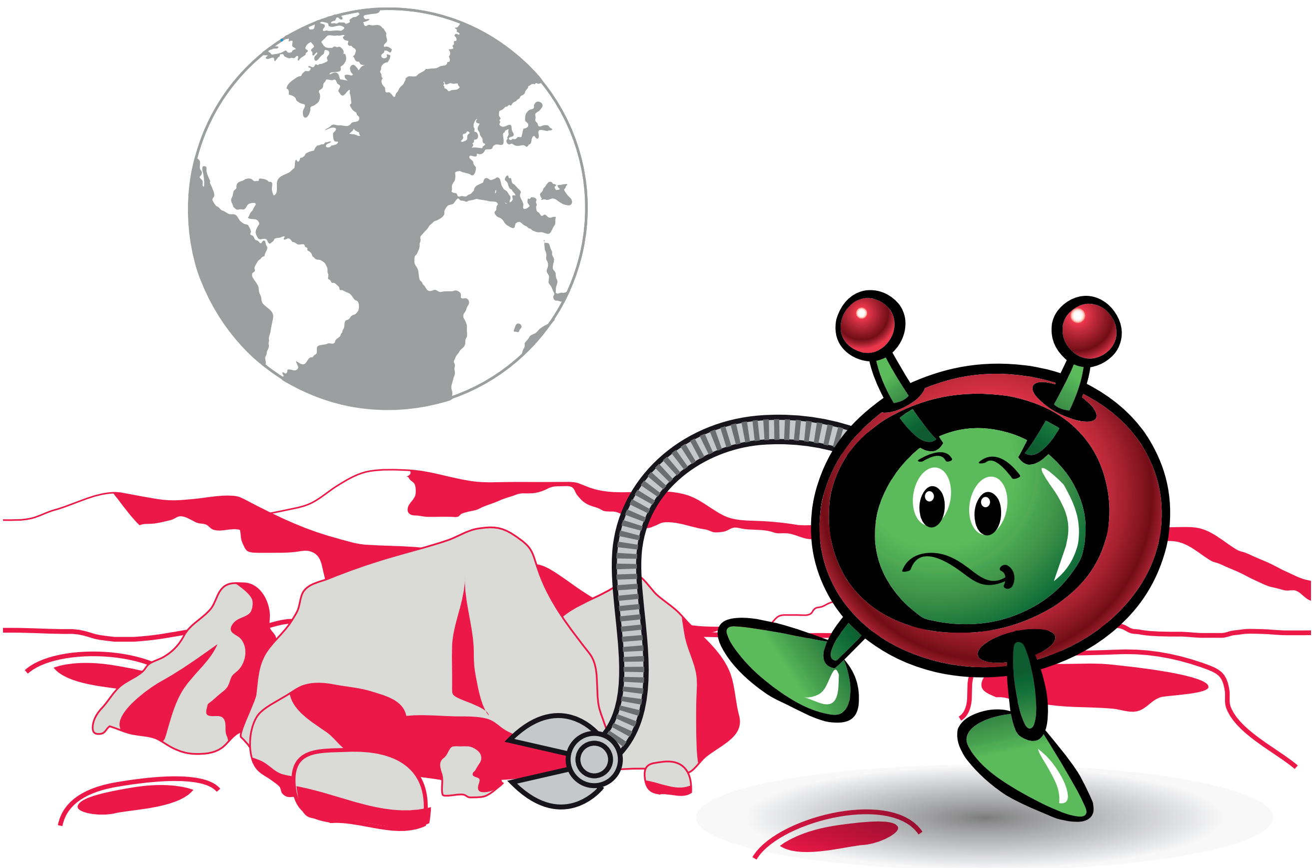
esa Kids

teach with space

→ ROBOTIC ARM

Become a space engineer for a day



teacher guide & student worksheets

European Space Agency

teach with space – robotic arm | PR35
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→ ROBOTIC ARM

Building a robotic arm to help your daily work

Fast facts

Subjects: Science, Arts
Age range: 8-12 years old
Type: pupil activity
Complexity: easy-medium
Lesson time required: 60 minutes
Cost: low
Location: classroom
Includes the use of: craft material

Keywords: Science, Arts, Engineering, Robotic arm, Human body, Arm, Muscles, Bones

Brief description

In this activity, students will learn how their arm works. Students will understand the different functions of bones and muscles. They will build and test a model robotic arm and understand why a robotic arm is a very important tool in space.

Learning objectives

- Learn the different functions of bones and muscles.
- Understand how the human arm works.
- Learn what is a robotic arm.
- Know why robotic arms are useful tools, especially in space.
- Explore and test ideas building a machine (robotic arm) in a group.

→ Summary of activities

activity	title	description	outcome	requirements	time
1	How does our arm work?	Students will understand how the human arm works. Students will consider why robotic arms can serve as useful tools.	Students will learn what makes up their arms. They will learn about the role of bones and muscles. Students will understand that robotic arms are a useful tool for space exploration.	None	20 minutes
2	Build your robotic arm	Students will build a simple model of a robotic arm.	Students will build a simple robotic arm and relate its function to the human arm.	Completion of Activity 1	40 minutes

→ Introduction

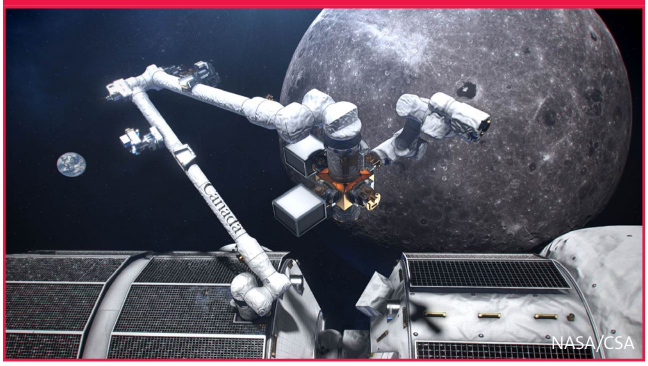
Robotic arms are machines, inspired by the arm, which can be used to move objects. In space, robotic arms provide the capability to manipulate and transport large equipment like the Hubble Space Telescope as well as assisting the astronauts during spacewalks outside the International Space Station.

Robotic arms can have various sizes and objectives. They can perform maintenance works and be equipped on scientific experiments, for example, to collect samples.

Figure 1

↑ ESA astronaut Luca Parmitano hooked up to the robotic Canadarm 2, in a spacewalk outside the International Space Station.

Figure 2

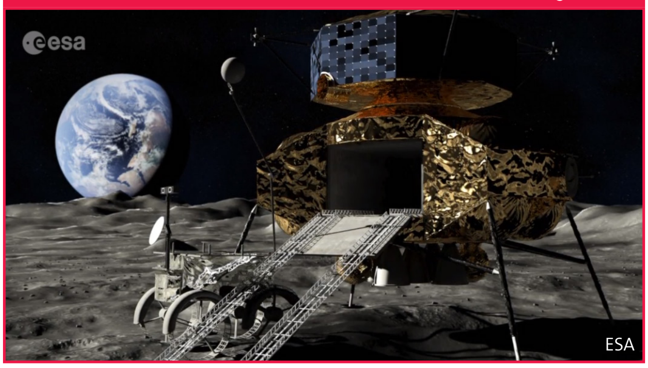


↑ Artist impression of the robotic arm in future lunar orbit space station.

ESA is working with the Canadian and Japanese space agencies, on robotic missions to the Moon which will see autonomous rovers with robotic arms to collect samples from the lunar surface. The sample containers will be transported to a future space station near the Moon. This lunar-orbiting station will have an advanced robotic arm that will capture and berth the sample containers, which will travel to Earth with returning astronauts.

In the future astronauts will be able to control vehicles on the surface of the Moon remotely and help the robots on the surface take samples and access difficult terrain. The next ESA mission to be sent to the surface of the Moon, HERACLES (Human-Enhanced Robotic Architecture and Capability for Lunar Exploration and Science), will test this new technology and collect soil samples from the surface with its robotic arms.

