DrGraeme's Lego MindStorms NXT Course for Beginners. Notes for Mentors

Contents of these tutorials:

If you want to look at these "Robotics Tutorials for Absolute Beginners" during the week between sessions, they can be found on the supplied USB drive, and also on the Internet at the temporary location http://www.DrGrae.me . The tutorials are:

Building your first Robot.

The purpose of this tutorial is to build the simplest possible Robot.

To make sure that our students can start as soon as possible, in this tutorial we build just about the simplest possible LEGO Robot that can actually move. It has two motors, two wheels, and two skids attached to the computer brick. We use two skids at the back of the Robot instead of wheels, because they are quicker to build. If your son or daughter is impatient, you can tell them that the next Robot we will build will have more than two wheels! The videos in this tutorial will work on both a Windows PC and a Macintosh. However you should take time to download the free VLC media player to your Macintosh, as most of the later tutorials need this media player to play the later videos. You can download the VLC player from http://www.videolan.org/vlc/index.html .

Teaching your Robot to start moving.

The purpose of this tutorial is to make sure that we can type the programming command into the program editor, move that command down into your Robot, and make the Robot move.

In this tutorial we start up the LEGO NXT program editor, put in one movement instruction, and find out how to plug in the cable that connects your laptop to your Robot. We then find out what icon to click on inside the laptop editor to send our program instruction via the cable into our Robot. Next we learn which button on the Robot to press, to make our Robot move. The videos in this tutorial will play on both Windows PCs and Macintoshes.

Teaching your Robot to move, smile and speak.

The purpose of this tutorial is to make our Robot move a controlled distance, put a facial expression on the Robot, and make the Robot speak.

The scenario we have chosen is that an Alien Ambassador has come to Earth, we don't know whether the Alien is dangerous or not, so we will send our Robot to approach the Alien instead of a human, because if anything goes wrong it will be a Robot and not a person that will be zapped. The student will need to figure out how far to send a Robot so that it does not collide with the Alien Ambassador and start an intergalactic war! Before the Robot starts, it should have a nice friendly smile on its face. When the Robot reaches the Alien Ambassador, we want our Robot to say a polite "Hello ", and we hope that the Alien's Universal Translator is working. We've had trouble in the past finding Alien Universal Translators that work, so mostly we have just had to tell a Robot to look disappointed, say a polite "Goodbye", and come back to its starting point. Students usually take some time to get these instructions just right, and it is worth spending the time to get the

instructions close to perfect, as these skills will be quite useful later on. The videos in this tutorial will play on both Windows PCs and Macintoshes.

Building your second Robot.

The purpose of this tutorial is to build a more versatile Robot that has a swivelling rear wheel.

This is a more complicated Robot than the first one we built. It will take longer to build, but it will give your son or daughter more practice in 3-D visualisation and 3-D manipulation as he or she completes this Robot. We believe it is important that our students create and program many different Robots during this course, as Robotics is not just about building, not just about programming, but learning how to make the whole lot work together. Both your students and you will find that there is a lot of difference between the theory of computer programming, and what your Robots will actually do in practice - in other words the students will learn to deal with the real, imperfect world (not some advertised ideal world); a skill that is a lot of use in later life! The videos in this tutorial (and all later tutorials) will play on Windows PCs, but you will need to download the free VLC media player (or similar players) to play these and subsequent videos on Macintoshes.

Going around the Moon.

The purpose of this tutorial is to give the student practice in sending the Robot in a controlled straight-line distance, and sending it to do a gentle controlled curve.

The scenario in this case is that our Robot leaves the Earth, goes out to one side of side of the Moon, goes around the Moon, and comes back to land safely on Earth. The nice thing about this tutorial is that it is just about impossible to get right the first time, and therefore guarantees that students have quite a bit of practice in understanding how to use their “straight line” and “curve” commands before they complete the Challenge. If you look at the “student videos” section of this tutorial, you will see an incredible array of variations that other students have used to solve this challenge in the past. It is worth encouraging your son or daughter to look at these videos, and try to copy at least one (or more) of these variations before proceeding to the next tutorial; this will have the effect of reinforcing their understanding of the commands that control their Robot, and how their Robot behaves when they give that command. As has been commented before, the videos in this tutorial (and all later tutorials) will play on Windows PCs, but you will need to download the free VLC media player (or similar players) to play these and subsequent videos on Macintoshes. I will assume that you have done this, and will not repeat this warning in the discussions concerning any subsequent tutorial.

A Robot Floor Cleaner.

The purpose of this tutorial is to give the student more practice in sending their Robot through controlled straight-line distances, but with the variation that very tight curves are needed to solve this challenge.

