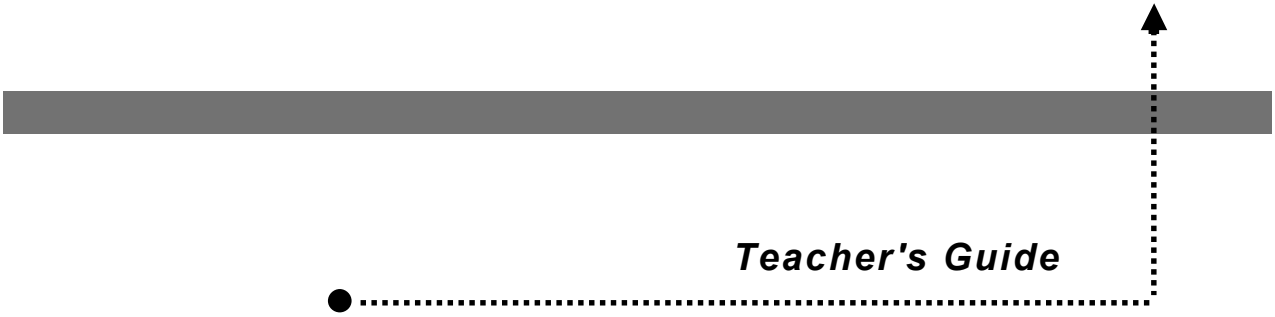
tekLINK

ROBOTICS & MATERIALS HANDLING 1

(SCORBOT-ER 4u)



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Robotics and Materials Handling 1 (SCORBOT-ER 4u) Teacher's Guide

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About the TEAM Program

intelitek's **Technology for Engineering and Automated Manufacturing (TEAM)** is a multi-segmented, curriculum-driven program designed to provide students with a broad base of competencies in modern manufacturing technology. Its educational hardware and software are based on actual industrial components and together emulate manufacturing environments. TEAM incorporates hands-on lab experience with simulation, creative design projects, problem solving and more.

A Student Activities Book and Teacher's Guide accompany every TEAM tekLINK. The activities include clearly defined objectives, subject overview, interactive tasks, and links to career opportunities and industrial applications. Assessments are facilitated throughout the curriculum. Measurable skill standards are defined for each chapter, and instructors apply a rubric to measure competency and check that objectives and skill levels are achieved. Skill standards for each tekLINK have been developed in accordance with National Skill Standards established by industry and educational leaders. Students work in teams and are exposed to various core technologies on a rotation basis. This modular concept allows the program to be tailored to the needs of each student.

TEAM students will master the technical skills needed for competent use of industrial equipment and manufacturing technology. Using these skills in design projects will then challenge them to combine tekLINKs in "islands of automation," or Flexible Manufacturing Systems (FMS). Ultimately, TEAM exposes students to Computer Integrated Manufacturing (CIM) systems, where they will manufacture a product - from concept, through design and all the way to production.

About Skill Standards

The rapid changes in the world of technology intensify the challenges facing educators. Students need to be adequately prepared for the demands they will face in the workforce. This entails acquiring skills that are relevant to the needs of industry. The content of industrial manufacturing and engineering training programs must be relevant and aligned with current technology. The solution to these challenges lies in the implementation of skill standards.

A collaboration of agencies, including industrial, educational, governmental, and civil rights organizations, has accelerated the initiative to develop standards for performance of work-related skills. Standards are developed from current industry practices, and provide the basis for the content of instructional programs. These industry-wide skill standards serve to define the areas critical for preparing individuals for the demands of the workplace. Additionally, skill standards provide a basis for assessment, measurable benchmarks to determine the success of training on an individual basis.

Many sets of skill standards – industry-wide, nation-wide, and state-wide - have been developed as a framework for schools to build on as they develop their educational programs. intelitek's curricula incorporate these standards in a flexible format designed to bridge the transition between school and the workplace.

intelitek's TEAM program, including this tekLINK, is designed to assure and facilitate the implementation of skill standards in engineering, automation and manufacturing education. The competencies developed in each tekLINK segment are clearly defined, correlated to nationally accepted standards, and presented in a way that enables appropriate assessment.

About the TEAM Activities Book

The Activities Book is a lab manual that contains 15 **Activities**, each of which can be completed in one 45-minute lab session.

Each activity begins with several lists:

- **Objectives** are the goals students will achieve.
- **Skills** are the competencies students will develop.
- **Materials** are the specific items students will need for each activity.

The **Overview** section introduces the students to the subjects that will be explored in each activity.

The **Procedures** contain a series of **Tasks**, or operations. The first time an operation is to be performed, instructions are given in a tutorial manner. In subsequent tasks, students should be able to perform these operations without guidance.

Many tasks are best performed when each team member takes on a different role. One student may, for example, handle the hardware while another student manages the software. The activities are designed so that students can switch roles and repeat tasks, thereby allowing everyone more "hands-on" time.

Questions and tables for entering results and observations appear throughout the tasks. Questions for discussion and review conclude each activity. All questions and tables are printed on a set of **Worksheets** supplied with this book. Students should record their answers in the worksheets, or as directed by the instructor.

The **Academics** section at the end of each activity contains enrichment material, such as industrial applications and opportunities, or the scientific background upon which the tekLINK technology is based.

In TEAM tekLINKs that include hardware (e.g., panel, robot), students will be directed to perform inventory and safety checks at the beginning of every working session, and to shut down the system properly at the end of each activity.

In TEAM tekLINKs that utilize software, it is assumed that students are familiar with the PC and are comfortable working in the Windows/DOS operating environment. However, instructions are explicit enough to allow novices to use the tekLINK's specific software.

About the Robotics and Materials Handling 1 tekLINK

The Robotic Workcell

The Robotics and Materials Handling tekLINK, which simulates a flexible manufacturing system, has the following elements:

