ROBOTICS LAB 1

for

AER525 – ROBOTICS

INTRODUCTION

Institute for Aerospace Studies
University of Toronto

Safety

Safety precautions in the robotic work environment serve to protect the human operators as well as the robotic equipment.

Although smaller and slower than an industrial robot, the SCORBOT robot is potentially dangerous. ***You must use caution when working with the system to avoid personal injury and damage to equipment.***

All necessary hardware installation and wiring connections are to be performed by the laboratory instructor or system manager.

Students should not tamper with wiring or connectors or any of the devices in the cell!

Be sure to heed the following safety guidelines:

- Make sure loose hair and clothing is tied back when you work with the robot.
- Make sure the robot arm has ample space in which to operate freely.
- Do not enter the robot's safety range or touch the robot when the system is in operation.
- Do not put your fingers into the gripper or any other moving part.
- Do not overload the robot arm. The combined weight of the workload and gripper may not exceed 2 kg (4.4 lb).
- Do not leave a loaded arm extended for more than a few minutes.
- Do not use physical force to move or stop any part of the robot arm.
- Do not drive the robot arm into any object or physical obstacle.
- Never leave a system unattended while it is in operation.

TO STOP THE ROBOT IN AN EMERGENCY:

Press the red emergency button on the power box

Or

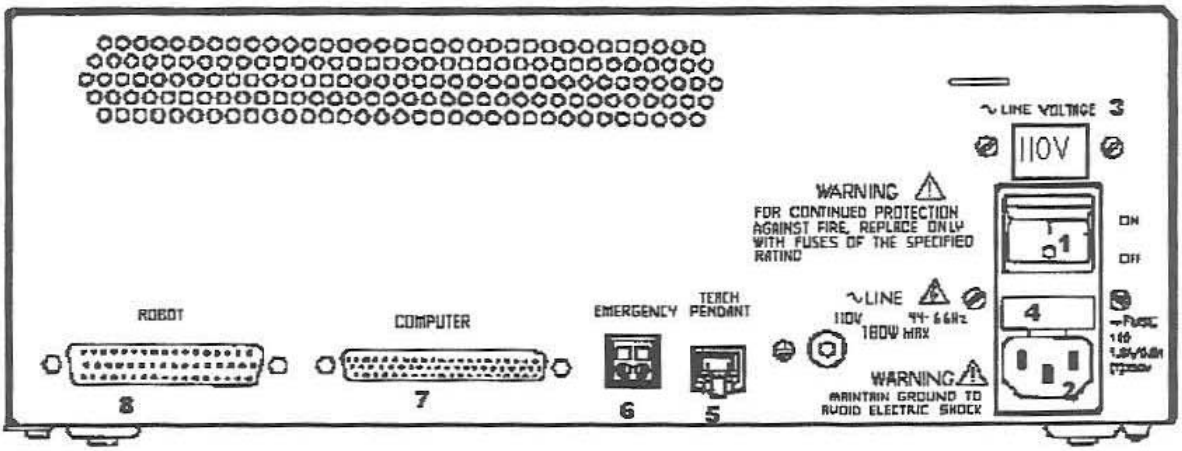
When using the teach pendant in teach mode, press the red emergency button on the teach pendant.

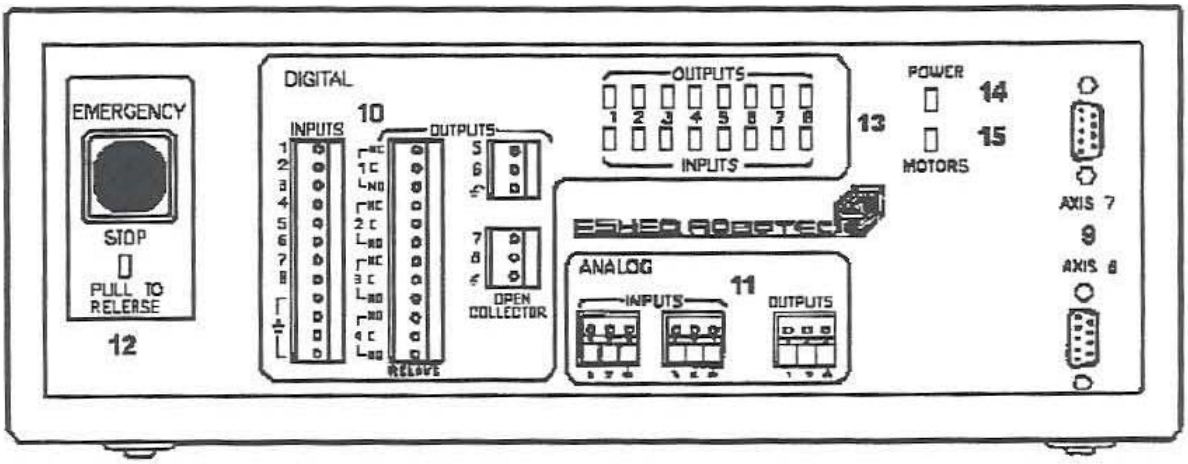
OPERATOR SAFETY

- Make sure that the robot is bolted to the work surface by at least three bolts.
- Do not go near the robot while it is in operation.
- Do not stick your fingers, or any other appendages, into the arm mechanism while the robot is in operation, as they may get caught between gears or belts.
- Turn off both the power box and the PC before either doing any work within the workspace of a connected robot or before connecting any inputs or outputs.
- Do not open the fuse covers while the controller is plugged into the 110 VAC receptacle.

EQUIPMENT SAFETY

- Make sure that all objects and machines that are not related to the robot's work are kept out of its work envelope.
- Do not exert any force on the arm for the purpose of changing joint positions, or for any other reason.
- Do not leave the system while it is in operation. Maintain direct supervision of the robot at all times.
- Do not turn on the controller if the PC is not on. Do not turn off the PC if the controller is still on.





NOTE: Diagram may differ slightly from actual box

KEY PARTS OF THE SCORPOWER BOX

Back Panel		**Front Panel**	
1*	Power On/Off switch	9	Axes 7 and 8 Driver D9 connectors
2*	Power Line 110 VAC socket	10	Digital I/O screw terminals
3	Line Voltage Indicator	11	Analog I/O screw terminals
4	AC Power Fuse Drawer	12*	Emergency button and LED indicator
5	TEACH PENDANT 6-pin telephone jack	13	Input/Output LED indicators
6	Remote EMERGENCY switch 2-pin WAGO connector	14*	Power LED indicator
7	Computer 62-pin D-type high density connector	15*	Motors LED indicator
8	Robot D50 connector		

* indicates parts which you may need to check during the lab

Experiment 1:

Homing and Moving the Robot

OBJECTIVES

In this activity you will accomplish the following:

- Activate and use SCORBASE robotic control software.
- Home the robot.
- Move the robot joints.
- Operate the gripper.
- Set and use different speeds of motion.

