WORKING ON ERASMUS+
UNIVERSE AN ODYSSEY OF SPACE AND TIME
STUDENT ACTIVITIES

UNIVERSE AN ODYSSEY OF SPACE AND TIME

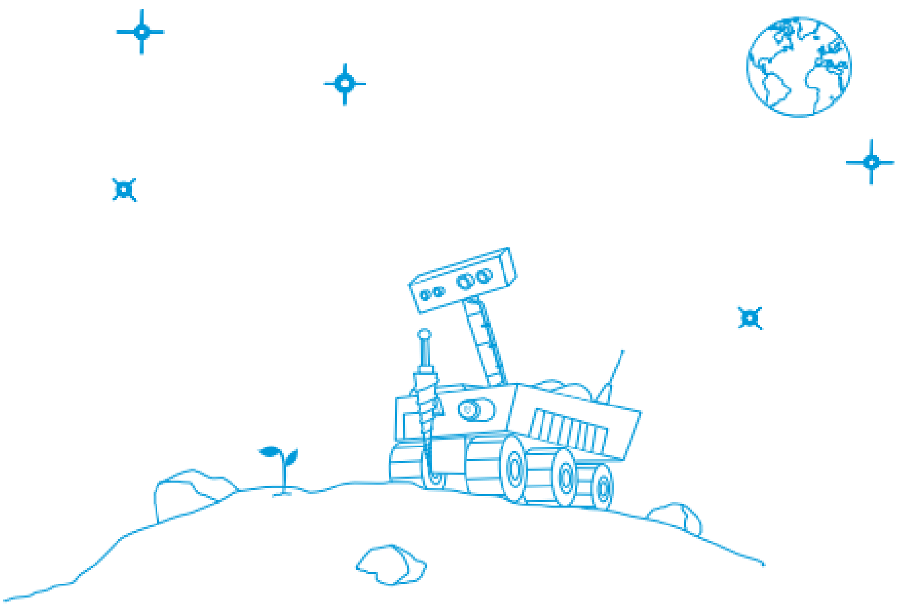
technology | T01b

esa

teach with space

→ BUILD YOUR MARS EXPLORATION ROVER

Building and programming a LEGO rover to collect science data



student activities

European Space Agency

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→ WHAT IS THE LINK BETWEEN SCIENCE, ENGINEERING, AND PROGRAMMING?

Exercise

Create your own satellite model with the LEGO pieces given to you (Figure A1).

Figure A1

↑ LEGO pieces

1. Describe the shape and scientific objective of the satellite model you created. Identify links between science, engineering, and programming.

2. Are there differences between your model and those of your fellow students?

Did you know?

Mars has always been a source of great fascination for humankind. In a couple of decades we will hopefully be able to walk on the surface of Mars, just like we did on the Moon. Before getting there though, ESA, together with other space agencies around the world, needs to collect more information about Mars' evolution and environment. ESA also needs to gradually build the technology foundation for the more complex elements required by human missions. This is being achieved with the many orbiters and landers launched to explore Mars, each advancing understanding one step at a time. The first European mission to the Red Planet was Mars Express, launched in 2003.