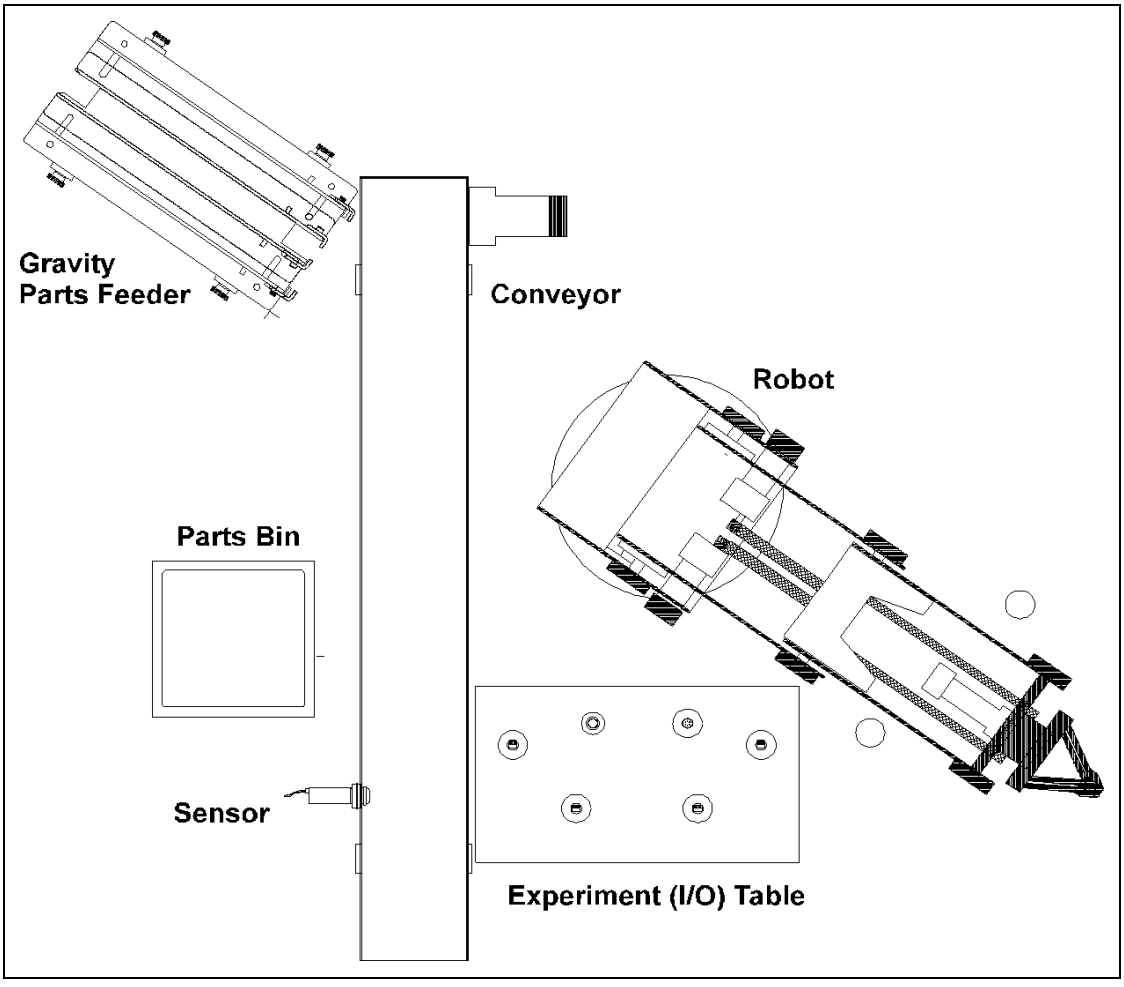


Figure 1

- SCORBOT-ER 4u Robot and Controller-USB. The SCORBOT robot is an instructional robot, which provides an inexpensive yet reliable simulation of industrial robots.
- Computer with SCORBASE software.

- Experiment (I/O) Table. This device contains microswitches that send input signals to the controller, and a lamp and a buzzer which respond to the controller output signals.. It is used 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 has entered the sensor's detecting range. The conveyor is defined as robotic axis 8, and controlled by the robot controller.
- Parts Feeder. This device supplies parts by means of gravity. It includes a microswitch sensor whose signal indicates to the robot controller that a part is available for pickup.
- Parts Bin. This box can represent a crate that is used to collect parts that must be discarded or taken to another location for further processing. It can also represent a crate or tray that is used for packing or storing various parts after processing.
- Workpieces. The tekLINK is supplied with a number of cylinders and cubes, referred to as round and square blocks in this manual, which represent materials and workpieces that the robot handles.

Note that the following items may also be included in the lab station:

- Coordinate grid. A plastic or aluminum mat marked with a metric grid to help students learn to manipulate and program the robot.
- Slidebase. This is an additional robotic axis that increases the working range of the robot. Although it may be configured in the software, ***the slidebase is not used*** in the Robotics and Materials Handling tekLINK.

SCORBASE for ER 4u Robotic Software

SCORBASE for *SCORBOT-ER 4u* is a robotics control software package, for robot programming and operation. SCORBASE for *SCORBOT-ER 4u* provides numerous capabilities:

- Communication with the robot controller over USB channel.
- Control and real-time status display of five robot axes, gripper and two peripheral axes.
- Full support and real-time status display of 8 digital inputs, 8 digital outputs, 2 analog outputs and 4 analog inputs.
- Position definition and display as well as manual robot movement in joint coordinates (joints angle) and/or Cartesian coordinates (X,Y,Z, Pitch and Roll).
- Robot movement definition as Joint, Linear, or Circular, with 10 active speed settings.
- Default setting of 1000 positions and 1000 active program lines (depending on the computer it can be more.).

- Interrupt programming for handling responses to changes in digital input status.
- Saving and loading projects.
- SCORBASE can be installed as part of RoboCell, an interactive graphic software package, which provides simulation of the robot and other devices in the workcell.

The *SCORBASE for ER 4u User's Manual* provides complete instructions for the installation, setup and operation of the SCORBASE for ER 4u software.

Materials Required for the Activities

The Activities in this book require the following components, which are supplied in the Robotics and Materials Handling 1 tekLINK.

- SCORBOT-ER 4u Robot and Controller USB
- Computer with SCORBASE for ER 4u software
- Experiment Table
- Gray Conveyor Belt (24V) with photoelectric sensor
- Gravity Parts Feeder with microswitch
- Parts Bin
- 6 Round blocks: 4 large, 1 medium, 1 small
- 4 Square blocks: 2 large, 1 medium, 1 small
- Coordinate grid (optional)

In addition, for some activities students will need the following materials, which are not supplied with the tekLINK:

- Transparency or other clear plastic material
- Small, self-adhesive squares of paper (e.g., Post-It™ Notes)
- Loose sheet of paper
- Diskette or personal directory on computer hard drive

tekLINK Requirements

To install and operate the Robotics and Materials Handling 1 tekLINK, your facility must provide the following items:

- Computer and Software Requirements:
  - Pentium III with 350 MHz processor, or higher.
  - At least 128 MB of RAM.
  - A hard drive with at least 20 -Megabyte of free disk space.
  - Windows 98/2000.
  - A Super VGA or better graphics display, minimum 256 colors.
  - A Mouse or other pointing device.
  - USB port.
  - Printer (optional).
- Table for computer and controller.
- Table for robot and devices.
- Grounded AC power supply. (A power outlet strip with on/off switch is recommended.)
- AC-12/24VDC adapter (for photoelectric sensor).

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!

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 2kg (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.

Instructors and System Managers

- Make sure the robot base is securely bolted in place. Make sure the controller's power cable is connected to a grounded power outlet.
- Turn off the controller's power switch before you connect inputs, outputs or any other device to the controller.

Installation

Procedure Overview

The system should be installed and checked according to the instructions in the order presented here.

- Prerequisites
- Unpacking
- Tables
- Coordinate Grid (if included)
- Slidebase (if included)
- SCORBOT-ER 4u Robot, Controller-USB and Gripper
- Peripheral Devices
- Cable Connections
- Software Installation and Activation
- Experiment (I/O) Table
- Conveyor and Photoelectric Sensor
- Gravity Feeder with Microswitch
- Bin and Parts
- Inspection

Although system configurations can vary, the setup defined here will enable students to perform the tasks in the Robotics and Materials Handling Activities Book.

User manuals are provided for each of the main components of the system: SCORBOT-ER 4u, Controller-USB, and SCORBASE for ER 4u robotic software. Refer to these manuals for complete details on installing, configuring and operating the hardware and software.

Unpacking

Before installing the equipment, examine it for signs of shipping damage. If any damage is evident, contact your freight carrier, and begin appropriate claims procedures.

Make sure you have received all the items listed on the shipment's packing list. If anything is missing, contact your supplier.

Tables

Refer to Figure 2.

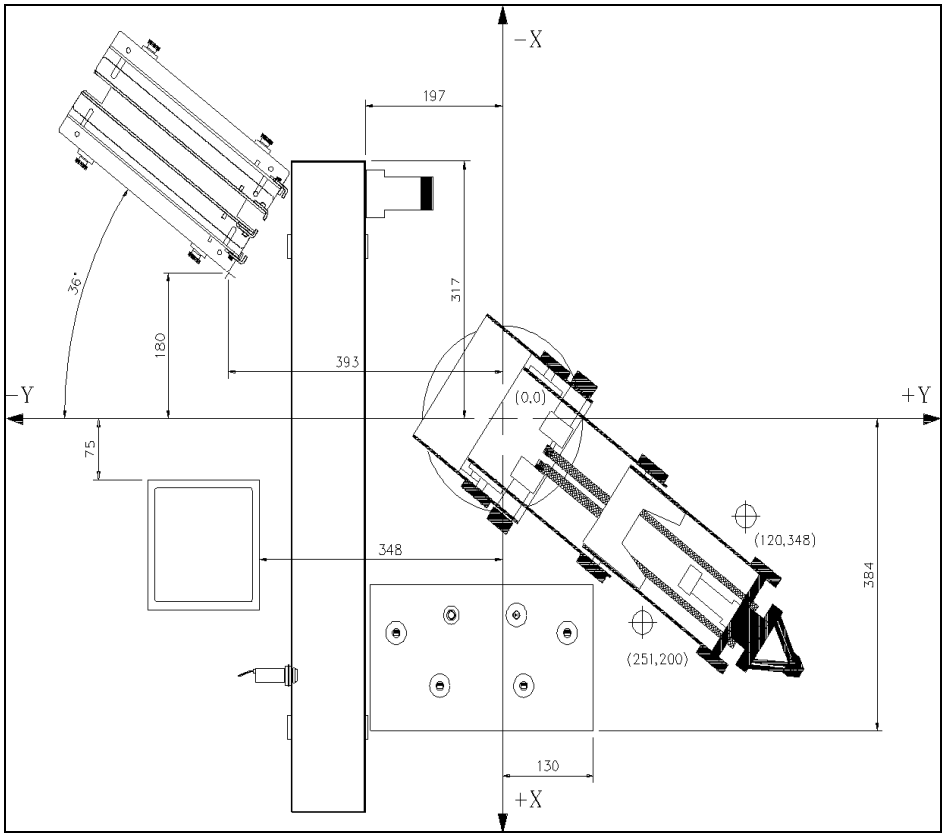


Figure 2 – Workcell Layout

1. Ensure that the workcell table is stable and sturdy enough to support the robot and equipment.
2. For personal safety and sufficient access to the cell from all sides, ensure that there is a free area of at least 1 meter around the workcell table.
3. Place the PC table and the workcell table within reach of the power supply.
4. Place the PC and the Controller-USB on the PC Table.

Coordinate Grid

If your system was supplied with a coordinate grid, place the grid on the workcell table.

Six mounting holes for the robot are marked on the plastic coordinate grid (the aluminum coordinate grid has actual holes). You can use these holes as a template to prepare holes in the workcell table for mounting the robot.

Slidebase

If the robot is to be mounted on slidebase, install the robot and slidebase according to the document*, Belt-driven Slidebase Installation Instructions*, which is supplied with the slidebase package.

SCORBOT-ER 4u Robot

Align the base of the robot with the holes in the coordinate grid and/ore the holes in the workcell table. Fasten the base of the robot arm to the workcell table with at least 3 bolts 120° apart.

Make sure the robot is securely bolted in place. Otherwise the robot could become unbalanced and topple over while in motion.

Do not yet connect any cables.

You may refer to the instructions given in *the SCORBOT-ER 4u User Manual*.

Peripheral Devices

Place the Conveyor, Experiment Table, Parts Bin and Gravity Feeder on the table, in the arrangement shown in Figure 2.

Once the devices are positioned properly, duct tape can be used to hold them in place.

Do not yet connect any cables or wires.

System Setup

Before installing the **SCORBOT-ER 4u**, be sure you have read and understood the safety instructions. Be sure you have ample space to set up the robotic system as shown in Figure 2.

1. Set up the **SCORBOT-ER 4u** on a sturdy surface with a minimum 700mm of free space around the robot.
2. Fasten the base of the robot arm to the work surface with at least 3 bolts 120° apart. The robot's base dimensions are:
   - Robot Base ∅ 240 mm (9.49")
   - Pitch Circle ∅ 207 mm (8.15")
   - Hole (6 off) ∅ 8.5 mm (0.33")

   Make sure the robot is securely bolted in place. Otherwise the robot could become unbalanced and topple over while in motion.
3. Place the controller and computer on a sturdy surface at a safe distance from the robot—well outside the robot's safety range.

Controller-USB Connections

Refer to Figures 3 and 4.

