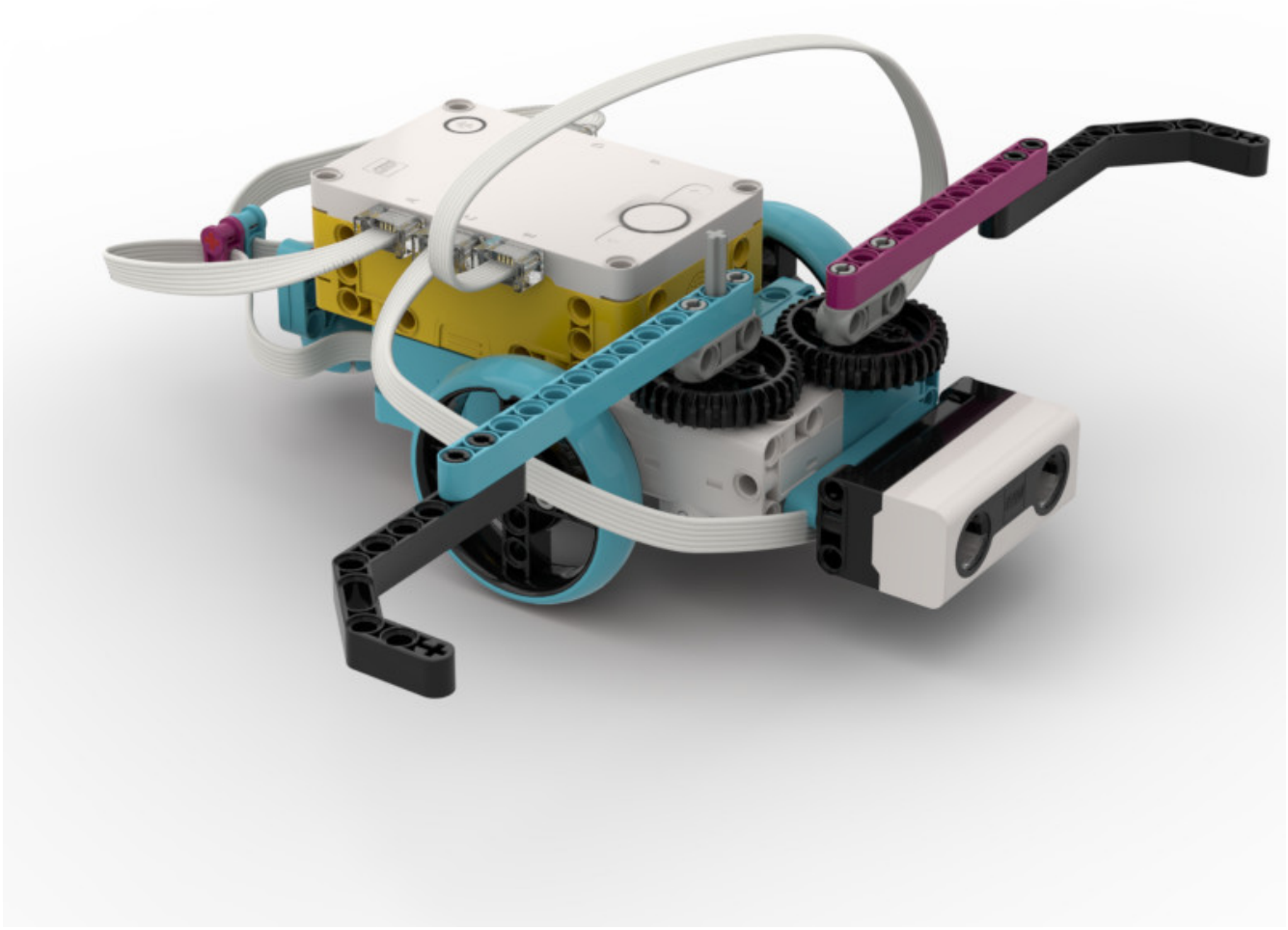
Classroom Activities for the Busy Teacher: SPIKE Prime



Classroom Activities for the Busy Teacher: SPIKE

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About the Author

Dr Damien Kee is an independent technology education expert, who specialises in bringing technology concepts to teachers and educators around the world. He works to educate teachers on the benefits and relative ease with which technology can be embedded into their daily classroom activities. With over 15 years' experience, Damien can be found anywhere from sitting on the floor of a classroom, working with young students first learning the intricacies of programming, through to presenting at conferences to some of the most skilled educators in the field.

Damien has run his popular workshops for Teachers and Students around the world in places such as Australia, China, USA, Japan, Jordan, UAE and Qatar

He is the author of several popular Teacher Resource books and was a member of the MCP (LEGO MINDSTORMS Community Partner Network). Damien has worked previously with LEGO Education as a trainer of a LEGO Education Distributor in Australia as well as directly with the LEGO Education team in Billund as a member of the software documentation team of the recent EV3 product line.

Damien received his Bachelor of Engineering (Electrical) in 2001 and his PhD (Robotics) in 2007 from the University of Queensland.

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Chapter 1: Introduction

This book is a guide for teachers implementing a robotics unit in the classroom. It is aimed at Primary and Middle years schooling (ages 7 - 15) but the wide range of activities can be adapted to suit older or younger students. The book is based around a single robot, "SPYKEE", which is used in all activities. This approach is valuable in resource limited classrooms, as it allows the teacher to work with a 'standard' robot, rather than using valuable classroom time building and breaking down robots each lesson. The SPYKEE design can be found at the back of the book, as well as being freely available online – www.damienkee.com. Please send me an email and let me know if you are using the design!

All activities are based around the 45678 LEGO SPIKE Prime kit available from LEGO Education.

It is assumed that the teacher has a basic knowledge of how to open the SPIKE Prime programming environment and how to download a program to the SPIKE hub. Please see the excellent tutorials built into the SPIKE software environment for more information.

The book is divided into sections that follow a 10 week plan, although this can be modified to suit the needs of the teacher. The first 6 weeks takes students through a series of activities, progressively exposing them to new aspects of the SPIKE programming environment. Following is a set of open-ended challenges from which teachers may pick and choose to suit their class.

All challenges follow a similar structure:

- Scenario setup + background information. Teachers are free to develop each scenario further as they see fit.
- Equipment list. Aside from the standard SPIKE robotics kit, all other required resources are easily sourced within a school environment.
- Teacher notes are provided on common issues that may arise with each challenge and how they are best dealt with.
- Programming examples in the SPIKE software environment.
- Student worksheets to fill out (photocopy / print permission is provided).
- Extension activities.

Lesson Plan

The following is a lesson structure for a 10 week unit on robotics. This plan assumes approximately 5 hours of content per week in class, although the ability of the students involved may require slightly more or less time as needed.

Week 1: Organisation and SPYKEE Basics

SPIKE kits are sorted to ensure all pieces are accounted for. During this week students will also build the SPYKEE or another equivalent robot. Students will learn how to use the SPIKE programming language to move their robot around the floor using Student worksheet – SPYKEE Basics. The 'Movement' blocks are the focal point of this week's challenge.

Week 2: History and Flowcharting

Students are introduced to robotics in general. Their use in society and the differences between fictional and real robots are described and the fundamental components of a robot are discussed. Students are asked to prepare a report on robots. Student worksheet – What is a Robot? is handed out with the due date left to the teacher's discretion. The concept of flowcharting is presented, and backed up by worksheet – Flowcharting. If these activities are finished early, move on to next week's activities.

Week 3: How Far, Data collection

Using the lessons learnt from the previous week, students will perform a data collection activity to measure how far the robot travels under a variety of different conditions.

Week 4: How Many Sides? That Bot has Personality

Students will learn about the 'repeat' structure as well as building on their knowledge of geometric shapes. Polygon properties such as internal and external angles are discussed. The Sound and Display are introduced, both as a way to personalise the robot, but also to help debug programs. This is a good time to consolidate the classes' knowledge before moving onto Sensors.

Week 5: Help! I'm Stuck! Let's go Prospecting!

The concepts of sensors are introduced and the Distance and Colour Sensors are used to assist the robot with navigation. Students give their robot the intelligence necessary to make decisions for itself.

Week 6: Stay away from the Edge, Prospecting and Staying Safe

These chapters continue the work with sensors, introducing a new programming concept (the IF Block).

Week 7: Prepare the Landing Zone

This chapter introduce the use of the Large Angular Motor as an additional actuator that can be used to manipulate objects.

Week 8: Major Project (Mini- Golf, Dancing Robots, Robot Wave, Robot Butler, Meet your Adoring Public!)

Teachers may choose one or a number of these activities for the students to undertake. They may work in small or large teams, each with a few robots per team. Student may wish to pursue their own project, in consultation with the teacher.

Week 9: Major Project

Students continue working on their major project.

Week 10: As Seen on TV!

Students develop a multimedia marketing presentation with which to 'sell' their robot to consumers. This may take on any number of media formats (website, speech, newsletter article etc.)

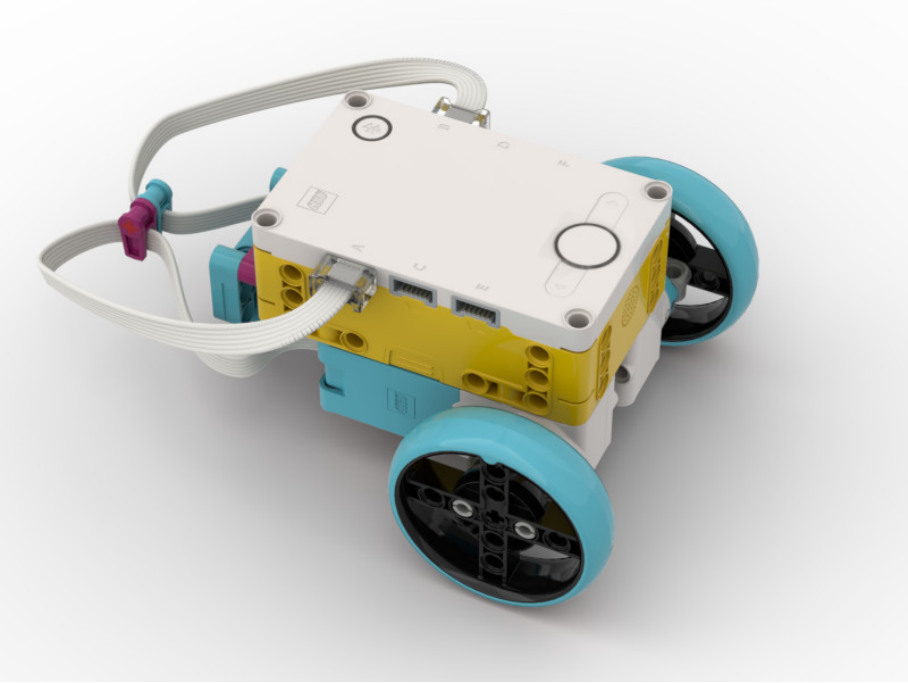
Resources

Extra resources that complement this book can be found on the website

http://www.damienkee.com

Chapter 2: SPYKEE Basics

Overview: Build a robot that is capable of driving around an obstacle course.



Project: THE SPACE AGENCY is in the market for a new planetary rover to explore the recently discover planet Tobor-3. You are required to construct and test a robot that can follow a set of commands to explore the planet's surface. Before the robot is deployed, it must be extensively tested to ensure it will perform as expected. You can't fly a technician to Tobor-3 to reboot the robot!

Equipment required

- 1 SPIKE robot kit per group
- 1 computer per group
- Masking tape and Tape measure

Teachers' Notes

This section will cover the following topics amongst others

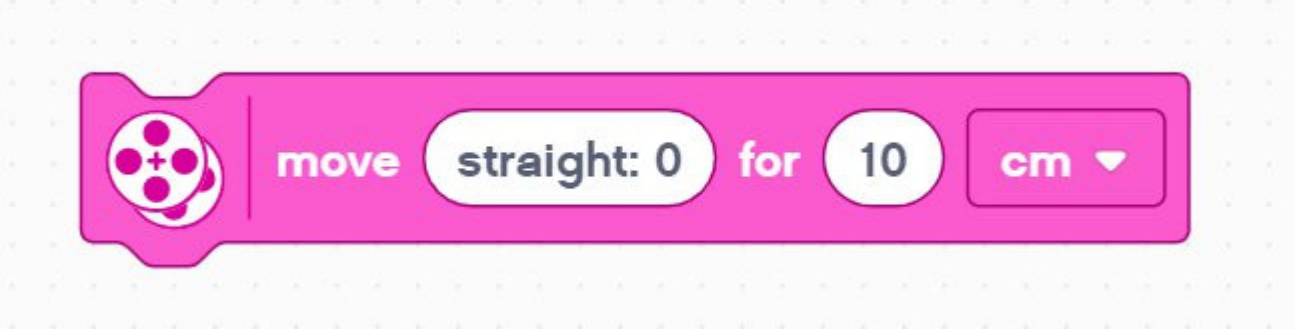
- Basic numeracy
- Decimal and fractional numbers
- Relationship between diameter and circumference
- Conversion between millimetres and inches

Get the students to build SPYKEE robot presented in Building Instructions.

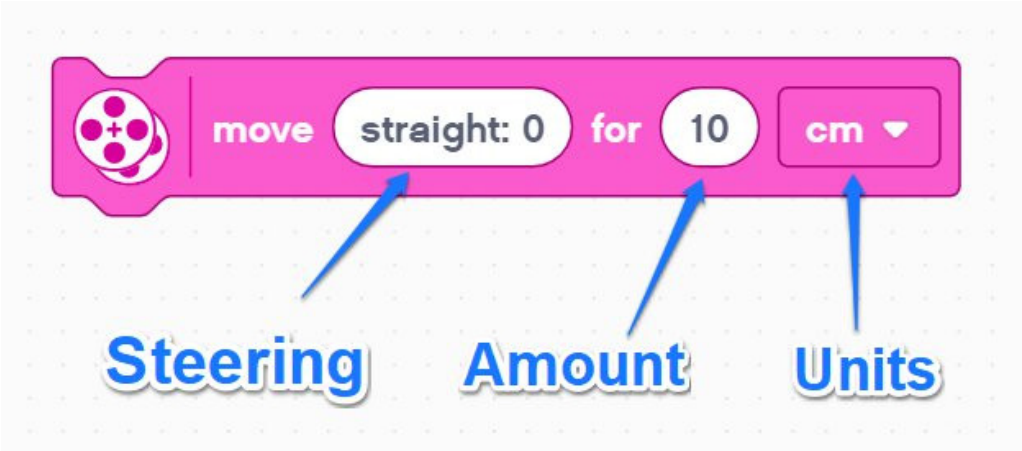
Photocopy and hand out Student Worksheet – SPYKEE Basics. This worksheet gives the students a range of different activities to follow that progressively increase in difficulty. To make our robot move, we need to send instructions to the motors which in turn drive the wheels. The SPYKEE design is often referred to as a wheelchair configuration, as it has a Left and Right motor that allows the robot to drive forwards, backwards and make turns.

SPIKE Software Specific

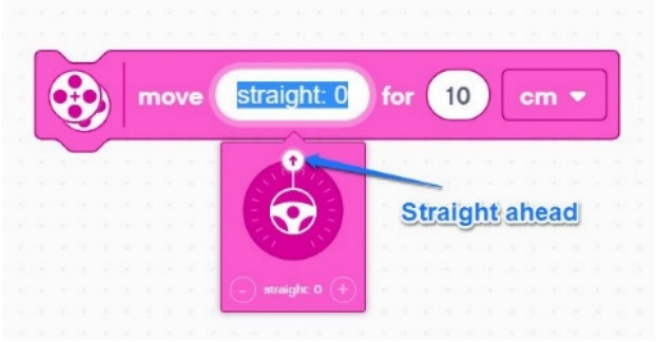
To perform the programming, we will need to know about the Move Blocks, located in the Movement Palette (Pink).

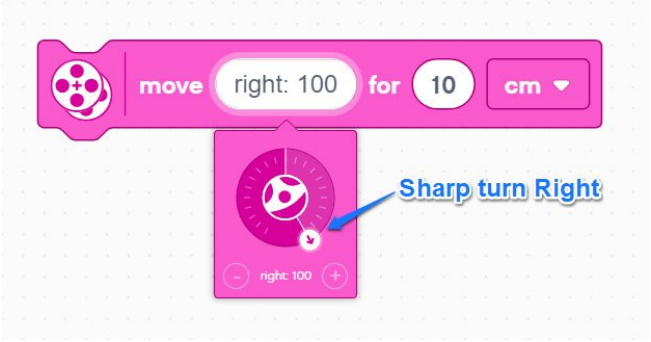


The Move Block has three parts to it as shown below. Steering, Amount and Units



Steering: Click and drag the wheel to set how sharply the robot will turn. A steering of '0' results in the robot driving in a straight line. 100 means a sharp turn right and -100 equates to a sharp turn left. Numbers in between will allow to robot to perform gentle to sharp turns.



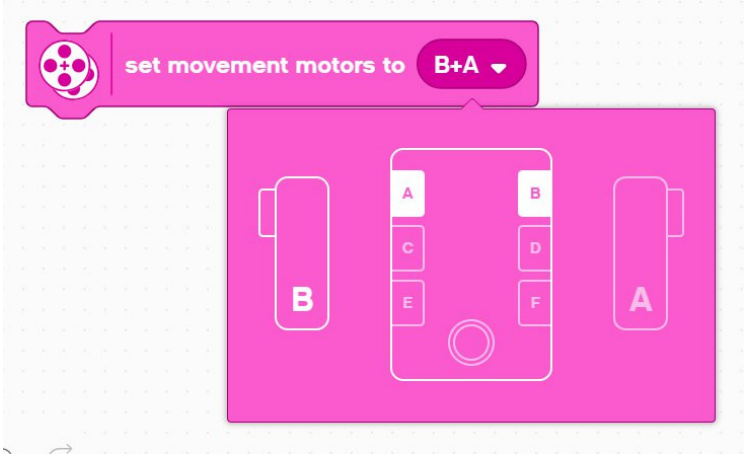


Amount: This section controls how far the robot will travel along the given steering curve.

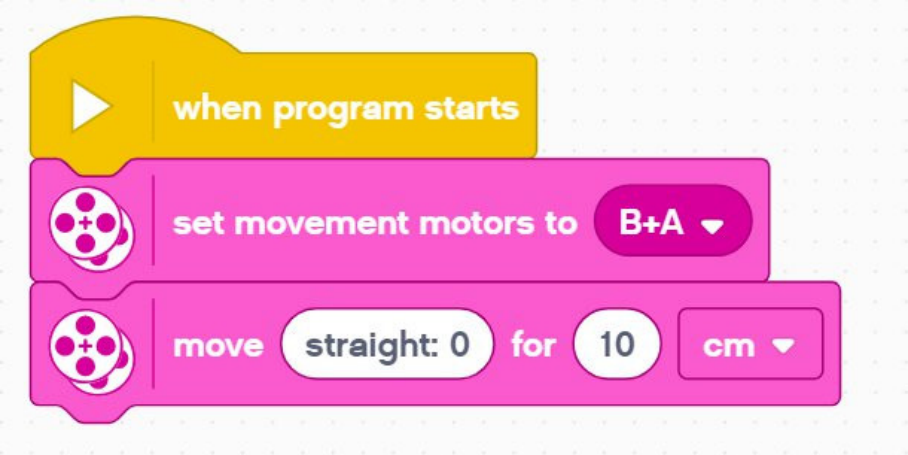
Units: cm / inches/ rotations / degrees / seconds: This specifies how much the robot will travel, in either centimetres, inches, rotations (of the wheel), degrees (of the wheel) or seconds.

Before we can run our first program, we need to let the software know which ports our motors are connected to.

For our robot, we have the left motor connected to the 'B' port and the right motor connected to the 'A' port. The Set Movement Motors block is used to let the software know of this setup. Notice how this is set up as B+A, ***not*** A+B



Let's add the 'Move Staight:0' Block. With this selected, we can now set the different Inputs to complete the activity on the Student worksheet: Drive Forward 10 cm Rotations.



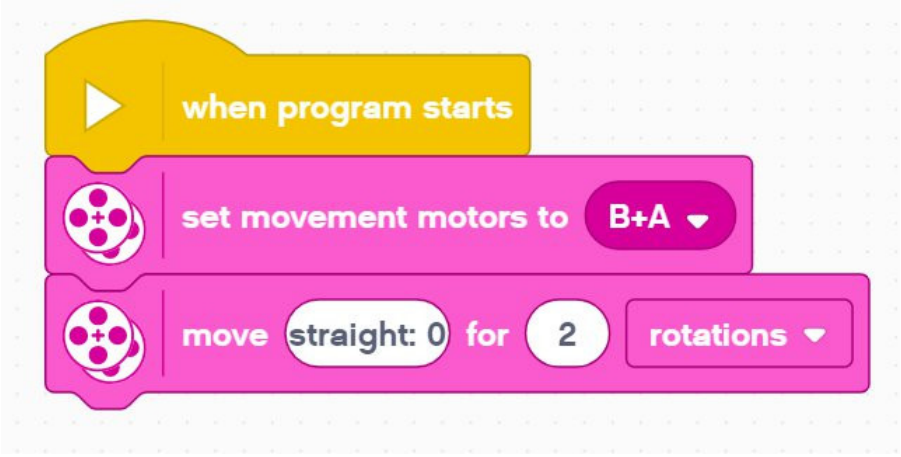
Download and run the program on your robot.

If all goes to plan, the wheels of your robot should drive forward 10cm. Use a ruler or tape measure to confirm this.

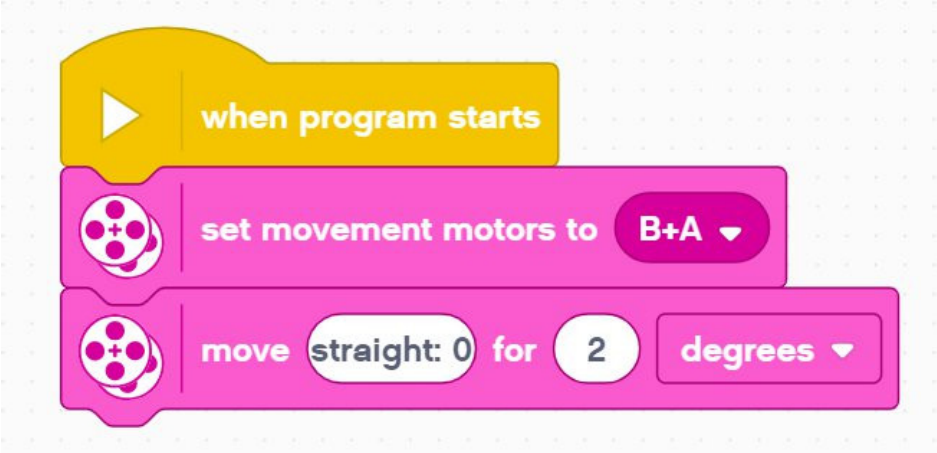
TIP: The actual distance travelled by the robot will dependent on the surface it is driving on. A hard, flat surface, like a tabletop, should give accurate results, whereas driving through carpet may result in the robot driving slightly shorter distances. This is due to the friction of the carpet as the robot tries to 'push' through.

From the worksheet:

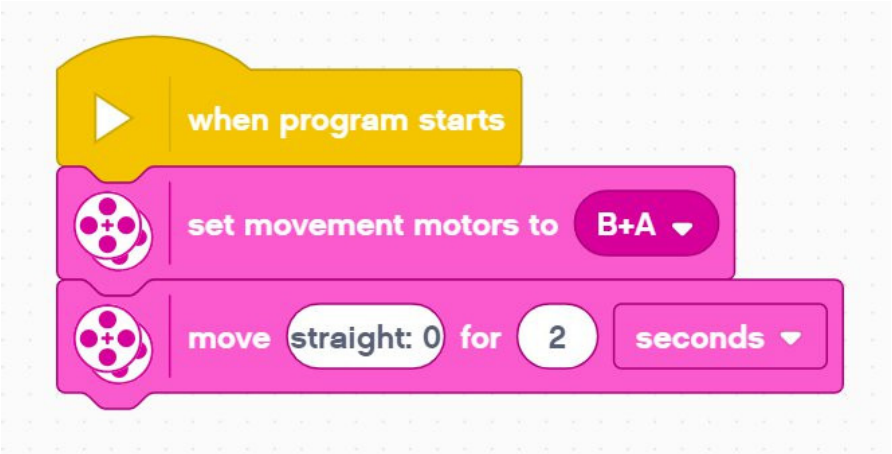
Drive Forward 2 rotations = 352mm or 13.9 inches (if you are using the SPIKE wheels provided)



Drive Forward 2 degrees = 1mm. While the robot will barely move, students may see the motors 'twitch' forward a very small amount.



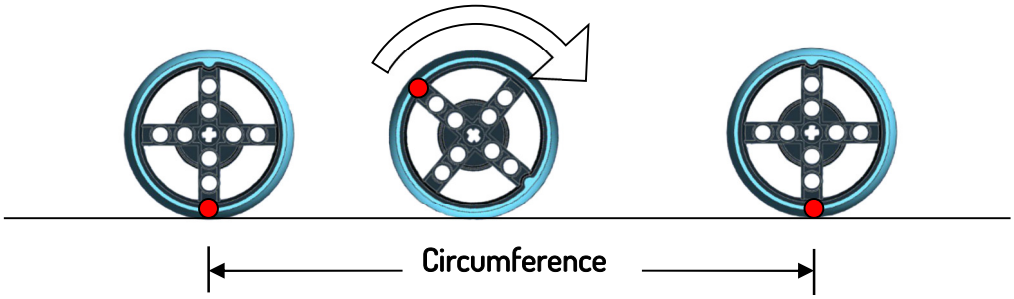
Drive Forward 2 seconds. How far the robot travels will be dependent on how fast the robot is driving. Two seconds forward at 20% power will travel a different distance than two seconds forward at 100% power.



How far will the robot drive if the wheels turn 3 rotations? To figure this out, we need to characterise how the robot performs. This means, take measurements to determine the specifications of the robot's movement. This is a good opportunity to either reinforce or introduce the correlation between the radius of a wheel and its circumference.

Calculating the circumference can be done either mathematically or experimentally depending on the ability of the students.

Experimentally: Take a wheel off the robot and make a mark on the tire with either chalk or masking tape. Create a starting mark on the table and line up our tire mark with it. Now slowly roll the wheel until the tire mark again touches the ground. Make another mark at this point and use a ruler to measure the distance.



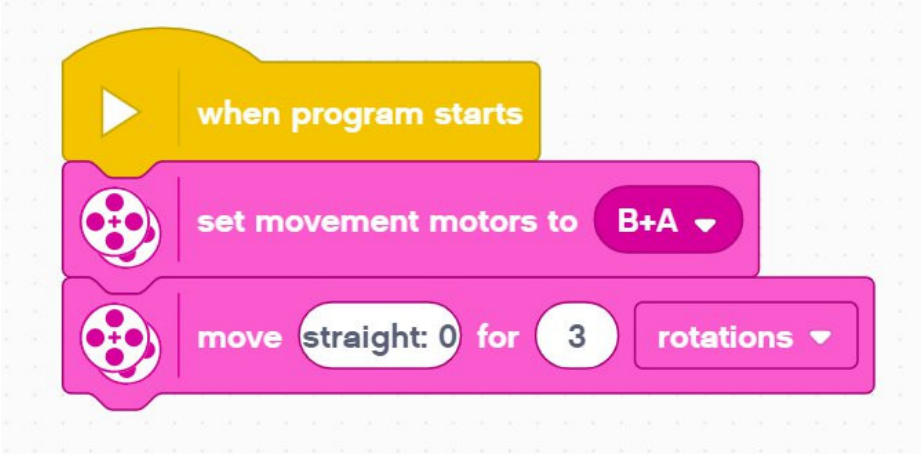
Mathematically: The circumference of a wheel can be calculated using the formulae: $c = \pi \times d$

Where c= circumference, π = 3.14 (approx) and d is the diameter of the wheel.

The wheel that comes as part of the standard SPIKE set is 56mm (2.2 inch) in diameter which results in a circumference of approximately 176mm (6.9 inch).

What this means, is that for one complete rotation, the robot will travel 176mm (6.9 inches). Given that one complete rotation is 360 degrees, we can calculate that 1 degree of the wheel turning will result in 0.49mm.

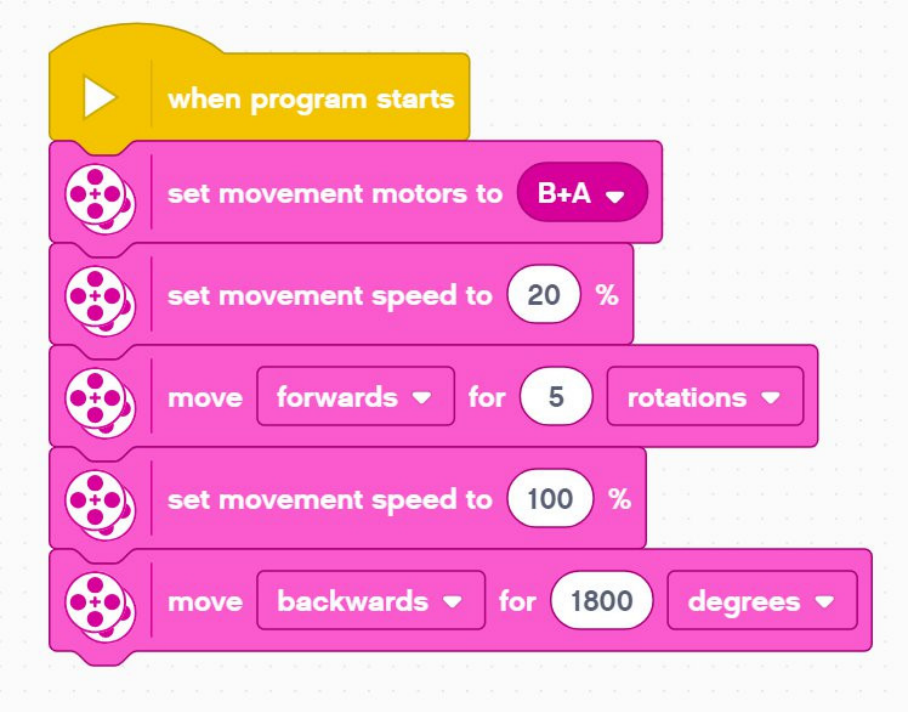
For 3 rotations, the robot will travel 528mm (20.8 inches)



Drive Forward 5 rotations slowly and then backwards 1800 degrees backwards as fast as possible.

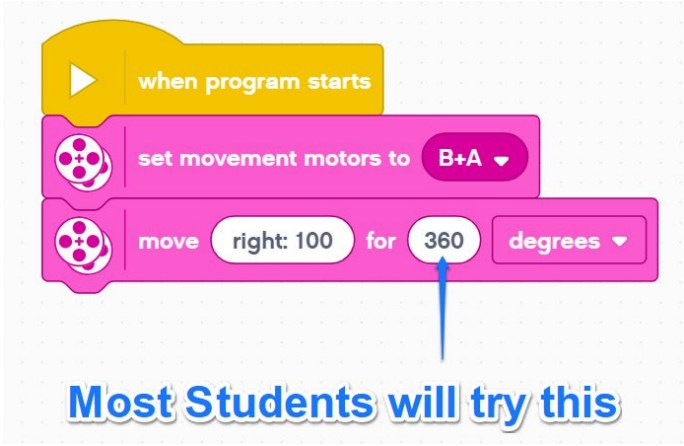
The Move block we have been using can only be used for a forward direction, so to complete this challenge, students will need the Move Backwards block. This challenge also introduces a change of speed. Use the Set Movement Speed block to change how fast the robot will travel.

Encourage students to calculate how far 1800 degrees is (1800 / 360 = 5 rotations). They should find the robot ends up exactly where it starts.



Making your robot turn

For the challenge where students are asked to make their robots turn around in a full circle (360 degrees), they will typically type in 360 degrees and proceed to run the program. When run however, if they are using the SPYKEE, they will find that their robot does not actually turn 360 degrees but in fact far less.



This occurs because the Move block is designed to control the wheels of the robot, not the whole robot. If we observe just the wheel, we will find that it does in fact turn exactly 360 degrees, just as it was told to do. The angle turned by the robot however is dependent on a few different conditions such as the size of the wheels and the distance between the wheels.

Calculating the required duration to make the robot turn 360 degrees is best done experimentally. Every robot design is slightly different, so the number of degrees required to turn a robot completely around may vary, even with robots that look the same.