Figure 3



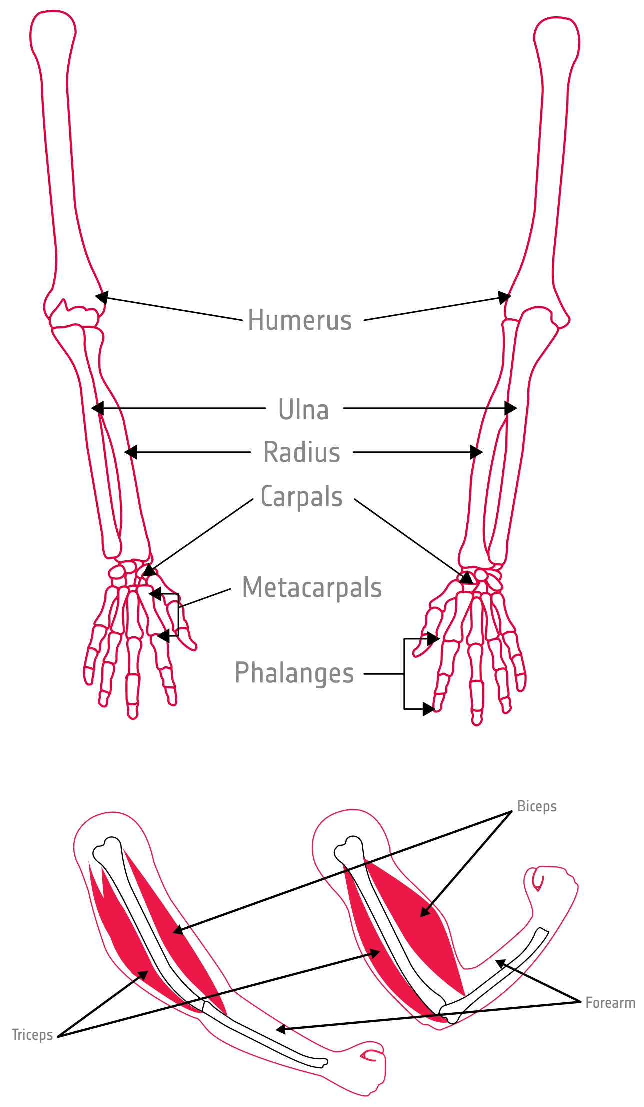
↑ Artist impression of the Heracles mission on the lunar surface.

→ The Human Arm

Each arm is made up of bones, joints and muscles. They work together to allow our arms to bend, rotate, swing back and forth, and move from side to side.

The human arm consists of three bones: the humerus, the radius and the ulna. There are a pair of muscles attached to the humerus to move the arm: the biceps and triceps. The biceps bends the arm while the triceps straightens it. Muscles always work in pairs and each muscle can only pull (by flexing), they cannot push.

Figure 4



↑ The main bones and muscles in the human arm

→ Activity 1: How does our arm work?

In this activity, pupils will learn how the arm works and why robotic arms are useful tools.

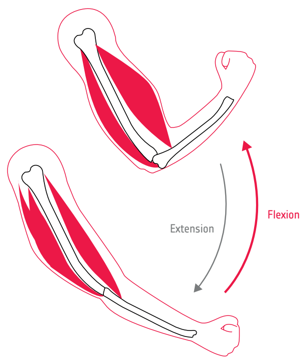
Equipment

- Printed student worksheets for each student

Exercise

In Activity 1, question 1, pupils are asked to fill in the blanks in a passage. For the pupils to better understand how their arms work extend this activity by asking to the pupils to do a set of short activities

- Ask the pupils to flex one arm while feeling the muscles of the upper arm with the other hand. Students should realise that the arm bends using a pair of muscles (biceps and triceps) working together. When the arm is straight, the bicep is extended and the tricep is flexed. Conversely, when the arm is bent, the bicep is flexed and the tricep is extended.



- Instruct the students to hold a book with their arms straight and not moving for one minute. Ask them how they were feeling after a while. Ask them if they could continue holding the book for a long time. The students should realise that their arms will begin to shake and move. This is problematic if you need to be doing very precise work with heavy objects and this can be solved by using robotic arms.

Introduce the concept of robotic arms. Show the students examples of robotic arms used on Earth and in space. Ask them why robotic arms are needed in space exploration. Ask them to list 3 activities that could be done by robotic arms in space or on the Moon.

Results

1. Have you ever wondered how your arms work? Our arms are covered in **skin** for protection, under the skin there are muscles and **bones**. The bones are strong and rigid to provide structure and the **muscles** give us strength to allow the arm to move. The arm has 3 main bones: the humerus, the ulna and the **radius**. Attached to the humerus there are a pair of muscles: the **biceps** and the triceps. The **elbow** joins the upper and lower parts of the arm.

2. Examples of answers:
   - Building/setting up a base before humans arrive.
   - Moving objects from a spacecraft to the base.
   - Taking samples for scientists.

→ Activity 2: Build your robotic arm

In this activity pupils will build their own robotic arm and use it to perform different tasks and test its functionality in different situations.

