Module 2.2 - Control

Introduction

Computers can take advantage of powerful processors to model real life machines and situations and programming languages to issue instructions to computer controlled devices.

A control system is the part of the machine that stores instructions used to control the physical actions of the machine. In this module you will create your own control system. Then you will alter your system and try to make it more efficient. You will also see the consequences when the control system does not work correctly.

To create some examples of control systems you are going to use three separate programs:

- Under Control – In this program you will create a control system to control a set of traffic lights at a crossroads. You must program the lights to avoid collisions.

- RoboChallenge – In this program you will create a control system to manipulate a space craft's robot arm in order to retrieve a satellite.

- MiniLogo – In this program you will learn to issue commands in order to draw lines and shapes on the screen, much in the way of an etch-a-sketch.

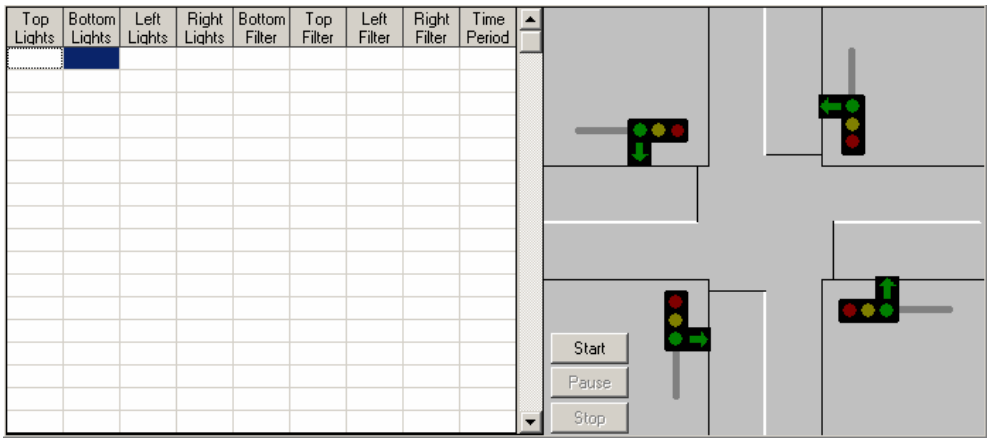
In addition, there is a more complex program that some pupils may choose to investigate:

- Roadworks – In this program you will create a control system to control a set of traffic lights controlling single lane traffic. This model will use sensors to detect when cars are waiting at the traffic lights.

Under Control

Under Control allows you to control a set 4-way junction traffic lights. Using the control table you control the status of all 4 lights and a filter to allow right hand turns. A delay for each light must be set until it is running perfectly with no accidents or long delays.

As in real life the cars will obey the lights. It is your job to create a control sequence that efficiently allows the cars to progress without crashing. In the event of a collision the program will stop and you can fix whatever caused the accident.



In the control table there are nine columns. The first four columns represent the colour of each traffic light facing in each direction. Their values can be:

R - red only
A - amber only
G - green only
S - red and amber together

The next four columns refer to the filters for each direction. Their values can be set to:

0 - off
1 - on

The last column is how long the line is shown. The unit is seconds.

To write a sequence table, click on the cells and type in the appropriate value. Delete will clear any cell or group of cells.

In the View menu, the Single Cars option allows you to have one car from each direction at any time. The Many Cars option shows two lanes on the approaches to the junction.

Cars will queue up and go with each phase of the lights, the number of cars waiting in each direction is shown. This allows fine-tuning of your sequence - alter the times so cars do not wait too long.

When you have created a sequence, click on Start to run it. The cars can go left and straight on but can only turn right when the filter is on.

Task 1

- Copy and complete the following table. It may be necessary to add more rows.

Top Lights	Bottom Lights	Left Lights	Right Lights	Bottom Filter	Top Filter	Left Filter	Right Filter	Time Period

- Construct and write a rotational sequence where traffic is allowed to go from the north only then the east only, then south, then west. Cars should have the option to turn right, left or to go straight ahead.

