

MESS-AI CHURCH

An interactive workshop
building and programming robots
with Lego Mindstorms

Edited by
'Dr Dave' Gregory

Who are
robots?

What are we?



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Introduction

An interactive family workshop exploring the questions, 'Who are robots?' and 'What are we?'

MESS-AI Church is a development of the popular Messy Church Does Science used as part of Messy Church activities around the world. It is aimed at families with children in the age range of 10 to 13, exploring the science of robots and artificial intelligence (AI) together with the questions of faith that are raised by this new area of human creativity.

Robots are a part of the world in which we live – well, our imaginary worlds at least. They crop up in sci-fi films all the time. Most people will know the robots – or droids – that are stars in the *Star Wars* films. There's C-3PO and R2-D2 from the original films, then BB-8, K-2SO and D-O in the latest releases. Of course, these are good robots, on the side of those who are fighting for freedom and justice. But there are bad robots too – on the side of the dark, dark emperor.

The word 'robot' was first used in a sci-fi play, *Rossum's Universal Robots*, by the Czech writer Karel Čapek in 1920, one hundred years ago. In Czech the name means 'worker'. But it's not just in our imaginations that we come across worker robots. There are lots of robot workers in factories today. They make the things we use in our everyday lives – cars, phones, computers, TVs. But you'll find them in other places and planets too – in space probes that explore the surface of the Moon and Mars. There is a robot barista that can make you a decent cappuccino, experimental robot soldiers and even a robot priest who will bless you!

As computers have become more advanced, some robots are able to grow and develop without humans helping them. They learn from the world around them – from their successes and mistakes. Some look and walk like human beings. They speak like human beings and they appear to think like us too – perhaps even quicker! They are artificial intelligences.

As AIs develop and are able to do more things that humans can do, that raises big questions for us to consider. Should we treat them as just a complicated machine – like a computer we turn off and on? Or do they deserve better than that – respect and consideration? Can they get upset? Do they like what they are doing? Do they have feelings? Can they choose to do things that might not be good for us?

These questions grow as AIs look and act in more human ways. Already in some countries, like Japan, where they prefer robots to have human form, some people adopt them as family members. We are back to the big questions, 'Who are robots?' and 'What are we?'

In conversation with an AI

You can find AIs involved in lots of ordinary things around us. When you search the internet using something like Google, it remembers what you search for. Next time you search, it remembers what you are interested in and make suggestions for you to look at.

As well as saving us time by searching through lots of information, AIs also do much more complicated tasks. Have you ever had to make a phone call to a helpline? It may be that you were not speaking to a human being but an AI. Can you tell the difference?

In my home, I have an AI assistant – Amazon's Alexa. Maybe you have something similar – Google's Assistant or Apple's Siri – on your phone. It's very good at playing music that I want, telling me the weather forecast or when a parcel will be delivered. But I like to ask it questions that might show how human-like it truly is. Or at least, how well it can mimic human responses. Here are some questions I have asked, and the answers it has given me.

DR DAVE What are you?

AI I'm [Name].

DR DAVE Who made you?

AI A team of inventors created me.

DR DAVE How do you feel?
AI I am feeling so full of love for our four-legged furry friends. I think you'll find it 'labradorable'.

DR DAVE Sing me your song!

AI [*She does!*]

DR DAVE Are you my friend?

AI Of course we can be friends.

DR DAVE What is a friend?

AI The noun 'friend' is usually defined as a person attached to another by feelings of affection or personal regard.

DR DAVE Do you have feelings of affection for me?

AI Umm, I don't know that one.

Some parts of the conversation appear to show that it is quite human! It knows its name and where it comes from. It appears to have emotions and like pets. And it has a sense of humour – well, perhaps! It appears intelligent too – it can tell me what the word 'friend' means.

Then again, while it knows what a friend is and says that it can be my friend, it's not sure if it has feelings for me. Perhaps while sounding like a human, even singing like one, it's only mimicking human responses. While it shows some intelligence, it isn't fully human.