MATERIALS

In this activity you will need the following materials:

- SCORBOT-ER4u Robot and Controller.
- Computer with SCORBASE software.
- 2 different blocks (any shape).
- Worksheets for Experiment 1.

OVERVIEW

HOMING

The location of the robot axes is monitored by encoders which track the amount of movement relative to an initial position. To obtain repeatable robot performance, this initial position—home—must be identical each time the robot is used. Thus, whenever the system is activated, the homing program, which is internally programmed into the controller, must be executed.

During the homing procedure, the robot joints move and search for their home positions, one at a time, in the following sequence: shoulder (axis 2), elbow (axis 3), roll (axis 5), pitch (axis 4), base (axis 1).

To find its home position, the axis rotates until its encoder produces an index pulse. Then axis continues to move until the switch which is

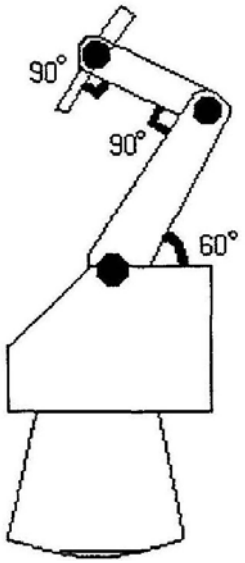


Figure 1-1

mounted on the joint sends a signal to the controller, indicating that the axis is homed.

After all axes are homed, the robot assumes the position shown in Figure 1-1. Whenever the robot receives a Search Home or Go Home command, it will move and stop at this position.

EMERGENCY STOPS

Program execution and robot motion may be stopped for any of the following three reasons:

- *Emergency stop initiated by operator*. Pressing the controller's red EMERGENCY pushbutton immediately halts any running program and robot motion.

  The Homing routine can only be stopped by means of the EMERGENCY button.

- *Regular stop initiated by operator*. Pressing the SCORBASE Stop icon halts a running program as soon as the command currently in progress is completed (such as a robot movement).

- *Stop initiated by software*: If the SCORBASE software identifies mechanical failure in any motor, it will stop the routine and display an error message which indicates the problem.

SCORBOT SELF-PROTECTION

Robots may hit obstacles in their environment or even parts of their own structure. Robots which are incapable of identifying and responding to impact conditions may suffer damage to motors, gears or transmissions, or to components in controller. The SCORBOT robot, however, can identify obstacles and stop its motors without loss of exact positioning. Thus, once the obstacle is removed, work can be resumed immediately.

MANIPULATING THE ROBOT

The robot does not know where to go, how to get there, or what to do when it reaches its target. You must guide it and teach it. SCORBASE provides commands which allow you to manipulate (move) the robot.

GRIPPER

Operation of the gripper on the SCORBOT robot differs from operation of the other robot axes. Whereas the operator can give a command for a specific amount of axis motion, the operator can instruct the gripper only to open or to close. The gripper opens completely or closes completely. If, however, the gripper is picking up an object, it will stop its closing motion when it grasps the object.

SPEED AND RESOLUTION

The slower you go when driving a car or riding a bicycle, the more easily you can stop exactly where you want. The same is true in robotics. The slower a robot moves, the more precisely it can stop; this ability to stop precisely at a position is called *resolution*.

PROCEDURES

Task 1-1: Inventory and Safety Checks

1. Check whether all materials required for this activity are available at your lab station.
2. Check whether your lab station conforms to the Safety Guidelines for the robotic workcell.
3. Complete the Inventory and Safety Check List on the Worksheet for this activity.

Task 1-2: Activating the System

1. Turn on the computer. (Always turn on first.)
2. Turn on the controller. (Do not turn on if the computer is off.)
3. From the SCORBASE program group, select SCORBASE.
4. Create a new project: File | New Project.
5. Switch to Level 2 "Advanced" mode: Option | Level 2.

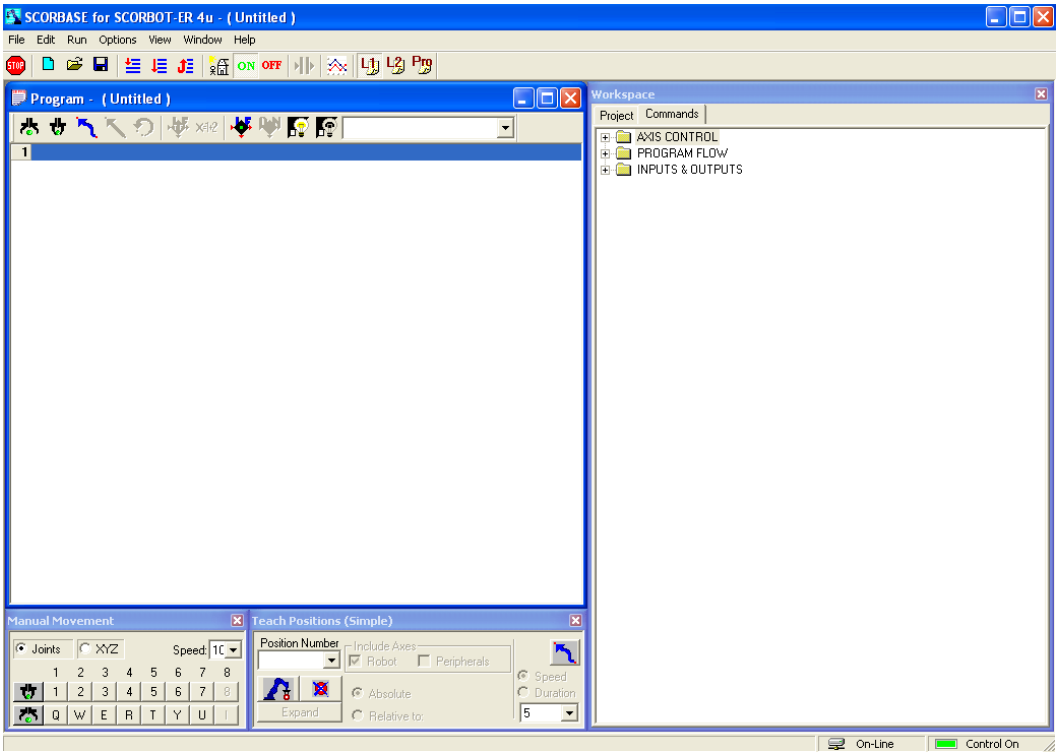


Figure 1-2

Task 1-3: Homing the Robot

1. To start the homing routine, do either of the following:
   - Click the Search Home (All Axes) button: 

- Select Run | Search Home - All Axes.