Task 2

- Copy and complete the following table. It may be necessary to add more rows.

Top Lights	Bottom Lights	Left Lights	Right Lights	Bottom Filter	Top Filter	Left Filter	Right Filter	Time Period

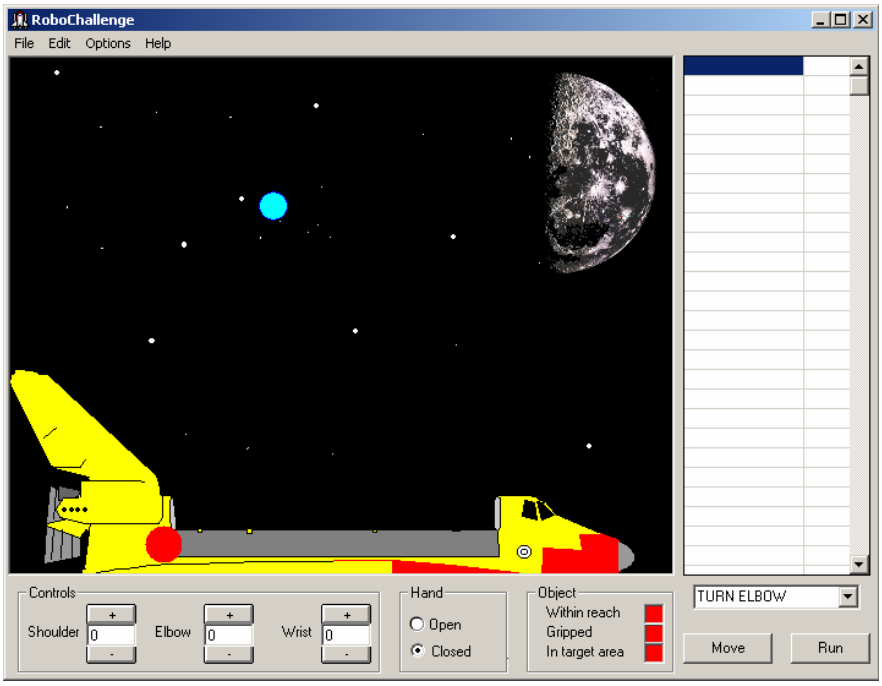
- Construct and write a sequence allowing traffic to flow north/south, then east/west including filters so that traffic coming from each direction has the chance to turn right. Try to keep the queues of cars down by altering the time for each phase of the traffic lights.

Robo Challenge

The idea of Robo Challenge is to use the robot arm to grab the satellite (a blue circle) and carry it to the loading bay area of the ship without hitting any obstacles. The robot can be manipulated directly, it can also be programmed.

Each time you run the program the blue satellite is randomly positioned on the background but it is always within reach of the arm.

Choose Robo Challenge from the Start Menu. The program will start and you will be looking at the following screen:

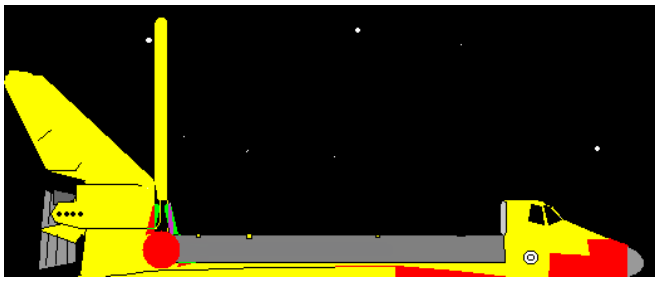


The robot arm's starting position is docked within the space shuttle. To see the arm you need to raise it out of the shuttle in such a way that it does not rupture the bottom of the craft.

