THE ROYAL SOCIETY

Can we design a robotic arm?

Objective

Students will construct a robot arm out of ice lolly sticks and use it to try and pick up a ping-pong ball. They will then adapt it to perform a particular task of their choice, like pulling open a door or picking up a plate.

Introducing the experiment

Ask students to make a list in their groups of all the possible uses of robotics – where they are used and why they are beneficial. Can they think of examples where a robot cannot replace a human?

You may want to have students watch the video *Mission X – Train like an astronaut*, where NASA astronaut Mike Hopkins goes through a visual check of the end effector on the International Space Station (ISS).

During the experiment

Helpful hint

It is easiest to divide the materials into trays so that students can keep their materials together and the work may extend over more than one lesson.

You may wish to start the lesson before handing students their worksheet, as they will have to design their robots without the guidance diagram. You can then hand the worksheet to them after they have designed their first model.

Answers to questions on the student worksheet

1. **Was it more difficult to grab the eraser or the ping-pong ball?**
   Answers will vary, but most will find the eraser easier to grab due to friction and the shape of the surface.

2. **What is an object that would be difficult to hold with your end effector?**
   For example, small or very large objects.

3. **What is an object your arm would not be well-designed to pick up?**
   For example, flat or thin objects such as a coin or a wire.

4. **Did gravity play a role in how easy it was to use your robotic arm?**
   Answers will vary, but in general gravity will make it harder to move an object due to the object having weight. On the International Space Station (ISS) there is a similar amount of gravity as on Earth, but because the ISS, the arm, astronauts and the objects are all falling in the same direction the effect of gravity is negligible.

For more information regarding gravity, visit *What Is Microgravity? (Grades 5 – 8)* (nasa.gov).

Adapting the robotic arm for new conditions

1. **Try to make your robotic arm even longer. Does the arm work better when it is longer?**
   Answers will vary, but generally the arm is more difficult to use when longer.

2. **Remove some sections of your arm. Does your robotic arm work well when you make it shorter?**
   Answers will vary.

3. **What material would you use to pick up an egg?**
   Answers will vary.

4. **Remove a number of cotter pins. Does the robotic arm still work?**
   Answers will vary. Depending on which cotter pin is removed, if the arm still works it will most likely not work as well.

Discussion points after the activity

Have students share their ideas for improving their end effectors and how the end effector can work with the arm.

Useful information for this experiment

Robotic arms are important machines that help people work on Earth as well as in space. Scientists have designed and used robotic arms for years to be able to perform repetitive tasks exactly, work in dangerous areas or handle materials that are too heavy or dangerous for humans to move. On Earth, robotic arms are used for everything from moving heavy equipment to performing delicate surgery. In space, robotic arms are used to move heavy equipment and even astronauts around, and others are used for experiments and specific maintenance tasks. There are even human-sized arms that can perform tasks that humans typically do, but they never get tired.

Robotic arms are similar to human arms. Your arms are covered in skin for protection, and inside your skin are nerves, muscles and bones which allow the movements to occur. Like the skin on your arms, the robotic arms in space are also covered with fabric. The protective layers of the robotic arms on the ISS are to keep the wires, motors, and metal safe from space radiation which is similar to how your skin protects your nerves, muscles, and bones of your arms. Additionally, the robotic arms have joints much like our elbows and wrists, and even have parts that are similar to our hands which hold items.

For more school experiments and to access the accompanying videos, visit **royalsociety.org/schoolexperiments**

THANKS

This activity is based on an original activity from ESA's *Mission X: train like an astronaut* project. Original concept by ESA / NASA who have kindly agreed to its use in the Royal Society Brian Cox School Experiments.

Can we design a robotic arm?

Your task is to build a robotic arm.

Instructions

1. Punch three holes in the ice lolly sticks using the hole punch. See image for location of holes.
2. Connect two lolly sticks using a cotter pin, forming a cross.
3. Repeat steps 3 and 4 for all other ice lolly sticks.
4. Now connect all the crosses together. Carefully check the sample drawings as an example.
5. Make a cut in both erasers or sponges in the side.
6. Insert the ends of the grabber into the erasers or sponges. This is the end effector and used to grab things.
7. Try using your robotic arm to grab an object from the table. Can you successfully do this?
8. Use your robotic arm to try to pick up an eraser and something round, like a ping-pong ball. Can you successfully do this?

