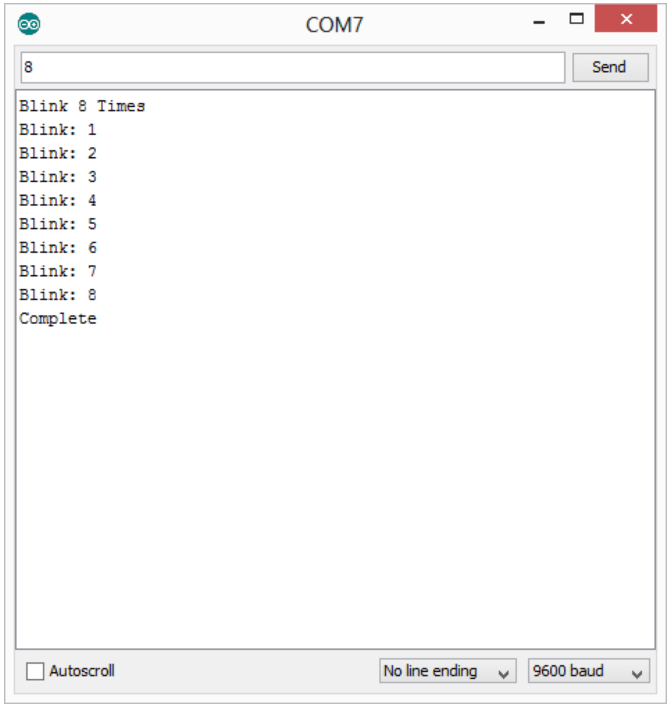
Engineering Challenge Review

Challenge Review

Challenge 1: Type in the number of times to blink an LED

Source Code: *Lessons\Lesson2-BasicIO\Section4-SerialRead\Serial_ReadBlink*





8

```
Blink 8 Times
Blink: 1
Blink: 2
Blink: 3
Blink: 4
Blink: 5
Blink: 6
Blink: 7
Blink: 8
Complete
```

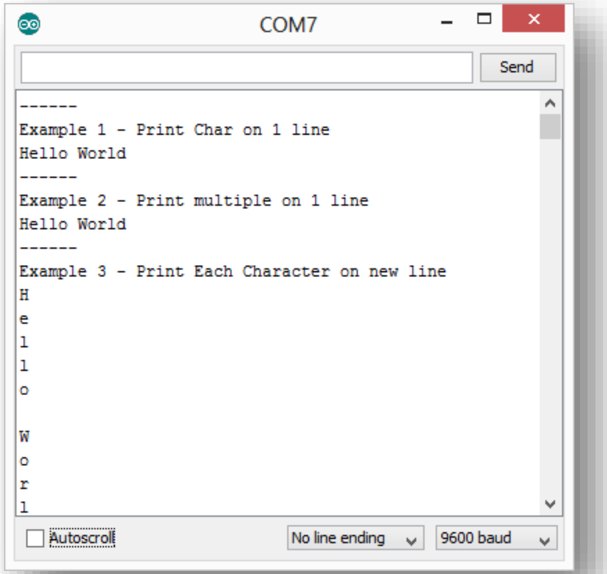
☐ Autoscroll   No line ending   9600 baud

* Other names and brands may be claimed as the property of others

Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section4-SerialRead\Serial_ReadBlink

Using Alternative Terminals

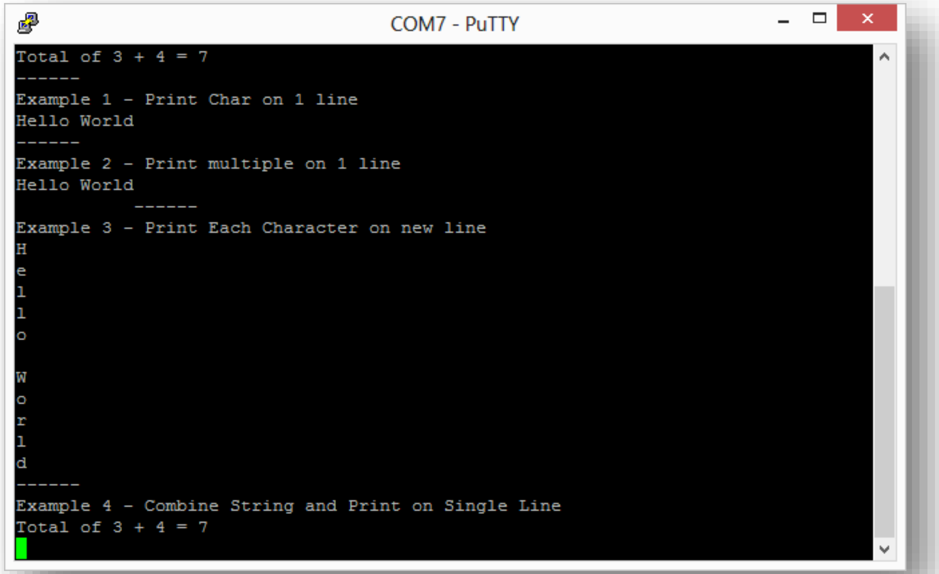
- Although nicely integrated into Arduino IDE, you are not required to use the integrated Serial Monitor.
- Use any Terminal connecting to the proper COM port at the correct baud rate
- Simultaneous use (multiple sessions to COM port), not viable



```
------
Example 1 - Print Char on 1 line
Hello World
------
Example 2 - Print multiple on 1 line
Hello World
------
Example 3 - Print Each Character on new line
H
e
l
l
o

W
o
r
l
```

