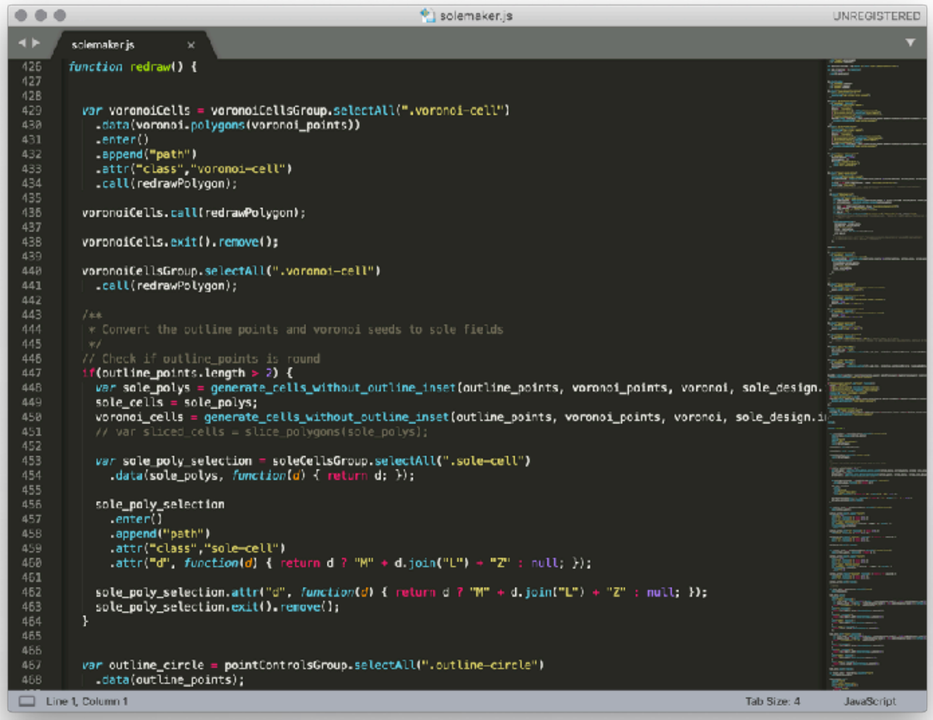
Data as a Material?

Using Arduino

Hfg-Karlsruhe May 25 2021



WEAR sustain

Solemaker

ArcInTexETN

Marie Skłodowska-Curie actions European Training Network (ETN)

Stitch and Solder

Objectives

- Soft sensors provide a new and interesting information at the programing level. Today we will use the **Arduino** platform for the realization of **interactive** prototypes. We will add **sensors** and **actuators**, to create a system of **Wearable Technology.**
- Understand how to write a **SKETCH.**
- **Digital Output**
- **Digital Input**
- **Serial Communication**

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Program

- Part 0
  - Syntax and the Arduino Programming Language
- Part 1
  - Digital Output
  - Digital Input
- Part 2
  - Elaboration

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Input, Elaborate, Output

Programing Design

Programing

- **Input**: data coming from a series of sensors, each one capable of transforming the measurable size of interest into tension (analog sensor) or in a bit sequence (digital sensor).
- **Elaboration**: group of algorithms that evaluate the input data and produce output results.
- **Output**: changes made by a series of actuators in the environment surrounding a system, each capable of transforming the result of the elaboration into physical actions (a light, a written message on a display, the rotation of a motor, data sent to a remote processor).

Design

- Designing **input**: sensors react to a measurable size interesting to humans. How is this expressed within a program.

- Designing **output**: actuators produce the desired effect. Instructions are needed to make the actions take place.

- Designing **logic**: elaboration is the interpretation of the input data. Our program evaluate and co-relates the sequence between events. It then organizes the output data.

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Welcome to the Programming Language “Arduino”

- A Program is called Sketch
- Based on the C+ Programming Language
- http://arduino.cc/en/Main/Software

Part 0 :: Syntax

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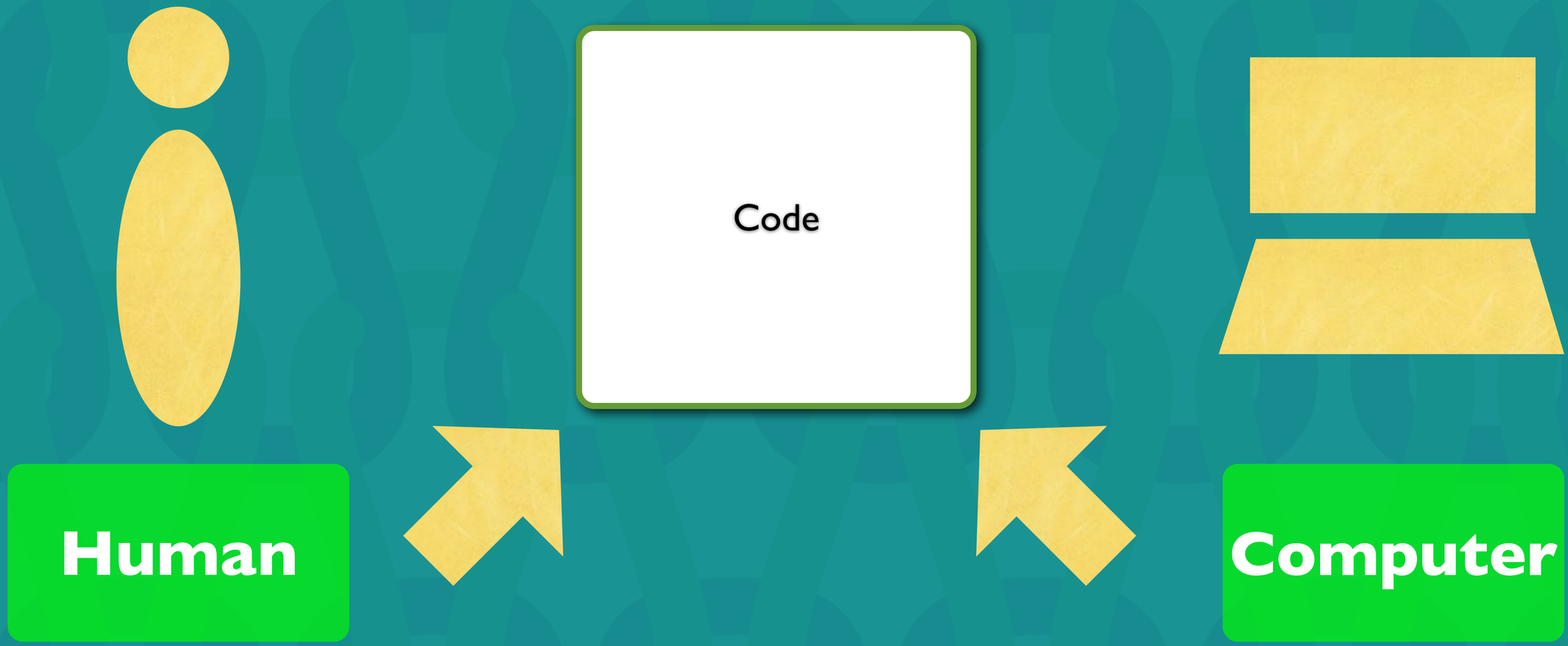
Designers Guide to programming