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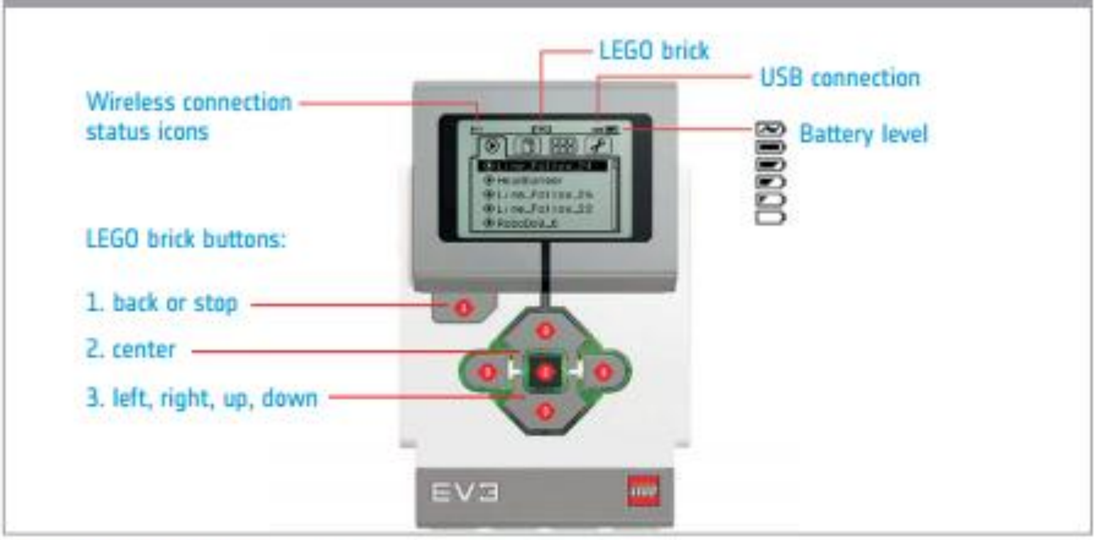
→ HOW DOES THE LEGO BRICK WORK?

Take the LEGO brick and switch it on by pressing on the central button (Figure A2). The general parameters displayed on the LEGO brick screen are described in the image.

Figure A2



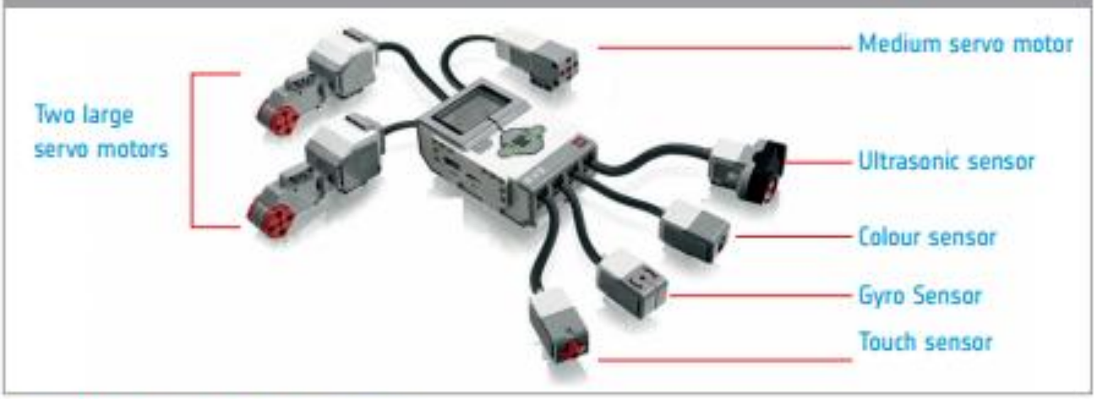
↑ LEGO brick computer screen description

Turn the LEGO brick on its side to identify the ports :

- There are 4 ports at the top (A to D) to connect **the robot's motors**
- There are 4 ports at the bottom (from 1 to 4) to connect the **robot's sensors.**

The LEGO brick motors and sensors are the heart of your robot. In the basic version of the LEGO Education Mindstorms EV3 kit, you have 3 motors and 4 sensors (Figure A3). You also have the possibility of adding other sensors, such as the temperature sensor.

Figure A3



↑ LEGO brick with motors and sensors connected

→ ACTIVITY 2

Exercise

1. Before working with the LEGO brick, look at Figure A4 and write what 'programming' means to you :

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Figure A4

```
#include <iostream>

using namespace std;

int main()
{
    cout << "Hello world!" << endl;
    return 0;
}
```

↑ Programming code C++

In order to give instructions to the LEGO brick and have it execute actions, it is essential to structure the actions in a very logical way. To facilitate this process, the LEGO brick uses icons representing basic sets of instructions.

2. Connect the two large servo motors to ports B and C and connect the touch sensor to port 1.

1. In the third section (Figure A5), select the 'Brick program' tab to create a program.

Figure A5

↑ Brick program menu

2. Select the area (circled in red) between the ▶ and ⇄ (Figure A6) to add the instructions.

Figure A6

↑ Empty brick program

3. Look at the different icons on Figure A7 and select the large servo motors icon.

Figure A7

↑ Brick instructions

4. The large servo motors have been added to the program. Make sure the motors are properly connected to ports B and C.

Figure A8

↑ Brick program with motor

5. Define a precise period of time you want the motors to run for by selecting the clock icon and placing it to the right of the motor icon.

Figure A9

↑ Brick program with clock

3. Before testing the program, write down what you predict will happen when it starts.

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To start the program, press the ▶ icon.

4. Describe the actions of the robot and compare them with your predictions.

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____

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Exercise

Look at Figure A10. In the boxes below, describe the actions you expect from the robot when you will run this program.

Figure A10

↑ Brick program

Instruction 1	Instruction 2	Instruction 3

To verify your expectations, insert the same instructions you see in Figure A10 into your LEGO brick. If necessary, correct your predictions using another colour.

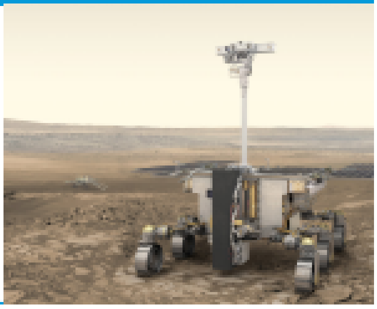
Exercise

1. Define a new set of instructions in order to move the two large servo motors in the opposite direction after you press and release the touch sensor. Draw the icons to be used in your program below.

2. Complete your program by adding an icon that will produce the sound of the word 'STOP' at the end of the action. Explain your approach below.

Did you know?

Mars is a potential destination for human space exploration. Before astronauts can be sent there, key technologies must be demonstrated using robotic missions. An important step will be a mission that can land, then move to collect interesting samples of soil and rocks, before finally returning them to Earth. The ExoMars rover, developed by ESA, provides important mission capabilities that will be needed for a Mars Sample Return: surface mobility, subsurface drilling for collecting samples, sample processing, distribution, and analysis with instruments.



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→ HOW DO YOU REMOTELY CONTROL A ROBOT?

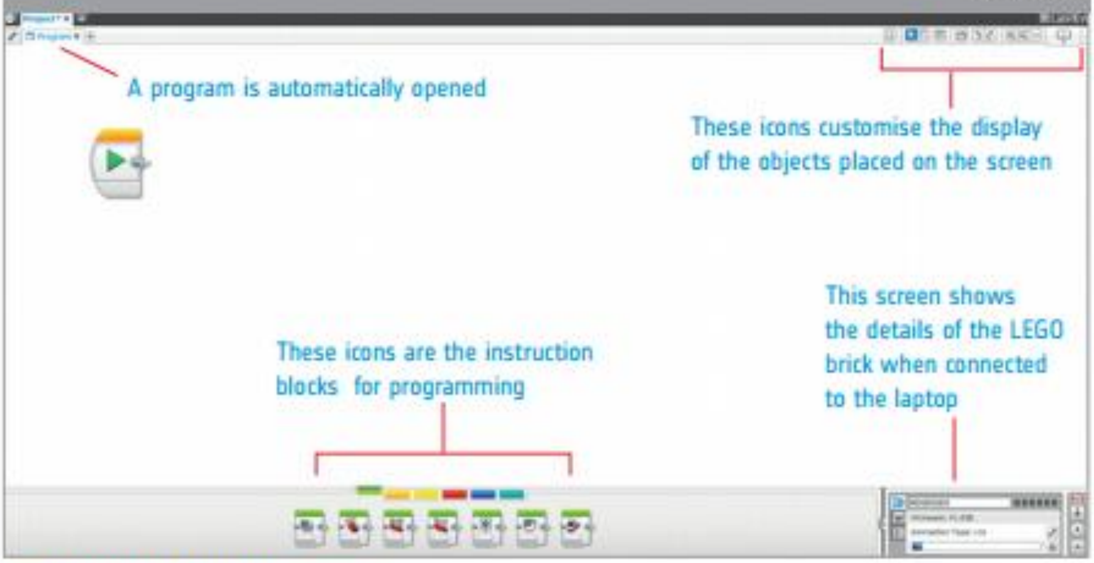
The LEGO Mindstorms software remotely controls a robot by communicating with the LEGO brick. Launch the LEGO Mindstorms EV3 Education software and click on '+' (circled in red in Figure A11) at the top left of the window to open a new project.