To raise the arm out of the shuttle move the shoulder through at least 90 degrees by using the Shoulder control, type 90 into the text box marked shoulder:

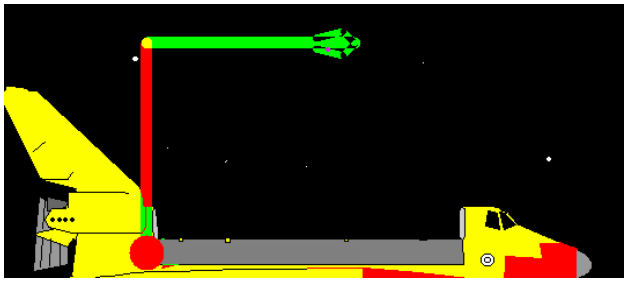
Then click on the Move button:

The upper arm will now move into an upright position:



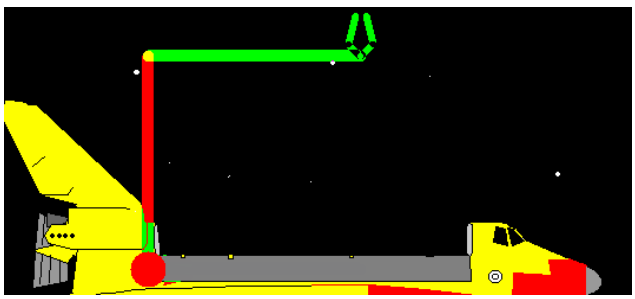
To extend the forearm, give an angle such as 90 to the Elbow text box:

Then click on Move, the forearm will now move to a 90 degree angle with the upper arm:



The plus and minus buttons can be used to move one degree at a time. The wrist can be rotated towards the blue satellite. Put the angle 270 into the Wrist text box:

Then press Move. The wrist will now be at 270 degrees to the forearm:



Open the Hand by clicking on the Open option:

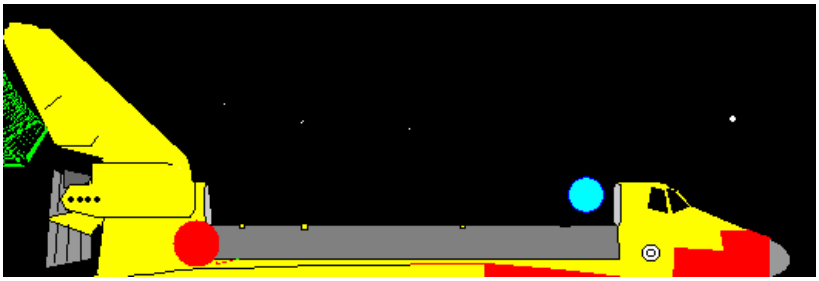
Now click Move again and the hand will open.

These are the basic movements. It is for you to experiment with how you can manipulate the controls to get the fingers of the hand directly around the satellite. When you have successfully positioned the hand to within grasping distance of the satellite you will see the 'Within reach' indicator turn to green:

The hand can now be closed to grip the satellite. At this point the target area, marked with a dotted line, will flash on and off and the Gripped indicator will turn green:

You can select 'Show target area' from the options menu to permanently mark this area. This is where the satellite should be carried to. Manipulate the arm until the satellite is in this area. At this point you will see the 'In target area' indicator turn to green.

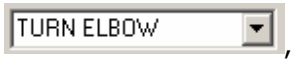
You can now release the satellite and carefully stow the arm.



Task 3

Use the Shoulder, Elbow and Wrist text boxes along with the plus and minus buttons to manually move the robot arm to safely retrieve and dock the satellite.

Task 4

Plan and create a control sequence using the drop down menu, 

, and entering numbers of degrees to move the robot arm and retrieve the satellite.

Record the control sequence in a table in your jotter like the one below.

