

# Programming **Arduino** with **Scratch (S4A)**

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<http://stem.lupacovka.cz>

# Computer programming & computer program



- Computer programming:
  - act of writing computer programs to solve a problem
- Computer program
  - structured collection of a sequence of instructions written using a Computer Programming Language to tell the computer to do a specific task

Robotic  
arm  
playing  
chess



## Calorie Calculator

Modify the values and click the Calculate button to use

US Units	Metric Units	Other Units
Age	<input type="text" value="25"/>	
Gender	<input checked="" type="radio"/> male <input type="radio"/> female	
Height	<input type="text" value="180"/> centimeters	
Weight	<input type="text" value="60"/> kilograms	
Activity	<input type="text" value="Lightly Active - exercise/sports 1-3 times/week"/>	
<input type="button" value="Calculate"/>		

You need **2,207** Calories/day to maintain your weight. **2,207**  
You need **1,707** Calories/day to lose 0.5 kg per week. **1,707**  
You need **1,207** Calories/day to lose 1 kg per week. **1,207**  
You need **2,707** Calories/day to gain 0.5 kg per week. **2,707**  
You need **3,207** Calories/day to gain 1 kg per week. **3,207**

<https://www.calculator.net/calorie-calculator.html>

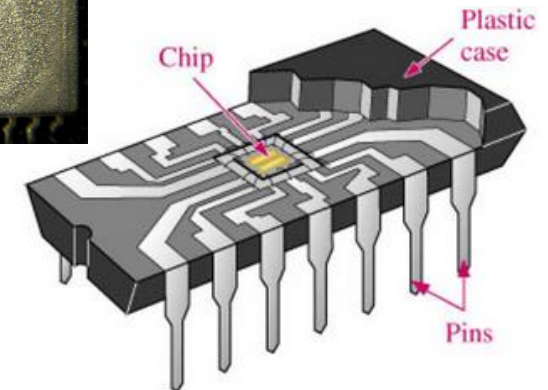
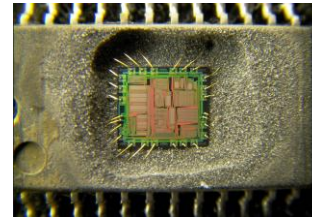
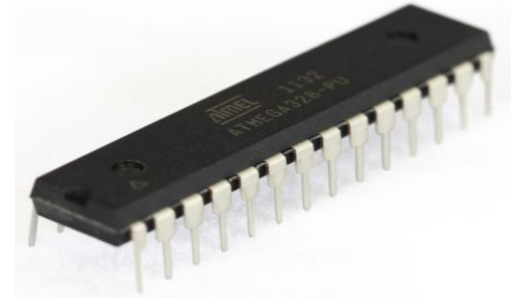
Image taken from:

[https://www.flickr.com/photos/steve\\_hoge/5143590110/](https://www.flickr.com/photos/steve_hoge/5143590110/)

# Microcontrollers



- A microcontroller is a computer system on a single chip that does a job (MCU,  $\mu\text{C}$ )
  - control electronic equipment
  - exists in electrical device, cars, washing machines, microwave ovens, telephones
  - includes central processing unit (CPU), memory (a small amount of RAM, program memory, or both), and programmable input/output peripherals, which are used to interact with various units



# Arduino



- Arduino is an open-source electronics prototyping platform that contains both hardware and software founded by Massimo Banzi and David Cuartielles in 2005
- **open-source**: Original design files are freely distributed enabling people to study them, make changes and share those changes with others
- **Electronics**: Science sector dealing with the study of flow and control of electrons (electricity) and the study of their behavior and effects in devices using such electrons
- **Prototyping**: An original model, form or an instance that serves as a basis for other things
- **Platform**: A combination of a hardware system with software environment that can be programmed and execute other software



# Arduino Uno platform – I



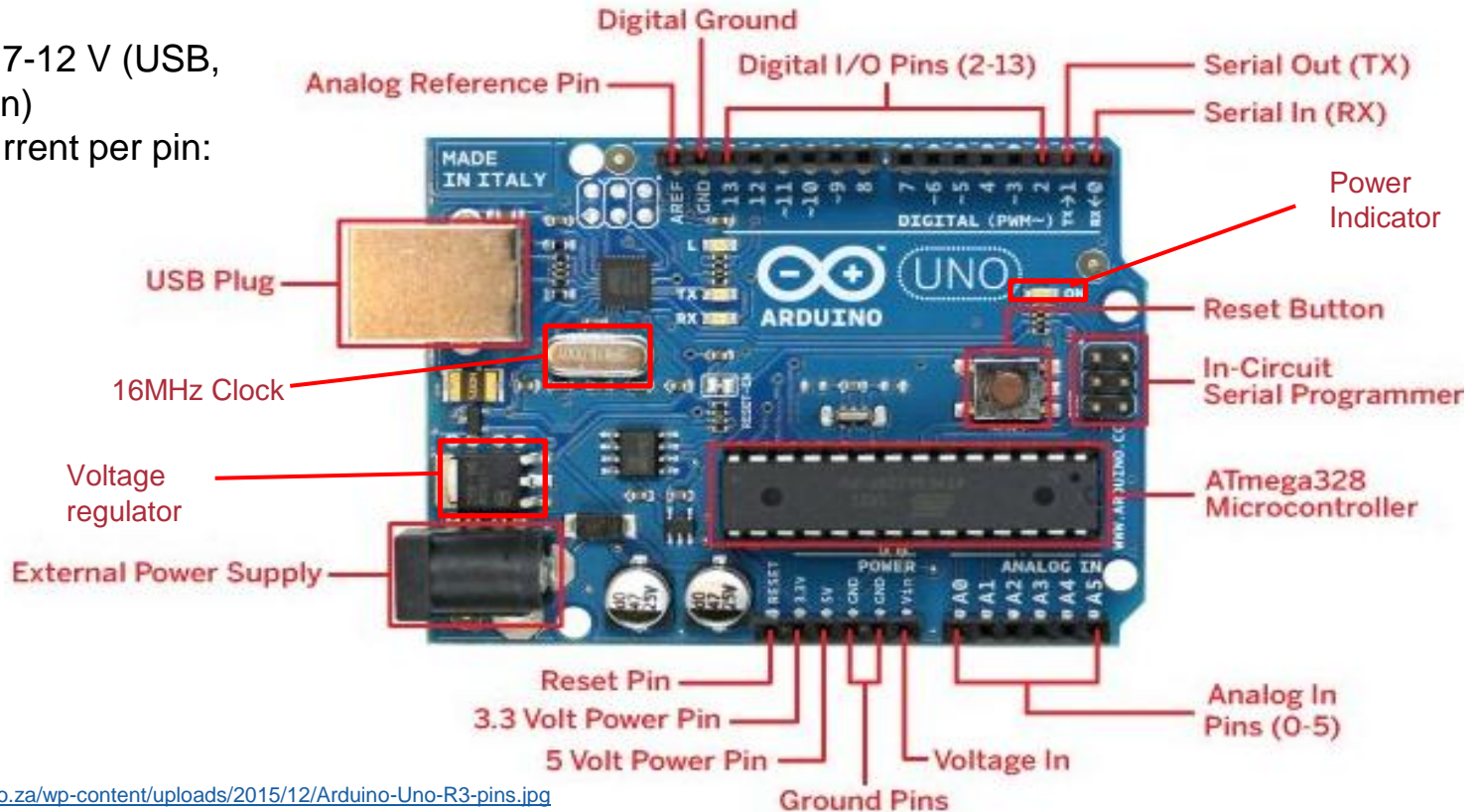
- One of the many flavors of Arduino platforms
- It is able to read inputs (e.g. light on a sensor, a finger on a button, or a Twitter message) - and turn it into an output (e.g. activating a motor, turning on LEDs, publishing something online)
- It can sense and react with the environment
- The  $\mu$ C on the Arduino board is programmed using the Arduino programming language (Wiring Language which is based on C++) and the Arduino Integrated Development Environment (IDE)
- The software consists of a standard programming language compiler and a boot loader that executes on the microcontroller