□ Autoscroll   No line ending   9600 baud

Arduino Serial Monitor

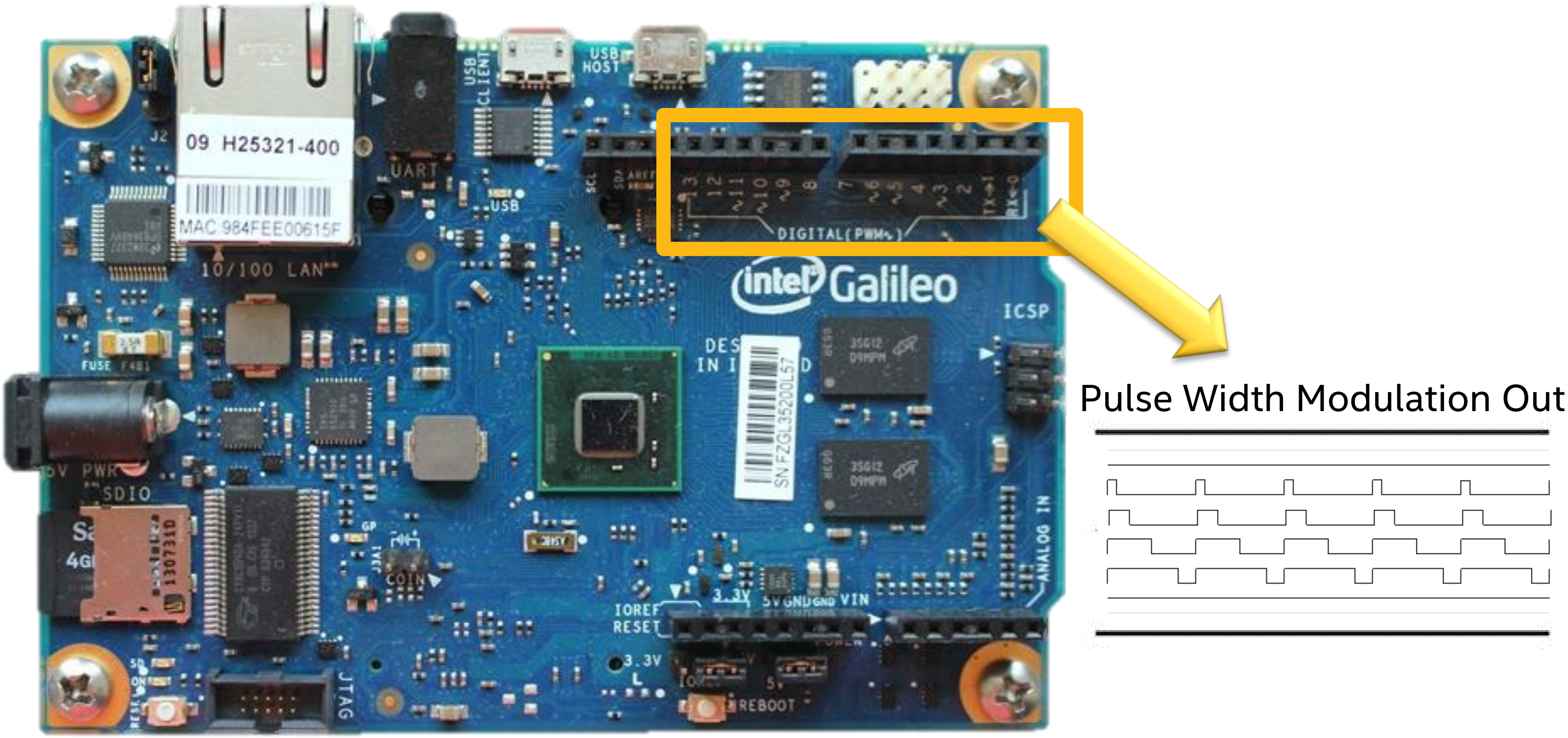


```
Total of 3 + 4 = 7
------
Example 1 - Print Char on 1 line
Hello World
------
Example 2 - Print multiple on 1 line
Hello World
           ------
Example 3 - Print Each Character on new line
H
e
l
l
o

W
o
r
l
d
------
Example 4 - Combine String and Print on Single Line
Total of 3 + 4 = 7
```