Turn Elbow	60
Close Hand	
Turn Shoulder	90
Turn Wrist	270

Mini Logo

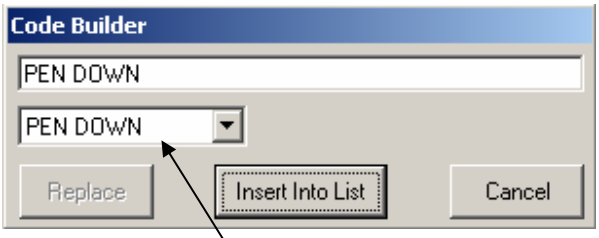
MiniLogo is a program that allows you to control a cursor on screen that, by issuing commands to move and turn, can draw lines and shapes on the screen.

This program gives a basic introduction to the concepts of programming and control.

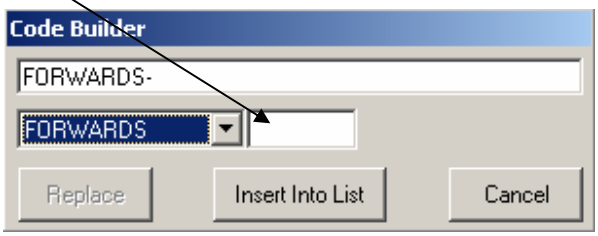
When you first open MiniLogo, you will see a blank code list.

Click on the Code Builder button, 

, and the following dialog box will appear.



Choose a command from the pop up menu and, where appropriate insert a value for the distance or number of degrees to turn.



Click on Insert Into List and continue until you have entered a list of instructions then press the Run Code button, 

, to see the effects of the instructions.

Task 5 – Drawing Simple Shapes

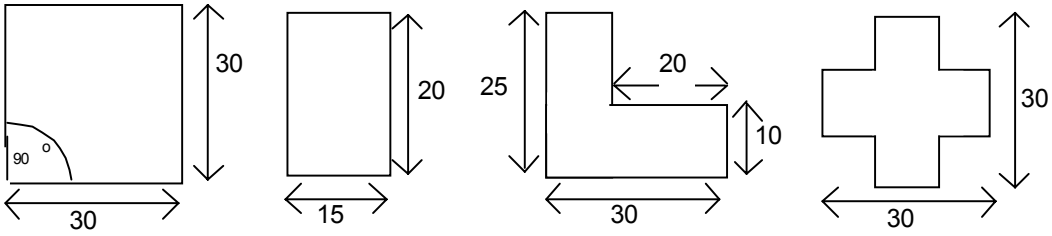
In this task you will learn how to draw simple shapes using commands for forward, back, left and right. The following commands may be used.

Command	What It Does
PEN DOWN	Puts pen on paper, ready for drawing
PEN UP	Removes pen for paper
FORWARDS *Distance*	Moves you forward by a number of units
BACKWARDS *Distance*	Moves you backward by a number of units
LEFT *angle*	Left turn by a certain number of degrees
RIGHT *Angle*	Right turn by a certain number of degrees
CLEAR SCREEN	Prepares screen for a new task

- Enter the following instructions.

```
PEN DOWN
FORWARD 60
RIGHT 120
FORWARD 60
RIGHT 120
FORWARD 60
```

- Run these instructions and note the shape drawn.
- Now write your own instructions to produce the following shapes.



- In your jotter record the instructions used to produce these shapes.

Task 6 – Changing Colours

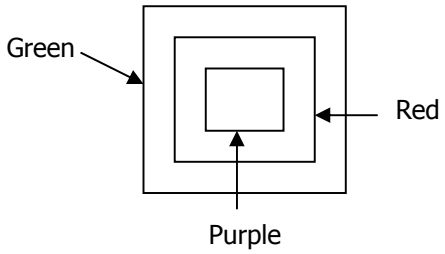
In this task you will learn to change the colour of the lines that you are drawing.

Choose to insert an instruction and choose to Set Colour, 

.

The options for colours appear in the drop down menu on the left.

- Write a program to produce the following diagram. Use the PEN UP and PEN DOWN commands to move without drawing a line.



- In your jotter record the instructions used to produce these shapes.

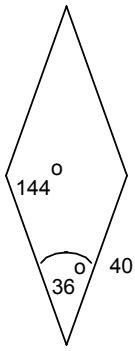
Task 7 – Repeating Instructions

In this task you will learn how to repeat a set of instructions several times.