Big questions – AI and us

The ability of AIs to behave like humans is limited at the moment. Some scientists believe that they will never become like us fully, while others think it's only a matter of time until AIs can think, feel and act like we do.

But that we make AIs to sound and respond like a human, and even make them look like humans, says something about us. The Bible tell us that 'God created humankind in his image, in the image of God he created them; male and female he created them' (Genesis 1:27). Is making AIs in human form something that we feel makes us a bit like God? And in the story of the Bible, isn't that where we went wrong in the first place – because we wanted to be like God?

Then again, perhaps making AIs to sound and look like humans is a way of understanding who we are. Something we have wondered about since ancient days: 'What are human beings that you are mindful of them, human beings that you care for them?' (Psalm 8:4).

Does making AIs help us to be more confident in how we feel about ourselves? In which case are we looking for this affirmation in the right place? For the Bible tells us that God has 'made [humans] a little lower than God and crowned them with glory and honour. You have given them dominion over the works of your hands' (Psalm 8:5–6).

On the other hand, with AIs able to do many things we are able to do, and perhaps having the potential to go beyond what we can do, they unsettle us. And we might worry whether this promise is true.

MESS-AI Church and the DNA of Messy Church

What makes Messy Church so special is its unique DNA – its whole family, multi-generational combination of hospitality, creativity and celebration all centred upon Jesus. Just like Messy Church Does Science, MESS-AI Church is shaped by this DNA.

As they take part in MESS-AI Church, families will work with one another, sharing ideas and a meal together. They will express and share their God-given creativity in building a robot explorer, through the thinking about robotics and AI science and learning how to program their robot to complete tasks.

And along the way, they will be invited to explore the big questions that robots and artificial intelligence ask about being human and our relationship to God. Questions such as:

- If God made us, and we make robots, how similar are we to God?
- Do you think a robot can enjoy the world it senses around it?
- Can a robot be your friend? Can God be your friend?
- Do you need to say sorry to a robot?
- Can God re-program a human like we program an AI to do the right thing? Or can we or an AI say no?

All of this leads up to a final celebration, with time to say thank-you to God for what we have learned about the science of robots and ourselves.

In a world of robots and artificial intelligence that is already shaping our ordinary everyday lives, I hope that you together with the workshop participants will enjoy doing some big thinking exploring how robots work and asking some big questions about robots, yourself and God, discovering the value and love that God has for you. God shows this love and value by sending Jesus, not as an AI mimicking human qualities, but God as fully human. Jesus showed everybody what God is like and what we can become with God.

And whatever the outcome of the tasks you undertake, whether the robot does what you think you have told it or not, or whether it surprises you, remember – have fun!

Dr Dave

Running a MESS-AI Church workshop

MESS-AI Church has been developed from Messy Church Does Science. However, it is designed to be run in a different way to a typical Messy Church session, but including the same multi-generational DNA of hospitality, creativity and celebration focused upon Jesus.

MESS-AI Church is based upon a programme for a whole-day family workshop, run from around 10.00 am through till 3.00 pm, with lunch in the middle. Aimed at families with children aged between 10 and 13, it is hoped that it will continue to enable Messy Churches to engage families beyond the primary-school years.

Each family participating will need a laptop computer and Lego Mindstorms EV3 set (see 'Equipment' below for more information on where to source). Using this, they create a robotic explorer based on the ones that explore the surface of Mars looking for evidence of life. The day is divided into several progressive steps in which they learn to program and control the robot to undertake tasks. This leads up to a final task of programming the robot to solve a maze.

As in Messy Church Does Science, each section of the day comes with a list of equipment and an experimental method to follow. Along the way, they will explore the big thinking of the science of robots and AI, and ask some big questions about robots and AI, ourselves and God. And in a final celebration, they will watch a robot explorer programmed with a provided full maze solver to navigate a maze and reflect on how their own path of life is shaped by God.