PuTTY

Basic I/O - Analog Writes

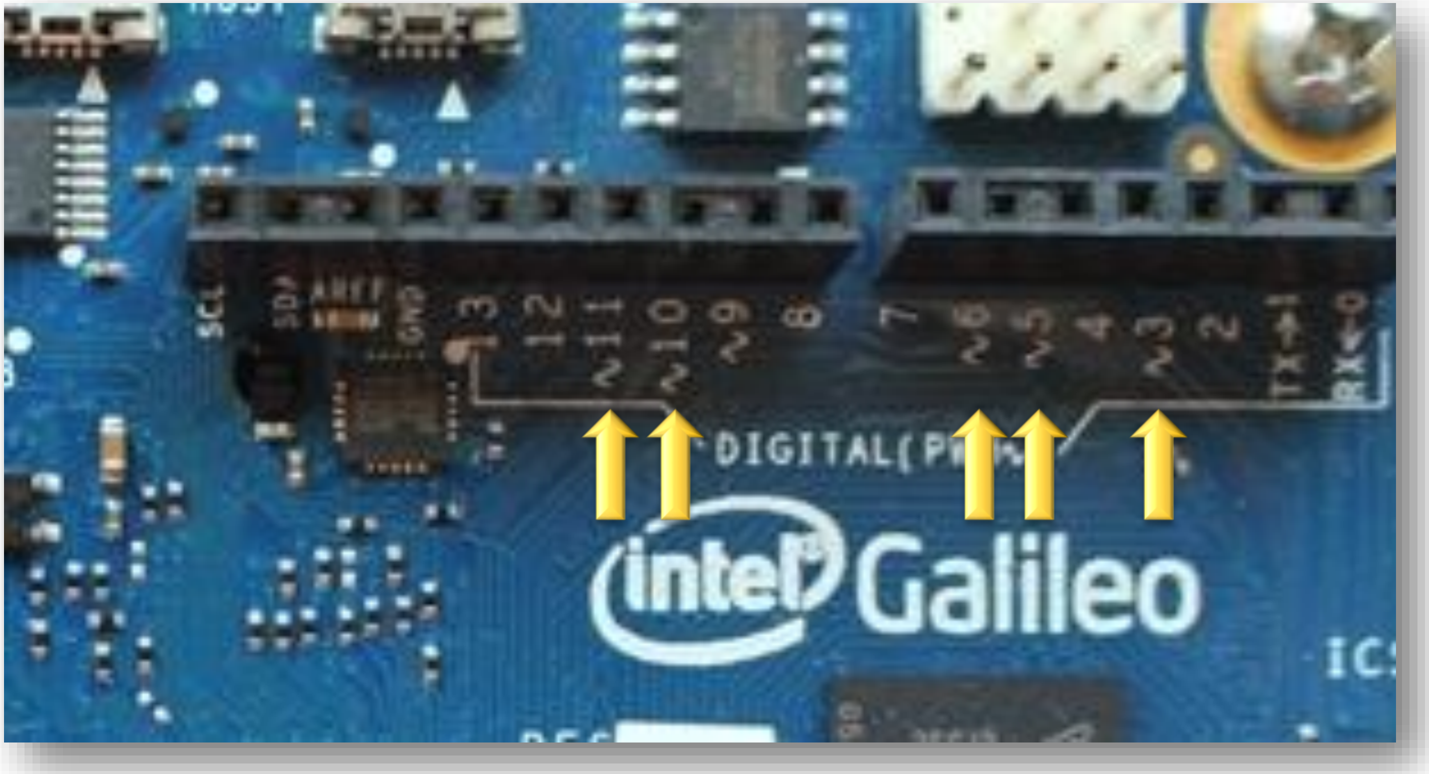
Analog Write



Pulse Width Modulation Out

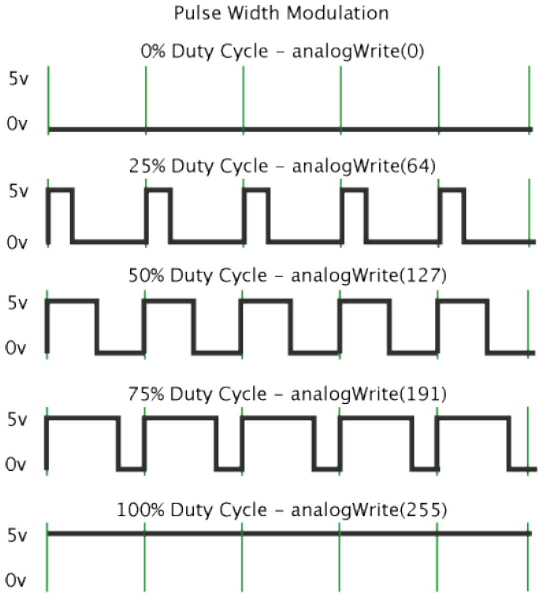
Pulse Width Modulation

- PWM is a technique for getting analog results with digital means
- Can be used to light a LED at varying brightness or drive a motor at various speeds
- PWM is supported on Pin 3, 5, 6, 9, 10, and 11



Pulse Width Modulation

- Digital control is used to create a square wave, a signal switched between on and off.
- This on-off pattern can simulate voltages in between full on (5 Volts) and off (0 Volts) by changing the portion of the time the signal spends “On” (5volts) versus “Off” (0volts)
- To get varying analog values, you change, or modulate, that pulse width
- A call to analogWrite() is on a scale of 0 – 255…
  - analogWrite of 255 requests a 100% duty cycle (always on)
  - analogWrite of 127 is a 50% duty cycle (on half the time)
  - analogWrite of 0 is a 0% duty cycle (Always off)


Pulse Width Modulation
0% Duty Cycle – analogWrite(0)
5v
0v
25% Duty Cycle – analogWrite(64)
5v
0v
50% Duty Cycle – analogWrite(127)
5v
0v
75% Duty Cycle – analogWrite(191)
5v
0v
100% Duty Cycle – analogWrite(255)
5v
0v

Source: http://arduino.cc/en/Tutorial/PWM

Analog Write – Key Concepts

Reminder pinMode(): Configures the specified pin to behave either as an input or an output

- Syntax: pinMode(pin, mode)
- Example: pinMode(11, OUTPUT) set pin 11 to output mode

analogWrite(): Writes an analog value (Pulse Width Modulation wave) to a pin.

- Syntax: analogWrite(pin, value)
- Example: analogWrite (11, 32) send PWM of 100 to pin 11
- What's the Duty Cycle if analogWrite is 32?

Serial Read – LED Fade

LAB

Project Name: LED Fade *(Instructor Lead)*

Objective: Change the brightness of an LED to make it appear to fade in and out

Software Elements

- analogWrite()
- pinMode()

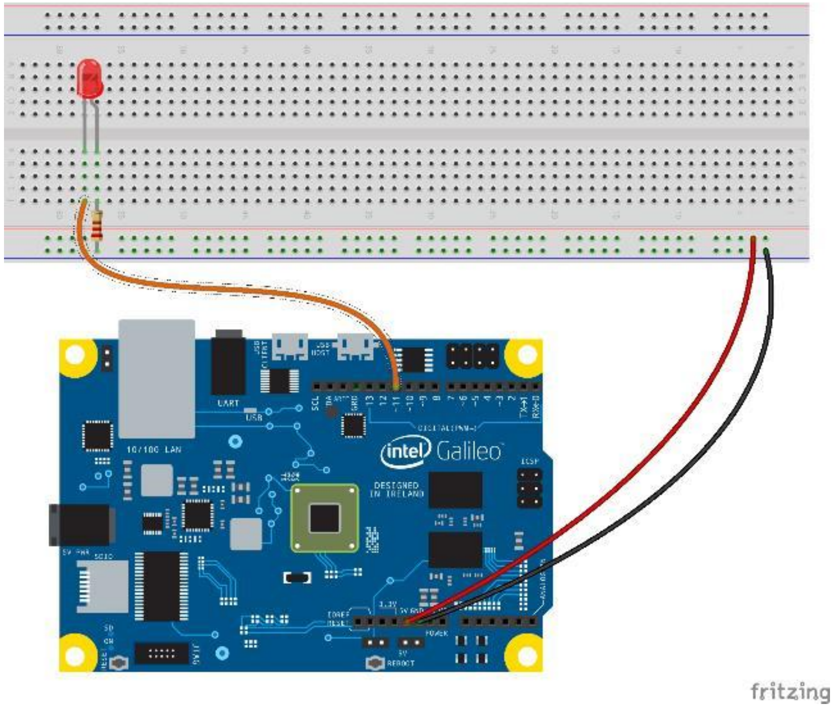
Components

- Breadboard (QTY1)
- Jumper Wires
- 5mm LED (Qty 1)
- 220 Ohm Resister (Qty1)