In this scenario a “floor” is divided into squares, and to “clean” this floor the Robot must pass over each square. The squares can be passed in any order. Again it is interesting to consult the menu in this Challenge, and look at what other students have done in the past. They have used many different ways to build their Robots, and many different ways to solve this Challenge. It is interesting that at Grade 5 or 6 level there is often a different approach between boys and girls in this Challenge. Often boys will charge ahead and get it done quickly and roughly, but often girls think about it beforehand, and sketch out a more intelligent approach which only covers each square once. Hmmm…

A Child and a Lolly Jar.

The purpose of this tutorial is to show how to control a Robot by use of a sensor, in this case a sound Sensor.

This is the first time we have used a sensor, and we use a sound Sensor because it is probably the easiest of the sensors for students to understand. For this reason, we suggest that this challenge be attempted before your child attempts any other tutorial that involves sensors. The scenario is that it is just before teatime, and our young Robot is hungry. The cookie jar beckons. Our pet Robot knows that cookies just before tea are a bad thing because it won't want to eat as many healthy vegetables and fruit at tea time. But those cookies do look nice! So when everything is quiet the Robot will start creeping towards the cookie jar with a big grin on its face. Mum sees it. “Stop!” she shouts. Our Robot stops, screws up its eyes and cries. Then after things are quiet again, it looks both ways, puts another smile on its face and creeps towards the cookie jar again…

A Robot Tug-of-War.

The purpose of this tutorial is to encourage the student to rebuild and modify her or his Robot so it is better at the “Tug of War”.

This is the first tutorial that pits one Robot against another. It is useful in that it gives students free rein to change their Robots in any creative way they wish. In the past we've had some weird and wonderful variations – and the way the Robots quite often fall apart can teach your children quite a lot about how to build a strong Robot! This challenge is usually a fairly hilarious one, but we generally don't spend a lot of time on this tutorial, as some children don't like the competitive aspect. It does not matter how much the Robots fall apart, because in the next tutorial we will build another new Robot.

Building your Third Robot.

The purpose of this tutorial is to build a versatile Robot that can serve as a platform for the use of multiple sensors.

After our Robot has probably been wrecked in the Tug-of-War, we build this three wheeled Robot. This Robot can be used in quite a few of the following Challenges.

Adding a Light Sensor to your Third Robot.

The purpose of this tutorial is to show you how to add either one or two Light Sensors to the Robot we built in the previous Challenge.

We only need to add one Light Sensor for any of the next eight tutorials, and will only need two Light Sensors when we come to the tutorial “Your Robot Follows a Line”. Because of this, we suggest you only add one Light Sensor to your Robot at this stage, as this will save confusion before we get to the “Your Robot follows an Edge” tutorial.

Reminder - How to Calibrate your Light Sensor.

The purpose of this tutorial is to teach you how to calibrate the Light Sensor on your Robot.

LEGO Light Sensors are incredibly sensitive to variations in light that we would not necessarily notice ourselves. In practice, it is necessary to calibrate the Light Sensors of a LEGO Robot at least once in every Robotic session. A streak of sunlight across the floor can often cause our Robot to erratically misbehave. We have also found that the big windows in the room we are using will cause the light

on the floor to change as the sun seems to move through the heavens during the day. Your children will get a lot of practice in calibrating their Light Sensors…

Robot SUMO!

The purpose of this tutorial is to learn how to use the Light Sensor in a SUMO competition.

Our LEGO Light Sensor measures variations in reflected light from the floor. In this tutorial your child teaches his or her Robot to go at high speed across the floor, but when it comes to a ring around the floor that is a contrasting shade, the Robot to backs away, turns around, and charges forward again. This is a variation of a Japanese SUMO competition, where the purpose of the event is to push your opponent out of the arena. This challenge is generally a lot of fun, and your child is encouraged to change her or his Robot in whatever way they want, to make them even better SUMO Robots. Instead of a ring, we often use a rectangle, as this adds more unpredictability to the event. Even if Robots are destroyed in the process of this event, it does not take children all that long to rebuild the third Robot (and this also provides more much-needed build practice). We usually do not have a time limit to this event.

Bull in the Ring...

The purpose of this tutorial is to give your child further practice in the use of a Light Sensor.

This scenario is a gentler version of bullfighting. Instead of the bulls being killed, they are pushed out of the arena. It is similar to the SUMO competition, but instead of pushing one opponent out of the arena, there are multiple “bulls” (plastic cups) to push out of the arena. This is the first tutorial where we actually time how long the Robots take to complete the event. The Robot that pushes all of the bulls out in the shortest time is lauded as the top Robot.

If there is sensitivity among participants about competing against others, we may omit the Robot SUMO event, and instead use this tutorial, but without the timing element, so that there is no “winner”. Mostly however, this is not necessary, and participants can get quite excited, cheering their Robot on.