# Arduino Uno platform – II



- Input voltage: 7-12 V (USB, DC plug, or Vin)
- Max output current per pin: 40 mA



# Arduino Uno Kit



 UNO R3 Arduino主板 Shift Register	 USB Cable USB线	 Expansion 原型扩展板	 mini bread 小面包板	 9V Step Motor 9V 步进电机	 Motor Drivers 电机驱动板
 74HC595 74HC595	 SW-520D*2 按钮传感器*2	 Flame 火焰传感器	 Temperature sensor LM35 温度传感器	 IR Receiver 红外接收器	 LDR CDS*3 光敏电阻*3
 Red*10 LED红*10	 Green*10 LED绿*10	 Blue*10 LED蓝*10	 Key Switch (yellow)*2 黄色按键开关*2	 Key Switch (Red)*2 红色按键开关*2	 830 breadboard 大面包板
 Storage box 元器件盒	 SG90 舵机	 Active Buzzer 有源蜂鸣器	 Passive Buzzer 无源蜂鸣器	 1602 display 1602 显示屏	 Remote Control 红外遥控器
 7segment 1位数码管	 4 7segment 4位8字数码管	 8*8matrix 8*8点阵	 Jumper Wire 面包线	 F-F Dupont wire 母对母杜邦线	 2.54mm 4pin 2.54mm 排针
 10K Variable 10K 可调电位器	 9V Battery 9v电池+电池盒	 Resistance * 10 电阻1K*10	 Resistance * 10 电阻10K*10	 Resistance * 10 电阻220K*10	 Resistance * 10 电阻330K*10
 Cap * 4 电容*4	 Resistance card 色环卡	 Firm Packing 优质包装袋			

# Putting parts together



- How can I connect various sensors to Arduino?
- How can I connect actuators to Arduino?
- How can I tell or program an Arduino to do a job?