Analog Write – Fade LED

LAB

```
/*
 Fade

 This example shows how to fade an LED on pin 11
 using the analogWrite() function.

 This example code is in the public domain.
 */

int led = 11;           // the pin that the LED is attached to
int brightness = 0;    // how bright the LED is
int fadeAmount = 5;    // how many points to fade the LED by

// the setup routine runs once when you press reset:
void setup()  {
  // declare pin 11 to be an output:
  pinMode(led, OUTPUT);
}

// the loop routine runs over and over again forever:
void loop()  {
  // set the brightness of pin 9:
  analogWrite(led, brightness);

  // change the brightness for next time through the loop:
  brightness = brightness + fadeAmount;

  // reverse the direction of the fading at the ends of the fade:
  if (brightness == 0 || brightness == 255) {
    fadeAmount = -fadeAmount ;
  }
  // wait for 30 milliseconds to see the dimming effect
  delay(30);
}
```

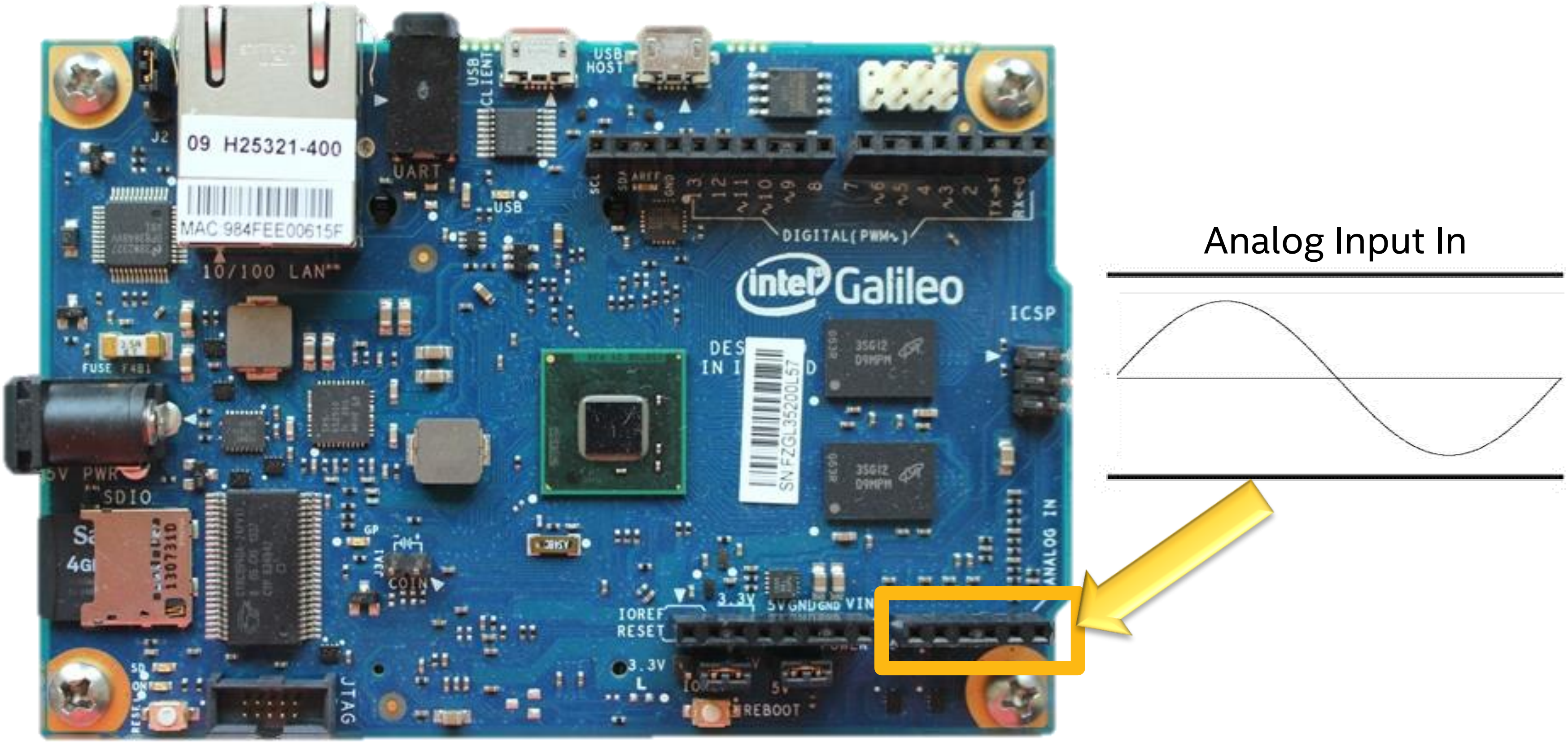


* Other names and brands may be claimed as the property of others

Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section5-AnalogWrite\Blink_Fade

