

ERP Software installation

The ERP can be programmed either manually or with the Engino® software included in the set. Manual programming does not apply to sensors. A machine that executes a series of commands is not a true robot; a true robot is one that can be programmed to take its own decisions based on the feedback received from its sensors. To be able to create such a program you need to install the **Engino® Robotics Pro 1.2 software**, which can be downloaded from the website: www.enginorobotics.com. Alternatively you can use the CD included in your Engino® Robotics package.

1. Go to the website www.enginorobotics.com.

Click on the “**download software**” tab and choose “**for Windows / Engino Robotics PRO 1.2**”. For Android and iOS you can download the **EnginoRobot BT** app for manual control, but this does not offer visual programming through the flow diagram or the text editor.



2. Click on the “**Install**” button.

3. In the pop-up window click on the “**save**” button.

4. Go to the folder “**downloads**” (or in other location where your downloaded files are) and find the file “**setup.exe**”. To start the installation of the ERP software, double click the file and press the button “**RUN**” in the pop-up window.

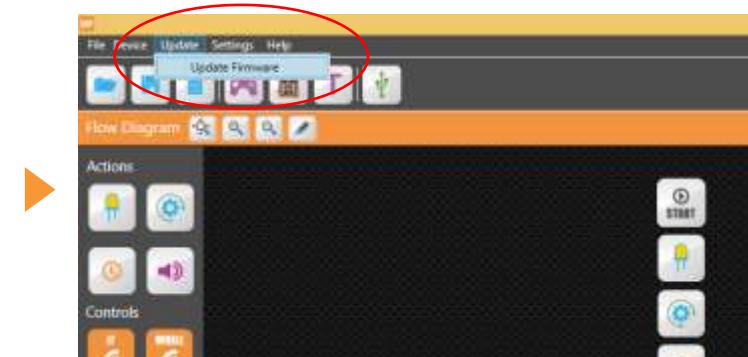
5. Once the installation is completed the software will start automatically and a **shortcut** will be created on your Desktop.



Firmware update

The ERP development team is continually upgrading the controller's embedded software (firmware) to fix potential bugs and add new functions. Once you connect your controller with the ERP software and click the USB button, you will be informed if there is new firmware update. For this, you need to set the controller in DFU (Device Firmware Update) mode:

1. Turn the controller OFF by pressing the ON-OFF button (no LED should be lit).
2. Connect the controller with the PC through USB.
3. Keep the “program” button pressed. Then press the “ON-OFF” button once while still pressing the “program” button. If you do this correctly, the ERP device will be set in DFU mode with the orange and green lights half lit.
4. Wait for a few seconds until the PC connects with the ERP.

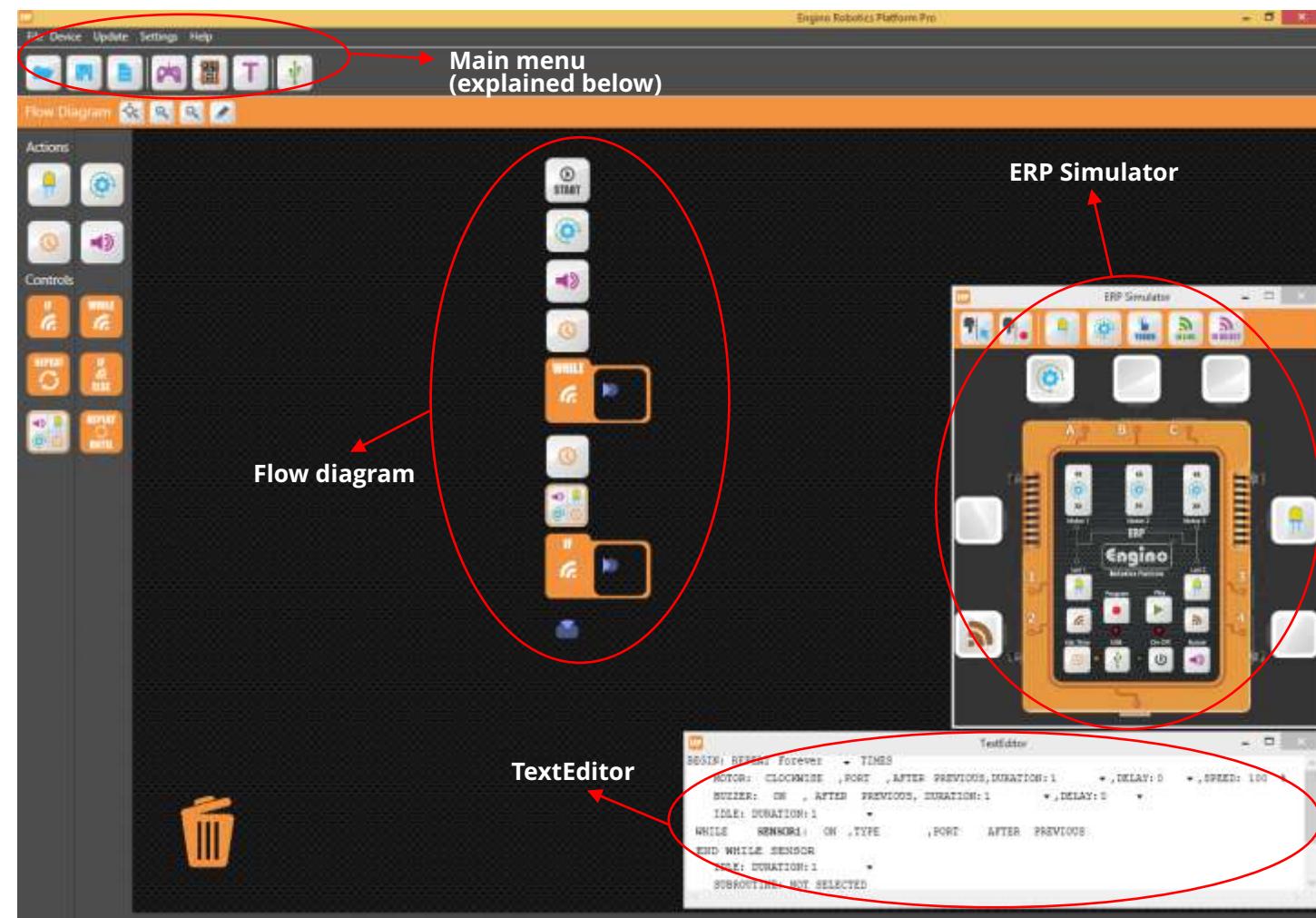


5. Inside the ERP software of your PC, select the tab “**Update**” and click “**Update Firmware**”. This will bring the setup program.
6. On the pop-up window click on the “**update firmware**” button. The software will seek the latest version of the firmware online and a new window will show up promptly with the number of the version. Select “**Yes**” to continue.
7. If the upgrade is successful you will see a message on the screen and hear a sound from the controller.

The ERP Software

The patent pending ERP software consists of 3 windows: the **FLOW DIAGRAM**, where you can drag and drop blocks to create a sequence of commands; the **ERP SIMULATOR**, where you can program the same way as you would do manually; and the **TEXT EDITOR**, where you can view and edit the program in an easy to read text format.

To connect the ERP controller to your PC, place the included USB cable on the controller's port (at the bottom) and the other end on a USB port of the computer. Turn ON the controller by pressing the ON/OFF button and wait for a few seconds until your PC installs the device. Then click on the USB button inside the ERP software to connect. Note that the ERP cannot be powered by the PC through the USB cable, but only with the batteries.



“File” allows you to create and save a new program, open an existing one and exit the application.

“Device” allows you to send a program to the controller or receive a program from the controller's memory.

To update the firmware in the latest version you must be connected to the Internet.

From “Settings” you can change the default motor speed and configure the IR sensors.

Go to [enginorobotics](http://www.enginorobotics.com) website to download the booklet or other teaching material and get help in any issue concerning your package.



ERP Simulator programming

The Simulator has the same interface as the actual device. You can click on the buttons using your mouse the same way as you would program the physical device. The Simulator has some advanced features. As it is connected real time with the other windows, a change in one window is reflected on the others, allowing easier editing. **Important: You should first set-up the Simulator the same way you have built the actual robot by dragging the Motor, LED light and Sensor icons to the appropriate ports.**

Transition from ERP Simulator to Flow Diagram:

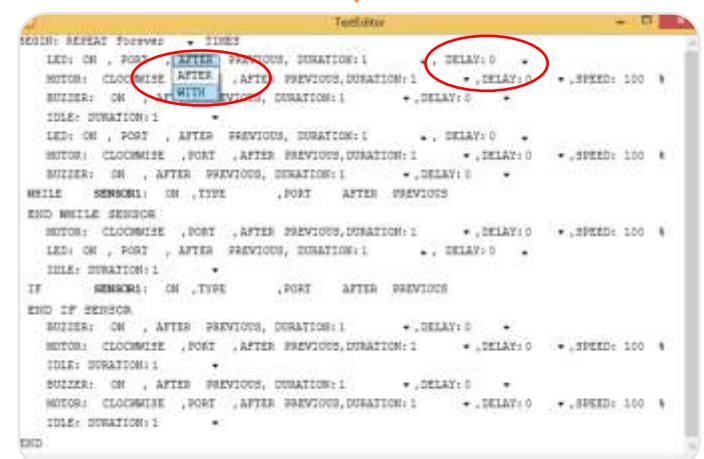
One of the great advantages of the Simulator is that it allows you to built a program very easily simply by clicking on the usual command buttons. If you click on any of the buttons on the Simulator in record mode (for example "Motor 1") you will see that automatically an icon is created in the Flow diagram under the START button. If you click on another button (for example "Led 1") then another icon will appear under the previous one creating a visual sequence of commands. The icons in the Flow diagram allow the user to edit the parameters by right clicking on each block.

Recording example 3:

Connect three motors at each of the ports A, B and C and two LED lights at each of the ports Led 1 (port 1) and Led 2 (port 3). Click on the "Program" button to record and you will notice that each step is recorded on the Flow Diagram automatically. The program you write can then be saved or downloaded to the controller using the file menu commands.