Think about drawing an equilateral triangle, you have to turn 120° and draw a line three times. You could replace these instructions,

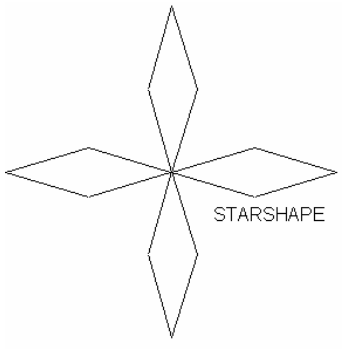
RIGHT 120 FORWARD 50 RIGHT 120 FORWARD 50 RIGHT 120 FORWARD 50	with this alternative set of instructions	REPEAT 3 RIGHT 120 FORWARD 50 END REPEAT

- Create a set of instructions to produce the following shape.

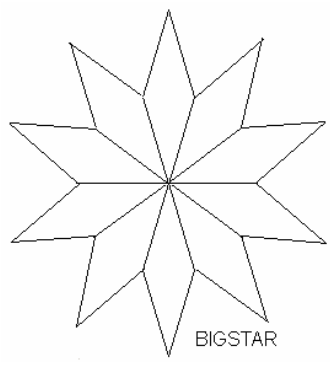


- Insert REPEAT commands to produce the starshape below. If you can produce the starshape try to amend your program to produce the Bigstar shape on the left.

Basic Task



Extension Task



- In your jotter record the instructions used to produce these shapes.

- Experiment with the Repeat commands, the colour tools and all other commands to produce an interesting design. Can you write your name using Logo? Can you draw a flower?

Extension Tasks

Roadworks

Roadworks is an alternative traffic light control system. There is only one lane of traffic and lights have been put up at either end. Using the control table you need to allow traffic to pass through the lights without accidents.

Roadworks is different to Under Control because it accesses the rows of the control table depending upon different conditions. That is, the program will miss out records as it is going down the table if they are not relevant.

Conditions are made using the current colours of the traffic lights and the state of the heat sensor at the top of each traffic light that indicates whether there is a queue or not.

On the main screen of Roadworks you have a grid containing 7 columns and 99 rows. You don't need to use the 99 rows, but you must use all 7 columns.

From left to right the columns are:
Left light state: This is the left lights state (R for red, G for green etc).
Right light state: This is the right lights state.
Left sensor state: This is the state of the heat sensor on the left-hand light.
Right sensor state: This is the heat sensor on the right-hand light.
New Left light state: What the left light will change to when there is a match (see below).
New Right light state: What the right light will change when there is a match (see below).
Delay: The wait until the program looks for another match.

You can assign the following states:

In the Light columns (1, 2, 5, 6):
G = Green
A = Amber
R = Red
S = Stop (amber and red)

And in the sensor columns (3, 4):
N = No
Y = Yes
A = Any
In the Delay column (7): the delay can be anything between 0 and 50 (in seconds)

Each row of the table you have defined is examined in turn. If the light states and heat sensors values match the current row of your table then the lights will change to whatever you have specified in that row. For example if you had:

Left light state	Right light state	Left sensor state	Right sensor state	New left light state	New right light state	Delay
G	R	N	Y	R	G	8

In this example: when the lights are green on the left and red on the right and there is a car on the right, but not at the left. Then this line will trigger, causing the colour of the lights to change to Red on the left, and green on the right. After an 8 second delay it will continue down the list looking for a line that matches the new criteria.

When you have completed the control table start the simulation by clicking on the Start button. Initially the lights and delay will be set to what you have specified in the first row.

Cars will come at different intervals - depending on what is selected on the Options/Traffic dialog. Cars pass at different speeds, but they will always obey follow what the light indicates. i.e. they will not wait if the light shows green and a car is already coming down the road. On the event of a crash the simulation will stop running.