Figure A11

↑ LEGO Mindstorms EV3 Education interface

The project window is described in Figure A12. It allows you to arrange instruction blocks to program the LEGO brick. Identify all the tabs to fully understand their functions. Connect the LEGO brick to your laptop using the USB cable.

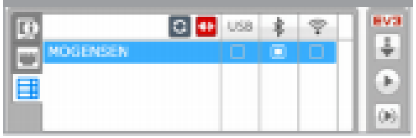
Figure A12



↑ LEGO Mindstorms EV3 program window

Start the wireless communication between the robot and the laptop by using Bluetooth and disconnecting the USB cable. The Bluetooth button is filled when the connection is established (Figure A13).

Figure A13

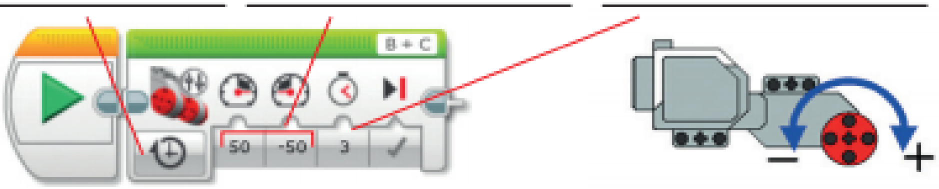


LEGO Mindstorms EV3 connection box

Exercise

1. In the green category of instruction blocks, select the fourth icon which runs the two large servo motors. Using the 'drag and drop' method, place it beside the 'play' icon. Configure the parameters of the block as shown in Figures A14/A15. Describe each parameter's function before starting the program.

Figures A14/A15

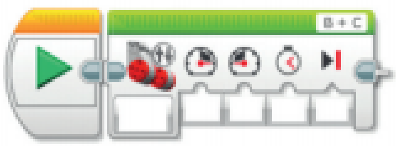


Large LEGO servo motors block — Direction of LEGO motors

To verify the explanation of your parameters, click on the green play button or on the small play button ▶ at the bottom right of your screen. To execute the program without the USB cable, download it ⬇ onto the LEGO brick and start it by pressing the centre button of the LEGO brick.

2. Write a set of instructions to move the robot forward for two seconds and then turn right. Complete Figure A16 with the correct block, and fill the small boxes with the defined parameters.

Figure A16



Large LEGO servo motors block to be completed

3. Write down how you expect the robot to behave if it receives the following set of instructions:

Figure A17

LEGO instructions blocks

4. Verify your hypothesis by inserting these instructions on your laptop and running the program on the LEGO brick.

→ HOW DO YOU BUILD A ROVER AND HAVE IT MOVE SAFELY?

Using the LEGO pieces, build the structure of a robot that will safely move on the Martian surface. You can either follow the instructions given in Annex 1 or, using your imagination, create a rover to your liking. Look at Figure A18. Define the adequate wheel system necessary for the rover to move safely by identifying all the constraints and limitations related to a Martian terrain.

Figure A18

↑ LEGO wheel systems

Exercise

1. Justify your chosen wheel system below :

___

___

___

___

___

Figure A19

↑ LEGO wheel systems to be defined

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2. Think about how your rover will behave on Mars with this chosen wheel system. How will it react to different parameters (e.g. the slope of the surface, the unevenness of the surface)? Consider the impact of the wheel constraints on the movement of the rover. Implement different situations to test the rover's performance, and write your results in Table A1.

parameters	observations	explanations

Table A1, Specifications of the rover

Did you know?

