Unit 6: Robotics

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Contents

Textos Marea Verde

Prior knowledge

Activity: Summarize your general knowledge on this topic.

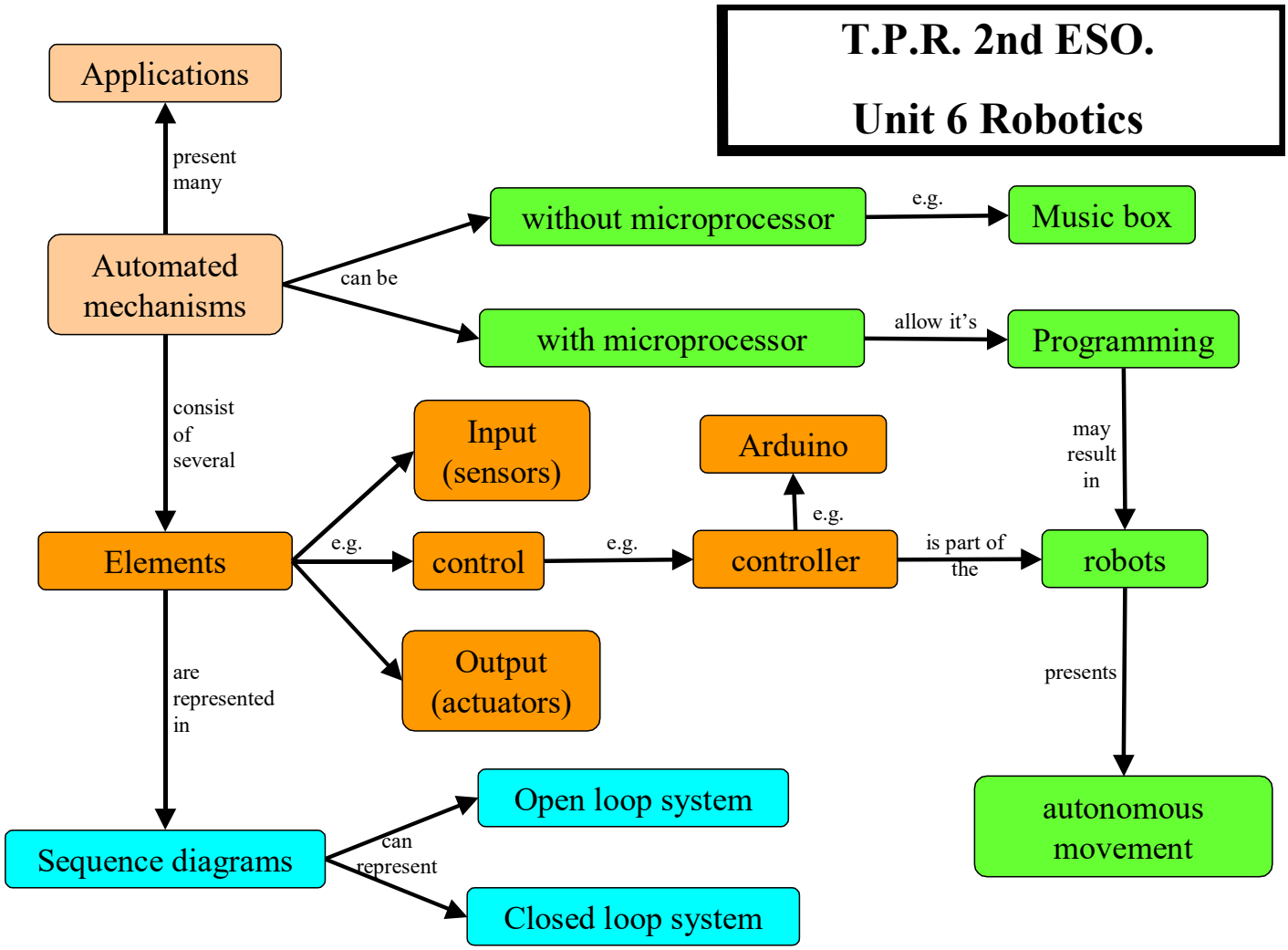
Keywords

Activity: Copy following keywords, understand their meaning and translate them into English.