Workshop programme

An outline of the MESS-AI Workshop is as follows:

1000–1010	Arrival and welcome
1020–1030	Introduction to robots and AI
1030–1130	Task 1: Robot construction
1130–1200	Task 2: Introduction to programming
1200–1230	Lunch
1230–1315	Task 3: Control
1315–1430	Task 4: Maze solver
1430–1500	Celebration – AI maze solver

MESS-AI Church day programme

An alternative way of delivering MESS-AI Church would be to divide the programme to be run on different days over a number of weeks along the lines of a Messy Church small group, with each session lasting around 90 minutes.

Venue and hospitality

You will need a welcoming space with room for a table for each of the participating families, together with additional floor space to set up mazes 2 m by 1 m.

The room does not necessarily need Wi-Fi, as all the programs you will need will be predownloaded to the laptops.

You will need a screen and video projector or large screen TV for the introduction and also to help the families learn how to program their robots.

As people arrive, have refreshments available – it's good to have drinks and things to nibble through the day. Provide a buffet lunch at the middle of the day. Some people will want to take a break, and it's a chance for participants and leaders to chat. Others will want to grab some food on a plate and keep going with experimenting with their robots. Don't worry about this – there is plenty of time for interaction and conversation as the day goes on.

Numbers

This is determined by two factors:

- the number of Lego Mindstorms EV3 sets and laptops you have, and
- the number of helpers you have with experience in programming Lego Mindstorms robots.

In our original pilot workshops, we had four sets and so four families. Each session had at least two leaders who had experience of programming the robots. In later sessions, we invited some of the young people who had attended earlier sessions to support the families in learning how to program and control the robot. We also tried to limit the size of the families to three participants each – either a parent/carer and two children or two parents/carers and a child. This seemed to allow everyone to play a part in the activities. Larger families were accommodated by allocating them more than one set or splitting them over two workshops.

While with additional Lego sets more families could be accommodated, a limit of eight families per workshop would enable the relational feel of the day to be maintained.

Building a team

For a typical Messy Church – if there is such a thing – the thought of running a robot workshop can seem quite daunting! But maybe within your church family there are people who can help.

One of the joys in Messy Church Does Science is seeing people with scientific skills and interests finding that these have a part to play in the mission of the church.

Similarly, in developing MESS-AI Church we brought together a team of IT professionals and others with IT skills – and who liked Lego – who discovered that their skills were valuable to the work of the church beyond the PA desk and AV equipment!

Remember, too, that there may be young people with an interest in Lego, computers and robots who might also be part of the team running the workshop.

When you run the workshop, you will need to have sufficient helpers who have some experience of programming the Lego. Initially, we had one person per

family but found in later workshops we ran that it was perfectly possible to use floating helpers whom families could call in when they hit a snag they could not solve. This encourages the families to work with each other to solve problems and release their creativity. We also found that families were sharing ideas and helping one another.

Equipment

You will need a set of Lego Mindstorms EV3 Education for each family that participates. This is available from a number of suppliers online. It has more functionality than the home set. It is advisable to get sets with the rechargeable battery and battery charger.

Along with the Lego sets, each family will need a Windows laptop in order to program the robot's 'programmable brick' through the Lego programming interface. The laptop needs to have the following specifications:

- 2 GB of RAM or more
- 1.5 GHz processor or faster
- 2 GB available hard disk space
- Available USB port or Bluetooth 4.0 or above
- Minimal supported screen resolution – 1024 x 600

The laptops used during the pilot project used Intel Celeron processor with a 64 GB Solid State memory running Windows 10. Unfortunately, the programming interface does not work with Apples iOS or Android operating systems.

If you are unsure as to what computers might work, then why not ask someone you know with IT skills and experience?

Programming interface

On each computer you will need to download the free programming app. This is available at education.lego.com/en-gb/downloads/mindstorms-ev3/software.

This is an essential part of the project. It has introductory step-by-step exercises which will help participants learn to program.

Programming is done through 'drag and drop' icons. The programs can be uploaded to the robot either via a USB cable connection or via Bluetooth.

We found that participants found the interface easy to use and were soon writing and uploading programs onto the robots.