In addition to the robot axes, the system includes a conveyor belt, which is configured and controlled as axis 8. This conveyor does not have a home position, and will not move during the homing routine, although it is checked.

If your system includes a slidebase (on which the robot is mounted), it is configured and controlled as axis 7. This slidebase has a home position, and will be moved during the homing routine.

Q 1-1 *Describe the homing routine. Note the order in which the axes moved, fast or slow motion, dialog boxes and messages on the screen.*

Task 1-4: Moving the Robot

1 Select the Manual Movement dialog box.

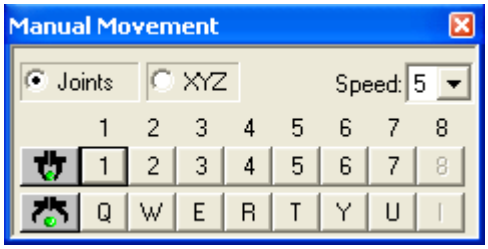


Figure 1-3

The Manual Movement dialog box allows you to assume direct control of the robot and peripheral axes. By clicking with the mouse on the screen, or pressing keys on the keyboard, you move the axes.

The following chart explains how clicking the buttons (or pressing the keys on the keyboard) moves the robot's joints.

Keys	Joint Motion
1 / Q	Rotates the BODY to the right and left
2 / W	Moves the SHOULDER up and down
3 / E	Moves the ELBOW up and down
4 / R	Moves the wrist (PITCH) up and down
5 / T	Rotates the wrist (ROLL) to the right and left

Movement of an axis will continue as long as the button or key is pressed, or until a software or hardware limit is reached.

2 Try manipulating the robot. Click and quickly release, or click and hold down the buttons/keys.

- Press W to move the robot shoulder down.
- Press E to move the robot elbow down.
- Press Q to move the robot base left.

- Press 1 to move the robot base right.
- Using the 10 buttons or keys listed above, practice moving the robot joints.

Do not use the following keys. You will learn more about them later.

6 / Y	Opens and closes the gripper incrementally
7 / U	Moves peripheral axis (if connected)
8 / I	Moves peripheral axis (if connected)

3 Open the Robot Movement dialog box: View | Robot Movement.

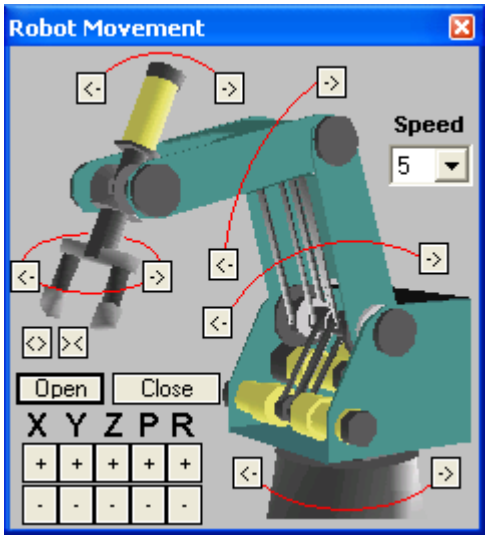


Figure 1-4

4 Clicking the arrows in this image of a robot will move the corresponding robot joints.

Try manipulating the robot. Click and quickly release, or click and hold down the arrow buttons.

Close the Robot Movement dialog box.

Task 1-5: Robot Working Limits

1 Send the robot to its home position: Run | Go Home-All Axes.

Do NOT select Run | Search Home – doing so will execute the homing routine.

2 Select the Manual Movement dialog box. (If it has disappeared from the screen, select the menu item View | Manual Movement.)

- Press W to move the robot shoulder down.
- Press E to move the robot elbow down.

3 Rotate the robot base until it encounters a mechanical stop.

A message box will appear:

Figure 1-5

Click OK and rotate the robot base in the other direction until it encounters another mechanical stop.

You have just seen the working limits of the robot base.

4 Repeat Step 3 for one or two other robot joints.

5 Send the robot to its home position.

6 Move the robot arm down toward the table. Continue moving the arm until an error message appears:

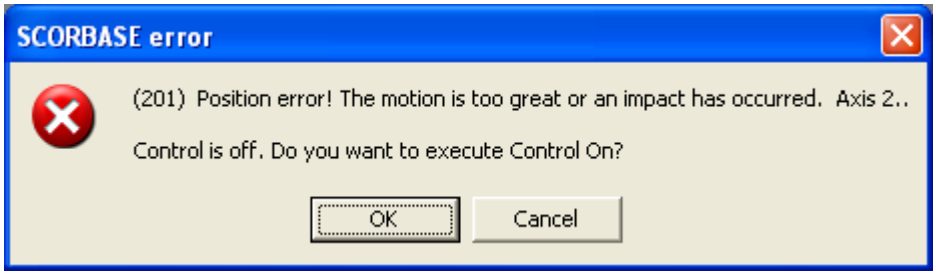


Figure 1-6

Q 1-2 *Describe the system response to the encounter between the robot arm and the table.*

7 Choose OK to the Control On prompt.

8 Send the robot to its home position.

Task 1-6: Operating the Gripper

1 From the Robot Movement dialog box, do the following:

- Click on Open. The gripper will open. (If the gripper is already open, it will not move).
- Click on Close to close the gripper.
- Click on the gripper arrows to open and close the gripper. The gripper will open and close in incremental movements.

From the Manual Movement dialog box, do the following:

- Click the Open Gripper button to open the gripper. The gripper will open. (If the gripper is already open, it will not move).
- Click the Close Gripper button to close the gripper.

2 Open the gripper.

Take and **carefully** hold a round or square block between the gripper fingers as shown in Figure 1-7. Close the gripper on the block.

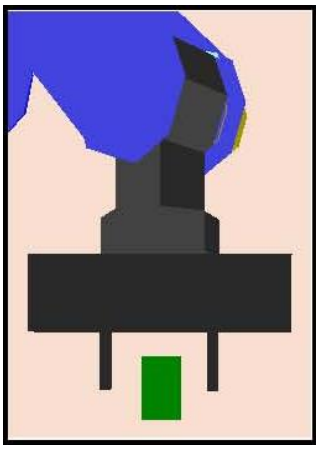


Figure 1-7

3 Gently extract the block from the gripper. Again click on Close Gripper.

4 Take another block and repeat steps 1 to 3.

Q 1-3 *What effect does the Close Gripper command have on the gripper?*

Q 1-4 *What kind of objects can the SCORBOT gripper grasp?*

Task 1-7: Changing Speed Settings

1 Look at the Speed box in the Manual Movement dialog box. By default, the speed setting is 5. Speed 10 is the fastest setting. Speed 1 is the slowest speed.

- Select 10. Now with the speed set at the fastest rate, try moving the robot joints.
- Select 1. Now with the speed set at the slowest rate, try moving the robot joints.

2 Send the robot to its home position. Place one of the blocks on the work table.

- In the Speed box, select 10. Now with the speed set at the fastest rate, bring the gripper as close as possible to the block.
- Send the robot to its home position. Select 3. Now with the speed set at a slow rate, again bring the gripper as close as possible to the block.

Q 1-5 *What did you observe? Was it easier to manipulate the robot at a slower or faster speed?*

Task 1-8: Team Discussion and Review

Q 1-6 *What is the robot home position and why is it needed?*

Q 1-7 *What conditions or actions which will cause the robot controller to detect a malfunction or error?*

Q 1-8 *How does each robot joint affect the gripper location and orientation?*

Task 1-9: Inventory Check and Shut Down

1 Check whether all materials required for this activity have been returned to their proper place at your lab station. *Make sure there is no block in the robot gripper.*

2 Select Run | Go Home – All Axes.

The robot should always be brought to its home position before the system is shut down.

3 Exit SCORBASE.

4 Turn off the controller, and then turn off the computer.

Experiment 2:

Recordering Robot Positions

OBJECTIVES

In this activity you will accomplish the following:

- Record absolute positions.
- List and delete positions.
- Save and load positions.
- Move the robot to recorded positions.

MATERIALS

In this activity you will need the following materials:

- SCORBOT-ER4u Robot and Controller.
- Computer with SCORBASE software.
- Worksheets for Experiment 2.

OVERVIEW

RECORDING POSITIONS

Once you have moved the robot to a location in space, you can record this *position*. Once a position is recorded, you can give the robot a command to go to it.

A recorded position is a set of coordinates which defines the distance each axis has moved relative to the home position. These coordinates are measured by means of encoders which are attached to the motor on each robot axis. The encoder monitors the rotations of the motor, and sends a corresponding number of signals, or encoder counts, to the controller.

Before you exit SCORBASE, recorded positions should be saved to a position data file. The positions can then be reloaded and used later.

PROCEDURES

Task 2-1: Inventory and Safety Checks

1 Check whether all materials required for this activity are available at your lab station.

2 Check whether your lab station conforms to the Safety Guidelines for the robotic workcell.

3 Complete the Inventory and Safety Check List on the Worksheet for this activity.

Task 2-2: Startup

1 Launch SCOREBASE from the SCOREBASE program group.

2 Create a new project: File | New Project.

3 Switch to Level 2 "Advanced" mode: Options | Level 2.

Task 2-3: Recording Positions

1 Activate the robot system and **home** all axes.

2 Using the Manual Movement dialog box, bring the robot arm to the position illustrated in Figure 2-1.

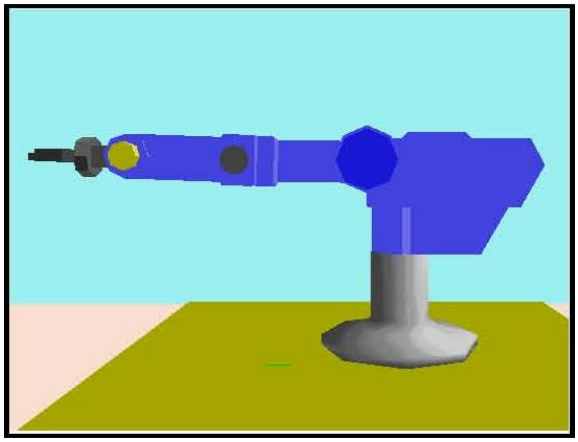


Figure 2-1: Position #1

3 Select the Teach Positions dialog box.

In the Position Number box enter 1, as shown in Figure 2-2.

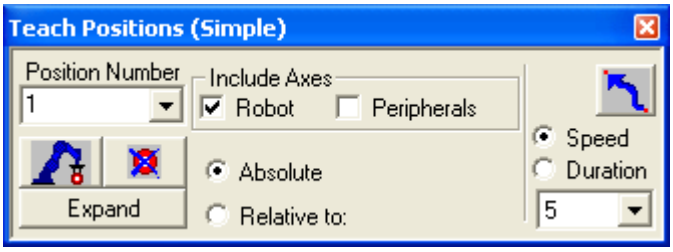


Figure 2-2

4 Click the Record Position button: 

You have just recorded position #1.

This number will now represent the specific position (that is, the coordinates of the robot when the position was recorded.)

5 Turn the base axis about 45°, as shown in Figure 2-3, and record this as position #2.

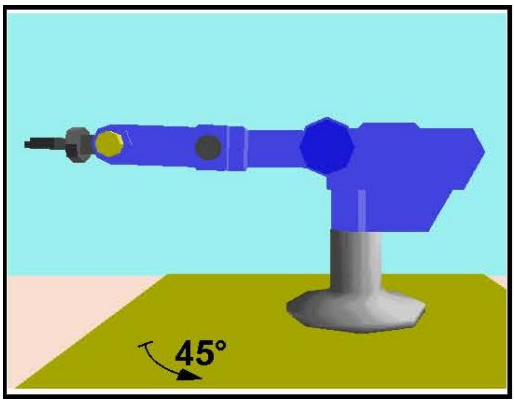


Figure 2-3

6 Bring the robot arm to the position shown in Figure 2-4, and record this as position #3.

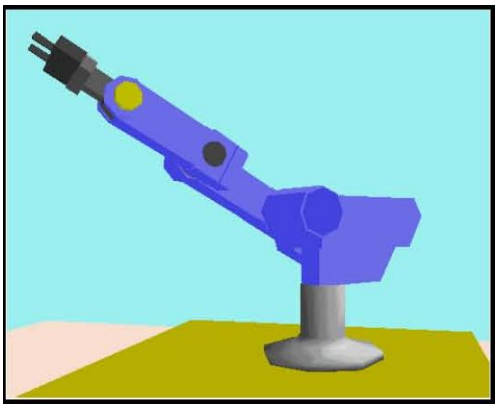


Figure 2-4: Position #3

7 Bring the robot arm to the position shown in Figure 2-5, and record this as position #4.

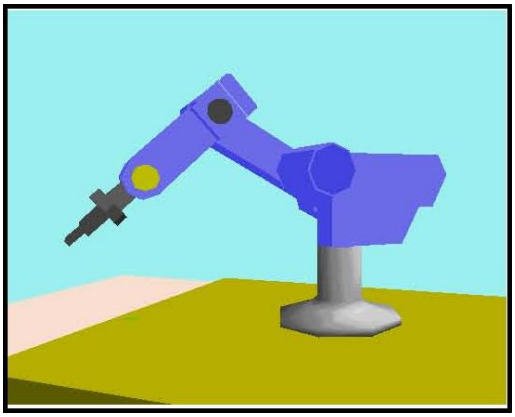


Figure 2-5: Position #4

8 Bring the arm to the position shown in Figure 2-6, and record this as position #5.

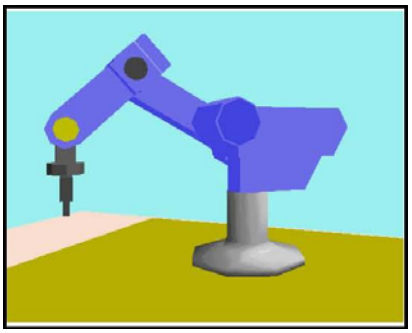


Figure 2-6: Position #5

9 Moving only the wrist roll axis, bring the arm to the position shown in Figure 2-7, and record this as position #6.

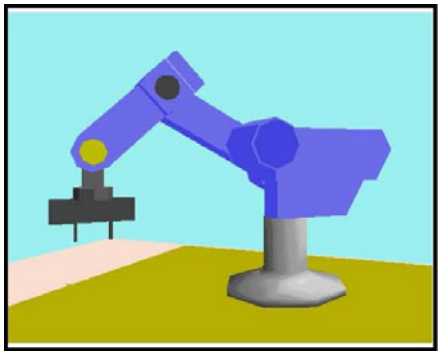


Figure 2-7: Position #6

10 Move the robot one more time, to a position of your choice, and record this as position #7.

11 Select Run | Go Home – All Axes. The robot will move to the home position.

12 Move the axes to bring the robot to the position shown in Figure 2-8.

Record this as position #99.

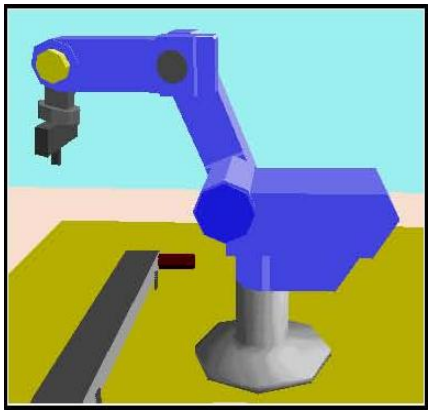


Figure 2-8: Position #99

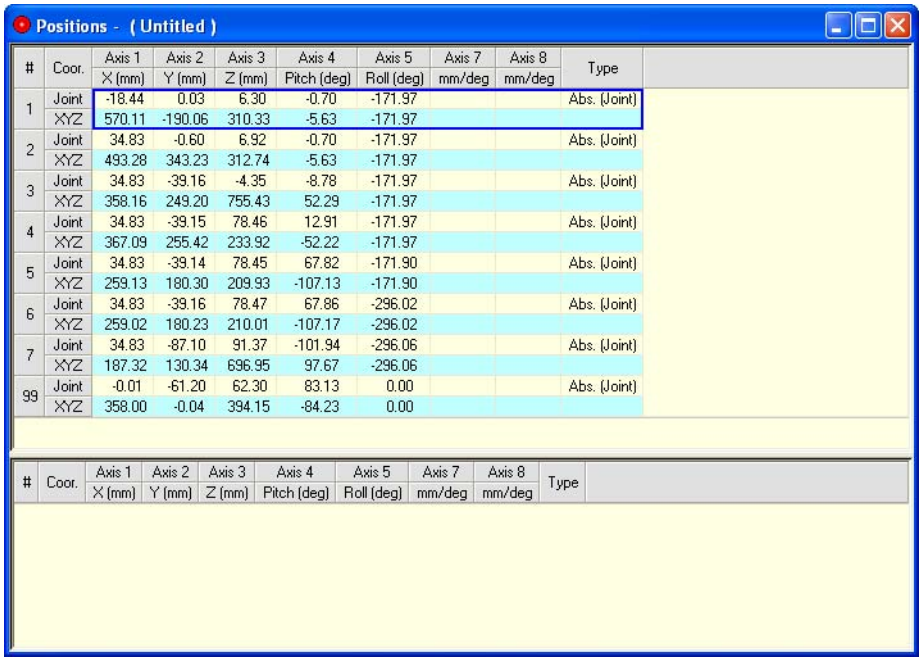
There are now eight different positions in the computer's memory.

Note: If a position was recorded previously, selecting Record will overwrite the existing position coordinates with new coordinates.

Task 2-4: Listing and Deleting Positions

1 Select View | Positions.

The Positions dialog box will appear, showing the positions which you recorded in the previous task.