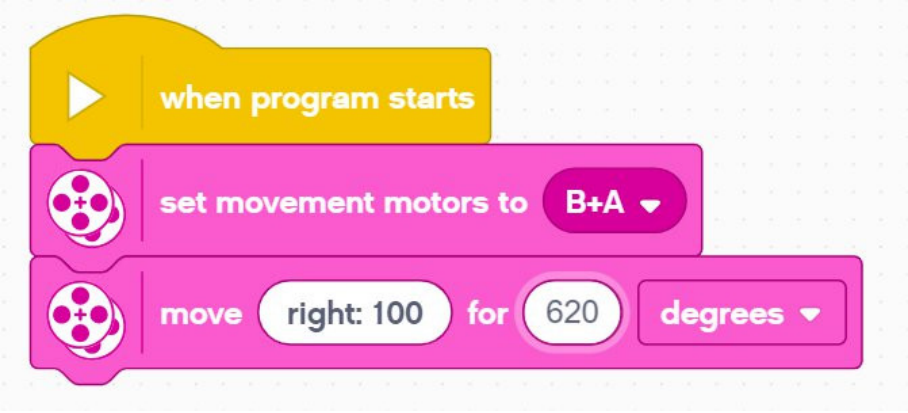
From the Worksheet:

Make your robot turn around a complete circle (360 degrees).

Keep increasing the Degrees parameter of the wheels until the robot does indeed turn 360 degrees. A sharp turn with the Move Block Input to either the left (-100) or right (100) is required. Students can perform trial and error with different values until an acceptable solution is found.

To test, place a strip of tape on the floor. Start the robot with both wheels on the tape. A perfect 360 degree turn will result in the wheels ending up back on the tape.

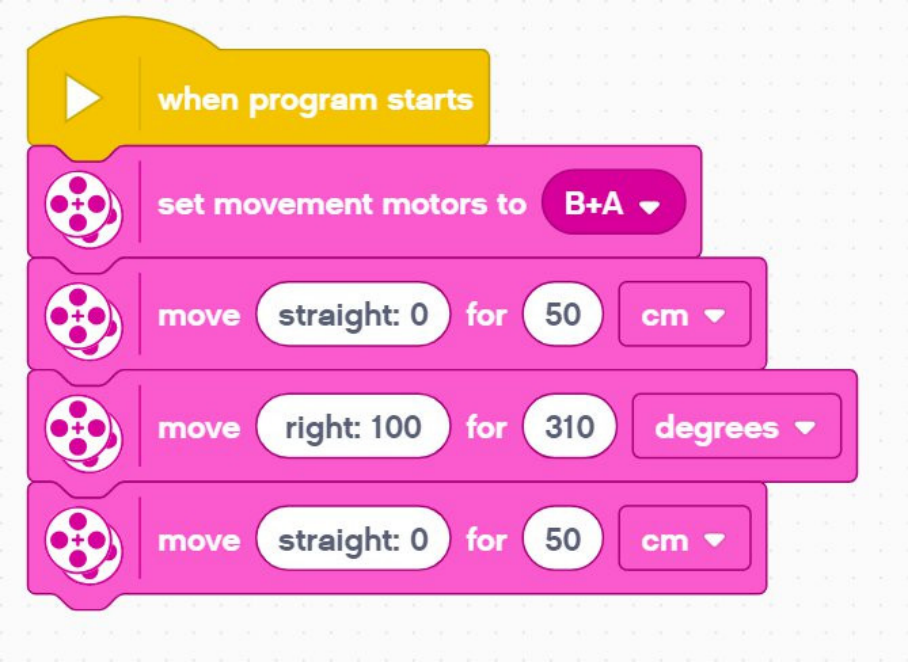
For the SPYKEE, with fresh batteries, on a smooth surface, a sharp turn of 620 degrees of the wheels gives an accurate 360 degree turn of the robot. Your robot's number might vary but should be close to this number.



Drive forward 500mm (20 inches), turn around 180 degrees and drive back to the start.

Layout two strips of tape, 500mm apart as our test distance.

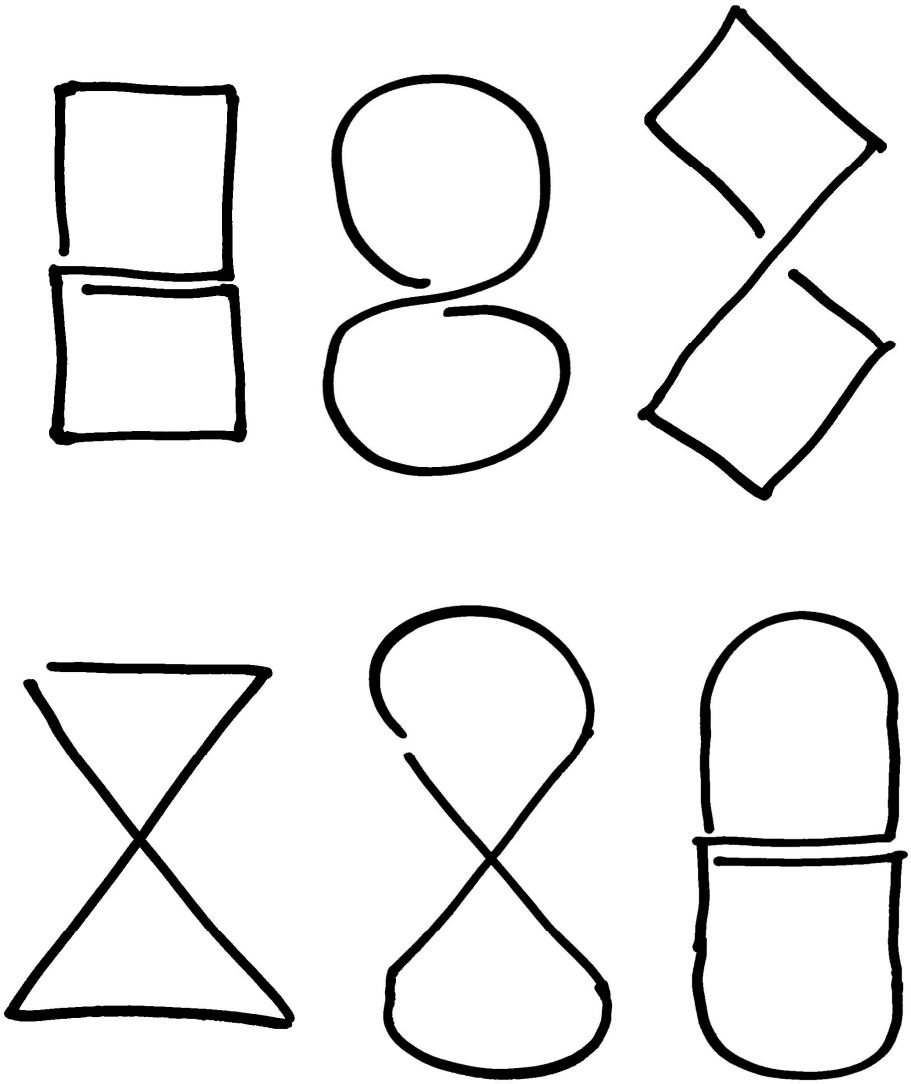
Using the turning angle discovered above, the students can do a rough calculation of what is necessary to turn 180 degrees. For the SPYKEE, on a flat surface the wheels require approximately 310 degrees (620 / 2) to perform an accurate 180 degree turn.



Make your robot drive in a Figure 8 shape:

When running the 'figure of eight' challenge, it can be left open ended or a specific shape can be offered. Encourage the students to draw a picture of the path they are attempting before they start programming. Encourage them to look at each of the individual movements and relate them back to separate Move Blocks. To create a test environment, place 2 markers down, 500mm (20 inch) apart. The robots will need to perform their path around these markers and are not allowed to hit or move the markers. Robots should ideally make it back to where they start.

If your students are unsure of what a 'figure of eight' looks like, here are a variety of different versions. The digital figure of 8 is the easiest to implement, as the students already know how to drive straight and perform accurate 90 degree turns. If students quickly finish one version, encourage them to try a more complex version.



Chapter 3: What is a Robot?

Overview: Discover what a robot is, and what function it performs.

Project: Students are asked about what they think a robot is, and what it does. Students research robots in general and present a report based on one specific robot.

Equipment required

- Access to research materials, (Library, Internet etc)
- Computer to write report

Teachers' Notes

This section will cover the following concepts

- Research skills
- Report writing
- Word Processing
- Design with Multimedia
- Oral presentation

Photocopy or print Student Handout – What is a Robot? and distribute to the class. You may choose to start discussion immediately or give the students time to perform preliminary research. Bring the group together and start to form a class opinion of robots.

Pose the following questions to the group.

- What is a robot?
- Where did the term 'robot' come from?
- Name some types of robots
- Why do we have robots? / What function do they perform in society?
- What are the main components of a robot?

There are many different interpretations of what a robot is, with some of them quite different. There is no single definitive answer that encapsulates all the functions of a robot. The following is a list of different dictionary definitions available.

American Heritage Dictionary

"A mechanical device that sometimes resembles a human and is capable of performing a variety of often complex human tasks on command or by being programmed in advance.

A machine or device that operates automatically or by remote control"

Cambridge Advanced Learner's Dictionary

"a machine used to perform jobs automatically, which is controlled by a computer"

Oxford Dictionary

"a machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer."

Keep in mind that while there is no universally accepted definition of a robot, the following points seem to cover the vast majority of robots.

- A robot is artificial. It has been manufactured and does not occur naturally.
- It is controlled by a computer of some description. This may range from a full sized personal computer to a small embedded micro-controller.
- It can sense the surrounding environment.
- It can perform actions and movements.

Despite these requirements, it is still very difficult to categorise a robot. The question can be posed to students; Is a washing machine a robot?

- It is artificial.
- Modern washing machines are controlled by miniature computers inside them.
- It senses when the lid is open.
- It performs movements by spinning the clothes back and forth.

Could a railway boom gate be considered a robot?

- It is artificial.
- It is controlled by computers.
- It senses when a train is approaching.
- It can raise and lower the boom gates.

Why do we have Robots?

There are many reasons that robots are used in society, each one filling a need. This question may also be posed as:

"What advantages are achieved by having robots in certain situations?"

Robots are generally built to serve for what is commonly known as the 3 D's; Dull, Dirty and Dangerous.

In an industrial setting, the use of robots allows repetitive tasks to be performed accurately time after time. Robots can generally perform simple tasks far quicker than humans can. This leads to increased productivity and better quality control of goods. Some types of robots, particularly those that need to pick up and put down fragile items, are so accurate that they can stop within a human hairs width of the objects they need to manipulate. Medical robots are reaping the benefits of such accuracy, allowing doctors to perform surgery on patients who are in another city or on the other side of the world.

Exploratory robots and military robots are designed to keep people away from harmful situations. Robot operators can drive a robot into an unsafe area and use the sensors and cameras on board to gather information. This is particularly useful for search and rescue missions in disaster areas, where the environment may be unsafe for humans to go looking for survivors.

Entertainment robots are another category and provide a lot of fun and interest for people. They can be typically found on TV, highlighting the fun things that robots can do. The range of sophistication goes from the very complex humanoids such as ASIMO and NAO, to the toys like RoboSapien and the LEGO® MINDSTORMS system. Household robots such as the vacuuming Roomba was one of the first robots to be marketed as a domestic robot with later versions that have been developed to mop floors and clean out gutters. The dream of a robotic butler to pick up our clothes and do our chores is not far away.

Name different types of robots?

There are a variety of different categories for robots, including but not limited to:

- Entertainment (ASIMO, NAO, AiBO, animatronics, RoboSapien, LEGO®)
- Domestic (Roomba, automatic lawn mowers)
- Movies (C3PO, R2D2, Wall-E, Johnny 5)
- Industrial (welding, Pick and Place, factory automation)
- Medical (remote surgery, minimally invasive surgery)
- Exploratory (Mars rovers, deep sea ROV's, unassisted aerial vehicles)
- Military (PackBot, bomb disposal, search and rescue)

What are the main components of a robot?

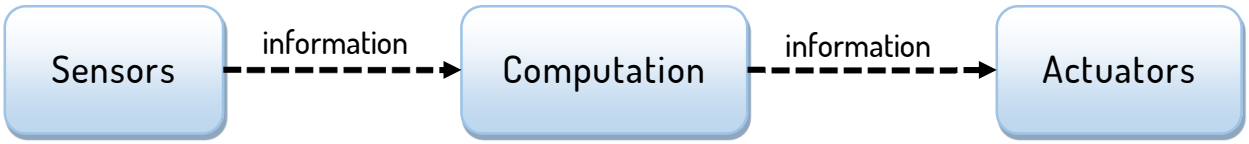
Robots can be broken down into three distinct components; Sensors, Computation and Actuators.

Sensors are used to 'feel' the surrounding environment. The robot uses these sensors to take in information about where it is and what it is doing. Different sensors can be used to sense different conditions including light and dark, temperature, bump sensors, ultrasonic, infrared... the list goes on and on. Think about what senses a human has, and how a robot replicates them. Sensors are classed as inputs, that is, they take information about the world and input it into the robot's brain.

The Computation component consists of an onboard computer that the robot uses to process the information coming from its sensors. This can be as small as a few integrated circuits right through to a full personal computer. The level of complexity of the required tasks will dictate the amount of computational ability needed by the robot.

The last distinct component of a robot are its Actuators. Actuators are a fancy way of saying 'parts that do things'. These may be motors in the wheels, or engines that make the arms go back and forth. It could also be hydraulic pistons or pneumatic cylinders. Actuators are a form of outputs, along with lights and speakers. The robot Computation tells these outputs to do different tasks.

The sensors provide the information to the computers, which in turn tell the motors what to do.



Path of information flow in a robot

Where did the term 'Robot' come from?

While the idea of artificial beings have been around for many years, the term 'robot' was first coined by Czech writer Karel Čapek in his play R.U.R. (Rossum's Universal Robots) in 1920. The word is derived from the Czech 'robota', which translates as 'forced work', 'slave' or 'servitude'. Čapek credits his brother Josef as the true inventor of the word.

Robots have enjoyed the majority of their exposure through movies and science fiction writings, such Star Wars and the Asimov series of 'Robot' books.

Robots in their presently accepted state were first developed in the 1950's, with George Devol's Unimate robot, capable of lifting hot pieces of metal from a die casting machine and stacking them. The first Unimate was sold to a General Motors assembly plant in New Jersey.

Assessment

Students are to present a report on robots. This may be done as a report, slideshow presentation, poster or oral report. Students will give a brief overview of robotics based on the preceding discussion and perform a more in depth analysis of one particular robot as approved by the teacher.

The following is a good list of real world robots.

- ASIMO, NAO, AIBO, Roomba
- Spirit / Opportunity / Curiosity (NASA rovers)
- PUMA arm, SCARA arm

Decide on the format of the assignment (written, multimedia etc). The due date is at the teacher discretion.

Extension activities

Any of the following questions could be used to promote further discussion:

- What are the differences between real robots and fictional robots?
- What attributes of robots are still only being dreamed about?
- Should robots have rights? Does a robot have a right to be cared for and maintained?
- Is there such a concept as robot abuse?
- Should a robot be compensated for their work?
- Will robots working in dull jobs force people to learn more complex skill sets?

Look into the RoboCup mission for 2050 – www.robocup.org

"By the year 2050, develop a team of fully autonomous humanoid robots that can win against the human world soccer champion group."

Chapter 4: Flowcharting

Overview: An introduction to flowcharting.

Project: Students are introduced to the concept of flowcharting. This process will allow them to co-ordinate their thoughts and will make programming less difficult as they progress. A larger project is systematically broken down into a series of more manageable tasks that are more readily completed. This is especially important as computers and robots are extremely literal, they will do exactly as they are told, no more and no less.

Equipment required

- Blackboard / Whiteboard
- Markers

Teachers' Notes

This section will cover the following concepts

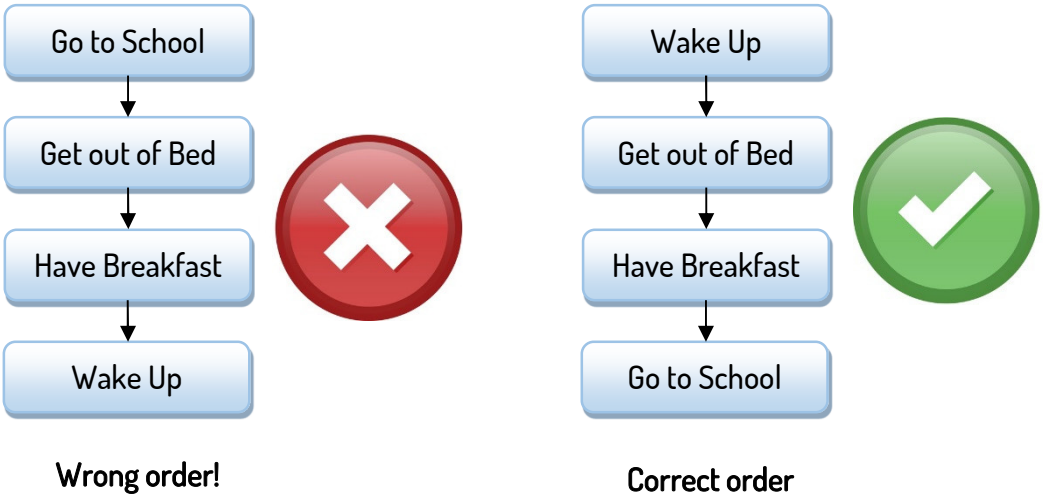
- Flowcharting / storyboarding
- Computational Thinking
- Sequencing of actions

This section is best done on a whiteboard, blackboard or other large projection screen. The concept of a flowchart should be explained with emphasis on both the correct order of tasks and providing sufficient detail. With both these concepts understood, generating a program for a robot becomes considerably easier.

Theory

When planning the program for a robot, it is very beneficial to go through a flow charting process. Flow charting allows us to take the ideas we have for a robot and start to assemble them in a logical fashion.

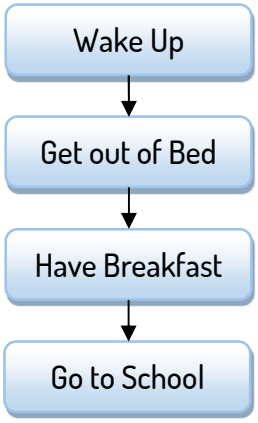
As an example, let us have a look at a typical student morning. We will look at how we approach our morning as a series of different individual tasks. Firstly, we need to get the order in which we do each step correct. If we try and do things in the wrong order, the whole day may not work. In addition, the amount of detail for each task is important. Each task should be sufficiently small enough, so as it can be done as a single step. If we keep these tasks short, simple and concise, it is easier plan out the bigger tasks. Occasionally, some steps need to be revisited and broken down further into smaller steps.



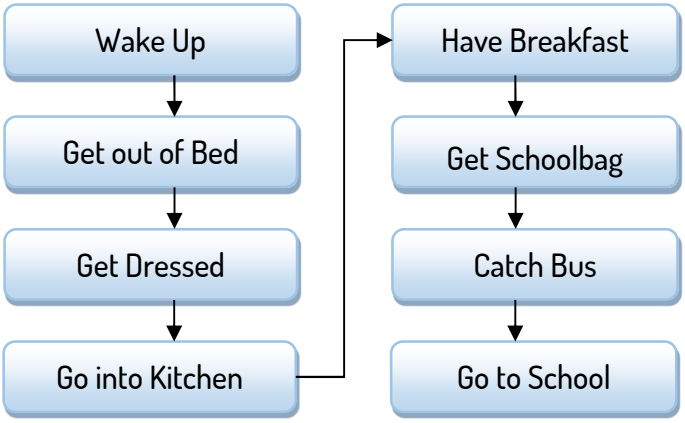
The order in which we do each task is very important. If we get the order around the wrong way, the tasks will not make sense.

When we start programming our robots, we will also need to sketch out a flowchart of how we would like our robot to behave. If we can break down the whole program into little tasks like we did above, it will be easier to program our robot. Ideally, each individual task will relate directly to a single block in the SPIKE programming environment. Once we have this sequence of tasks, we can start putting them into a language that the robot will understand. We will be using the SPIKE programming language to make our robot perform each of the tasks that we have defined.

It is important to remember that the first draft of the program is not expected to be perfect. Changes will almost certainly have to be made along the way as flaws and inconsistencies are found. It is vital to have a plan or road map first, before we start programming, even if that plan changes along the way.



Not enough detail



Better flowchart with more detail

How much detail we put into our flowchart is important. The one on the left has only a few broad steps. The one on the right is far more detailed and would be easier to convert into a program.

Assessment

Photocopy and hand out Student Worksheet - Flowcharting. Lead the class in a discussion about flowcharting and have the students complete the worksheet. Emphasise the need to have the correct order of tasks as well as sufficient detail.

Chapter 5: How Far?

Overview: Test the robot for distance characteristics.

Project: In the initial construction of the robot the travelling characteristics are required. After characterising the properties, THE SPACE AGENCY have asked that you use your data to make predictions about the distance your robot will travel, given specific time constraints.

Equipment required

- 1 SPIKE robot kit per group
- 1 computer per group
- Masking tape
- Tape measure
- Stopwatch

Teachers' Notes

This section does not require any additional software knowledge. All activities can be performed with the use of just the Move block. The SPYKEE is used to perform data gathering and scientific analysis.

Photocopy or print and hand out Student Worksheet – How Far?

This section will cover the following topics

- Data gathering
- Graphing
- Interpolation / Extrapolation
- Decimal numbers and fractions
- Averaging of data
- Position and distance

Theory

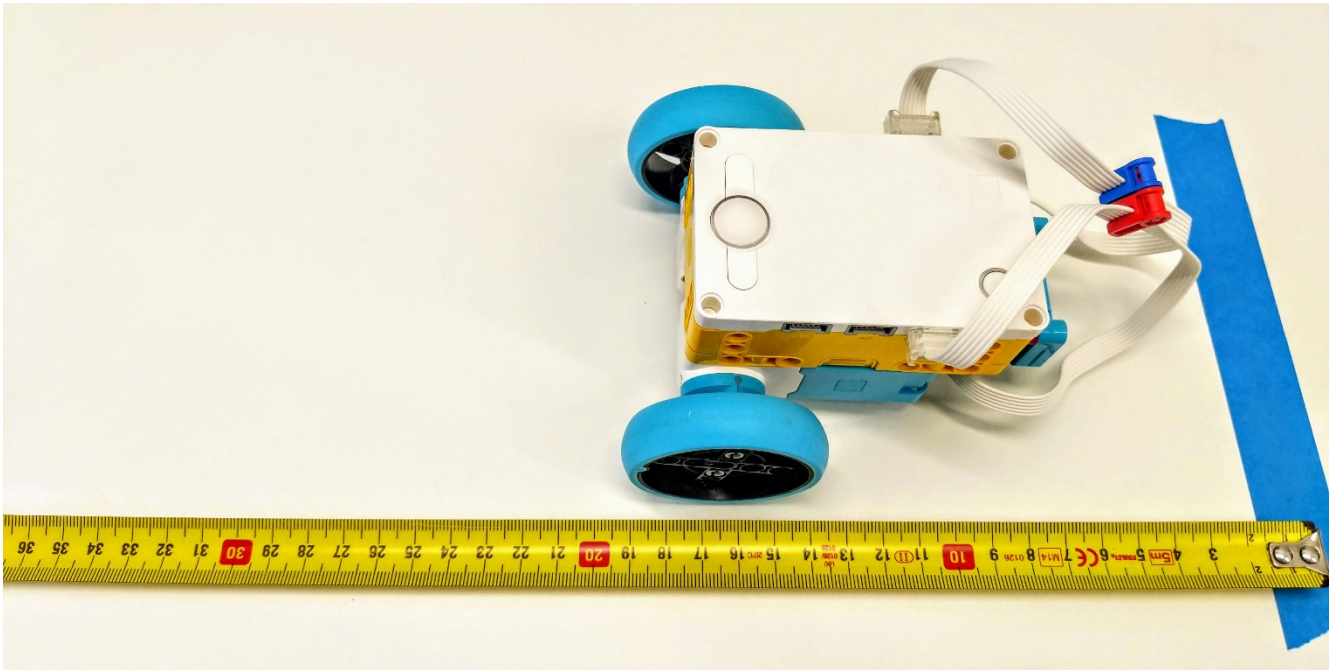
This activity will look at the effect that changing the time of travel of the robot has on the distance it moves. It will become evident that the longer a robot travels the further it travels, but can the relationship between time and distance be predicted?

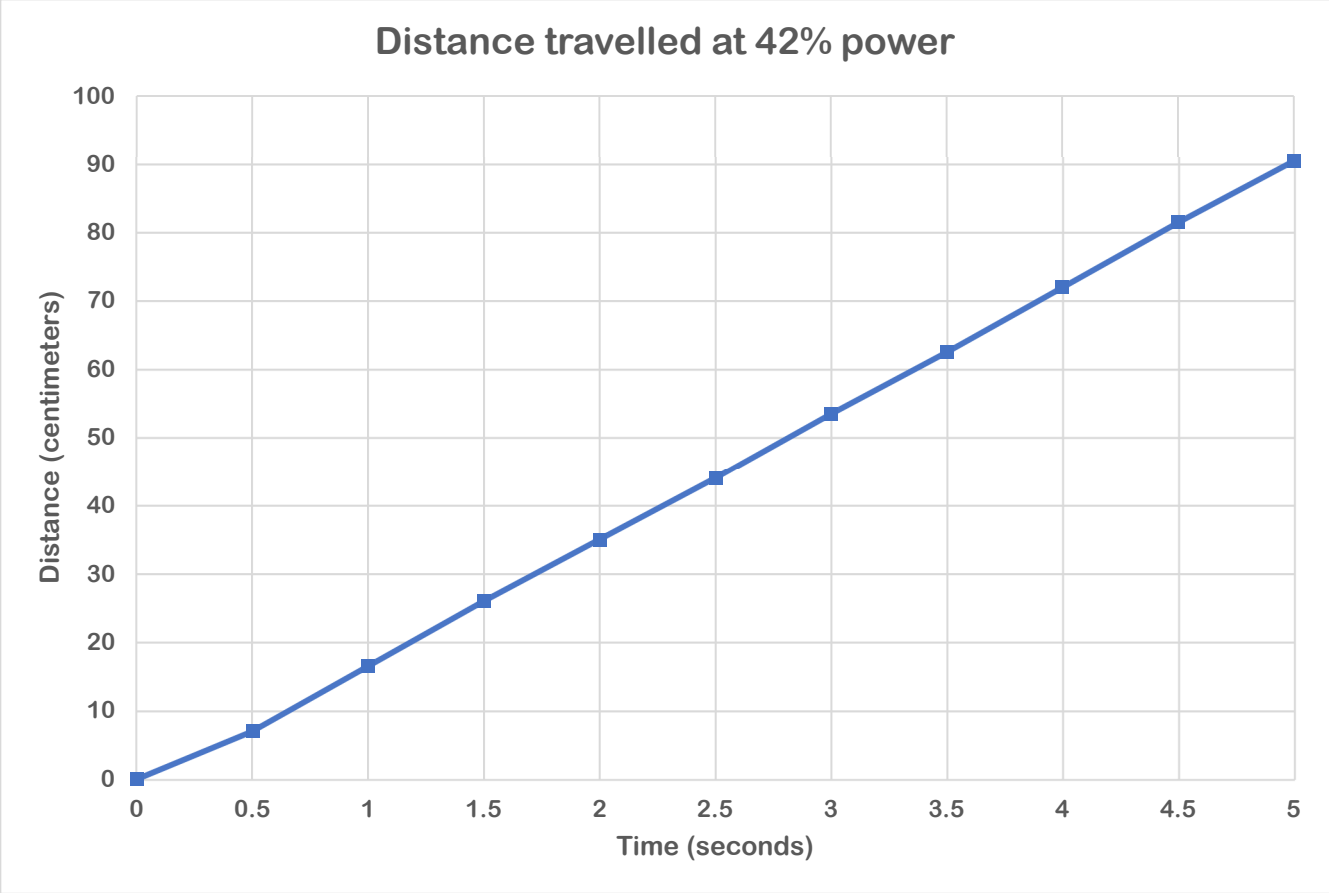
Students will program their robot to travel for 1 second at a specific power level. The same experiment is run again this time for 1.5 seconds at the same power level. Students should take as many measurements as time allows with a wide variety of times. Encourage the students to take multiple runs and take the average of all their data to reduce the impact of experimental error. Keep increasing the length of time the robot is travelling and record the distance.

By plotting the distance travelled (vertical axis) against the time taken (horizontal axis), students build up a graph of their data. Students should find that there is a linear (straight line) relationship between the time programmed and the distance travelled. The slope of this line is the velocity of the robot (distance/time).

A random power level between 20% and 100% is assigned to each group, ensuring different results for each group. They cannot copy other groups' data as it would be inaccurate for their robot.

This data was taken for the standard SPYKEE running with a full battery. Lower battery levels will change the speed of the robot so ensure that all data is gathered in one session, using the same robot each time.





Look out for...

To set up, we will need a starting line and a tape measure. Encourage the students to work out what materials they will need and gently push them in the right direction if they miss out on anything.

If this same experiment is run on carpet, students can expect to see a decrease in the distance of the robot due to the additional friction between the castor wheel and the carpet surface. Encourage this line of thought and get the students to run the same experiment with the same power level on multiple surfaces.

Be wary of very high power levels. Depending on the surface the robot is travelling on, sometimes the wheels can 'slip' as they start up, giving a slightly shorter distance than should be measured.

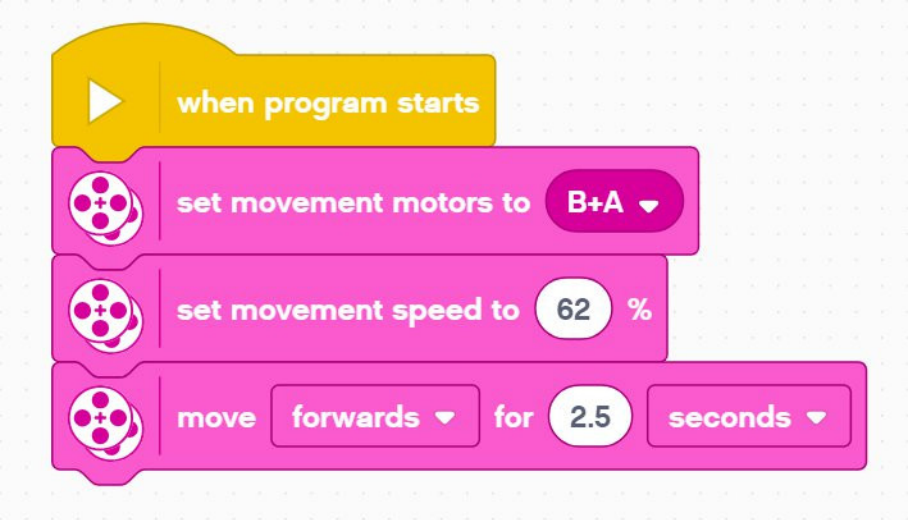
The Challenge!

To test that the graph is correct, place an object a random distance away from the starting line. Students will then need to read off their graph through either interpolation (reading within the graph) or extrapolation (reading beyond the graph) to determine the amount of time required to reach the marker. As an added constraint, require the robots to drive up to the marker but not knock it over.

Eg. Place a drink container 60cm away. Looking at the graph above, the SPYKEE robot would require approximately 3.4 seconds to reach that distance. All groups will have constructed their graphs with different power levels and as such all groups should have a different time requirement.

Example Program

Make your robot drive forward for 2.5 seconds at 62% power



Chapter 6: How Many Sides?

Overview: Attach a drawing device to your robot and plot out some geometric shapes.

Project: Once on Tobor-3, your robot will be required to identify interesting geological formations for later analysis. Your robot will be required to mark off an area so that a passing satellite can easily identify the item in question. Initially you will be required to draw a square but will then move onto other shapes and designs.

Equipment required

- 1 SPIKE robot kit per group
- 1 computer per group
- Large marker
- Large sheet of paper

Teachers' Notes

Attach the large marker to the front of the robot. Students could use tape and rubber bands or they may choose to design their own attachment out of the remaining LEGO pieces. It is best to secure the marker in at least two locations as it will minimises the marker twisting as it draws.