TextEditor programming

The Text Editor is a unique feature of the Engino® ERP software. You can't actually create a program from zero in the Text Editor, however you can view and edit an already existing program written in a user friendly pseudo language. The text commands are constructed automatically as you drag and drop icons on the Flow diagram or as you press the buttons on the Simulator. Each line describes each block in the same order as in the flow diagram and you can change some of the variables either from collapsing menus (e.g. choosing delay time) or by writing a value (e.g. speed). These changes affect the flow diagram and subsequently the program.



```

REPEAT FOREVER
LED: ON, PORT: A, AFTER: PREVIOUS, DURATION: 1, DELAY: 0
MOTOR: CLOCKWISE, PORT: A, AFTER: PREVIOUS, DURATION: 1, DELAY: 0, SPEED: 100
MOTOR: CLOCKWISE, PORT: B, AFTER: PREVIOUS, DURATION: 1, DELAY: 0, SPEED: 100
MOTOR: CLOCKWISE, PORT: C, AFTER: PREVIOUS, DURATION: 1, DELAY: 0, SPEED: 100
LED: ON, PORT: 1, AFTER: PREVIOUS, DURATION: 1, DELAY: 0
LED: ON, PORT: 3, AFTER: PREVIOUS, DURATION: 1, DELAY: 0
IF SENSOR: ON, TYPE: 1, PORT: AFTER: PREVIOUS
  MOTOR: CLOCKWISE, PORT: A, AFTER: PREVIOUS, DURATION: 1, DELAY: 0
  MOTOR: CLOCKWISE, PORT: B, AFTER: PREVIOUS, DURATION: 1, DELAY: 0
  MOTOR: CLOCKWISE, PORT: C, AFTER: PREVIOUS, DURATION: 1, DELAY: 0
ENDIF
END IF SENSOR
IF SENSOR: ON, TYPE: 1, PORT: AFTER: PREVIOUS
  MOTOR: CLOCKWISE, PORT: A, AFTER: PREVIOUS, DURATION: 1, DELAY: 0
  MOTOR: CLOCKWISE, PORT: B, AFTER: PREVIOUS, DURATION: 1, DELAY: 0
  MOTOR: CLOCKWISE, PORT: C, AFTER: PREVIOUS, DURATION: 1, DELAY: 0
ENDIF

```

Android and iOS applications

Install the **EnginoRobot BT** app, free of charge, available on Google Play or Apple Store. The application simulates the actual ERP device. To use it, you need to connect the controller with your smart device through Bluetooth. Push the "idle time" button on the ERP when it is switched on, open the app and connect your device with the ERP Bluetooth network.

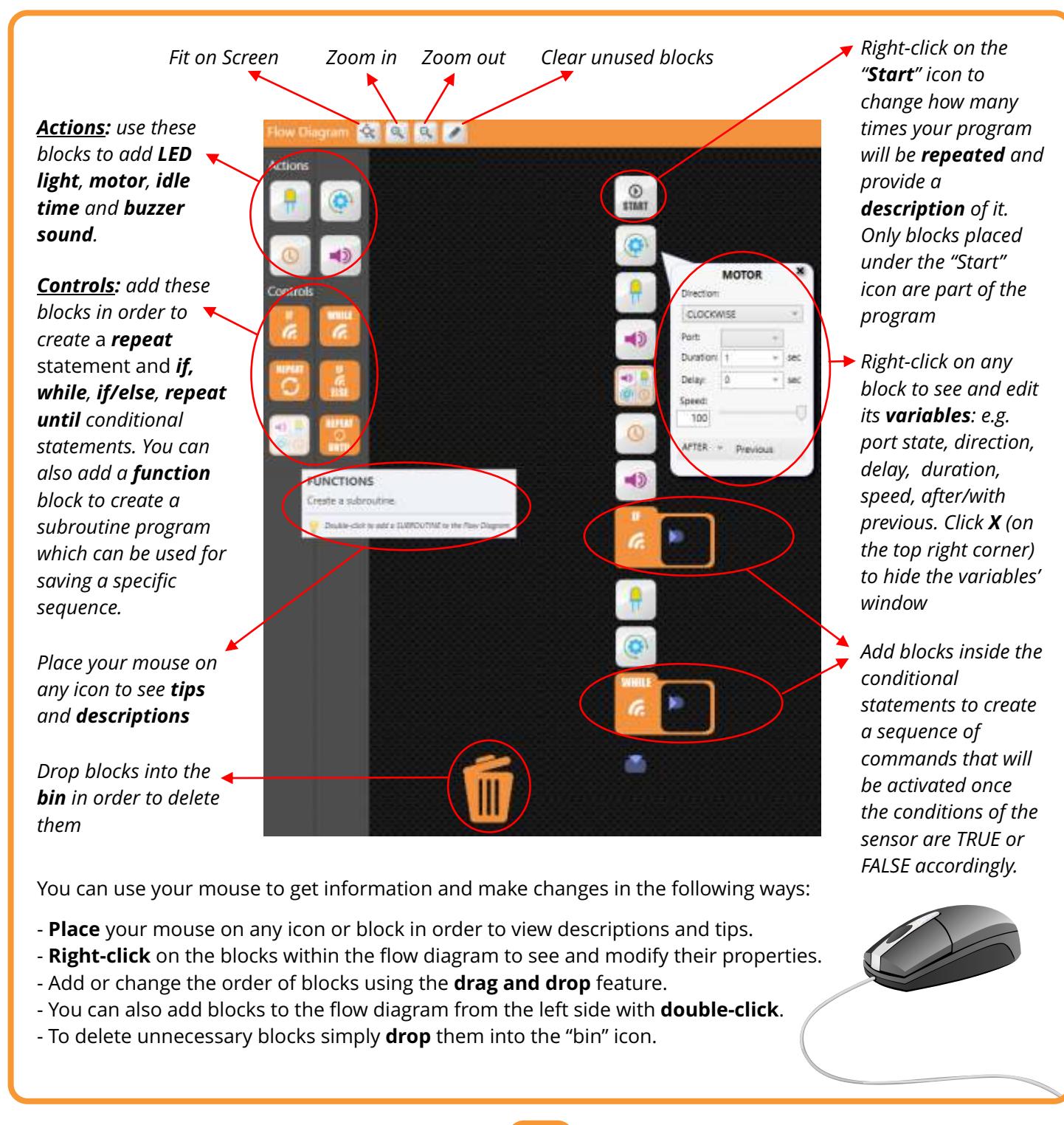


Flow diagram programming

To create a program, you can either **drag** the blocks from the left side of the screen **and drop** them below the "START" icon in the main window, or **double-click** on the blocks. Automatically, a new space (arrow) is created under each inserted block, so that the next step can be added. The order of the icons determines the sequence of the commands. With right-click on the icons the user can change the variables of each command, such as the port output, duration and order (with or after previous). When the program is completed, push the "**Send program**" button at the top control panel and the program will be transferred to the ERP controller by USB connection.

Below you can see an example of the flow diagram with descriptions of all the variables and blocks. For detailed explanations, read the next pages about:

- how to use the *action* blocks;
- the difference between *delay* variable and *idle* block;
- the *After/With Previous* variable;
- how to use *functions* to create subroutine programs;
- how to use the *GamePad* window;
- how to use the *touch* and *InfraRed* sensors;
- how to *configure the InfraRed sensors*;
- how to use the logic gates *AND* and *OR*;
- detailed explanation of two programming examples: *obstacle avoiding robot* and *line following robot*.



Actions: use these blocks to add **LED light, motor, idle time and buzzer sound**.

Controls: add these blocks in order to create a **repeat** statement and **if, while, if/else, repeat until** conditional statements. You can also add a **function** block to create a subroutine program which can be used for saving a specific sequence.

Place your mouse on any icon to see tips and descriptions

Drop blocks into the bin in order to delete them

Fit on Screen **Zoom in** **Zoom out** **Clear unused blocks**

Right-click on the "Start" icon to change how many times your program will be repeated and provide a description of it. Only blocks placed under the "Start" icon are part of the program

Right-click on any block to see and edit its variables: e.g. port state, direction, delay, duration, speed, after/with previous. Click X (on the top right corner) to hide the variables' window

Add blocks inside the conditional statements to create a sequence of commands that will be activated once the conditions of the sensor are TRUE or FALSE accordingly.

You can use your mouse to get information and make changes in the following ways:

- **Place** your mouse on any icon or block in order to view descriptions and tips.
- **Right-click** on the blocks within the flow diagram to see and modify their properties.
- Add or change the order of blocks using the **drag and drop** feature.
- You can also add blocks to the flow diagram from the left side with **double-click**.
- To delete unnecessary blocks simply **drop** them into the "bin" icon.



Actions

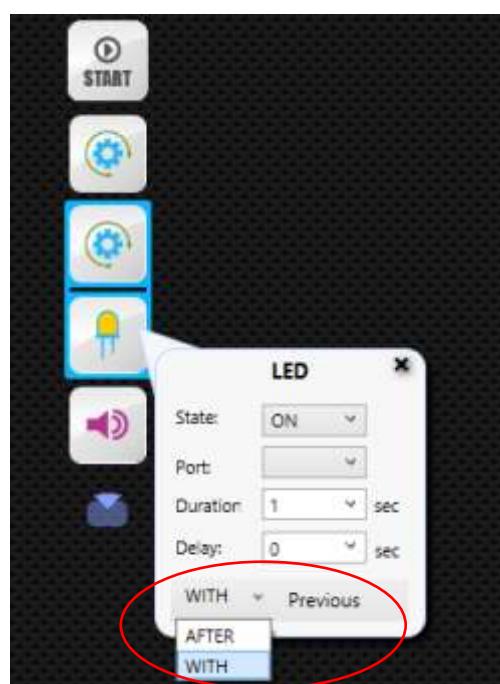
In the "actions" section, there are four blocks that either control specific peripherals (motors, LED lights) or have specific functionality (sound, idle time). In order to add an action block inside the flow diagram, simply **drag and drop** the icons at the left of the screen and place them under the start block or **double-click** on them to move automatically. Once a block is inside the main screen you can **right-click** on it to change its variables, that is to change the properties of the element it controls.

Important: In order to choose the "port" variable for each action and statement, you first need to add the appropriate icons on the ERP simulator.



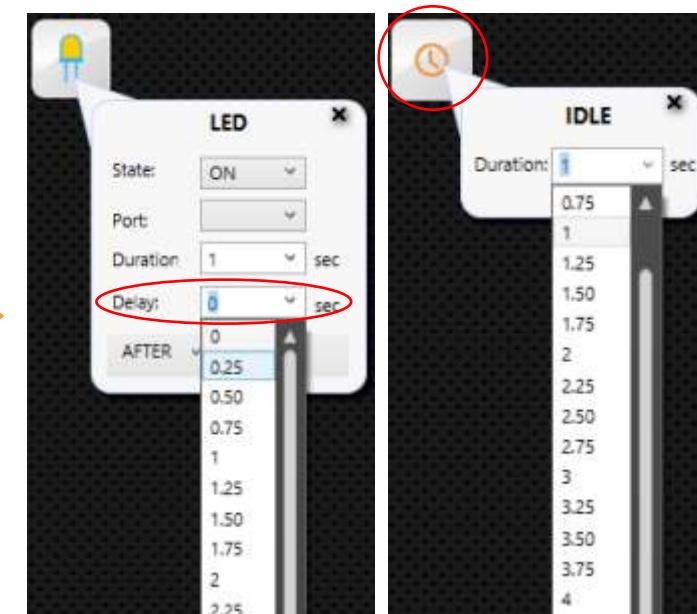
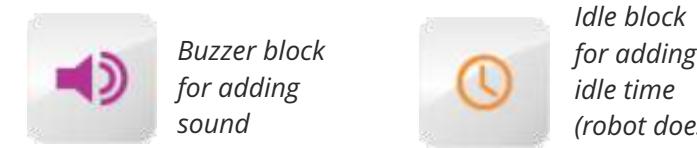
Delay variable and Idle block

The "Delay" variable is considered to be a more advanced feature as compared to the "Idle" block. The "Idle" block simply defines a period of time when the controller will do absolutely nothing and it starts counting idle time after the previous command is finished. The "Delay" variable works in parallel with the previous command and delays it by the set period of time. If the new command for example is "After Previous" then the "Delay" will behave exactly like the "Idle" block. However, if the new command is "With Previous" then the "Delay" will postpone the beginning of the particular command while the others are running in parallel. The "Delay" time starts counting from the beginning of the "With Previous" sequence.