Basic I/O Analog Read

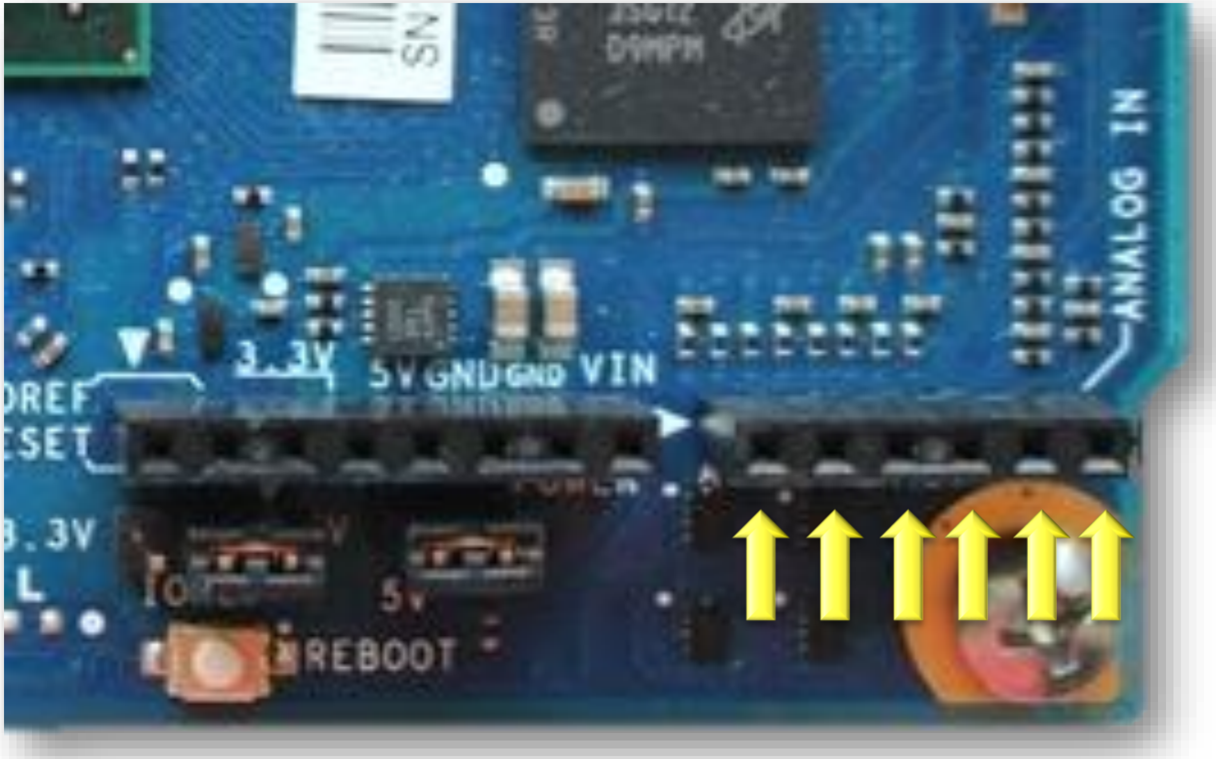
Analog Read



Analog Input In

Analog Pins

- Analog Pins are A0-A5
- Will map input voltages between 0 and 5 volts into integer values between 0 and 1023
- Can also be used as digital pins: analog input 0 as digital pin 14 through analog input 5 as digital pin 19



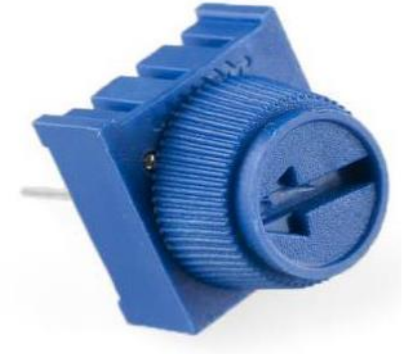
Analog Read – Key Concepts

analogRead(): Reads the value from the specified analog pin.

- Syntax: analogRead(pin)
- Example: analogRead(A0) reads analog value of pin A0

map(): Re-maps a number from one range to another. Value can be mapped to values that are out of range.

- Syntax: map(Source, fromLow, fromHigh, toLow, toHigh)
- Example: map(val, 0, 1023, 0, 254)



Analog Read – POT Value Read

LAB

Project Name: Reading Analog Values *(Instructor Lead)*

Objective: Read POT value and map to alternative range

Software Elements

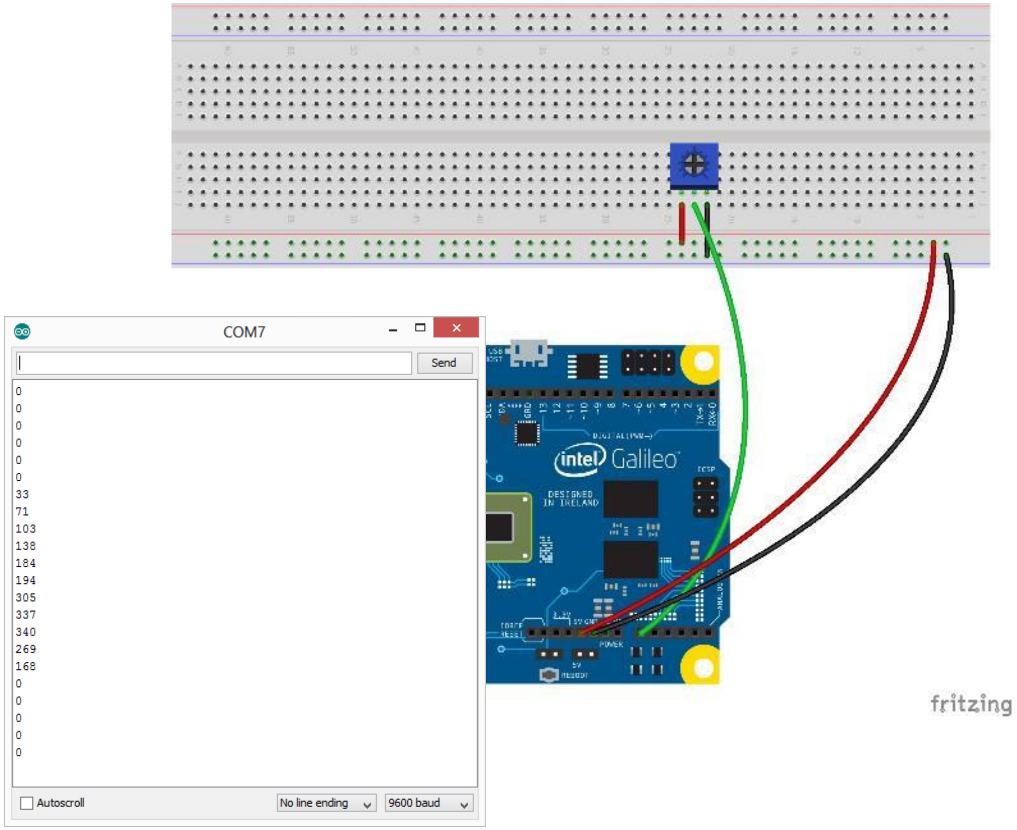
- analogRead()
- Serial.println()
- map()

Components

- Breadboard (QTY1)
- Jumper Wires
- Potentiometer

Analog Read – Read and Write POT Value

```
/*
  AnalogReadSerial
  Reads an analog input on pin 0, prints the result to the serial monitor.
  Attach the center pin of a potentiometer to pin A0, and the outside pins to +5V and ground.

 This example code is in the public domain.
 */

// the setup routine runs once when you press reset:
void setup() {
  // initialize serial communication at 9600 bits per second:
  Serial.begin(9600);
}

// the loop routine runs over and over again forever:
void loop() {
  // read the input on analog pin 0:
  int sensorValue = analogRead(A0);
  // print out the value you read:
  Serial.println(sensorValue);
  delay(500);        // delay in between reads for stability
}
```