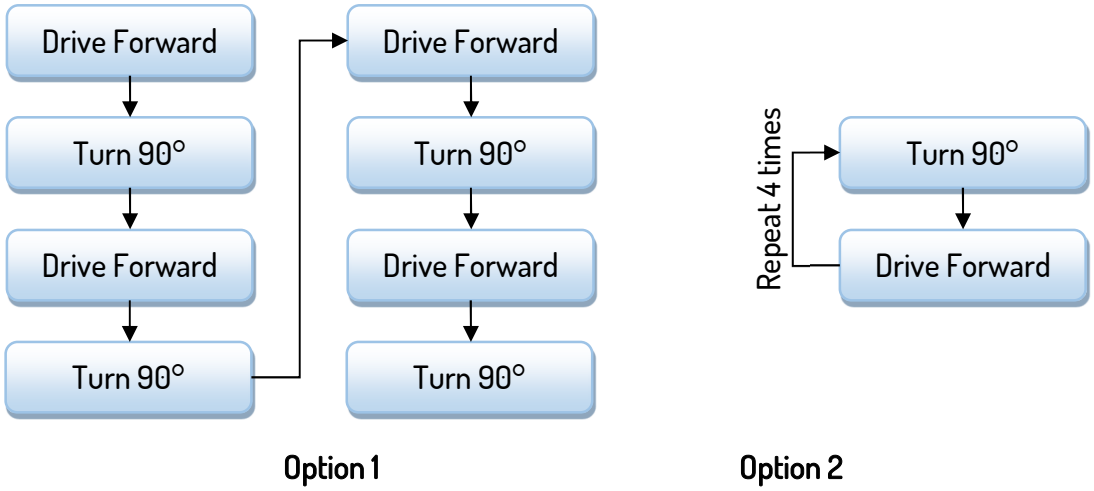
This chapter will cover the following topics:

- Basic geometric shapes
- Internal and external angles of a polygon

To draw a square, most students will initially decide to plan out each individual step resulting in 8 blocks (4 sides and 4 corners). But if asked how they would do a hexagon or a triangle, they can be guided towards understanding the need to repeat sections of code ie." Drive forward and turn, then repeat a certain number of times". This can be achieved with the **Repeat** Block.

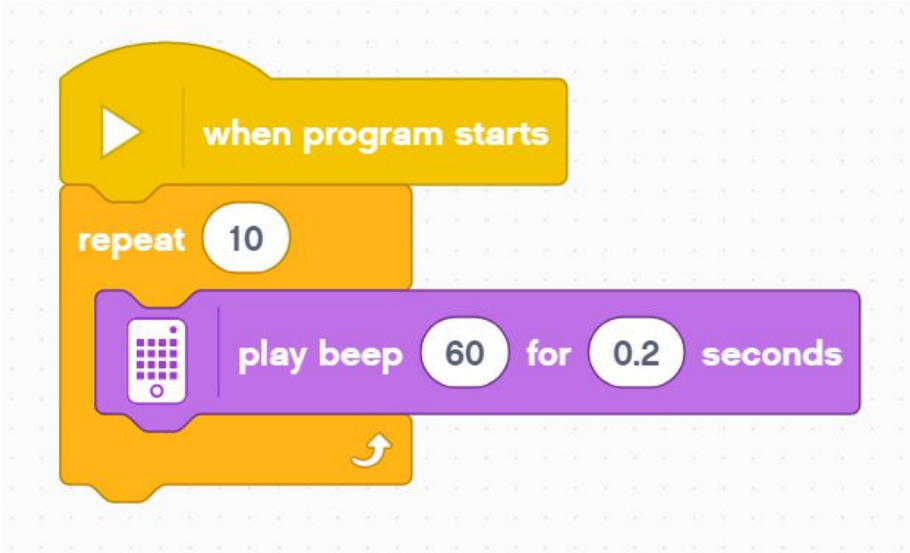
Print and hand out Student Worksheet – *How Many Sides?*

To make our robot drive in a square, we will need to program it to go forward, turn 90 degrees, go forward, turn 90 degrees, go forward, turn 90 degrees, go forward and do a final 90 degree turn. If we look carefully at the program, we can see that it consists of drive forward, turn 90 degrees and repeated 4 times.



Driving in a square. Which is easier?

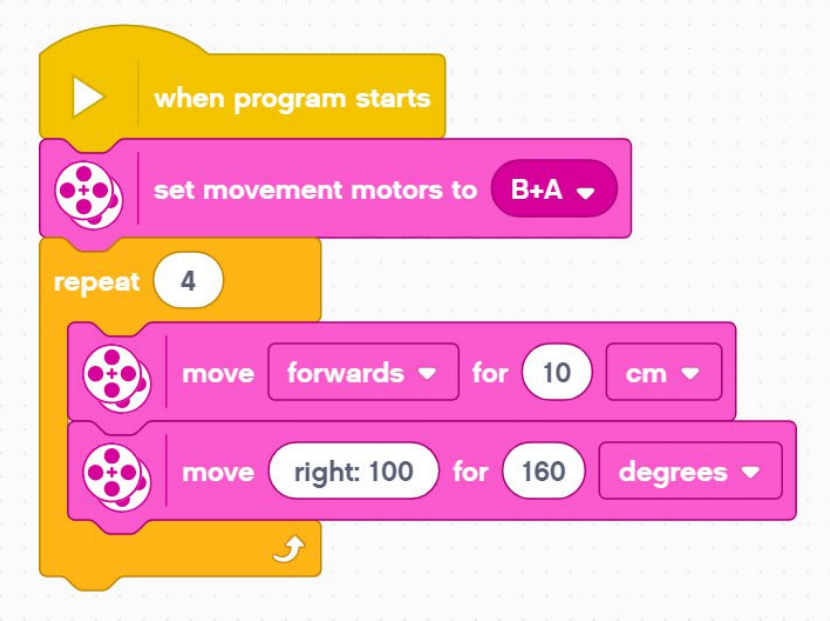
We can use the **Repeat** Block to achieve this simpler form of programming. Everything within the border of the **Repeat** Block will get repeated based on the values we specify.



Repeat Block: This example program will play a sound file 10 times

Example Program

Make your Robot drive in a square. Remember that the amount of wheel turn required to make your robot turn 90 degrees will vary between robots. Use the values you discovered in Chapter 2 as a starting point. Adjust as necessary.



Theory

Cumulative error becomes a factor when using the **Repeat** Block, as errors in the turn angle can build up every time the robot performs the turn. Eg. Let us assume the robot turns 92 degrees instead of 90 degrees. To the human eye, the first turn looks fine, but as the robot progresses around the square, the 2 degree error from each turn is accumulated into an 8 degree error at the end of the square.

When progressing to the octagon, it is important to realise that the angle the robot must turn is the external, or exterior angle of the polygon.

The following equations can be used to calculate the internal and external angles of a polygon.

$$\text{internal angle} = \frac{(\text{number of sides} - 2) \times 180^\circ}{\text{number of sides}}$$

$$\text{external angle} = 180^\circ - \text{internal angle}$$

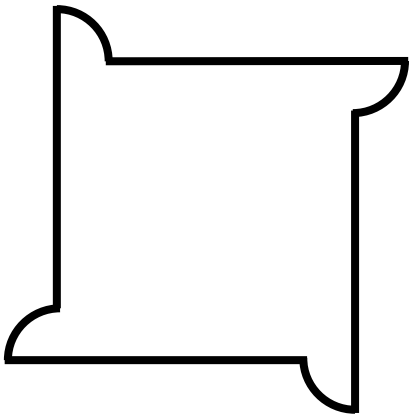
Shape	Number of sides	Internal angle	External angle
Octagon	8	135°	45°
Hexagon	6	120°	60°
Triangle	3	60°	120°

TIP: Don't forget that the angle required by the robot is not the same angle required by the wheel. Refer back to SPYKEE Basics to determine wheel turns for accurate Robot turns, and for calculating the required durations for the sides of each shape.

Look out for...

The critical component in this challenge is the angle. A robot with the correct turn angle will arrive exactly back where it started. Mark the starting point with a dot of tape on the floor and measure how close each robot finishes.

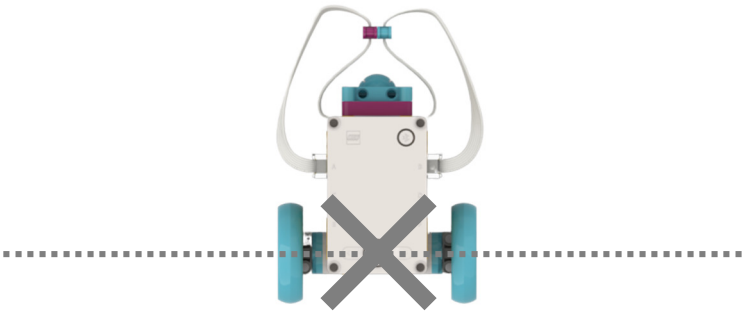
With this robot design, the marker is not located at the point from which the centre of the robot will pivot. When drawing with a marker attached, the following shape will result.



As the marker is located in front of the wheels, the corners will not be perfectly square as indicated in this diagram

Extension Activity

Modifying the mechanical structure of the robot is a good extension activity to run. Have the students change the design of the robot so that it will draw precise corners. This is achieved by locating the marker pen exactly in between the wheels. When the robot turns on the spot, the pen will not travel any distance, and will just rotate over the corner point. (Hint: You will need to move the SPIKE Hub so that there is space between the wheels to mount the pen)



The marker pen needs to be located exactly at the centre of the axis of rotation of the wheels to ensure sharp corners.

Chapter 7: That Bot has Personality!

Overview: Use the Light and Sound blocks to give your robot some personality.

Project: THE SPACE AGENCY are extremely happy with the progress of the project so far, but have asked if it is possible to inject a little personality into your robot. Using the sounds as well as the display screen, it will be possible for the robot to let us know what it is up to!

Equipment Required

- 1 SPIKE robot kit per group
- 1 computer per group

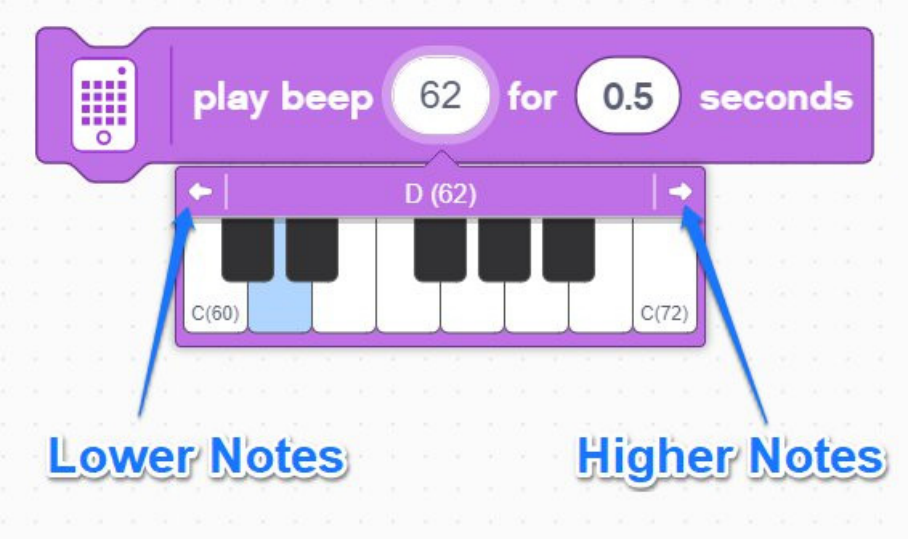
Teachers' Notes

As well as being a lot of fun, the use of Light and Sound Blocks are an excellent way of 'debugging' programs. By making the robot play a certain sound or show a certain display at a particular point in the program, students determine if it reached that point, just by listening and watching out for it. Eg. Suppose we wanted the robot to perform an elaborate sequence of movements to reach a position; we might be looking at 10 or more blocks. A mistake in any of these blocks will follow through to all the other blocks. If we put in a sound effect after the 5th block, students can then use that as a reference point to figure out if they need to make corrections before or after that point.

There is no Student worksheet for this chapter, but teachers are encouraged to give the students a glimpse of the different blocks and get them to incorporate them into their programs. These blocks can be beneficial in all programs that students create, regardless of the challenge required.

Sound Blocks

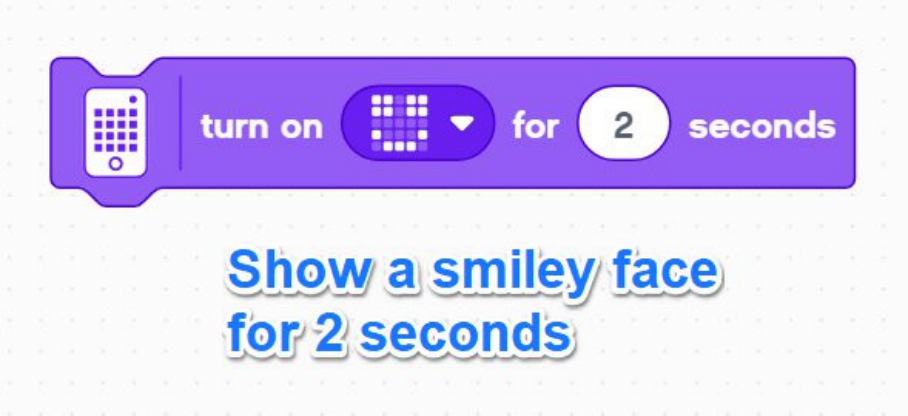
Play Beep: You can configure both the note being played and the length of time the note will be heard.



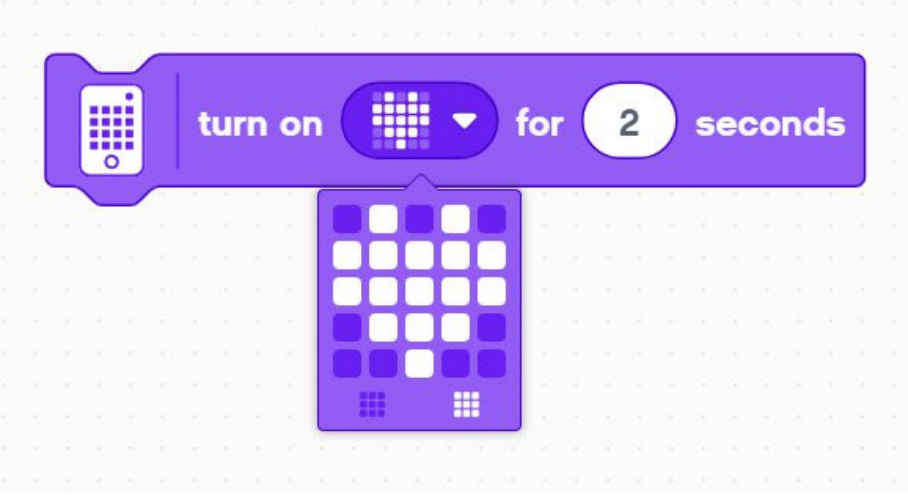
Play Sound: This block will play a pre-recorded sound effect from your computers' speakers. Click on 'Add Sound to search the existing library of sounds that you could use.

Light Blocks

The SPIKE hub has a display on top that consists of 25 LED lights arranged in a 5x5 grid. The Light Blocks can be used to turn these individual lights on or off, as well as setting the brightness of the display.



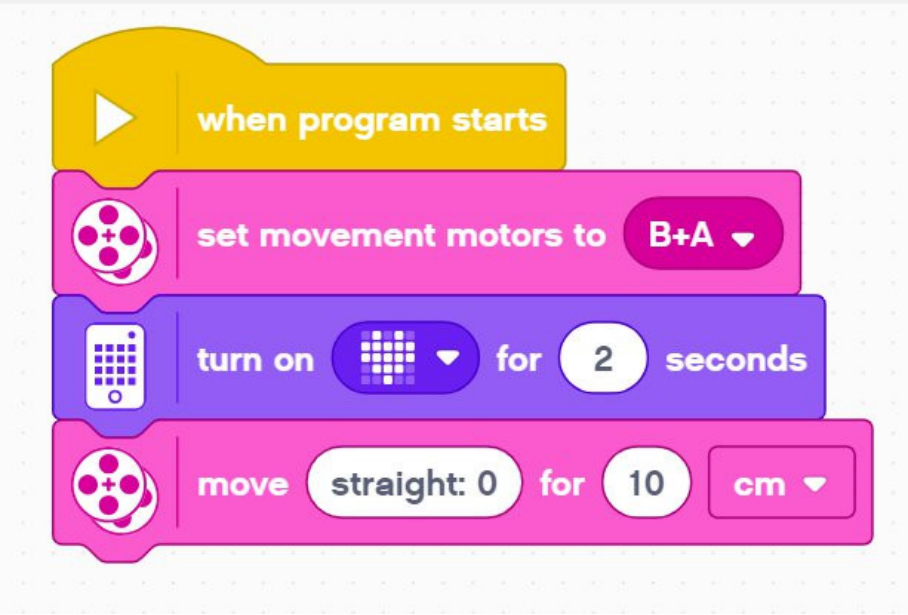
Select individual LED's to make them turn on or off as necessary



As with the Sound Block, the Light Block is an excellent way for students to keep track of where in the program their robot is currently at. Eg. Have your robot display on the screen a smiley face when it is driving forward, and a frowning face when it is driving backwards.

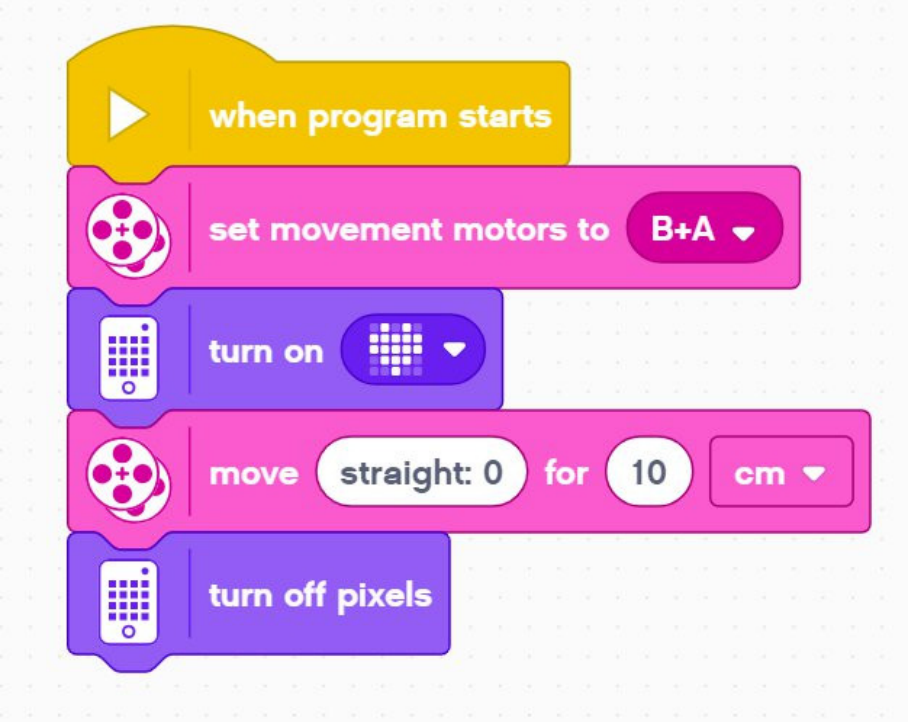
Turn On vs Turn On for (?) seconds

Turn on for (?) seconds will show the picture as intended, for the time specified and will then turn off all the LEDs.



The robot will show the Heart display for 2 seconds. It will then turn off the heart display and drive forward 10 cm.

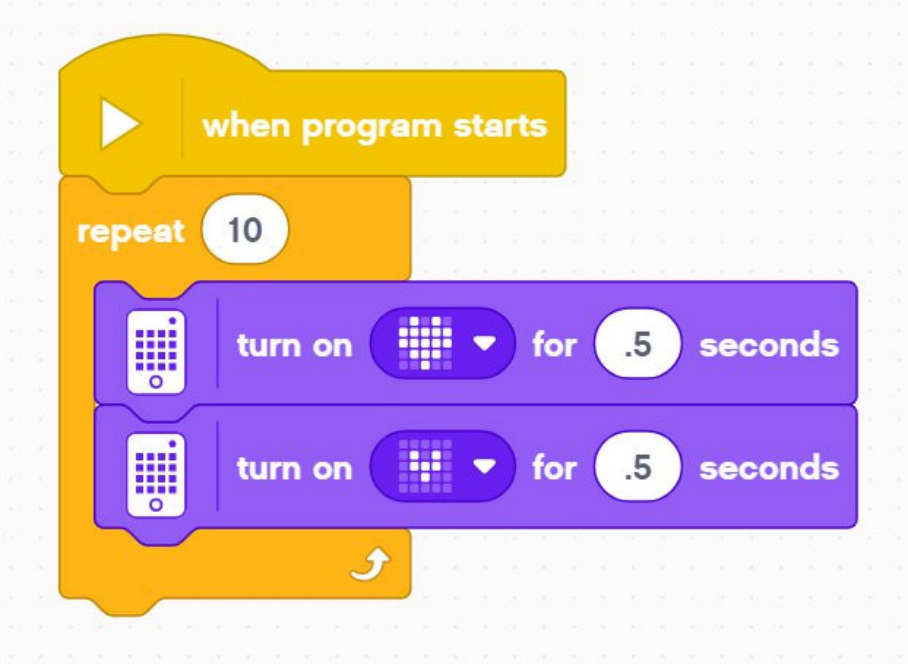
Turn On, will turn on the picture as intended and will leave the picture on the display until a Turn Off Pixels block is used.



The robot will show the Heart display while it is driving 10cm

Extension Activity

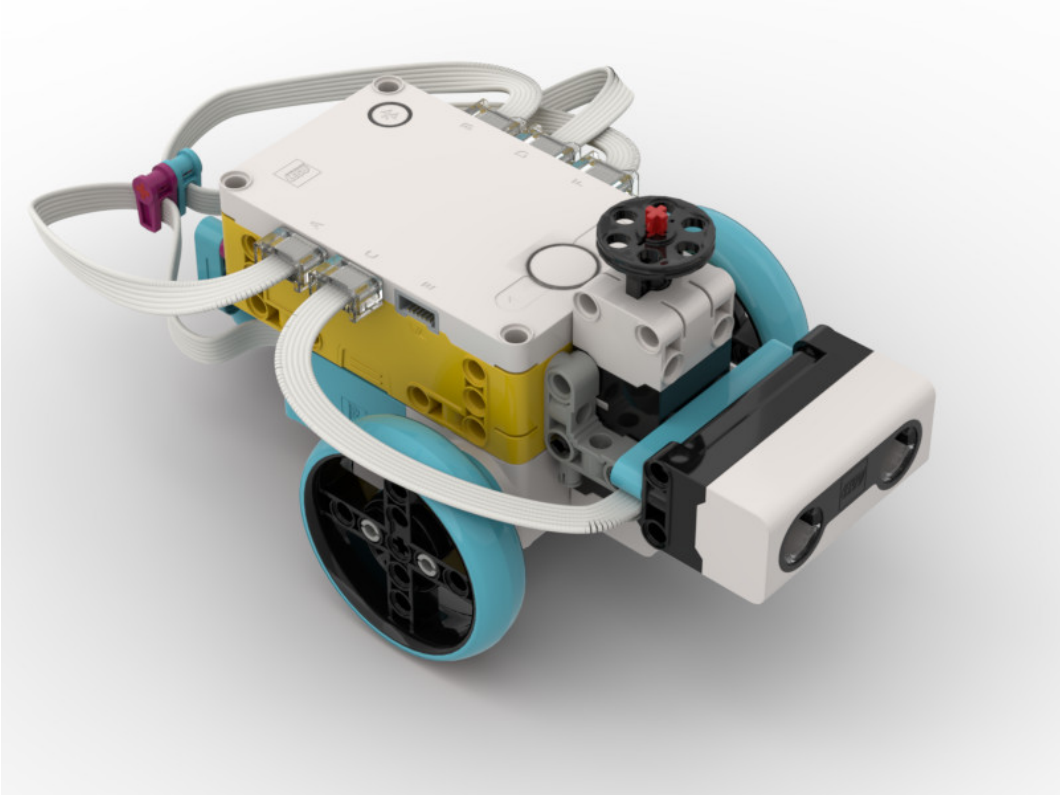
Can you create a program to simulate an animation of a beating heart?



Chapter 8: Help, I'm Stuck!

Overview: Equip your robot with a Sensor to help it detect obstacles.

Project: Whilst on Tobor-3, your robot will undoubtedly come up against obstacles in its path. THE SPACE AGENCY is worried about a cliff wall that is blocking the robot's progress. They have asked that you demonstrate your robot's ability to detect such obstacles and navigate away from them. It is important that your robot does not physically touch these obstacles as we do not wish to damage the robot or contaminate our research environment.



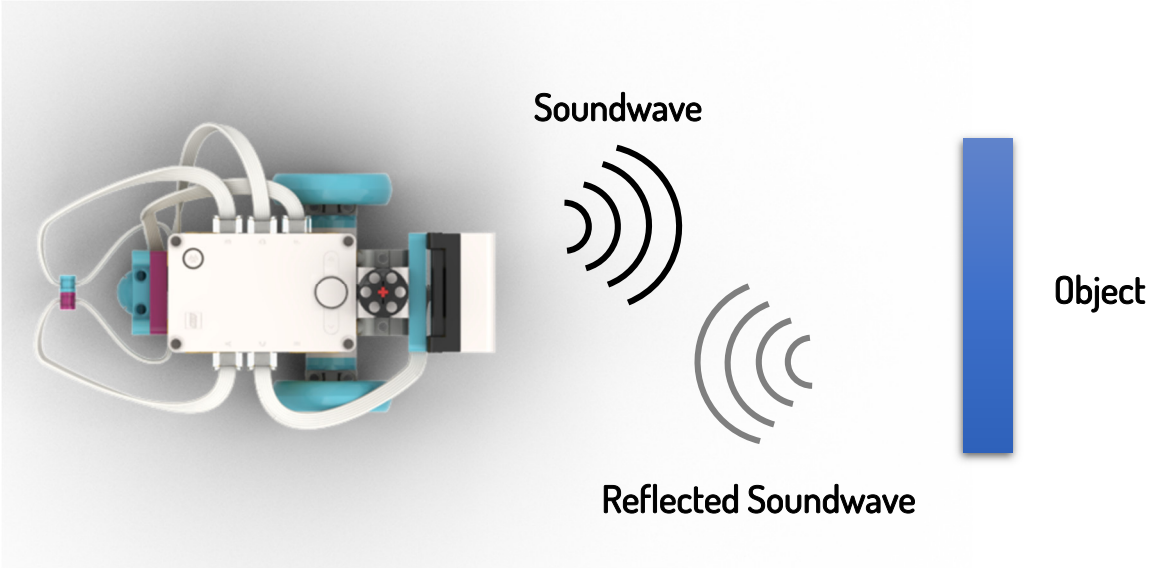
Equipment required

- 1 SPIKE robot kit per group
- 1 computer per group

Connect the Sensor Stack attachment to the front of the robot and ensure the cables are connected. For this chapter we will assume the Ultrasonic Sensor is connected to Port C.

Theory

The Distance Sensor employs the use of ultrasonic range finding to determine the distance to an object. Ultrasonic sensors, or SONAR (SOund Navigation And Ranging) sensors emit a very high frequency soundwave from one of the two openings in the sensor. This soundwave is typically 40KHz, far above what a human ear can detect. This soundwave travels through the air, bounces off an object with the echo returning to the other opening on the sensor. By measuring how long it has taken for the sound to travel out to the object and return, the sensor can determine how far away the object is.



The robot can determine the distance to the object by timing
how long it takes a reflected soundwave to return to the sensor.

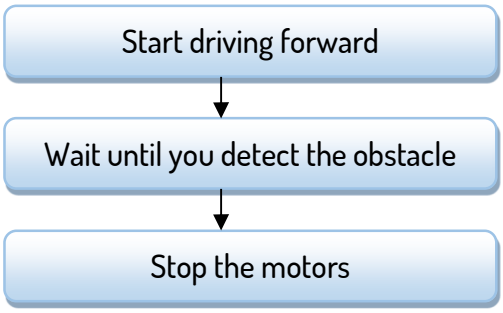
The reading of the Distance Sensor will depend on the surface off which the ultrasonic waveform is reflected. Smooth, perpendicular surfaces give accurate readings, whereas irregular surfaces, (such as hands, other robots, angled walls etc) may give different results. The key here is to do plenty of testing.

Teachers' Notes

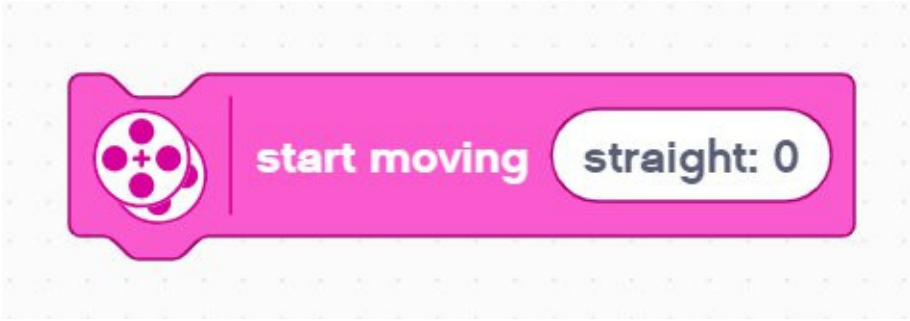
Print and handout Student Worksheet – *Help, I'm Stuck*.

The first step of this challenge is to detect an obstacle and then stop. In this case, we do not want to tell the robot's wheels to move a set distance. Moving, for example, 50 cm forward will not help us if the obstacle is 100 cm away. It would be disastrous if the object was only 20 cm away!

It helps to use a flowchart to plan what the robot will do.



This approach will still use a pink Movement Block, but in this case we will chose the **Start Moving** Block. This will turn the motors on, making the robot drive forward and immediately proceed to the next programming block. The motors will continue to drive, until another Movement Block instructs it otherwise.



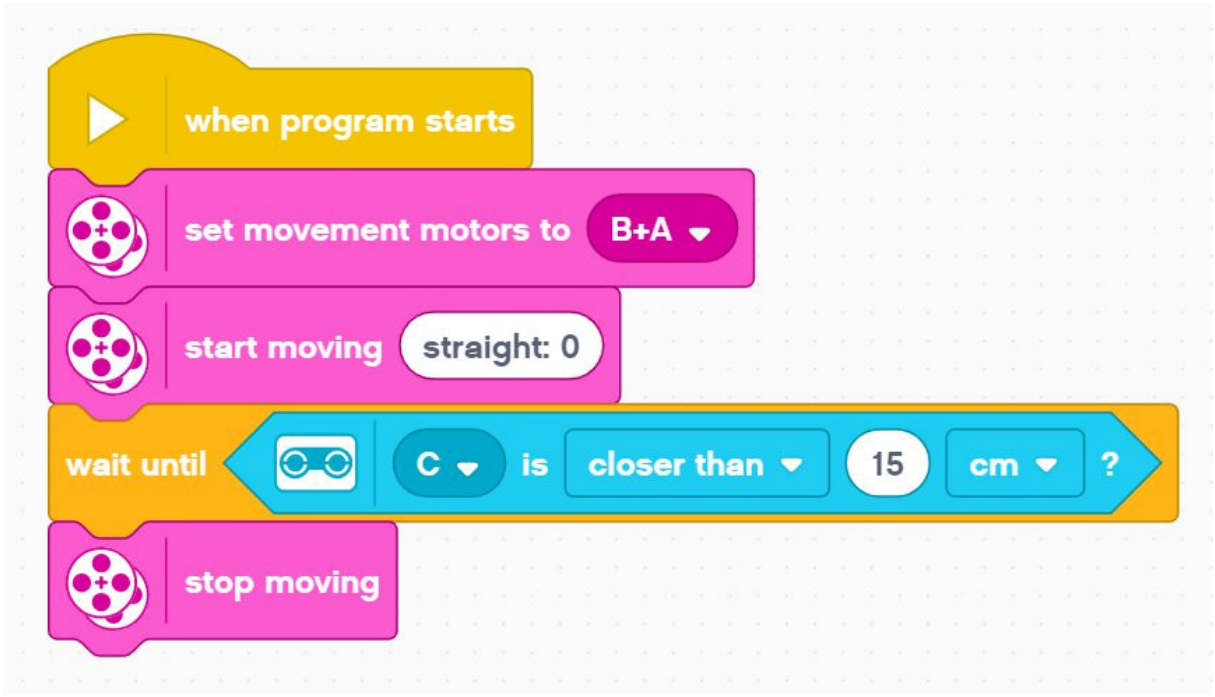
Start the robot driving. No fixed amount is specified

The Wait Block

The next block will instruct the robot to wait until an obstacle has been detected. This is achieved with a **Wait Until** Block from the orange Control section. The **Wait Until** Block needs to be combined with the appropriate Sensor Block to make this program work. Notice how the blue Distance Sensor block fits within the orange Wait Until block.