The motor does not work if the switch is on position **0**. In position **II** the motor works in the direction of the ERP. In position **I** the direction is reversed.

Motors do not need extra batteries to work.



After/with previous variable

As mentioned before, Engino Robotics has created an innovative way of parallel programming (various tasks executed simultaneously by the robot). For this, you can right-click on any block inside the program, thus opening a tab with all its variables. Within this tab you can find the "After/With Previous" variable. By default, this variable is set as "After Previous", which means that the command (block) will be executed after the previous command is completed. If you wish the command to run in parallel with the previous one, select "With Previous". The blocks that work in parallel are joined together with a coloured line. This applies for as many blocks as the user wishes to work together including the conditional statements of the sensors and the blocks they contain. The "Idle" block and "Functions" do not have this feature.

Controls - Functions block

A function is a subroutine program with specific sequence of commands. It is basically a program within the program, that can be saved, edited and **repeated**. Functions can be quite useful when you want to add a routine fast e.g. *wheels moving forward*, without the need of adding blocks and editing the variables every time.

In order to add a function simply drag the "functions" block from the left side of the screen (under controls) inside the flow diagram. Right-click on the block to view its properties. You can find already saved functions in the **drop-down menu** or search for them by clicking on the "Open from drive" button. You can have a quick view in text form of the subprogram by clicking on the "Quick view" button or see a description you wrote by clicking on the "Description" button.



To change the properties of a function you can click on the "Edit" button or create a new one with the "New Function" button. On the new pop-up window you can find the same blocks and use it the same way as with the main program. There is also a separate subroutine TextEditor. Once you finish editing, you can save the function by clicking on the save/load icon and exit the subroutine window to get back to the main screen.



The difference between "function" and "repeat" statement (described in the next page) is that in a function program you can add conditional statements (like if and while), but in the repeat statement you can only add action blocks and just set the number of times they will repeat. Also, a function can be saved.

GamePad

The Gamepad can be used to control two motor ports (A, B, C) simultaneously. In order to enable it, first connect your PC with the robot through a USB cable and click on the "USB" icon. Then click on the "GamePad" icon found under the main menu. Inside the GamePad window find the "Ports" menu and choose the pair of ports you wish to control: A-B or B-C or A-C. The system will lock your selection and you can only select another pair if you uncheck the small square. To control the robot, click on the arrows or use the arrows on your keyboard. By clicking on the program button you can record every step and transfer it on the flow diagram at the same time. The GamePad can be quite useful in situations that you wish to put a robotic vehicle into motion in an easy way, without thinking about the direction of rotation of the motors (clockwise and anti-clockwise).



You can use the keyboard arrows to control the ERP

Sensors

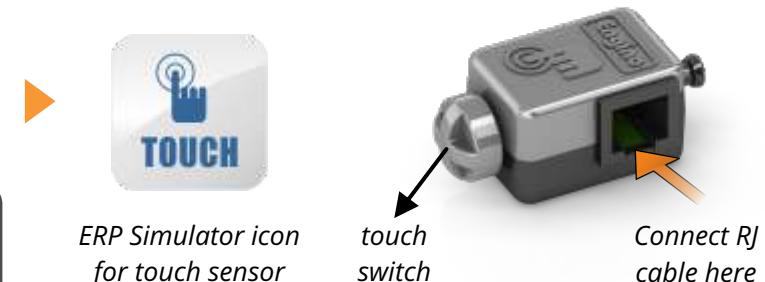
Your set includes two types of sensors: a **touch sensor** and an **infrared sensor**. Even though the ERP can work with either analogue or digital sensors, these two particular sensors are treated as digital and therefore there is no need to distinguish between the two in the program. A digital sensor sends a simple signal (state) back to the controller, either TRUE or FALSE.

The ERP software has two commands developed for robotic programming that make it easy even for beginners to create complex programs. This is based on the "WITH / AFTER PREVIOUS" variable which enables the program to check whether the sensor is TRUE or FALSE, while all the other previous commands are being executed. Conventional flow diagrams would require a loop within a loop, but ERP software solves this problem, reducing the programming steps significantly.

Touch sensor

You can connect the Engino® touch sensor through RJ cable at the **ports 1, 2, 3 and 4** of the ERP controller. The Engino® touch sensor is basically a **touch switch**.

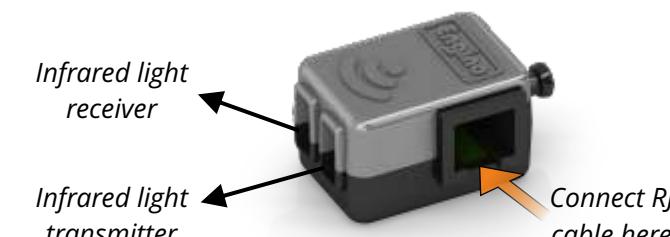
When the **switch is pressed** the circuit closes, there is a current flow and the sensor is **TRUE**.
When the **switch is not pressed** the sensor is **FALSE** because no current is flowing through its circuit.



Infrared (IR) sensor

You can connect the Engino Infrared sensor through RJ cable only at the **ports 2 and 4** of the ERP controller.

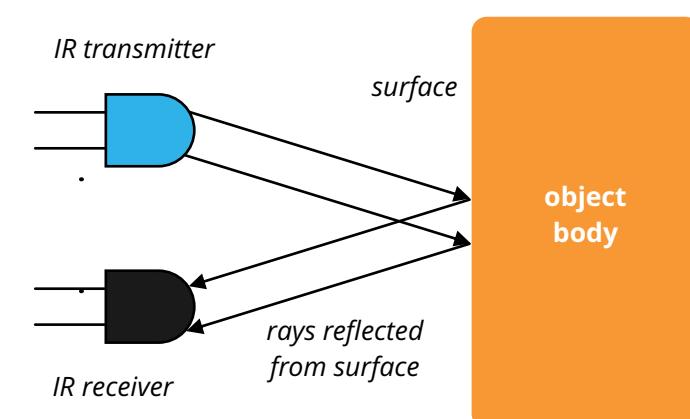
The Engino® infrared sensor is an **active** IR sensor consisting of two elements: an **infrared transmitter** (source) and an **infrared receiver** (detector). The IR source is an LED that emits infrared radiations within the near infrared region (700nm to 1400nm) of the electromagnetic spectrum. These are invisible to the human eye. When the radiation reaches an object, some of it is reflected back to the IR receiver, which is a phototransistor specially made for detecting infrared radiation. Based on the intensity of the reception from the detector and the instructions from the program (configuration) the sensor is either TRUE or FALSE.



ERP Simulator icons for IR Line Follow and for IR Object Detection

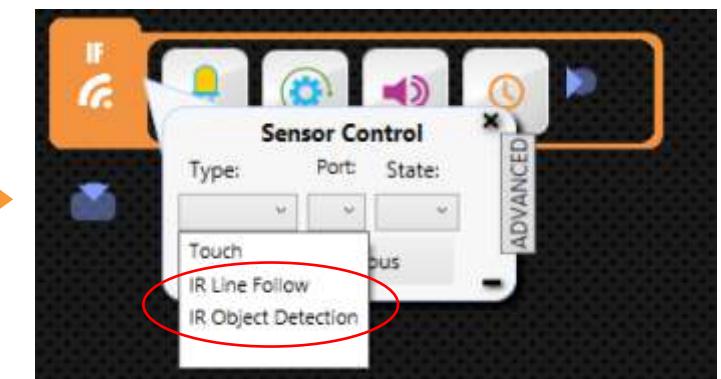
The IR sensor can be used on a robot in 2 situations: for detecting objects in its path and for distinguishing between black and white colours. In the first case, the object reflects the emitted radiation back to the receiver reducing the resistance of the phototransistor thus changing the current flow. The sensor is in TRUE state when it gets a lot radiation back from an object and in FALSE state when little or no radiation hits it.

In the second case, it is well known that white colour reflects the entire radiation that falls on it, while black colour absorbs the entire radiation that falls on it. So, for example the robot can follow a black line drawn in a white background, as it will get opposite readings between the different coloured areas.

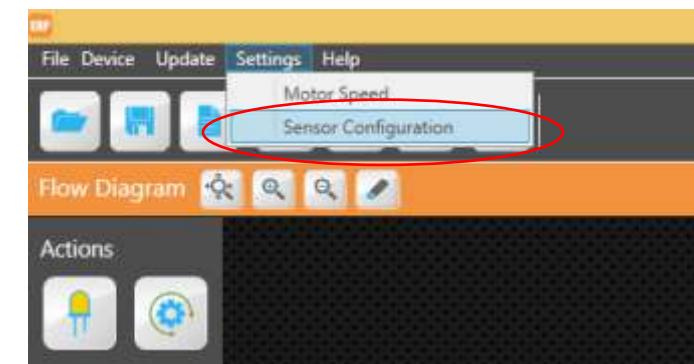


Infrared sensor configuration

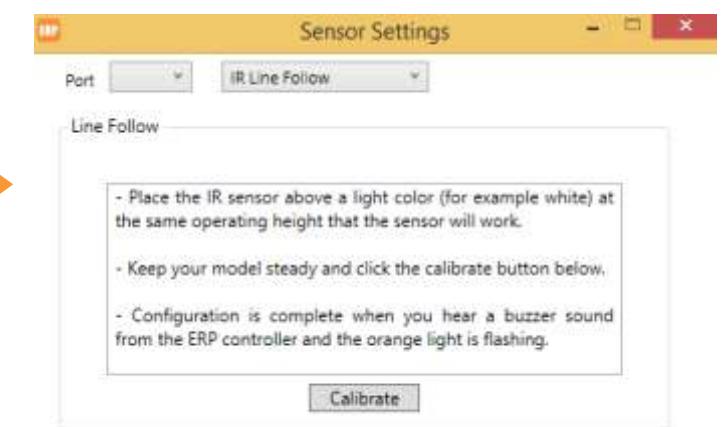
When you create a program that contains an infrared sensor you will need to configure its state so that the robot will "know" when to act in a TRUE or FALSE situation. This can only be done within the ERP software. Place a conditional statement (if, while etc.) inside the flow diagram and make a right-click to view its properties. Click on the drop-down menu of the "Type" variable and choose between two types of IR configurations: **Line Follow** and **Object Detection**, depending on what you want your robot to do.



Remember to place the correct sensor icon in the port of the ERP Simulator according to your robot's set up (either 2 or 4 for the Infrared sensors) and choose the corresponding port in the statement menu.

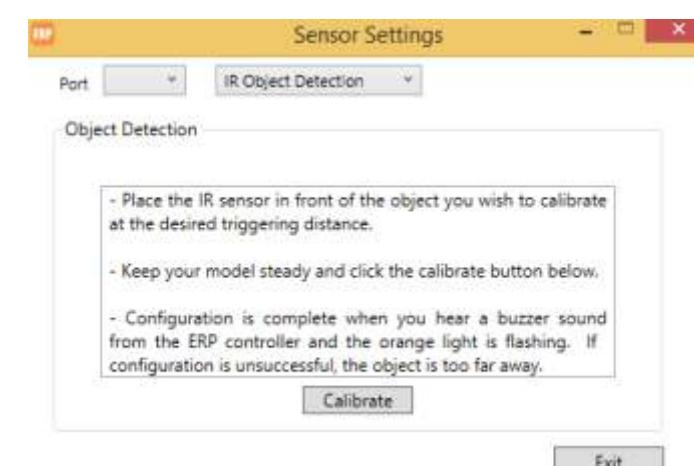


The configuration is done from a special window. To view this, go to the main menu and under "Settings" tab choose "Sensor Configuration". Inside the pop-up window choose the configuration you wish to make in the same type as in the conditional statement block.