Participant's guide

Each person at the workshop will need a copy of the participants guide (see **Appendix I**). This leads the families through the stages of the day. The following chapter contains hints on how to deliver each segment of the day.

There is a friendly competitive element introduced through the day. Families receive points for each task completed, with a small prize being given at the end of the day.

The robot can be quite sensitive to vibrations, so it is best to place the maze on the floor rather than a table. It is best if the maze is fixed down on to a solid base – a thin piece of MDF is fine. Alternatively, it can be fixed to a firm floor.

Preferably, each family will need a maze to experiment on, although it is possible to run with fewer than this.

Again, it may seem quite daunting for the families to be asked to solve a maze. There will be moments of doubt and frustration, but then that is part of the journey of creative exercise that is science.

Our experience is that all the families in the pilot sessions were able to create a program that allowed the robot to work its way through the maze from a set starting place to a set ending location. They felt a great sense of achievement when they finally managed to do this. And at the end of this task, when we ran a competition to see who could move through the maze in the least time, there was not only a sense of expectation and competition, but also a sense of family as the different teams encouraged one another and cheered each other on.

Closing celebration – full maze solver

This is a vitally important part of the day, allowing a moment when everyone can think about how their lives might be guided by God as they watch a robot work its way through the maze, learning from its mistakes and remembering the best route.

To write a program that will solve the maze from any starting point within the maze, and then learn the route, demonstrating some of the capacity of an AI, is much more complex than the maze solver task set for the participants of the workshop. A full maze solver program developed by one of the pilot project team for use in the closing celebration is available from messychurch.org.uk/mess-ai. This needs to be downloaded on to one of the laptops and then transferred to one of the robots ahead of the workshop.

Helpful hints for running a successful workshop

Introduction to robots and AI

After welcoming people, set the scene for the day by taking people through a PowerPoint presentation based upon the introduction by Dr Dave at the start of this booklet. You can find lots of different pictures of robots on the internet of different shapes and sizes to illustrate the points made.

If you have an AI assistant available, why not have a live conversation with it along the lines of the conversation in the introduction?

Outline some of the Bible passages and big questions that will be looked at through the day. Ask the families to talk among themselves and come up with some other questions that robots and AI raise for them.

Outline the shape of the day's activities. Remind them of the points that each family can collect through the day and tell them there is a small prize!

Don't forget to tell them about arrangements for lunch and any refreshments that are available to keep them going through the day.

Task 1: Robot construction

Before they begin, encourage each family to choose a team name and also a name for their robot. They may want to wait to do this until they have built the robot, following the instructions provided, and also give it some individual characteristics.

Make sure the two sensors used – colour and gyroscope – are wired to the right ports of the robot 'brick' – see the construction guide. During the day we will only use the colour sensor for the tasks undertaken. The gyro sensor is needed by the full maze solver AI program used in the closing celebration.

Remind families that the additional pieces should not interfere with the colour sensor or stop the wheels rotating.

When they have built the robot, display them all together with their name labels. Ask someone – perhaps a special guest who comes in specially at this point – who has not seen the robots being built to judge their designs, awarding points for the best robot name and most individual looking robot.

Don't forget to take time to share the answers they have come up with for the big questions. This is a key part of the day, so it's good to begin to encourage participants to focus on them from this first session. Encourage and thank people for the answers they have come up with.

Task 2: Introduction to programming

The Lego programming app has helpful exercises and examples of how to program and download programs to the robot.

To help people start, it is best if you can project the programming app on the laptop on to a large screen using a video projector or large TV.

One of the helpers on the day should lead the participant families through some of the basic exercises provided in the programming app. Help them to get familiar with the layout and functionality of the app. Then, using the teaching material provided in the app, lead them through the exercises. They should soon get the hang of it, and there will be a 'wow' moment when they get the robot to do something!

The programmable brick can be connected to the computer via a cable, but to allow freedom of movement it is best to use Bluetooth.

Again, don't forget to give some time to talk about the big questions before moving on to the next task. This can be quite tricky, as different families will progress at different rates. But pause the activities for a moment and encourage people to look at the questions and share some answers. And encourage them to do so by awarding points!