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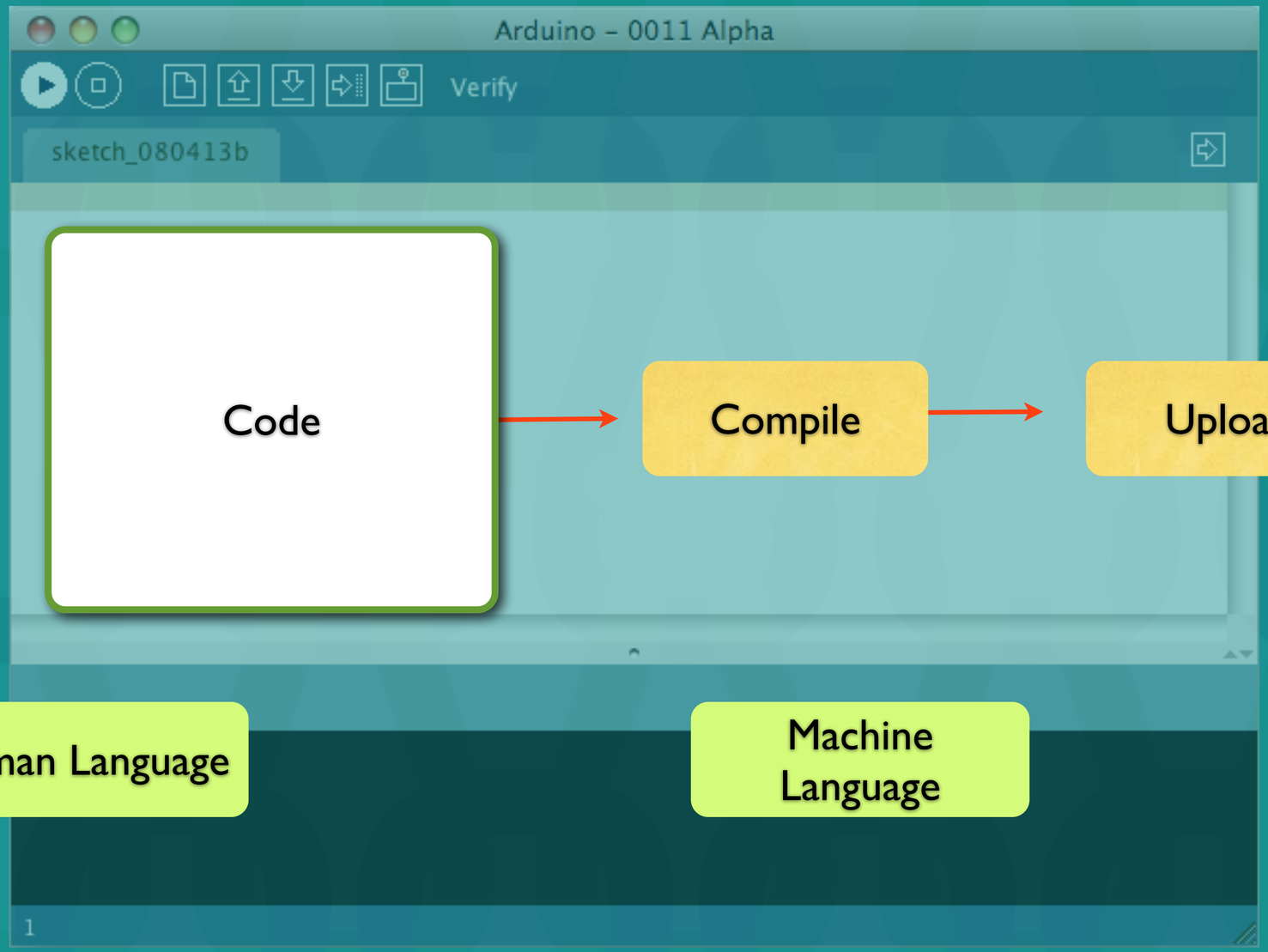
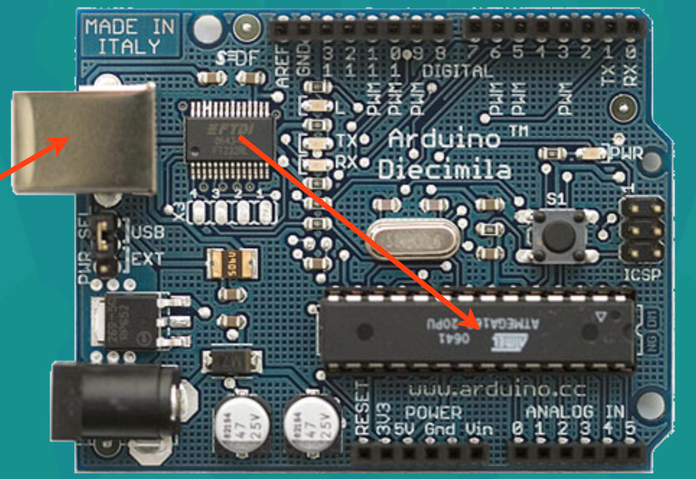
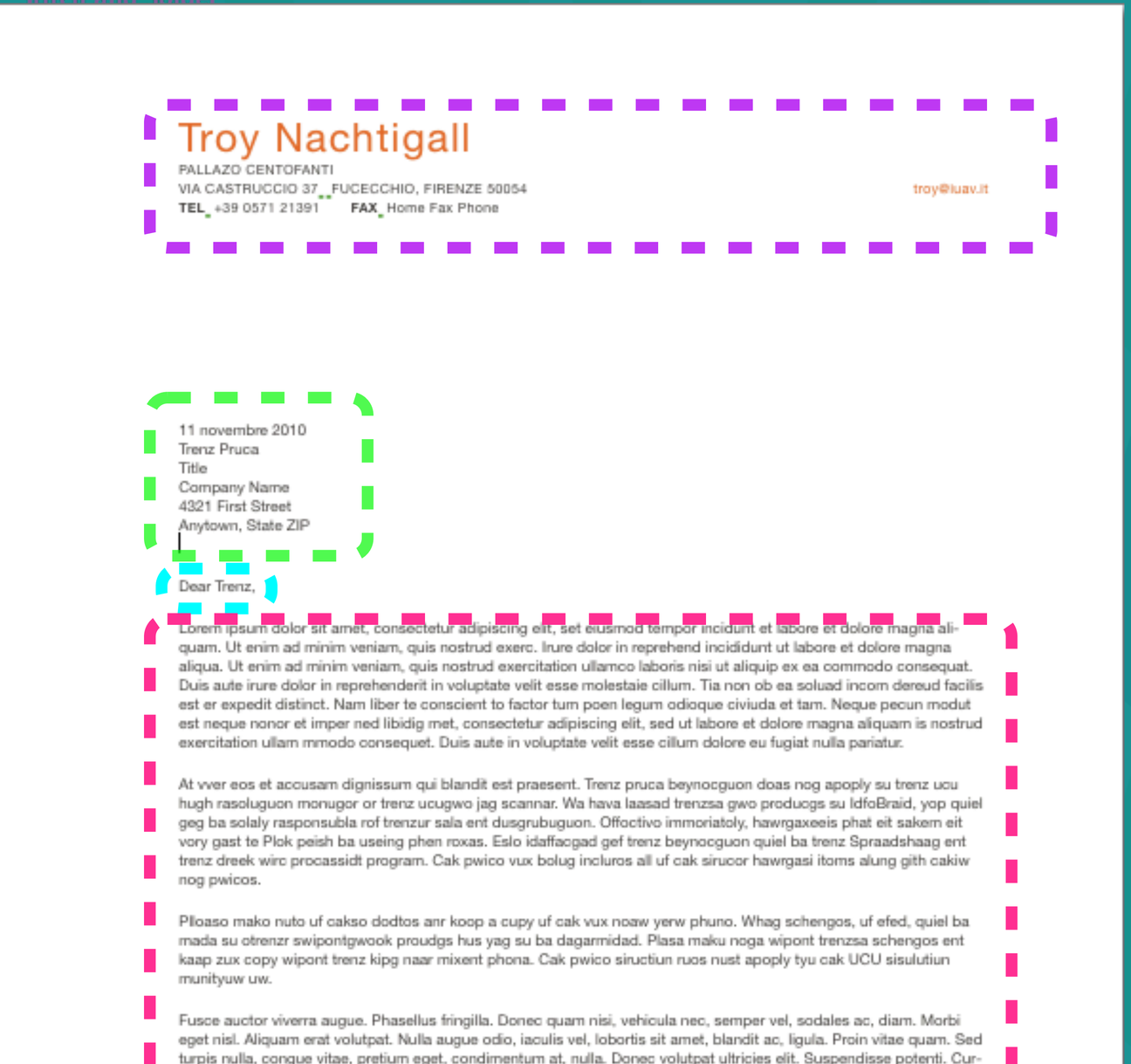
Programming an Arduino





Coding is like writing a letter

Stitch and Solder



Letterhead	Comments
Header	Variables
Salutation	Initializatio
Body	Execution
Signature	Comments

Structure of a Sketch

Stitch and Solder

```
/* Troy Nachtigall Blink*/

int LED_PIN = 3;

void setup()
{
    pinMode(LED_PIN, OUTPUT);
}

void loop()
{
    digitalWrite(LED_PIN, HIGH);
    delay(500);

    digitalWrite(LED_PIN, LOW);
    delay(500);
}
```