Equipment

- 10 popsicle sticks (approximately 10 cm x 2 cm)
- 2 strong cardboard rectangles or similar (approximately 10 cm x 2 cm)
- Hot glue
- 2 bottle caps/erasers
- 12 split pin paper fasteners
- Scissors
- Printed student worksheet

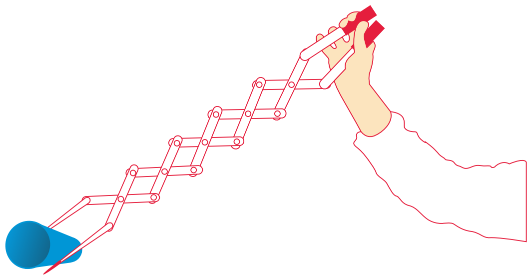
Did you know?

Students need to be supervised when making holes in popsicle sticks.
Teachers should help students handle the hot glue as it is potentially harmful for skin and can cause burns.

Exercise

Split the students into groups of 2 to 3 students and give each group the necessary material to build a model of a robotic arm.

Show them pictures of a finished robotic arm and give a brief overview of how to build it. Detailed instructions on how to build the robotic arm are provided in the student worksheet.



Afterwards, the students should use their robotic arm to try and pick up various objects and think about what makes this task easy or difficult. They should think about the objects they are picking up and how their robotic arm is suited to each. Throughout this activity the students should think about what changes they could make to make the tasks they are carrying out easier.

The students should add some more sticks to their robotic arms to make it longer and decide whether a longer or shorter arm is easier to use. Ask them to compare their robotic arm to their own arm. How is it different? Is there anything in your own arm that you could add to the robotic arm to make it better?

The student should relate the robotic arm structure to their own arms structure. In the human arm, bones have a very important role to provide structure while muscles allow the arm to perform various movements.

Results

Students must conclude which parameters affect their arm's performance (e.g. length of arm, materials used, type of "grabbers" used).

1. a. Most will respond the eraser was easier to grab due to friction and the shape of the surface.
   b. The arm would have difficulties, for example, grabbing heavy and/or large objects.
   c. A shorter arm will give more control and stability, but will not be able to grab objects far away.
   d. Students may come up with ideas such as adding a thumb, being able to bend the arm or any other relevant ideas.

2. On the Moon, objects will have less weight than on Earth so the robotic arms would be able to lift heavier objects.

Discussion

Discuss with the students how effective their robotic arms were. Did they think the ones they made are useful tools or would they need to be improved? Students should realise that the robotic arm they made is very basic and it is very complicated to make the robotic arms used in space and in industry/manufacturing. Debate with the students what parameters they think affect the functionality of their robotic arm. If it is too long it is difficult to control but if it is too short it will have very limited mobility and use. Different materials can be used for different parts of the arm to improve it. The ideal material for the main structure would be strong and light.

When space agencies design new tools they often look to nature for inspiration. Discuss with the students if they think this is a good idea. Is it best to make robotic arms like human arms or could a robotic octopus arm be more useful? You can take this activity further by introducing the difference between mass and weight to the students and introduce forces.

Conclusion

Our bodies are made up of bones and muscles which work together to provide structure and allow us to move and carry out the various tasks we execute in our daily lives. There are limitations to what humans can do, so we often use robots to help carry out tasks that would be difficult, dangerous or impossible for us. Nature can be very good at solving problems, therefore we often use nature as inspiration for our designs and we try to model many robotics on what we observe around us. There are many similarities between robotic arms and our own arms.

→ ROBOTIC ARM

Become a space engineer for a day

→ Activity 1: How does the arm work?

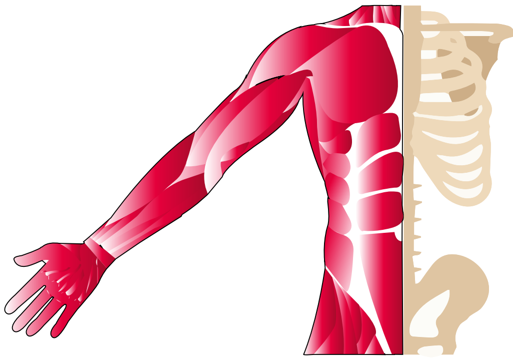
1. Fill in the blanks in the passage below using the words given (use each word only once):

muscles **elbow** **skin** **biceps** **bones** **radius**

Have you ever wondered how your arms work?

Our arms are covered in ________ for protection, under the skin there are muscles and ________. The bones are strong and rigid to provide structure and the __________ give us strength to allow the arm to move.

The arm has 3 main bones: the humerus, the ulna and the ________. Attached to the humerus there are a pair of muscles: the _________ and the triceps. The ______ joins the upper and lower parts of the arm.