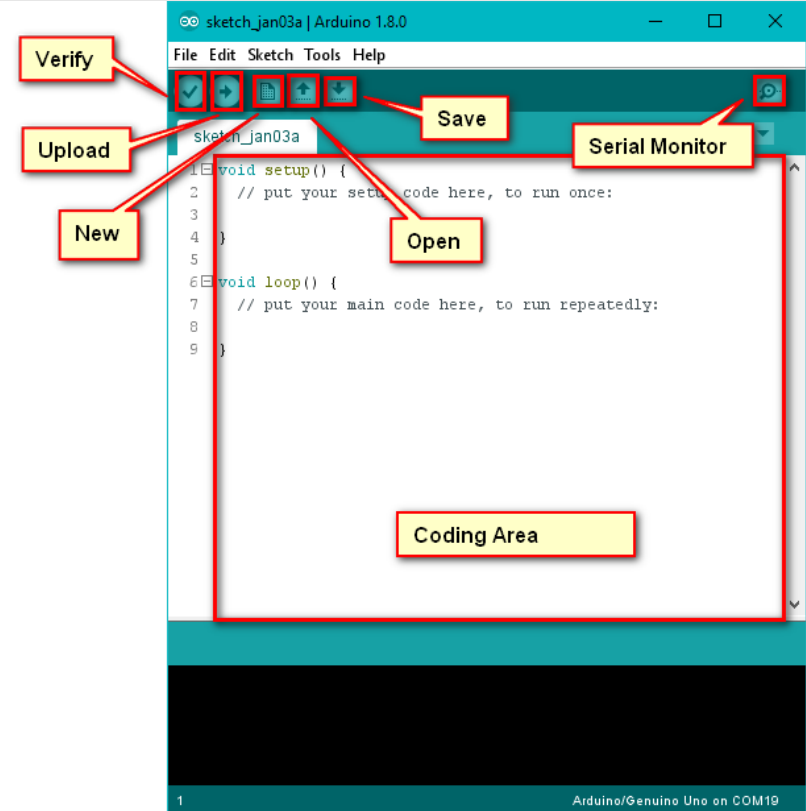




# Programming Environment



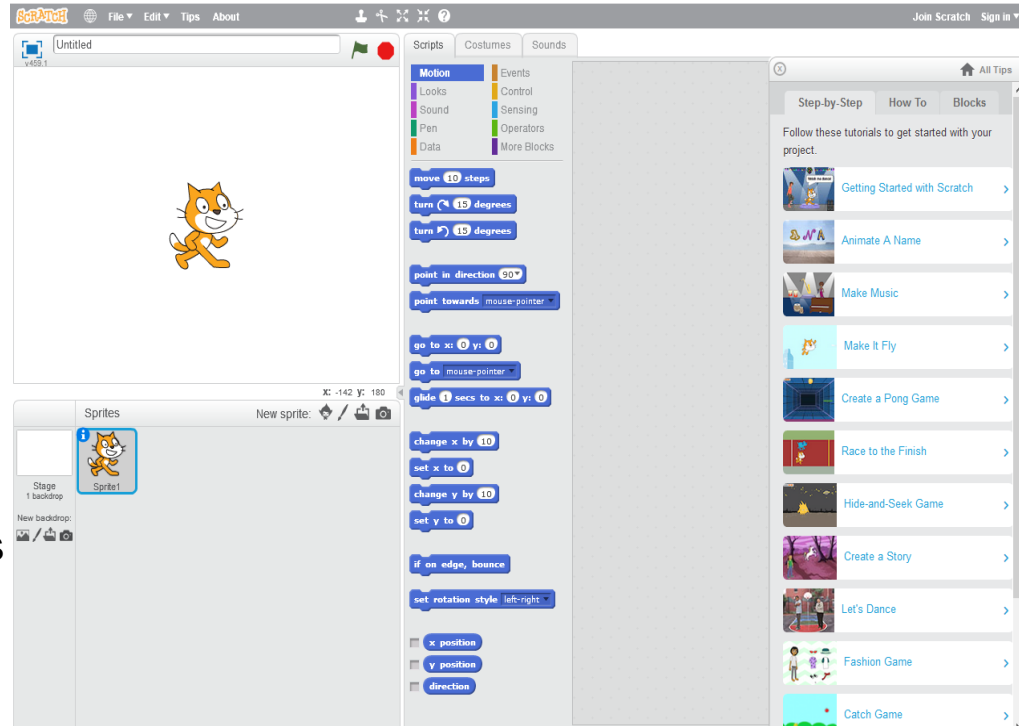
- It is an computer software framework that includes:
  - A text editor to create computer programs
  - A compiler to compile the created programs using the text editor into binary format **or**
  - An interpreter to execute the programs created directly



# Scratch



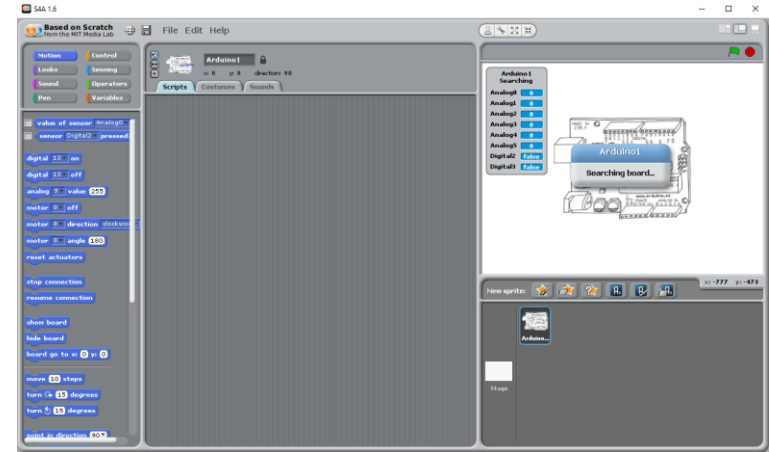
- Scratch is an open source visual programming language for teaching programming to children
- One can create interactive stories, games, and animations – and share the creations with others on the web
- Developed by the Lifelong Kindergarten group at the MIT Media Lab, USA
- Programming resembles to putting parts together assembling a puzzle



# Scratch for Arduino S4A - I



- S4A, developed in 2010 by the Citilab Smalltalk Team, is a Scratch modification that allows for simple programming of the Arduino open source hardware platform
- It provides a high level interface to Arduino programmers so as to manage sensors and actuators
- An Arduino sketch (S4AFirmware16.ino) has to be loaded to the board to communicate with S4A through USB



# Scratch for Arduino S4A - II



- Comparison of a simple program that blinks a LED connected to LED BUILTIN PIN # 13 on Arduino and in S4A

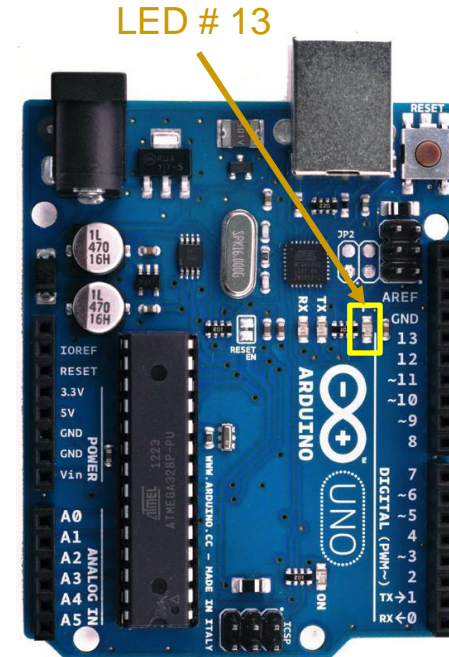
## Arduino Code

```
Blink $
// 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);
}

// 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
}
```

## S4A Program

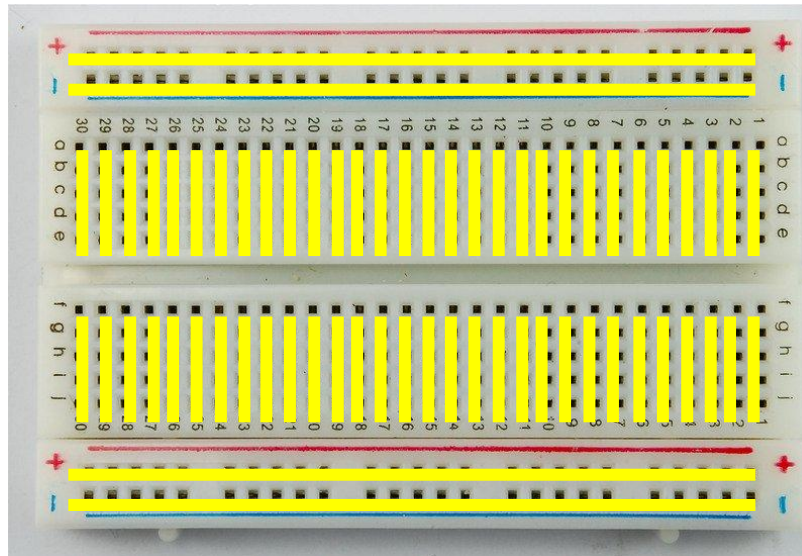
```
when clicked
  forever
    if sensor Digital1 pressed?
      digital 13 on
    else
      digital 13 off
```