From the **line follow configuration** window choose the correct port and follow the instructions. Note that this procedure works only with light colours, so do not use black colour for configuration. *"Place the IR sensor above a light colour (for example white) at the same operating height that the sensor will work. Keep your model steady and click the calibrate button below. Configuration is complete when you hear a buzzer sound from the ERP controller and the orange light is flashing".*

State **TRUE** activates the IR sensor for **white colour**. State **FALSE** activates the IR sensor for **black colour**.



From the **object detection configuration** window choose the correct port and follow the instructions. *"Place the IR sensor in front of the object you wish to calibrate at the desired triggering distance. Keep your model steady and click the calibrate button below. Configuration is complete when you hear a buzzer sound from the ERP controller and the orange light is flashing. If configuration is unsuccessful, the object is too far away".*

State **TRUE** activates the IR sensor for distances **equal or smaller than the triggering distance**. State **FALSE** activates the IR sensor for distances **larger than the triggering distance**.

Important: You can only have one configuration mode each time, either line follow or object detection and the triggering point for TRUE or FALSE will be the same for both IR sensors. Also, for more accuracy, note the following factors: 1) light; configure the sensors within the environment where the robot will be used e.g. in a room with the same light. 2) reflection and transparency; an object that reflects light (e.g. a mirror) works as if it was white colour, while a transparent object works as if there was no object at all.

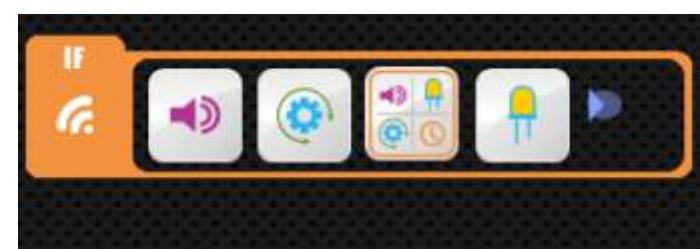
Controls - Statement blocks

A statement is simply a set of instructions that tells a robot what to do. In the Engino software, statements are formed by placing the appropriate blocks inside the flow diagram. There are five types of statement blocks: **If**, **While**, **Repeat**, **If/Else** and **Repeat until**. These can be found on the left side of the screen and you can add them in the flow diagram with double-click or drag and drop. Place elements or function blocks inside the statement blocks in order to create a sequence of commands. Note that you cannot place other statements inside the statement blocks directly. If you wish to add a statement within a statement you can use a function block.



Conditional statements

The decision making capability of the robot is based on sensors' feedback. The statements of the sensors are called conditional because they are executed only when the condition of the sensor is met. There are four conditional statement blocks: **IF**, **While**, **IF/Else** and **Repeat until**. Right-click on the blocks to change their properties: *type of sensor, port, state, after/with previous, advanced menu and logic gates*. If the commands are in conflict (e.g. controlling the same port) then by default the new command will apply.

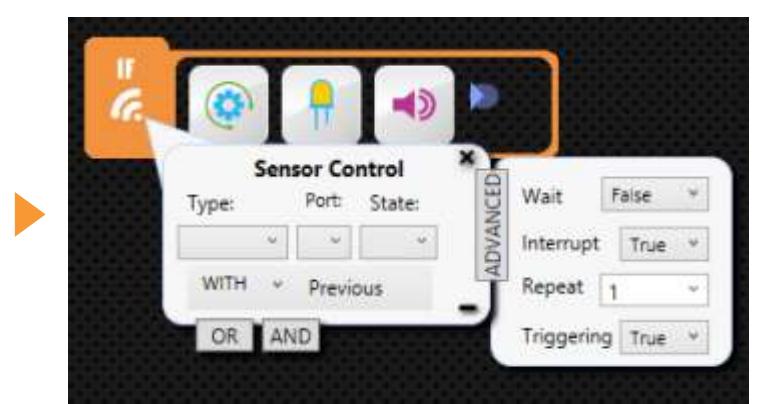


While conditional statement: the WHILE block is activated as long as the condition of the sensor is met (True or False), thus playing the subprogram in a loop. Once the condition stops, then the loop will stop too and the rest of the program will continue accordingly. For example, *while the touch sensor is pressed, the buzzer and LED light will be on (until the sensor is released)*.



Repeat statement

The "Repeat" block is used for repeating a specific sequence of commands. Inside the statement you can put any action or function block in order to create a routine. Then right-click to set the **number of repeats**.

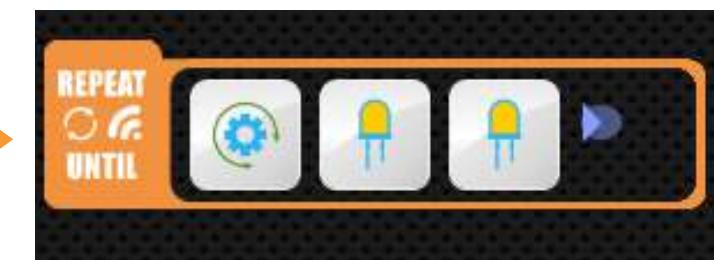
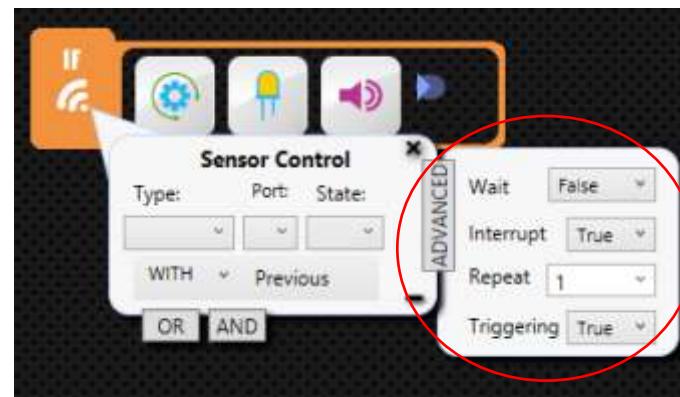


IF conditional statement: the IF block is activated when the condition of the sensor is met (True or False). For example *if the IR sensor detects black colour then the motor will rotate clockwise*. Note that if the sensor is activated for a second time, the loop will start again even if the previous sequence is not finished.



IF/ELSE conditional statement: the IF/ELSE block has two parts. The sequence in the first part is activated when the condition of the sensor is met (for example True), the same way as the IF block. When the condition is opposite (for example False) then the robot will execute the ELSE sequence, that is the blocks placed inside the second part of the block.

Repeat until conditional statement: the REPEAT UNTIL block is used for repeating a specific sequence of commands that will stop only when the sensor is activated. In other words, the program gets into a loop when it reaches the block and gets out of it when the condition of the sensor is met. For example *motor rotates continuously until the touch sensor is pushed*.



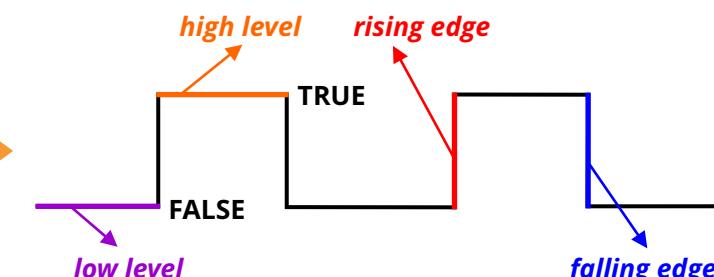
Advanced menu

Repeat: with this variable you can set how many times the conditional statement will be executed. To do this change the number inside the box (by default is "1").

Interrupt: control whether the statement will be interrupted (true) or not (false) when called by another statement. For example, a motor rotates when a condition exists. If interrupt is "true" and another statement calls the motor, even if first condition still exists, it will go to the second one. By default is "True".

Wait: control whether you want the robot to wait until the conditional statement is executed and then continue with the rest of the program. In other words, the remaining program (blocks outside the conditional statement) will continue only when the sensor is activated. To set this choose "True" on the drop-down menu (by default is "False").

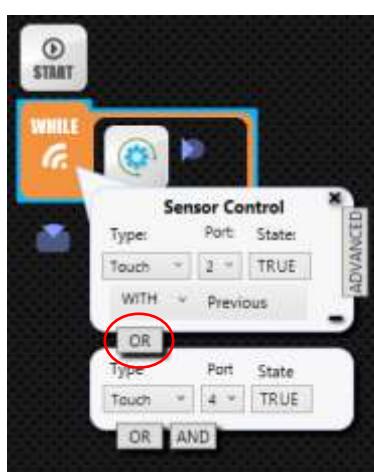
Triggering: control how the sensor is activated electronically. If triggering is "True" (default value) the sensor is activated on the *rising edge* or on the *falling edge* of the digital signal. This practically means that a touch sensor would activate when it makes the *transition from not pushed to pushed* (rising edge) or *from pushed to not pushed* (falling edge), depending on the state of the sensor (TRUE or FALSE respectively). If triggering is "False" the sensor is activated on the high level or on the low level of the digital signal. This means that a touch sensor would activate when *is pushed* (high level) or *not pushed* (low level), depending on the state of the sensor (TRUE or FALSE respectively).



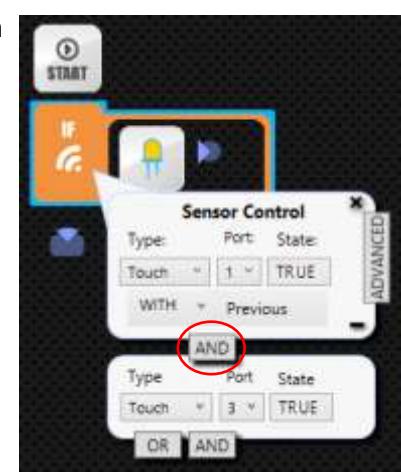
Logic gates

A logic gate is the application of Boolean algebra in electronics. The Boolean algebra has two values: 1 for True and 0 for False. For the ERP, two logic gates are used: OR and AND. Their results help the robot decide whether it will execute the conditional statement or not. To use them, right-click on any conditional statement block and find the logic gates at the bottom of the "sensor control" menu. Click **—** (at the right-down corner) to cancel the logic gates.

OR logic gate: When one or both inputs are "True" then the output is "True". Only when both inputs are "False" the output is "False". For example, *the motor will rotate while sensor 2 or sensor 4 or both are activated. If none of the sensors (2 and 4) is activated the motor will not rotate*.