COM7

```
0
0
0
0
0
0
33
71
103
138
184
194
305
337
340
269
168
0
0
0
0
0
```

□ Autoscroll

No line ending

9600 baud

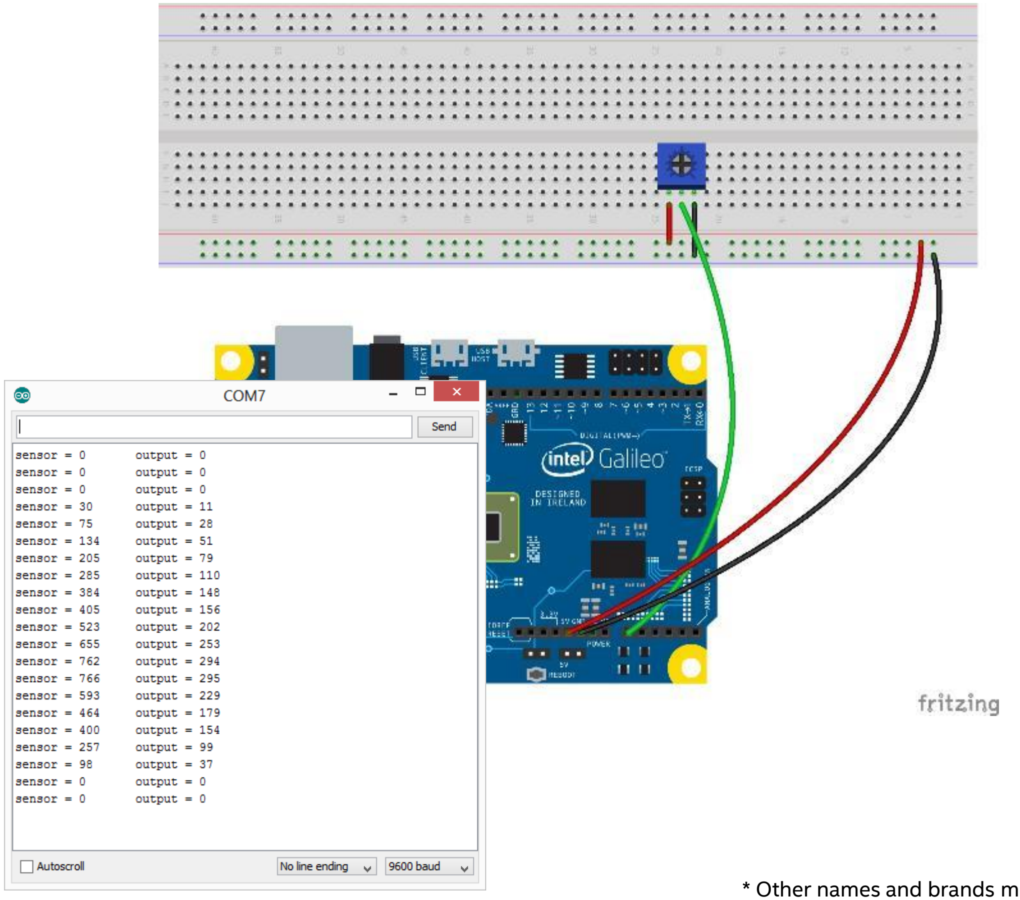
* Other names and brands may be claimed as the property of others

Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section6-AnalogRead\AnalogReadSerial

Analog Read – Read and Write Map Value

LAB

```
const int analogInPin = A0;  // Analog input pin that the potentiometer is attached to
//const int analogOutPin = 11; // Analog output pin that the LED is attached to

int sensorValue = 0;        // value read from the pot
int outputValue = 0;        // value output to the PWM (analog out)

void setup() {
  // initialize serial communications at 9600 bps:
  Serial.begin(9600);
}

void loop() {
  // read the analog in value:
  sensorValue = analogRead(analogInPin);
  // map it to the range of the analog out:
  outputValue = map(sensorValue, 0, 1023, 0, 255);
  // change the analog out value:
//  analogWrite(analogOutPin, outputValue);

  // print the results to the serial monitor:
  Serial.print("sensor = " );
  Serial.print(sensorValue);
  Serial.print("\t output = ");
  Serial.println(outputValue);

  // wait 2 milliseconds before the next loop
  // for the analog-to-digital converter to settle
  // after the last reading:
  delay(200);
}
```



```
sensor = 0      output = 0
sensor = 0      output = 0
sensor = 0      output = 0
sensor = 30     output = 11
sensor = 75     output = 28
sensor = 134    output = 51
sensor = 205    output = 79
sensor = 285    output = 110
sensor = 384    output = 148
sensor = 405    output = 156
sensor = 523    output = 202
sensor = 655    output = 253
sensor = 762    output = 294
sensor = 766    output = 295
sensor = 593    output = 229
sensor = 464    output = 179
sensor = 400    output = 154
sensor = 257    output = 99
sensor = 98     output = 37
sensor = 0      output = 0
sensor = 0      output = 0
```

□ Autoscroll   No line ending   9600 baud

* Other names and brands may be claimed as the property of others

Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section6-AnalogRead\AnalogReadSerialMap

Analog Write- Engineering Challenge

LAB

Using your own circuit design and Arduino sketch, design a solution that solves the following challenges.

Use previous Lab example as needed for reference

Challenge 1: Fade LED based on POT Value

Engineering Challenge Review

Challenge Review

Challenge 1: Fade LED based on POT Value

```
// These constants won't change.  They're used to give names
// to the pins used:
const int analogInPin = A0;  // Analog input pin that the potentiometer is attached to
const int analogOutPin = 11; // Analog output pin that the LED is attached to

int sensorValue = 0;        // value read from the pot
int outputValue = 0;        // value output to the PWM (analog out)

void setup() {
  // initialize serial communications at 9600 bps:
  Serial.begin(9600);
}

void loop() {
  // read the analog in value:
  sensorValue = analogRead(analogInPin);
  // map it to the range of the analog out:
  outputValue = map(sensorValue, 0, 1023, 0, 255);
  // change the analog out value:
  analogWrite(analogOutPin, outputValue);

  // print the results to the serial monitor:
  Serial.print("sensor = " );
  Serial.print(sensorValue);
  Serial.print("\t output = ");
  Serial.println(outputValue);

  // wait 2 milliseconds before the next loop for the analog-to-digital converter to settle after the last reading:
  delay(2);
}
```