# Breadboards



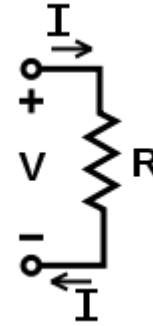
- A breadboard is used to create circuits and connect different sensors and actuators to the Arduino board through jumper wires, and electronic components
- Horizontal hole groups are linked power and ground columns are connected vertically



# Ohm's Law (Basic Electronics Law)



- A physics law which states that current passing through a conductor is proportional to the input voltage
- Voltage (V): is the measure of electrical potential
  - unit of measurement = Volts (V)
- Current (I): is the amount of flow through a conductive material
  - unit of measurement = Amperes or Amps (A)
- Resistance (R): is the material's opposition to the flow of electric current
  - unit of measurement = Ohms ( $\Omega$ )

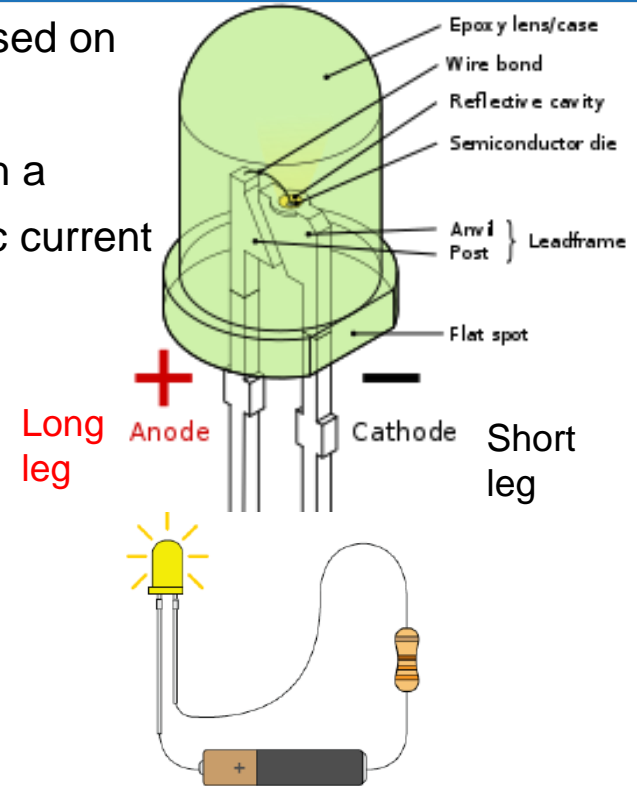
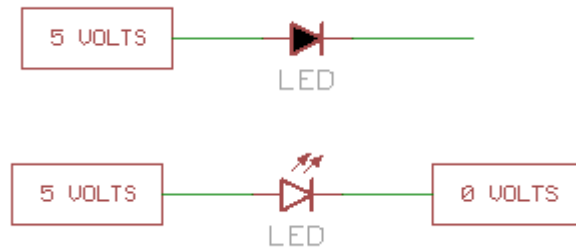


$$V = IR \dots \text{To find voltage}$$
$$I = V/R \dots \text{To find current}$$
$$R = V/I \dots \text{To find resistance}$$

# How a LED works



- It is a light-emitting diode that emits light when activated based on the Electroluminescence (EL)
- An optical phenomenon and electrical phenomenon in which a material emits light in response to the passage of an electric current
- Electricity flows from a higher voltage to a lower voltage



# S4A installation



- Install S4A into your PC
  - Download the program from <http://vps34736.ovh.net/S4A/S4A16.zip>
  - Unzip it to a folder named S4A
- Installing the Firmware into your Arduino
  - Download Arduino IDE from [https://www.arduino.cc/download\\_handler.php](https://www.arduino.cc/download_handler.php) and run the file arduino-1.8.5-windows.exe to setup it
  - Download S4A firmware from <http://vps34736.ovh.net/S4A/S4AFirmware16.ino>
  - Connect your Arduino board to a USB port in your computer
  - Open the firmware file (S4AFirmware16.ino) from the Arduino environment
  - In the Tools menu, select the board version and the serial port where the board is connected
  - Load the firmware into your board through File > Upload