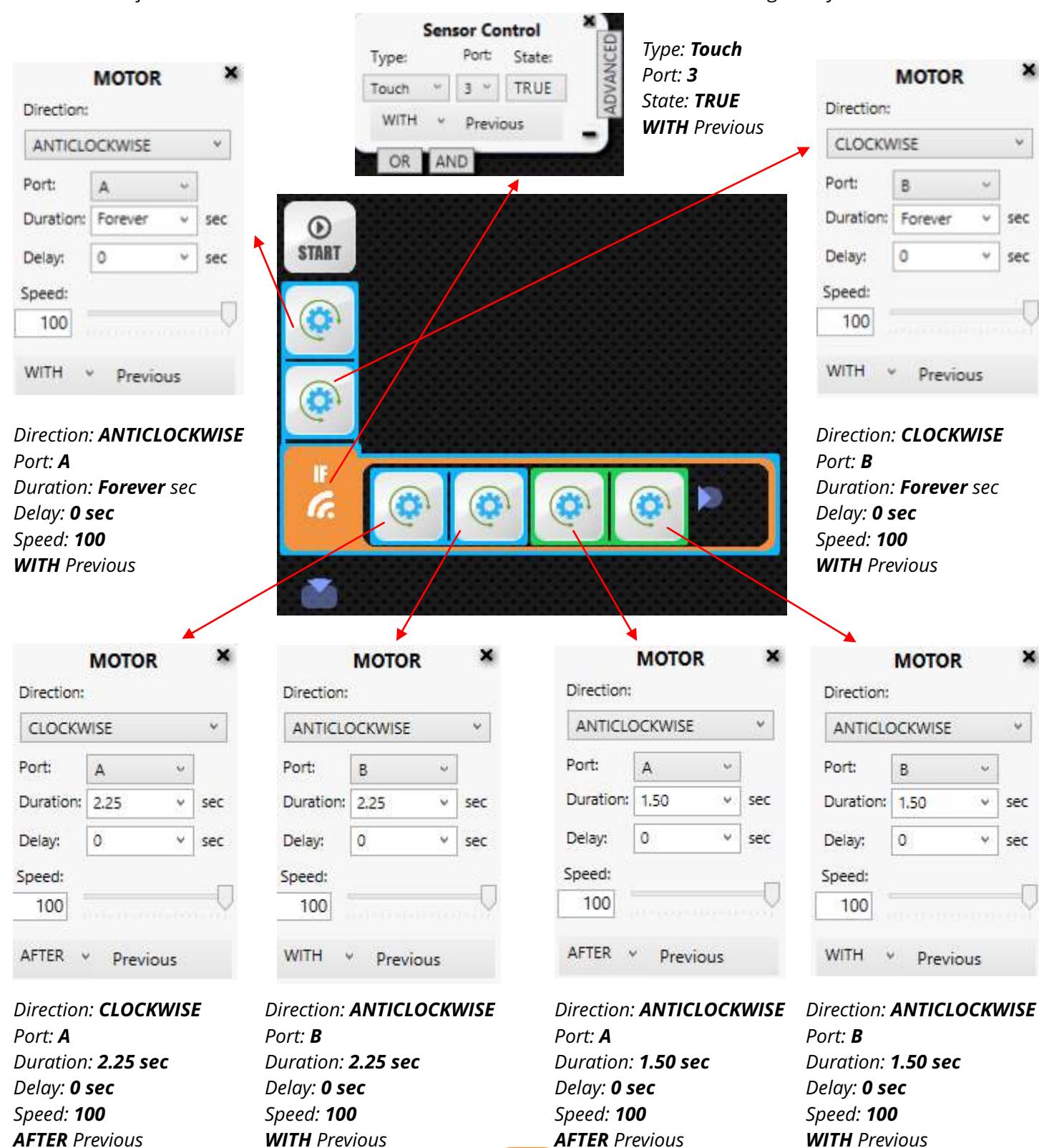
AND logic gate: When both inputs are "True" then the output is "True". Otherwise, the output is "False". For example, *the light will work only if both sensors 1 and 3 are activated at the same time. When one of the two or none of them is activated, the light will not work*.



Example program 1: obstacle avoiding robot

Follow the instructions below in order to create your own "obstacle avoiding robot" using a touch sensor:

- Find the instructions in **pages 53-55** and build the Engino **jeep car robot**.
- Make sure you connect all cables correctly. The touch sensor must be connected in **port 3** of the ERP controller.
- Open the ERP software on your PC, turn on and connect your robot with USB cable and click the USB button.
- Place the appropriate icons on the ERP simulator according to the model (e.g. motor in port A, TOUCH in port 3).
- Create the program you see below and right-click in every block to adjust the variables.
- Send the program to the ERP device (click on the send button).
- Place the jeep car on the floor. Put motor switches in position **II**. Then push play to test the program. The car should move forward until it finds an obstacle (for example a wall) and the touch sensor is activated. When this happens it should move backwards and turn 90 degrees to the right in order to avoid the obstacle.
- You can adjust the times for more accurate motion and also add buzzer and LED lights if you wish.

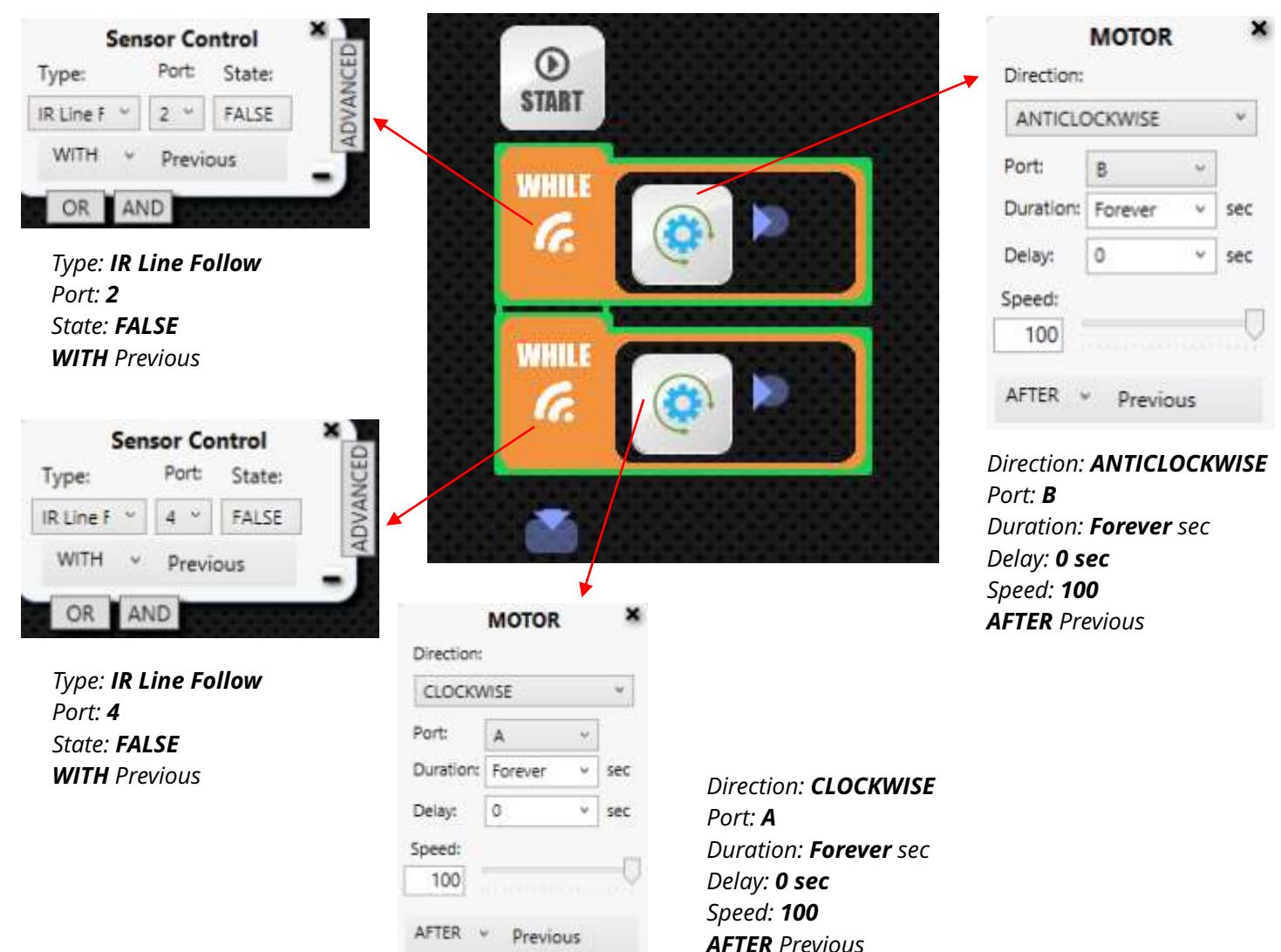


29

Example program 2: line following robot

Follow the instructions below in order to create your own "line following robot" using two infrared sensors:

- Find the instructions in **pages 56-58** and build the Engino **humanoid robot**.
- Draw a black line 5 cm thick on a white piece of paper with a black marker (alternatively you can stick black tape) and create a path with smooth turns. You can also download a path at enginorobotics website (see below).
- Open the ERP software on your computer and connect your robot with USB cable (click the USB button).
- Place the appropriate icons on the ERP simulator according to the humanoid (e.g. IR LINE in ports 2 and 4).
- Create the program you see below and right-click in every block to adjust the variables.
- Configure the IR sensors in ports 2 and 4 so that they activate when they detect black colour (State FALSE). For this go to the main menu and choose "**Settings/Sensor Configuration**" and follow the instructions.
- Send the program to the ERP device (click on the send button).
- Place the humanoid on the black line with sensors looking downwards. Put motor switches in position **II**. Then push play to test the program. The humanoid should follow the black line and stop at white colour.

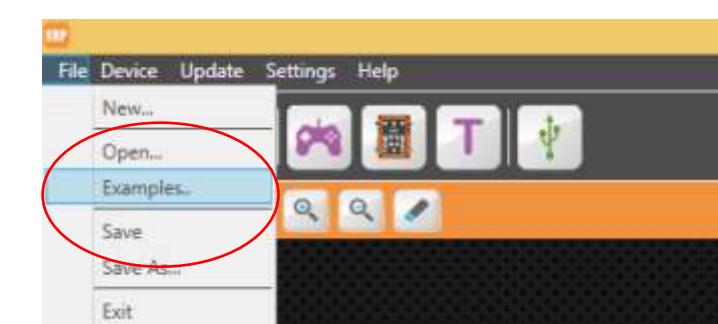


30

More examples, templates and solutions

You can find examples, printable templates and the solutions to the experimental activities at the website: www.enginorobotics.com/teaching_resources/examples

You will need to complete a simple form to gain access. In order to view an example program simply go to the menu on the top left corner, click "File" and then "Examples...". Choose the example you want according to the Engino robotic model you have built. The program will appear inside the flow diagram.



Theory

What we will learn

"At bottom, robotics is about us. It is the discipline of emulating our lives, of wondering how we work". This quote from the professor of Computer Science Rod Grupen best describes how scientists perceive robotics: a simulation of real life functions using mechanics and computers. But will humanity ever be able to create robots that have feelings and can truly take their own decisions in situations that are not predicted in a programming language? Whatever the future holds, young people of today must have a clear view of what robots are, starting from the basics of robotics and programming sciences and ending up building their own fully functional devices! The next pages are specially designed with this idea in mind!