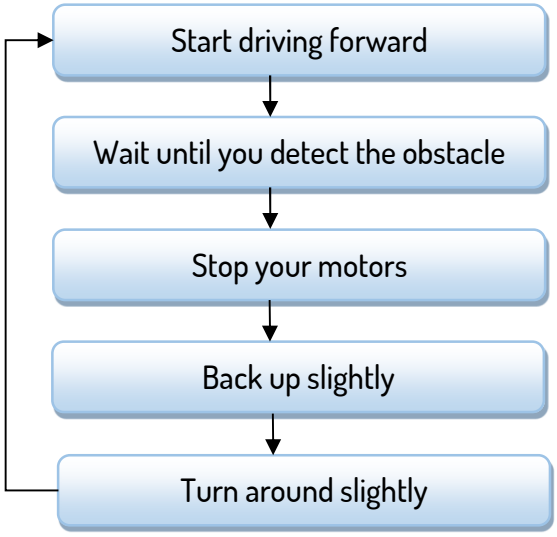
TIP: For a lot of robotics applications, we tend to avoid the 'equals' setting. It is rare, especially with sensors, that a value will ever precisely equal our requirements. Let's say our robot is moving very fast; it takes a reading of 11cm, and then by time it has a chance to take another reading, it is down to 9cm. Because the sensor never reads 'exactly' 10cm, the robot will not stop.

We're nearly finished! Now the robot starts driving and will continue driving until an object is detected less than 15cm away. If we just leave the program as is, the robot will know there is an object, but without telling the motors what to do, it will just drive into it. Our last block will tell the robot to stop moving.



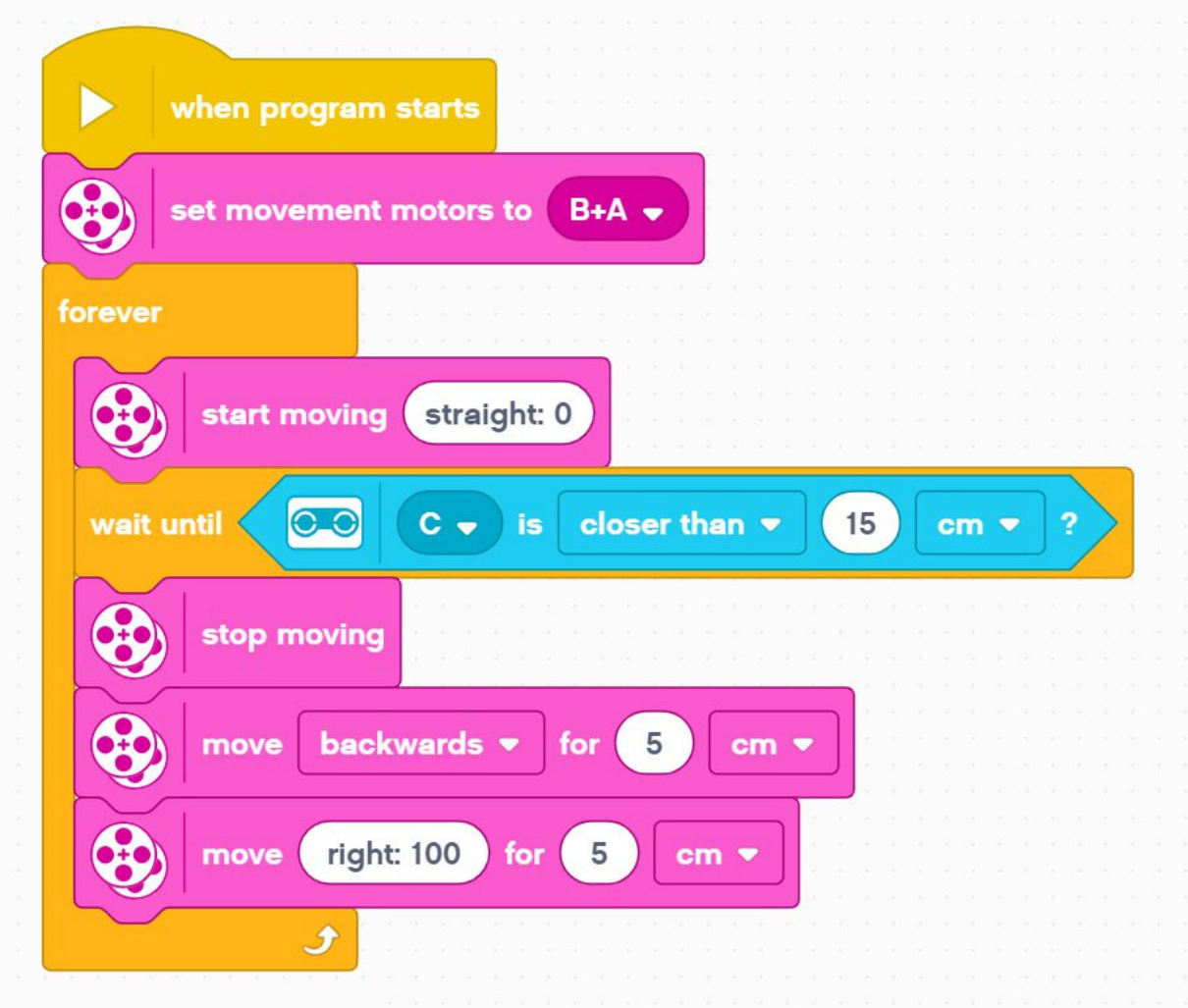
Extension Activity

Now that our robot has detected the obstacle, it will need to navigate away from it. We will again use a flow chart to plan out how it will achieve this.



Using the **Repeat** Block we discovered earlier, we can put together a program that will avoid the wall, and repeat those instructions forever. In this case we will use a special form of the Repeat block call the Forever block, which will repeat the instructions forever, with no end at all.

Example Program



Look out for...

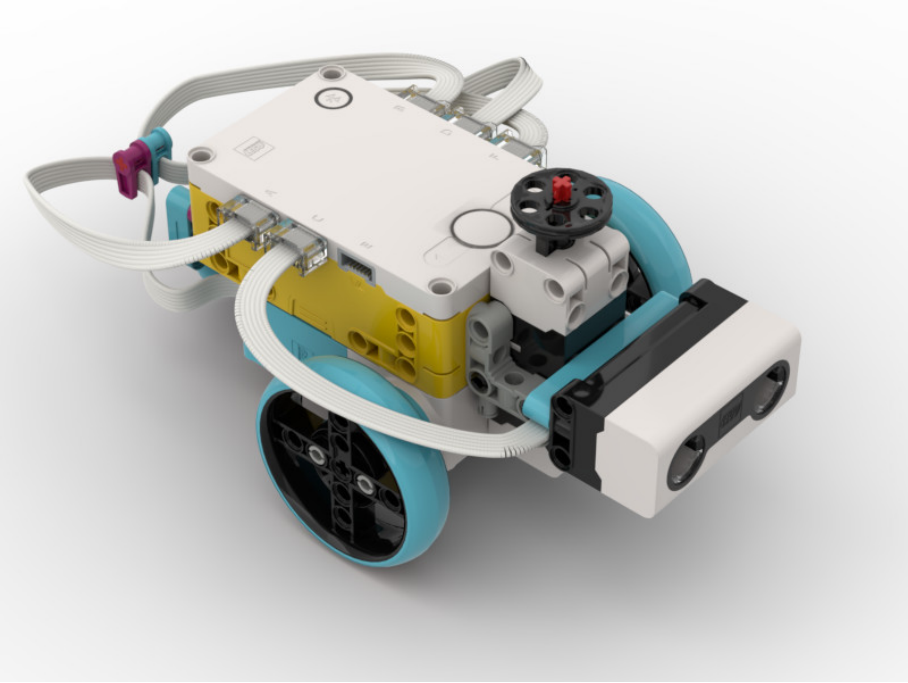
Students must also remember that the distance measure of the sensor is taken from the front of the sensor, which may not be the front of the robot. Be especially careful of any attachment or part of the robot that is in front of the sensor.

Students may find that the readings they get from their sensor do not match what they are able to measure with a ruler. This is a result of the ultrasonic waveform bouncing off the intended object at unusual angles.

Chapter 9: Let's go Prospecting!

Overview: Use the Colour Sensor to identify different coloured surfaces.

Project: THE SPACE AGENCY is very impressed with your robot's ability to navigate the surface. They are hoping that you can use a sensor on your robot to help them detect some mineral deposits of Spiketrium they believe are on the surface. These minerals are easy to spot due to their bright yellow appearance. Your task is to navigate a geological section, locate the mineral, stop and announce that a mineral has been found.



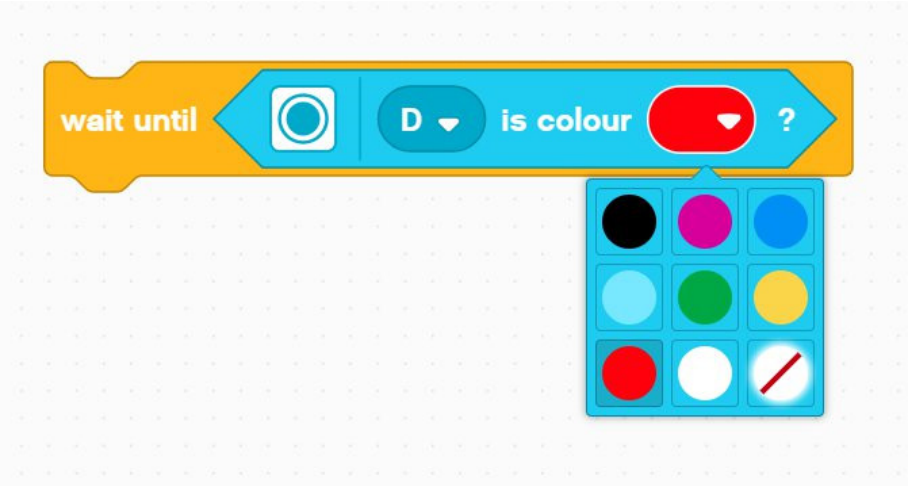
Equipment required

- 1 SPIKE robot kit per group
- 1 computer per group
- Different colour paper

Teachers' Notes

Follow the instructions in Building Instructions, and attach the Sensor Stack attachment to the robot. Print and hand out the student worksheet – *'Let's go Prospecting'*.

Just as with the Ultrasonic Sensor, we will be using a **Wait Until** Block combined with the Colour Sensor block.

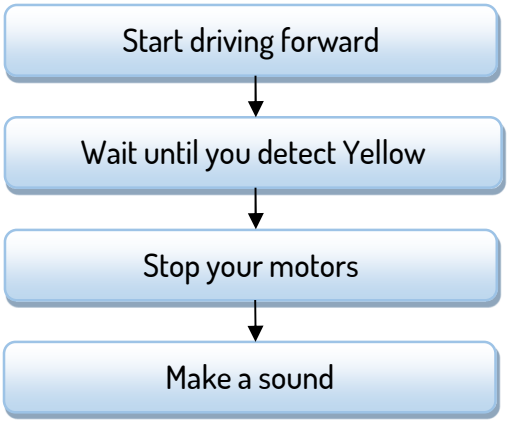


Within the Colour Sensor parameters, it is possible to choose which colours to wait until. This sensor can detect 8 different possible situations:

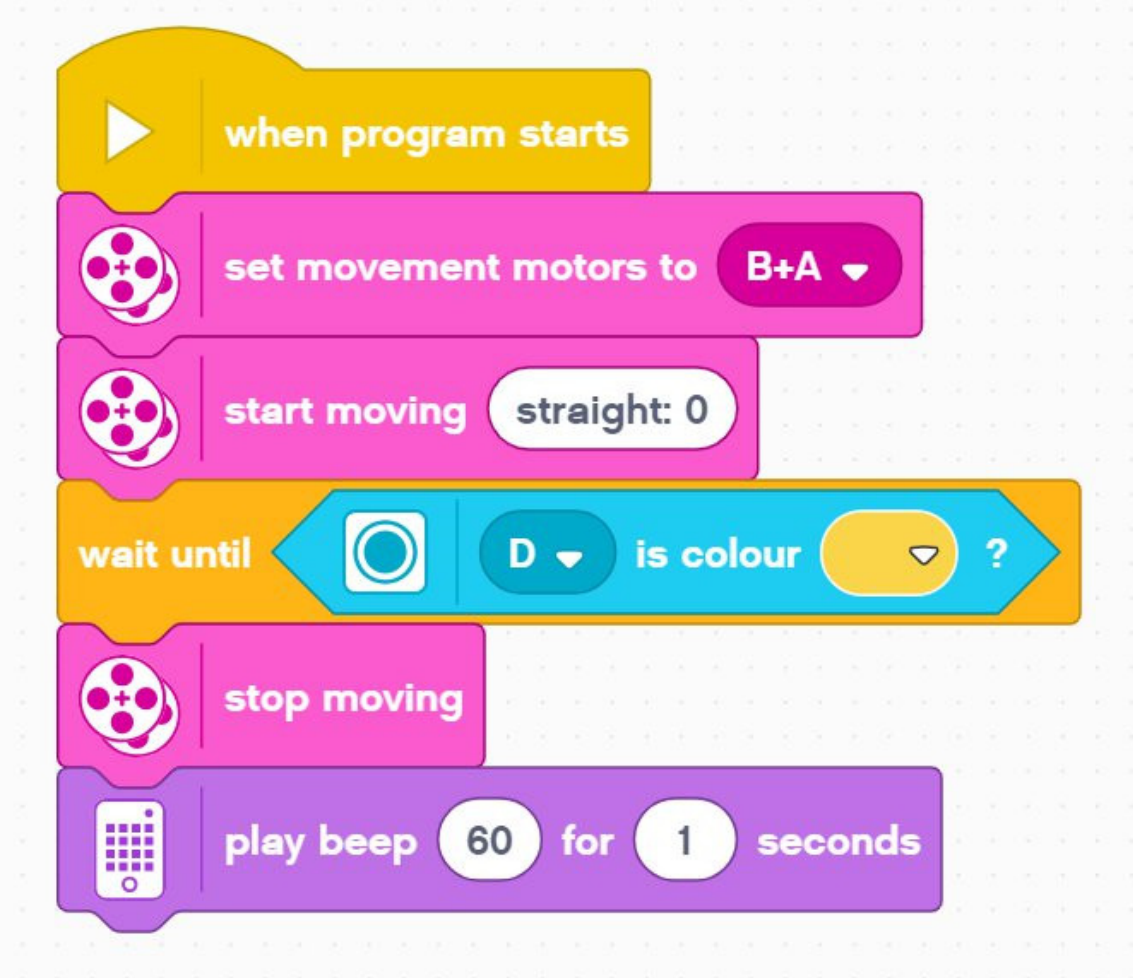
- No Colour
- Black
- Purple
- Dark Blue
- Light Blue
- Green
- Yellow
- Red
- White

These colours are tuned specifically to the standard LEGO palette, but there is enough leeway that everyday items of colour should work. The best way to determine if your coloured paper will work is to test it on the robot.

We will use a flowchart to plan out how we will approach this challenge.

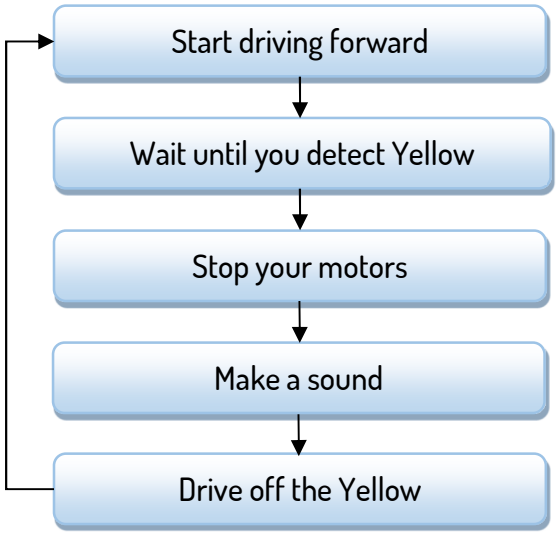


Example Program

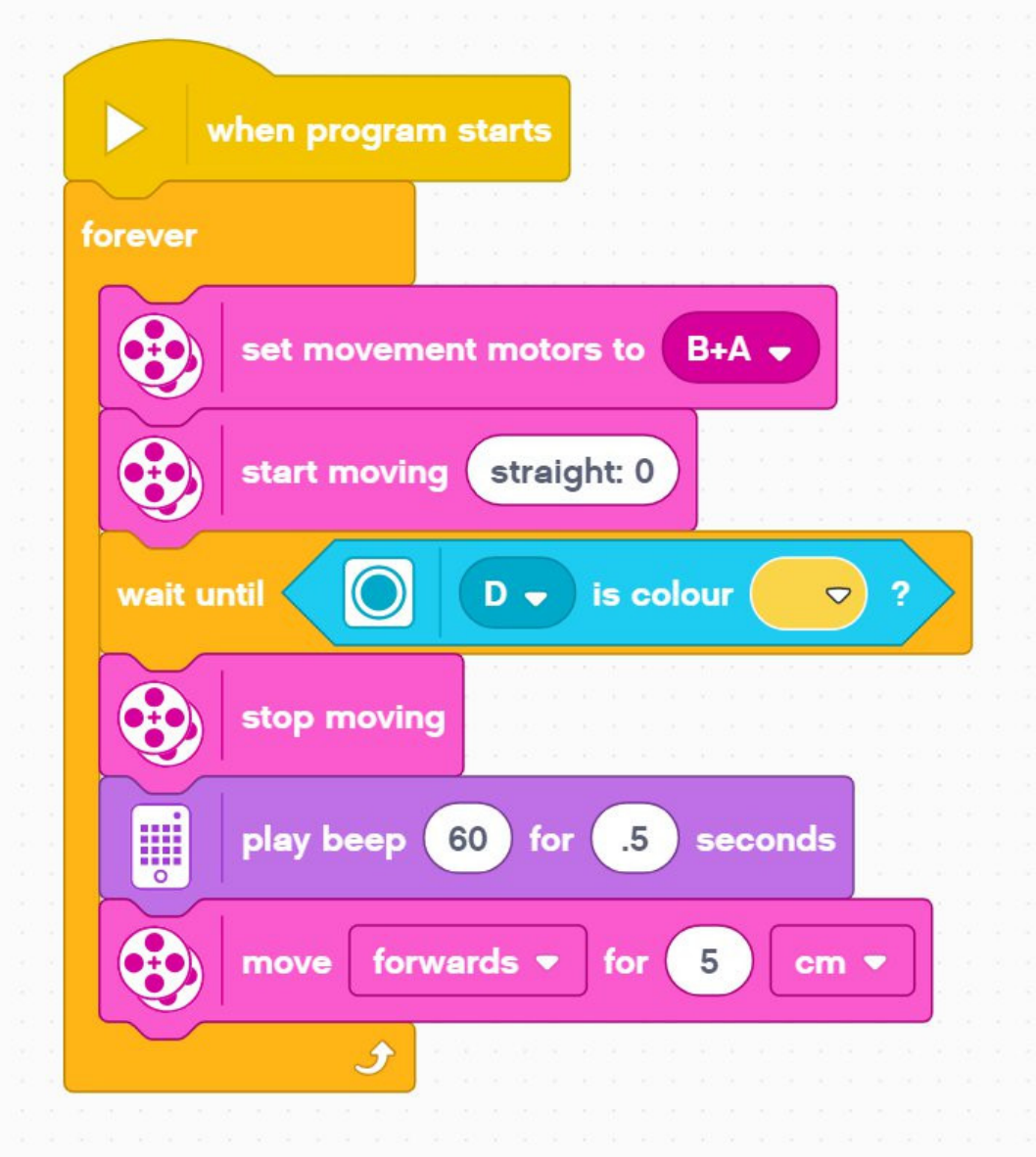


Extension Activity

THE SPACE AGENCY are pleased that you can locate a mineral deposit, but they are certain that there are more available. Modify your program so once a mineral deposit has been detected, your robot will continue driving to find the next mineral deposit and will repeat the process. A flowchart will again assist us in planning out our program. It is common for students to forget to drive off the yellow before they start looking for the next yellow. If this is the case, the robot will stay on the same patch of yellow, constantly beeping over and over!



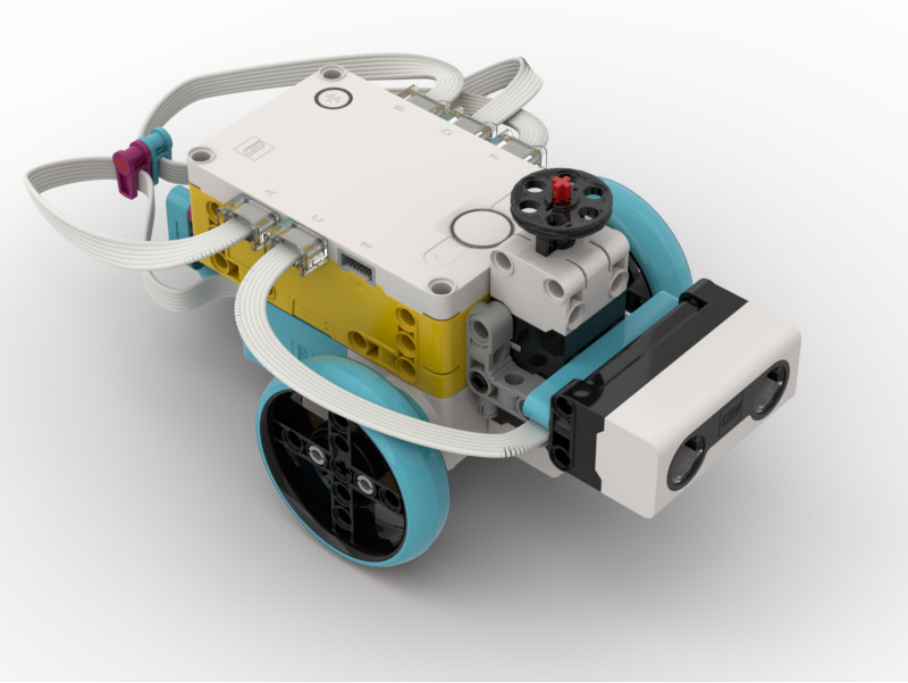
Example Program



Chapter 10: Stay Away from the Edge

Overview: Use the Colour Sensor to remain on the table.

Project: Another challenge the robot faces is staying safe whilst navigating on top of a large plateau. Get too close and over you go! THE SPACE AGENCY has asked that you prove your robot can stay away from the edge of a cliff.

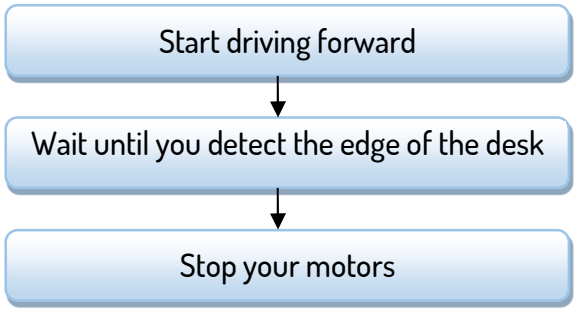


Equipment required

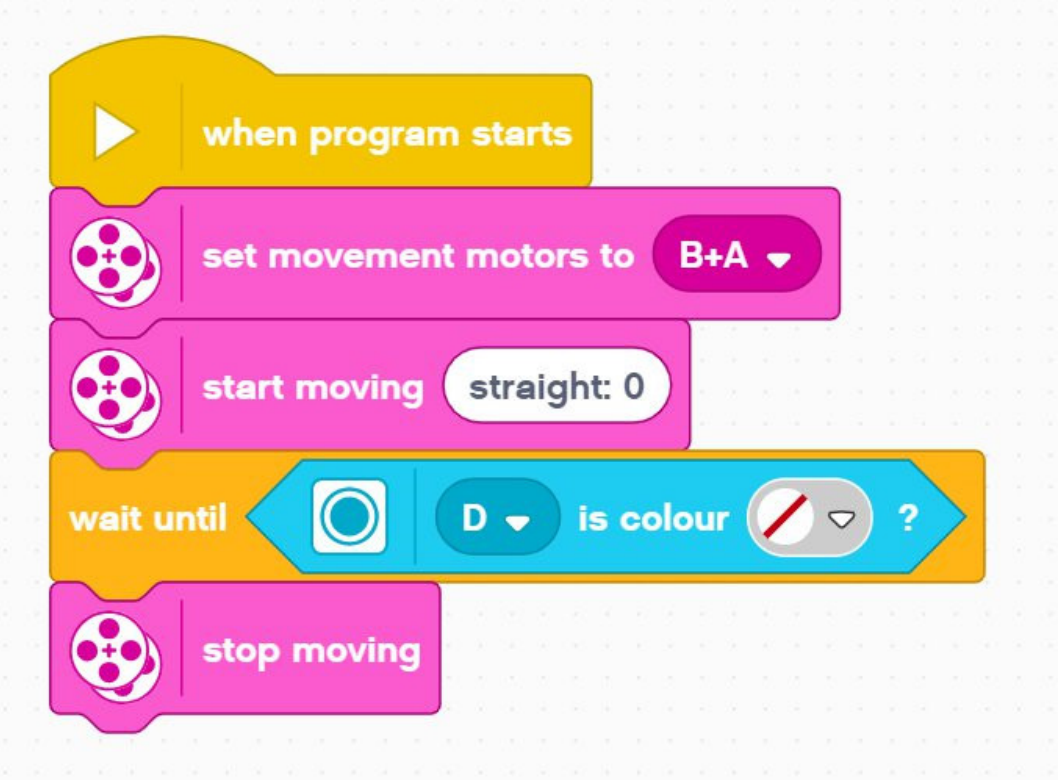
- 1 SPIKE robot kit per group
- 1 computer per group
- Table top

Teachers' Notes

The algorithm for this particular challenge is very similar to the previous challenge, but using the Colour Sensor to detect "No Colour". Make sure your students are ready to catch the robot; just in case!



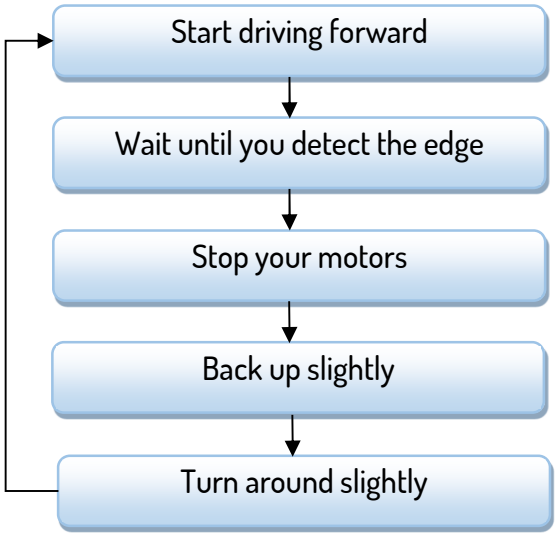
Example Program



TIP: If your robot only barely stays on the table, try lowering the power of the Move Block.

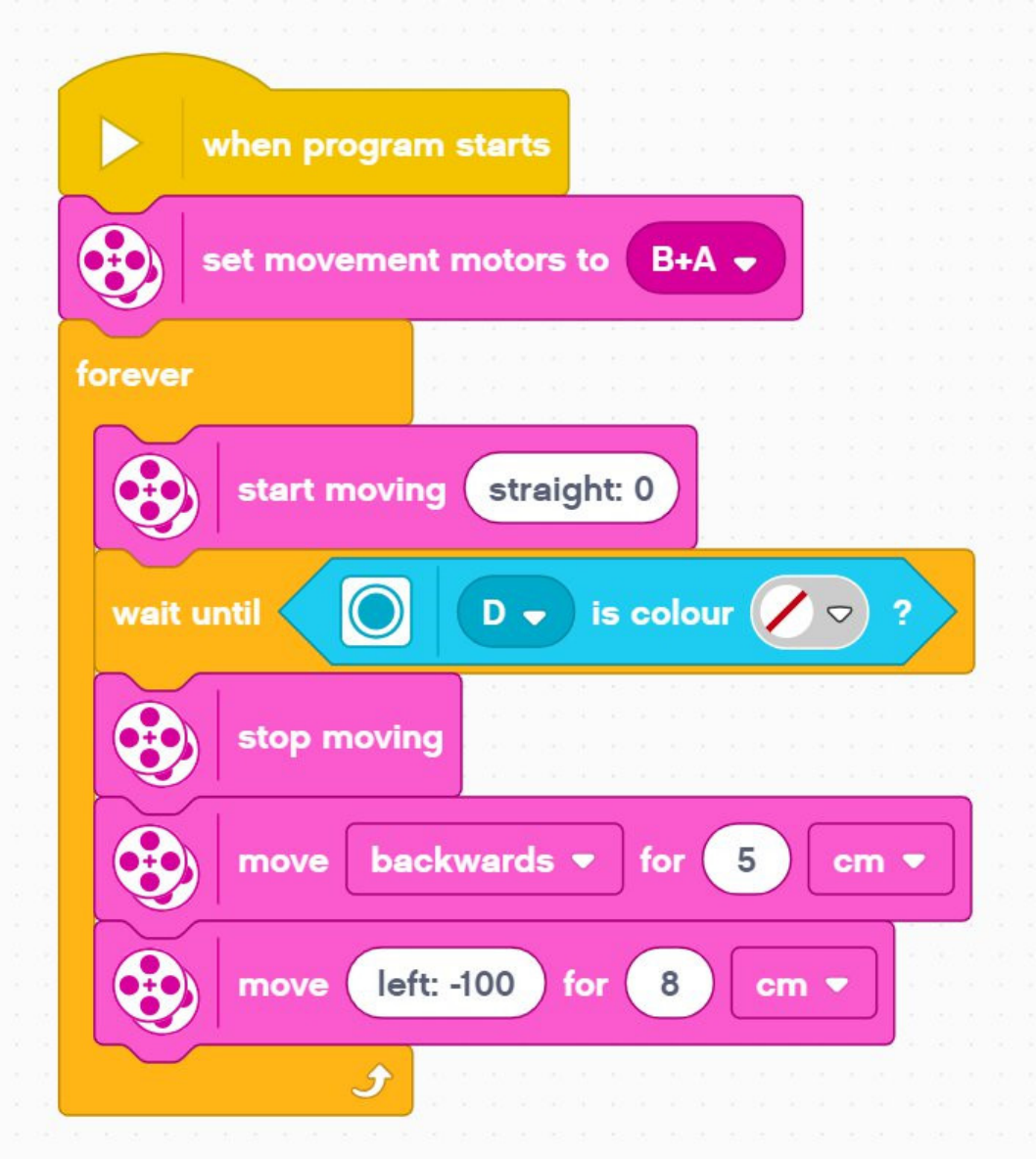
Extension Activity

Now that our robot has detected the edge of the table, it will need to navigate away from it. Again we will use a flow chart to plan out how our robot will achieve this.