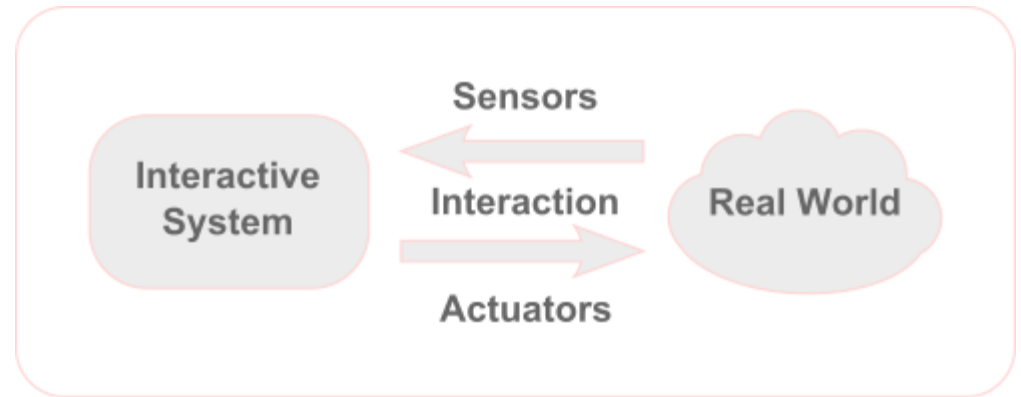




# Physical computing



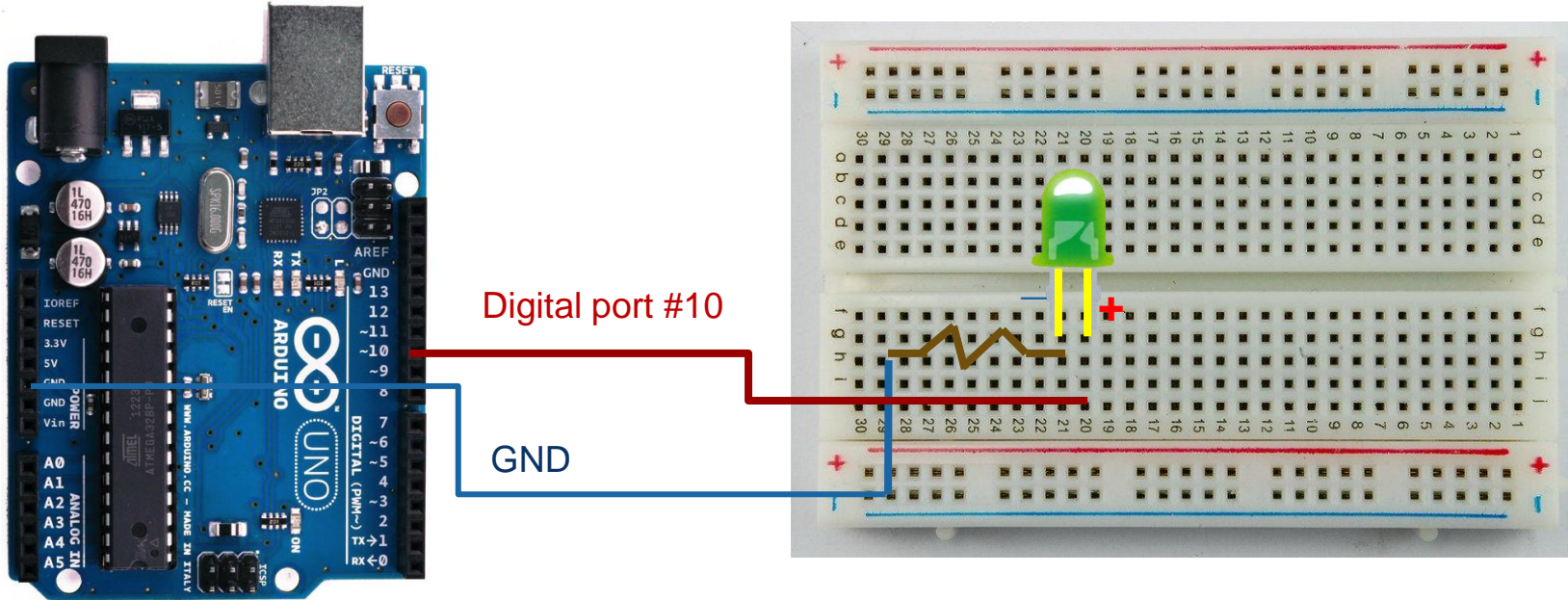
- Design interactive physical systems by the use of software and hardware that can sense and respond to the real world
  - smart automotive
  - traffic control systems
  - factory automation processes
  - Smart buildings
  - Robots





# Lab 1 – Control a LED from S4A (I)

- Connect a LED and a 220Ω Resistor on the breadboard and with Arduino according to the schematic below



# Lab 1 – Control a LED from S4A (II)



- In S4A select
- Digital off and on I/O
- Drag and drop them to scripts area
- Change them to #10

The screenshot shows the Scratch IDE interface. On the left, the Scripts area contains two 'digital 10' blocks: 'digital 10 on' and 'digital 10 off'. A yellow arrow points to the 'digital 10 on' block, with the text 'Press here to switch on or off the LED' below it. The right panel shows the Arduino hardware configuration with a list of pins and a diagram of the Arduino Due board.

Pin	Value
Analog0	155
Analog1	154
Analog2	153
Analog3	154
Analog4	153
Analog5	152
Digital2	false
Digital3	false



# Lab 1 – Control a LED from S4A (III)

- From control place wait 1 sec block in between the on of motion blocks
- LED switches on and off every 1 sec if you click on the block of commands

Based on Scratch from the MIT Media Lab

File Edit Help

Arduino 1  
x: 0 y: 0 direction: 90

Scripts Costumes Sounds

when clicked

when space key pressed

when Arduino 1 clicked

wait 1 secs

forever

repeat 10

broadcast

broadcast and wait

when I receive

forever if

if

if

digital 10 on

wait 1 secs

digital 10 off

wait 1 secs

digital 10 on

wait 1 secs

digital 10 off

wait 1 secs

Arduino 1  
port: COM3

Analog0	153
Analog1	152
Analog2	150
Analog3	152
Analog4	152
Analog5	150
Digital2	false
Digital3	false

Arduino Duemilanove

New sprite: [Icons]

Arduino...

Stage

x: -971 y: 226

# Lab 1 – Control a LED from S4A (IV)



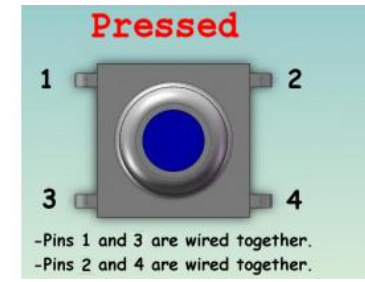
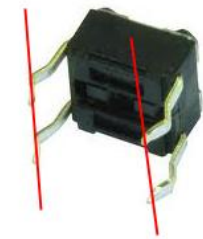
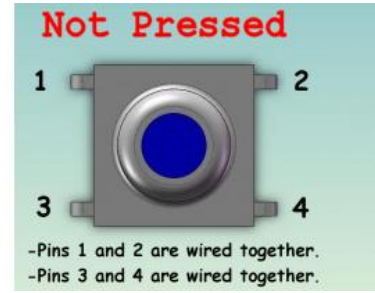
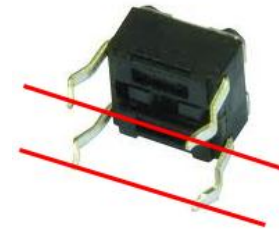
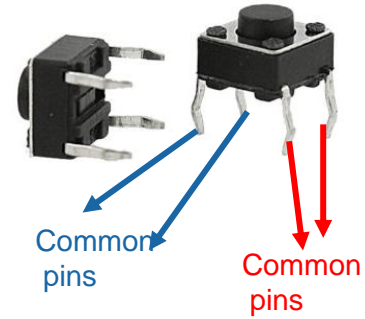
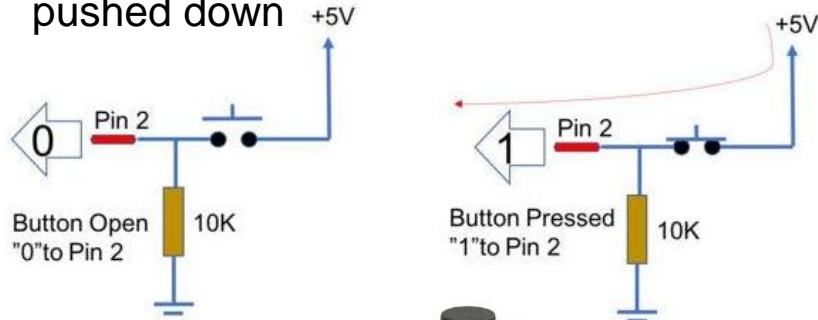
- How to make Loops in the program?