Robotics cannot exist without computer programming

This booklet of **Discovering STEM: Robotics** contains a comprehensive **theoretical section** with building challenges and interesting facts, so that you can learn all about robots and their applications in daily life. The booklet also contains an **Engino® Robotics Platform (ERP) manual**, explaining in detail all aspects of Engino's innovative robotic system. Discover all the scientific principles applied through **experimentation**, step-by-step guides and fascinating exercises. Follow the **building instructions** to build exciting robotic models such as **an experimental robot, a dinobot, a forklift, a jeep car, a humanoid, a grabber, a house and a pedestrian crossing**. A lot more learning material is available online!



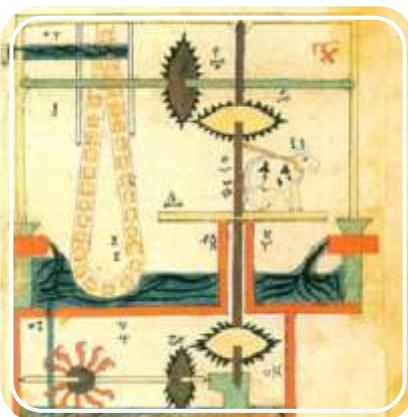
Automatic devices were found in hieroglyphics

Ancient inventors and craftsmen set out to build the early "robots". These ranged from simple to complex devices designed to perform various tasks in seemingly autonomous ways. Hence, they are called automatons, translated from Greek as "acting on one's own will", even though technically this was not actually the case. As early as the 4th century BC, Archytas had supposedly created a steam flying device called "pigeon". People of his time said that his machine could fly a distance of 200 meters! Heron of Alexandria (10 - 70 AD) was also an inventor who had many creative ideas such as the automatic opening of temple doors, wine purring statues and steam or wind powered machines such as his famous "aeolipile".



Modern replica of Heron's aeolipile device

03



Al-Jazari's drawing of a hydropowered chain pump

In 1898, the Serbian-American inventor Nikola Tesla demonstrated the first radio-controlled vessel. Real robots, meaning those that are able to receive feedback from their surroundings and react to it, only appeared in the 20th century. In 1948, Grey Walters created small robotic turtles with light and touch sensors that could search for "food". Some years later, George Devol patented his Unimate robot that was capable of doing industrial work. This was installed in 1961 in a factory to lift hot pieces of metal from a die casting machine and stack them up.



A Unimate robotic arm

History of Robotics

The history of robotics has its origins in the ancient world. Since antiquity, people were thinking about artificial constructions that could replace humans by doing different tasks, as having minds of their own. A Greek myth tells the story of Talos, a gigantic bronze humanoid that was built by Hephaestus (the Greek God of blacksmiths), for protecting the island of Crete. Accounts of robot-like creatures are found all over the world from Norway to Middle East, India and China, in various forms: texts, drawings, paintings and even in ancient Egyptian hieroglyphics.



Did you know?

The science fiction writer Isaac Asimov devised the **"Three law of robotics"** in his short story "Runabout" published in 1942. These are: 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 Law.



Isaac Asimov (1920 - 1992)

In the middle ages, we can find many examples of automatons, usually in the form of animals or humans. People built fun machines that were programmed to do simple tasks like moving their feet or turning their heads, using precise clockwork technology. The Muslim engineer Al-Jazari (1136-1206) described 100 automated, mechanical devices in his book: "The Book of Knowledge of Ingenious Mechanical Devices". Later on, the french inventor and artist Jacques Vaucanson (1709 - 1782) played an important role in robotics' development as he tried to demonstrate how things work in nature. Some of his inventions included figures that play real instruments (flute and tambourine) and the famous "digesting duck", which imitated food digestion.



Two types of Roomba vacuum cleaners

04

Definition of Robot

The term "robot" was first introduced in 1920 by the Czech writer Karel Capek in his novel R.U.R., meaning "labour" in Slavic language. This shows how people first conceived the notion of robots: "devices performing tasks that are too dangerous, complicated or just boring for humans to do". However, a more scientific definition is that a robot is a mechanical device that receives feedback from its surroundings and is able to respond to it accordingly. Therefore, robots have, to a certain degree, real autonomous behaviour and in a way they think and act for themselves. However, this depends on their program language and their pre-determined commands.



Robotic metro doors with touch sensor

Types of Robots

Robots come in a variety of forms and shapes and can perform single or multiple tasks in different settings and conditions. In this way one robot may belong to more than one category. So, how can we distinguish one from another? A handy categorisation can be according to the functionality of each robot. This gives us some information about the usefulness of the robot and an idea of how it should look like or what components should have in order to perform well. The main types according to function are described below:



Industrial robotic arm

Industrial robots, which are automated robots used in factories for lifting heavy objects or making routine jobs e.g. welding, painting and handling materials.

Entertainment robots, which are robots made mostly for fun and have less practical use, e.g. robotic toys.



Robotic arms used in a car assembly line

For example, an automatic sliding door (found in shops, hotels etc.) is robotic. It has a motion sensor which sends a continuous infrared signal. If this signal is interrupted, because someone gets in front of the invisible beam, the central processor gives the command for the door to open. After some seconds the door closes and the procedure is repeated. Other examples of robots include domestic heating systems and motion-activated lights. However, remote controlled cars or toys are not robots. They just receive direct commands through a controller in order to move. As this is not feedback, they are not able to make decisions concerning the objects around them e.g. stop before hitting the wall.



Robotic pool cleaner



Toy robot



Bomb disposal robot



Water robot

Medical robots, used in health sector (hospitals, pharmacies, clinics and medical centres) for training doctors or even performing accurate procedures e.g. surgery robot.

Military robots, which are part of advanced armies and police forces. They are used instead of people, usually in life threatening situations, for transporting ammunition, bomb disposals or even engaging in war fights, e.g. small tank robots.

Domestic and service robots, which are robots designed for commercial everyday use at home or at work, making life somewhat easier e.g. vacuum cleaner robot.

Exploration robots, which are robots used for exploring harsh environments that are too difficult for people to reach like Earth's caves, oceans (e.g. water robots) or even other planets.

Virtual robots, which are robots used in virtual conditions. These are usually some type of large, eye-covering glasses with screens assorted with special gloves in order to see and feel inside the world of augmented reality.



Virtual reality gear

Hobby robots, which are robots created from robot-enthusiasts rather than large production companies. Their purpose can be experimental for testing different components and technologies or simply recreational e.g. flying drone.

Competition robots, which are robots made for competing other robots in different challenges. This category is similar to the previous one because hobbyists are those who usually organise competitions in order to test their robots' skills and gain valuable experience. Competitions are also held among robot development teams from around the world, helping them to improve their designs.



Robot football players



Flying drone robot

Applications in real life

The 21st century is surely the age of robotic science and advanced technology! Robots can be found everywhere, not only the ones with the humanoid look that people know best, but often in very simple forms like heat sensing systems in houses and distance sensors in cars. The applications of robotic systems in daily life are vast and people are becoming more and more dependable on them. Read below about some characteristic examples of robotic usage and challenge yourself by building and programming the suggested models from **Engino® Robotics**. You can find the models' building instructions in the last pages of this booklet.

Building Challenge

Traffic lights: traffic control is a very important aspect of road safety, for both drivers and pedestrians. Robotic systems make sure that each traffic light is on at the correct time and order. Especially, in pedestrian crossings (zebra type), people cross the street with the help of a touch sensor. This is set to execute the following sequence: from green light on, it changes to orange light and then to red light for cars and in parallel, it switches from red light on to green light for pedestrians, while emitting a beeping sound. After some time the reverse sequence is activated to bring the lights back to their normal state.

Try out this fun exercise by building the Engino robotic model of "pedestrian crossing" (pages 64-67) and help the Engino® man to walk across the road in a safe manner! Use the printed cardboard for the road found in the set.



Engino® "pedestrian crossing" model

Building Challenge

Dangerous missions: robots can successfully replace people when it comes to dealing with dangerous tasks. This way human lives are not put in risk and missions are completed faster and better because of the advanced capabilities of robots. For example, a robot can detect dangerous materials which can be defused with the help of remote human control. The operator uses the sensors of the robot to see and manipulate the bomb.

Build the Engino® "Humanoid robot" model (pages 56-58) and put the IR sensors face down to follow a certain path or face forward to detect "dangerous" objects and warn with sound. You can also control its movement with the EnginoRobot BT application through a smart device.



Engino® "humanoid" model

Building Challenge

Industrial use: another increasing use of robotics is in the industrial sector, where robots replace the work of people. These are usually stationary or line-guided moving robots that have a flexible arm for lifting heavy objects or doing delicate work (like welding). They are ideal for factory assembly lines. People worry that automated procedures result in less jobs, but this is not true as new positions are created for handling and fixing the robotic machines, not to mention the better quality of products.

Build the Engino® "grabber robot" (pages 59-63) and program the touch sensor to pick up objects. Guide its movement with the help of IR sensing technology.



Engino® "grabber" model

Space exploration

People have always been amazed by the wonders of outer space and the prospect of exploring new worlds or even discovering alien life forms. However, the conditions outside Earth's atmosphere can be devastating to humans: solar storms, lack of oxygen, gravity fields and absolute zero temperatures (-273 degrees Celsius) are among the dangers. All these require very expensive space suits and years of training and planning just for a short stroll around the Earth or on the Moon. As for distance (e.g. a journey to another planet) explorers must be willing to return to Earth after decades of years or even not at all!



Mars Rover "Curiosity"



Mars Rover "Opportunity"

Building Challenge

Robotic houses: modern houses are becoming increasingly "smarter" and many manual functions are now done automatically! For example, automatic doors open and close using motion detectors, while heat sensors detect variances in temperature and activate the cooling or heating system. Engineers are already experimenting with smart fridges that will be able to re-stock on their own by detecting the absence of specific products (milk, eggs, butter) and ordering them online!

Experiment with house automation by building the Engino® "automated house" model (pages 68-70). Set the door and fan into motion using IR or touch sensors.



Engino® "automated house" model

Did you know?

On November 12th 2014, for the first time in history, a robotic module named *Philae* landed on the surface of a comet! This impressive feat was part of the *Rosetta Space Mission*, a robotic space probe that was orbiting and studying the comet 67P since January 2014. The mission seeks to find if the comet can provide a key to deciphering the origins of the solar system and life on Earth.



Representation of the Rosetta Space Mission

Robotic components

As we have seen so far, there are tons of different types of robots, used in a variety of applications. People, basically, interact with robots on a daily basis without even noticing it! Although there is such an abundance of robots, they have three common components: a mechanical form of structure, a controller which contains the necessary hardware and a variety of peripherals for interacting with the environment. Of course, robots also require some sort of power source that comes in the form of a battery carried by light weight robots or power socket connection for stationary and heavy robots.