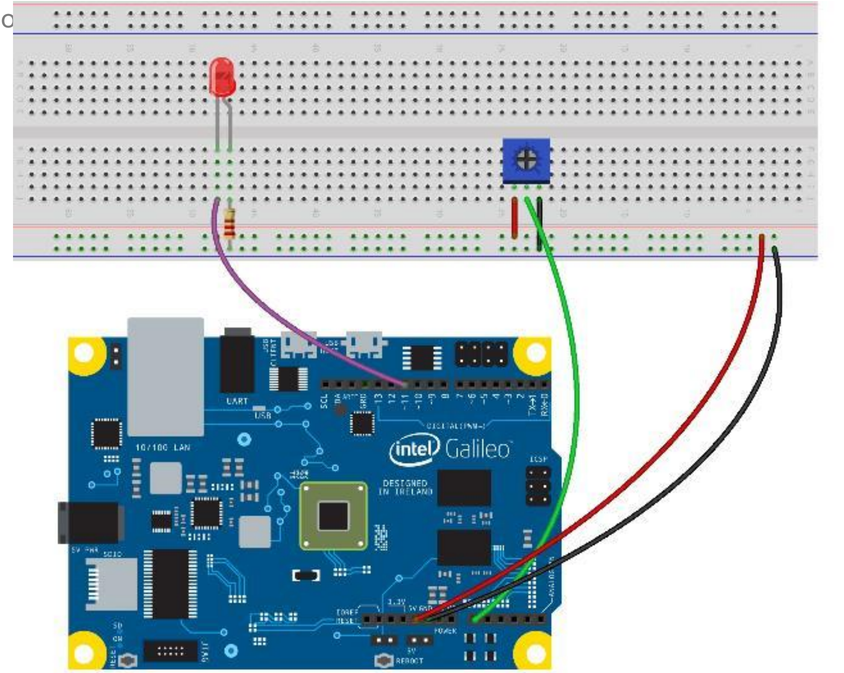


Image Source from Fritzing*

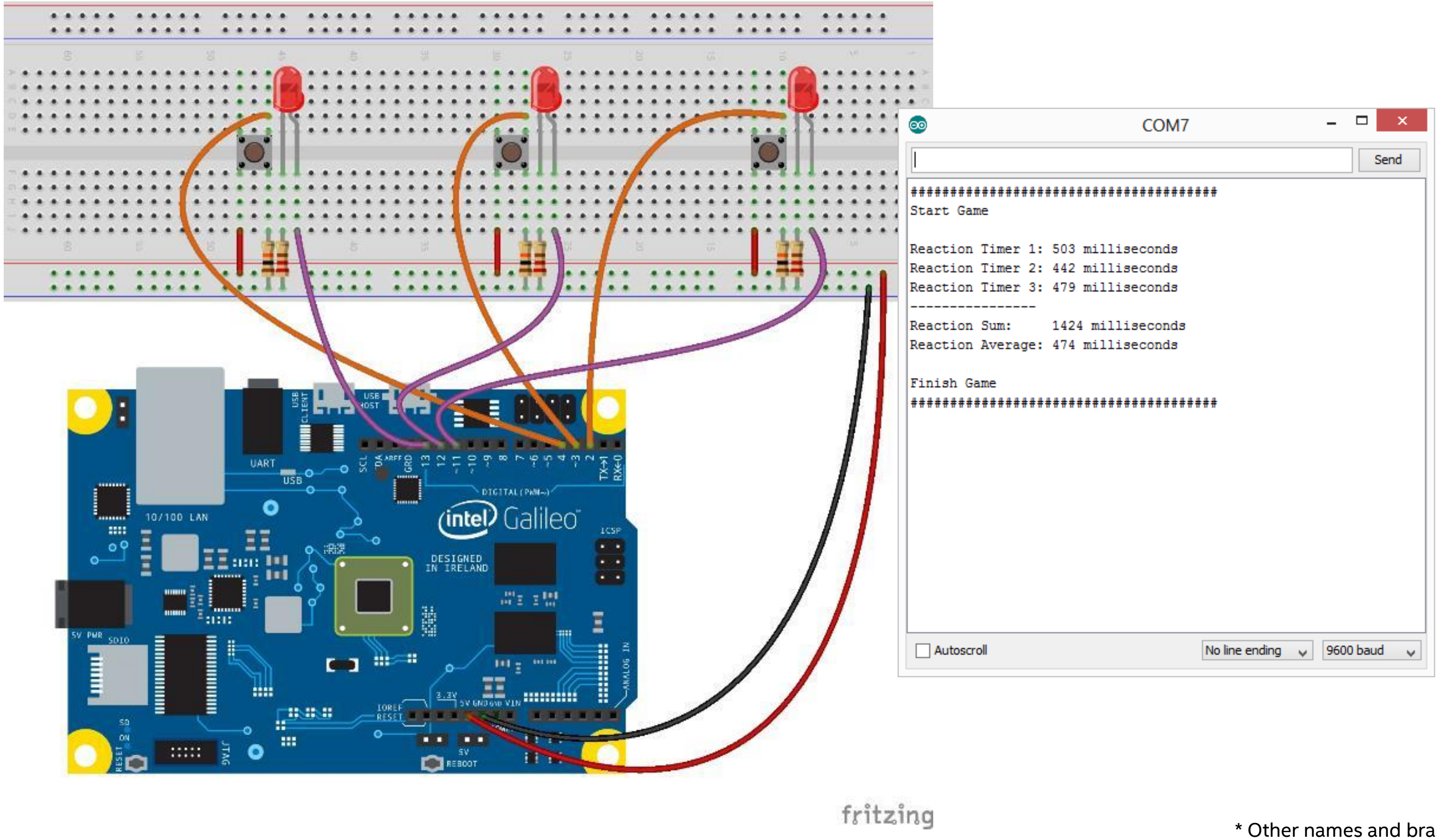
Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section6-AnalogRead\AnalogReadMapFade

* Other names and brands may be claimed as the property of others

Section Review Challenge

Reaction Timer

Source Code: *Lesson2-BasicIO\Section7-Review\ReactionTimerInital*



```
########################################
Start Game

Reaction Timer 1: 503 milliseconds
Reaction Timer 2: 442 milliseconds
Reaction Timer 3: 479 milliseconds
----------------
Reaction Sum:     1424 milliseconds
Reaction Average: 474 milliseconds

Finish Game
########################################
```

* Other names and brands may be claimed as the property of others

Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section7-Review\ReactionTimerInital

Capstone - Engineering Challenge

LAB

Using your own circuit design and Arduino sketch, design a solution that solves the following challenges.