A screenshot of the Scratch IDE interface. The top menu bar includes 'Based on Scratch from the MIT Media Lab', 'File', 'Edit', and 'Help'. The left sidebar shows various tool categories: Motion, Control, Looks, Sensing, Sound, Operators, Pen, and Variables. The main workspace displays a script for an 'Arduino1' sprite. The script starts with a 'when space key pressed' event, followed by a 'repeat 10' loop. Inside the loop, the following blocks are stacked: 'digital 10 on', 'wait 1 secs', 'digital 10 off', 'wait 1 secs', 'digital 10 on', 'wait 1 secs', 'digital 10 off', and 'wait 1 secs'. The right sidebar shows the 'Arduino 1 port: COM3' settings, a list of analog and digital pins with their current values, and a visual representation of an Arduino Uno board with a speech bubble saying 'Hello!'. The bottom right corner shows the 'New sprite:' area with an 'Arduino...' option and a 'Stage' area.



# Lab 1 – Control a LED from S4A (V)

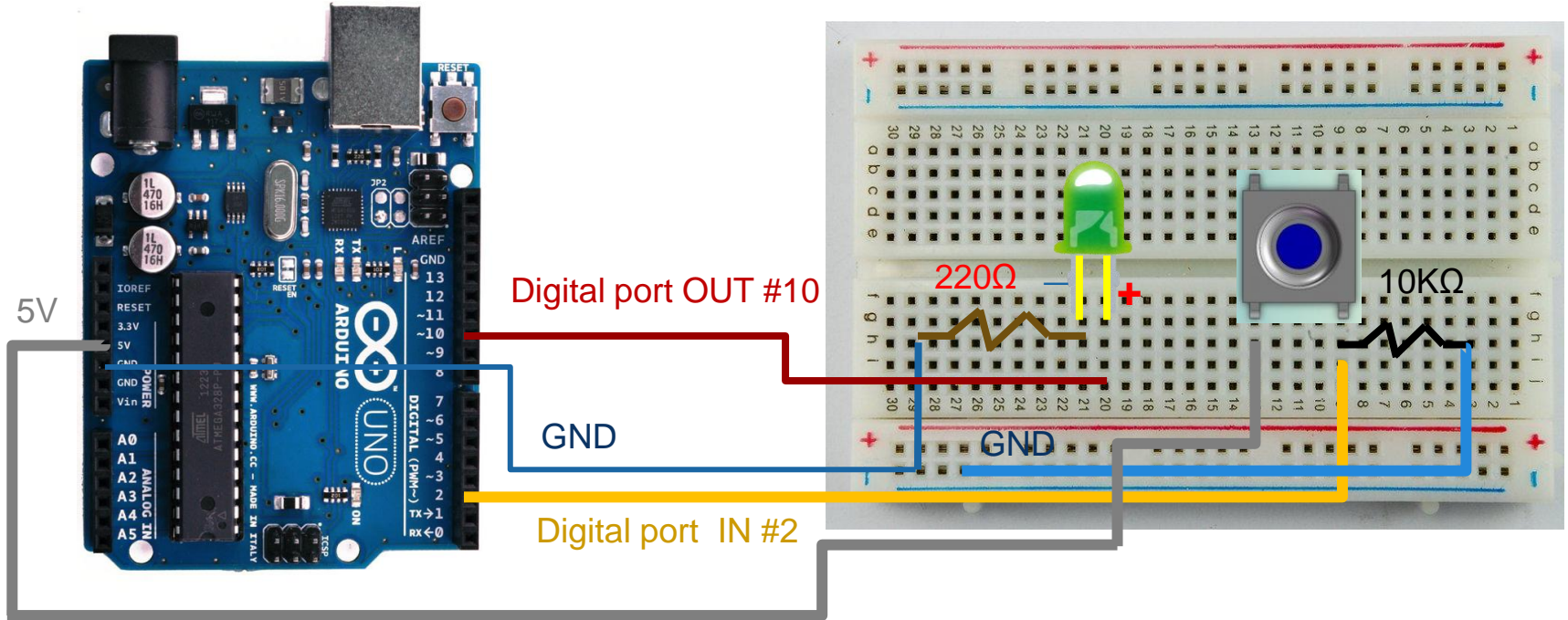
- When button is pushed, turn ON the LED for 10 seconds and then switch it OFF
- 10KΩ pull down resistor is required to avoid inducing a dead short circuit when the button is pushed down





# Lab 1 – Control a LED from S4A (VI)

- Connect a LED and a 220Ω Resistor on the breadboard and with Arduino according to the schematic below



# Lab 1 – Control a LED from S4A (VI)



- S4A program

```
when clicked
  forever
    if sensor Digital2 pressed?
      digital 10 on
      wait 10 secs
    else
      digital 10 off
```

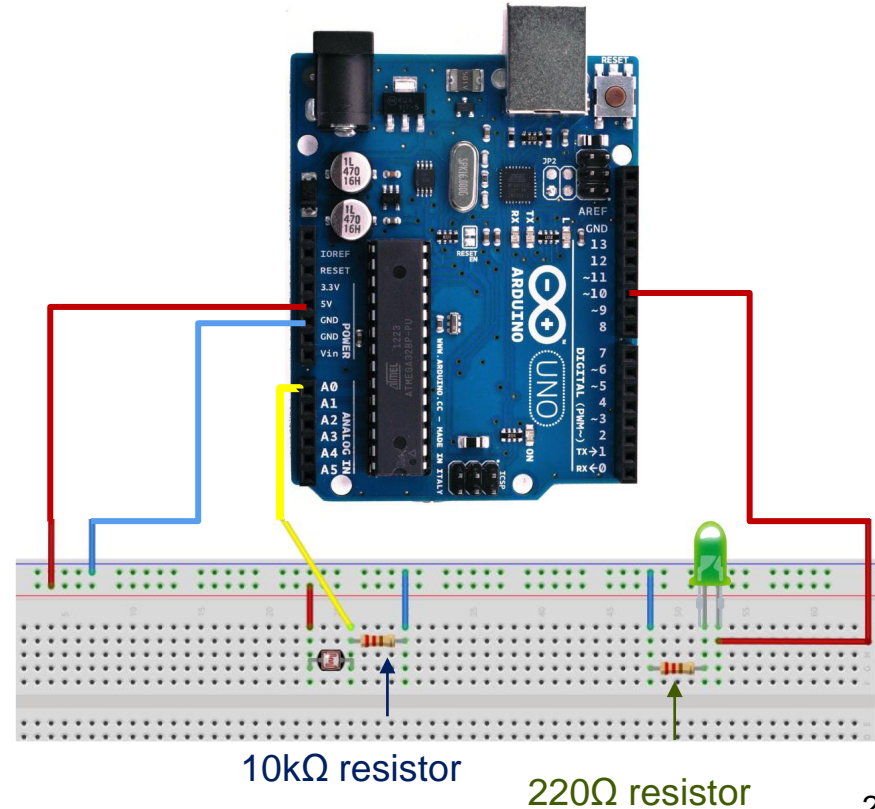
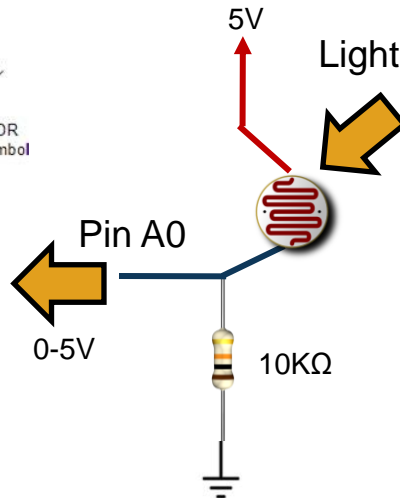
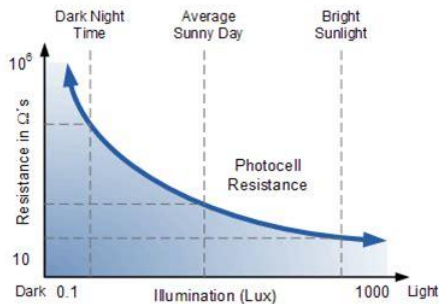
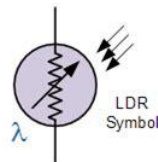
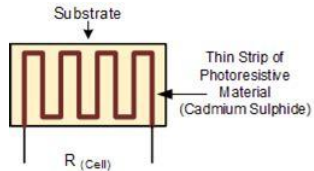
The image shows a Scratch-style code editor with a grey background. The code is written using yellow blocks. It starts with a 'when clicked' block, followed by a 'forever' loop block. Inside the loop, there is an 'if' block with a 'sensor Digital2 pressed?' block. If the sensor is pressed, the code sets 'digital 10 on' and then 'wait 10 secs'. If not, it sets 'digital 10 off'. The code ends with a return arrow block.



# Lab 2 – Turn on a LED when LDR sensor is covered Automatic Night Light (I)



- CdS - LDR (Cadmium Sulfide - Light Dependent Resistor) or photocell sensor
- Its resistance is inversely dependent on the amount of light falling on it



# Lab 2 – Turn on a LED when LDR sensor is covered Automatic Night Light (II)



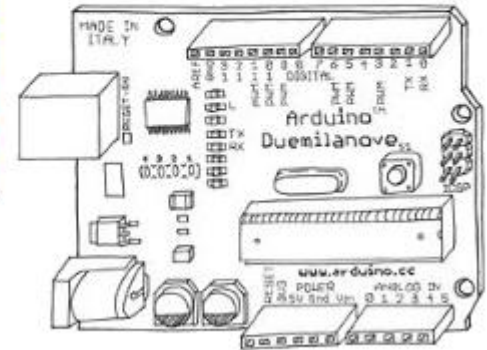
- Write down the Voltage values at Analog pin A0

CONDITION	A0 VOLTAGE (mV)
Lab's light are switched ON	
Lab's light are switched ON & Hand on the LDR	
Lab's light are switched OFF	
Lab's light are switched OFF & Hand on the LDR	

- What is the threshold value that differentiates darkness from lightness?

Arduino 1  
port: COM3

Analog0	673
Analog1	665
Analog2	656
Analog3	648
Analog4	641
Analog5	631
Digital2	false
Digital3	false



# Lab 2 – Turn on a LED when LDR sensor is covered Automatic Night Light (II)



- Program S4A
- Sense the threshold voltage value of the sensor in an if loop
- Depending on the value of the sensor
  - Switch on and off the LED

Based on Scratch from the MIT Media Lab

File Edit Help

Arduino 1  
x: 0 y: 0 directions: 90

Scripts Costumes Sounds

when clicked

forever

if value of sensor Analog0 < 500

digital 10 on

say LED ON for 2 secs

else

digital 10 off

say LED OFF for 2 secs

Optimize threshold value to proper set the LED on

2\_ldr\_led

Arduino 1  
port: COM3

Analog0 671

Analog1 663

Analog2 655

Analog3 647

Analog4 639

Analog5 631

Digital2 false

Digital3 false

Arduino Uno Duemilanove

New sprite: Arduino...

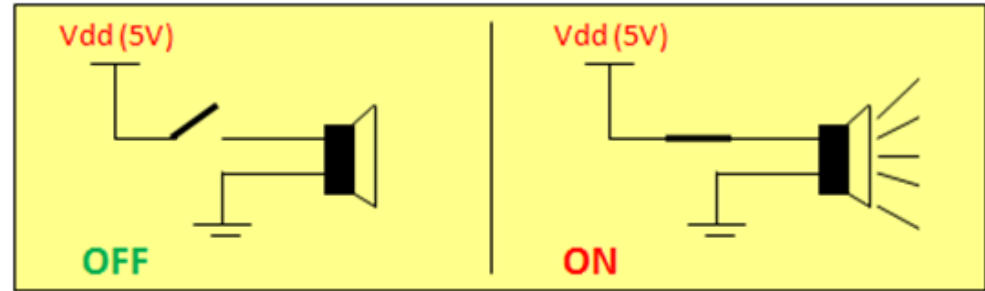
Stage

x: 742 y: 446

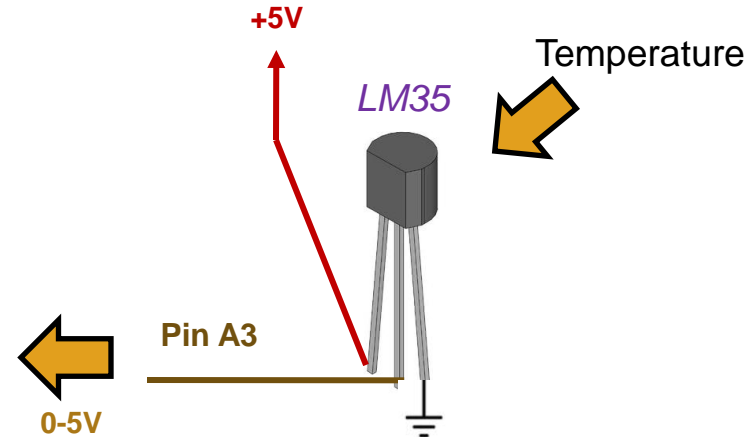
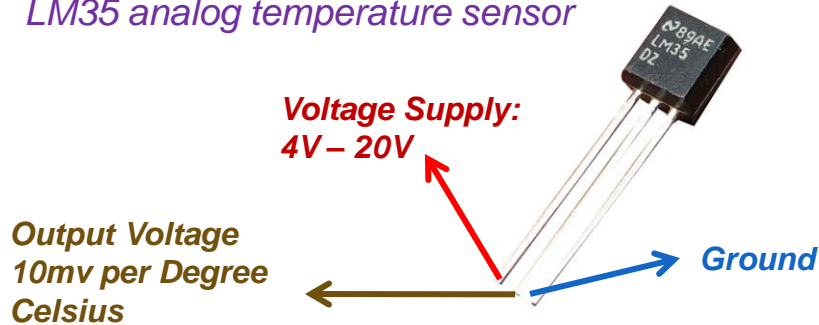


# Lab 3 - Temperature Alarm – (I)

- Program Arduino to buzz when temperature goes higher than a value



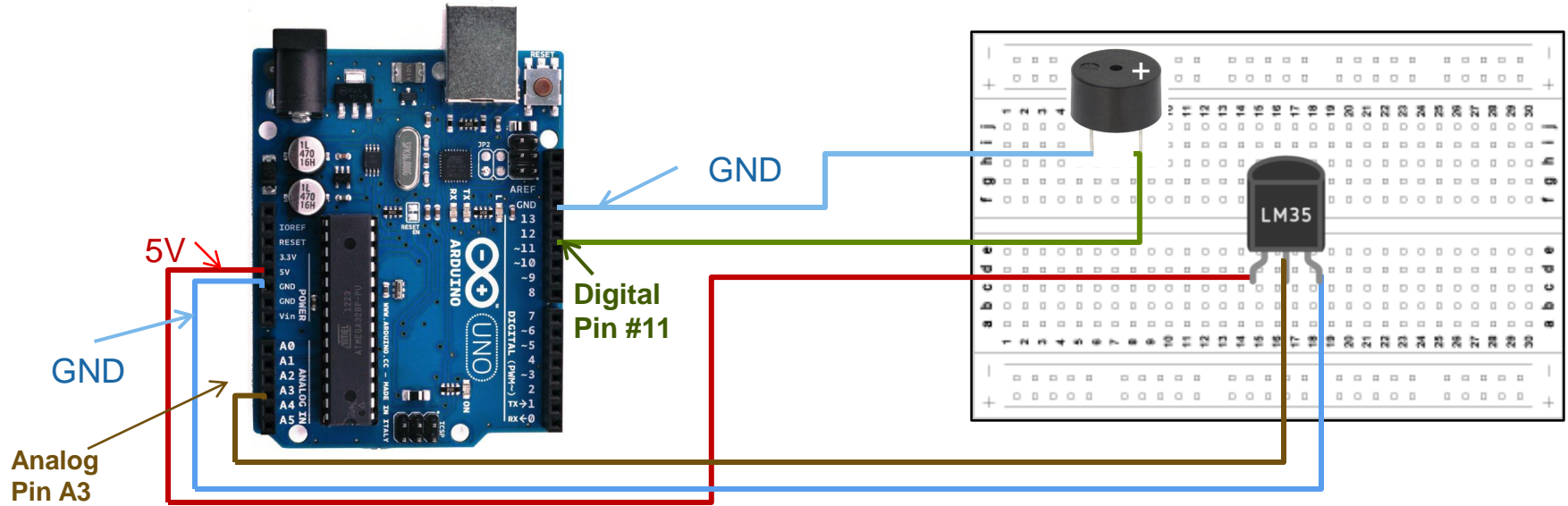
LM35 analog temperature sensor





# Lab 3 - Temperature Alarm – (II)

- Schematic Topology



# Lab 3 - Temperature Alarm – (III)



- Read the voltage value in pin A1
- Does it correspond to real room temperature?
- How to calculate the temperature value in °C since voltage values are read in A1 from the LM35 sensor?
  - Formula according to LM35 datasheet
  - Find what percentage of the range (1024 = 10bits representation of ADC) value in A1 is, multiplying that by the range itself (5000 mV), and divide it by 10 mV per °C
    - **Temperature in °C = (A1 value \* 500)/1023**

# Lab 3 - Temperature Alarm – (IV)



- S4A program
  - Loop forever
  - Enter the formula in S4A
  - If temperature is above 25°C
    - Buzzer is activated
  - Else
    - Buzzer is deactivated

- Make 1 variable
  - temperature

The screenshot shows the S4A programming interface. The 'Variables' category is selected in the top right. Below the category buttons, the following actions are visible:

- Make a variable
- Delete a variable
- temperature
- set temperature to 0
- change temperature by 1
- show variable temperature
- hide variable temperature
- Make a list

# Lab 3 - Temperature Alarm – (I)



## Final S4A program

```
when clicked
  forever
    set temperature to value of sensor Analog3 * 500 / 1023
    say temperature
    if temperature > 25
      digital 11 on
    else
      digital 11 off
```

Arduino 1  
port: COM3

Analog0	660
Analog1	652
Analog2	644
Analog3	46
Analog4	53
Analog5	57
Digital2	false
Digital3	false

temperature 22.48

temperature 22.5



# Thank you



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*Aristotle University of Thessaloniki*  
*Greece*



<http://stem.lupacovka.cz>