Structure

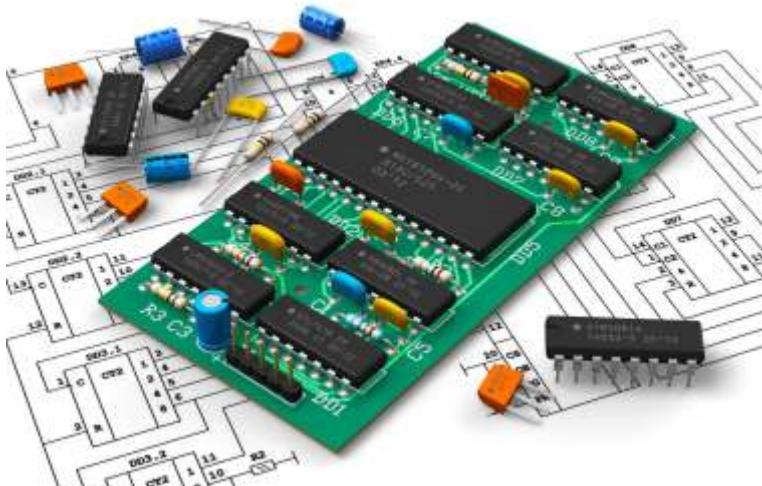
Robots have a specific type of structure according to their functionality. The parts are carefully selected as to provide the chosen designed features e.g. stability, flexibility, nice look, waterproofing etc. Usually engineers draw inspiration from nature and their robotic inventions imitate aspects of life itself. Some categorise robots according to how they look and the means they use for moving. In this sense, we have the following types of structures: 1) stationary robots that do not change position e.g. arms in factories, 2) wheeled robots, with any number of wheels attached or even tracks, 3) legged robots that resemble people (humanoid) or animals (e.g. dog), 4) animal-behaviour robots, capable of swimming, flying and jumping, 5) swarm robots that have a simple design and are able to communicate with each other in order to do complex tasks (e.g. building a bridge).



A stationary robot used in medicine

Controllers

The controller is the brain of the robot. It is the main processing device that is connected with the sensors and all other electronics comprising of its "logic and senses". There are two approaches on the development of robotic controllers: a) imitation of **biological systems** and b) **Artificial Intelligence (A.I.)**. The first works at finding out how the human brain works and how it causes certain behaviours, applying this knowledge on robots. On the other hand, A.I. approach studies the computer and tries to imitate the behaviour itself using mechanical means.



Electronic components of a controller

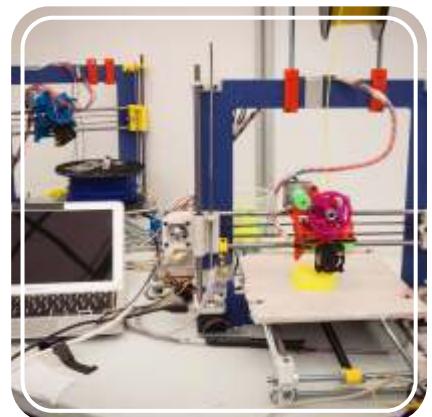


Did you know?

Swarm robots are tiny devices connected simultaneously via infrared light. These robots work together in order to form various shapes or complete complex tasks that cannot be done by single units e.g. passing over a gap. They are built in big numbers out of simple materials, have low manufacturing cost and are programmed with simple commands. They are designed mostly to provide answers related to physical laws of natural swarms (birds and insects) or to study teamwork dynamics.



Swarm robots collaborating together



A variety of peripherals make a robotic 3D printer

Peripherals

Peripherals are devices connected with the micro-controller through cables (or sometimes wirelessly) to enhance the use of a robot. These are essential to robots for utilising the tasks that were designed for and help them to interact with their surroundings. Robots receive information through different types of **sensors**. They then act accordingly using a different set of peripherals for sending information back to their environment through movement, sound, light etc. These are called **actuators** and **effectors** as they act on and affect the environment. Peripherals come in a variety of shapes, sizes, colours and functions, depending on the purpose of the robot built. Below you can see the different types of peripherals used for utilising main functions: touch and vision sensors, motion, indicators and other peripherals.



A robotic hand imitating grip



A wheeled robotic lawn mower



Smart devices connect through Wi-Fi

Touch: called also tactile sensors, they work by physical interaction with the environment and they are sensitive to touch, force and pressure. Their most common use is found on the touch screens of smartphones and tablets (capacitive and resistive sensors).

Vision: sensors that use wave technology to measure the changes in the electromagnetic radiation spectrum. The way light and other waves (infrared, sonar

etc.) bounce off different objects creates variations that can be detected and measured by the sensors. The robotic vision technology has a vast range of applications: from detecting and recognising objects (or living creatures) to motion analysis and even scenery reconstruction (e.g. 3D mapping of a building). An example of how accurate vision technology can be is the driverless vehicle, which works entirely by sensor feedback combined with GPS technology.

Motion: these are the most common output peripherals (actuators) that convert electrical or other form of energy into motion. Usually electrical motors are preferred for rotating wheels or gears with light load. More advanced robots use hydraulic or pneumatic pressure for more strength and precision (e.g. linear motion).

Indicators: robots are equipped with LED (Light-Emitting-Diode) lights and digital screens for displaying different types of indications and warnings such as flashing light, text, images or even animation.

Other: this category includes other peripherals that send or receive information. For example a microphone records sound and a speaker transmits sound back. A Wi-Fi device communicates wirelessly with computers or other robots for completing tasks (e.g. swarm robots).



Different colours of LED lights

Programming

Besides the mechanical components, programming is essential for the actual function of the robot. As mentioned before, a device is considered robotic only if it is capable of interacting with its environment. The robot interprets all the receiving information and decides on the appropriate actions according to its program, through the micro-controller. Robot manufacturers usually provide their own programming languages, resulting in many types of robotic software. Fortunately, there are few basic notions that one should follow when developing a program, which are described next.



A programmer at work

Programming languages

The most important element of any computer or robotic development is its programming language. Generally, a programming language is a set of grammatical rules and vocabulary for instructing a robot to perform specific tasks. A language consists of two main components: the form (syntax) and the meaning (semantics) of the text. There are two general types of programming languages: low-level, that use the machine way of understanding (machine code with numbers and symbols) and high-level that contain human language (in text form) and automation, making the programming process more simple and understandable to people. In computer software, the executable description of a program (created with a programming language) is called "source code". Within the source code there are algorithms, which are specific step-by-step sets of operations that need to be performed, created by single programming elements called statements (explained below).

Anyone who wishes to develop a computer program should choose the programming language very carefully, as they are designed and used for different reasons. The most common high-level languages are:

- C++ language is probably the most widely used as many applications are developed with it.
- Java can be used in any device where Java Virtual Machine (JVM) is installed, regardless of the system.
- Javascript is a client web language used for making operations on the PCs of the users instead of the network server.
- Python is considered one of the easiest programming languages to learn.



HTML language is used specifically for developing websites



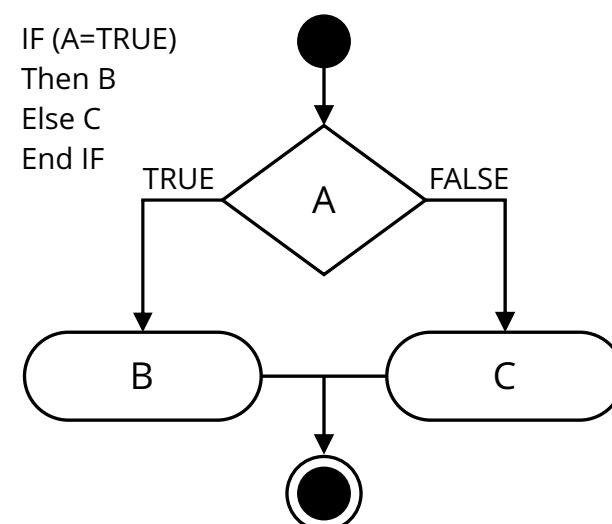
Statements are written in lines of text

Statements

In computer programming, a statement is an instruction (command) that basically tells a computer what to do. As you can imagine, these commands should be precise for the robot to function well. Moreover, the sequence of the commands, in other words "the task order", is equally important. Imagine that you follow instructions for baking a cake. If the recipe steps are incorrect or they are written in the wrong order, chances are that you would end up with a kitchen mess! In text-based programming languages, the commands are usually written line by line and contain special characters for different tasks. This is simulated in the Engino® software, which contains a TextEditor window that uses pseudo-language (not actual programming language) allowing users to edit the different commands and view them according to their sequence order as lines of text.

Conditional statements

By definition, robots are capable of making decisions depending on the surrounding conditions and their built-in program. The sensors provide the robot with a continuous flow of information from its environment. Once a specific value is reached and a predefined condition is true e.g. an InfraRed sensor detects black colour, then a sequence of commands within the program instructs the robot what to do e.g. LED light on. These instructions are called conditional statements, because the statements are executed only if a specific condition is met. The conditions are based on a True or False (yes or no) decision that usually derives from Boolean logic and Boolean algebra, meaning that the robot will execute a sequence or not according to these calculations. The Boolean logic is explained in the next page about how to calculate the true results with two examples of logic gates (AND and OR).

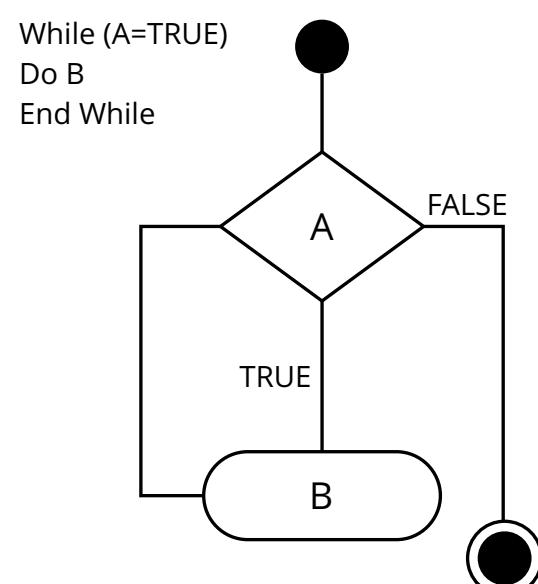


"If...then...Else" conditional statement diagram

There are slight variations among programming languages about the type and number of conditional statements, as they are used for different purposes. For robotics, there are many types of conditional statements which cover the types of decisions that a robot would make. Two of them are described briefly below.

If...Then...Else conditional statement: the idea underneath is that **if** a condition is true then the robot should execute a specific sequence; **Else** it should execute a different sequence. For example, *if Infra-Red sensor detects black colour, motor rotate clockwise; Else rotate anti-clockwise*.

While conditional statement: while a condition is true the robot should execute a specific sequence, therefore the sequence will play in a loop (non-stop). When the condition stops, the sequence will stop as well. For example, *when the touch sensor is pressed, LED light is switched on. When the touch sensor is released the LED light will switch off*.

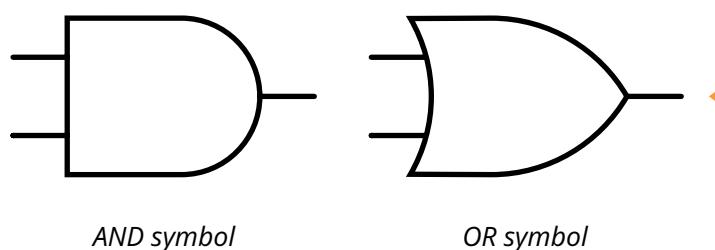


"While" conditional statement diagram



ASIMO's walking is slow because of algorithms

On the Engino® Robotics software, you can add conditional statements by using the **IF**, **WHILE**, **REPEAT UNTIL** and **IF/ELSE** blocks. Furthermore, any sequence of statements can be repeated either by using the "**REPEAT**" block, the "**repeat**" variable, loop the whole program with the "**start**" block or by using a "**function**" block.