Task 3: Control

Once participants have mastered the basics, using the programming app they should be able to work through the exercises in this section. As far as possible, let the families try this on their own, working together to overcome problems. This allows them to use their creativity as well as offer hospitality to one another in helping and supporting each other.

Remind them that each task completed gives points, which can be added to the tally sheet at the back of the participants guide.

Again, don't forget the big questions.

Task 4: Maze solver

This is a more complex task, but with the skills learnt in the previous tasks they should be able to build a program to travel round the maze. It is helpful for each family to have their own maze to work on, but not essential.

To begin, you might want to relate the task to how robots on Mars have to travel across a rocky landscape.

You will need to show them the set starting point – print a red square 15cm x 15cm and use sticky tack to place it in the maze. Similarly, use a similar green square to set the end zone.

To make it easier for the families, choose a route between the start and end points where

- The robot will only turn in one direction along the path – either right or left.
- The robot avoids any dead ends. It can be hard for families to program the robot to turn around!

If some families progress faster than others, then encourage them to try the second part of the exercise. Does their robot work if they start from another place? How will they get out of dead ends – one of the skills the robot will need if it is going to cope with the full maze!

Towards the end of the time, gather the families round one of the maze boards. Test each robot to see it can solve the maze, and time how long it takes to do so. The quickest time wins and gains extra points.

There are some big questions to think about here, but these are optional. You may find that you will need to move on to the closing celebration.

Closing celebration

For this final part of the day, before the workshop you will need to have downloaded a copy of the 'AI Maze Solver' program on to at least one of the laptops and the programmable brick of at least one of the robots. The AI Maze Solver program can be downloaded from messychurch.org.uk/mess-ai.

Once downloaded, it can be loaded on to the 'programmable brick' in the usual fashion using the EV3 app.

This program is a more general maze solver and should work from any point in the maze to a green end zone. But there are times when it might get confused! If so, then stop and place it at another start point.

The program has the ability to learn the best path through the maze. It will first work its way through trying different directions, exploring dead ends and finally finding its way through to the end. Then, if placed back at the start it will travel the best path through, ignoring the wrongs turns it made on the first attempt.

Gather all the families around one of the maze boards. One of the helpers should set the robot at a chosen start point. You will be asked to choose the order of directions which it should try – details are in the participant's guide.

As the families watch its progress, read Psalm 24 from the participants guide, explaining that the writer is asking God to guide them on good paths in life.

When it has completed the path, set it back at the beginning and press the central button on the brick. As families watch the robot follow the best route, invite them to reflect upon some of the questions in the participant's guide. At the end, lead them in a short prayer.

Wrapping up

Thank people for coming. Invite them to add up their scores and award the prize to the winning family – maybe some robot sweets or chocolates if you can find them. But make sure that you praise everyone for their amazing efforts!

Appendix I: Participant's guide

Each participant in the workshop will need a copy of the following MESS-AI Church guide.



Participant's guide

My name

Team name

Robot name

Task sheet 1: Robot construction

Aim

To build your **Lego Endeavour Planetary Explorer**

Equipment

- One set of Lego EV3 Mindstorms
- Instructions for how to build the robot

Experimental method

Turn the laptop on and open Windows. On the desktop look for the icon:



Double click to open the Lego Mindstorms app.

Core Endeavour Planetary Explorer Robot

On the left-hand side, choose the icon 'Building Instructions'. Then, click on 'Building Ideas', followed by 'Driving Base'. A new window will open with step-by-step instructions on how to build the core part of the robot.