Automated mechanism	Controller board	Actuator
Robot	Sensor	IDE

Mindmap of the unit

Activity: Analize and try to understand following mindmap



6.1 Automated mechanisms and robots

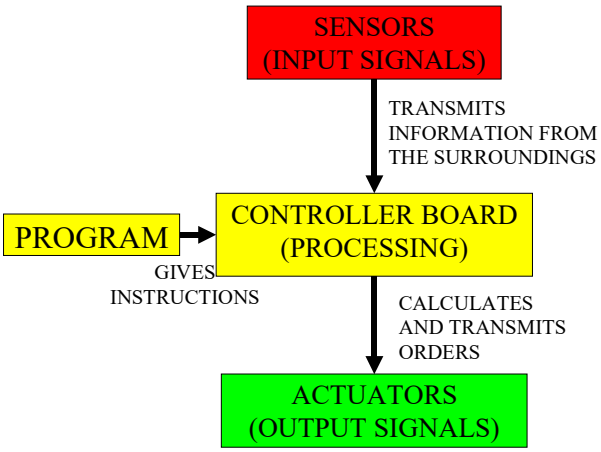
Automated mechanisms and **robots** are machines that performs specific, repetitive tasks with a high level of precision, saving time, effort and risks to the human beings.

The word '**robot**' comes form the czech word 'robota' that means forced laborer or slave. There is general agreement that a **robot**[1] is a programmable automated machine that captures information abouts its surroundings, process this information and acts on it; furthermore it should be able to move somehow.

6.1.1.1.1 Difference criteria	Automated Mechanism	Robots
Complexity of the task	low	high
Sense and manipulate their environment?	it might be	yes
Process information electronically?	it might be	yes
Easily programmable?	no	yes
Do they move around?	it might be	yes
Examples	Windscreen wipers, toilet tanks, music boxes,...	Robots in assembly lines or to detect explosive, work in outer space...

To process the information the robot has a **controller board** (or **controller card**), which is an electronic circuit that has the basic components of a computer:

- ❑ Processing unit
- ❑ Memory
- ❑ Input ports (to connect sensors: light sensors, heat sensors...)
- ❑ Output ports (to connect actuators: motors, lights, displays,...)



To programme a **controller board** it must be connected to a computer.

Until now, **controller boards** such as Enconor, Fischer and Lego were used. However, control systems have changed dramatically since the appearance of Arduino boards.

Is it a robot?

A. Music boxes
B. Smartphone
C. Solar arthropodes
D. Electronic robot
E. Digital weather station
F. Mechanical vehicles
G. Mechanical animals
H. Mechanical maid

Activities: Copy following exercises and solve them in your notebook:

1) Watch the image and decide if the different devices are a robot or not. Fill in following table (the first example is already solved).

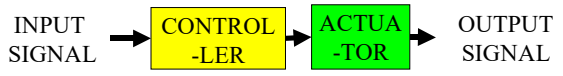
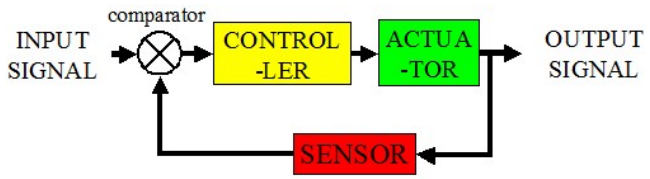
[1] The word robot can refer to both physical robots and virtual software agents, but the latter are usually referred to as bots.

Device	Complex task	Sense the environment	Manipulate the environment	Process information	Electronic process	Easily programmable	Moves	Is it a robot?
A) Music box	no	no	Yes (creates music)	Yes (cam position)	no	Programmable, but not easily	no	no
(...)								
H) Mech. maid								
3D printer								

6.2 Control systems

Definition: A control system is a set of elements (mainly electronic) that receive information from the outside (input signal) and generate an output response (output signal), with the aim of regulating the behaviour of an automated mechanism so that it does what we want it to[2].

Types of control systems: Control system use control loops that can be open (open loop systems) or closed (closed loop systems).

	open loop system	**closed loop system**
Diagram		
The output signal ...	...is not taken into account in the control action	... is compared to the input signal to adjust the control action to the required value.
Example	Fan: it operates regardless of the room temperature Heating boiler controlled by a timer: heat is applied for a constant time, regardless of the temperature of the building	Heating boiler controlled by a thermostat: a temperature signal is feed back to ensure the controller output maintains the building temperature to that set on the thermostat. Heat is applied only if the building temperature drops below that set on the thermostat.