Logic gate AND: When both inputs are "true" then the output is "true". Otherwise, the output is "false". This is seen more clearly on the next table, where there is only one combination of inputs in order to have an output that is "true" (1), while the other combinations result into "false" (0). In more practical terms, you can use the AND gate for example if you want both sensors to detect black ("true") in order for the robot to turn. If none ("false") or only one of the sensors detects black colour then the robot will not turn.

Input 1	Input 2	Output
0	0	0
0	1	0
1	0	0
1	1	1

Truth table for AND logic gate

Input 1	Input 2	Output
0	0	0
0	1	1
1	0	1
1	1	1

Truth table for OR logic gate

Logic gate OR: When one or both inputs are "true" then the output is "true". Only when both inputs are "false" the output is "false". As you can see in the next table through the OR logic gate, there are three combinations of inputs that create a result that is "true" (1) and only one combination which results into "false" (0). In comparison with the previous example, you can use the OR gate if you want any or both of the sensors to detect black in order for the robot to turn. If none of the sensors detects black colour then the robot will not turn.

Parallel programming

Very often robots have to do tasks simultaneously, for example turn their wheels, move their arms and light up LED lights all at the same time. Therefore, simply by placing commands one after the other is not enough to fulfil the required tasks. Programmers use special characters in order to create a program that contains parallel commands. However, this is not an easy task, as robotic programming languages are complex and require advanced skills in order to achieve parallelism, often with many repeated text lines.

One of the great advantages of the Engino® Robotics Platform software is that it allows parallel programming to be done very easily! The software uses visual programming (blocks instead of text), which contains an innovative After/With Previous variable allowing parallel features to run. The user can choose between "after previous" if he/she wants the command to be executed when the previous command is finished or "with previous" if he/she wants the command to be executed at the same time. The blocks that work in parallel are joined together with a coloured line. This reduces the complexity of programming in a great extent, as the order of commands become more clear and easy to formulate. With the addition of delay and duration variables, each command can start and finish in any desired order and time.



After/With Previous variable

Logic gates

A logic gate is the application of Boolean algebra in electronics. The Boolean algebra has two values: 1 for True and 0 for False and uses three operations: AND, OR and NOT. Most logic gates have **two inputs** that result into **one output**. The combination of all this data can be expressed through seven basic logic gates named AND, OR, XOR, NOT, NAND, NOR and XNOR. Their results help the robot decide which statement to follow. Here you can see examples of AND and OR.



Machine that uses manual programming

By using a **teach pendant**, which resembles a traditional controller, the user controls the robot remotely, so that it executes specific movements e.g. pick up a car part and place it on a conveyor belt. While the manual programming is taking place, the sequence of commands is generated and saved automatically, thus the robot is ready to work in the exact same way on itself. The programmers are able to further edit the code, making any changes related to speed, accuracy and fluidness of the motion. When all is set, the finished program is sent back to the robot.



A worker using a teach pendant

Manual programming

Usually the procedure to create a factory robotic program is by writing all the commands in a programming language, checking if it works for certain conditions and adjusting it back and forth until a satisfying result is reached. This process requires complex coding skills and is often limited in a specific range of motion e.g. a robot simply moves objects from one place to another. But what if we want to mimic the delicate movements of a worker to program a robot to do actual human job without the need of writing complex program instructions? Modern robotic technology allows us to do just that through manual programming.

Did you know?

The first computer programmer was a female English Mathematician, named Augusta Ada King (Countess of Lovelace). Ada wrote the first algorithm in history that was intended to be executed by a machine in 1837. Specifically, it was an algorithm to compute Bernoulli numbers using the Analytical Engine, a proposed idea from Charles Babbage for a mechanical general-purpose computer.



Painting of Augusta Ada King (1815 - 1852)



Manual programming done with ERP

DISCOVERING STEM



www.engino.com



build an experimental robot

This experimental model will introduce you to the main programming notions and the innovative Engino® Robotic Platform (ERP) controller. It can also help you test different variables and programs that you create either manually or through the software.

- What **inputs** and **outputs** are.
- How you can **manually program** a robot.

build a humanoid robot

Build this amazing humanoid robot and make use of its dual capability! With the use of programmable sensors the robot can distinguish between black and white colours or detect objects in its path. Learn how to use and calibrate the infrared sensor so that the robot can follow a line or warn you about obstacles.

- How **infrared sensors** work.
- What **logic gates** and **WHILE statements** are.

build a grabber robot

This unique grabber model simulates real life factory robots that are programmed to follow specific paths and do several tasks like carrying heavy objects. Try this yourself and learn all about loops and how to combine two different types of sensors.

- What **loops** are.
- How to use a **REPEAT-UNTIL statement**.

build a forklift robot

This exciting forklift model will help you discover the different ways of controlling your Engino® robots. Learn how to use the GamePad to move the vehicle or even program the forklift wirelessly to lift, carry and set down objects.

- How to **control a robot wirelessly**.
- Other types of **digital and manual controls**.

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ERP 1.2

DEVELOPED FOR TEACHING ROBOTICS PROGRAMMING AT PRIMARY AND SECONDARY EDUCATION

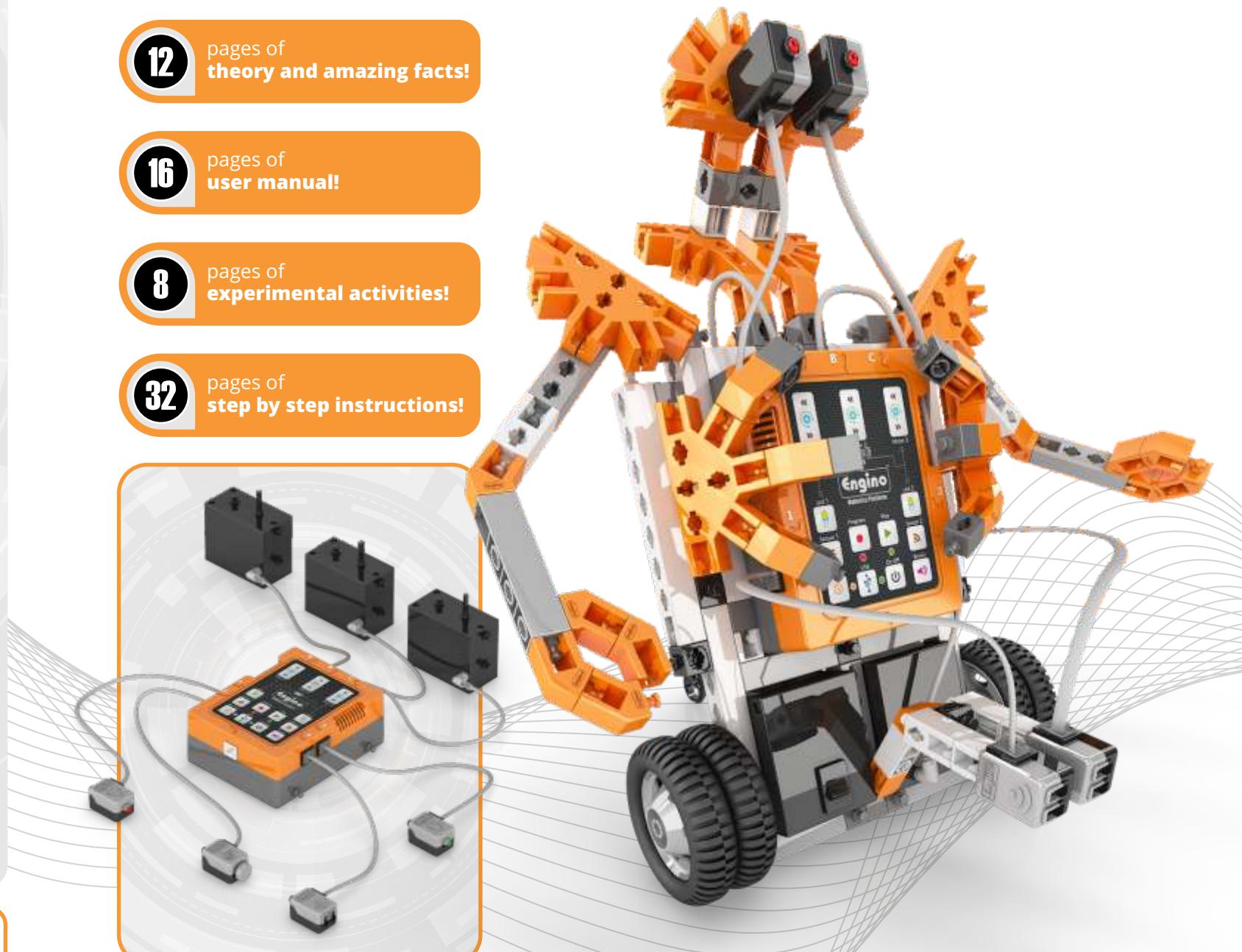
The Engino® Robotics Platform (ERP) is specially designed for Primary and Secondary school children and even robotic hobbyists! It takes into account the latest technological trends and the most modern pedagogical principles of learning. The set consists of all the necessary parts for studying robotics! These include an ERP controller, RJ cables, one touch sensor, two InfraRed sensors, three motors, five LED lights and a USB cable! You can find easy-to-follow instructions for all the robots in the booklet included. The booklet provides detailed explanations of the different scientific principles applied and incorporates innovative activities for hands-on learning, along with a detailed user manual with programming examples to get you started!

12 pages of
theory and amazing facts!

16 pages of
user manual!

8 pages of
experimental activities!

32 pages of
step by step instructions!



3D interactive instructions
to download on your smart device



8
models to build

8-16+

Discovering STEM

The purpose of STEM education - Science, Technology, Engineering and Mathematics - is to provide students with the necessary skills, knowledge and experience in order to cope with the technological challenges of the future. Modern pedagogical theories suggest that the study of engineering should be incorporated in all other subjects, starting from elementary level. DISCOVERING STEM series, offers a practical solution for facing all these educational issues, aiding the teacher to engage students in STEM disciplines in a fun, exciting and interesting way! The educational packages are also ideal as a home learning tool! The series covers a broad area of subjects: Mechanics and Simple machines, Structures, Newton's Laws, Renewable Energy and even Programmable Robotics.

Brand AWARDS:



- > levers & linkages
- > wheels, axles & inclined planes
- > pulley drives
- > cams & cranks
- > gears & worm drives
- > buildings & bridges
- > newton's laws
- > solar power
- > simple machines
- > physics resource master set
- > architecture set
- > amusement park set
- > robotics pro erp

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STEM

Science • Technology • Engineering • Mathematics



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29/3/2016

Letter of intent

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Registered Address: Kerinias 34, Ipsonas, 4187, Limassol, Cyprus

Product Name: STEM ROBOTICS ERP PRO EDITION with Bluetooth

Model Number: STEM70

FCC Identifier: 2AHXT-STEM70

We hereby declare that we shall print the below information in a leaflet that will be included in the affermented toy:

FCC Statement:

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment to an outlet on a circuit different from that to which the receiver is connected.

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Note: Modifications to this product will void the user's authority to operate this equipment.

Name: Costas Sisamos

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Signature of applicant: