Activity 1

INTRODUCTION:

Pick and Place with Sorting

Basing on Gripper Size

1 OBJECTIVES:

In this activity the student will learn the following:

- The basic robotic system components
- Introduction to RoboCell simulation software
- Initialization of the robot and robot workspace
- Move the robot manually to a given position
- Picking and placing an object
- Record various positions of the robot
- Write a basic program for the robot basing on the previously recorded positions
- Determine the size of the object using gripper-opening sensor as a feedback.
- Using gripper-opening distance in sorting basic objects: small cube, medium cube, big cube, and cylinder.

2 ACTIVITY:

At the end of this experiment the student should be able to sort 3 different cubes according to their sizes, picking them from known different locations. The big cube should be on the ground.

3 INSTRUMENTS

3.1 Robotic System Components

Figure (1) shows elements of a typical robot system. The robot system includes a manipulator arm, an end effector (the gripper or tool connected to the end of the arm), a controller and a computer. Other devices such as a hand-held control pendant or camera may also be included.

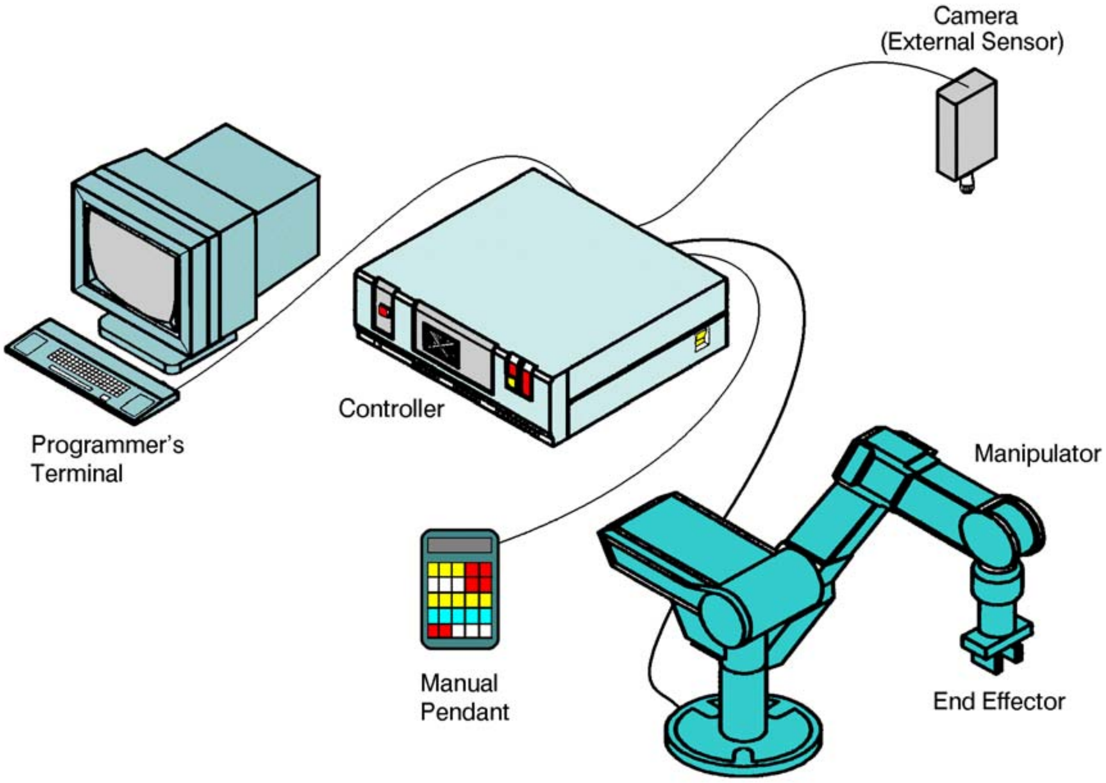


Figure (1). Elements of typical robotic system.

Some robot systems contain internal feedback devices (such as encoders), and may include external sensing devices (such as a vision system).

3.1.1 End Effector

A robot must be properly equipped for the kind of task it is to perform. The end effector of the ER 4u is a gripper that can be used for grasping and picking up objects. In other robotic systems the end effector may be a tool, such as a welding gun, a spray gun for painting, or a grinding tool for milling.

3.1.2 Manipulator (arm)

A manipulator is a mechanical arm that moves (manipulates) the end effector to the required positions and orientation. The manipulator arm must be strong enough to carry the specified payload and flexible enough to perform the required movements with the required level of accuracy.

3.1.3 Controller

The controller controls the power supplied to the motors that drive the arm. The controller's microprocessors simultaneously perform many functions during robot program execution:

- The controller calculates the motion required of each axis to produce the proper arm movement.
- The controller monitors the motion of the axes and sends commands to the motors in order to control the speed and correct positioning errors.
- The controller reads input data from sensors and sends output signals that activate grippers, tools and other devices.
- The controller receives commands from the computer or the control pendant and transmits status messages to the operator.

3.1.4 Sensors

Most robotic arms have internal sensors that provide data on the position or motion of the arm joints. These sensors help the controller to position the arm accurately.

Some robotic systems include external sensors, which provide data on objects in the robot's vicinity. Without these sensors the robot might not know when and where objects are to be handled or avoided.

3.2 <u>The Robotics and Materials Handling</u>

The Robotics and Materials Handling station, shown in Figure (2), simulates a robotic work cell. It has the following elements:

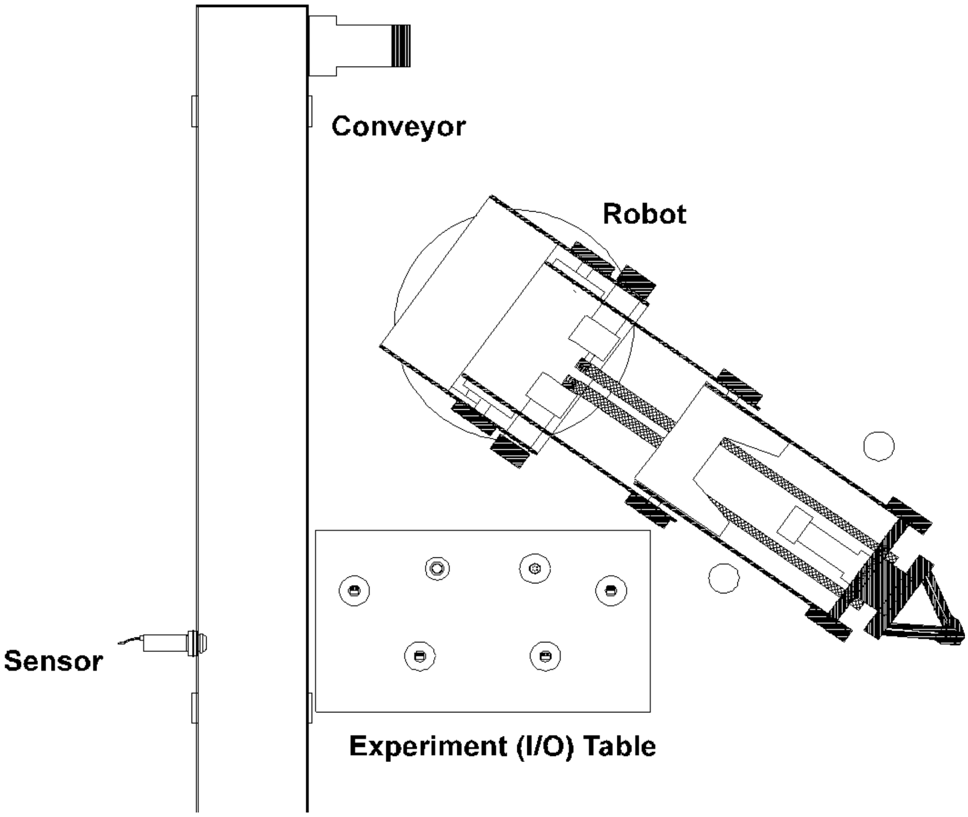


Figure (2). Robotic Work cell.

- SCORBOT-ER 4u robot and controller. The SCORBOT robot is an instructional robot, which provides an inexpensive yet reliable simulation of industrial robots.
- Computer with SCORBASE or RoboCell software.
- Experiment (I/O) table. This item contains microswitches that send input signals to the controller, a lamp and a buzzer that respond to the controller output signals. You will use it to simulate the input and output signals that provide communication among the devices and machines in the robot's environment.
- Conveyor belt. This device serves to demonstrate the delivery of materials to and from the robot. It includes a photoelectric sensor whose

signal indicates to the robot controller that a part is in the vicinity of the sensor.

- The robotic cell is supplied with a number of cylindrical and cubical blocks, referred to as round and square blocks in this manual, which represent materials and work pieces that the robot handles.
- A coordinate grid. A metal or plastic mat marked with a grid to help you in learning to manipulate and program the robot.

3.3 SCORBASE

SCORBASE, shown in Figure (3), is a robotics control software package, which provides a user-friendly tool for robot programming and operation.

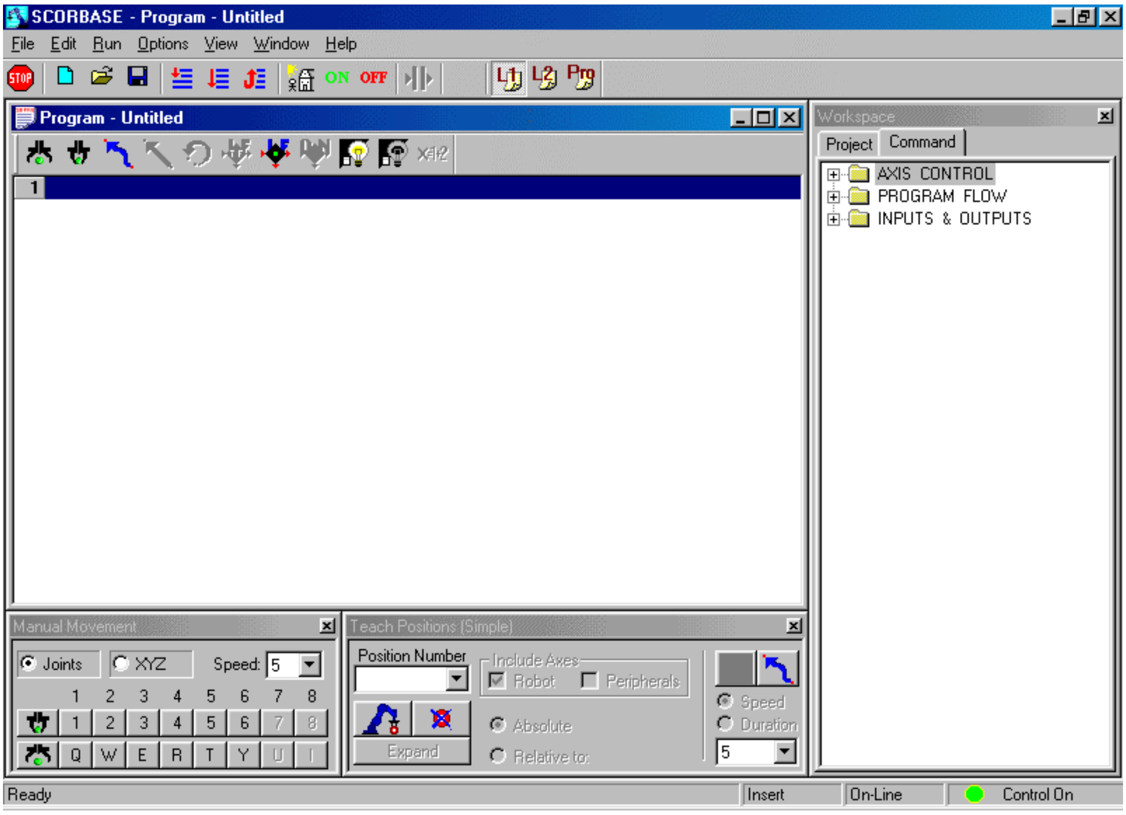


Figure (3). SCORBASE and RoboCell robotic software main window.

4 RoboCell Robotic Software

RoboCell software will enable you to write programs, and then test their execution by using a virtual robot. Such simulation capabilities will help reduce the cost in planning your final industrial robotic system, as well as significantly reduce the risk of accidents or failures. In this course RoboCell software will be used in robotics experiments.

RoboCell is a software package that integrates SCORBASE robotic software with a 3D Image module. Every project in RoboCell is composed of three files that usually bear the same name with a different extension:

- By default, positions and program files are saved in one combined operation and have the same name with different extensions.

- A file, with the 3DC extension, containing the data regarding the robot cell. After loading a 3D model file, the 3D Image window shows a graphic image of the cell.

When the SCORBASE program is executed, the virtual robot will move within the defined workcell, according to the program positions and commands.

4.1 <u>The RoboCell 3D Image Window</u>

The RoboCell 3D Image Window simulates a video camera output screen. The camera is controlled by the user to focus in on a clear, centered view of the cell and robot actions. The user has several options to control the camera, such as:

⬇	• Top View - places the camera on top of the cell at the center of the image.
↖	• Redirect Camera - allows the user to define a position that will be in the center of the image.
	• Zoom In/Zoom Out - zooms in and out of the image by pressing the right mouse button and moving it forward or backward.
	• Rotating the Image - rotates the view of the image by pressing the right mouse button and moving it to the right/left.
	• Moving the Camera Up/Down - use the window’s scroll bar to adjust the viewing angle of the image.

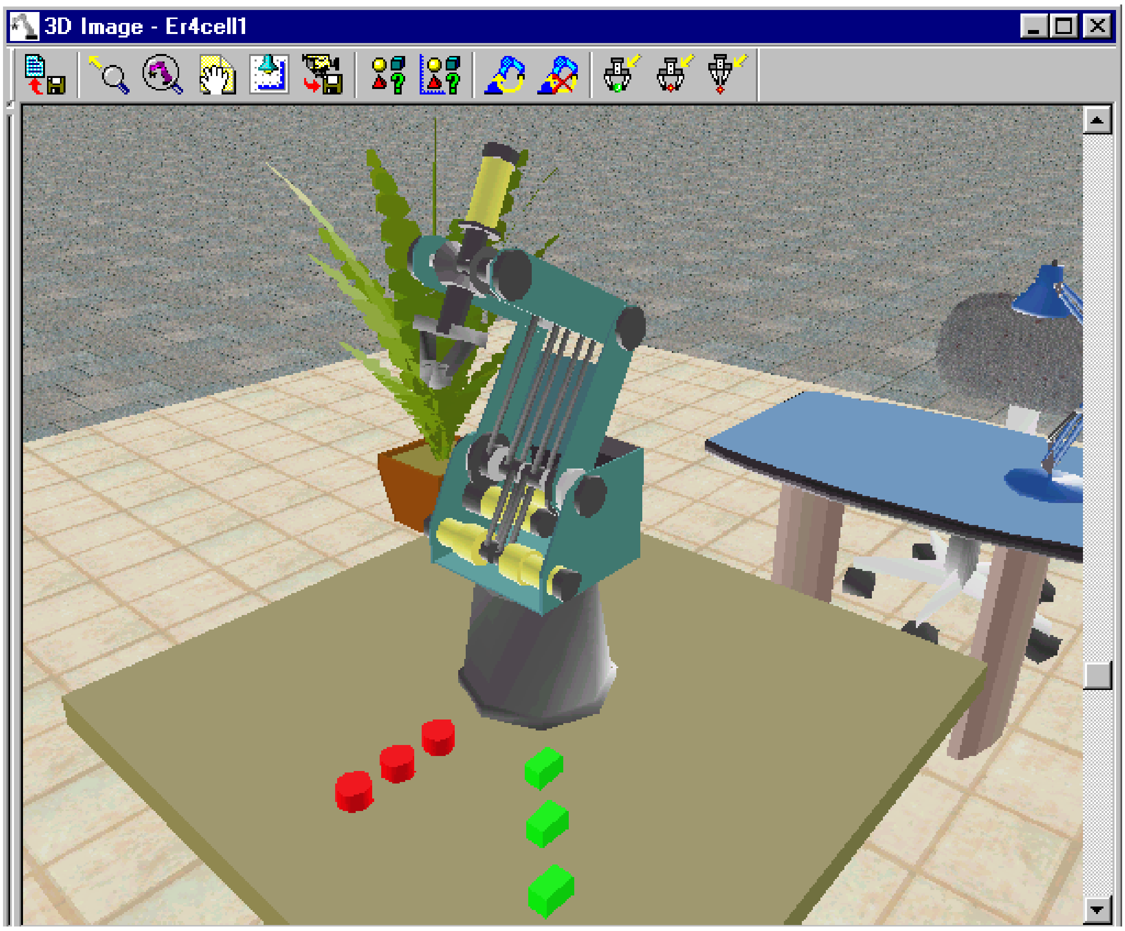


Figure (4). RoboCell 3D Image Window

4.2 RoboCell Toolbar

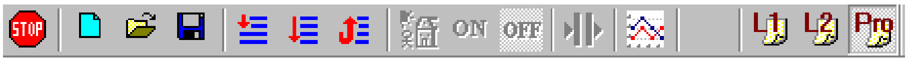


Figure (5). RoboCell toolbar.

STOP	Stop	• Immediately stops program execution and movement of all axes.
🗋	New	• Opens a new, untitled project.
📂	Open	• Opens an existing project.
💾	Save	• Saves the currently active project.
☰	Run single line	• Executes the selected (highlighted) program line.

	Run single circle	- Executes the program from the selected (highlighted) program line, to the end of the program.
	Run continuously	- Executes the program from the selected (highlighted) program line. When the last program line is reached, the program starts again from the first line.
	Search Home	- Search Home for all axes
ON	Control On	- Enables servo control of the axes.
OFF	Control Off	- Disables servo control of the axes. When control is off, axes cannot be moved.
	Pause	- Stops program execution after the current line is executed.
	Charts	- Opens the Charts window.
L1	Level 1	- Displays list of commands and options at introductory level. Commands related to higher level are disabled.
L2	Level 2	- Displays list of commands and options at advanced level. Commands related to higher level are disabled.
Pro	Pro	- Displays list of commands and options at professional level. At this level, all options and commands can be activated.

4.3 **3D Image Toolbar**

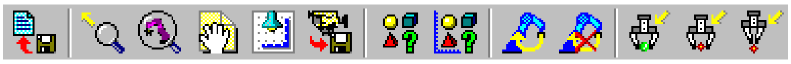


Figure (6). 3D image toolbar.

	Reset	• Reloads the currently open 3D model file. The • robot and all peripheral axes assume their home positions. All objects return to their original positions. The graphic display returns to its default view. Selecting Reset Model while a robotic program is running will interrupt its • execution, but will not stop or reload the program. You must select the SCORBASE Stop command, and then bring the cursor to the first line of the program before resuming • program execution.
	Redirect Camera	• Allows you to select a different focal point in the graphic display of the cell. To change the center point of the graphic display window, select Redirect Camera and then click on any point in the scene. It now becomes the center • point of the graphic display.
	Follow-me Camera	• When selected, the camera follows a specific focal point. This function is similar to Redirect Camera, only automatic and continuous. • This function is particularly useful for following the motions of the robot gripper. But it can also be used to track any object in the cell, such as a cube that is being moved.
	Drag	• Allows you to move the robot screen in a desired direction. Clicking on this icon and .dragging. the mouse to the left will drag the entire scene within the window to the left.
	Top View	• Displays an overhead view of the cell.

	Save Camera	- Saves the current view of the cell. The graphic display will show this view whenever you select Reset Model or Restore Camera Position, or when the 3D Image file is loaded.
	Names	- When selected, a label appears on the object showing its name.
	Positions	- When selected, a label appears on the object showing its position. The coordinates indicate the center point of the object relative to the cell's point of origin.
	Path	- When selected, a line showing the path of the gripper will be drawn on the screen whenever the robot moves. Clear this menu option to stop the display of the path.
	Clear Path	- Removes the robot path drawn on the screen.
	Send Robot to Object	- Moves the robot (gripper) to an object in the cell. Be sure the gripper is open before using this command. - First select Send Robot to Object, then click on the target object. By default, the gripper will move to a point that is 10 mm above the object's position.
	Send Robot to Point	- Moves the robot (gripper) to any location in the cell. It is similar to the Send Robot to Object command, but allows you to send the robot to any point on any object in the cell. When you click on an object, such as the table, the target point is the point where you click, not the object's position. - First select Send Robot to Point, then click on the target point. By default, the gripper will move to a point that is 10 mm above the point selected.
	Send Robot to Above Point	- Moves the robot (gripper) to a point above any selected location in the cell. First select Send Robot Above Point, then click on the target point. By default, the gripper will move to a point that is 150 mm above the target point.

5 EXPERIMENTAL PROCEDURE:

5.1 Running RoboCell and Opening the Demo 3D model File

1. Turn on the computer.
2. Run RoboCell by doing one of the following:
   - Click **Start | Programs | RoboCell for ER 4u | RoboCell for ER 4u.**
   - Click on the RoboCell for ER 4u icon.

   The opening screen appears.

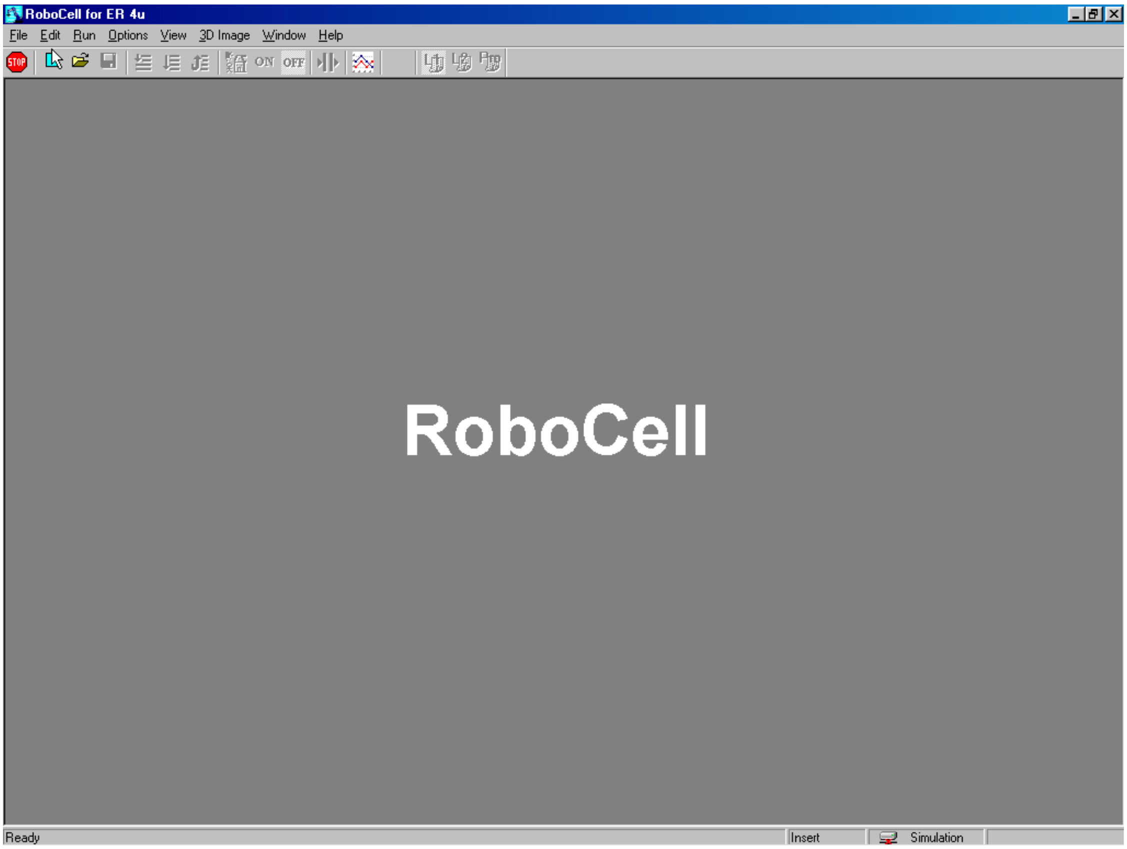


Figure (7). RoboCell for ER 4u program window.

3. Every SCORBASE program is part of a project, which can also include the user-defined positions, project data and 3D model files. In order to write your first SCORBASE program, you must open a new project.

   To open a new project, do one of the following:

- Select File | New Project.
- Click on the New Project icon.
- Press [Ctrl] + N.

The RoboCell screen now appears as shown Figure (8).

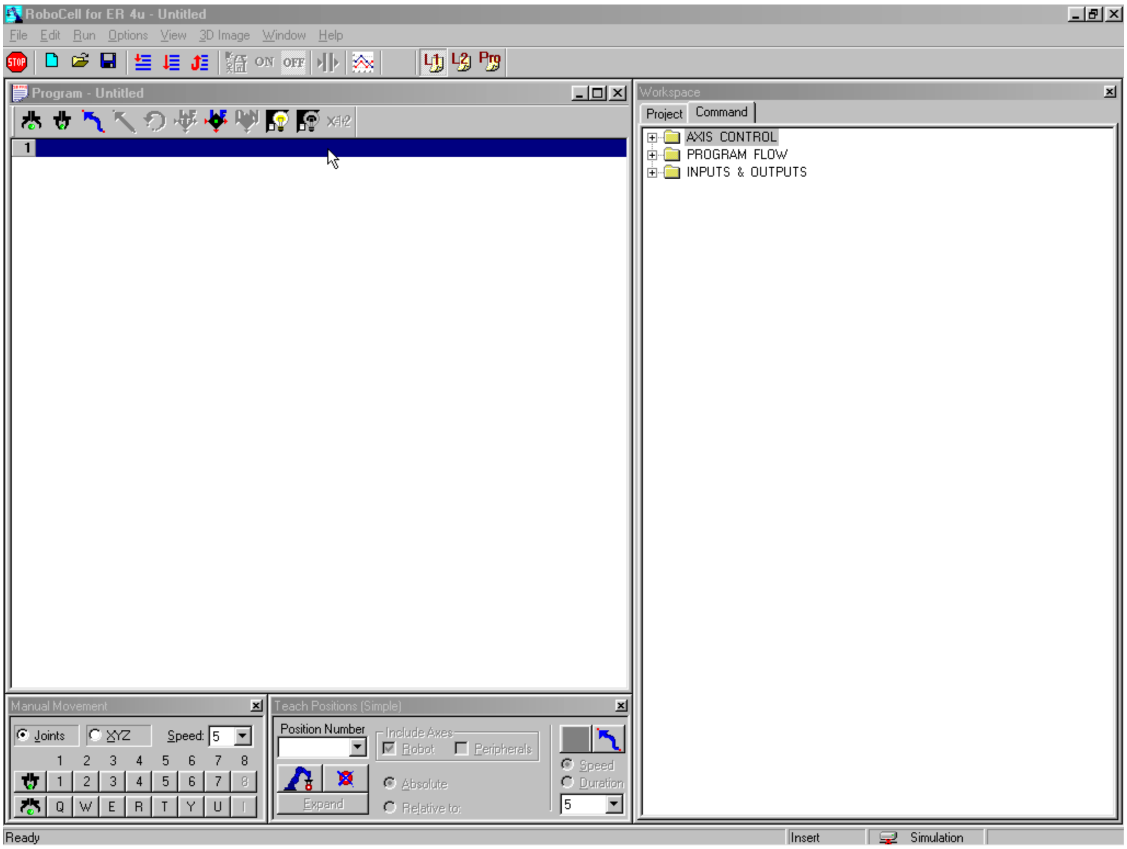


Figure (8). RoboCell window after opening a new project.

4. You now need to open a 3D image model for this project.

- Select **File | Import 3D Model.**

The Import 3D Model dialog box opens.

- Go to the directory **C:\Program Files\Intelitek\RoboCell\Projects\ER4u** as shown in Figure (9)

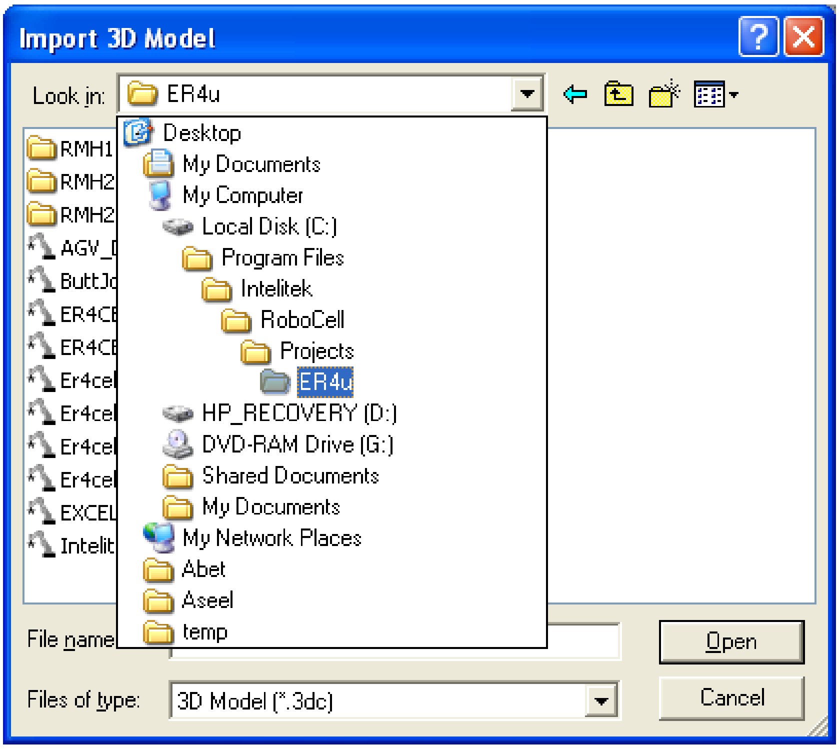


Figure (9). Importing 3D Model.

- Open the cell **CLASS 1.3DC** (the cell may be any other as provided by yours instructor).

  A 3D image opens, displaying the SCORBOT-ER 4u robot centered on a table with 3 cubes of different colors and sizes placed in front of it.

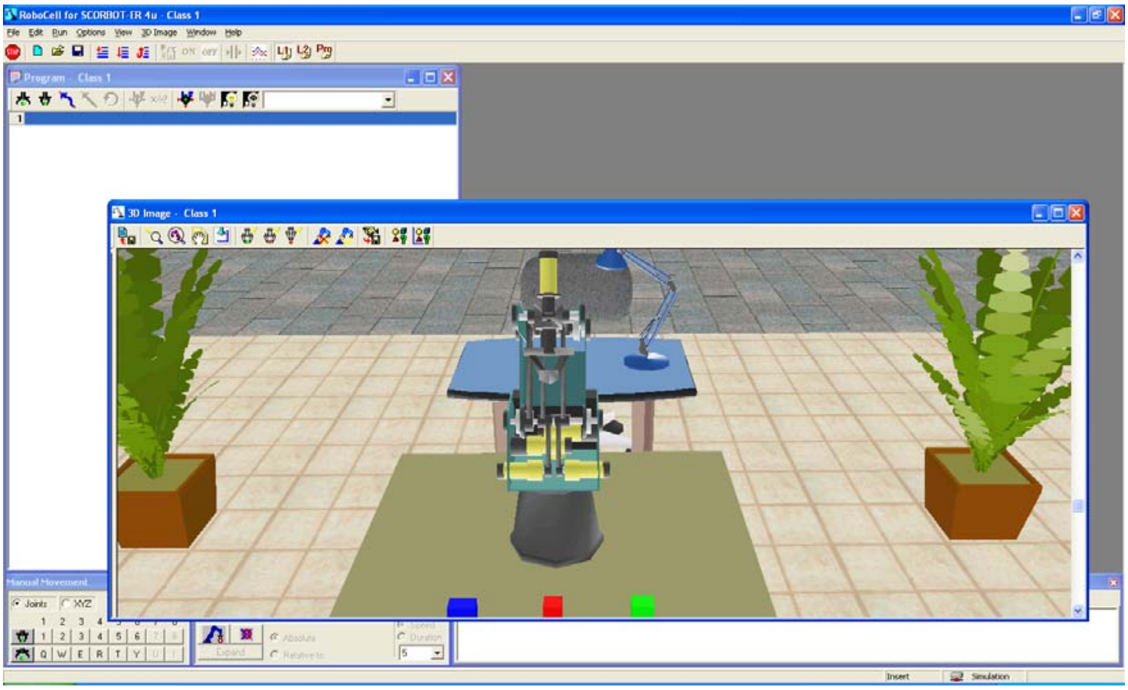


Figure (10). 3D cell model.

- You now need to arrange the windows in positions optimal for viewing the 3D Image and teaching/recording positions. Select **Window | Simulation & Teach** to arrange the windows.

  You screen should now look like Figure 2-12.

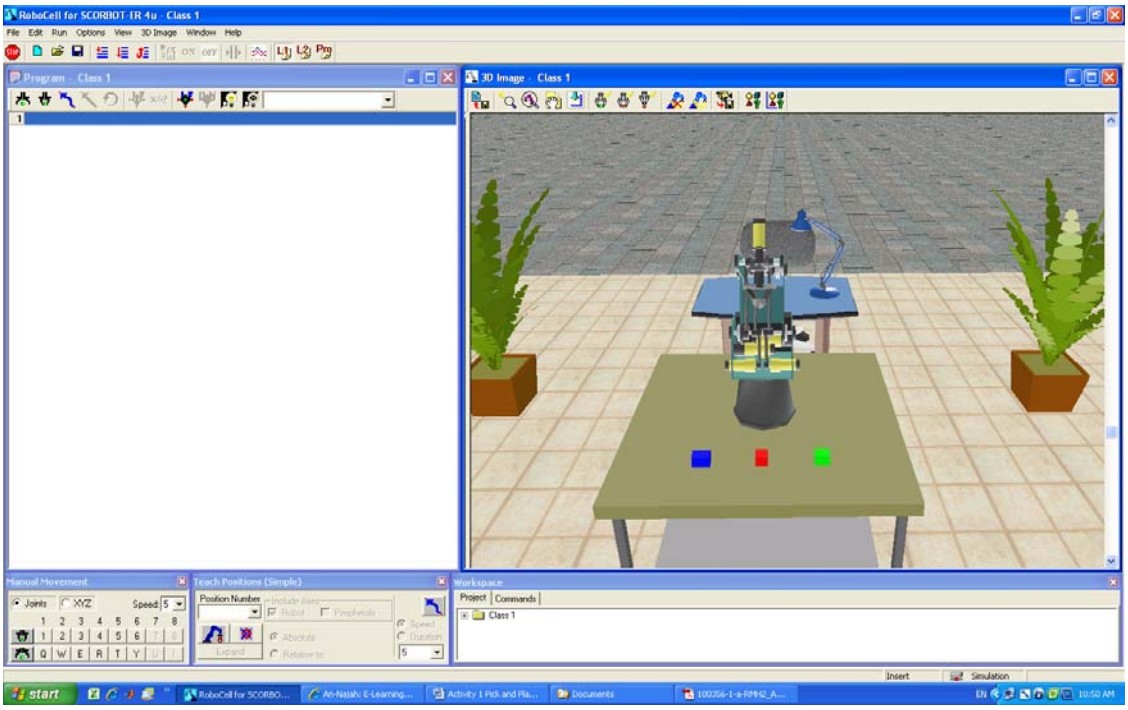


Figure (11). 3D cell model after rearranging program windows.

5.2 **Recording Positions**

1. Move the robot to the positions shown in Figure (12) and record them.

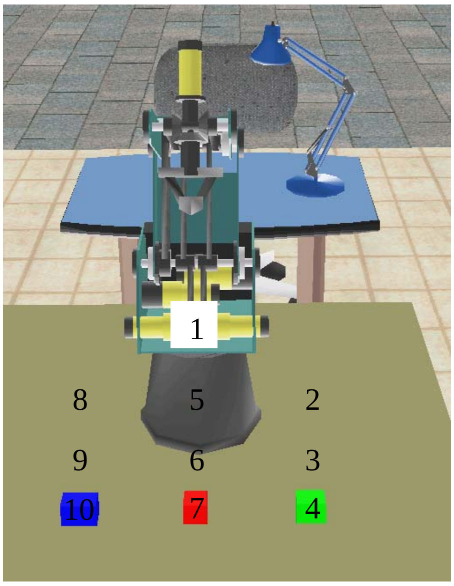
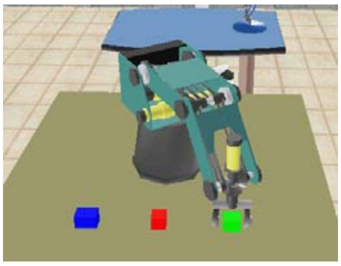


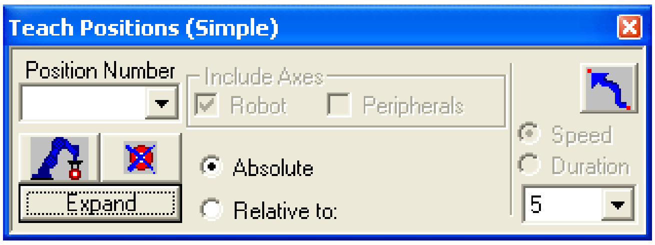
Figure (12). 3D cell model after rearranging program windows.

Note that positions (3, 6, & 9) are just above the cubes. You can record them relative to positions (4, 5, & 10) 40 mm above as follows:

2. Move the robot to position 4 and record it. Be aware of the orientation of the gripper.



3. Change programming level to level 2 . You should be able to click **Expand** on **Teach Positions** window.



Position Number

Include Axes: ☑ Robot □ Peripherals

● Absolute

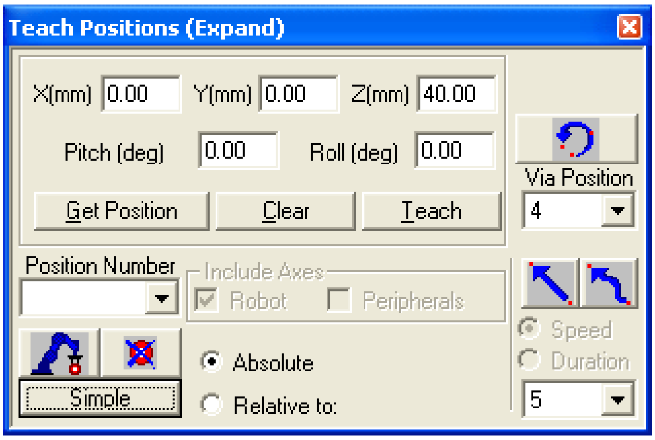
○ Relative to:

● Speed

○ Duration

5

4. Click it, new items appear.



Teach Positions (Expand)

X(mm) 0.00 Y(mm) 0.00 Z(mm) 40.00

Pitch (deg) 0.00 Roll (deg) 0.00

Via Position 4

Position Number

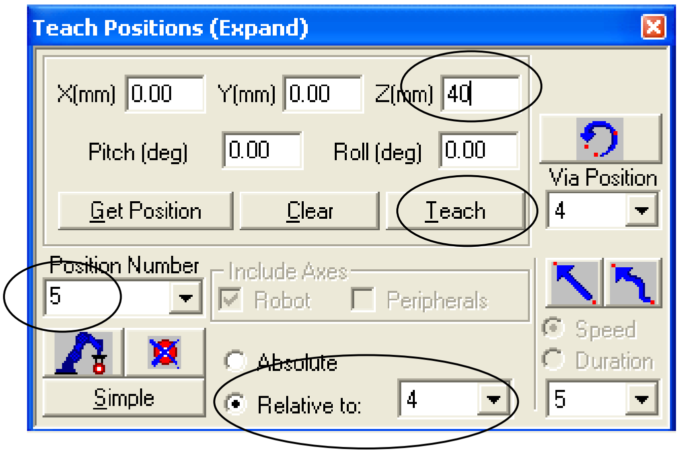
Include Axes: ☑ Robot □ Peripherals

● Absolute

○ Relative to:

● Speed ○ Duration 5

5. Now you can record position 5 relative to position 4, which will be 40 mm above it (in the z-direction).



Teach Positions (Expand)

X(mm) 0.00 Y(mm) 0.00 Z(mm) 40

Pitch (deg) 0.00 Roll (deg) 0.00

Via Position 4

Position Number 5

Include Axes: ☑ Robot □ Peripherals

○ Absolute

● Relative to: 4

● Speed ○ Duration 5

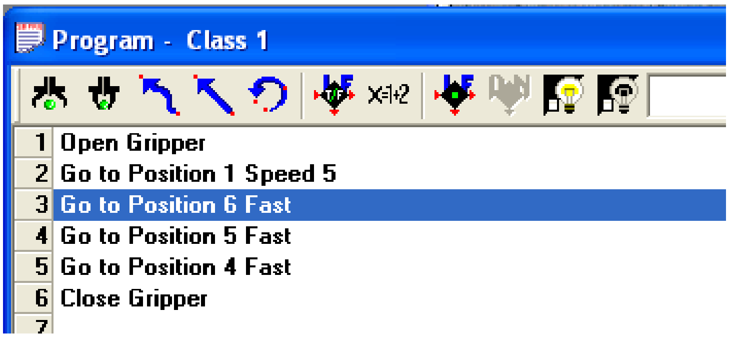
6. After filling all the previous values, click on **Teach**.

   Note that if you click on **Get Position** you will obtain the position of each point and you will know whether this position is absolute or relative.

7. Repeat the previous steps for all the other positions. Record positions (2, 5, & 8) relative (3, 6, & 9) 50 mm above.

5.3 Size of gripper as a variable in the program

1. Make the following simple program

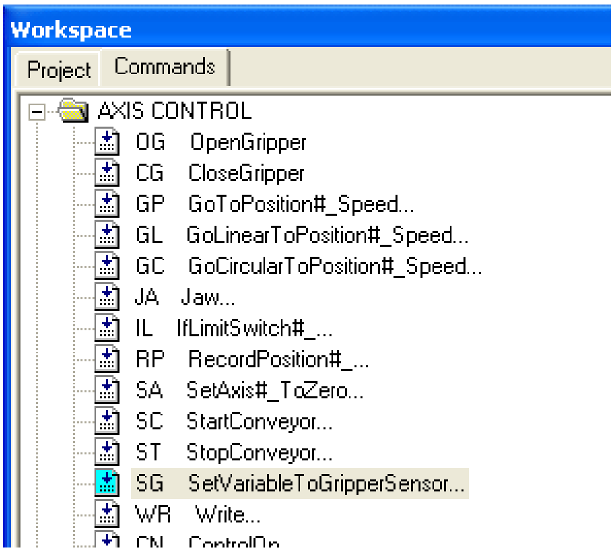


Program - Class 1

```
1 Open Gripper
2 Go to Position 1 Speed 5
3 Go to Position 6 Fast
4 Go to Position 5 Fast
5 Go to Position 4 Fast
6 Close Gripper
7
```

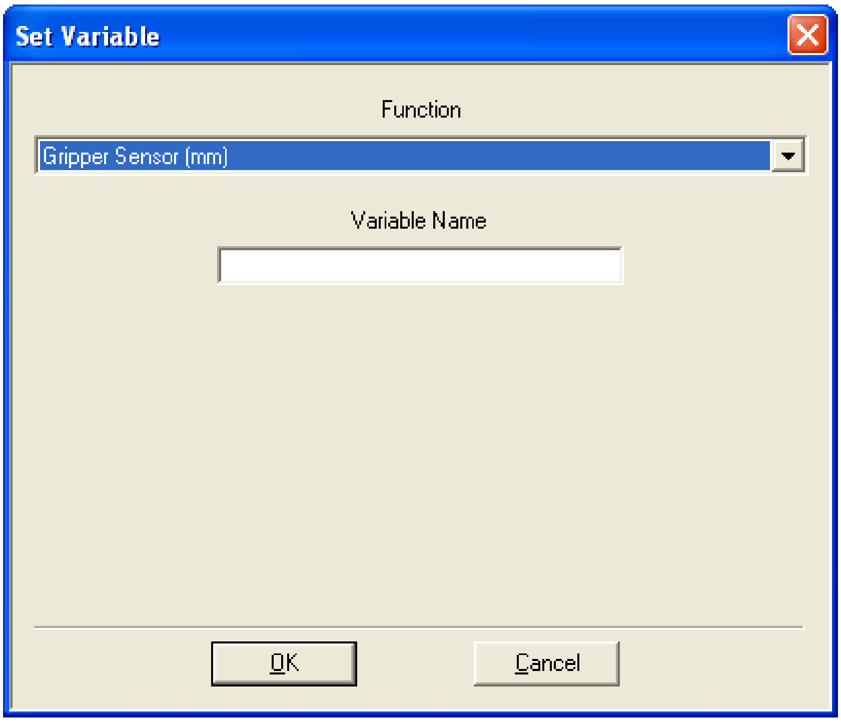
2. Change the level to Professional to be able to use new commands from **Workspace | Commands** window

3. In the **Workspace | Commands** window go to **AXIS CONTROL | SetVariableToGripperSensor**… and double click on it.



```
AXIS CONTROL
  OG  OpenGripper
  CG  CloseGripper
  GP  GoToPosition#_Speed...
  GL  GoLinearToPosition#_Speed...
  GC  GoCircularToPosition#_Speed...
  JA  Jaw...
  IL  IfLimitSwitch#_...
  RP  RecordPosition#_...
  SA  SetAxis#_ToZero...
  SC  StartConveyor...
  ST  StopConveyor...
  SG  SetVariableToGripperSensor...
  WR  Write...
  CN  ControlOn
```

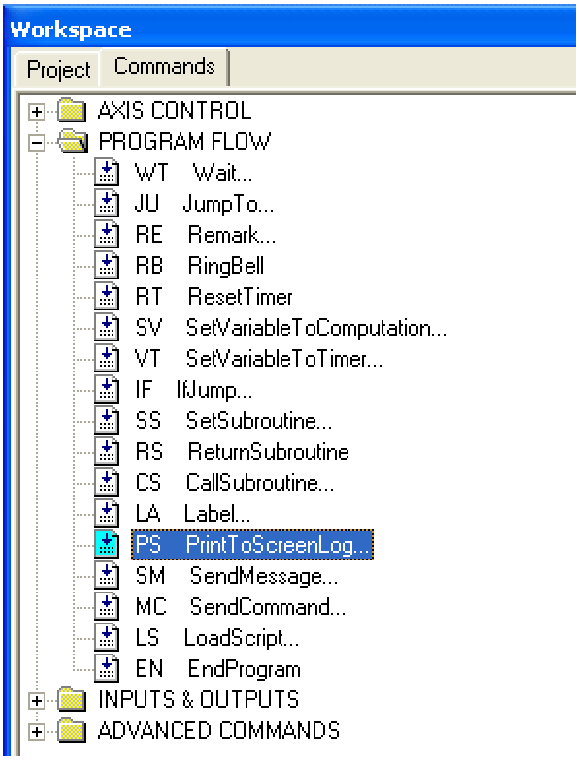
The following window opens:



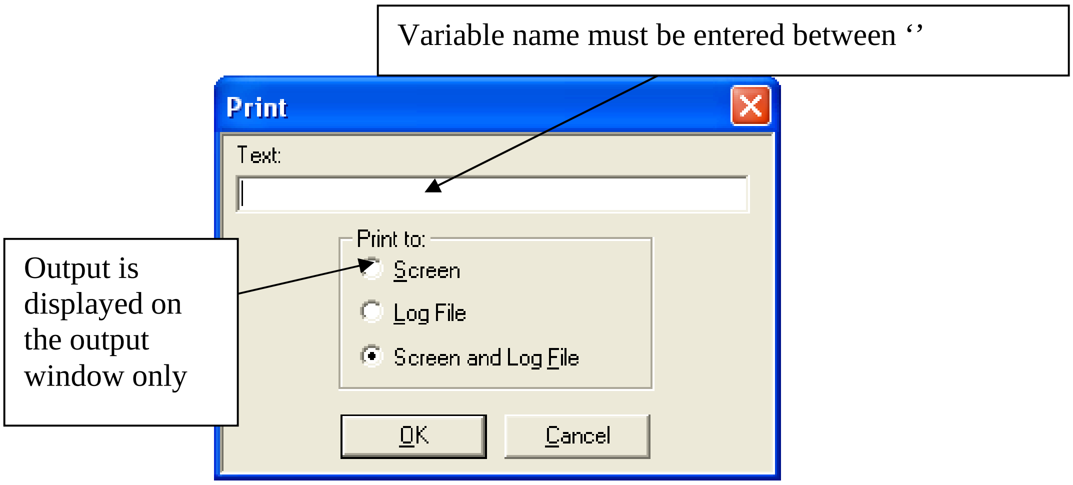
Function

Gripper Sensor (mm)

4. Set Variable Name to SIZE (for example). This creates the variable **SIZE** which measures the gripper opening distance at any position.
5. In the **Workspace | Commands** window go to **PROGRAM FLOW** | **PrintToScreenLog**… and double click on it.



The following window appears:



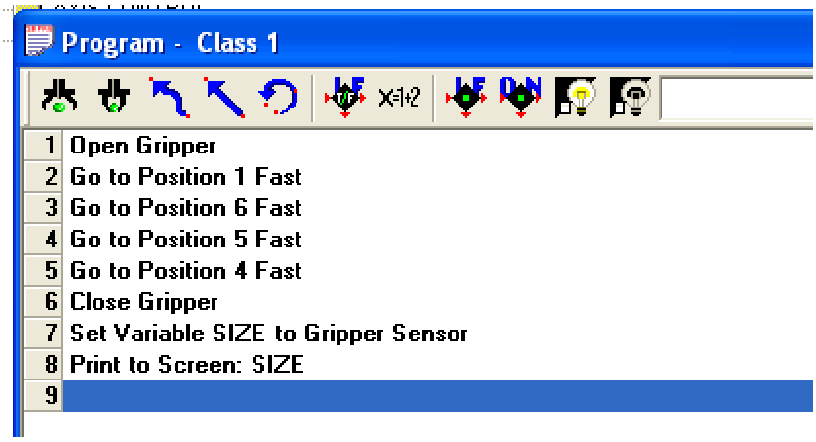
○ Screen
○ Log File
● Screen and Log File

Variable name must be entered between ‘’

Output is displayed on the output window only

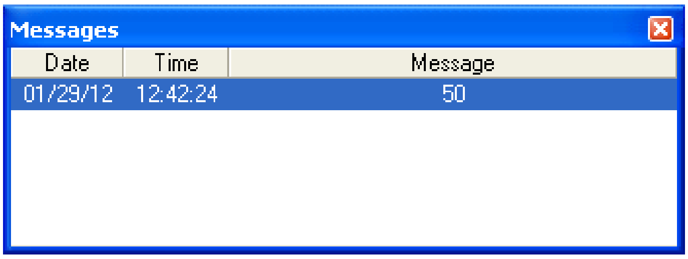
6. In the **Text** field place 'SIZE' (variable name).

7. The resulted program should have the following form:



```
Open Gripper
Go to Position 1 Fast
Go to Position 6 Fast
Go to Position 5 Fast
Go to Position 4 Fast
Close Gripper
Set Variable SIZE to Gripper Sensor
Print to Screen: SIZE
```

8. If we run the program from the first line a new window appears displaying the output:



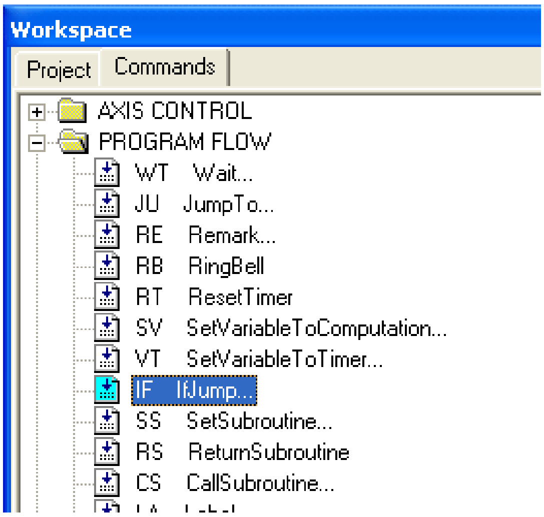
Date	Time	Message
01/29/12	12:42:24	50

9. If, for some reasons, this window does not appear, it can be opened from **View | Messages** menu.

   As can be seen, the size of the cube is displayed and equals 50 mm.

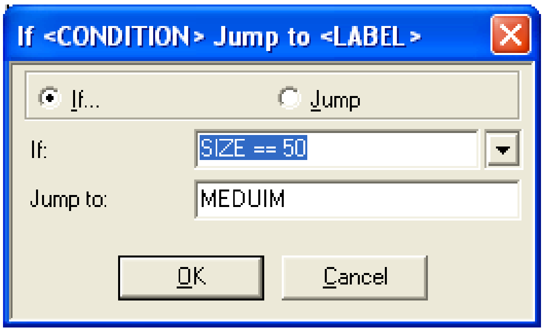
5.4 Programming an if statement basing on size of gripper-opening

The if statement can be found in **Workspace | Commands** window | **PROGRAM FLOW** | **IfJump**…



It can be used in the program as follows:

1. Double-click on **IfJump** command. The following window appears:

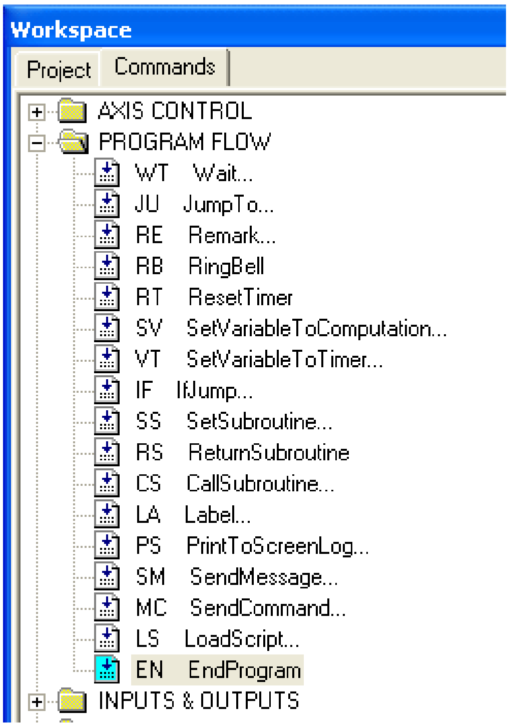


● If... ○ Jump

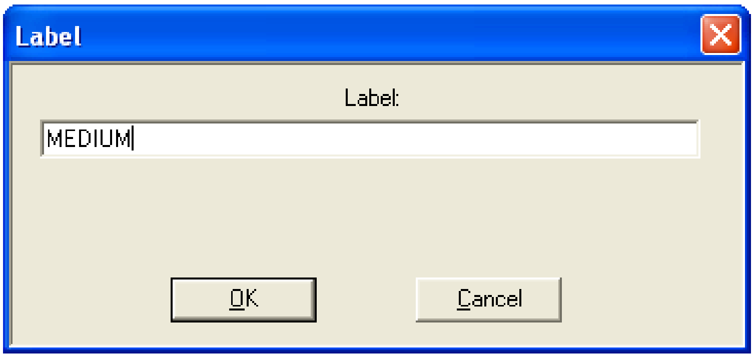
If: SIZE == 50

Jump to: MEDUIM

2. At any instant the user can end the program using End command from the same **Command** window group.

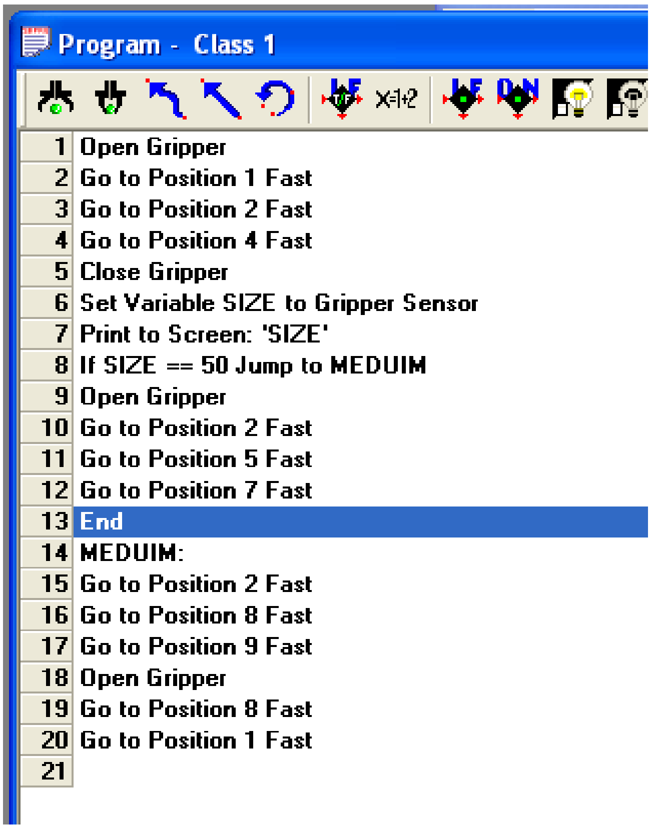


3. Also the label can be placed at any position of the program using the **Label** command in the previous figure. If double clicked the following window appears:



Label: MEDIUM

4. After some modifications the resulted program is shown in the next figure:



```
Open Gripper
Go to Position 1 Fast
Go to Position 2 Fast
Go to Position 4 Fast
Close Gripper
Set Variable SIZE to Gripper Sensor
Print to Screen: 'SIZE'
If SIZE == 50 Jump to MEDUIM
Open Gripper
Go to Position 2 Fast
Go to Position 5 Fast
Go to Position 7 Fast
End
MEDUIM:
Go to Position 2 Fast
Go to Position 8 Fast
Go to Position 9 Fast
Open Gripper
Go to Position 8 Fast
Go to Position 1 Fast
```