You can select a speed for the display via the ratio buttons on the right, and control tables can be saved and loaded via the file menu.

The options menu allows you to select an initial queue of cars (2, 24 or 60) and alter the rate in which cars arrive (Few, Moderate, Rush hour)

You can select a speed for the display by checking Normal or Fast to the right of the grid

Extension Task 1

- Copy and complete the following table. It may be necessary to add more rows.

Left light state	Right light state	Left sensor state	Right sensor state	New left light state	New right light state	Delay

- Construct and write a control sequence from scratch that will allow cars to pass through the roadwork's with no collisions and without long delays.

- Test your control sequence with a 60 car queue and rush hour traffic. It needs to keep it under control so cars are coming from both sides without the queues going over 40.

In your jotter describe the effects of the following lines of instructions.

(a)

Left light state	Right light state	Left sensor state	Right sensor state	New left light state	New right light state	Delay
R	G	Y	N	G	R	5

(b)

R	R	Y	N	A	R	5

(c)

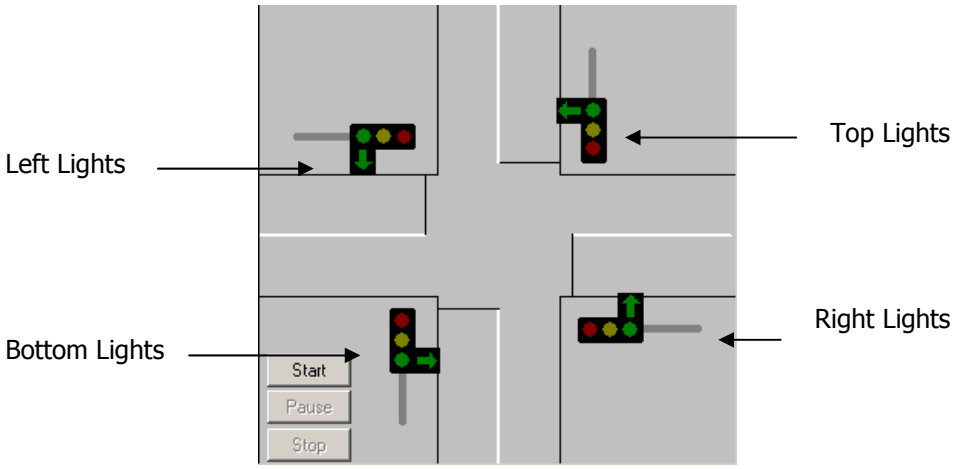
G	R	N	Y	A	S	5

(d)

A	S	N	Y	R	G	1

Homework Exercise 1 – Under Control

The following instructions screenshot is from the Under Control program.



1. Describe the effect of the following instructions?

(a) (1)

Top Lights	Bottom Lights	Left Lights	Right Lights	Bottom Filter	Top Filter	Left Filter	Right Filter	Time Period
G	R	R	R	0	1	0	0	10

(b) (1)

G	G	R	R	0	0	0	0	10

(c) (1)

S	R	A	G	0	0	0	0	10

(d) (1)

A	R	G	S	0	0	1	0	10
R	R	A	G	0	0	0	1	10

2. Which of the following control sequences could lead to a collision?

(a) (1)

Top Lights	Bottom Lights	Left Lights	Right Lights	Bottom Filter	Top Filter	Left Filter	Right Filter	Time Period
G	G	R	R	1	1	0	0	10

(b) (2)

A	S	G	R	0	1	0	0	10
R	G	A	R	1	0	0	0	10

3. How could filters improve the following system? (1)

Top Lights	Bottom Lights	Left Lights	Right Lights	Bottom Filter	Top Filter	Left Filter	Right Filter	Time Period
G	G	R	R	0	0	0	0	10
R	R	G	G	0	0	0	0	10