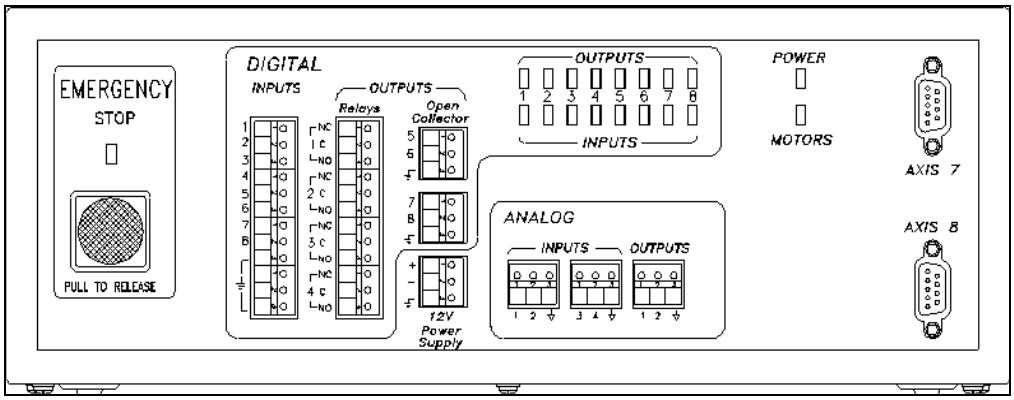


Figure 3: Front Panel

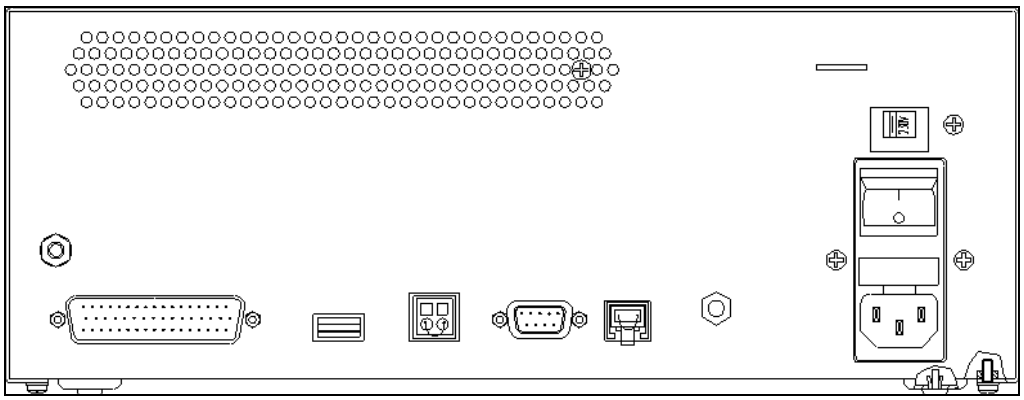


Figure 4: Back Panel

1 Make sure the PC power switch is turned off.

Make sure the Controller-USB power switch is turned off.

2 Connect the robot to ROBOT port on the Controller-USB. Use the robot cable with the D50 connector. Tighten the connector screws.

3 It is assumed that you will not be using a teach pendant. Therefore, connect the Emergency By-Pass plug into the TEACH PENDANT port on the Controller-USB.

If you will be connecting a teach pendant, connect it at this time. Follow the instructions in the *Controller-USB User's Manual* for installing the teach pendant.

4 It is recommended that you set the teach pendant Auto/Teach switch to AUTO before you power on the system.

5 Connect the power cable to the POWER socket on the Controller-USB and to an AC power source.

6 Connect the USB cable from the PC USB socket/terminal to the Controller USB socket.

7 Once you have made all the required hardware connections, you can turn on the PC.

8 After you have turned on the PC, you can turn on the Controller-USB.

The green power and motor LEDs will light up.

Software Installation and Activation

Software Installation

The SCORBASE software is supplied on a CD. To install the software, do the following:

1 Close any applications that are open before you begin the installation.

2 Insert the Robotic Software for ER 4u CD-ROM into the CD-ROM drive.

3 Choose **Run** from the Start menu.

4 Type **D:\Setup** and click OK. If necessary replace D:\ with the letter of your CD-ROM drive.

5 Follow the instructions for installation of SCORBASE for ER 4u as they appear on the screen.

The following figures show the installation process:

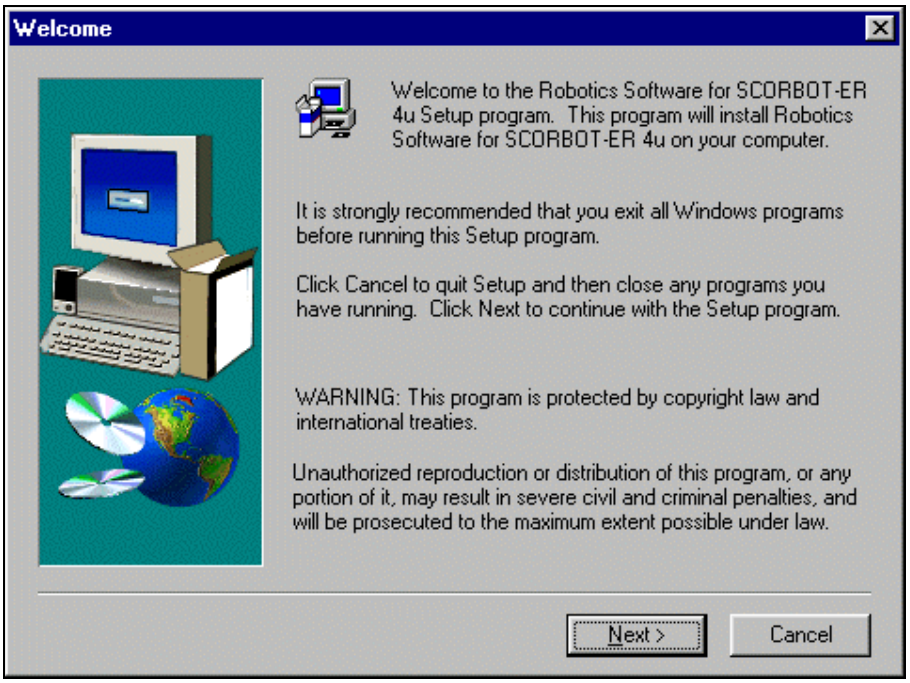


Figure 5

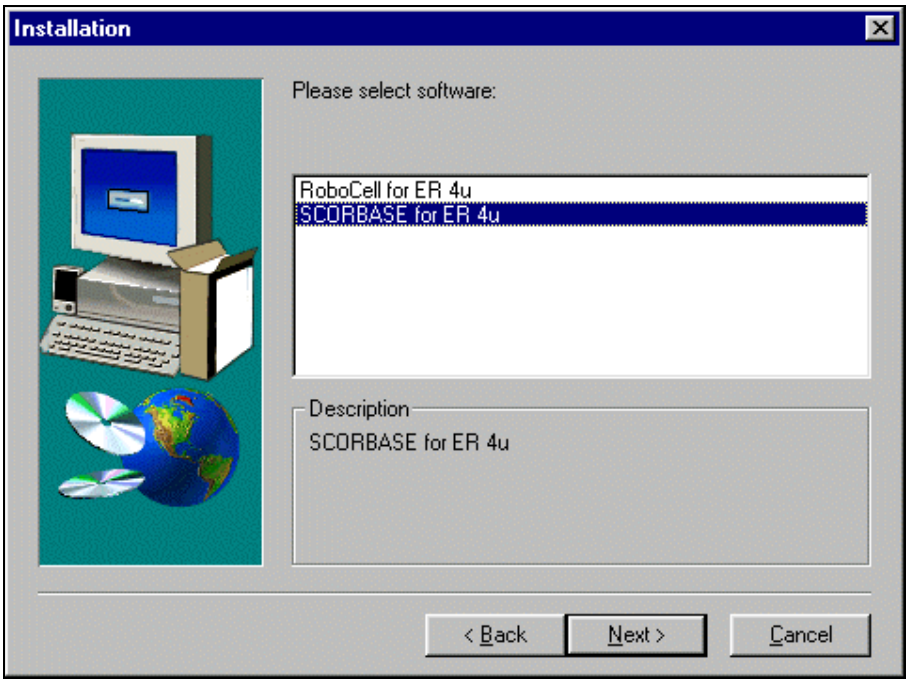


Figure 6

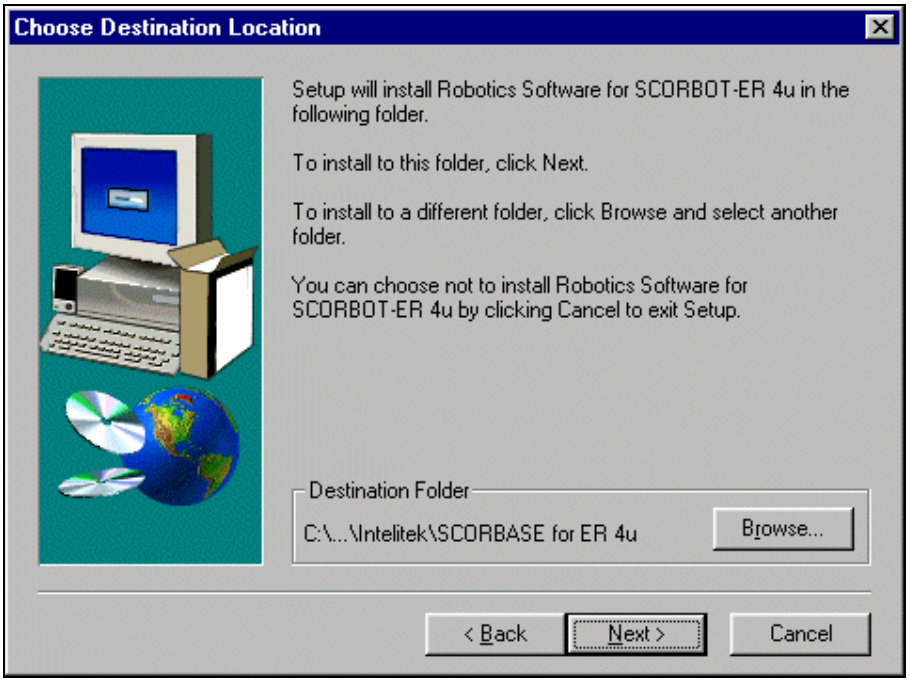


Figure 7

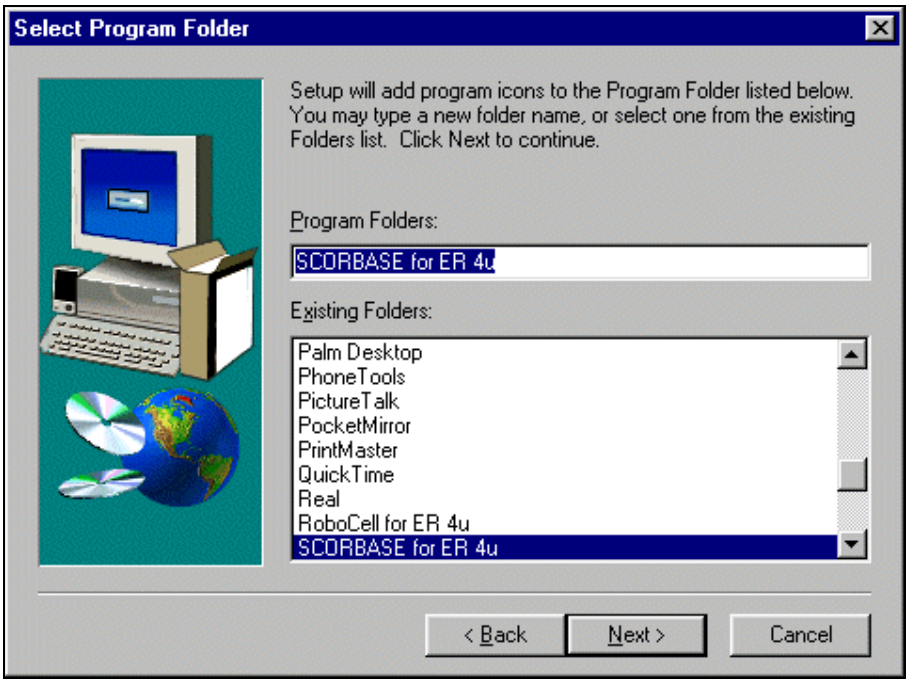


Figure 8

6 When installation is complete, a program group window will appear, similar to the one shown in Figure 9.

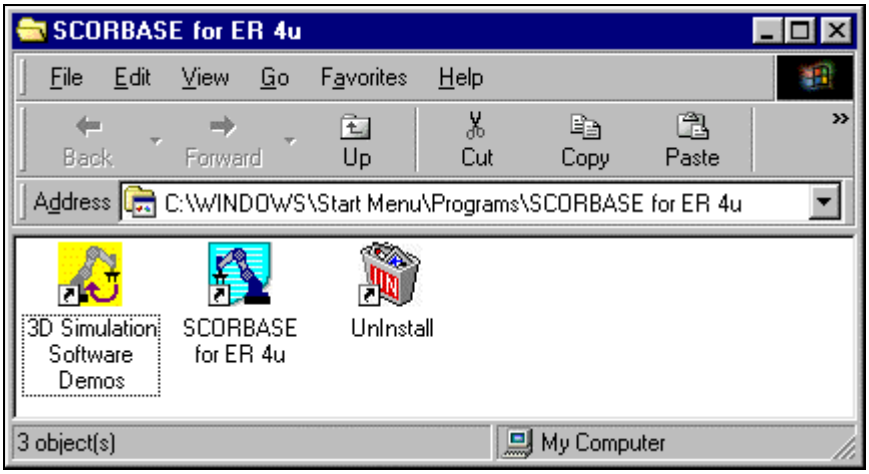


Figure 9

Uninstalling the Software

To uninstall SCORBASE, do one of the following:

- Select **Start | Programs | SCORBASE for ER 4u**.

  Activate the **Uninstall** command.

  OR

- Click on the **Uninstall** icon in the SCORBASE for ER 4u program group.

Activating the Software

To start SCORBASE, do the following:

1. Make sure that all components that will be used are installed and connected according to the installation procedures detailed in the User manuals supplied with the robot and controller.
2. Turn on the computer and the controller.
3. Do one of the following to activate the software:
   - Select **Start | Programs | SCORBASE for ER 4u**.

     Select the SCORBASE for ER 4u command.
   - Click on the **SCORBASE for ER 4u** icon from the SCORBASE for ER 4u program group.

The SCORBASE application window will appear.