Basic elements of a control system:

- Sensor: Detects physical or chemical variables (e.g. room temperature)
- Comparator: compares input signals (e.g. room temperature with that set on the thermostat)
- Controller: depending on the signal sent by the comparator, it sends a signal to the actuator (e.g. switching on/off the boiler)
- Actuator: Converts energy in order to activate a process (e.g. the boiler)

[2] The framework for the behaviour of future complex robots are called "Laws of Robotics"; the best known are those written by Isaac Asimov in the 1940s in a science fiction story:

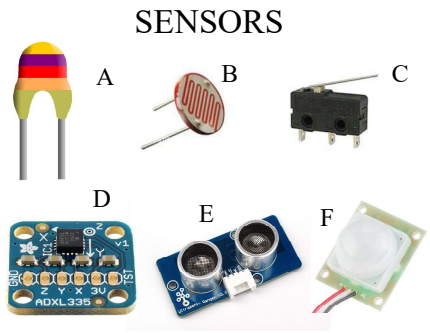
1 A robot may not injure a human being or, through inaction, allow a human being to come to harm.

2 A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.

3 A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws

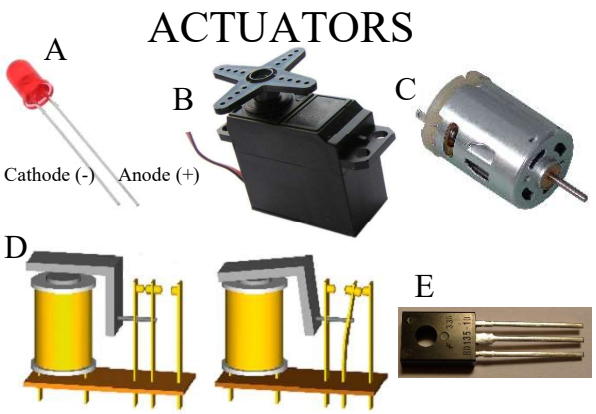
Types of sensors

Sensor	Physical / chemical variable	Image
Temperaure sensor or NTC (negative temperature coefficient)	Temperature	A
Light intensity sensor (light-dependent resistor)	Light	B
Limit sensor (limit switch)	Distance	C
Accelerometer	Acceleration	D
Ultrasonic sensor	Distance	E
Motion sensor	Movement	F



Types of actuators

Actuator	Remarks	Image
LEDs	• Connect both poles correctly: anode to + and cathode to -. • Connect in series with a 220 Ω resistor to withstand the current	A
Servomotors (or servos)	• It only rotates from 0º to 180 º. • Connect the three wires: + 5V, GND, digital pin	B
DC motors	• Depending on the polarity, the shaft turns one way or the other • Do not connect directly to Arduino which only provides a maximum of 40mA; use a relay or transistor	C
Relays	• It is a switch controlled by an electromagnet • Opens or close contacts	D
Transistor	• Is used to amplify signals or as a switch	E



Activities: Copy following exercises and solve them in your notebook:

2) Fill in following table (one example is already solved)

Automated mechanism	control action	process variable	sensor	actuator	type of control system
Fan					
Heating boiler with timer					
Heating boiler with thermostat	switching on/off of the boiler	building temperature	temperature sensor	Boiler motor	Closed loop system
Traffic light					
Airport sliding door					
Lift					

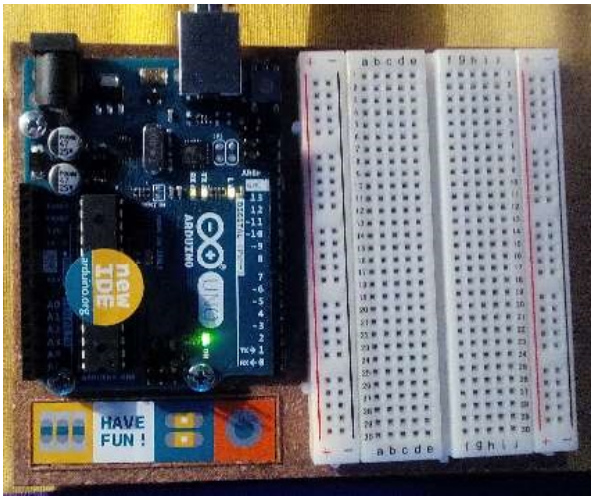
3) Read Asimov's 3 laws of robotics and comment them. Which do you think is the most important one. Why? Do you think nowadays robots are complex enough to be necessary the use of such laws?

4) What does AI stand for? And captcha? Have you ever used the latter?
5) How can you recognize the cathode and anode of a LED?
6) What is a NTC?
7) What for will you use a transistor or a relay? Why?
8) What differences are there between a servomotor and a DC motors?
9) How many cables has a Servomotor? And a DC Motor?
10) How can you change the rotation sense of a DC motor?

6.3 Working with Arduino

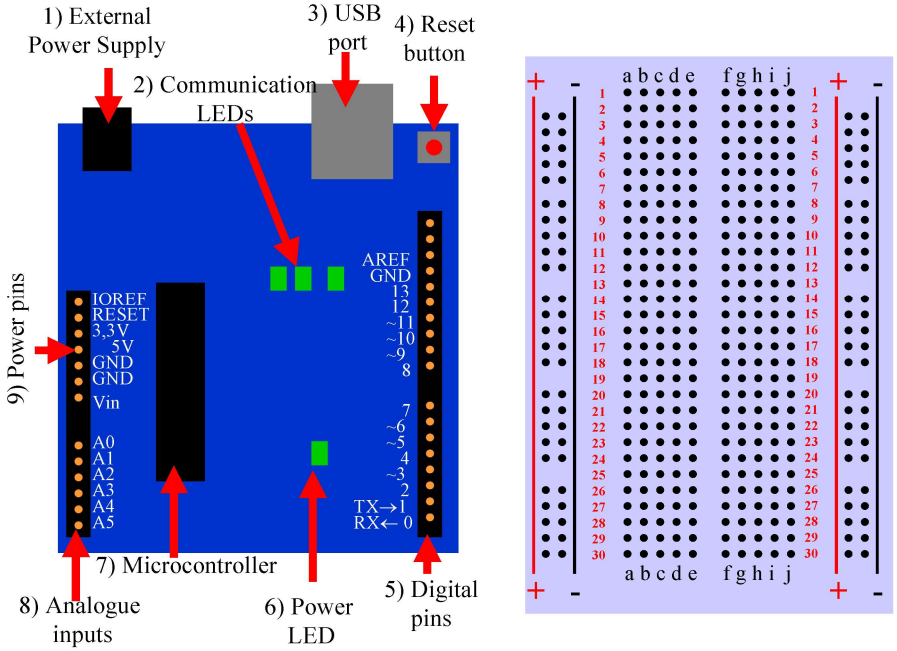
Main parts of the Arduino board:

ARDUINO BOARD & PROTOBOARD



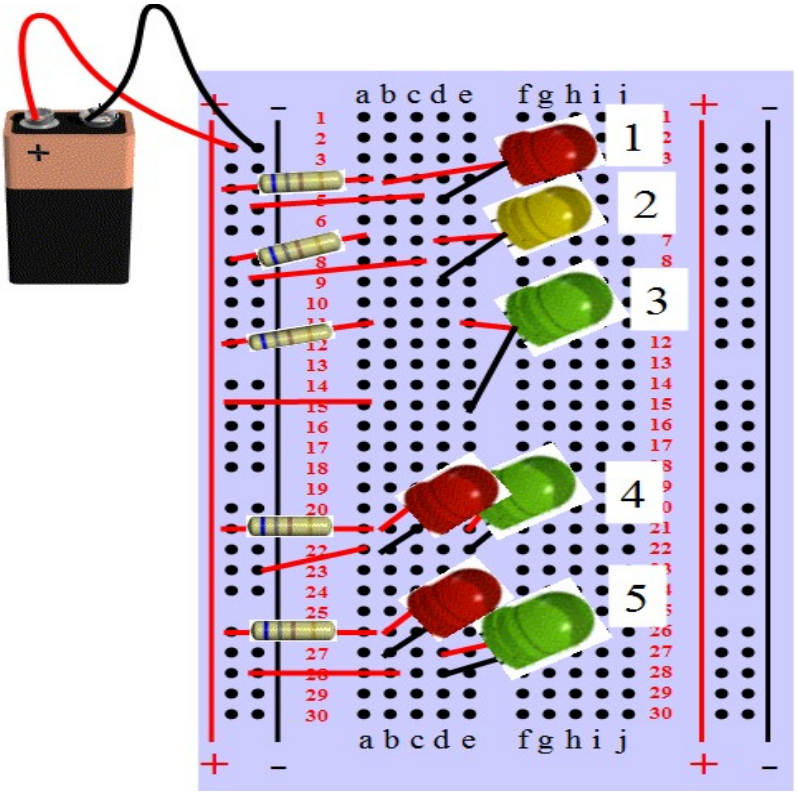
1. External power supply: to supply power to the board (7-12 V) when the USB port is not connected.
2. Communication LEDS: They turn on when communication is established with the computer. Blink when uploading a programm.
3. USB port: for communicating with the computer and also as power supply
4. Reset button: for resetting the microcontroller
5. Digital pins: There are 14. They can work as **digital** (ON / OFF) **input or output ports** (U= 0 or 5V; I_{max} = 40 mA). Pins with the symbol ~ (3, 5, 6, 9, 10 and 11) can work also as **analogue** (variable values between a range of 0 and 5V) **output ports**.
6. Power LED: It turn on when there is power supply
7. Microcontroller: The "brain" of the board
8. Analogue input ports: There are 6. Convert the direct voltage values delivered (range between 0-5V) to digital values.
9. Power pins: To supply a circuit with +5V, 3,3V or GND (ground = reference value; 0V).