Adding an Ultrasonic Sensor to your Third Robot.

The purpose of this tutorial is to teach your child how to add an Ultrasonic Sensor to their third Robot.

The Ultrasonic Sensor uses ultrasonic sound waves (that are too high for the human ear to hear) to bounce off objects (e.g. walls), and measures the time that the echo takes to come back. The sensor uses this time to estimate the distance from the Robot to that object. We use the Ultrasonic Sensor in the next three tutorials.

SUMO using an Ultrasonic Sensor

The purpose of this tutorial is to use the Ultrasonic Sensor in a practical application.

The purpose of this SUMO event is the same as the previous SUMO event, to push the opponent out of the arena. The last time we played SUMO, the Robots did not know where their opponent was, and the Robots found each other largely by chance. Now that your Robot is equipped with an Ultrasonic Sensor, it can look for an opponent, and when it finds an opponent, it can charge.

The Ultrasonic Sensor can also be used as a useful check of theory against practice, of Physics against Engineering. Many students expect the Ultrasonic Sensor to send out a beam of sound that is as

straight as the beam from a laser, however the ultrasonic beam is more like an ellipse. If the Ultrasonic Sensor is too sensitive, it can detect the opponent early, and charge straight past it. The Ultrasonic Sensor will reflect differently for a hard surface (like a wall) and a soft surface (a soft cuddly toy will absorb much of the sound and only reflect a little). The shape is also important, a flat surface (like a wall) will reflect more than a curved surface (a bottle reflects much of the sound sideways, and echoes only a little back to the sensor). Lots of room for experimentation by your child here.

Bull in the Ring using an Ultrasonic Sensor.

The purpose of this tutorial is to gain more practice in the use of the Ultrasonic Sensor.

This is similar to the previous "Bull in the Ring" tutorial, except that the Ultrasonic Sensor can be used to find the "Bulls".

Minesweeper.

The purpose of this tutorial is to give further practice in the use of the combination of the Light Sensor and Ultrasonic Sensor.

This scenario is that your Robot is a ship, and it has to travel from a home port to a distant port through a sea that is sown with mines. The Robot has to avoid the mines and get safely to the destination port, without damage. In this tutorial your child is encouraged to make changes to his or her Robot, so that their Robot is less likely to suffer damage and more likely to detect the mines.

Your Robot Follows an Edge.

The purpose of this tutorial is to follow the edge of a line using one Light Sensor.

Following a line is a classic problem in Robotics. In this tutorial we learn to follow the edge of a line using one Light Sensor. It is important that there was a clear distinction in shade between the background colour and the line itself. This skill has a potential use in competitions such as the Robocup Junior. There is information on line following using two light Sensors at http://www.drgraeme.net/DrGraeme-free-NXT-G-tutorials/ChV4.htm Challenge 102.

The web site http://www.DrGraeme.org/EV3/C5/C5.html contains videos that show how to set up tape mazes suitable for use by line-following Lego NXT or EV3 Robots; to see them click on tutorials C5.1 and C5.2. There are also downloadable line templates available at tutorial C5.3; these can be used to set up a maze or circuit suitable for line-following by either a Lego NXT or EV3 Robot; these templates can be printed on an A3 printer.

Adding a Touch Sensor to your Third Robot.

The purpose of this tutorial is to add a Touch Sensor to our third Robot, and to use this to respond to an object.

Using a Touch Sensor is an excellent way to assist our Robot to travel around a walled arena or maze. In this tutorial your child will learn how to use the Touch Sensor to stop your robot when it reaches an obstacle. The Robot can then be programmed to back away from the obstacle, turn around, and go forwards in a new path where it will not be impeded by the obstacle that has just blocked its path.

Your Robot follows a Wall.

The purpose of this tutorial is to show one method of programming a Robot to solve mazes.

Many (but not all) mazes can be solved by using the “left-hand” or “right-hand” rule. To use this rule, a Robot (or person) keeps their left (or right) hand on the maze wall, and walks forwards – eventually coming to the maze exit. This is the method used in this tutorial. The wall-following Robot in this tutorial uses only one sensor – an Ultrasonic Sensor set at 45 degrees to the direction of the Robot travel.

The web site http://www.DrGraeme.org/EV3/C5/C5.html contains a video that show how to set up walled mazes and arenas; to see it click on tutorial C5.4 . The DrGraeme maze system we developed prevents “maze boredom” by allowing many different mazes to be constructed from a stock of individual stackable (and thus easily stored) maze elements. An example of the method of construction of a sample maze component is shown in this video. This video also includes a sample maze run of a Lego NXT Robot that uses two sensors.

Have fun! ☺