Comments → Letterhead

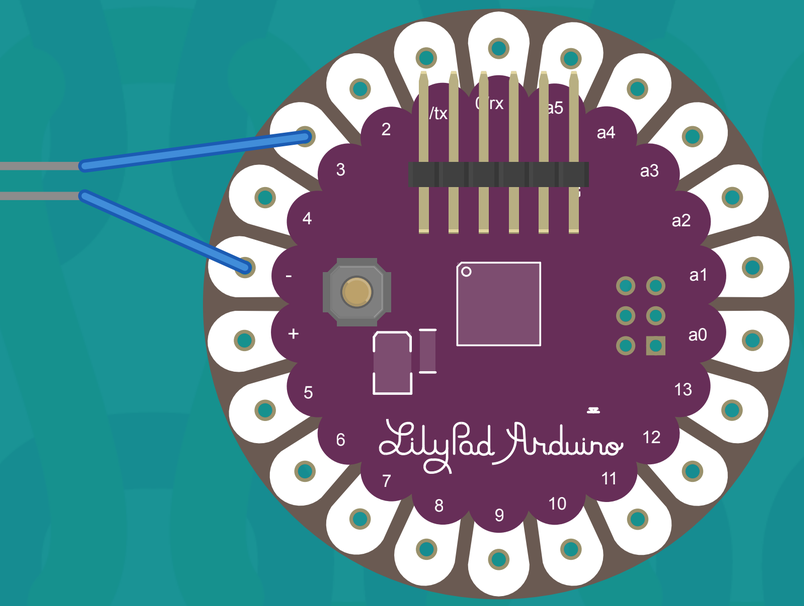
Variables → Header

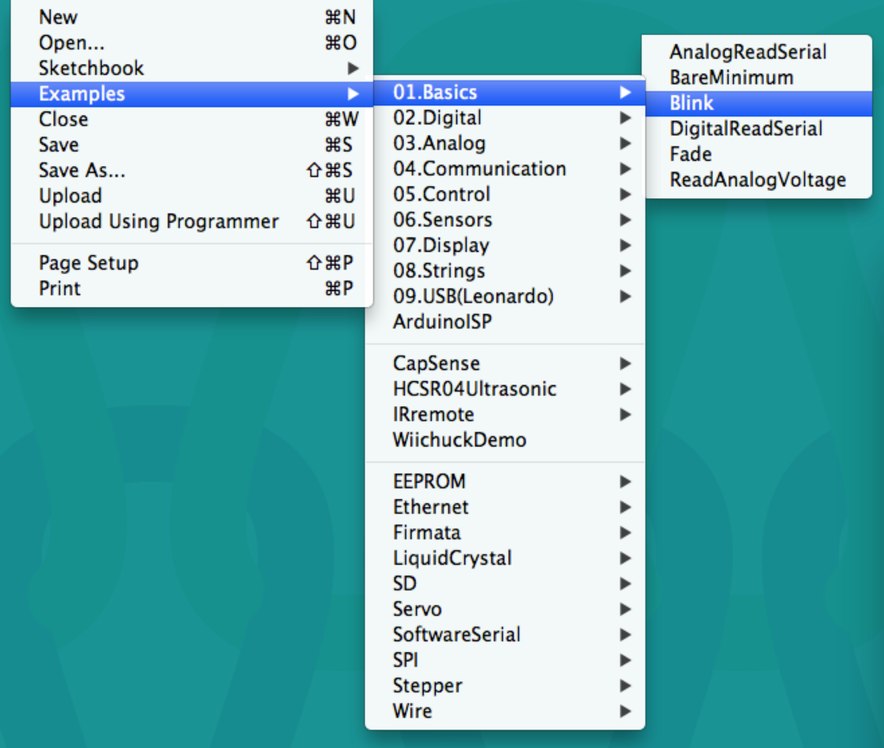
Initializatio → Salutation

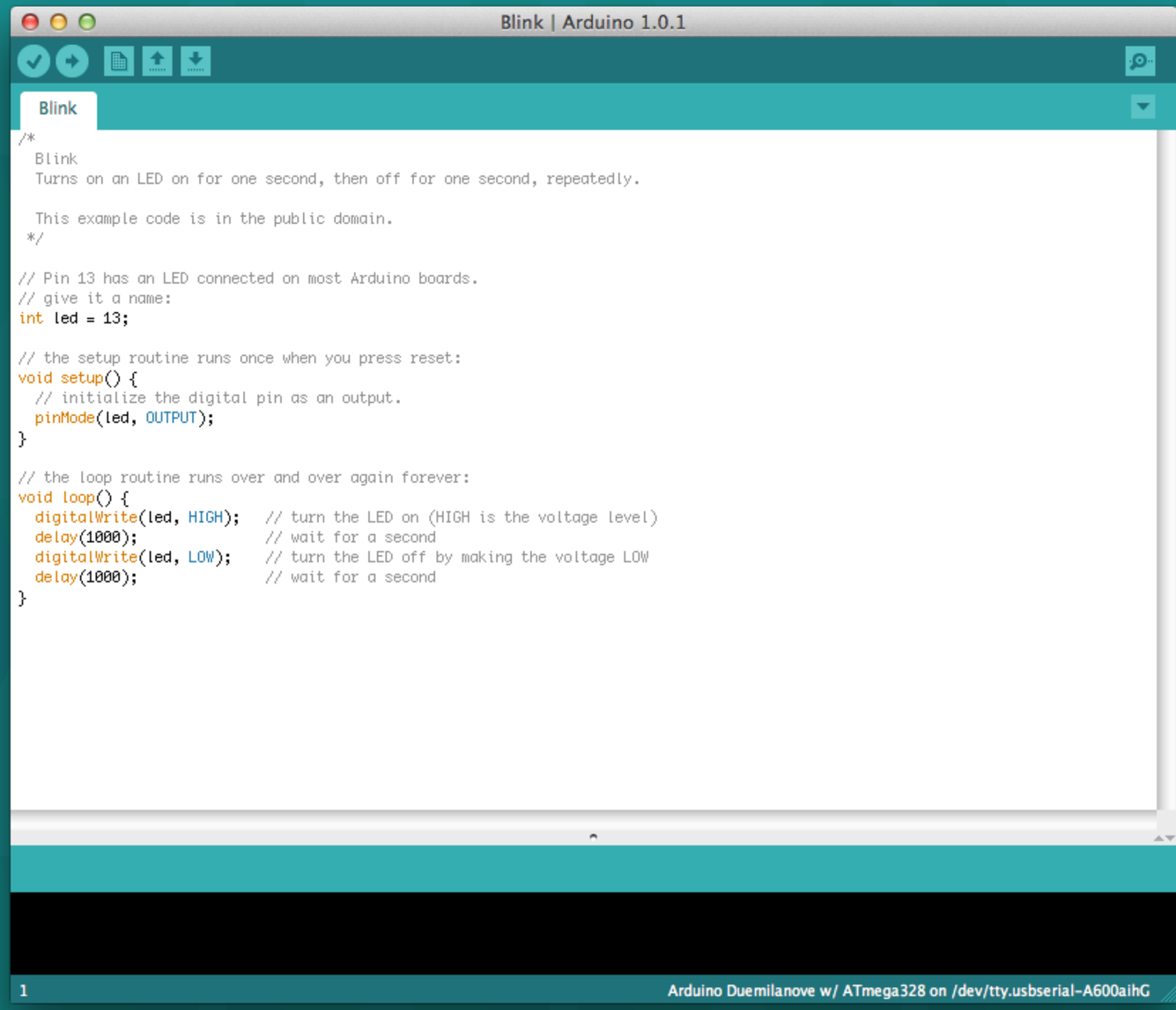
Execution → Body

Stitch and Solder

LET'S TRY Blink







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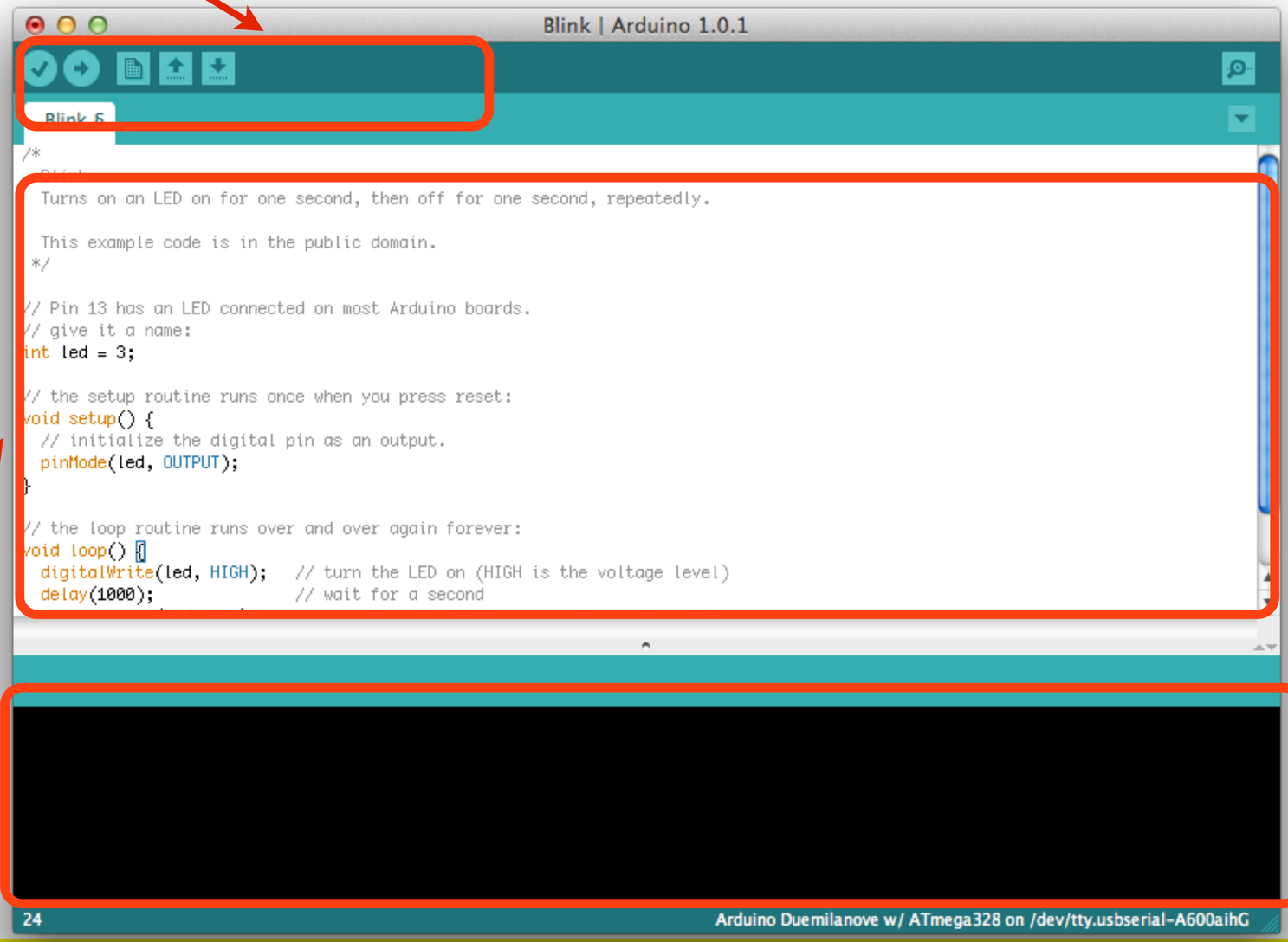
IDE

Toolbar



Console

Editor

IDE Toolbar

Stitch and Solder

File Manager
New, Open, Save

Compile

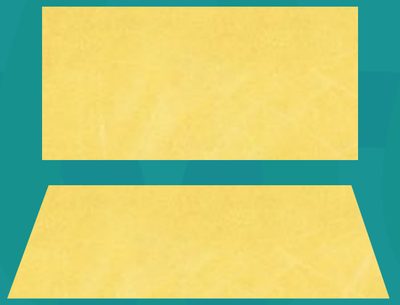
Activate Serial Console

Compile and Upload

Stitch and Solder

Syntax

Machine Language



- In human language we use a “.” but in Arduino we use “ ; ”
- Paragraphs are open and enclosed with { }.
- The subject of the sentence is placed in ( ).