ARDUINO BOARD & PROTOBOARD



Protoboard :

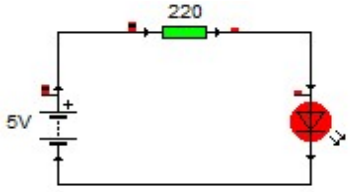
A protoboard, also called breadboard, is a construction base for mounting circuits without having to solder connections. Electronic components or wires are directly inserted in the holes. To use one , we only need to know how the holes are connected between them:



- Vertical connections: all the holes in each column are interconnected; they are usually reserved for connecting the positive (+) or negative (-) pole of the power source. Usually you have two vertical connections at the right and two at the left.
- Horizontal connections in the center: five holes in each row are interconnected (a-e, and f-j); here we insert the components of the circuits and the wires to connect them.

Activities: Copy following exercises and solve them in your notebook:

11) Look at the circuits on the protoboard above, and fill in following table (one example is already solved).

Circuit	Component	Start	End	Circuit scheme
1	resistor	+ pole	a4	
	LED red	b4	d5	
	wire	c5	- pole	
(...)				
5				

Analogue and digital sensors :

Analogue sensors provide a voltage variation within a range (0-5V) that depends on the variation in the physical variable measured. They are connected to analogue input ports, which convert the voltage values to digital values.

Digital sensors provide a voltage values either of 0V or 5V that are interpreted by the controller as LOW (digital value 0) or HIGH (digital value 1).

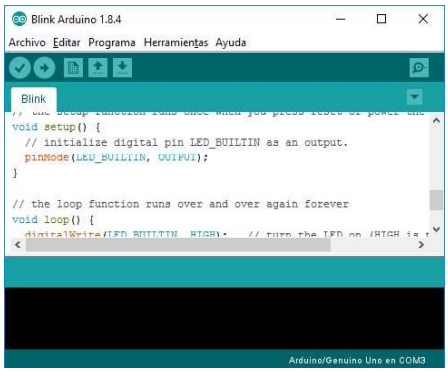
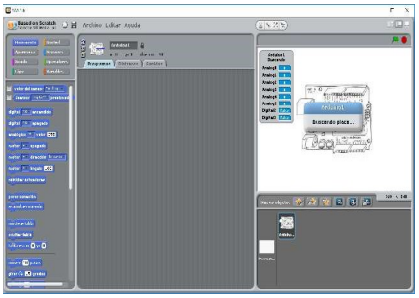
Sensor	Input port to connect	Voltage values provided to the input	Digital value interpreted by the controller
Analogue	Analogue	Range between 0 - 5 V (depending of physical variable measured)	Range: e.g. **01011001**
Digital	Digital	Either 0 or 5 V (for example switch OFF or ON)	Either LOW (**0**) or HIGH (**1**)

IDE:

Remember, an **Integrated Developmet Environment** (IDE) is a program that allows to:

- **program**
- **compile**
- **run** the program
- **save** the program

There are several IDE for the Arduino board:

IDE	Programming language	Connection	GUI (Graphical user interface)
Arduino IDE	Complex language (similar to C), to be seen in 3rd ESO.	The Arduino board stores the program, so it only needs to be connected with the USB cable for transferring the program.	
S4A	Modification of Scratch blocks language.	The Arduino board needs to stay connected to the computer with the USB cable to run the program.	

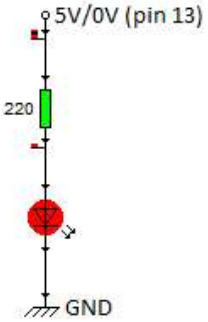
Steps for using S4A:

1. Run the Arduino IDE
2. Select the correct Arduino Board: *Menu bar/Tools/Board*
3. Select the correct port: *Menu bar/Tools/Port*
4. Open the S4A firmware: *Menu bar/File*
5. Upload the S4A firmware: click on 
6. Run S4A
7. Start using the S4A IDE.