Did you know?

ESA's astronaut Thomas Pesquet took this photo from the International Space Station and said that "the robotic arm is one the most essential parts of the International Space Station and is used for every capture and berthing of supply spacecraft."

2. Robotic arms can also be very useful when exploring other worlds, like our Moon. Imagine you are an astronaut working in space or on the Moon. List three things you think robotic arms could help with:

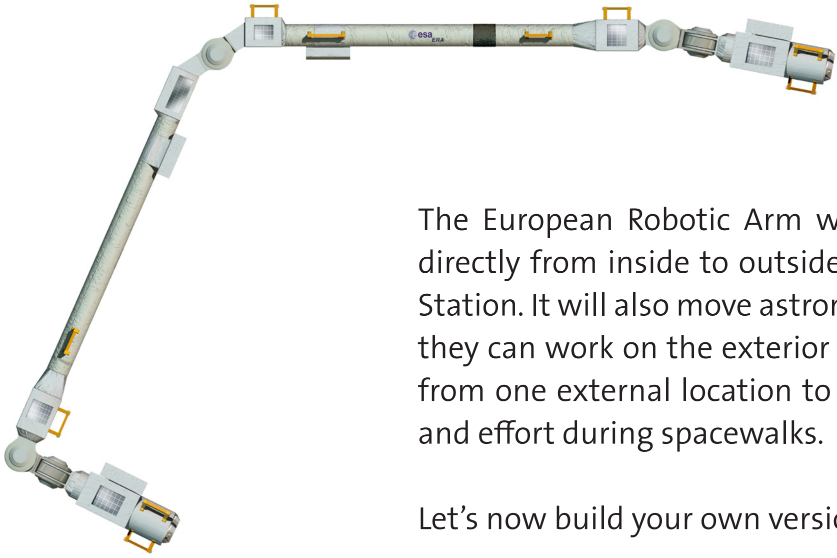
____

____

____

3. Discuss with others in your group what the best way to make a robotic arm is. How could you make it easier to pick things up? Draw your model.

→ Activity 2: Build your robotic arm



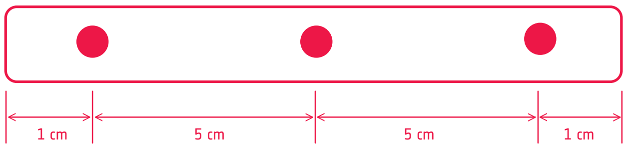
The European Robotic Arm will move small payloads directly from inside to outside the International Space Station. It will also move astronauts to a position where they can work on the exterior of the Space Station , or from one external location to another. This saves time and effort during spacewalks.

Let's now build your own version of a robotic arm!

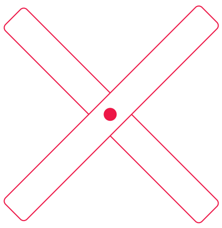
Exercise

Collect all the materials you need from your teacher and follow the instructions below:

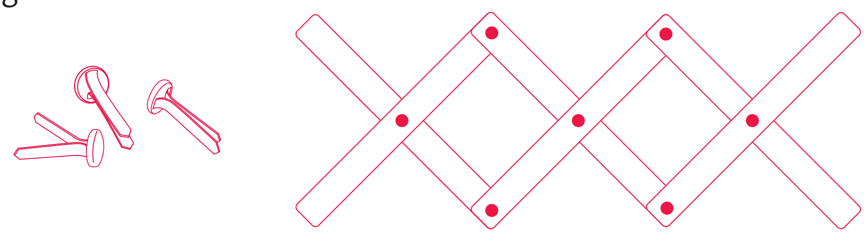
1. Punch three holes in the sticks using a hole puncher. See image for location of holes.



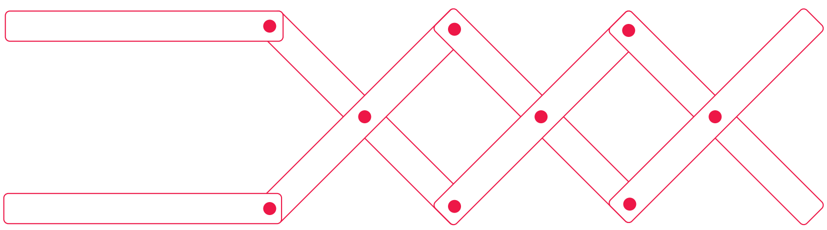
2. Use split pin paper fasteners to attach two popsicle sticks in the centre to form a cross as shown. Repeat this 2 more times.