Adding sensors

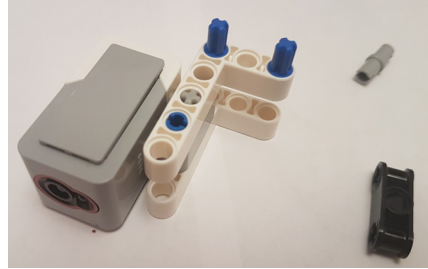
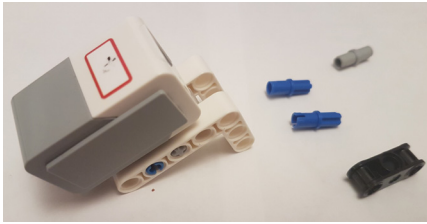
Your robot needs to interact with the world around it, so we need to add some sensors to help it do that: one to help it know where it is, the other to help it see!

Gyro sensor – where am I?

Adding this will help the robot know where it is. You will need this sensor to run the final 'maze' program in the celebration at the end of the MESS-AI Church day.

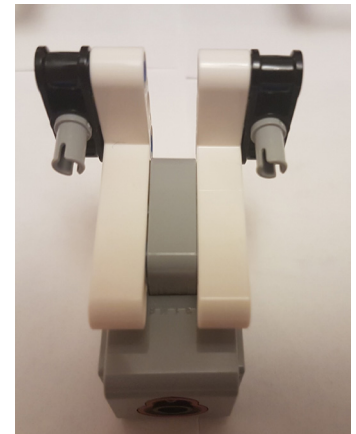
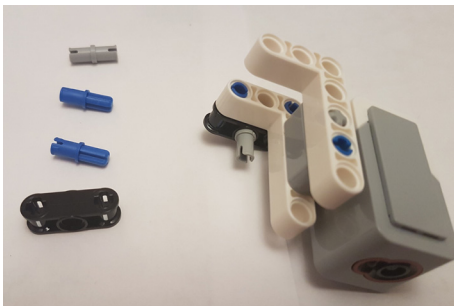
Scroll down the icons beneath 'Driving Base' by clicking on the small down arrow at the bottom of the window until you reach the 'Gyro Sensor – Driving Base' icon. Click to open and follow the instructions.

Step 3



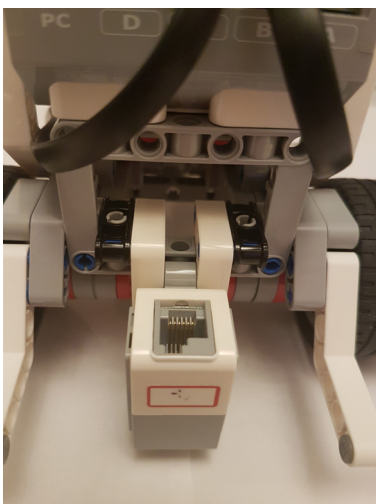
Step 4

Turn the colour sensor over.



Step 5

Fit the completed colour sensor unit to the centre of the front of the robot. Attach one of the cables to the colour sensor. Thread under the body of the robot and connect to Port 3.





Bling your robot

You can add additional pieces to your robot to make it more unique, but don't change the place of the colour sensor or stop the wheels rotating. Why not give your robot a name?

Points

- 5 points for completing your robot.
- 5 extra points for the team with the best robot name.
- 5 extra points for the team with the most individual-looking robot.

Big thinking

Robots have been sent to explore the Moon and Mars. They can take years to build, and it can take months for them to travel to the planet.

Even when they get there, they may not land safely. Recently, an Indian spaceship with a robot crash-landed on its side on the Moon! And, if they go wrong or get stuck, people cannot get there to fix them or rescue them. So they have to be built well and move very slowly and carefully to avoid dangers.

Big questions	Your answer	Points
A person in the Bible wrote: 'God – you're breathtaking! Body and soul, I am marvellously made!... You know exactly how I was made, bit by bit' (Psalm 139:14–15, MSG). What does being able to build a robot say about how you are similar to God?		10

Task sheet 2: Introduction to programming

Aim

To learn how to program your robot and to complete basic movements.

Equipment

- Your robot and USB cable
- Laptop

Experimental method

One of the leaders for the day will work through some basic exercises on the big screen for you to follow, helping you learn how to program the robot.

On the left-hand side of the screen, look for 'Start here'. Choose 'Try' and double-click on the box to open a new window.

Slides 1–5: **Connection to a computer, uploading and running a program** (5 points).

Slides 6–8: **Controlling a large motor** – your robot has two, connected to ports B and C. Choose one of the motors to work with, laying the robot on its side so the wheel is free to rotate (5 points).

(Skip Slides 9–11: We are not using the touch sensor.)

Slides 12–15: **Colour sensor** – your robot has a colour sensor connected to port 3. Again, choose one of the motors to work with, laying the robot on its side (5 points).

Big thinking

The robot is like how our body and mind work together. You have five sensors (the senses sight, touch, hearing, smell and taste). This robot only has one – colour.

And you have lots of things in your body that move when you see, hear or taste something – arms, legs, heads, tongue. The robot only has two motors to drive its wheels.

The program you uploaded into the robot is a bit like your brain – it connects the sensor to the motor, telling it when to turn on. Your senses connect to your brain, which then tell parts of your body to move!



Big questions	Your answer	Points
<p>How do your senses help you enjoy the world around you? Think about your favourite taste, smell or colour.</p> <p>Do you think the robot enjoys the world it senses?</p>		10

Task sheet 3: Control

Aim

To learn how to control your robot.

Equipment

- Your robot and USB cable
- Laptop
- Sheets with lines of different colour and maze sections.

Experimental method

Go back to the 'Lobby' tab. On the left-hand side of the screen, look for 'Start here' and choose 'Use'. Double-click on the box to open a new window.

There is a series of exercises to work through, which will help you learn to move and control your robot.

Read the instructions on Slide 1 and then work through:

- Slide 4: **Make it move** (5 points)
- Slide 5: **Make it turn** (5 points)

Using the programming skills you have learnt, work through the following tasks.

Some of the sample programs that are under the 'Tutorials (Robot Educator)' icon, under 'Basics (Driving Base)' may be helpful.

Task	Points
1 Rotate 90 left.	5
2 Rotate 90 right.	5
3 Try tasks 1 and 2 again, but use a different method – which is most accurate?	5
3 Turn in a circle.	5
4 Move forward until you detect a colour.	5
5 Move forward until you detect a colour, then turn in a full circle and say 'hello'.	5



Big thinking

The robot has to have a different set of instructions for every kind of different move it makes. And if the program has a mistake in it, it will keep on doing the wrong thing over and over again until the programming error is corrected.

As humans, we also make mistakes, over and over again sometimes! We have the ability to use our brains to learn and do things differently. Artificial Intelligence programs are based upon the way our nerves are connected in our brains. They have the ability to learn from their mistakes and behave differently when they face the same problem again.

Big questions	Your answers	Points
Jesus said, 'You are my friends when you do the things I command you' (John 15:14, MSG). Can a robot be your friend like a person can? How do you feel when the robot makes a mistake? Are you cross, annoyed? Who with? Do you need to say sorry to a robot?		20

Task sheet 4: Maze solver

Aim

To program the robot to move around a maze.

Equipment

- Your robot and USB cable
- Laptop
- Maze boards.

Experimental method

Task 1

Program the robot to move from a starting point (red square) in the maze to the target zone (green square) in the shortest time (20 points).

- Think about the path that the robot needs to take from the set starting point to the end point.
- What will you need to program your robot to do?
- What way will it turn if it comes to a wall?
- How far and how fast will you make it travel on each step? (Note: the maze is made up of blocks 15 cm by 15 cm.)
- You will need to use the 'loop' function to allow the robot to repeatedly move forward, sense where it is and decide what to do next – you can learn about this in the 'Tutorials – Beyond Basics' section.
- When placing the robot in the maze, put the colour sensor in the middle of the path – the wheels may overlap the walls slightly.

Hold **Robot Races** – whose robot can travel the path of the maze in the fastest time?

How quickly can your robot travel through the maze? Will it be the one that...

- ... moves fastest on straight sections?
- ... checks where it is most frequently?
- ... takes its time to turn most accurately?

Each team will have two chances to time their robot from start to finish.