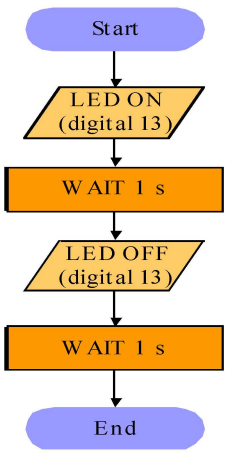
How to connect electronic components when using the S4A.			
Output ports		**Input ports**	
Digital	**Analogue**	**Digital**	**Analogue**
10, 11, 12 and 13 4, 7 and 8 for servomotors	5, 6 and 9	2 and 3	A0, A1, A2, A3, A4 and A5

Activities: Copy following exercises and solve them in the workshop using the arduino board and S4A: (these exercises are also suitable for the 3rd grade ESO).

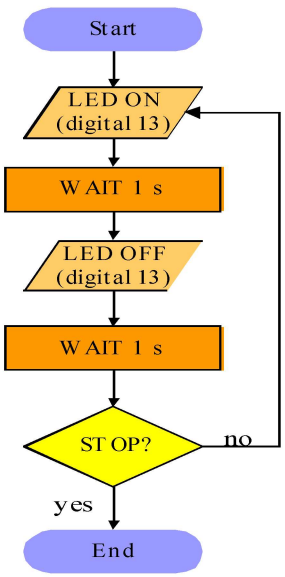
12) Build following circuit on the protoboard and arduino board and program following algorithms.

Circuit	Component	Start	End	Circuit scheme
c.1	Red wire	5V	+ pole	
	Black wire	GND	- pole	
	long wire	Digital 13	a 13	
	resistor 220 Ω (rrbg)	c 13	h 13	
	LED (red)	j 13	j 14	
	short wire (green)	f 14	d 14	
	short wire (green)	b 14	- pole	