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Syntax

Human Language

- // and /* */ are used for commenting.
- Space and Return are only for humans.
  They mean nothing in Machine language.

Commenting

- Good code uses comments because when we come back to a piece of code months later we can figure out what we were up to.
- Be sure to describe how your sensor works.

```
// Comment a single line or remaining
part of a line

/*
Comment out everything between the two
comments
*/
```

Part 1 Input, Output, Serial

Stitch and Solder

Part 1 - Digital Output

Output

Arduino Test

Stitch and Solder

```
/*
  Blink
  Turns on an LED on for one second, then off for
one second, repeatedly.
  This example code is in the public domain.*/
```

Sketch Name and Description

```
void setup() {
  // initialize the digital pin as an output.
  // Pin 13 has an LED connected on most Arduino
boards:
  pinMode(13, OUTPUT);
}
```

Declare Outputs and Inputs
leftStrap is OUTPUT

```
void loop() {
  digitalWrite(13, HIGH);   // set the LED on
  delay(1000);              // wait for a second
  digitalWrite(13, LOW);    // set the LED off
  delay(1000);              // wait for a second
}
```

Execution
Turn on the Left Strap
Wait a second
Turn off the Left Strap
Wait a second
Do it again

Stitch and Solder

output - digitalWrite

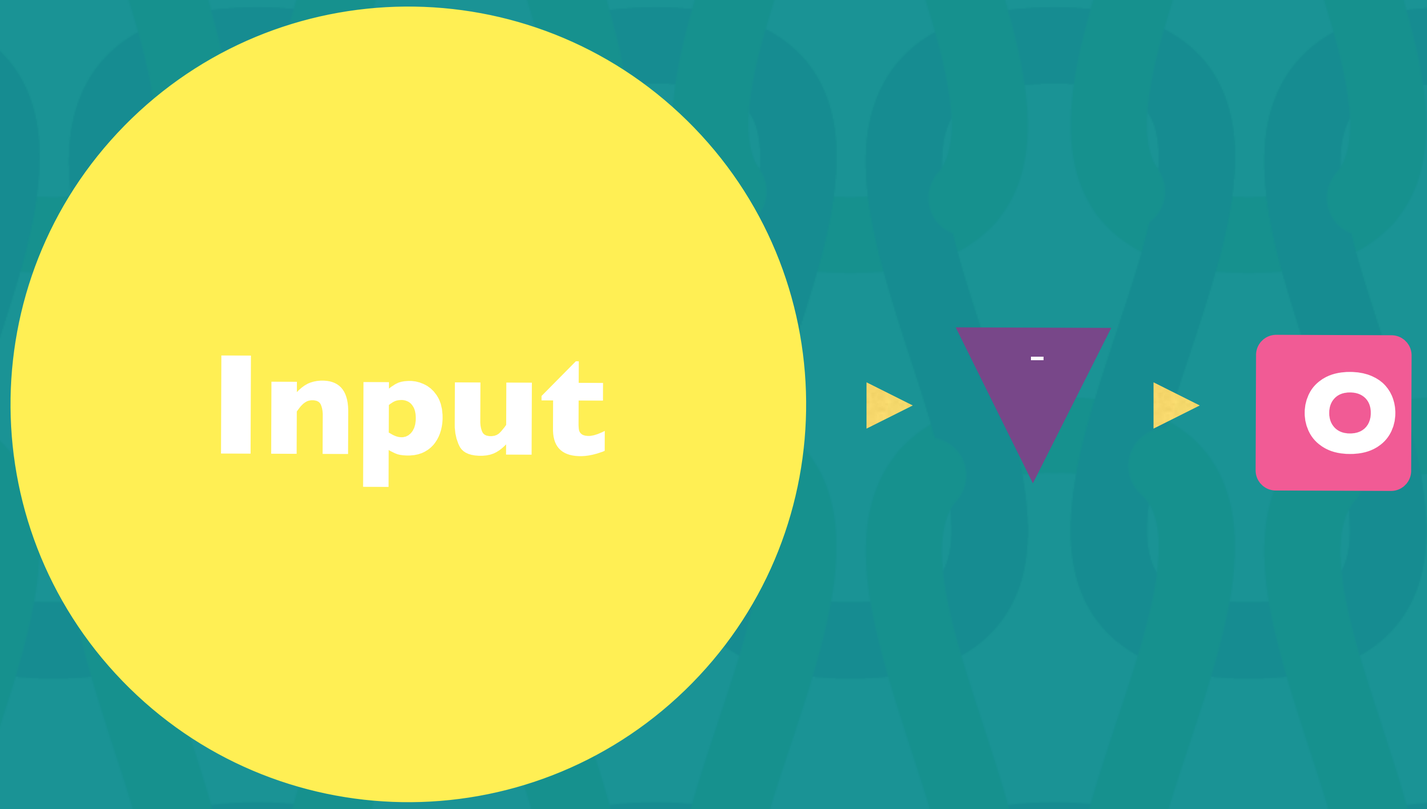
- To turn on an output PIN, we set the pin to HIGH
- LOW turns a pin off.
- we use the function (verb) digitalWrite to talk to PINs
- digitalWrite(PIN, HIGH/LOW)

  - delay is in Milliseconds
  - don’t forget the ;

```
digitalWrite(leftStrap, HIGH);
  delay(1000);
digitalWrite(leftStrap, LOW);
delay(1000);
```

Stitch and Solder

Part 1 Analog INPUT



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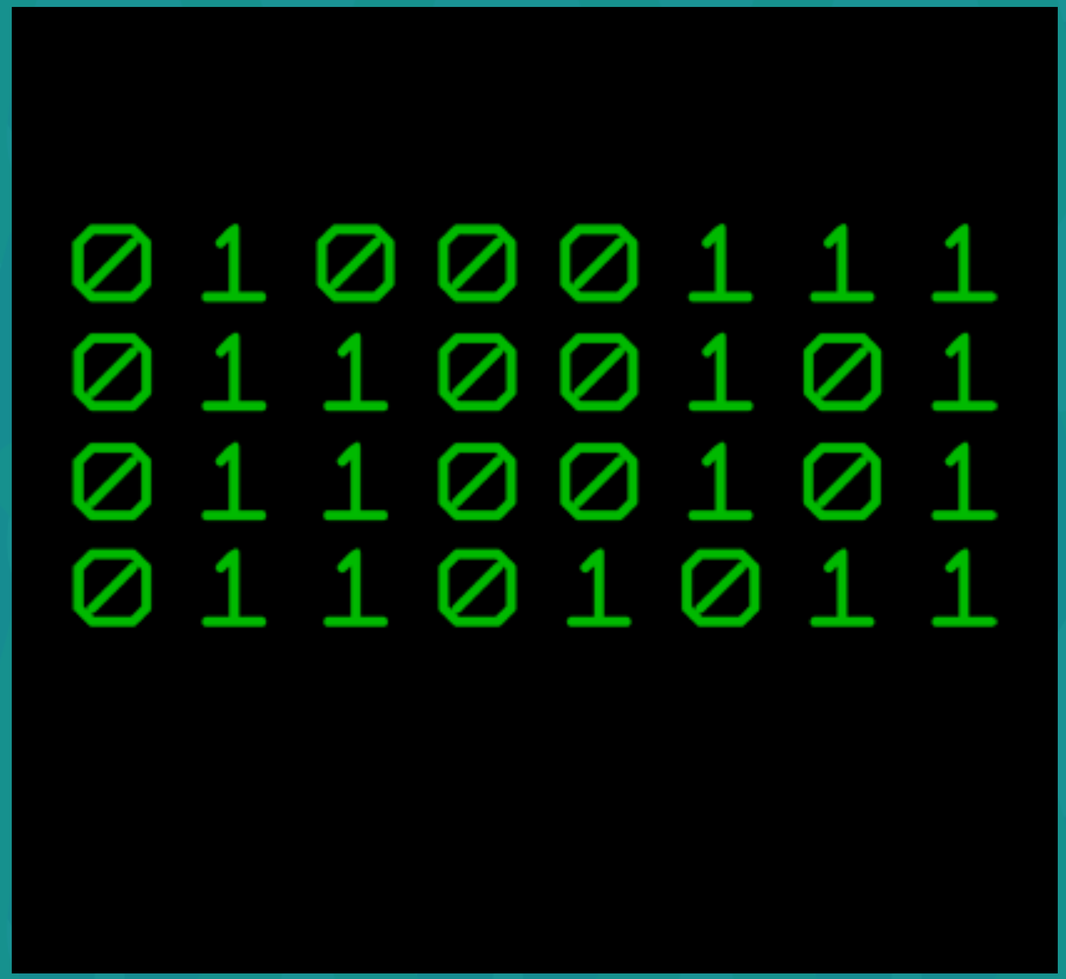
digital information

- Digital is **1** or **0** (2 bit)
- Digital is **on** or **off**
- in Arduino
  Digital is **5v** or **0v**
- logically, Digital is
  True or **False**
- Syntactically is
  High or **Low**