Use previous Lab example as needed for reference

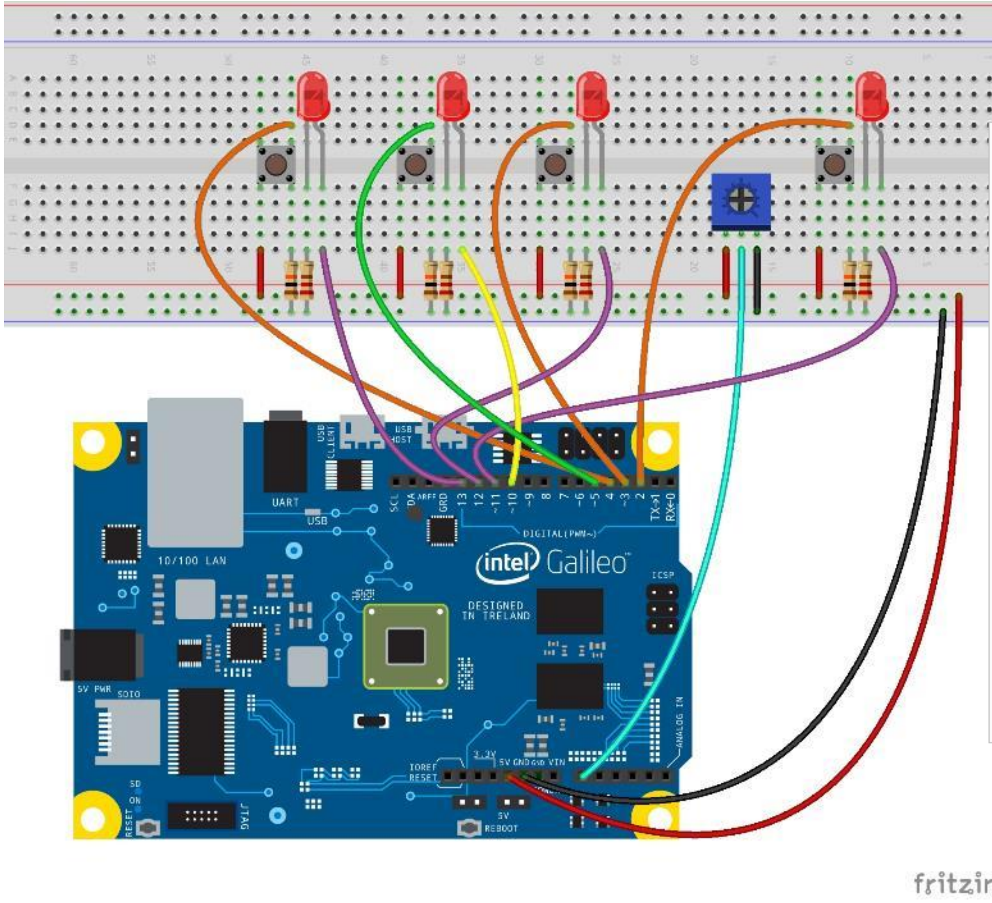
Challenge 1: Add additional Reaction Button and Indicator

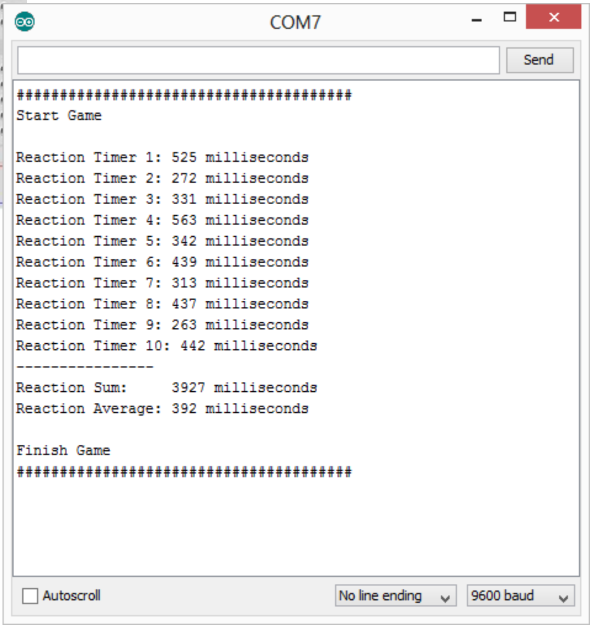
Challenge 2: Add variable knob to change the number of times the game ready indicator blinks before the start of game

Capstone – Reaction Timer

Challenge Review

Source Code: *Lesson2-BasicIO\Section7-Review\ReactionTimerChallenge*





```
#########################################
Start Game

Reaction Timer 1: 525 milliseconds
Reaction Timer 2: 272 milliseconds
Reaction Timer 3: 331 milliseconds
Reaction Timer 4: 563 milliseconds
Reaction Timer 5: 342 milliseconds
Reaction Timer 6: 439 milliseconds
Reaction Timer 7: 313 milliseconds
Reaction Timer 8: 437 milliseconds
Reaction Timer 9: 263 milliseconds
Reaction Timer 10: 442 milliseconds
----------------
Reaction Sum:     3927 milliseconds
Reaction Average: 392 milliseconds

Finish Game
#########################################
```

☐ Autoscroll   No line ending   9600 baud

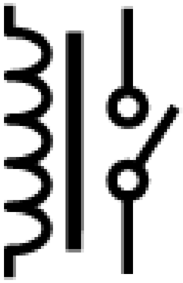
* Other names and brands may be claimed as the property of others

Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section7-Review\ReactionTimerChallenge

But wait there's more…

Reapplying Concepts Learned

digitalWrite +



Project Files - USB Drive:\Lessons\Lesson2-BasicIO\Section7-Capstone\RelayExample

Questions

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