Using the **Forever** Block we discovered earlier, we can put together the following program:

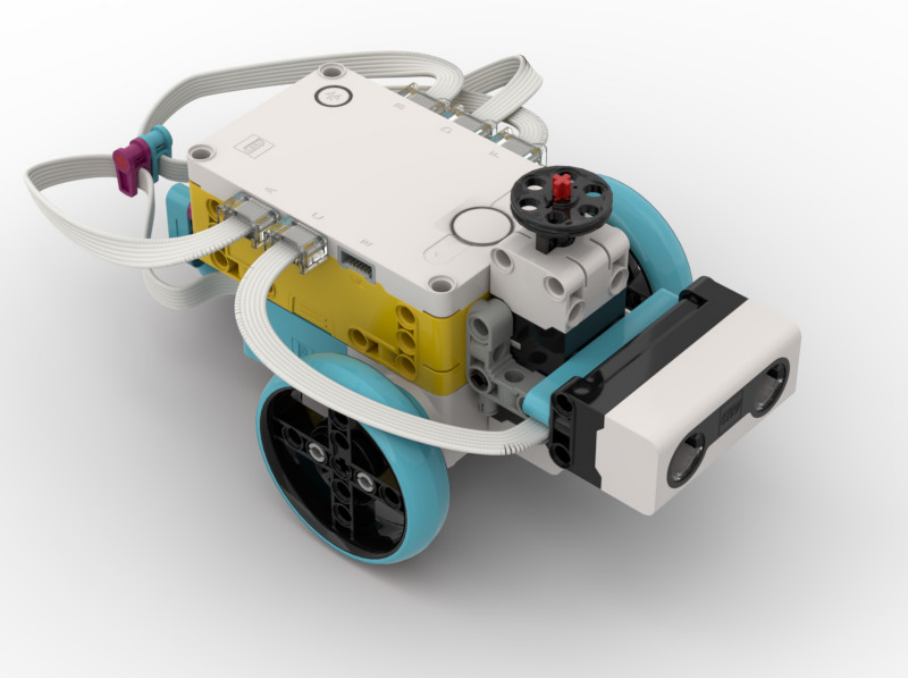
Example Program



Chapter 11: Prospecting and Staying Safe

Overview: Use the **IF** Block to distinguish between different colours.

Project: THE SPACE AGENCY is very impressed, but they note with your last program, while the robot is looking for the edge of the plateau, it is not doing any prospecting. Is there a way to do both at the same time?



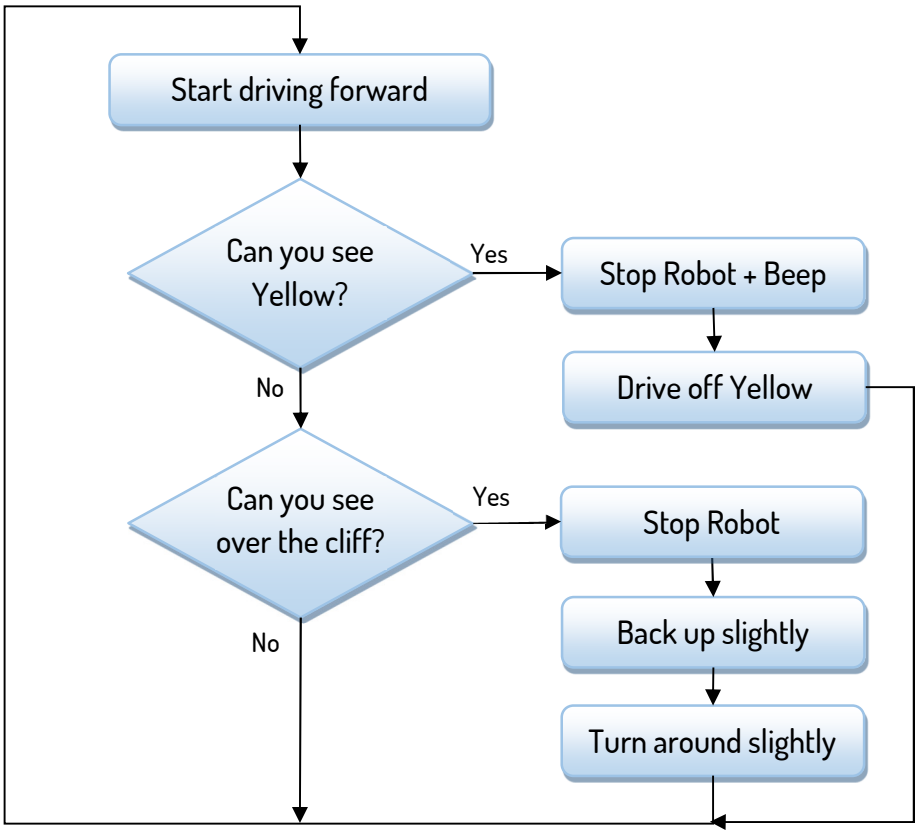
Equipment required

- 1 SPIKE robot kit per group
- 1 computer per group
- Table top
- Coloured paper

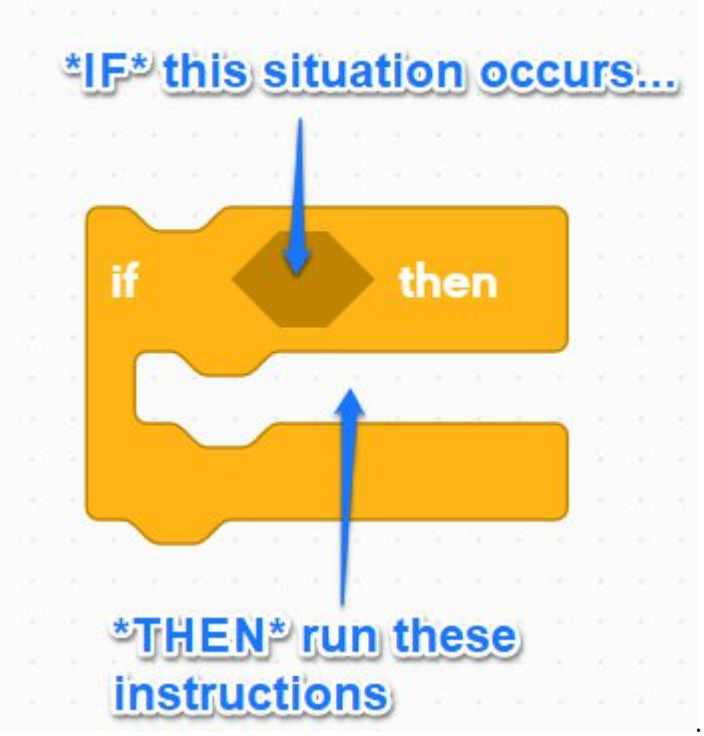
Teachers' Notes

In the previous few chapters, we have asked that the robot perform a specific set of actions when it encounters a specific colour. In this case however, we want the robot to firstly identify that it has detected a colour, but to perform a different set of actions depending on what was detected.

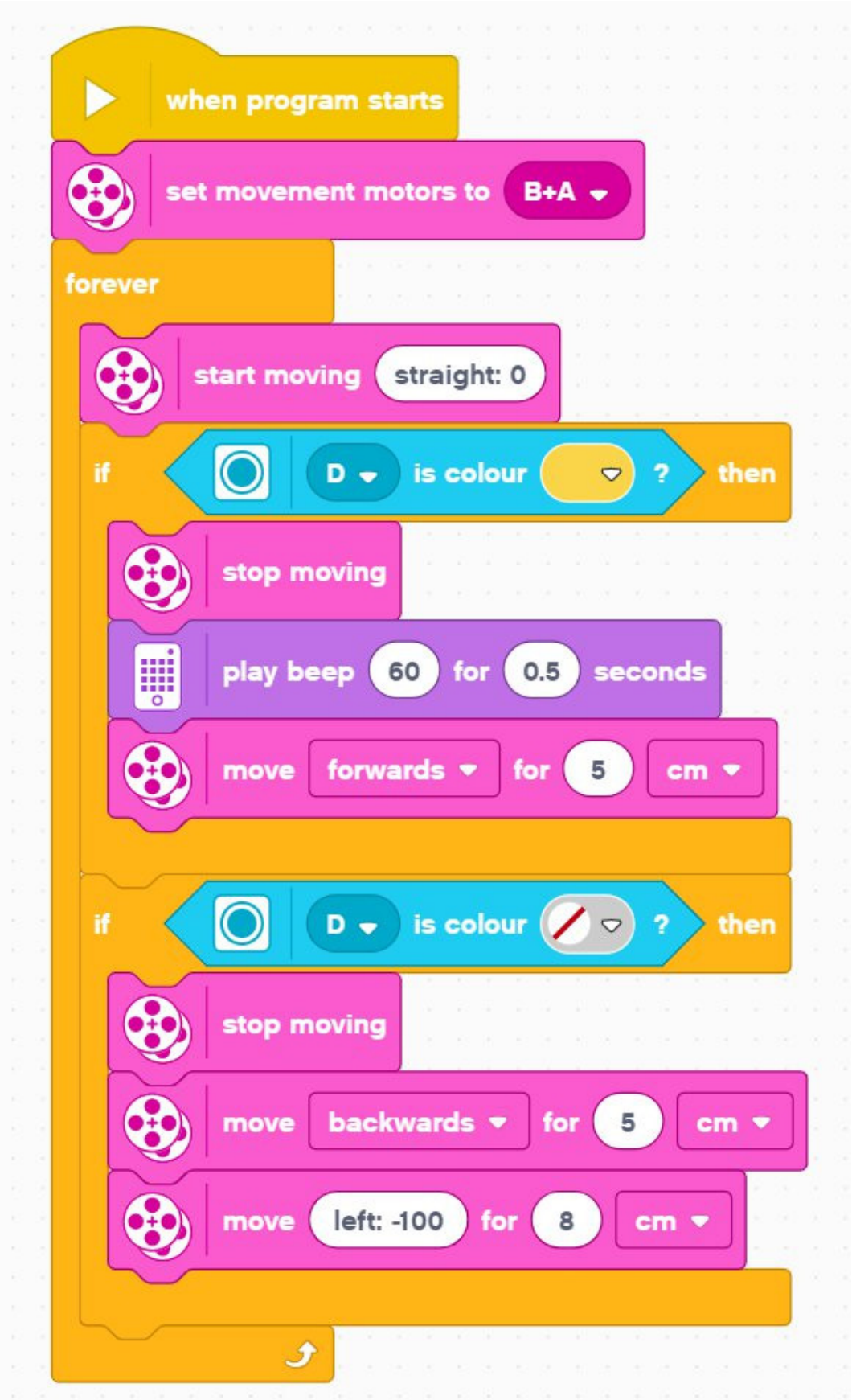
A flowchart of this challenge might look as follows.



The **Wait** Block by itself can be setup to detect more than one colour, but it cannot tell the difference between these detected colours. What is needed is some way of performing different actions based on the colour detected. The **IF** Block allows us to do that. The **IF** block looks very different from any previously used block. Rather than just having a set of instructions to follow, the **IF** Block essentially asks a question – IF a particular situation occurs, THEN perform some specific instructions



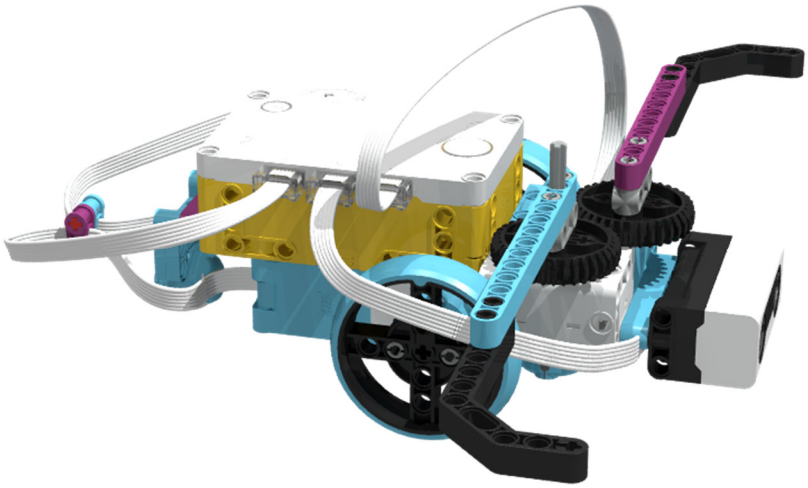
Example Program



Chapter 12: Prepare the Landing Zone

Overview: Use the Gripper Attachment to move objects.

Project: THE SPACE AGENCY has identified a good landing site for further spacecraft but unfortunately it still contains several large obstacles. Use your robot and an appropriate attachment to clear the area.



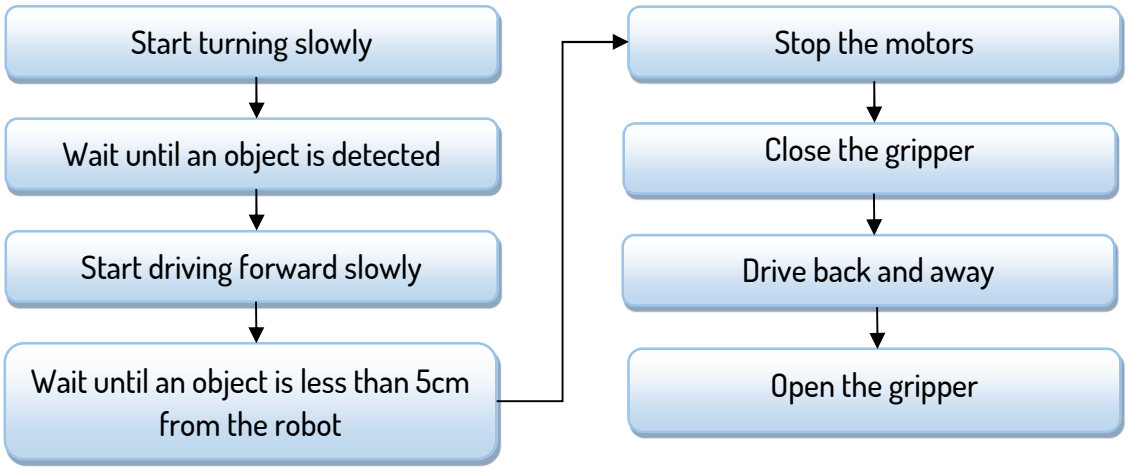
Equipment required

- 1 SPIKE robot kit per group
- 1 computer per group
- Objects to be moved (empty drink containers work well)

Teachers' Notes

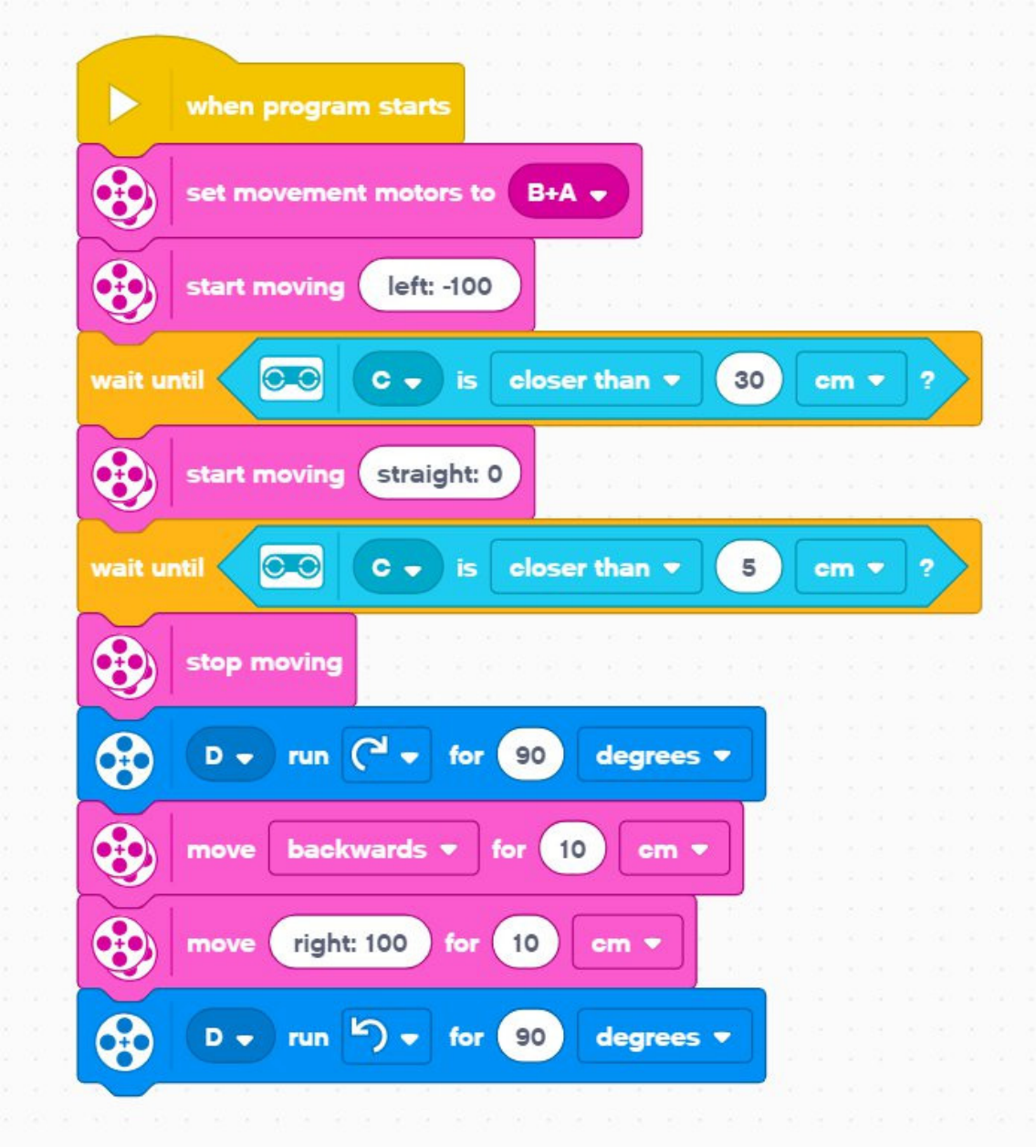
Have the students build the 'Gripper' attachment and connect it to the front of the robot. Also connect the Distance Sensor attachment to the front of the gripper. The example programs in this chapter will use a setup with the Large Angular Motor connected to Port D and the Distance Sensor connected to Port C.

Using this Gripper and the Distance Sensor, the robot has the capability of detecting, grabbing and removing obstacles. A flowchart of how this could be approached is as follows.



This task is very similar to the previous chapter. The major difference is in the use of the Gripper attachment. The arms of the Gripper are connected to the Large Angular Motor. To activate the Gripper, use the dark blue **Motor** Block. The turning direction of the motor is relative to light blue hub on the Large Angular motor. Because this design has the hub on the bottom, it means that a clockwise direction will cause the arms to close, whereas a counter-clockwise turn will open the arms.

Example Program



TIP: In the above example we have closed and opened the Gripper Attachment by telling it to rotate 90 degrees. It is impossible for the arms to turn through precisely 90 degrees, as the object stops them from completely closing. The SPIKE hub will *try* to get to 90 degrees, but if it doesn't quite reach that amount, it will assume the arms are not capable of turning further and will move on to the next instruction in the program.

While it would technically do the same thing if we instructed it to turn for example 5 whole rotations, it is good to encourage students to make reasonable estimates about how far it should close.

Look out for...

One of the more common problems that occur with this program is caused by the Distance Sensor. As was shown in the Distance Sensor chapter, the sound waves from the Distance Sensor fan outwards rather than just travelling in a perfectly straight line. Because of this, occasionally the robot detects the object just as it comes into view rather than when it is directly in front of the robot. This may result in the object being off-centre as the robot drives towards it, making it difficult for the Gripper to correctly grasp. This can be compensated for if necessary by adding an extra few degrees of turn once the object is detected.

Extension Activities

Using the **Repeat** or **Forever** Block, can you have your robot continue finding and removing obstacles?

Multiple obstacles are present, and all need to be removed. The safest place for them to be deposited is the Dangerous Removal of Obstacle Position (DROP). It is located to the side of the Landing Zone and can be identified by the bright red floor covering (Hint: You'll need to build in the Colour Sensor somewhere!)

Chapter 13: Meet your Adoring Public!

Overview: After your glorious mission, your robot will want to meet with its fans and supporters.

Project: Program your robot to respond in a positive way when somebody gets close. Use the **Motors, Movement, Light and Sound** blocks to convey a feeling of happiness.

Equipment required

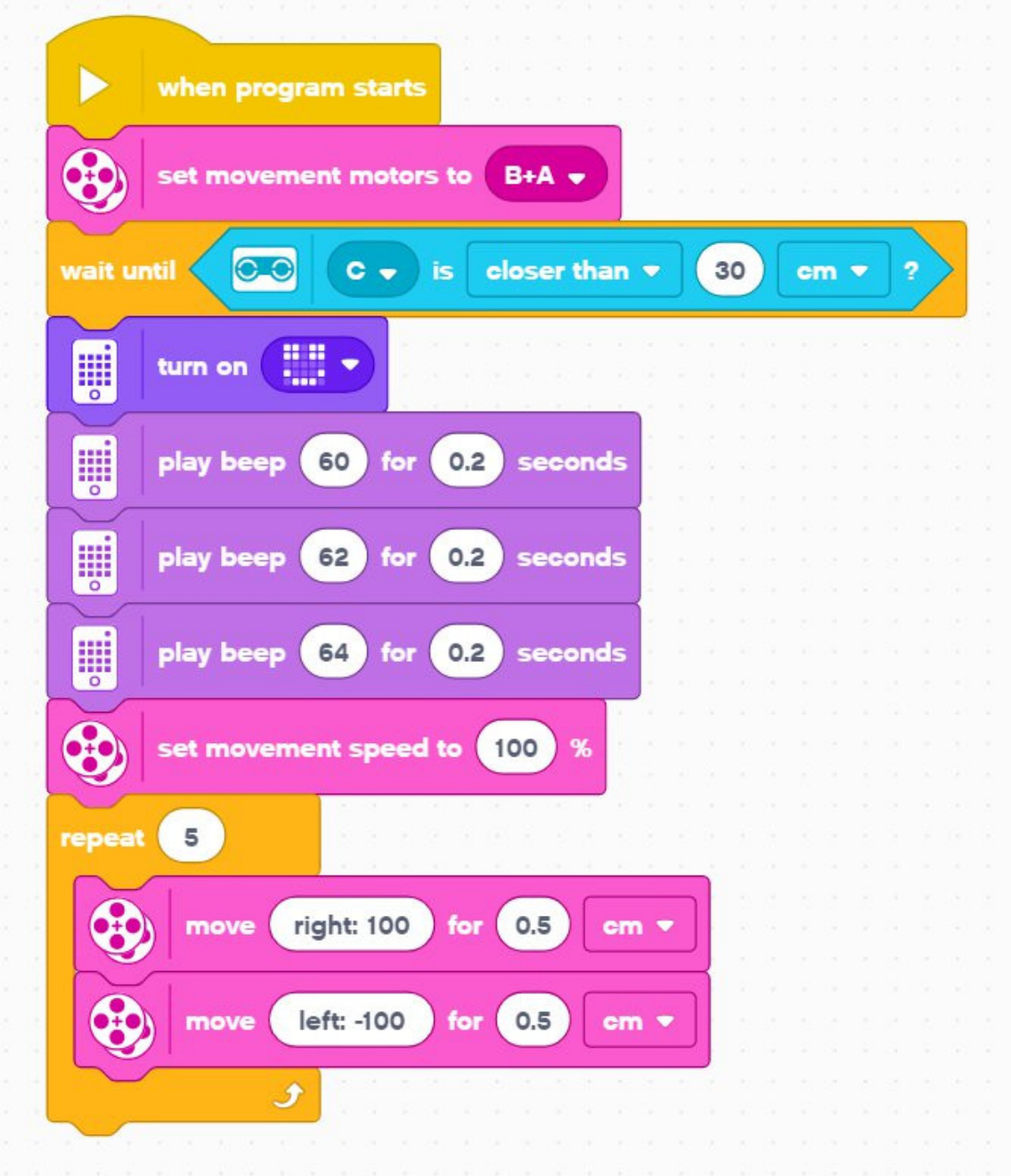
- 1 SPIKE robot kit per group
- 1 computer per group

Teachers' Notes

This project can be built up in stages. Initially just have the student's robot respond when somebody walks up to it. This is similar to the "Help! I'm Stuck" activity in the use of the Distance Sensor. But in this case, rather than waiting for the robot to drive up to an object, it will wait for an object to approach itself. Once the robot can accurately identify an object, students can then let their creative energies flow to have their robot respond with a feeling of happiness. 'Happiness' is a very subjective measure and it is always interesting to see what interpretation the students come up with.

Example Program

This program waits until somebody approaches within 30 cm (12 inches), plays a set of beeps and then does a little wiggle. The whole time it has a smiley face on the display.



Extension Activity

The natural extension to this project is to now have the robot act 'sad' when the person walks away. To implement this, you will again need a **Wait** block, but this time the robot is waiting for a **Greater Than** condition to occur as the person walks away. It is advisable that you increase the threshold distance as your robot may have moved from its initial starting position when it does its 'happy' movements. Sad actions generally include sad faces, low notes and slow movements.

Add a third motor to your tobot and connect a flag for a true parade loving robot!

Chapter 14: As seen on TV!

Overview: Create a multimedia presentation to market and sell your robot.

Project: THE SPACE AGENCY has decided to use your design to fly to Tobor-3. As a result of the associated publicity, many other people want to buy their own version of the robot. Create a marketing promotion to sell your robot.

Equipment required

- 1 SPIKE robot kit per group
- 1 computer per group

Teachers' Notes

Students should think of their group as a 'company' that must pitch a 'product' (in this case their robot) to the general public. It is left up to the teacher to decide the final format, but any of the following media types would be appropriate.

- School Newspaper article
- Video commercial
- Slideshow Presentation
- Poster presentation
- Website
- Oral Presentation

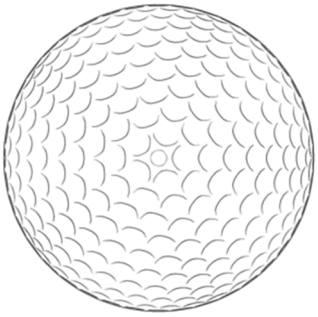
Students can have considerable leeway with the creative claims of their product if they are feasible.

Good – Our robot can be charge by solar panels

Bad – Our robot can fly just by driving very fast!

Issue that will need to be addressed include:

- Form – What does it look like?
- Function – What can it do?
- How does it move?
- How does it sense its environment?
- How much will it cost?
- Are there any special features?



Chapter 15: Mini-Golf

Overview: Build and program a robot to play a round of mini-golf.

Project: Students use the skills they have learnt from previous weeks to build a robot that can play a game of mini golf.

Equipment required

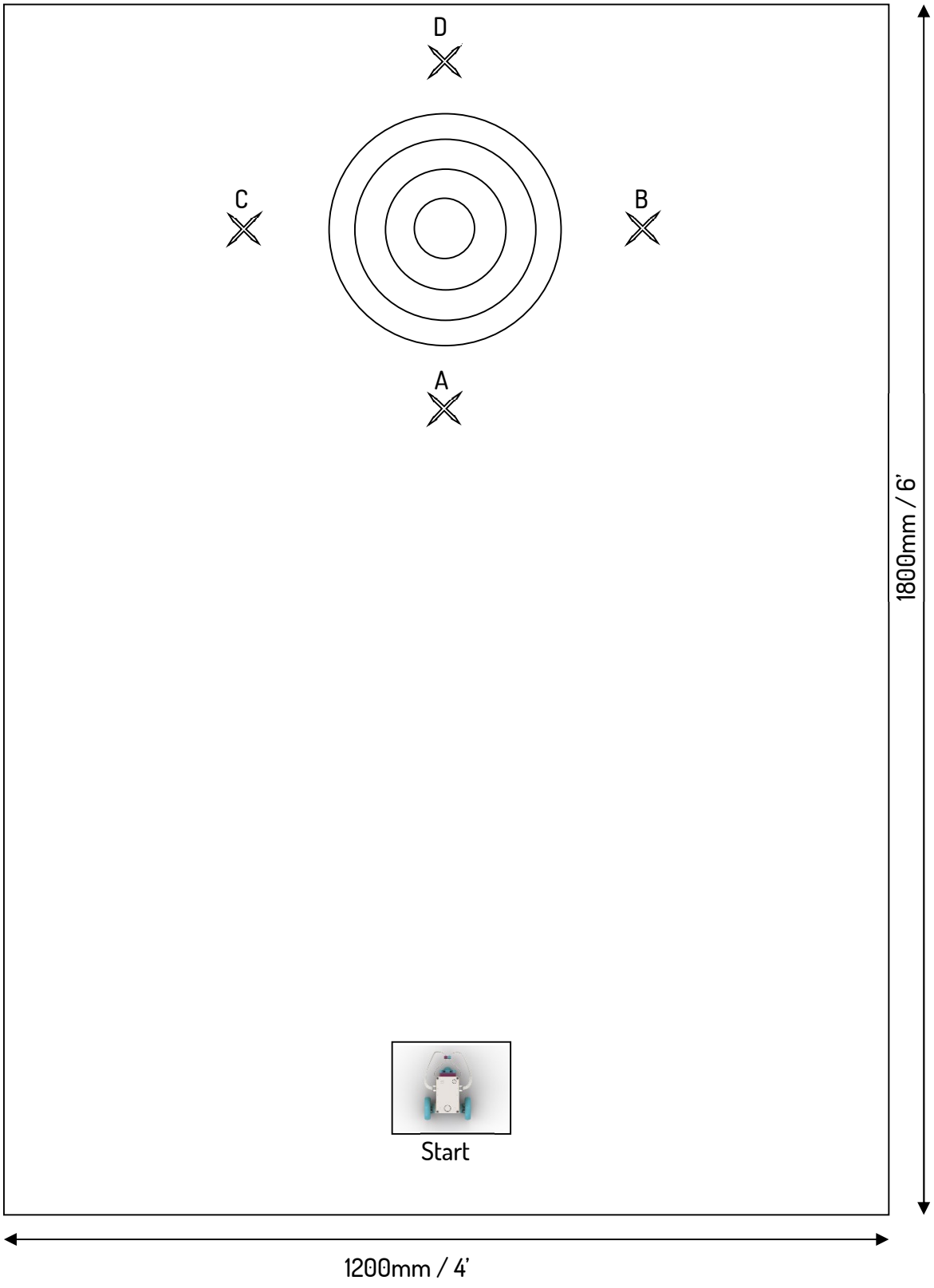
- 1 SPIKE robot kit per group
- 1 computer per group
- Small ball (table tennis / golf / squash)
- Putting green (see below)

Set up:

A putting green is required with a set cup location. This could be constructed with a sheet of MDF or plywood. Use a hole saw to cut a 50mm / 2 inch hole in the board to act as the golf cup. Sand down any rough edges. The same challenge can be used with just a level floor and some tape to mark out the bullseye, although you do not get the satisfying 'thunk!' as the ball rolls into the hole.

Print out or paint a bullseye pattern using the following dimensions as a guideline.

- Centre hole: 5cm / 2 inch
- 1st ring: 10cm / 4 inch
- 2nd ring: 20cm / 6 inch
- 3rd ring: 30cm / 10 inch


D
C
B
A
1800mm / 6'
Start
1200mm / 4'

Game Play:

Robot is placed in the starting box.

A standard golf ball is placed in either position A, B, C or D.

Competitor presses the run button and allows the robot to head off.

There are 5 rounds, with the golf ball placed is a different location for each round.

Robots have 1 minute in which to strike the ball. They may restart as many times as they wish within this time until the ball is struck. Once struck, the final resting position of the ball determines the points scored for the round.

The ball should be struck, not pushed, towards the cup.

Scoring

- 50 points for getting it in the hole
- 30 points for closest ring
- 20 points for the next ring
- 10 points for the outer ring
- 5 points for making contact with the ball

Teachers' Notes

The students will need to discover that they need some sort of 'bumper' on the front to ensure accurate and repeatable test runs. Something resembling a slight 'v' shape will probably work best as it will funnel the ball towards the centre of the robot.

Rounds 1 and 2 allow them to get points on the board. Hitting the ball as hard as possible should be naturally discouraged as if they miss the cup, they do not want it rolling completely off the bullseye.

Rounds 3,4 and 5 should promote planning. Ideally they should draw on a piece of paper what path their robot will take, and what movements they need to accomplish it.

Extension Activities

Is it possible to knock in all 4 golf ball locations from a single program? ie. No taking the robot back to the starting position to reset.

Research other mini-golf layouts and replicate some of the interactive elements (windmills, moving characters etc)

Chapter 16: Dancing Robots

Overview: Program your robot to perform their own dance routine

Project: Students will synchronise multiple robots to dance and move in time with the music. The focus for this challenge is the integration and coordination of multiple robots.

Equipment required

- 1 SPIKE robot kit per group
- 1 computer per group
- Music player
- Decorations (straws / pipe cleaners / coloured paper etc)

Teachers' Notes

Students can team up with other groups to create dancing partners or they can perform a solo dance.

Choose a piece of music approximately 60 seconds in length.

With either a stopwatch or software program, have the students map out the time it takes for significant sections of the music. Once they have the length of times required, they can start programming their robots to fill each time bracket. Test often with the music to ensure the robot's movements synchronise with the timing of the music.

When they are happy with their performance, have the student dress up their robots with decorations such as:

- Pipe cleaners
- Coloured paper
- Bobbly eyes
- Sequins
- Feathers

Look out for...

Here are a few tips to make the students robot presentation more visually appealing. The key concept is timing with the music. An entertaining robot dance to watch has the robots changing their movements in time with the music.

Alternate the robots' movements between fast and slow motions. The more variety and contrast there is in the performance, the better it is to watch. Do some research into the RoboCup Junior Competition. There is a division devoted to performing robots with many excellent examples available.

The following table is very useful in planning out robots dance sequences.

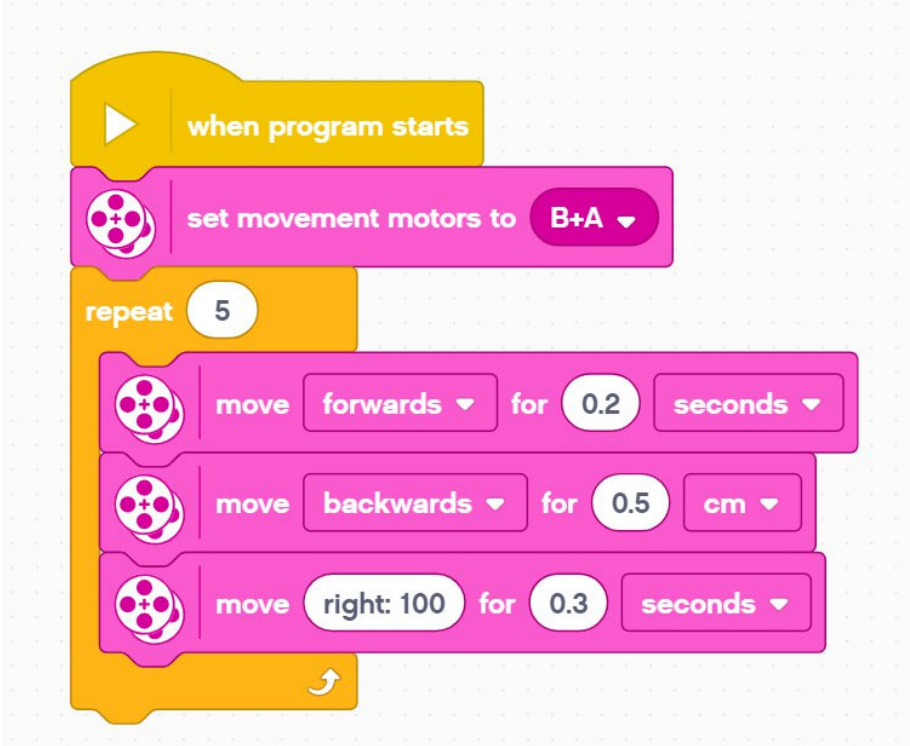
Song Name:	**'Robots Rock'**	**Artist:**	**The Amazing Androids**
Section	*Time*	*Description*	*Intended robot movement*
Intro	0 sec – 8 sec	Slow and steady. Just drums and bass guitar	Slow rocking from side to side in time with drums
1st Verse	8 sec – 15 sec	Guitars come in and speed gets faster	Looped forward and backwards movements, slightly faster than intro
Chorus	15 sec – 23 sec	Steady rhythm, quite fast	Robots even faster now, doing full turns on the spot
2nd verse	…	…	…
Chorus			

If you are finding resistance from the students to the concept of 'dancing' robots, the same activity can be performed but with a different context

- Robotic Marching Band
- Aerial stunt pilots (eg. The Flying Roulettes)
- Synchronised swimming

Keep the movements relatively short and repeat often. A robot that drives forward for 1 second is actually quite a long time. Encourage the students to use up time with the loop command. ie.

[(FORWARD 0.2 seconds, BACKWARD 0.5 seconds, turn clockwise 0.3 second) repeat 5 times]



Extension Activity

Create a music video of your robot in action. Take multiple videos of the robots in action. Using movie editing software, cut the different segments together. Add some special effect and the backing music and show it to the class.

Chapter 17: Robot Wave

Overview: Create your own robotic supporters for the local sporting match

Project: Students will synchronise multiple robots to perform a Robot wave.

Equipment required

- 1 SPIKE robot kit per group
- 1 computer per group

Teachers' Notes

Students will line their robots up, and on starting, each of the robots will move forward and then move backwards. Individually this program is quite unexciting, but when teamed up with multiple robots, the effect can be very appealing.

The emphasis for this challenge is the coordination of several robots. The program required to do the basic motion is quite straight forward, but the success of the robots is dependent on all robots running at the correct time.

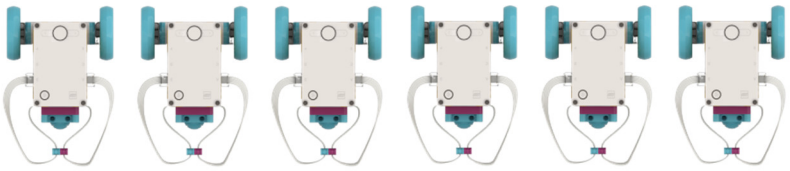
A Robot wave is created in a sporting stadium when a group of people stand up and sit down again. The people immediately to their side do the same and the 'wave' progresses around the stadium.

The basic program to implement a Robot wave is as follows.

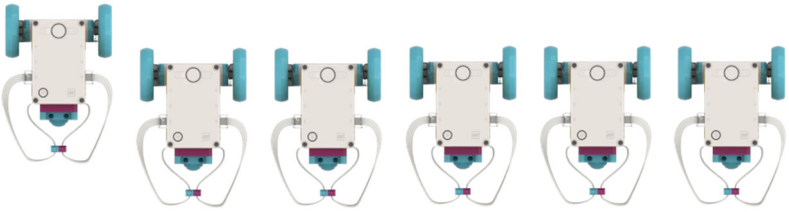
- Wait for a set period of time
- Drive forward for 1 second
- Drive backward for 1 second

The key component is how long each robot is required to wait before heading off. The first implementation should have Robot 1 wait for 0.5 seconds, before driving forward. Robot 2 will wait for 1 second, Robot 3 will wait for 1.5 seconds and so on down the line.

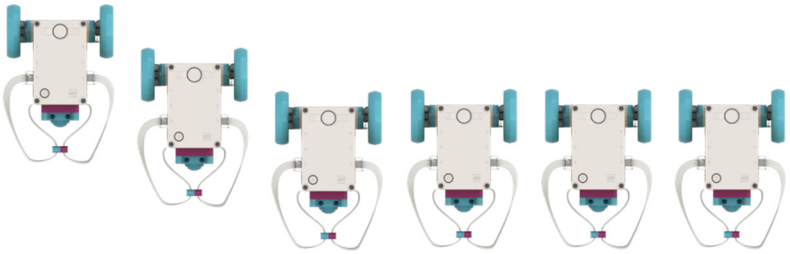
All Robots lined up



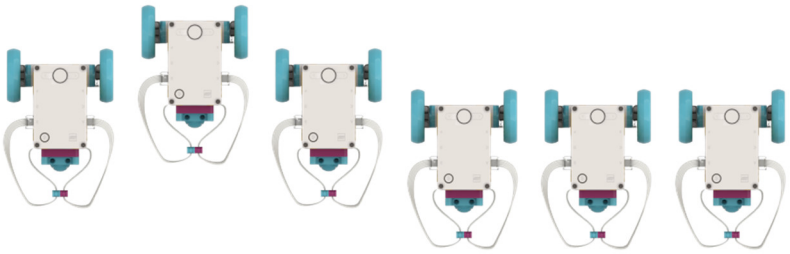
First Robot starts moving



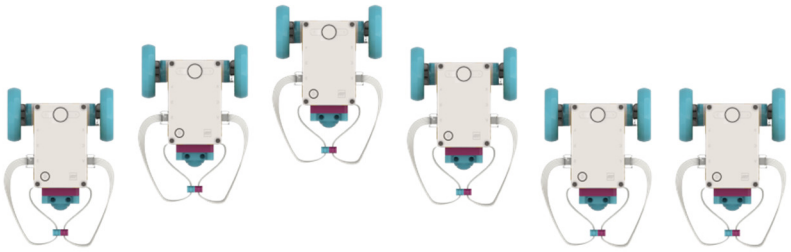
Second Robot starts moving



Third Robot Starts moving



Fourth Robot Starts moving



etc...

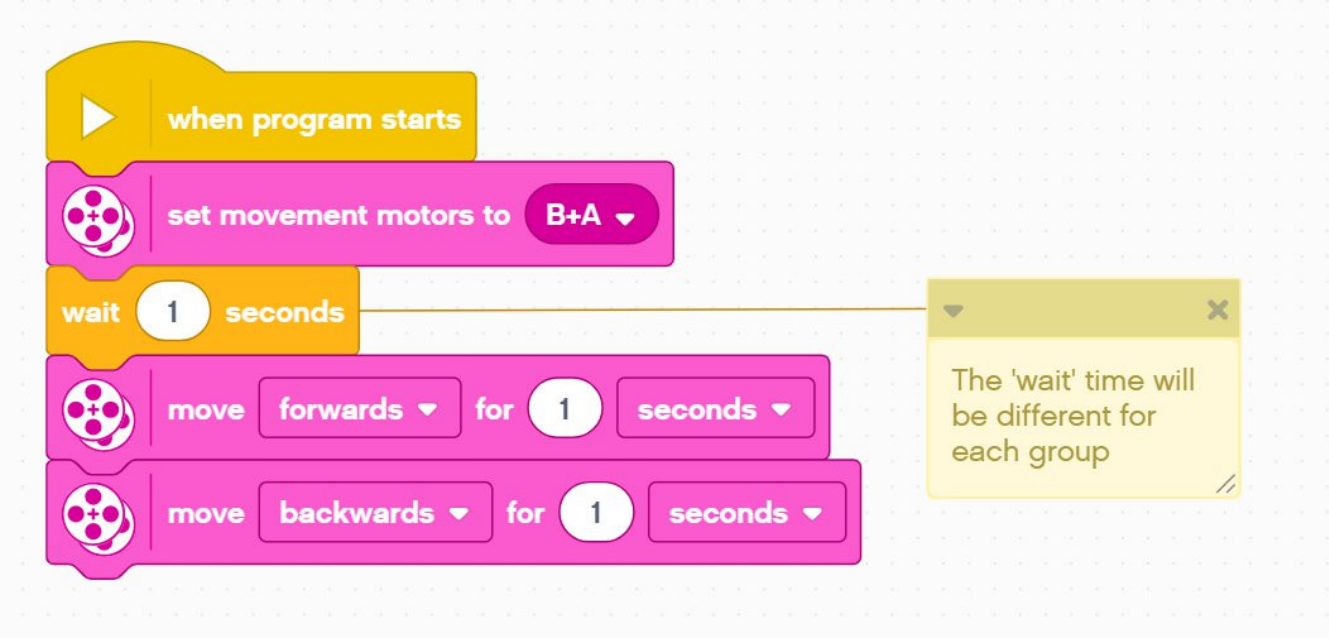
When using a 0.5 second delay between each robot, the required 'wait' time is half the group number. eg. Group 5 will need to wait for 2.5 seconds.

Once the initial wave has been mastered, it is possible to extend the number of motions that each robot performs. Rather than the basic 'Drive forward, Drive backward', try these different combinations or leave it to the group to devise their own choreography.

- Forward 1 second fast, Backward 1 second slow
- Forward 1 second, Backward 2 second, Forward 1 second
- Forward 1 second, Backward 2 second, Forward 1 second, Loop the whole procedure 4 times
- Arrange the robots in a circle rather than a straight line

Example Program

This program describes the basic Robot wave program



Extension Activities

Up and Back

Have the wave progress up the line, and then come back down the line to the starting robot. This will require some careful planning to ensure each robot knows how long to wait before performing their 2nd wave.

Cheerleaders

Add the 3rd motor to the robot to create some arms with pom-poms. Run the Robot wave using these pom-poms as well.

Chapter 18: Robot Butler

Overview: Build a robot that can assist the elderly and disabled

Project: Robots in the household are quickly becoming commonplace, with personal assistance robots widely regarded to become the most prevalent in the near future. Build a robot that can retrieve a snack for someone who is confined to bed.

Equipment required

- 1 SPIKE robot kit per group
- 1 computer per group
- Small platform to rest the snack

Teachers' Notes

This challenge can be as open ended as required. There is no extra content that is required to be taught, rather the challenge is in integrating the various systems and programming knowledge that has already been learnt.

A typical scenario is as follows.

> *Your great Aunt Winnifred is confined to her bed due to her bad ankle. You are required to build a robot that can fetch a snack from the kitchen and return it to her bedside.*
>
> *It must navigate from the bedroom, out the door and down the hallway to the kitchen on the left hand side. Once the robot is in the kitchen, it must drive up to within 5cm / 2" of the shelf. A snack is placed on the top of the robot and it must return to the bedroom.*

For this challenge student will be required to accurately plan a path out of the bedroom and down to the kitchen using the **Movement** Blocks. Once there, they then use the Distance sensor to approach the shelf. Students will need to build a platform on which to hold the snack. This platform could use the Touch Sensor to tell when a weight has been placed on the robot. Once the snack is on the robot, it must turn around and return to the bedroom.

This can be as open ended as desired and the scenario can be tailored to suit any ability or theme within the classroom.

Chapter 19: Student Worksheets

In this section you will find all the student worksheets referred to in the preceding chapters. The owner of this book has photocopy permission to reproduce as many copies of these worksheets as is required by their class. Worksheets can also be downloaded in PDF format from the following website:

www.damienkee.com

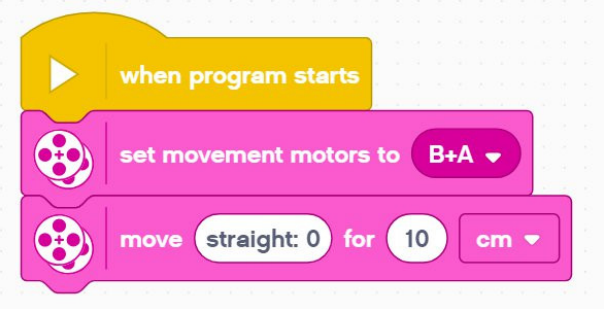
SPYKEE Basics

Group Name_____ Group Members_____

Project: THE SPACE AGENCY is in the market for a new planetary rover to explore the recently discover planet Tobor-3. You are required to construct and test a robot that is capable of following a set of commands to explore the planet's surface. Before the robot is deployed, it must be extensively tested to ensure it will perform as expected. You can't fly a technician to Tobor-3 to reboot the robot!

Before we send our robot into space, we must first test it thoroughly here on earth. Run the following experiments and observe how your robot behaves. Do not move to the next experiment until your teacher has seen your current experiment.

Drive Forward for 50cm. Download and test the following code



Drive Forward for 2 rotations of the wheels

How far did your robot travel? _____

Drive Forward for 2 degrees of the wheels

How far did your robot travel? _____

Drive Forward for 2 seconds of the wheels

How far did your robot travel? _____

What is the circumference of the robots wheel?

(hint: you will need to measure the diameter of the wheel) _____

How far will the robot drive if the wheels turn 3 rotations? _____

Program your robot to move 3 rotations and measure how far it goes.

Does it go as far as you expected?

Drive Forward 5 rotations slowly and then 1800 degrees backwards as fast as possible.

Make your robot turn around a complete circle (360 degrees).

What happened? How far did your robot turn if you type in 360°? _____

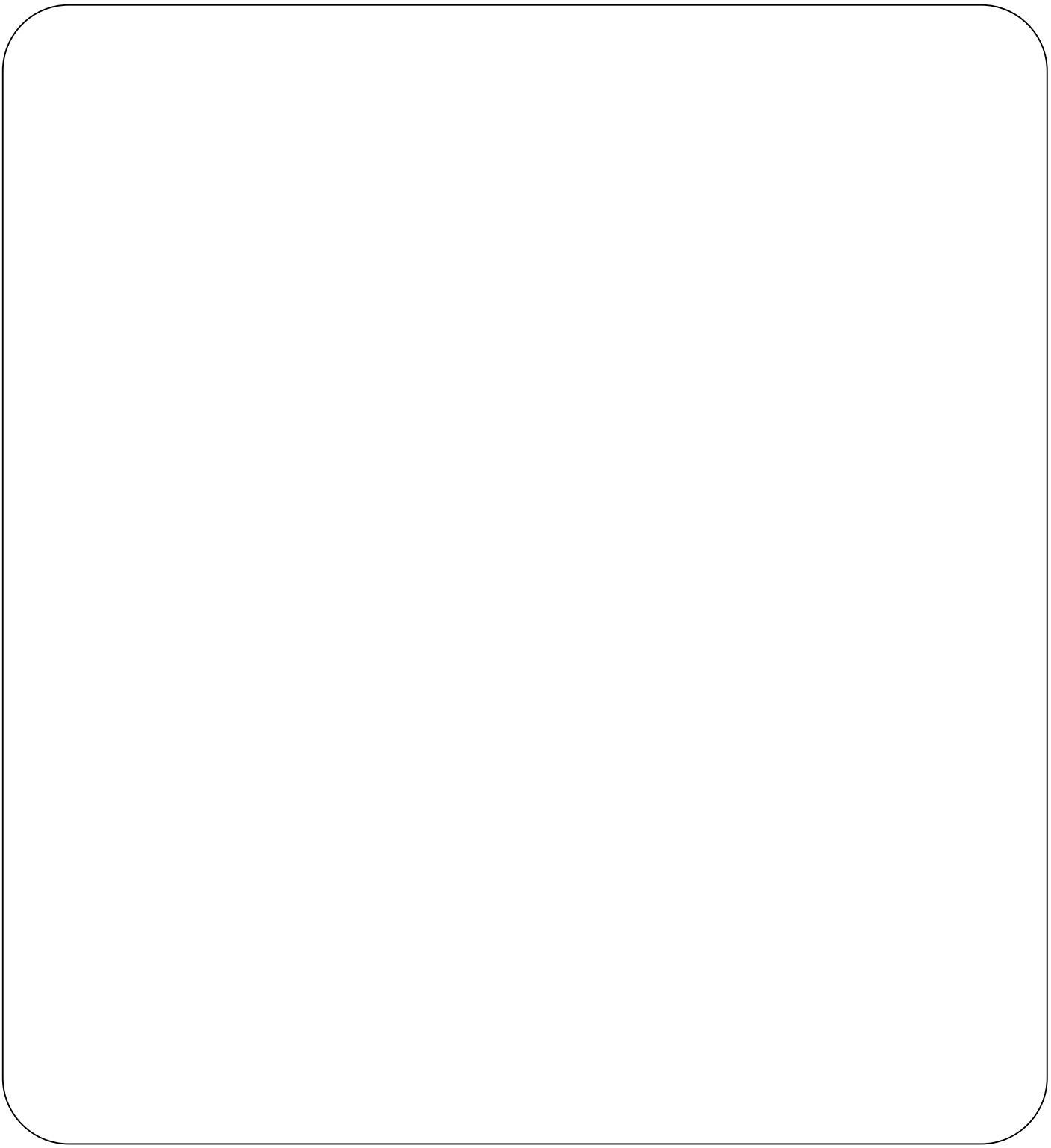
How many Degrees of the Wheel does your robot need to turn a complete circle?

(hint: keep experimenting until it is perfect!) _____

Drive forward for 500mm (OR 20 inches), turn around 180° and drive back to where you started

Make your robot drive in a 'figure of 8'

(hint: draw a diagram first in the space below before you start programming. Don't forget to mark your starting point!)



What is a Robot?

When you hear the word 'robot' some famous movie robots spring to mind. Robots in real life however are not yet up to the standard of their movie counterparts.

Robots are becoming more prevalent in today's society. They are used in high level applications such as space exploration right through to commercial vacuuming robots found in everyday households. You are required to do a research assignment on robotics in general and to focus on one robot in particular.

Robots come in many different shapes and sizes and are often tailored to meet a particular need or action.

Assessment

Create a report on robotics. Your teacher will tell you the format of the report. The following questions will need to be addressed in your work.

- What is a robot?
- Why do we have robots?
- Name some different types of robots?
- What are the main components of a robot?
- Where did the term 'Robot' come from?

Pick one robot and elaborate on it. You must have your robot choice approved by your teacher before you start your research. You will need to include the following information in your report:

Sensors - What information does it take in? (e.g. Sound, distance etc)

Software - What does it do? (e.g. Vacuum floors, explore space)

Mechanical - What materials is it made out of? How does it move? (e.g. motors, arms and metal frames)

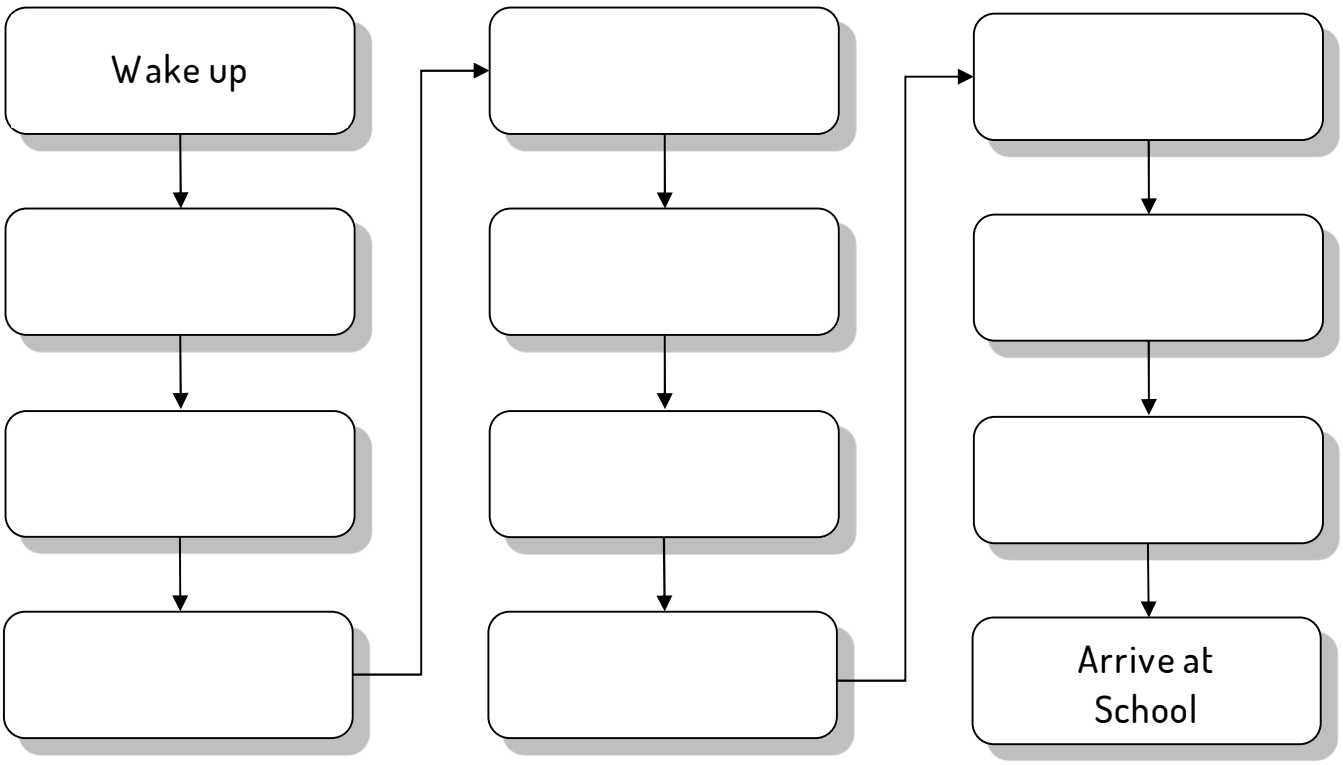
Robot Chosen _____ Due Date_____

Presentation Type_____ Page / Slide limit_____

Flowcharting

All robots need to have programs to make them run. The easiest way to start a program is to first have a plan. This plan consists of a flowchart of small steps that make up the entire program. Each step is simple enough that the robot can perform it without too much effort.

Task: Using the blank flowchart below, plan out your daily morning routine, from when you wake up until you get to school.



How far?

Group Name_____ Group Members_____

Project: In the initial construction of the robot the travelling characteristics are required. After characterising the properties, THE SPACE AGENCY have asked that you use your data to make predictions about the distance your robot will travel given specific time constraints.

Your group will be assigned a random power level to be assessed. Power Level Assigned _____

For this experiment you will need to measure how far the robot travels for different time values (eg. 1 second, 2 seconds, 3.5 seconds etc). The more data you gather, the more accurate your graph will be.

Plot the results either on the graph below or in a graphing software package.

(Hint: you will need to know the smallest and largest times you tested for, as well as the smallest and largest distances so that you can determine the horizontal and vertical axis scales)

Once you have plotted your data, can you see a relationship between the time taken and the distance travelled?

By looking at the graph, can you determine how many seconds your robot would need to travel exactly 30cm (12 inches)? _____ seconds

How about 1.5m (59 inches)? _____ seconds

Your teacher will assign you a test distance. How long does your robot need to travel this particular distance?

Test Distance = _____

Time required = _____ seconds

(Measure from Graph)

Actual Distance = _____

(Measure actual robot travel distance)

Time Taken

How Many Sides?

Group Name_____ Group Members_____

Project: Once on Tobor-3, your robot will be required to identify interesting aspects for later analysis. Your robot will be required to mark off an area such that a passing satellite can easily identify the item in question. Initially you will be required to draw a square, but will then move onto other shapes and designs.

Build a drawing attachment and fix it to your robot and program your robot drive in a square.

- How many sides does a square have?
- How many angles?
- How many degrees in each angle?
- Could you use the loop block to make the program simpler?

Fill in the following table for other common shape

Shape	Number of sides	Internal angle	External angle	Turn Angle required by the robot
Octagon				
Hexagon				
Triangle				

What was the most difficult part of this challenge?

How did you go about solving it?

Help! I'm Stuck

Group Name_____ Group Members_____

Project: Whilst on Tobor-3, your robot will undoubtedly come up against obstacles in its path. THE SPACE AGENCY is worried about a particular cliff wall that is blocking the robots progress. They have asked that you demonstrate your robot's ability to detect such obstacles and navigate away from them. It is important that your robot does not physically touch these obstacles as we do not wish to damage the robot. Connect the Distance Sensor attachment to the front of the robot and ensure the cable is connected.

There are several progressive steps we would like to make in order to solve this problem. Each program should be done individually and demonstrated to a teacher before moving on.

We would like our robot to drive forward until it encounters an obstacle.

- Drive until object is detected, then stop.
- Turn around when you detect the object.
- Repeat this action until you find your way around the obstacle.

What was the most difficult part of this challenge?

How did you go about solving it?

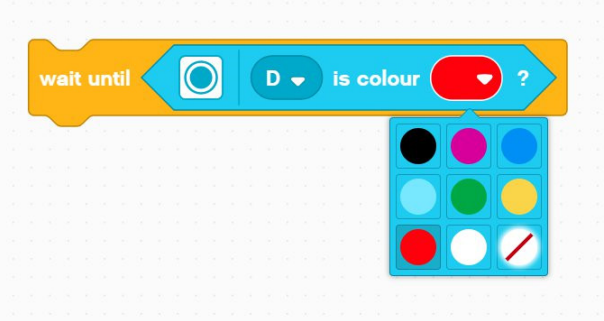
Let's go Prospecting

Group Name_____ Group Members_____

Project: THE SPACE AGENCY are very impressed with your robot's ability to navigate the surface. They are hoping that you can use a sensor on your robot to help them detect some mineral deposits of Spiketrium they believe are on the surface. These minerals are easy to spot due to their bright yellow appearance. Your task is to navigate a geological section, locate the mineral, stop and announce that a mineral has been found.

Build the Sensor Stack attachment for your robot.

The Spiketrium is known to be yellow in colour, so your robot will need to utilise the 'Wait for Colour' block to help detect it.



There are several progressive steps we would like to make in order to solve this problem. Each program should be done individually and demonstrated to your teacher before moving on.

- Drive until yellow is detected then stop.
- Shout 'Green' when you reach the Spiketrium.
- Drive off the green and go looking for more Spiketrium.

What was the most difficult part of this challenge?

How did you go about solving it?

Stay away from the Edge

Group Name_____ Group Members_____

Project: Another challenge the robot faces is staying safe whilst navigating on top of a large plateau. Get too close and over you'll go! THE SPACE AGENCY has asked that you prove your robot is capable of staying away from the edge of a cliff.

THE SPACE AGENCY has discovered that the Colour Sensor attachment, as well as being excellent for detecting Spiketrium, can also reliably give a reading of 'No-Colour' when it reaches the edge of the plateau. Modify your program so that the robot does not go over the edge.

There are several progressive steps we would like to make in order to solve this problem. Each program should be done individually and demonstrated to your teacher before moving on.

- Drive until the edge is detected then stop.
- Drive away from the edge and continue looking for the next edge.

What was the most difficult part of this challenge?

How did you go about solving it?

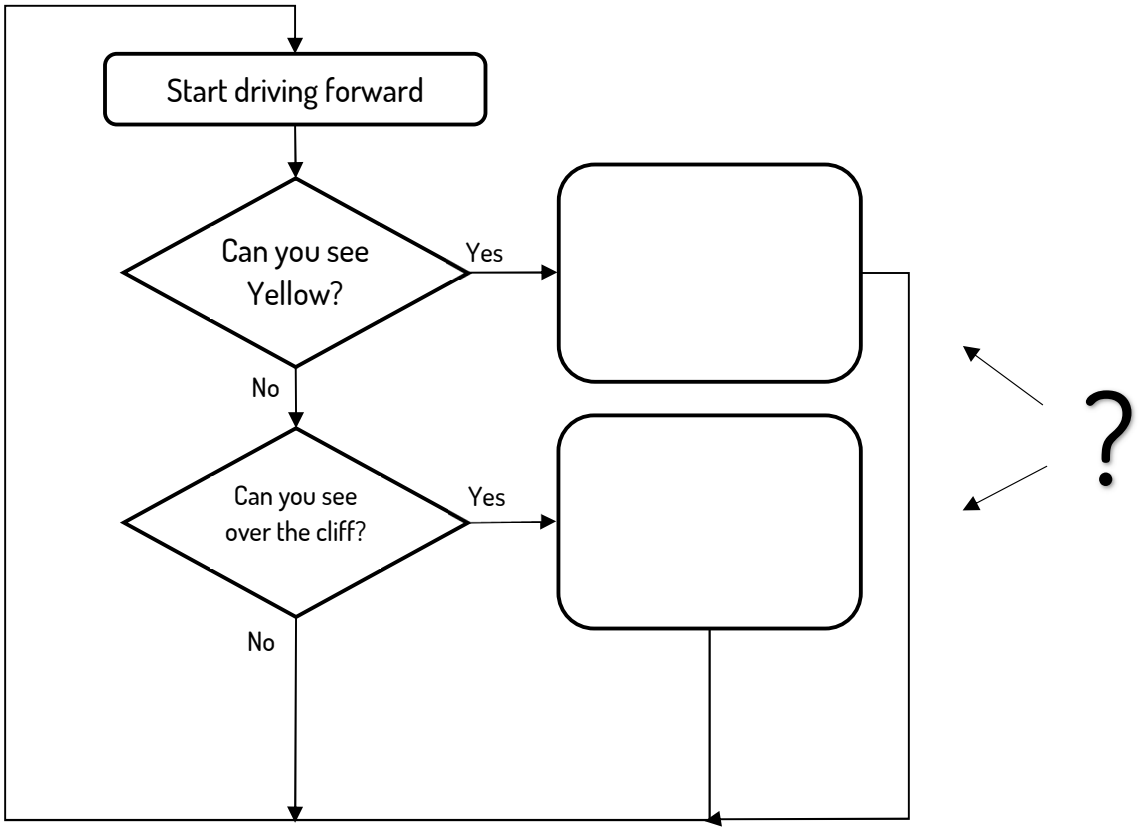
Prospecting and Staying Safe

Group Name_____ Group Members_____

Project: THE SPACE AGENCY are very impressed, but they note with your last program, while the robot is looking for the edge of the plateau, it is not doing any prospecting. Is there a way to do both at the same time?

As there is only one '*Wait*' Block that can be used to determine colour, you will need to find a way for the robot to be able to determine which colour it has seen. This can be achieved with a *'IF'* Block.

Use this flow chart as a starting point, and fill in the blank spaces



Prepare the Landing Zone

Group Name_____ Group Members_____

Project: THE SPACE AGENCY has identified a good landing site for further spacecraft but unfortunately it still contains several large obstacles.

Use your robot and an appropriate attachment to clear the area.

The robot will be required to turn to find an obstacle. Once located, have your robot drive up to the obstacle, take control of it with an attachment and move the obstacle to a new location.

Dangerous obstacle!
Must be moved!

This challenge is best approached as a series of programs. Ensure you have shown your teacher each intermediate program as you work towards the final solution.

- Turn until you see the obstacle and then stop.
- Turn to the obstacle and then drive up to the obstacle.
- Go to the obstacle and close the gripper sufficiently.
- Go to the obstacle, collect the obstacle and move it to a different location.

Extension Activity

Multiple obstacles are present, and all need to be removed. The safest place for them to be deposited is the Dangerous Removal of Obstacle Position (DROP). It is located to the side of the Landing Zone and can be identified by the bright red floor covering (Hint: You'll need to build in the Colour Sensor somewhere!)

As seen on TV!

Project: THE SPACE AGENCY has decided to use your design to fly to Tobor-3. As a result of the associated publicity, many other people want to buy their own version of the robot. Come up with a marketing promotion to sell your robot.

Your presentation may consist of one or more of the following media formats as notated by your teacher

- School Newspaper article
- Video commercial
- PowerPoint Presentation
- Poster presentation
- Website
- Oral Presentation

Be sure to include the following information in your presentation

- How does it look?
- What can it do?
- How does it move?
- How does it sense its surrounding environment?
- What are the standard missions it can perform?

Look back over your previous activities to help you answer these questions.

Remember, you are now pitching your idea to everyday people, not THE SPACE AGENCY scientists!

MiniGolf Score Sheet

	Points					
Group Name	Round 1 Position A	Round 2 Position A	Round 3 Position B	Round 4 Position C	Round 5 Position D	Total

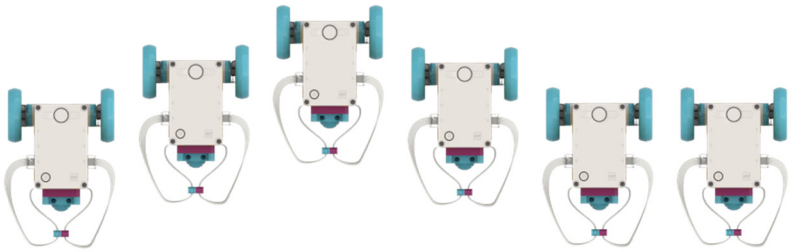
Dancing Robots

Group Name_____ Group Members_____

Artist:		**Song Name:**	
Section	*Time*	*Description*	*Intended robot movement*

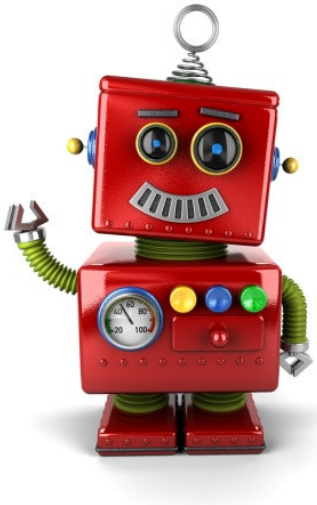
Additional Projects

Robot Wave: Synchronise a group of robots to perform the Wave, an audience move popular in sporting stadiums around the world. As a class, you will need to determine what order the robots will move and what action they will perform.



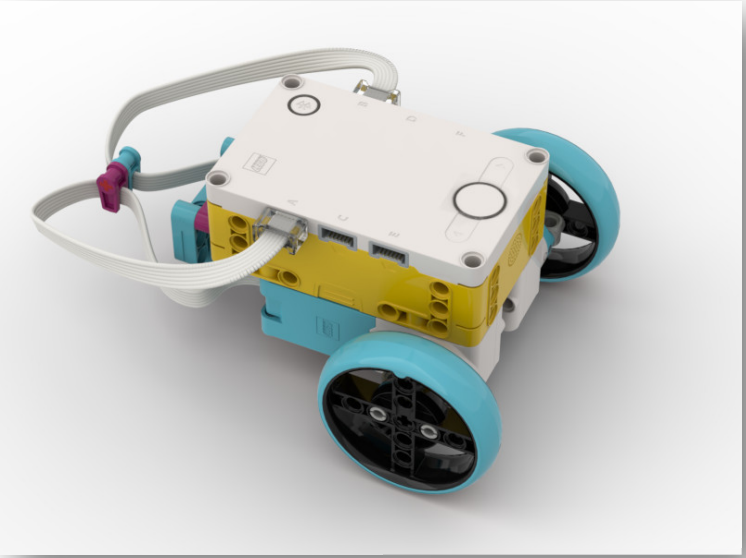
Robot Butler: Robots in the household are quickly becoming commonplace, with personal assistance robots widely regarded to become the most prevalent in the near future. Build a robot that can retrieve a drink for someone who is confined to bed.

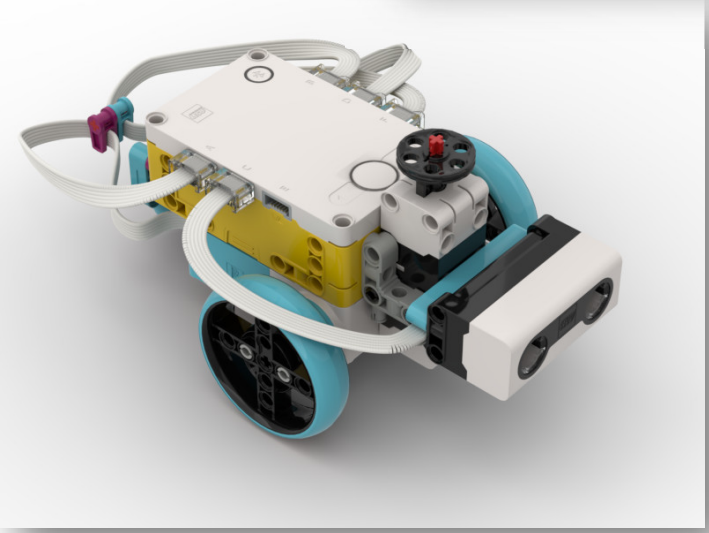
Meet your Adoring Public: Program your robot to respond in a positive way when somebody gets close. Use the **Move**, **Sound** and **Light** blocks to convey a feeling of happiness.

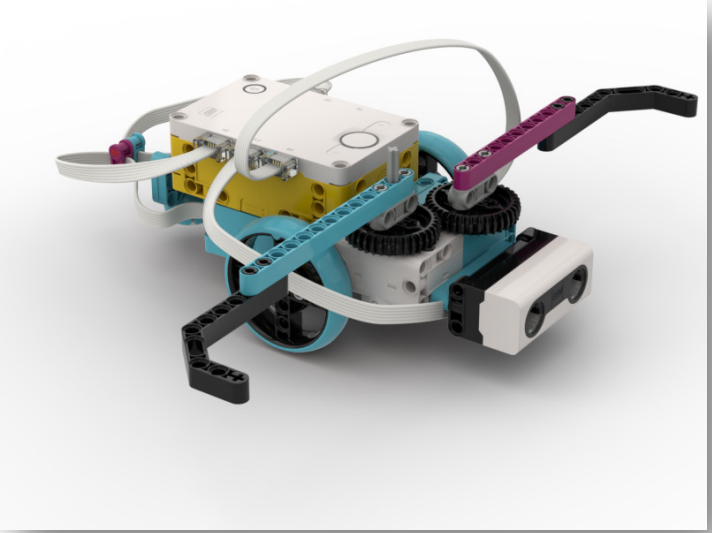


SPY KEE

Building Instructions







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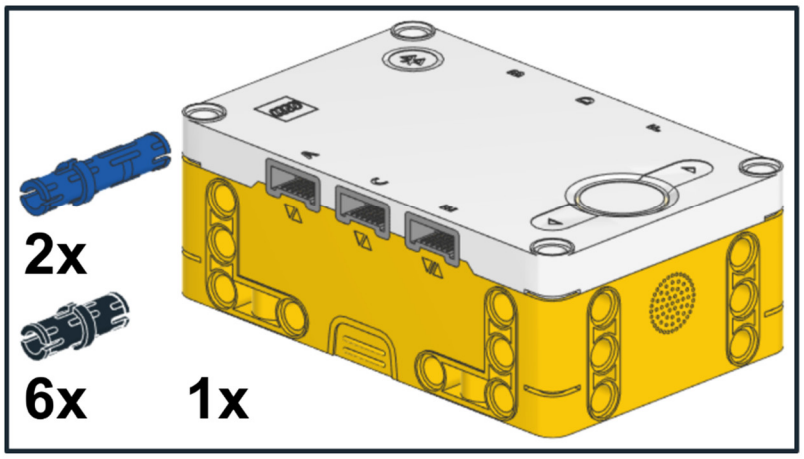
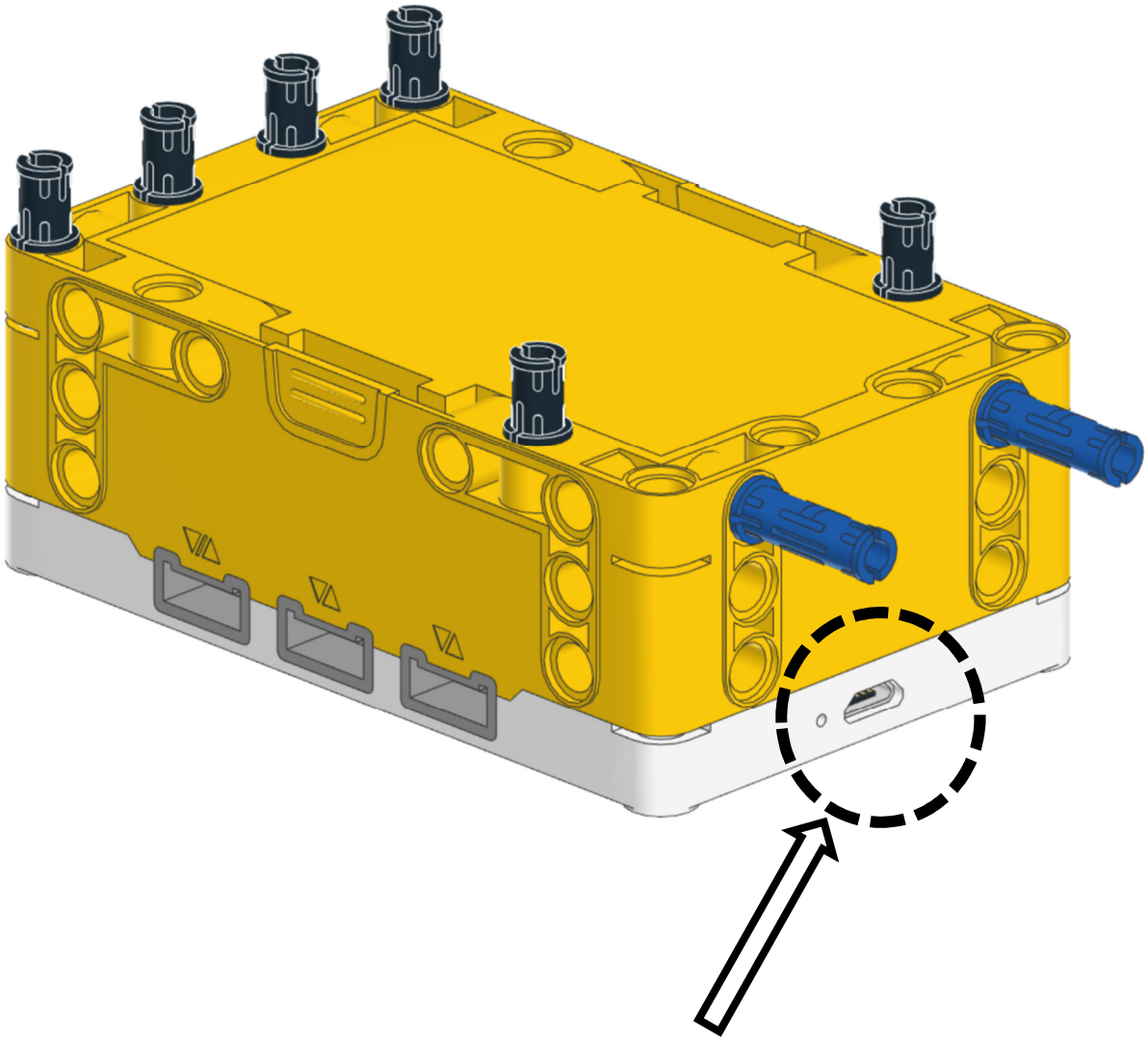
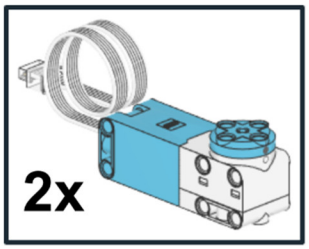


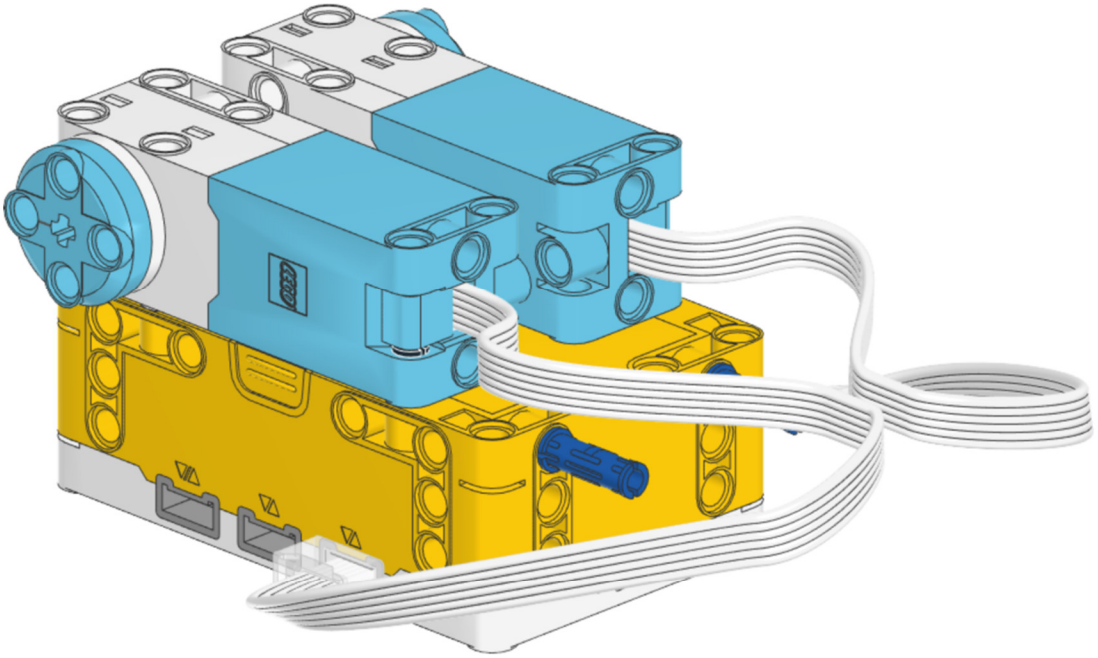


Charging Port on this side

Plug into A and B

2





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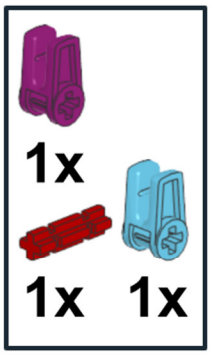

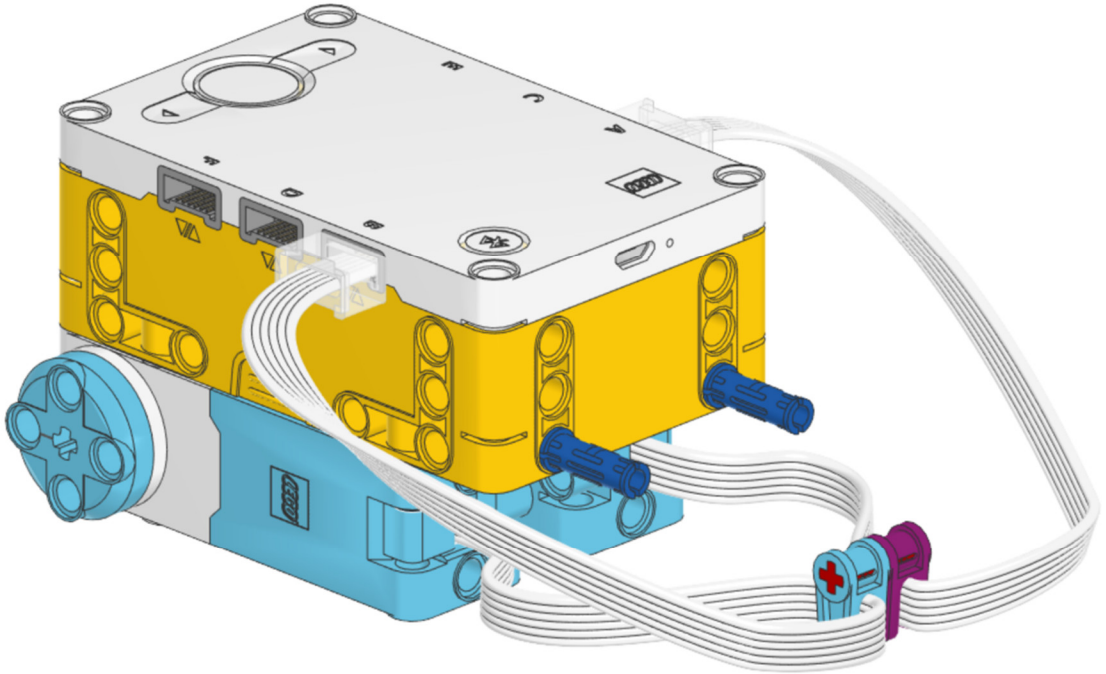

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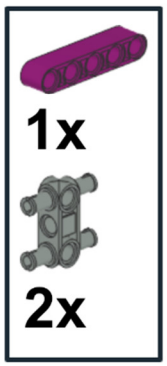

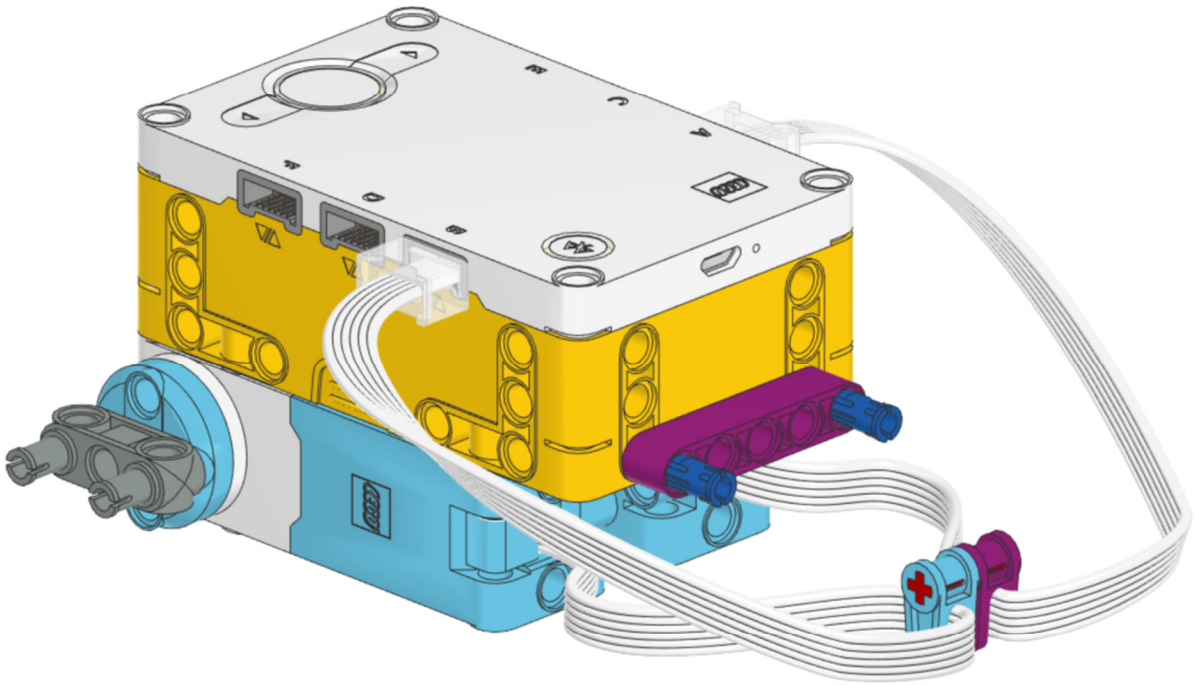

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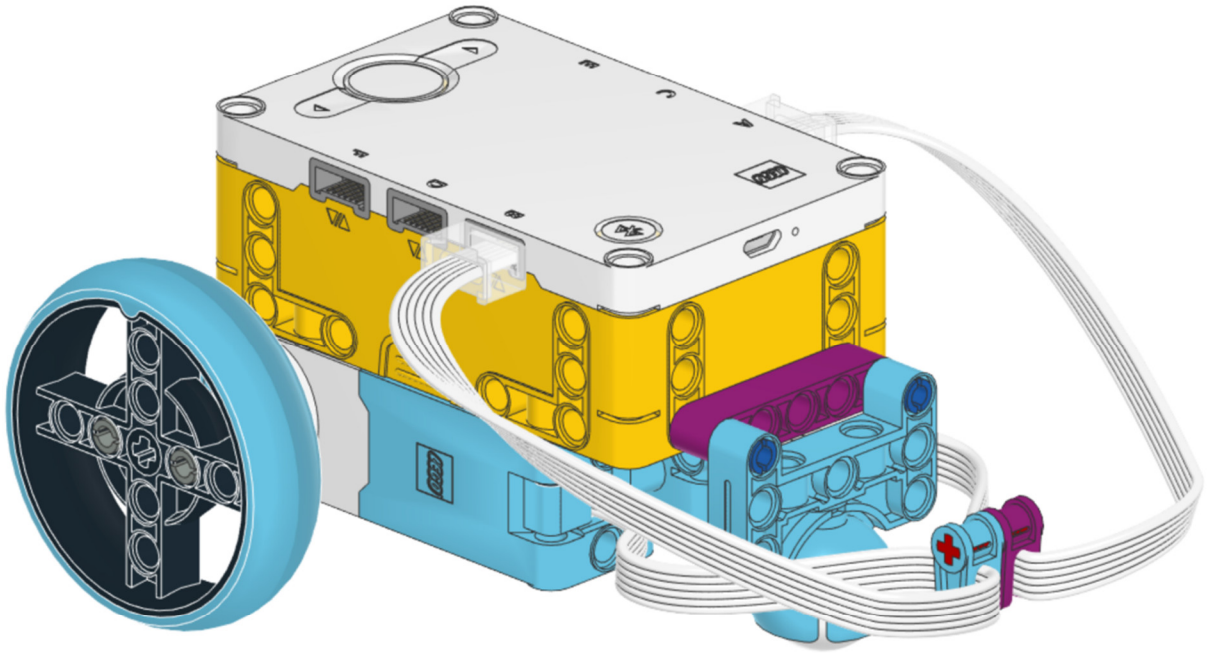
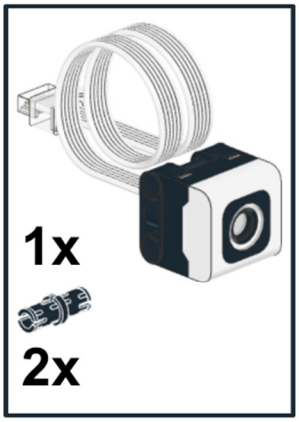
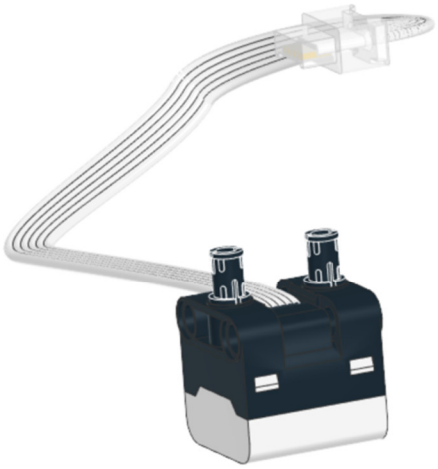


SPYKEE Base Completed!

Sensor Stack Module

1





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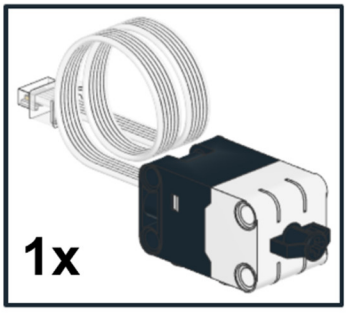

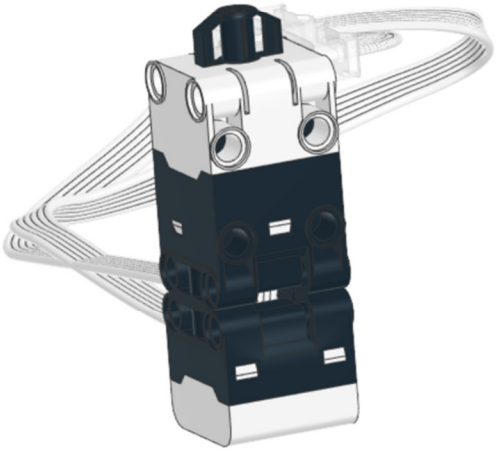

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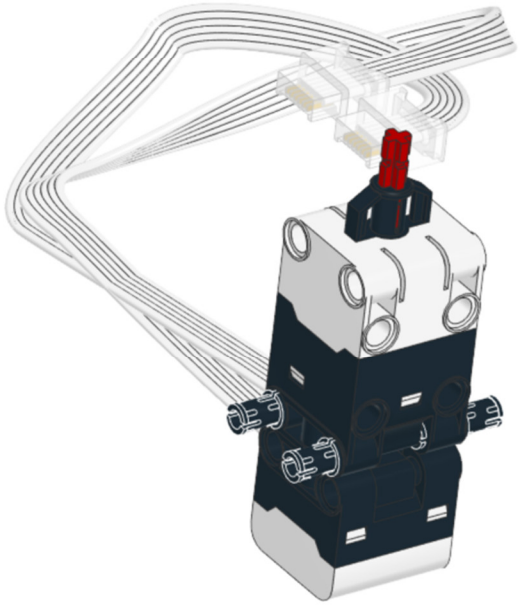

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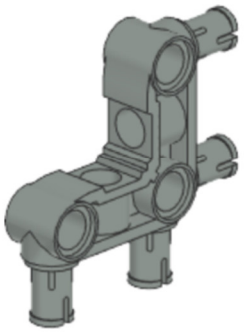

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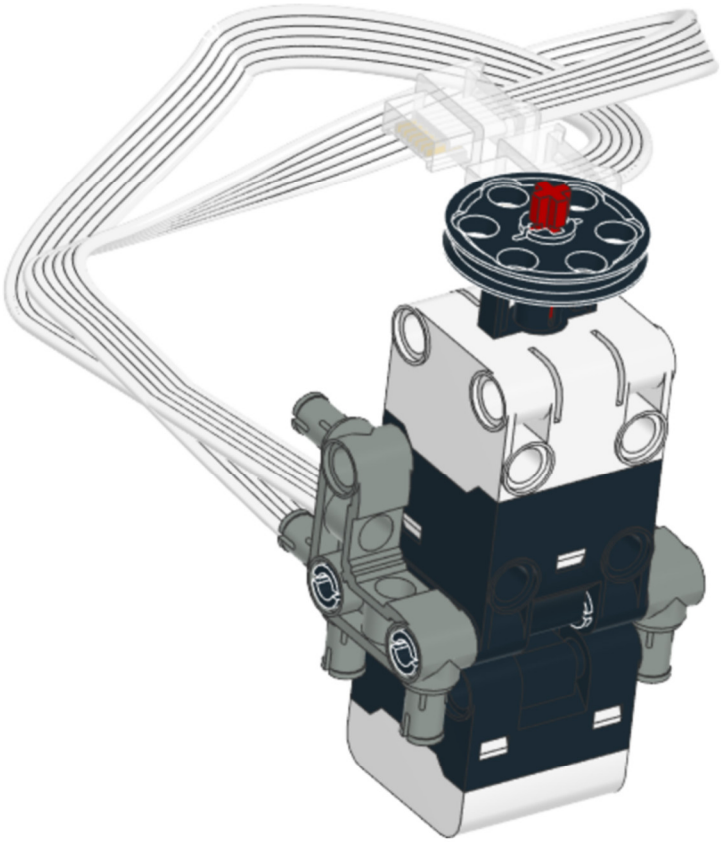

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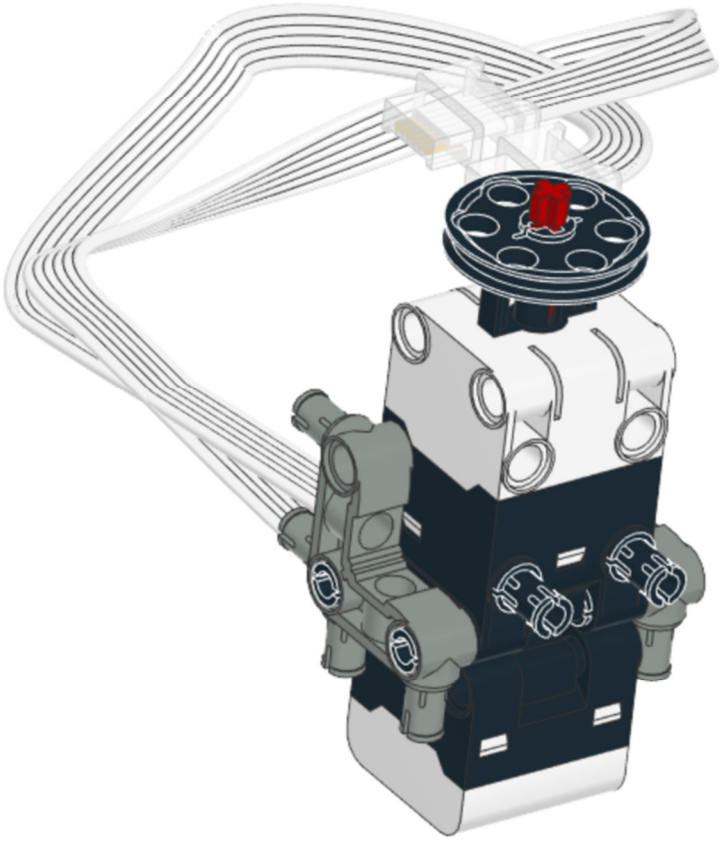

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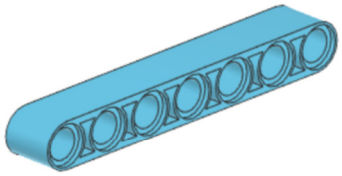

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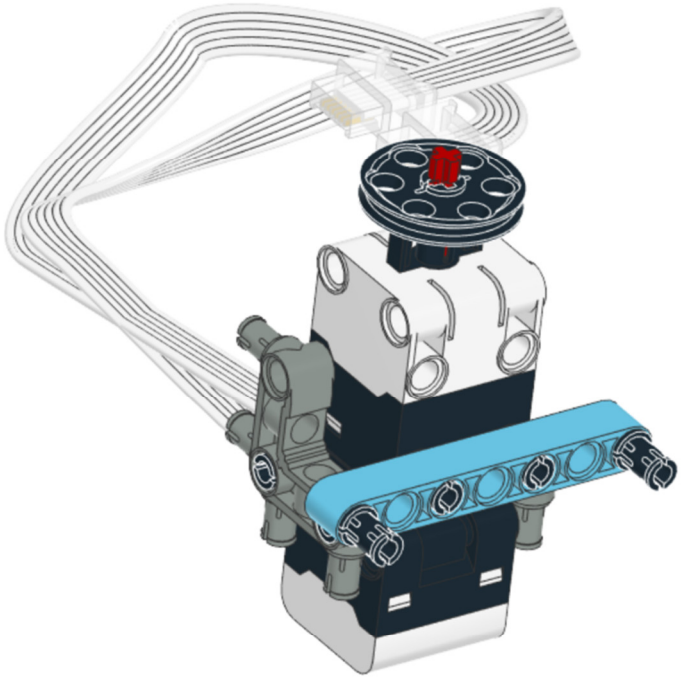