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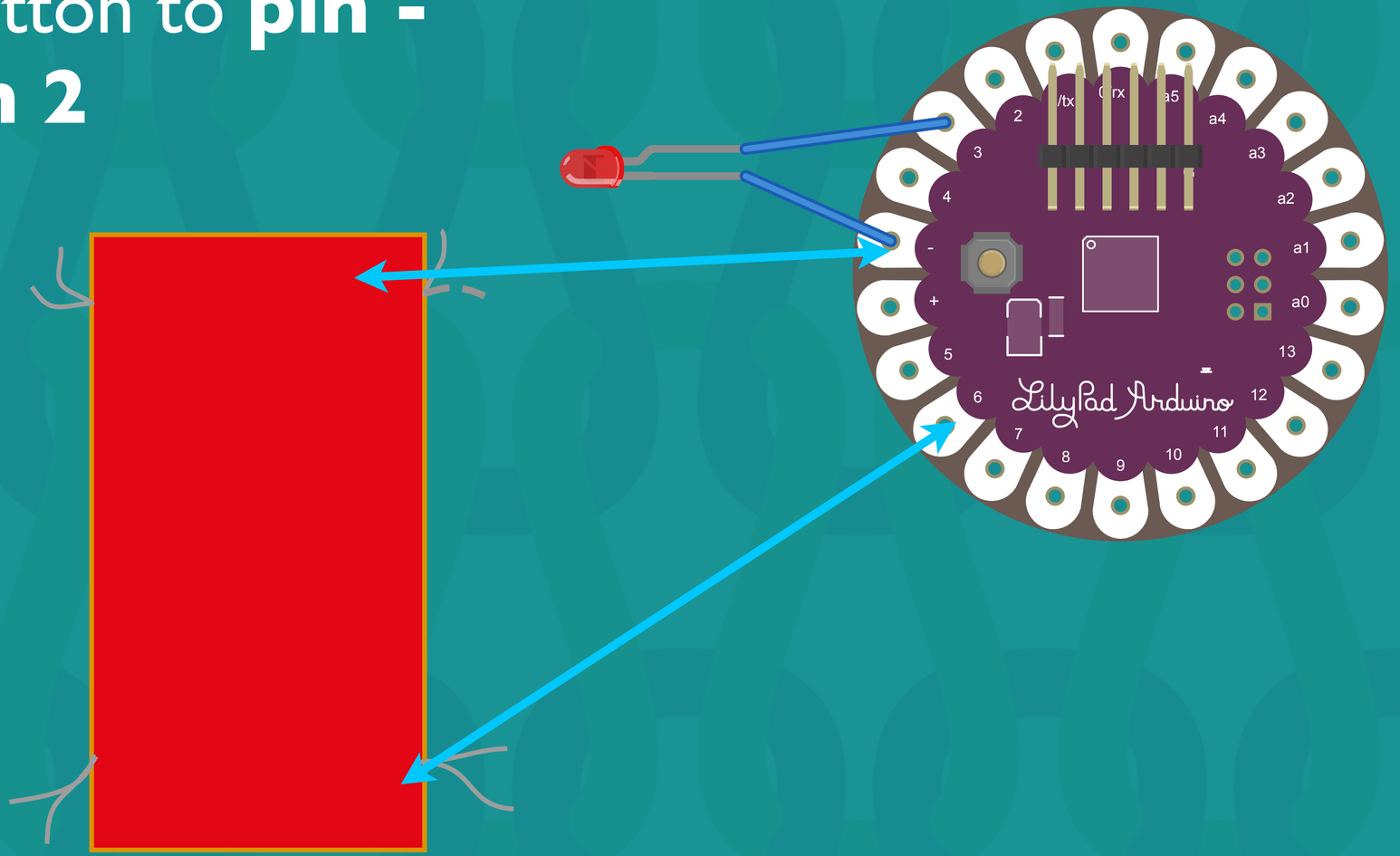
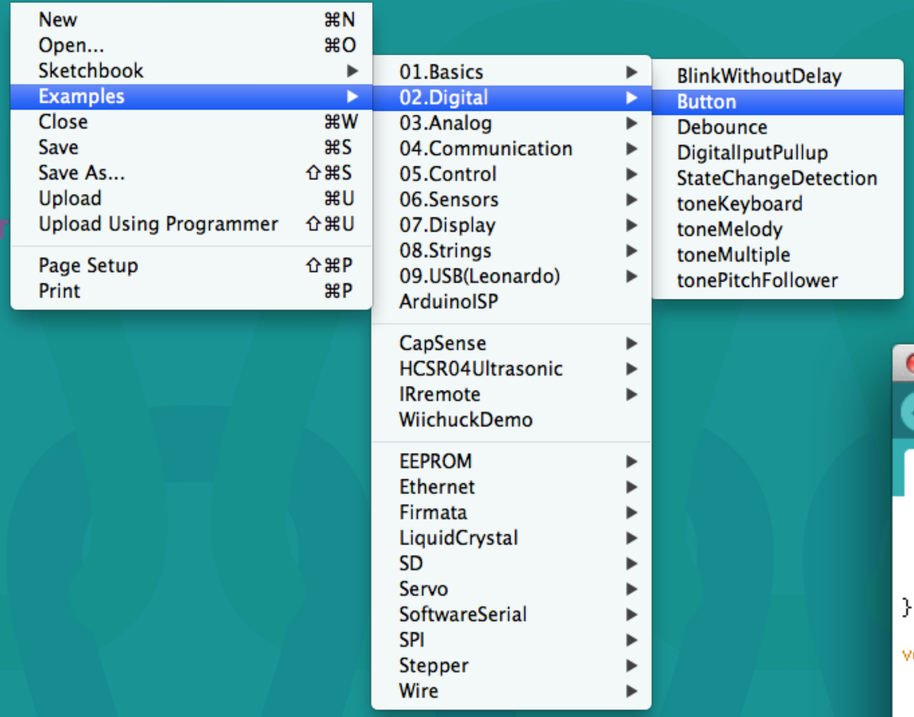
Connect our buttons

- Using aligator clips, connect one side of the textile button to **pin -** and the other to **pin 2**

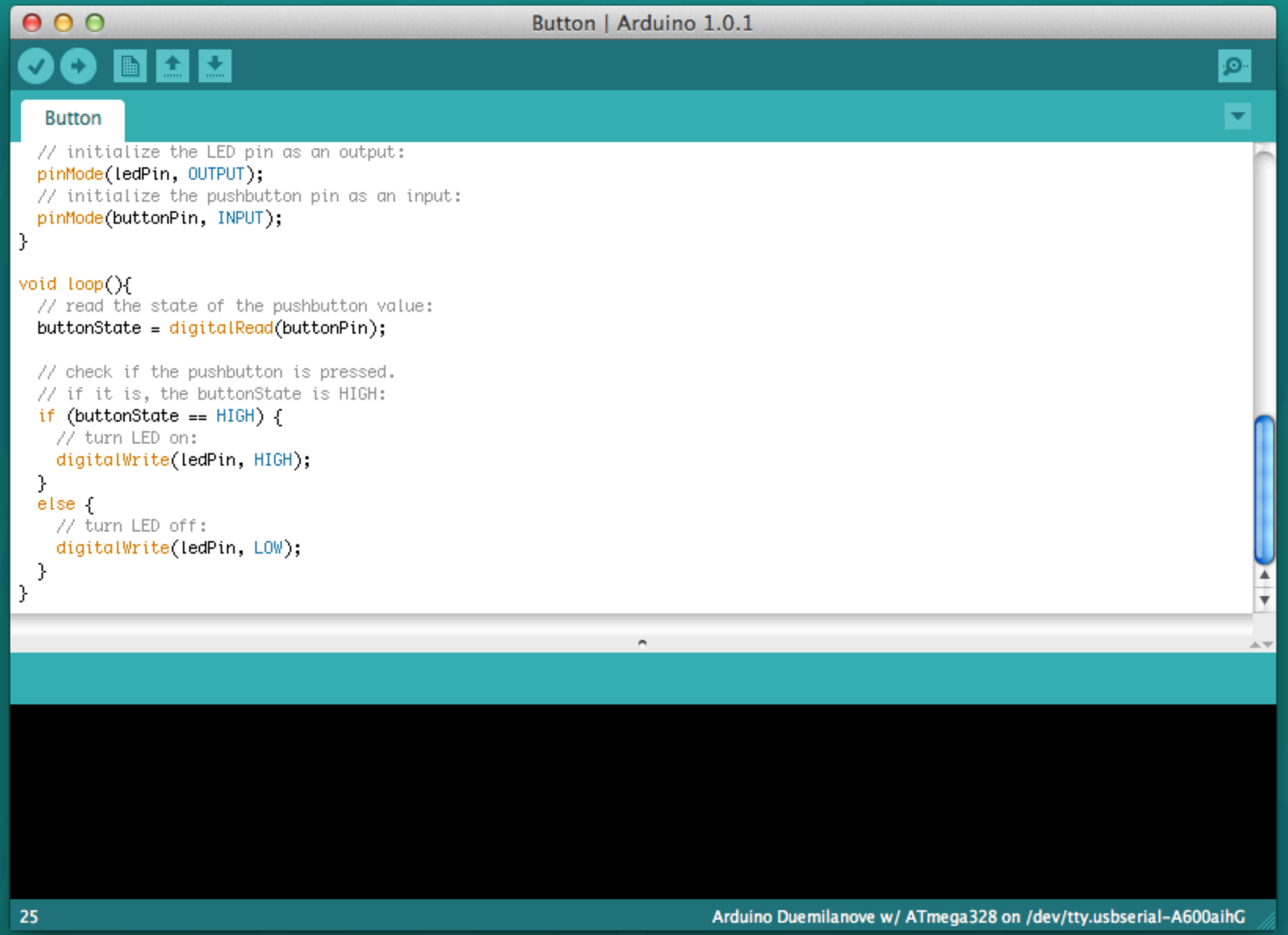


Stitch and Solder



Digital Button

- Load Sketch /Examples/ Digital/Button
- Change the button to Pin 5
- See if you can add the LED on Pin 3



Variables for Designers

1+2=3

a+b=c

vs.