Questions

1. Was it more difficult to grab the eraser or the ping-pong ball?

---

2. What is an object that would be difficult to hold with your end effector?

---

3. What is an object your robotic arm would not be well designed to pick up?

---

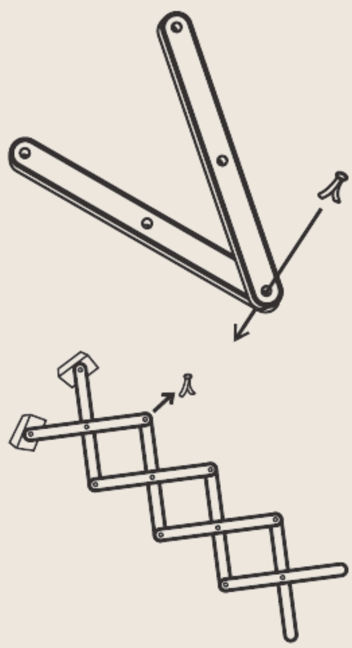
4. Did gravity play a role in how easy it was to use your robotic arm?

EQUIPMENT LIST

- Eight ice lolly sticks
- Scissors
- Hole punch or leather punch
- Cotter pins or split pin paper fasteners
- Two erasers or pieces of sponge.

SAFETY PRECAUTIONS

- Be careful when punching holes in the ice lolly sticks.



Adapting the robotic arm for new conditions.

Investigate how changes in design parameters and structure affects your arm's performance.

1. Try to make your robotic arm even longer. Does the arm work better when it is longer?
2. Remove some sections of your arm. Does your robotic arm work well when you make it shorter?
3. What material would you use for the end effector to pick up an egg?
4. Remove a number of cotter pins. Does the robotic arm still work?

Play with your design, because this will allow your team of engineers to investigate arm designs and better understand how they work.

When you are ready to move on, decide on a task or skill that you would like your robotic arm to perform. Will it help humans perform a task such as opening a door or holding something hot?

Our task / skill is:

Draw a design of the arm you would like to build to perform your task. Label the parts of the robotic arm such as the end effector or joint.

Now, get approval from your teacher before moving on to the next step.

Build your robotic arm and see how it works to perform your task.

You are the scientists and are now working together just like a group of robotic arm engineers.

THANKS

This activity is based on an original activity from ESA's *Mission X: train like an astronaut* project. Original concept by ESA / NASA who have kindly agreed to its use in the Royal Society Brian Cox School Experiments.

Can we design a robotic arm?

Background

Students will construct a robot arm out of ice lolly sticks and use it to try and pick up a ping-pong ball. They will then adapt it to perform a particular task of their choice, like pulling open a door or picking up a plate.

Robotic arms are important machines that help people work on Earth as well as in space. Scientists have designed and used robotic arms for years to be able to perform repetitive tasks exactly, work in dangerous areas or handle materials that are too heavy or dangerous for humans to move.

Preparation notes

Depending on how much time you have, you may want to add more ice lolly sticks so that students can change where they place the holes or the lengths of the sticks, when they are changing their design. You may also want to give them other materials that they can use for the end effectors as well.

To save time, we recommend punching holes in the lolly sticks before the lesson. Students may struggle to do this within the lesson and punching all sticks ahead of time with an adapted hole punch may also ensure uniformity. You can see an example of this being done in the accompanying classroom video for this topic.

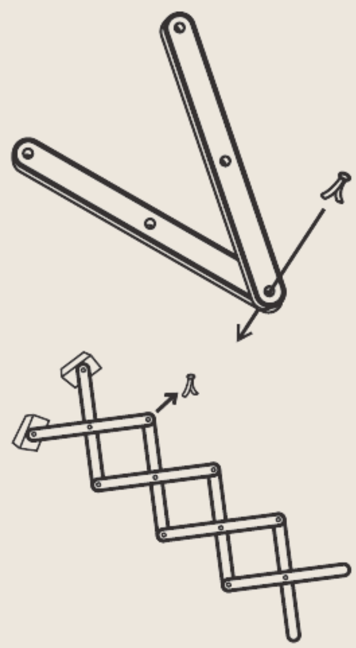
EQUIPMENT LIST

Materials for each group

- Eight ice lolly sticks
- Scissors
- Hole punch or leather punch
- Cotter pins or split pin paper fasteners
- Two erasers or pieces of sponge.

SAFETY PRECAUTIONS

- Students need to be careful when punching holes in the ice lolly sticks and using the metal pins.



THANKS

This activity is based on an original activity from ESA's *Mission X: train like an astronaut* project. Original concept by ESA / NASA who have kindly agreed to its use in the Royal Society Brian Cox School Experiments.