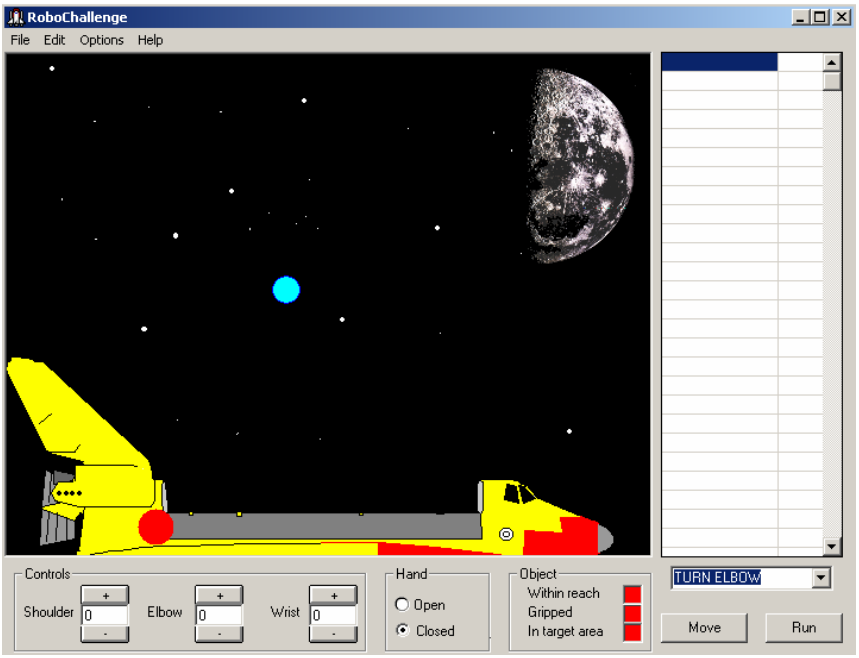
4. Why is it necessary to include Amber lights and Amber/Red lights? (2)

Total (10)

A+	10,9	A-	8,7	B+		B-	6	C+		C-	5	N	

Homework Exercise 2 – Robotics

1. The following is a screenshot from the RoboChallenge program.



(a) What is the purpose of the Within Reach indicator? (1)

(b) What must you do with the satellite once it is in the grip of the robot arm? (1)

(c) What problems can be encountered when moving the various parts of the robot arm? (1)

(d) Suggest another use for a robot arm. (1)

(e) Why would a real robot arm need to be more flexible than this model? (1)

(f) Why is it impossible to write a single control sequence to retrieve the satellite? (1)

(g) Why is space a suitable environment for using a robot arm? (1)

(h) How could the space shuttle robot arm be adapted by replacing the gripper with a different tool? (1)

(i) Suggest different tools that could be attached. (1)

(j) Why are robot arms used in many modern factories? (1)

Total (10)

A+	10,9	A-	8,7	B+		B-	6	C+		C-	5	N	

Homework Exercise 3 – Logo & Control Systems

In this module you have learned about computer based, control systems. These systems are any devices, with or without a sensor, that are programmed to perform a specific task.

For example, a kettle can be thought to be a control system. You switch on a kettle and the element heats water. This continues until a sensor detects that the water temperature has reached 100°.

1. Why is it useful to use electronic or computer based control systems? (1)

2. What is an advantage of having a sensor to detect waiting cars at traffic lights? (1)

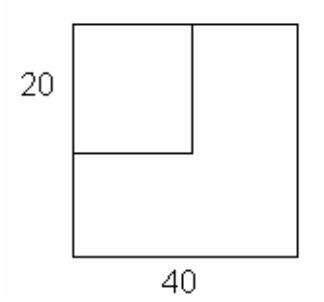
3. Describe an example of a control system found in your house that uses a sensor. (1)

4. Why is it useful to be able to change the instructions in a control system? (1)

5. Which type of sensor is used in a central heating system? (1)

6. Describe a system that does not use a sensor but that could be improved by using a sensor. (1)

7. Write Logo instructions to produce the following shape. (4)



Total (10)

A+	10,9	A-	8,7	B+		B-	6	C+		C-	5	N	