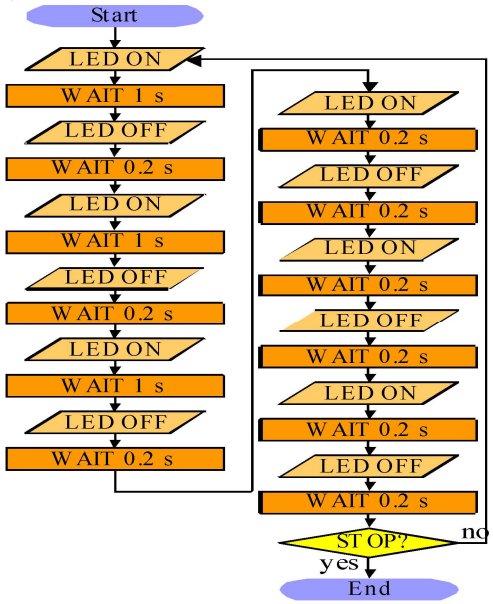
1) sequential



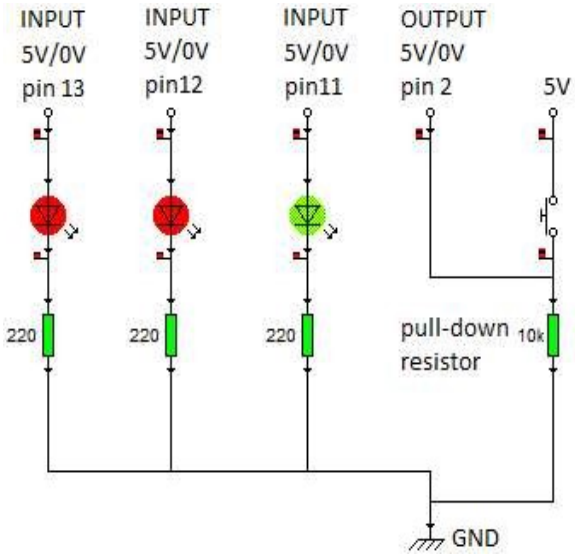
2) iterative



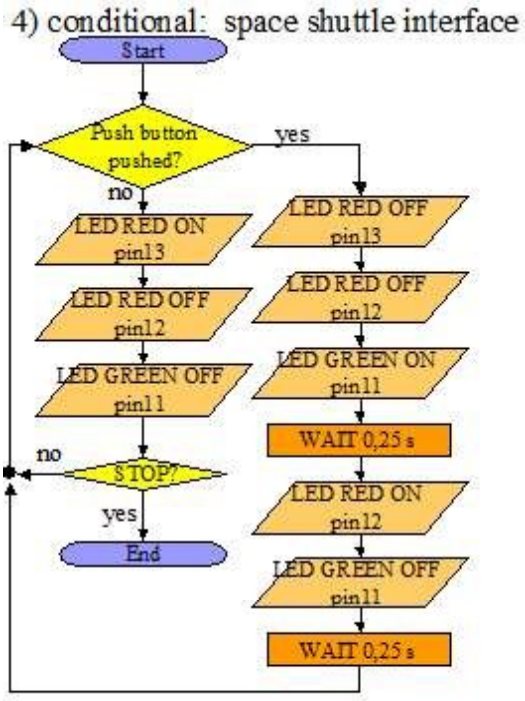
3) iterative



13) Build following circuit on the protoboard and arduino board and program following algorithms

Circuit	Component	Start	End	Circuit scheme
c.2	Red wire	5V	+ pole	
	Black wire	GND	- pole	
	wire	Digital 13	a 6	
	LED (red)	e 6	e 7	
	resistor 220 Ω (rrbg)	a 7	- pole	
	wire	Digital 12	a 9	
	LED (red)	e 9	e 10	
	resistor 220 Ω (rrbg)	a 10	- pole	
	wire	Digital 11	a 12	
	LED (green)	e 12	e 13	
	resistor 220 Ω (rrbg)	a 13	- pole	
	wire	+ pole	a 23	
	push button	e 23	e 21	
	wire	c 21	Digital 2	
	Resistor 10 kΩ (b**B**og)[1]	a 21	- pole	

1: with digital inputs we use a **pull-down** resistor (10 kΩ) connected to GROUND to pull the value down to a low value (0) when the circuit is on stand-by , avoiding that a high value (1) is detected in error.



14) We want to build a traffic light that works automatically according to following table (1≡ON; 0≡OFF);

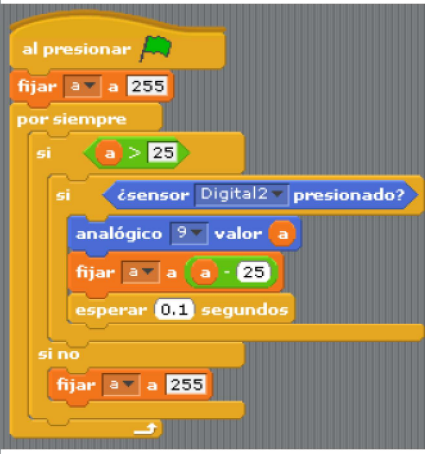
Time t (s) after pressing push button	OUTPUT				
	Road traffic			Foot traffic	
	Red	Yellow	Green	Red	Green
$25 \leq t$	0	0	1	1	0
$0 \leq t < 2$	0	0	1	1	0
$2 \leq t < 5$	0	1	0	1	0
$5 \leq t < 15$	1	0	0	0	1
$15 \leq t < 20$	1	0	0	0	1 (blinking I[1])
$20 \leq t < 23$	0	1	0	0	1 (blinking II[2])
$23 \leq t < 25$	0	1	0	1	0
1: blinking I = 0,75 s ON – 0,25 s OFF; 1: blinking II = 0,25 s ON – 0,25 s OFF					

a) Is this an automated mechanism or a robot? Give at least three reasons.
b) How many input and output ports do you need? Are they digital or analogue?
c) Which is the control action? The process variables? The sensors? The actuators?
d) What kind of control system is it, open loop or closed loop?
e) Draw the corresponding electric scheme.
f) Do you need a pull-down resistor? Why? Why not?
g) Program it with S4A.

15) We want to control the brightness of a LED (connected to pin 9 of the arduino board) with a push button (connected to pin 2).

Component	Start	End
	5V	+ column
Wire		- column
Wire	Pin 9	
LED	e 9	
R = 220Ω	a 10	
Wire	+ column	
Push button	e 23	
Wire	c 21	
R = 10kΩ	a 21	

a) Fill in the gaps of the table.
b) Draw the electric scheme.
c) Once correctly connected we run following S4A programs. Answer for each of them following questions.
   -Is this an automated mechanism or a robot? Why?
   -How many input and output ports does it use? Are they digital or analogue?
   -Is it an open or a closed loop control system? Why?
   -Do you need a pull-down resistor? Why?
d) Describe briefly for each program what happens to the LED connected to pin 9.