#	Coor.	Axis 1 X (mm)	Axis 2 Y (mm)	Axis 3 Z (mm)	Axis 4 Pitch (deg)	Axis 5 Roll (deg)	Axis 7 mm/deg	Axis 8 mm/deg	Type
1	Joint	-18.44	0.03	6.30	-0.70	-171.97			Abs. (Joint)
	XYZ	570.11	-190.06	310.33	-5.63	-171.97			
2	Joint	34.83	-0.60	6.92	-0.70	-171.97			Abs. (Joint)
	XYZ	493.28	343.23	312.74	-5.63	-171.97			
3	Joint	34.83	-39.16	-4.35	-8.78	-171.97			Abs. (Joint)
	XYZ	358.16	249.20	755.43	52.29	-171.97			
4	Joint	34.83	-39.15	78.46	12.91	-171.97			Abs. (Joint)
	XYZ	367.09	255.42	233.92	-52.22	-171.97			
5	Joint	34.83	-39.14	78.45	67.82	-171.90			Abs. (Joint)
	XYZ	259.13	180.30	209.93	-107.13	-171.90			
6	Joint	34.83	-39.16	78.47	67.86	-296.02			Abs. (Joint)
	XYZ	259.02	180.23	210.01	-107.17	-296.02			
7	Joint	34.83	-87.10	91.37	-101.94	-296.06			Abs. (Joint)
	XYZ	187.32	130.34	696.95	97.67	-296.06			
99	Joint	-0.01	-61.20	62.30	83.13	0.00			Abs. (Joint)
	XYZ	358.00	-0.04	394.15	-84.23	0.00			

#	Coor.	Axis 1 X (mm)	Axis 2 Y (mm)	Axis 3 Z (mm)	Axis 4 Pitch (deg)	Axis 5 Roll (deg)	Axis 7 mm/deg	Axis 8 mm/deg	Type

Figure 2-9

The position coordinates shown on your screen will differ somewhat from the ones shown in Figure 2-9.

2 Select position 7 (click on line). Right click the line and select Delete. At the prompt to delete the position, click **OK**. The position is now deleted.

3 Close the Positions dialog box.

Task 2-5: Saving the Positions and Exiting SCORBASE

1 Select File | Save Project. The Save Project dialog box appears.

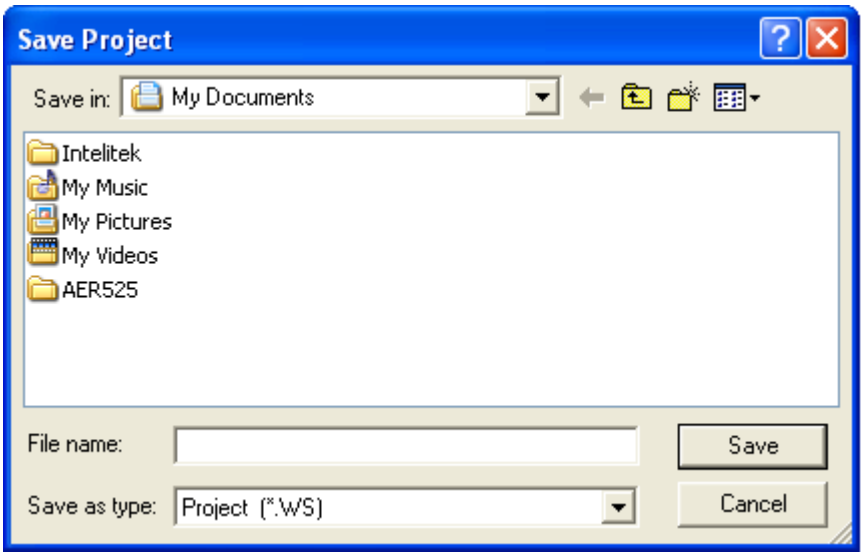


Figure 2-10

2 Browse to the My Documents\AER525 directory.

In the File name field, enter *USER***3**.

Do not type "USER." Instead, use **four characters** which identify you or your team, followed by **3**. The file name should be, for example, JANE3 or FOXY3.

Do not use a file name extension. SCORBASE automatically assigns the extension.

3 Choose **Save** to close the dialog box.

4 Select Run | Go Home – All Axes.

The robot should always be brought to its home position before the system is shut down.

5 Exit SCORBASE.

Task 2-6: Activating SCORBASE and Loading Recorded Positions

1 Reactivate SCORBASE, and **home** all axes.

When you intend to move the robot during a programming session, the robot must first be homed.

2 Select File | Open Project. The Load Project dialog box opens.

3 Browse to My Documents\AER 525. Select *USER*3 and choose **OK**.

Remember – do not look for a file named "USER3". Load the file you saved in the previous task (e.g. JANE3 or FOXY3.)

Task 2-7: Moving the Robot to Recorded Positions

You are now going to move the robot to the positions you recorded in Task 2-3.

1 In Teach Positions dialog box click the arrow next to the Position Number field to see the list of positions recorded. You should see a listing of 1 through 6 and 99.

2 Type or select 99. Then click the Go to position button: 

The robot (now at its home position) will move to position #99.

3 Send the robot to position #6.

4 Send the robot to position #5.

5 Send the robot to position #3.

6 Change to Speed 9 and send the robot to position #4.

7 Change to Speed 2 and send the robot to position #2.

8 Continue changing speed settings and moving the robot to different positions.

Task 2-8: Team Discussion and Review

Q 2-1 *When and why is it more practical to record positions before writing the robot program commands?*

Q 2-2 *When and why is it more practical to write the program commands before recording positions?*

Task 2-9: Inventory Check and Shut Down

1 Check whether all materials required for this activity have been returned to their proper place at your lab station.

2 Select Run | Go Home – All Axes.

The robot should always be brought to its home position before the system is shut down.

3 Exit SCORBASE. Turn off the controller. Then turn off the computer.

Experiment 3:

Writing and Running Robot Programs

OBJECTIVES

In this activity you will accomplish the following:

- Write and edit a simple robot program.
- Load and save a robot program file.
- Run the robot program.
- Abort the program execution.

MATERIALS

In this activity you will need the following materials:

- SCORBOT-ER4u Robot and Controller.
- Computer with SCORBASE software.
- Worksheets for Experiment 3.

OVERVIEW

ROBOT PROGRAMS

A robot program is a series of commands which tell the robot which tasks to perform. Previously you learned the Open and Close commands for opening and closing the gripper. In this activity you will learn the Go to Position command for sending the robot to recorded positions. These same commands are used when writing the robot program. Once written, a program may be stored on a disk together with the positions recorded for the robot. Permanent storage of operating programs and positions allows the programs to be reloaded and rerun at a later time.

A SCORBASE program can be written and debugged on a computer, without using the robot; this is called *off-line programming*. The system must be operating *on-line* with the robot only when the robot is being taught the positions required by the program.

PROCEDURES

Task 3-1: Inventory and Safety Checks

1 Check whether all materials required for this activity are available at your lab station.

2 Check whether your lab station conforms to the Safety Guidelines for the robotic workcell.

3 Complete the Inventory and Safety Check List on the Worksheet for this activity.

Task 3-2: Activating SCORBASE and Loading Recorded Positions

1 Activate the system, load SCORBASE, and **home** all axes.

2 Select File | Open Project. Browse to My Documents\AER525 and load the file *USER*3.

3 Select View | Positions. Make sure positions 1 through 6 and 99 are listed.

Task 3-3: Writing a Simple Robot Program

In this task you will write a simple program for moving the robot to positions #1, #2 and #3, and opening and closing the gripper.

1 Bring the cursor to the Commands tab in the Workspace window.

2 In the AXIS CONTROL group double click the command GP GoToPosition#_Speed... The Go to Position dialog box appears:

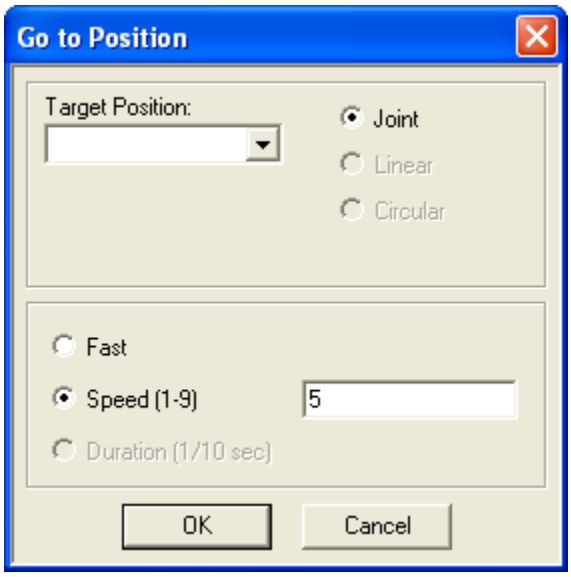


Figure 3-1

- Type or select 1 in the Target Position field.
- Select Fast for the speed setting.
- Choose OK.

  A command line now appears in the Program window:

  1 Go to Position 1 Fast

You have just written the first program line. It will send the robot to position #1.

3 The system is now waiting for you to enter another command.

Repeat the previous step, and enter a command to send the robot to position #2:

2 Go to Position 2 Fast

4 In the Command list, double click the command OG OpenGripper.

An additional command appears:

3 Open Gripper

5 Add two more commands:

4 Go to Position 3 Fast
5 Close Gripper

Your robot program now contains five command lines.

Task 3-4: Saving the Program

Once you have written a program, and before you run it, the program should be saved to disk.

1 Select File | Save Project As.... The Save Project dialog box opens.

2 Browse to My Documents\AER525. In the File Name field, enter *USER***4**.

Do not type "USER." Instead, use **four characters** which identify you or your team, followed by **4**. The file name should be, for example, JANE4 or FOXY4.

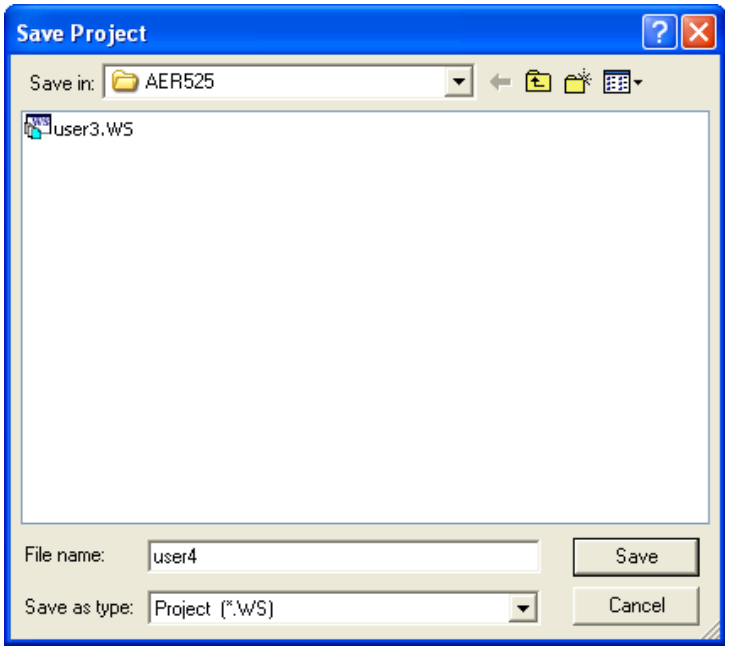


Figure 3-2

3 Choose Save.

The software actually saves two additional files named *USER4*. USER4.SBP contains the program you just wrote and USER4.PNT contains the positions you recorded in Experiment 2.

Task 3-5: Running the Program

1 From the View Menu, select Show All Dialog Bars. A new set of dialog boxes will appear:

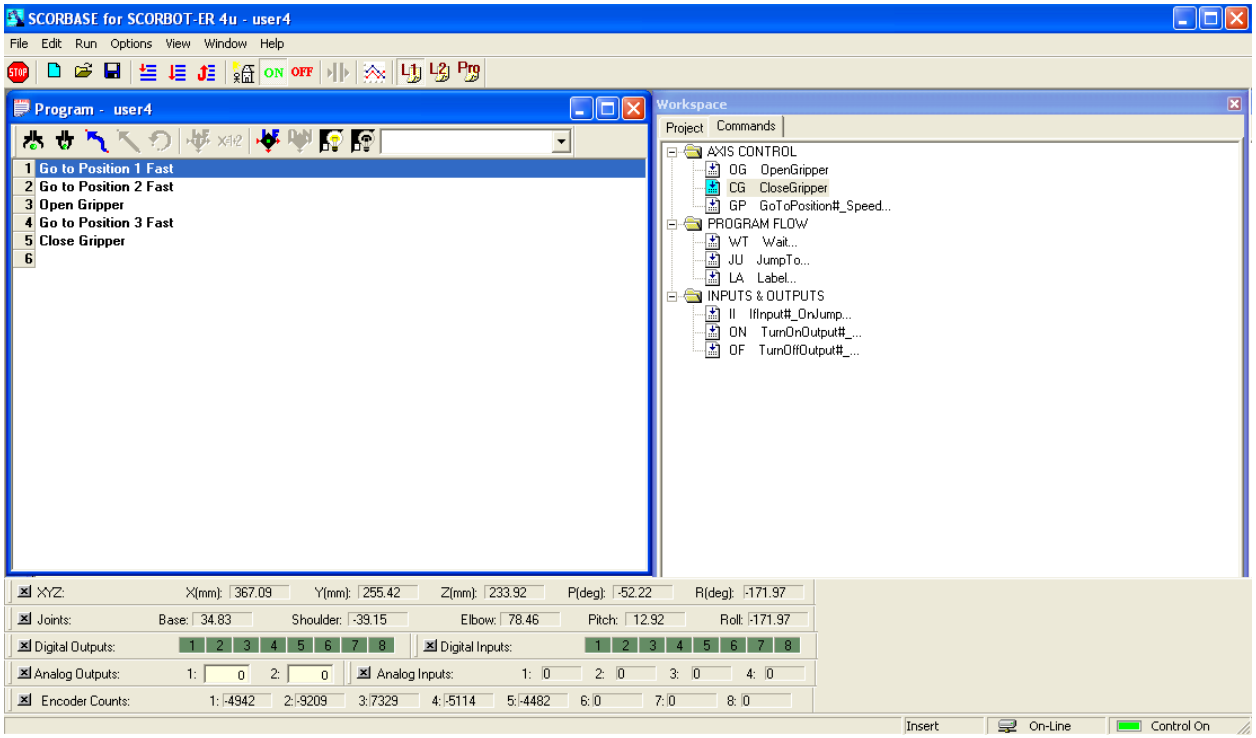


Figure 3-3

2 Bring the cursor to line #1 of the program.

The Run option buttons will now be active: 

Press F6 or click the first button (Run Single Line). The program will be executed one line at a time. The line currently being executed is highlighted in magenta the Program window. Continue pressing F6 or clicking on the button until the end of the program is reached.

3 With the cursor on the first line of the program, press F7, or click the second button. (Run Single Cycle) One complete cycle of the program will be executed.

4 With the cursor on the first line of the program, press F8, or click the third button (Run Continuously). The program will be executed in continuous loops.

Do not stop program execution. Continue to the next task.

Task 3-6: Aborting a Program

1 While the program is still running, press F9 or click the Stop button.

The robot will stop immediately.

2 Press the Run option functions key or button to resume continuous execution of the program from where it was halted.

3 Assume a real emergency has occurred:

- Press the EMERGENCY button on the controller.
- Release the EMERGENCY button. Confirm the prompts for Control On.
- Resume program execution.

4 Stop the program normally (F9 or Stop button).

Task 3-7: Inserting and Deleting Program Lines

1 SCORBASE programs are edited by means of standard Windows editing tools.

In the Program window, bring the cursor to the beginning of line 5. Enter a new command:

Go to Position 4 Fast

The new command is inserted at line 5 and the Close Gripper command moves down a line.

2 Insert another command, at line 6, to send the robot to position #5.

3 Add two commands at the end of the program: Open Gripper and Close Gripper. Your program now looks like this:

1	Go to Position 1 Fast
2	Go to Position 2 Fast
3	Open Gripper
4	Go to Position 3 Fast
5	Go to Position 4 Fast
6	Go to Position 5 Fast
7	Close Gripper
8	Open Gripper
9	Close Gripper
10	

Figure 3-4

4 Take a moment to familiarize yourself with the Edit | Cut, Copy and Paste options.

5 Delete program line #9.

6 Delete one of the two Open Gripper commands which remain in the program.

Task 3-8: Using Wait Commands

1 Insert a Wait command (from the PROGRAM FLOW group) at the end of the program.

Double click the command WT Wait in the Command list. A dialog box appears:

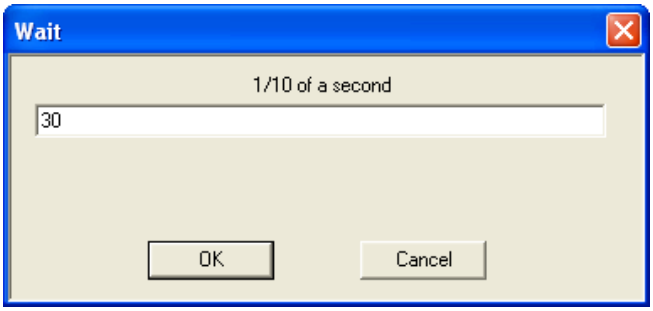


Figure 3-5

2 Type **30** (30 tenths of a second) and choose OK.

The command Wait 30 will cause the program (and robot) to pause for three seconds before beginning another cycle when the program is being executed in continuous loops.

3 Save the program again as *USER*4.

4 Run the program. Note the effect of the Wait command.

Task 3-9: Team Discussion and Review

Q 3-1 *Refer to the robotic workcell shown in Figure 3-6, and describe two or three robotic tasks which would require a command sequence similar to the one you programmed in this activity (program USER4).*

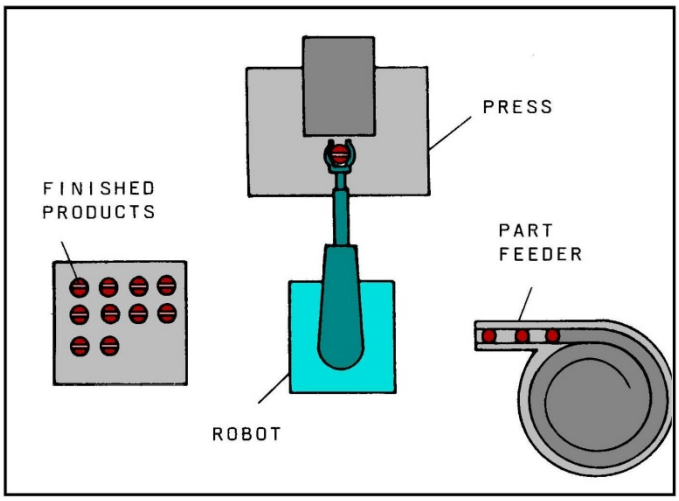


Figure 3-6

Task 3-10: Inventory Check and Shut Down

1 Check whether all materials required for this activity have been returned to their proper place at your lab station.

2 Select Run | Go Home – All Axes.

3 Exit SCORBASE. Turn off the controller. Then turn off the computer.