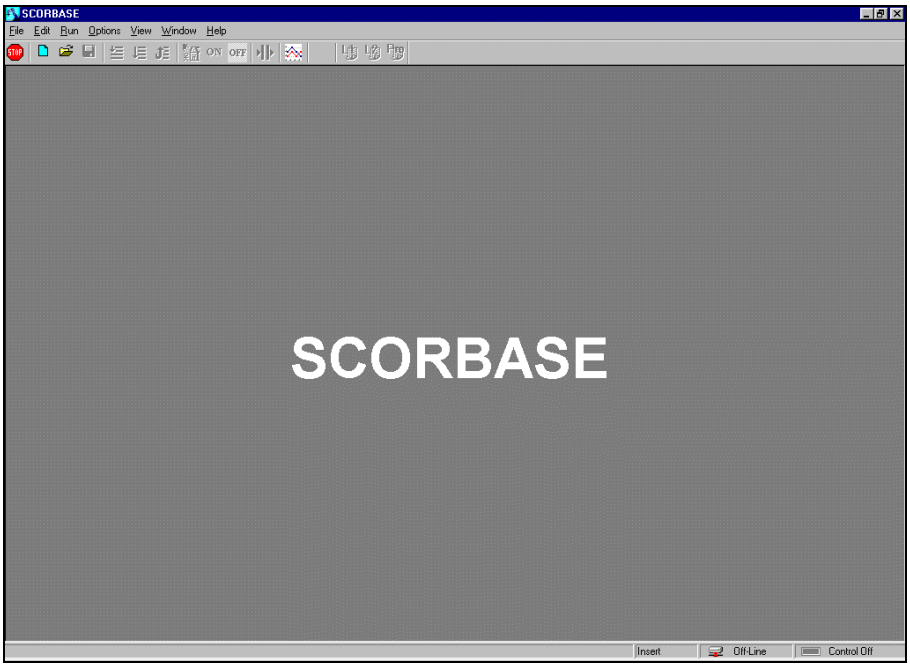


Figure 10: SCORBASE Opening Window

Only one application of SCORBASE can be active at a time.

Quitting the Software

1. Stop SCORBASE program (if running) and save project data.
2. Use any of the following standard Windows methods:
   - In SCORBASE, select **File | Exit**.
   - Press [Alt] + F4.
   - From the Title-bar click on application icon and select Close.

Experiment (I/O) Table

Connect the wire pairs from the Experiment Table to the Digital Input and Output terminals on the Controller-USB as follows:

1. Quit SCORBASE and shut down the PC.
2. Turn off the Controller-USB before making the input or output connections.
3. Connect the four microswitches to the **Inputs**. The input wire pairs have black sleeves.

   To connect a microswitch to a controller input, connect one wire of the pair to input ground and the other wire to the input terminal on the controller.

Microswitch, Input 1:	Purple, gray
Microswitch, Input 2:	green, blue
Microswitch, Input 3:	Yellow, orange
Microswitch, Input 4:	Brown, red

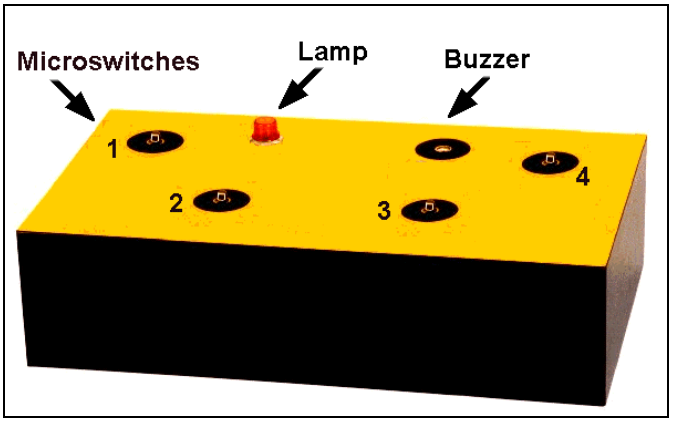


Figure 11 – Experiment Table

4. Connect the lamp and buzzer to **Outputs 1 to 4.**. The output wire pairs have red sleeves.

   To connect the lamp and buzzer to a controller output, connect one wire to the output COM terminal and the other wire to the same output NO terminal on the Controller-USB front panel.

Lamp, Output 1:	brown, red
Buzzer, Output 2:	black, white

5. Turn on the PC and start SCORBASE.

   The automatic initialization procedure should begin. It is recommended to home the robot.

   Then turn on the Controller-USB.

6 Place a block on the first microswitch, and do either of the following to check input:

- The LED for output 1 on the controller should be lit.
- In SCORBASE, select **View | Dialog Bars | Digital Inputs**. The number 1 in the Input 1 box should be highlighted red, as shown in Figure 12.

Figure 12 – SCORBASE: Digital Inputs & Outputs dialog box

7 Move the block consecutively to the second, third and fourth microswitches, and check the input signals for each.

8 Check the lamp by doing the following:

- In SCORBASE, select **View | Dialog Bars | Digital Outputs**.
- Click on the Output 1 box (the box should be highlighted in green).

Figure 13

The lamp on the Experiment Table should now be lit.

- Click again on the Output 1 box. The highlighting should disappear and the lamp on the Experiment Table should turn off.

Figure 14

9 Using Output 2, check the buzzer in the same way you checked the lamp. You will hear a buzzer when the output is on.

If the lamp and the buzzer fail to operate, try replacing the two AA batteries inside the Experiment Table. The batteries are accessed by removing the cover on the bottom of the table.

Once the table is positioned properly, duct tape can be used to hold it in place.

Conveyor and Sensor

1 Place the conveyor on the workcell table. Once it is positioned properly, duct tape can be used to hold it in place. It is preferable that you bolt the robot to the table.

2 Connect the D9 connector from the conveyor motor to the D9 connector marked **AXIS 8** on the Controller-USB.

3 Attach the photoelectric sensor to the side of the conveyor away from the robot, as shown in Figures 15 and 16.

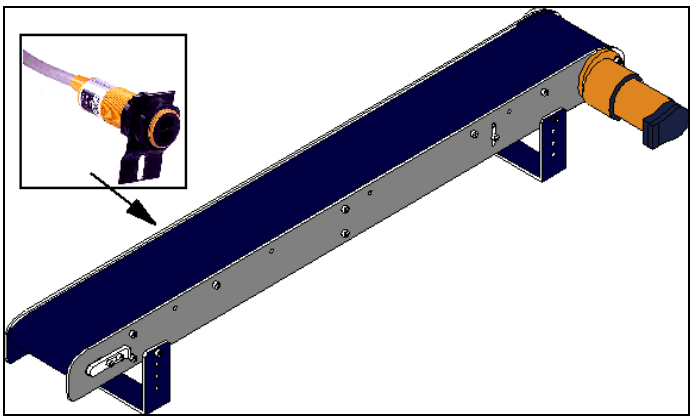


Figure 15

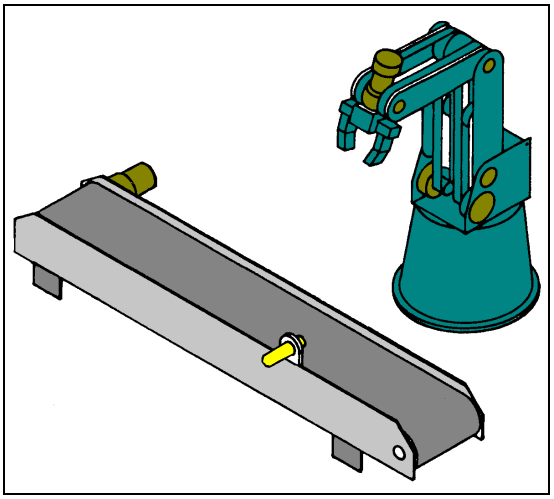


Figure 16 – Conveyor with Sensor

4. Connect the sensor to a 12-24V power source. There is a 12 volt power source on the controller front panel for this purpose.
5. Turn off the Controller-USB before you connect the input.
6. Connect the pair of wires from the photoelectric sensor to **Input 6** on the controller (one wire to input ground; one wire to the input terminal).
7. Turn on the Controller-USB.
8. In SCORBASE, select **Options | On-line** to work in on-line mode.
9. Place and keep an object in front of the photoelectric sensor, and do either of the following to check the input:
   - The LED for input 6 on the controller should be lit.
   - In SCORBASE, select View | Dialog Bars | Digital Inputs. The "6" should be highlighted in light green.