The locomotion of ESA's ExoMars rover is achieved using six wheels. Each pair of wheels is suspended on an independently pivoted bogie (the articulated assembly holding the wheel drives), and each wheel can be independently steered and driven. All wheels can be individually pivoted to adjust the rover's height and angle with respect to the local surface, and to create a sort of walking ability, particularly useful in soft, non-cohesive soil (e.g. dunes).

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→ HOW DO YOU COLLECT DATA FROM A ROVER?

As robotics assists with scientific experiments, it is necessary to add a sensor that will collect data from the robot.

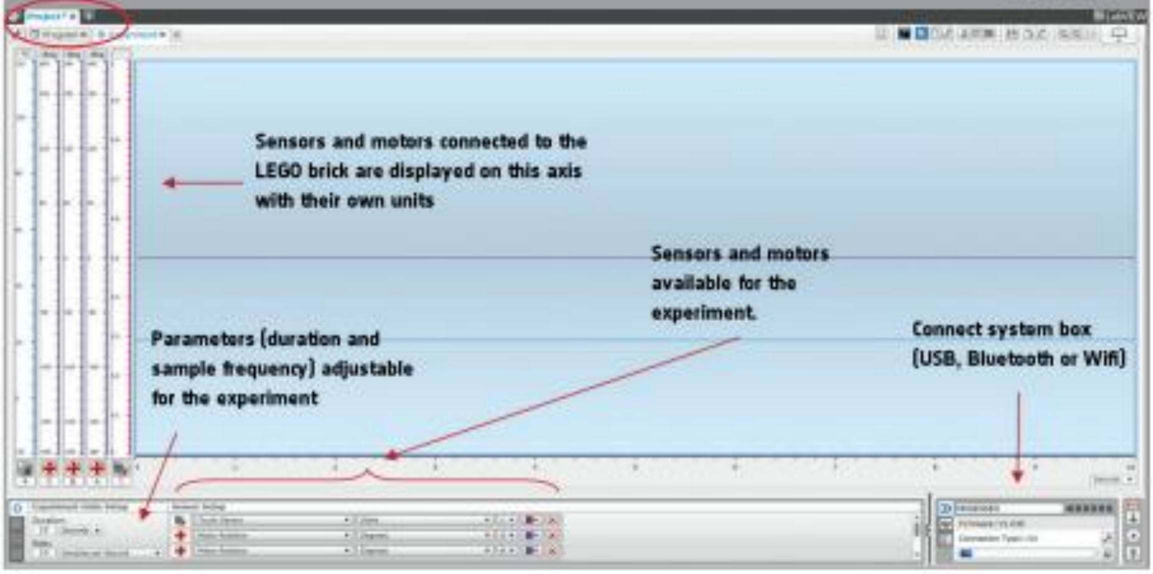
Select one sensor among the following: touch, colour, gyro, ultrasonic, or temperature, and connect it to port 1 of the LEGO brick.
Selected sensor : ______________________________

Launch the LEGO Mindstorms EV3 Education software (Figure A11) and open a new experiment by clicking on the '+' at the top left, circled in red in Figure A21. The experiment window is described in Figure A21. It allows you to collect the sensor measurements during an extended period of time. Identify all the tabs to fully understand their functions.

Figure A20

↑ Ultrasonic sensor connected to the LEGO brick

Figure A21



↑ LEGO Mindstorm EV3 experiment window

Start the wireless communication between the robot and the laptop by using Bluetooth and disconnecting the USB cable. The Bluetooth button in Figure A22 is filled when the connection is established.

Figure A22

↑ LEGO Mindstorms EV3 connection box

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Exercise

Imagine a context to conduct an experiment with the sensor you selected. In Table A2, define and comment on the experiment parameters (e.g. scale, sample frequency, duration ...).

context	
parameter 1:	
parameter2:	

Table A2: Experiment parameters

This icon shown at the top right of the screen enables you to draw the experiment prediction. Use this tool to draw your prediction curve before starting the program using the icon shown at the bottom right of the screen. Measures will be plotted on the screen in real time during the selected time.

Complete the graph with the data collected (label axes and include units) and analyse the differences between your predictions below.

The ESA Education Office welcomes feedback and comments
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