3=1+2

c=a+b

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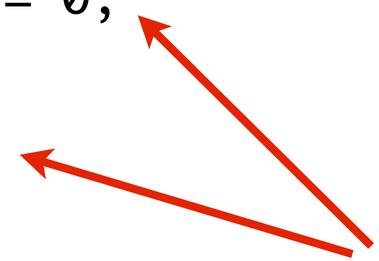
Variables

- Variables are used in the place of real numbers for readability and changeability
- Variables must have:
  - a name not already used by the programming language
  - the type of variable declared
- Variables are declared in the header.

```
int temperature = 0;

float PI = 3.14;
```



Initial Value

Declaring Variables

Type variable_name;

the ";" concludes the declaration

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Kinds of Variables

- Arduino has different kinds of Variables
  - Numbers (Integer and Floating Point)
  - Logic (boolean, “true” and “false”)
  - Characters
  - Vectors (Rarely used)

```
int i = 5;

float PI = 3.14;

boolean ready = false;

char key = ‘x’;

char name[6] = “Robert”;
```

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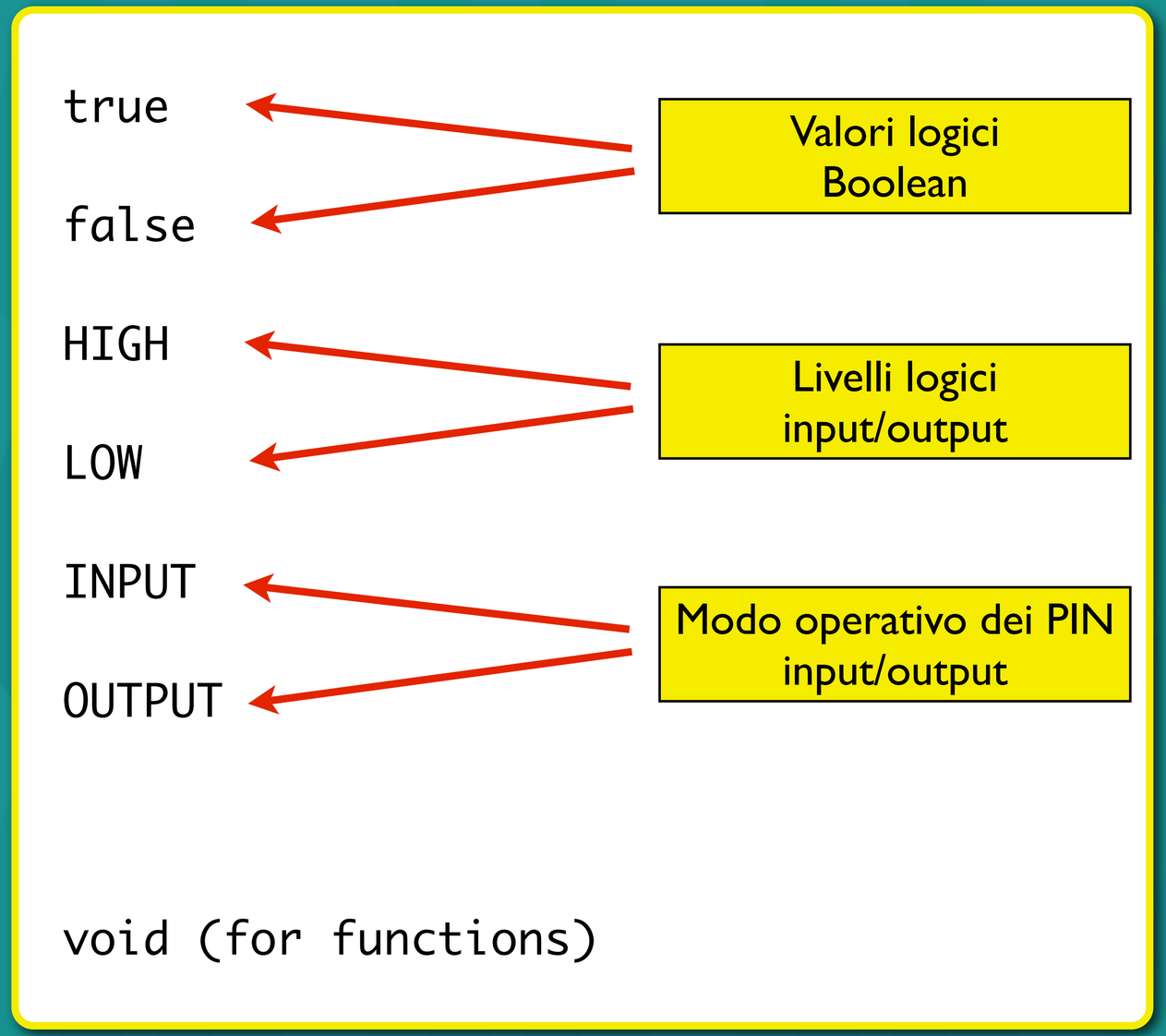
Constants

- The Arduino language predefines a series of constants:
  - The expressions true/false for logic
  - The state HIGH/LOW for turning on and off digital PINs
  - The Mode setting for the pins INPUT/ OUTPUT
  - Values for functions and setup void/setup



Solid Numbers (integer)

- byte
  - 8 bit, 0:255
- int
  - 16 bit -32768:32767
- unsigned int
  - 16 bit, 0:65535
- long
  - 32 bit, -2147483468 : 2147483647
- unsigned long
  - 32 bit, 0 : 4294967295

```
byte floor = 12;

int age = -1024;

unsigned int = 33000

long superdeep = -1208296770;

unsigned long = 4294967295
```

Floating Point Variables

- float
  - 32 bit, -3.4028235E+38 and 3.4028235E+38
- double
  - 64 bit, maximum number representable is about 2 x 10^308

```
float angle = 1.57;

double PI = 3.14159265358979323846264
33832795028841971693993751058209749445
92307816406286208998628034825342117069
82148086513282306647093844609550582231
72535940812848111745028410270193852110
55596446229489549303819644288109756659
33446128475648233786783165271201909145
64856692346034861045432664821339360726
02491412737245870066063155881748815209
20962829254091715364367892590360011330
53054882046652138414695194151160943305
72703657595919530921861173819326117931
05118548074462379962749567351885752724
89122793818301194912983367336244065664
```

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I’d like to talk to someone about this.

Stitch and Solder

Serial Port

Button | Arduino 1.0.1

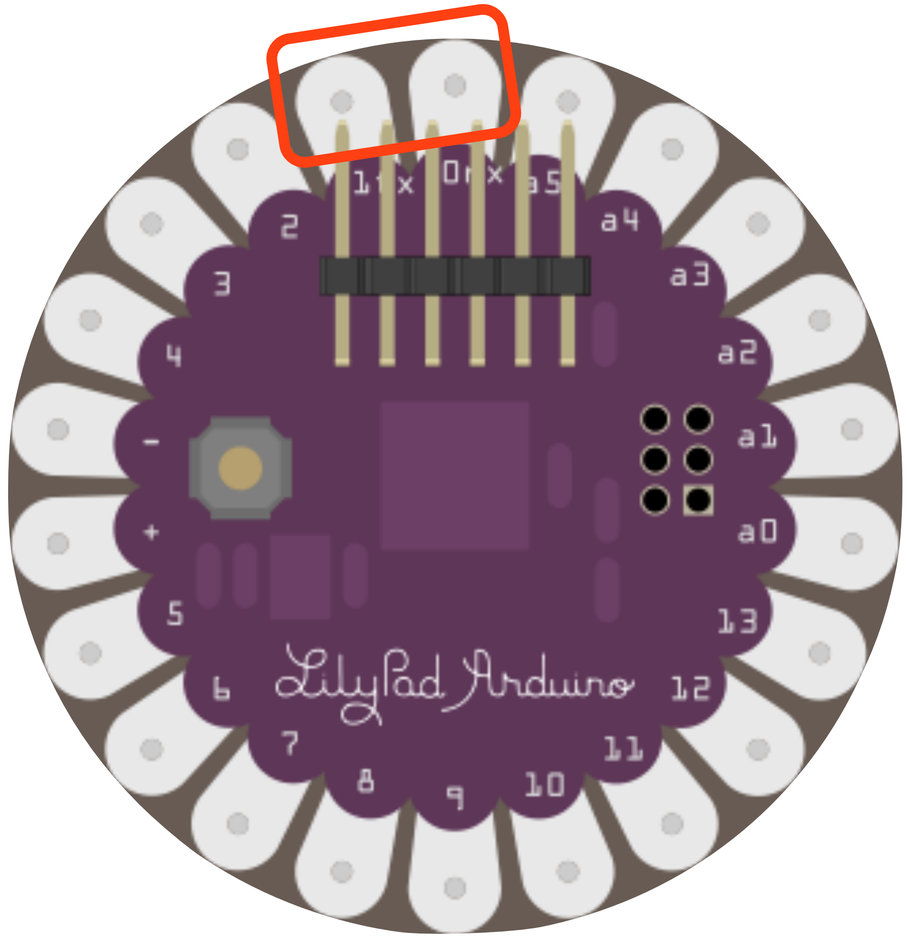
Button

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

25 Arduino Duemilanove w/ ATmega328 on /dev/tty.usbserial-A600aihG



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Serial Port

- Serial requires PINs 1 & 0
- The function Serial.begin() opens the serial port and sets it's speed in setup.
- The function Serial.print() writes a value to the serial port
- The function Serial.println() writes a newline

```
// initiate Serial Com and set speed
// SPEED
Serial.begin(9600);


// Print the VALUE to the serial port
Serial.print(VALUE);


// Print a newline to the serial port
Serial.println();
```

Add Code to your button

- Experimenting with textile sensors means having a way to understand what they are saying.
- Serial gives us a finite way to understand what is happening with our circuit.

```
void setup() {
  pinMode(ledPin, OUTPUT);
  // initialize the pushbutton pin as an
input:
  pinMode(buttonPin, INPUT);
  Serial.begin(9600);
}

void loop(){
  buttonState = digitalRead(buttonPin);
HIGH:
  if (buttonState == HIGH) {
    // turn LED on:
    digitalWrite(ledPin, HIGH);
  Serial.println("We are ON!!!");

}
  else {
```

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Part 2 Elaborating

Mathematic Operators

- There are 5 operators available for arithmetic
  - Addition: +
  - Subtraction: -
  - Multiplication: *
  - Division: /
  - Remainder: %
  - Integer math rounds to integer numbers

```
int a = 10;
int b = 3;
int c = 0;

c = a + b;     // c = 13

c = b - a;     // c = -7

c = a * b;     // c = 30

c = a / b;     // c = 3

c = a % b;     // c = 1

c = b % a;     // c = 3
```

Comparison Operators

- We can establish relations between numbers (values)
- The result is returned in a logical value of true or false
  - Equal: ==
  - Not Equal: !=
  - Greater than: >
  - Less than: <
  - Greater than or equal: >=
  - Less than or equal: <=

```
int x = 2;
int y = 3;
boolean b;

b = (x == y); // Equal
b = (x != y); // Not Equal

b = (x > y);  // Greater than
b = (x >= y); // Greater that or equal

b = (x < y);  // Less than
b = (x <= y); // Less than or equal
```

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Control Structures

- Using Math and Comparison operators we can control our code
- **if** tests a specific case
- **else if** is used for additional tests
- **else** happens if nothing else happens

```
if (temperature > 21)
{
   digitalWrite(rightStrap, HIGH);
   delay(1000);
   digitalWrite(rightStrap, LOW);
   delay(1000);

}
else if (temperature < 21 &&
temperature > 10)
{
   digitalWrite(leftStrap, HIGH);
   delay(1000);
   digitalWrite(leftStrap, LOW);
   delay(1000);
}
```

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Blocks

- A Block is a sequence of instructions grouped together with { }
- All lines of code in a block are executed as a group in sequential order.

```
{
    a = 12;

    b = c + d;

    delay(1000);

    digitalWrite(leftStrap, HIGH);
    delay(1000);
    digitalWrite(leftStrap, LOW);
    delay(1000);();
}
```

Unifying input and output

```
/* Read an analog Thermistor */

int thermistorSensor = 0;    // select the input pin for the thermistor
int temperature = 0;  // variable to store the value coming from the sensor

void setup() {
  // declare the ledPin as an OUTPUT:
  pinMode(thermistorSensor, INPUT);
pinMode(13,output);
  Serial.begin(9600);
}

void loop() {
  temperature = analogRead(thermistorSensor);  // read the value from the sensor:
  Serial.print("The temperature is ");
  Serial.println(temperature);
  digitalWrite(13,HIGH);
  delay (temperature);
  digitalWrite(13,LOW);
  delay (temperature);
}
```

Incrementing

- It is possible to increment and decrement a variable using the operators
  ++ and **--**
- Prefix operators calculate **before** it is used
- Suffix operators increment the variabile **after** it is used

```
int a;
int i = 5;

// increment “i” by 1 which becomes 6
i++;

// first increment “i” which becomes 6
// then assign “a”, which becomes 6
a = ++i;

// first assign “a”, which becomes 5
// then increment “i” which becomes 6
a = I++;
```

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Cycles

- Allows us to repeat a block of code for a specific number of times or while a certain condition is true.
- The cycle **for()** runs the block of code ten times

```
int i;

for (i = 0; i < 10; i++)
{
    powerLedOn();
    doSound();

    delay(1000);

    powerLedOff();
    stopSound();

    delay(1000);

}
```

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Cycle while()

- Executes a block of code as long as the logic case is true.
-

```
while (temperature > 25)
{
    digitalWrite(rightStrap, HIGH);
    delay(1000);
    digitalWrite(rightStrap, LOW);
    delay(1000);
    temperature = analogRead
          (thermistorSensor);
    }
```

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Debounce

- Textile Sensors can give false positives due to humidity, barometric pressure or many other things.
- Debouncing makes sure the sensor is really pressed by a human.

```
buttonstate = digitalRead(textilebutton);
   if (buttonstate == HIGH){
delay(500);
buttonstate = digitalRead(textilebutton);
if ((buttonstate == HIGH){
//Is the button really pressed?
...
```

Wrap up

Last Look at Hello Lilypad

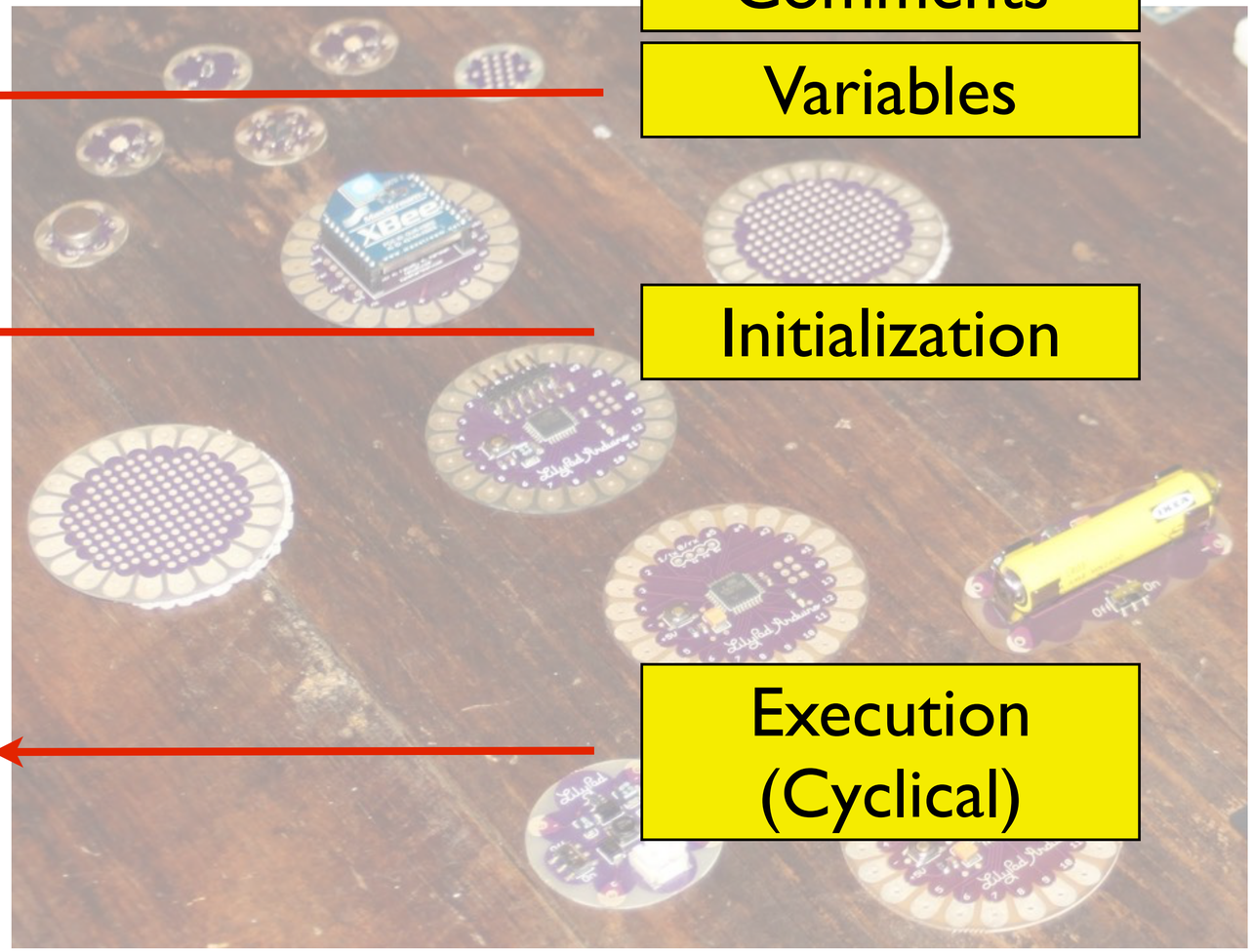
```
/* Troy Nachtigall Blink*/

int LED_PIN = 3;

void setup()
{
    pinMode(LED_PIN, OUTPUT);
}

void loop()
{
    digitalWrite(LED_PIN, HIGH);
    delay(500);

    digitalWrite(LED_PIN, LOW);
    delay(500);
}
```

Comments

Variables

Initialization

Execution (Cyclical)



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Comments and Variables

- Remember to comment your code

- Remember to declare your variables

```
/* Blink the LED Straps
by Troy Nachtigall
troy@wearabletechnology.it */

int thermistorSensor = 0;
int temperature = 0;
int leftStrap = 10;
int rightStrap = 11;
```

setup( )

- setup() is a function that runs **just one time** at the beginning of the program
- It is responsible for setting up the Arduino:
  - Configuring PINs as input/output
  - configuring serial ports
  - initializing Libraries

```
void setup()
{
    // PIN 13 as output
    pinMode(13, OUTPUT);

    // PIN 2 Sensor input
    pinMode(2, INPUT)
}
```

loop( )

- Loop is the “heart” of a sketch. The functions runs cyclicly as long as the Arduino has power (equivalent to an infinite while() cycle).

```
void loop()
{
    readSensorData();

    if (temp > 100)
    {
        powerOnFan();
    }
    else if (temp < 40)
    {
        powerOffFan();
    }

    // Start back at the beginning of
loop...
}
```

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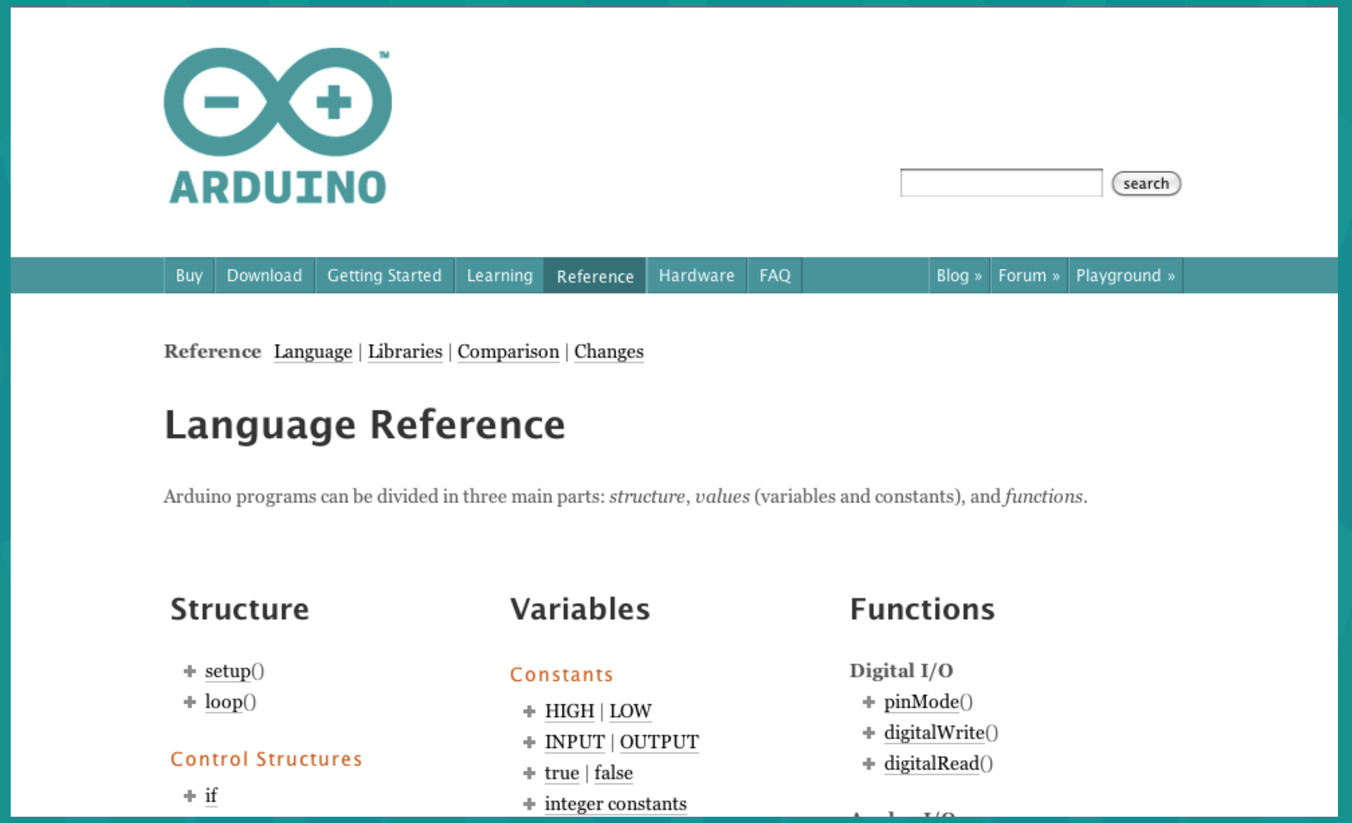
Input, Elaborate, Output

Stitch and Solder

Go Deeper!

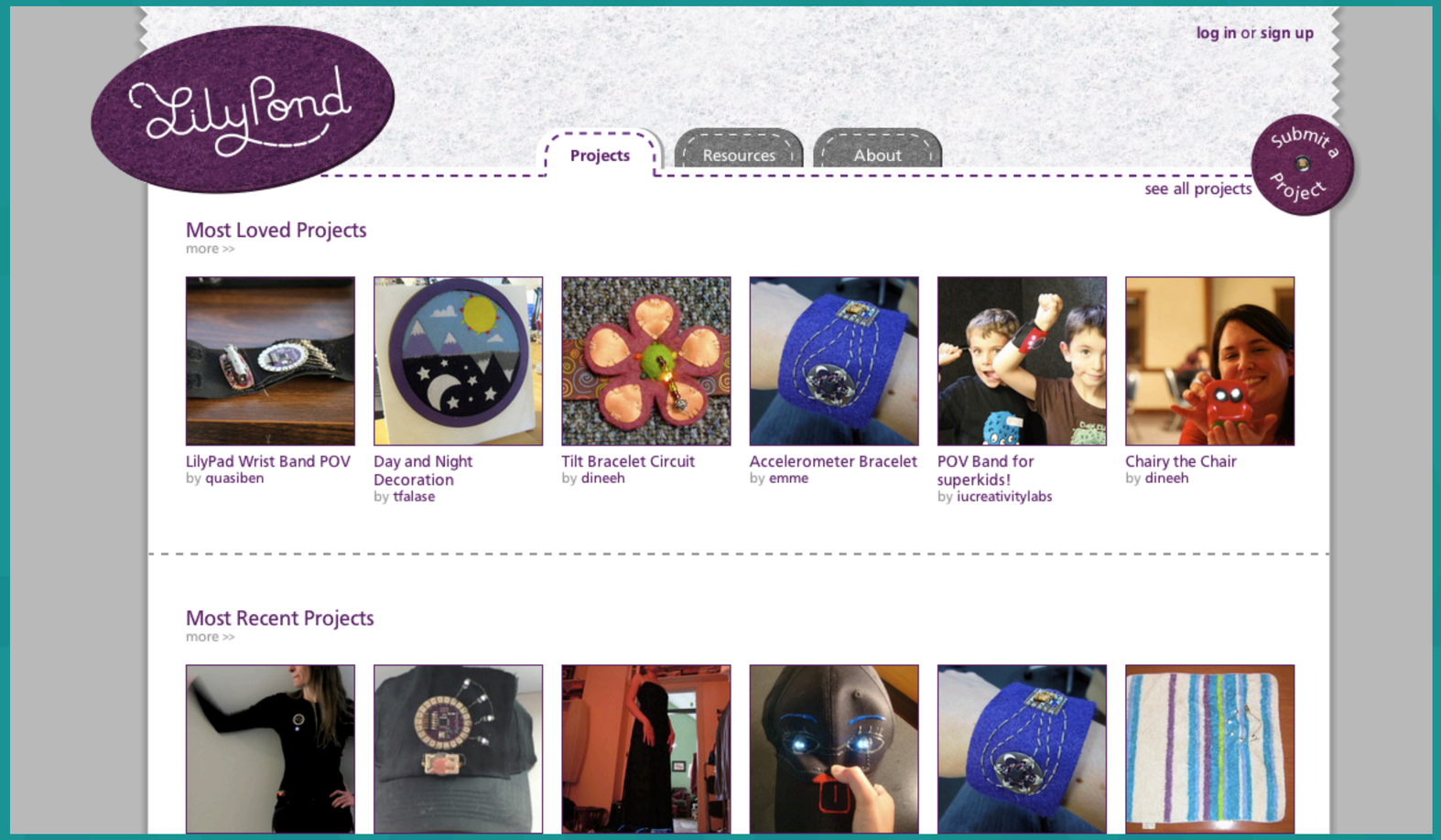
- Arduino - Reference Arduino - Foundations



Stitch and Solder

Lilypond

- LilyPond



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Codeing is like writing a letter

Letterhead	Comments
Header	Variables
Salutation	Initializatio
Body	Execution
Signature	

Thank You

- Thank you very much for your participation!
- Troy Nachtigall
- @stitchandsolder
- troy@wearabletechnology.it

Stitch and Solder

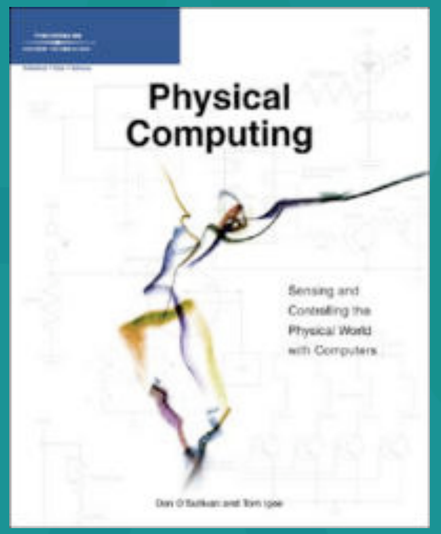
Acknowledgements

- Beyond the original material many thanks to the numerous people who contribute to the Arduino Community
- This presentation was inspired by:
  - Arduino Official Site: **http://www.arduino.cc**
  - Bionic Arduino: **http://todbot.com/blog/bionicarduino/**
  - Limor Ladyada web site: **http://www.ladyada.net/**
  - Wikipedia: **http://www.wikipedia.org**

Stitch and Solder

Further Reading

- Physical Computing:
  Sensing and Controlling
  the Physical World with Computers
  - Dan O'Sullivan, Tom Igoe
  - Course Technology, 2004



- Making Things Talk
  - Tom Igoe
  - Make Books (O'Reilly), 2007