Once the conveyor is positioned properly, duct tape can be used to hold it in place. Or it may be bolted to the table.

Gravity Feeder with Microswitch

1. Adjust the legs of the gravity feeder so that it slopes at an angle of about 20-25°.
2. Place the four large round blocks supplied with the system in the feeder slide. Adjust and set the width of the slide according to these round blocks.
3. Turn off the Controller-USB before you connect the input.
4. Connect the pair of wires from the feeder's microswitch sensor **to Input 5** on the Controller-USB (one wire to input ground; one wire to the input terminal).
5. Turn on the Controller-USB.
6. With parts pressing on the feeder's microswitch, do either of the following to check the input:
   - The LED for input 5 on the controller should be lit.
   - In SCORBASE, select View | Dialog Bars | Digital Inputs. The "5" should be highlighted in light green.

Once the feeder is positioned properly, duct tape can be used to hold it in place. Or it may be bolted to the table.

Bins and Parts

Make sure that 6 round and 4 square blocks are present at the lab station.

Once the bin is positioned properly, duct tape can be used to hold it in place. Alternately it may be bolted to the table.

Inspection

Take time to familiarize yourself with the safety instructions in the user manuals supplied with the hardware, particularly for the Controller-PC.

In addition to a safety check and an inventory check at the start of every working session, a routine inspection of the system should also be performed, in the following order:

1. Before you power on the system, check the following items:
   - The installation meets all safety standards.
   - The robot is properly bolted to the work surface.
   - All cables are properly and securely connected. Cable connector screws are fastened.
   - No output is connected directly to a power supply.
   - No people are within the robot's working range.

2 After you have switched on the PC and the controller, check the following items:

- The power and motor LEDs on the controller light up.
- No unusual noises are heard.
- No unusual vibrations are observed in any of the robot axes.
- There are no obstacles in the robot's working range.

3 Bring the robot to a position near home, and activate the homing procedure. Check the following items:

- Robot movement is normal.
- No unusual noise is heard when robot arm moves.
- Robot reaches home position in every axis.

Solutions Diskette

Solutions Diskette

A copy of all projects that students will save (***USER#***) throughout the tekLINK appears in the section, “Solutions to Programming Tasks”, at the end of this Teacher's Guide. The tekLINK may also include a Solutions Diskette, which contains the correct project files that the student will save throughout the tekLINK. Using the SCORBASE options described below, you can review the students' programs and positions to make sure they are correct.

Printing the Programs and Positions

Should your laboratory have a printer, you can request that the students print at the end of each activity both the List of Positions and the Program. You can then compare the students' printed programs and positions with those in the Solutions Diskette or in the “Solutions to Programming Tasks” section of the Teacher's Guide.

Printing Programs

To print a program, do the following:

1. Select **File | Print Program**.
2. In the Print dialog box make sure that the default All is selected and that Portrait is selected in the Orientation field.
3. Click OK in the Print dialog box to print.

Printing Positions Lists

To print the defined positions, the position window must be open and active. Do the following to open the positions window and then print the list of recorded positions.

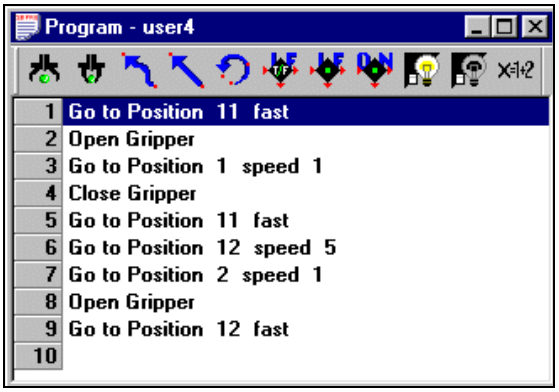
1. Select **Window | Project Screen** or from the software window, do the following:
   - Click in the Workspace window.
   - Double-click on the Project file.
   - Double-click on the Positions file for that Project.
2. Select **File | Print Positions**.

3 In the Print dialog box make sure that the default ALL is selected and that Portrait is selected in the Orientation field.

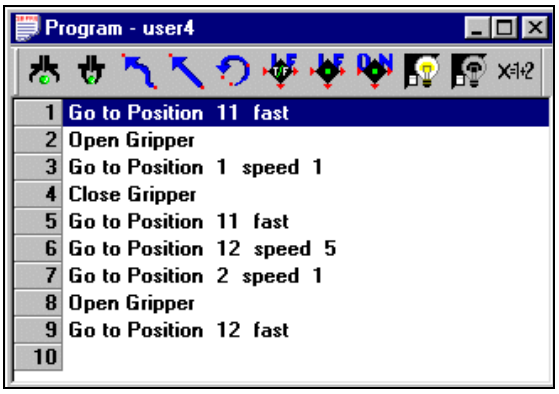
4 Click OK in the Print dialog box to print.

SCORBASE Programming Tasks

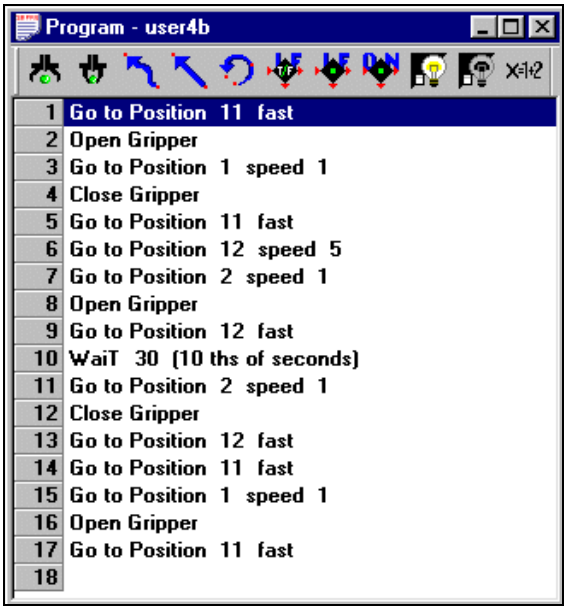
The following screen captures show the solutions for the student's SCORBASE programming tasks.