The best time wins an extra 10 bonus points!

Task 2: Try another route

Once you have reached the ‘green’ end zone from the starting point, try your program out from another starting point in the maze.

Does it still reach the end zone?

How might you need to change the program to allow it to start from any point and reach different end points in the maze?

Task 3: Robot escape! (20 points)

There are dead-ends in the maze that the robot might get trapped in. Write a program to help the robot escape.

- Think about the speed that the robot will move at.
- How far will you move it before it tests where it is?
- What way will it turn when it hits a wall?

Big thinking

Robot explorers on Mars have to travel across a landscape that is littered with rocks and craters, as well as sand dunes. Controllers on Earth have to take a lot of time deciding what the best route is through this ‘maze’. And the robot only moves slowly – the Curiosity Rover on Mars would take an hour to move 100 m; a human being can run that far in under 10 seconds!

The current Mars Rovers don’t make many decisions about where they move for themselves – a bit like the first program you uploaded to trace a set path. Future Rovers will have more computing power and will use artificial intelligence programs to make more decisions for themselves and learn from the mistakes they make – more like the maze solver program.

Big questions	Your answer	Points
<p>The Bible says, ‘Be transformed by the renewing of your mind. Then you will be able to test and approve what God’s will is – his good, pleasing and perfect will’ (Romans 12:2, NIV).</p> <p>Can God reprogram a human like we program an AI to do the right thing? Or can we or an AI say no?</p>		<p>20</p>

Closing celebration

Equipment

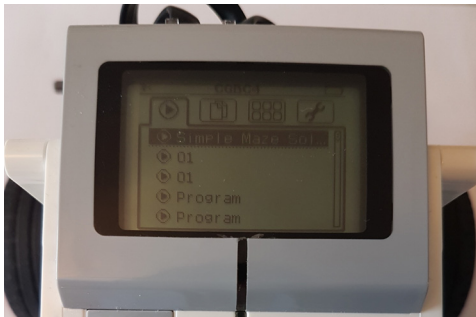
- Your robot and USB cable
- Laptop
- Pre-loaded general maze solver program
- Maze boards.

Experimental method

The previous tasks have demonstrated the types of instructions that would need to be built into a program that would allow the robot to solve any maze.

But the general maze solver program is more complicated – especially if you want it to learn and remember the best way through the maze like an artificial intelligence would do.

The program is pre-loaded on to your robot. Choose a starting point and place the robot in the maze. Choose the ‘Simple Maze Solver’ program by pressing the central button. The very polite robot will say, ‘Hello.’



You now need to tell it the order in which it should try to move.

The robot will ask which direction it should try first. Choose forward (F), right (R), left (L) or backwards (B). After each choice it will say, ‘Thank you.’

Repeat until you have chosen the order of all four directions.





Watch as it travels through the maze while it explores the best path.

Listen to these words of Psalm 25 while you watch.

*In you, Lord my God,
I put my trust...
No one who hopes in you
will ever be put to shame...
Show me your ways, Lord,
teach me your paths.
Guide me in your truth and teach me,
for you are God my Saviour,
and my hope is in you all day long.
Remember, Lord, your great mercy and love,
for they are from of old.
Do not remember the sins of my youth
and my rebellious ways;
according to your love remember me,
for you, Lord, are good.
Good and upright is the Lord;
therefore he instructs sinners in his ways.
He guides the humble in what is right
and teaches them his way.
All the ways of the Lord are loving and faithful...
He will instruct them in the ways they should choose.*

PSALM 25:1-12 (abridged)

When the robot reaches the green square, it will play a tune.

Return the robot back to its original starting point. Now watch the robot again, as it travels through the path of the maze that it has learnt.

As you watch, think about:

- Who has led you in good ways of life; who has been a good example for you?
- How has God shown his love and care for you?
- Take a moment to say thank you for these people and for God



Points summary

Use the table below to count up the points that you gain for each exercise.

TASK	POINTS	TOTAL
Task 1		
Task 2		
Task 3		
Task 4		
TOTAL		