16) We want to build a "LOVEMETER" with a temperature sensor TMP 36.

a) The TMP 36 has 3 terminals; connect the left one to 5V, the the right one to GND (IMPORTANT: Don´t connect it otherwise!). Connect that of the middle to the analogue input port, which renders values between 0 and 1023 .

b) To know the Voltage of the analogue terminal create a variable called 'Voltage' and fix it to: **Voltage = (Sensor value / 1024) · 5**

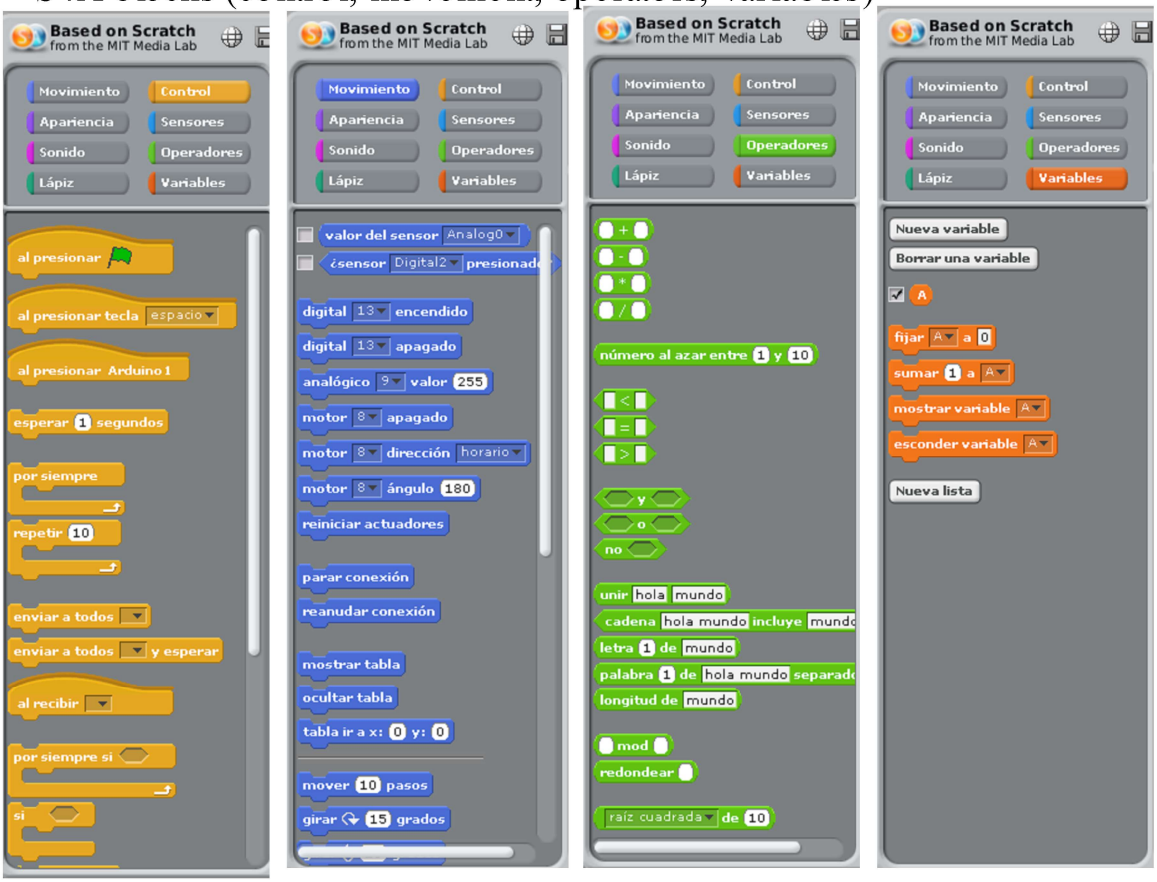
c) To know the temperature (ºC) of the sensor create a variable called 'temperature' and fix it to: **Temperature = (Voltage – 0,5) / 100**

d) Create a LOVEMETER according to following table (1≡ON; 0≡OFF);

Temperature (º C)	OUTPUT		
	Led terminal 13	Led terminal 12	Led terminal 11 (or 9)
< 24	0	0	0
24 ≤ and < 27	1	0	0
27 ≤ and < 30	1	1	0
30 ≤	1	1	1

e) Now put your finger on the sensor and let the LOVEMETER make the rest!

S4A blocks (control, movement, operators, variables)



SOLUTIONS (I)

12.1)

12.2)

13)

16)

SOLUTIONS (II)