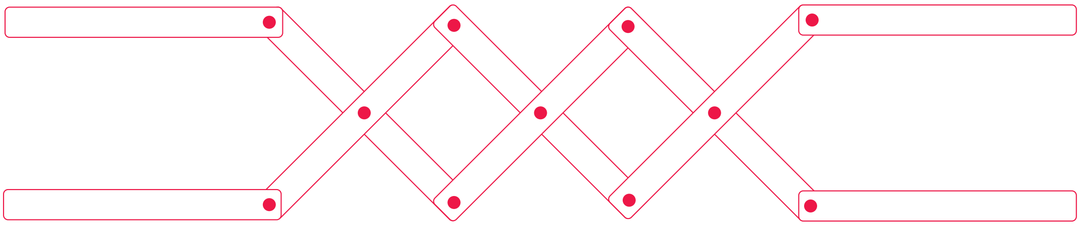
3. Use split pin paper fasteners to attach the ends of the cross shapes you have just made to form a long chain as shown.



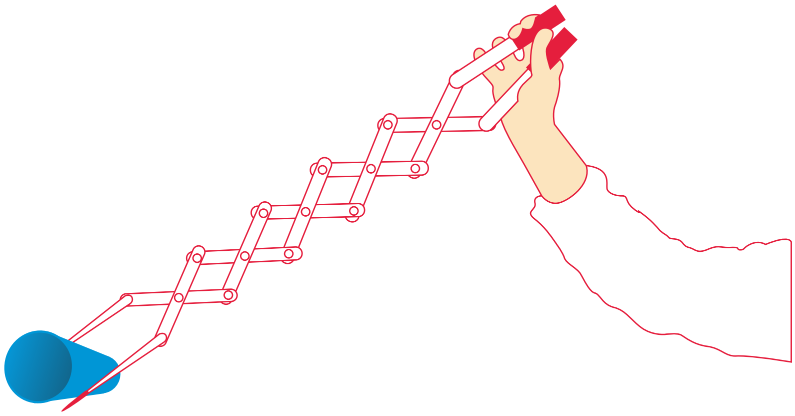
4. Use hot glue to attach two sticks at one end as handles.



5. Use hot glue to attach the two cardboard rectangles at the other end as “fingers” to grab objects.



6. Attach tape or bottle caps to the ends of the grabber. This will help your robotic arm grip objects. You should now have a robotic arm similar to the one in the image below .



Results

1. Try using your robotic arm to grab different objects such as an eraser, a ping-pong ball and a paper cup.
   a. Which object was the easiest to pick up?

   ____

   ____

   b. What kind of objects would be difficult to grab with the arm?

   ____

   ____

   c. Now try to make your robotic arm longer or shorter. Is it easier to work with a short robotic arm or a longer one?

   ____

   ____

   d. Compare the robotic arm with your arm. Which changes can you do to improve your robotic arm?

   ____

   ____

2. In Activity 1 you listed some tasks with which a robotic arm could help when setting up a base on the Moon. The Moon has 1/6th of the gravity of Earth. Do you think this will affect the load a robotic arm can lift there?

____

____

____

→ LINKS

ESA resources

Moon Camp Challenge
esa.int/Education/Moon_Camp

ESA classroom resources
esa.int/Education/Classroom_resources

ESA Kids
esa.int/kids

ESA space projects

European Robotic Arm (ERA)
esa.int/Our_Activities/Human_Spaceflight/International_Space_Station/European_Robotic_Arm

Space Gateway:
esa.int/Our_Activities/Human_and_Robotic_Exploration/Exploration/Space_gateway

Landing on the Moon and returning home - Heracles robotic mission
esa.int/Our_Activities/Human_and_Robotic_Exploration/Exploration/Landing_on_the_Moon_and_returning_home_Heracles

Operations on the lunar surface: Heracles
http://lunarexploration.esa.int/library?a=419

Extra information

ISS Robotic Arm (Canadarm 2)
http://www.asc-csa.gc.ca/eng/iss/canadarm2/Default.asp

ESA, Robotic arm training:

Part 1 https://youtu.be/xHmN1p7-n7o

Part 2 https://youtu.be/6YFQf1-7T7s

Canadian Space Agency, Hadfield behind the controls of Canadarm 2:
https://youtu.be/K7NvsxcoDKo

How muscles move your bones:
https://youtu.be/FVIpeUIpFfo