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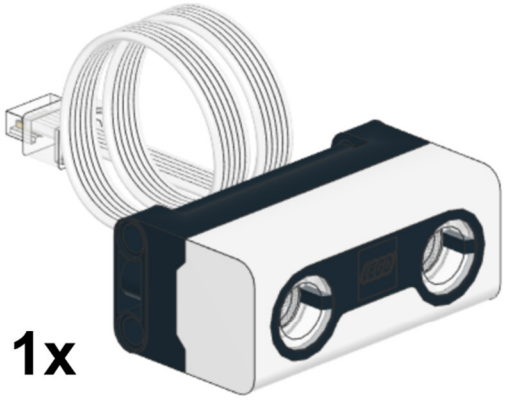

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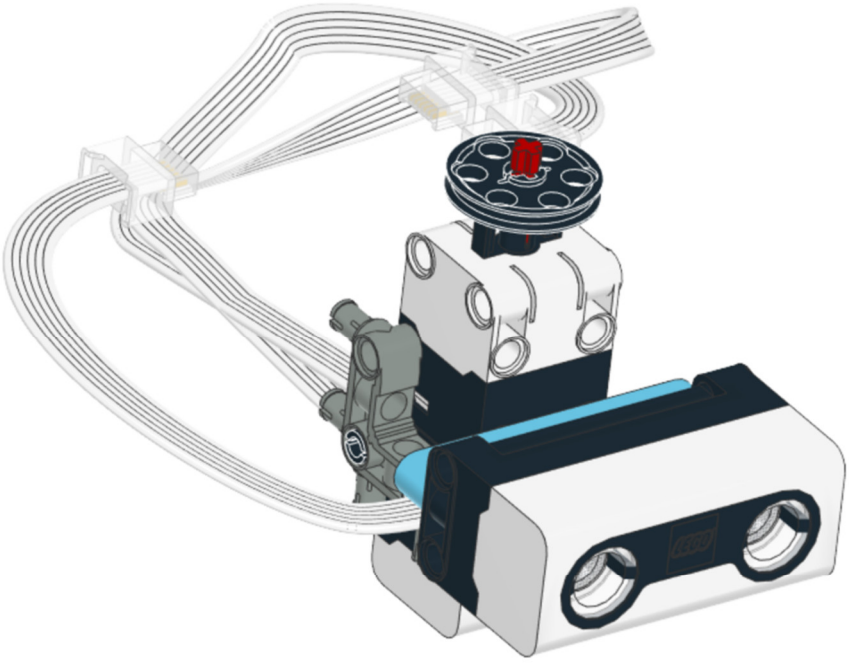
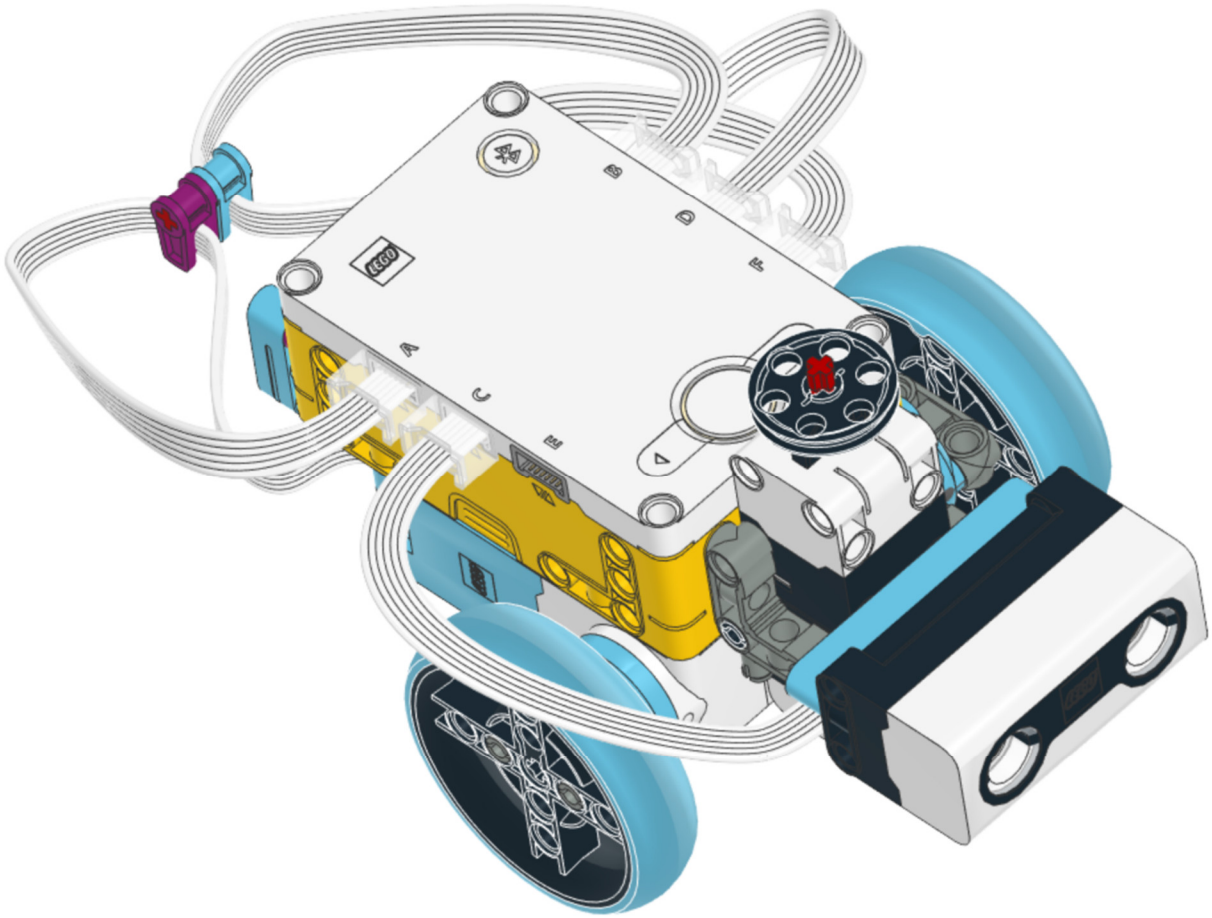


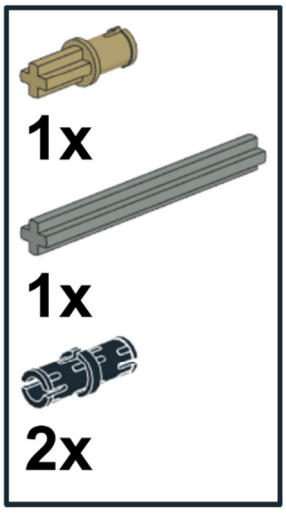
Attach to the front of the Base

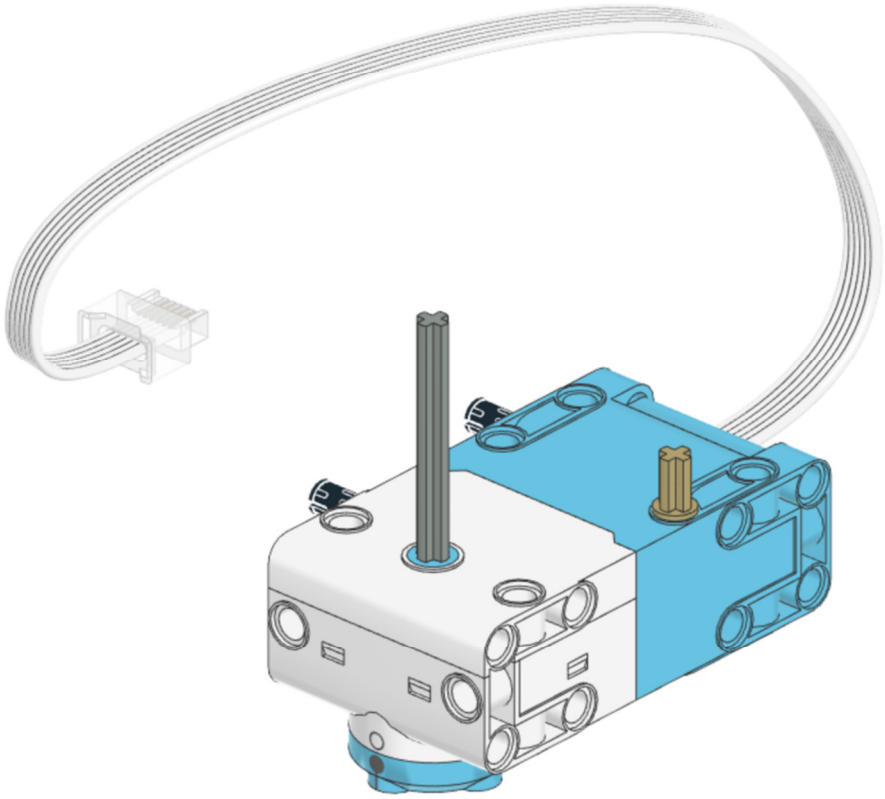
- Distance – Port C
- Color – Port D
- Force – Port F



Gripper Module

1





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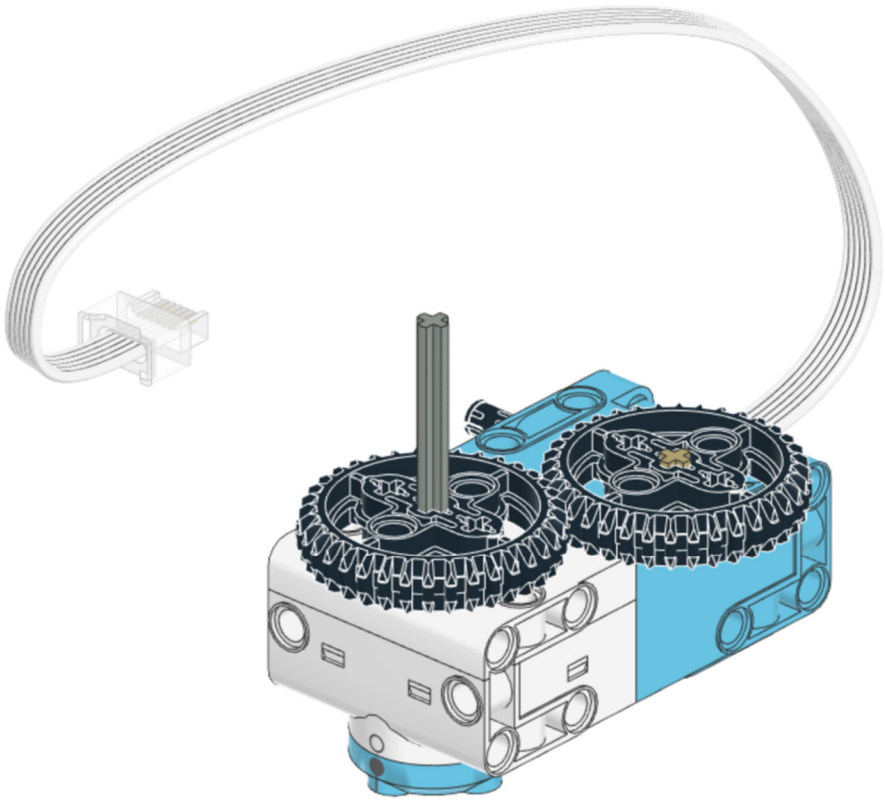

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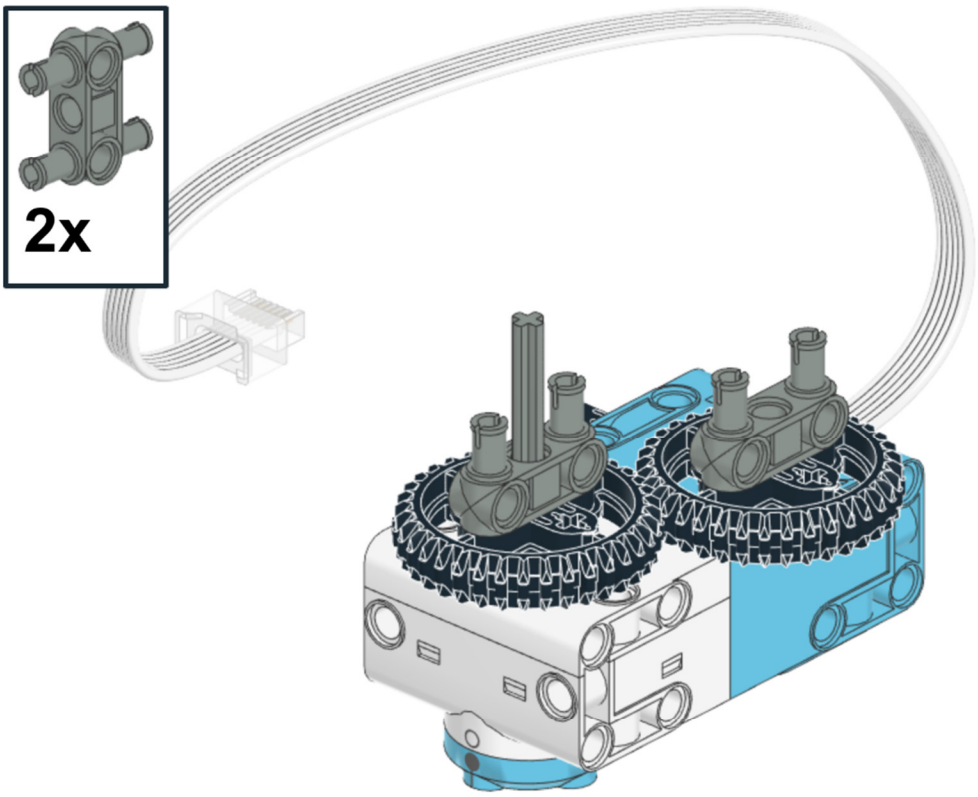

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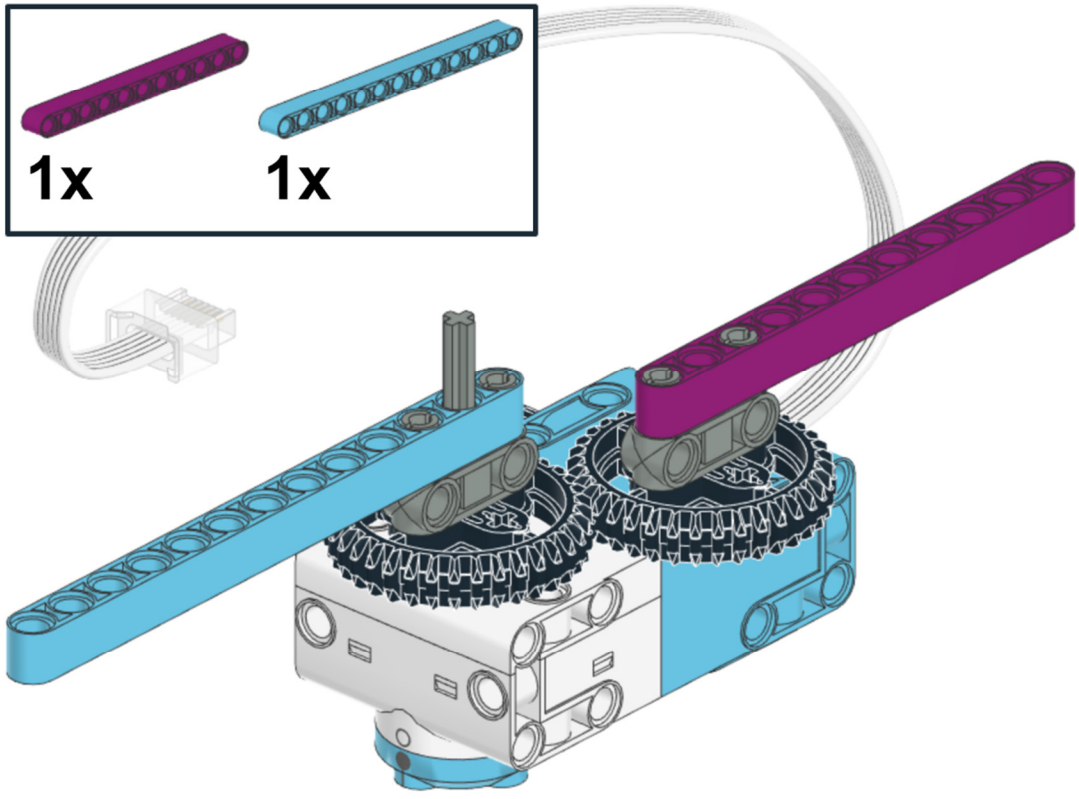

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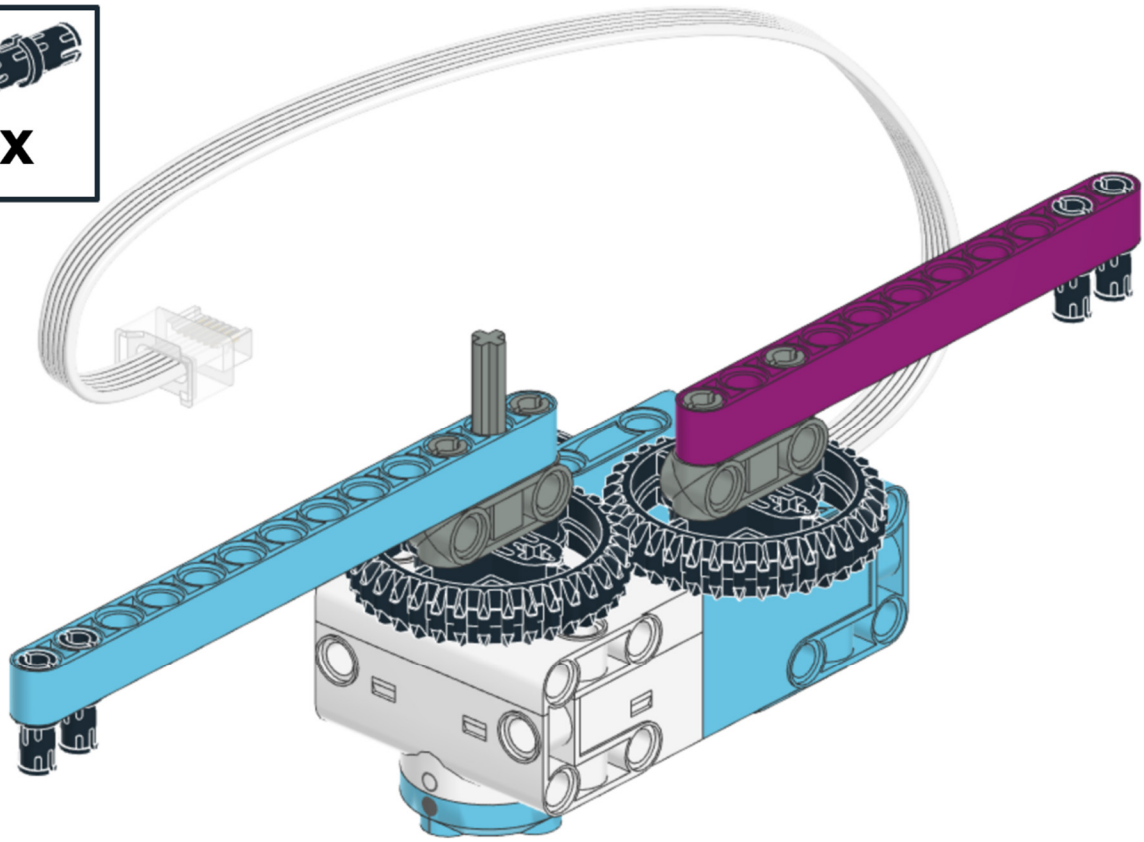

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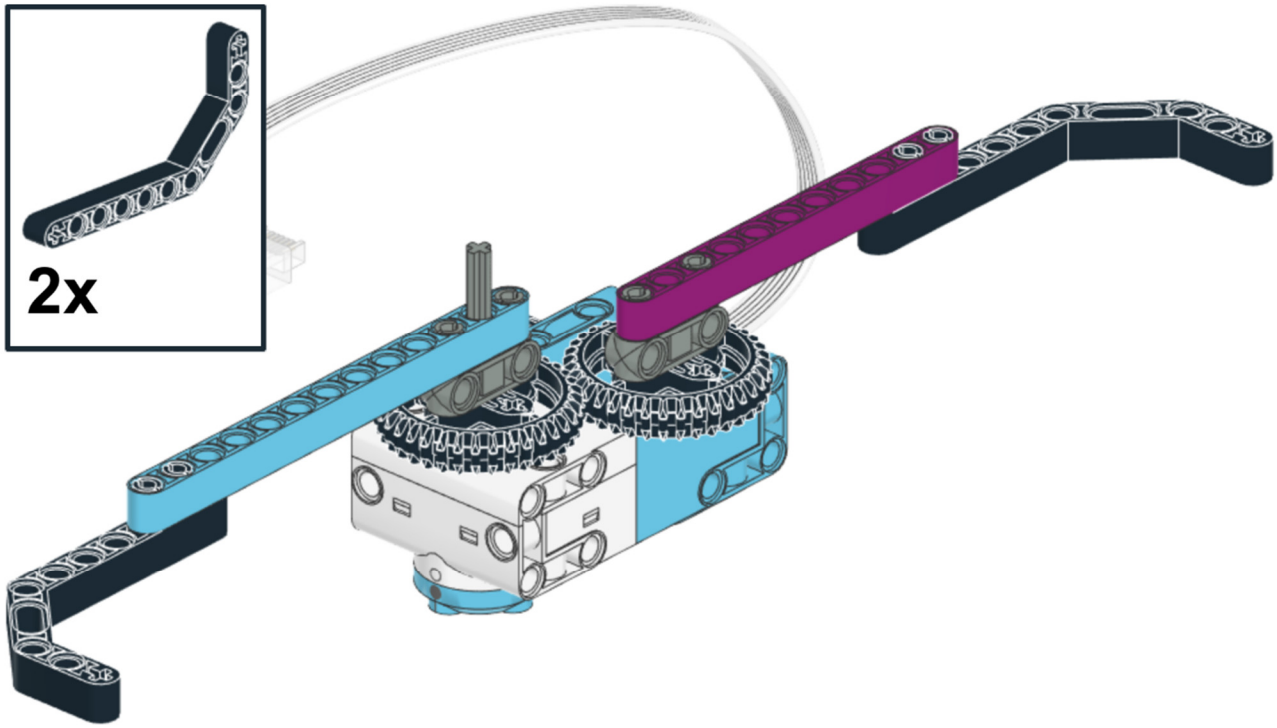

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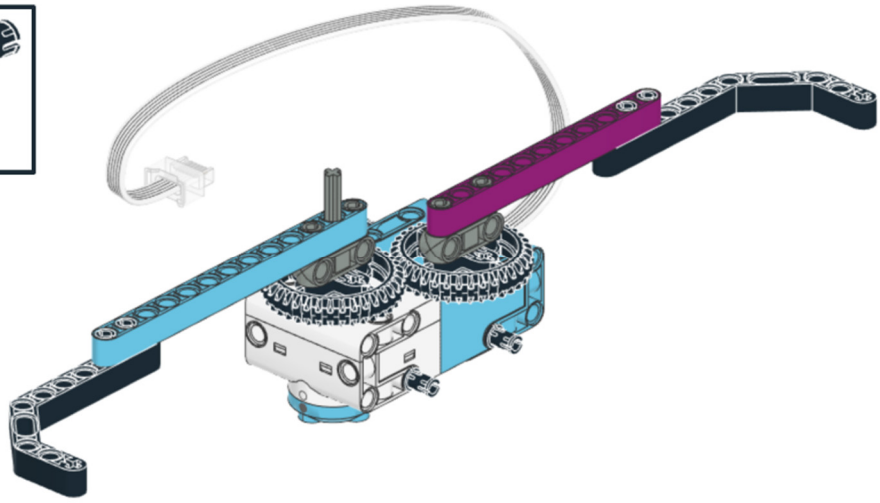

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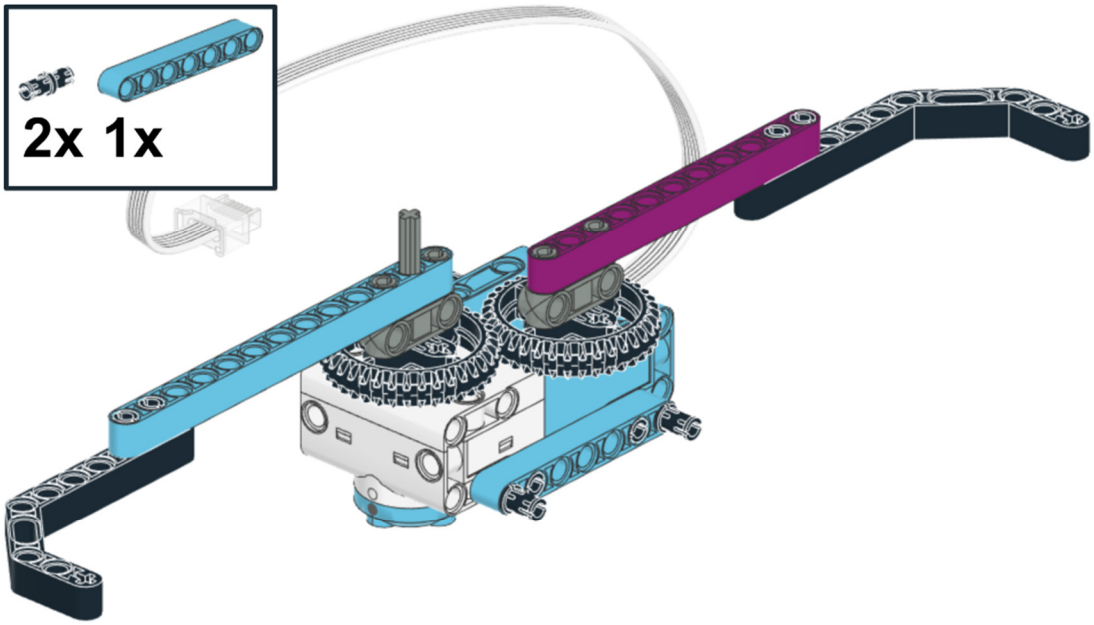

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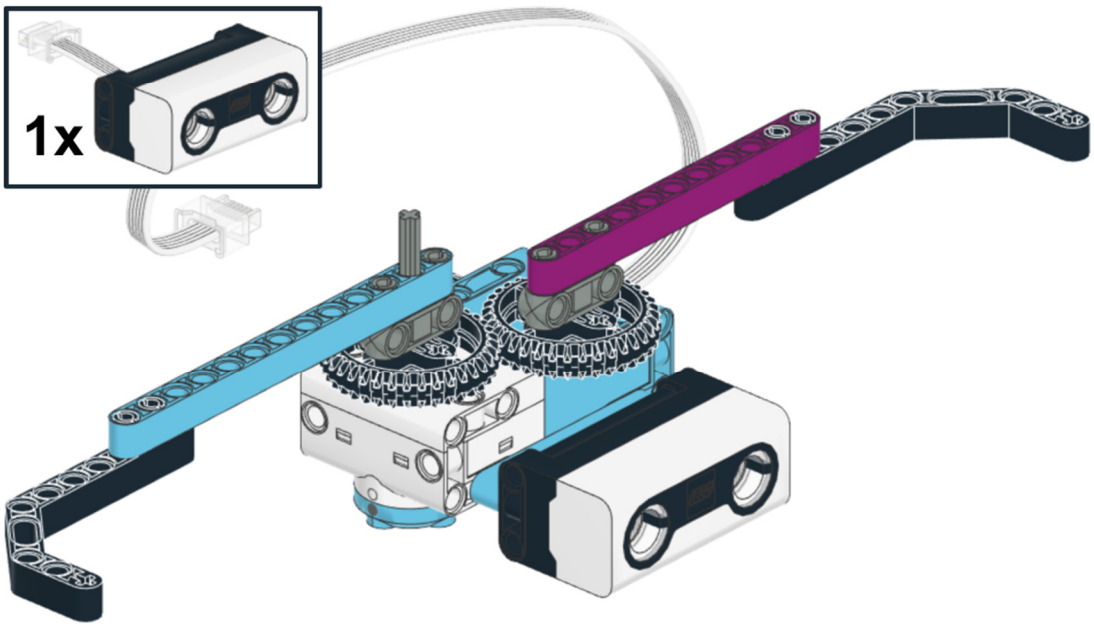
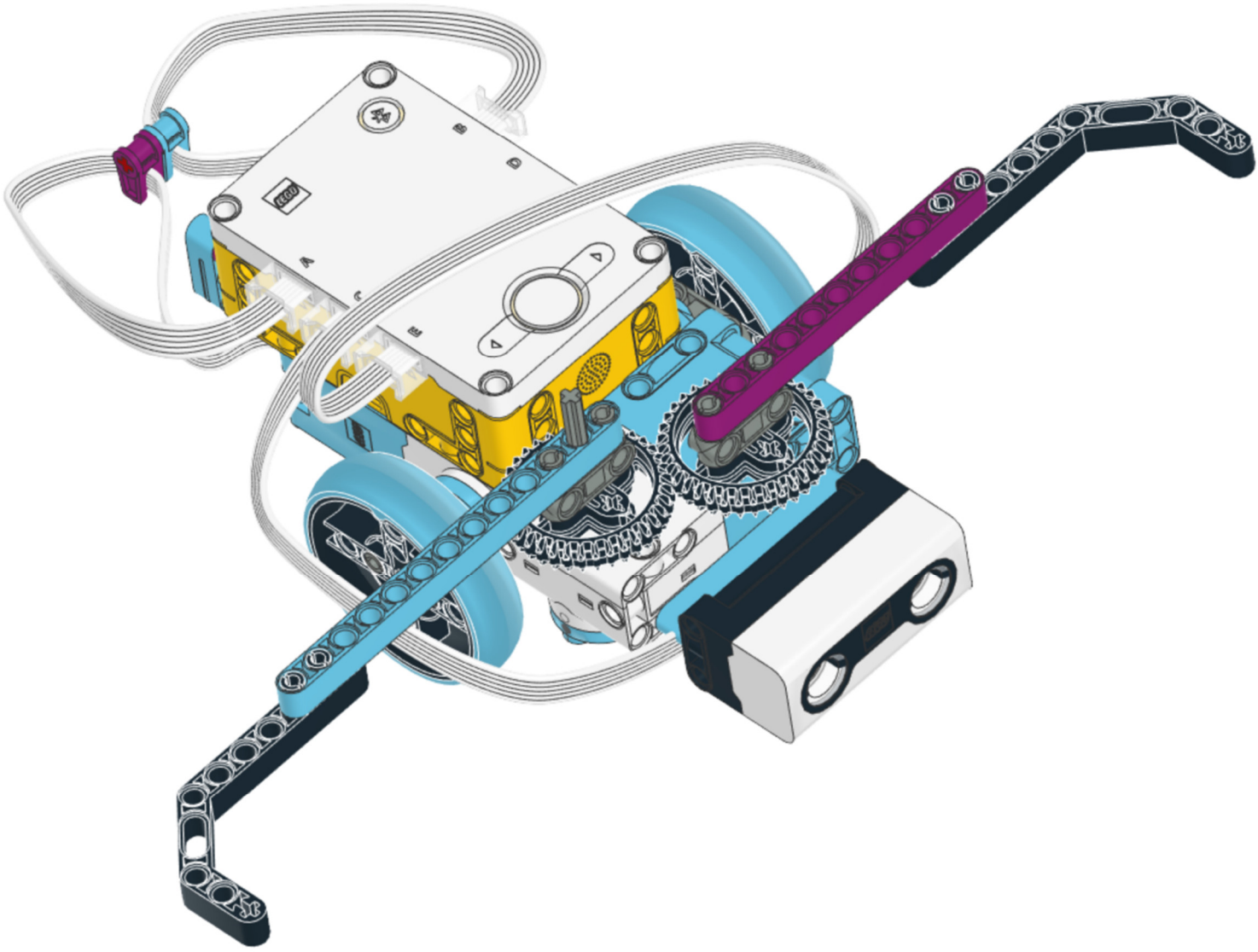


Attach to the front of the Base

- Distance – Port C
- Gripper – Port E