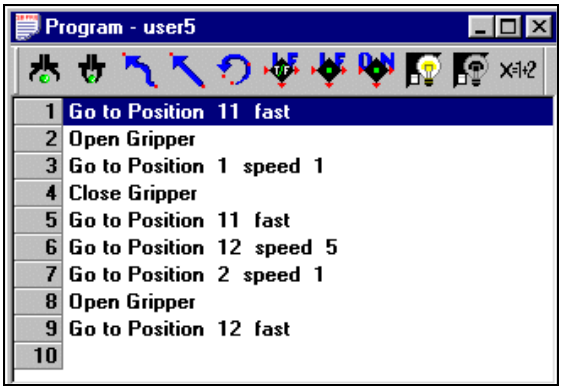
Program – 4



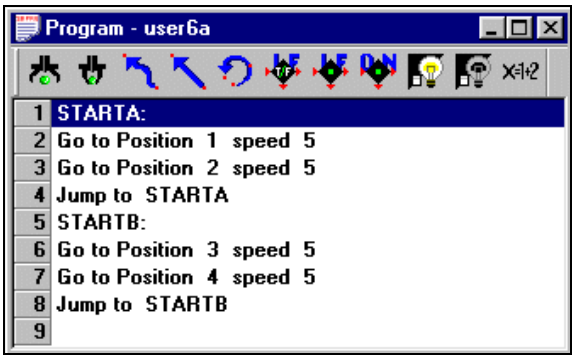
Program – 4a



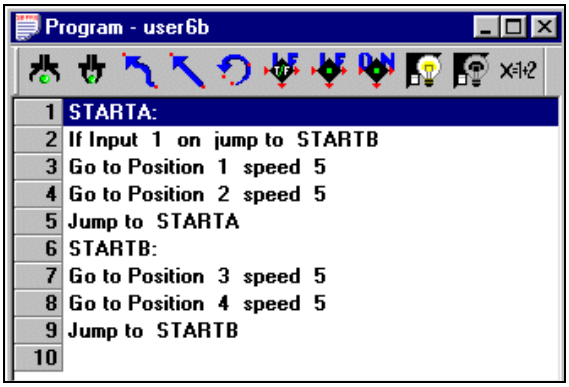
Program – 4b



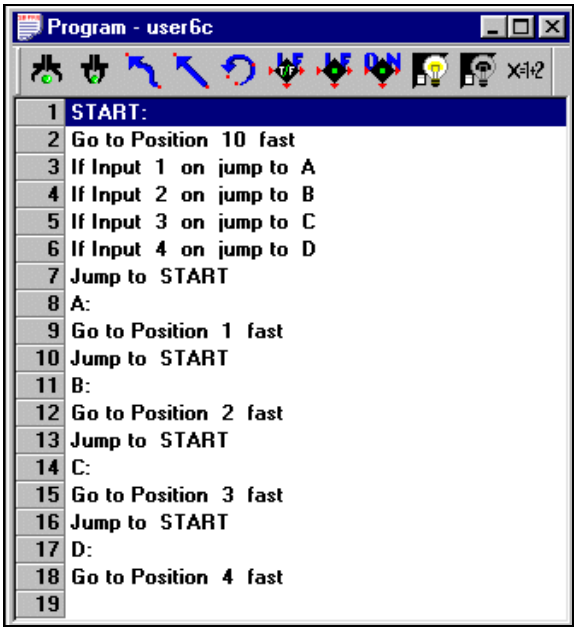
Program – 5



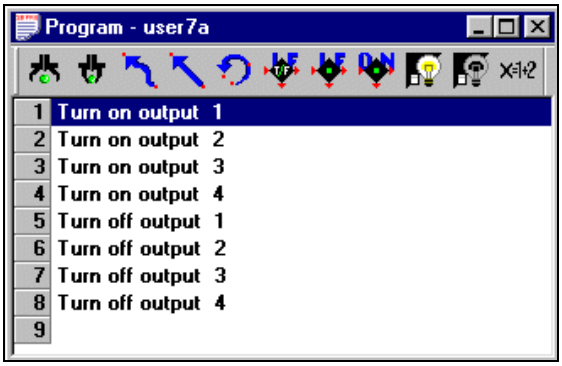
Program – 6A



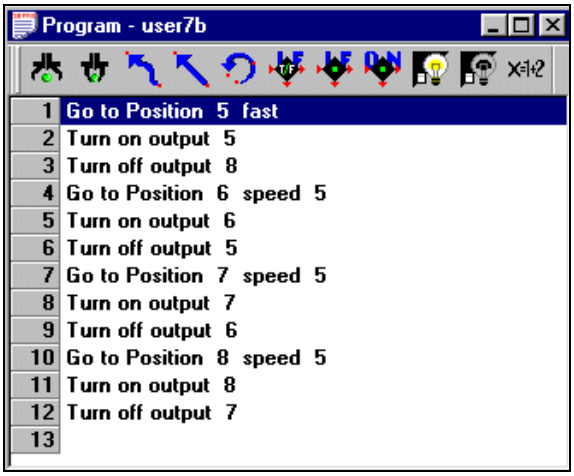
Program – 6B



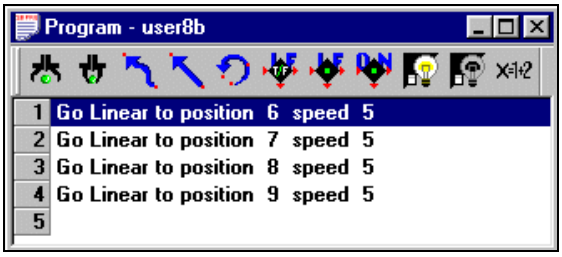
Program – 6C



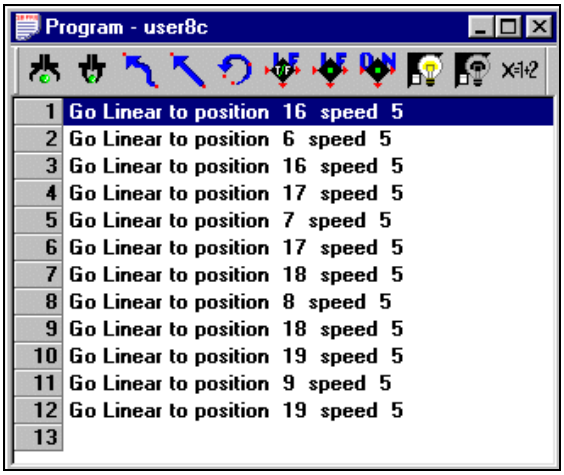
Program – 7A



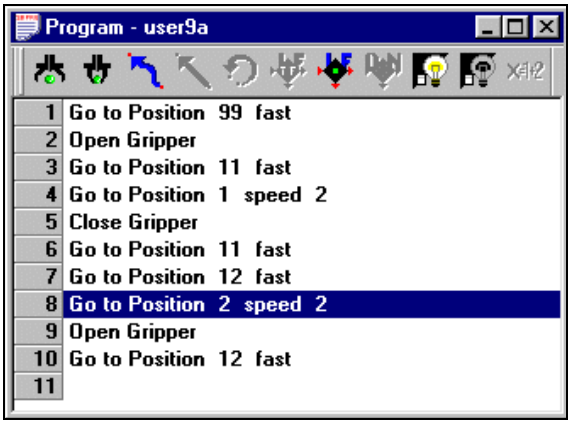
Program – 7B



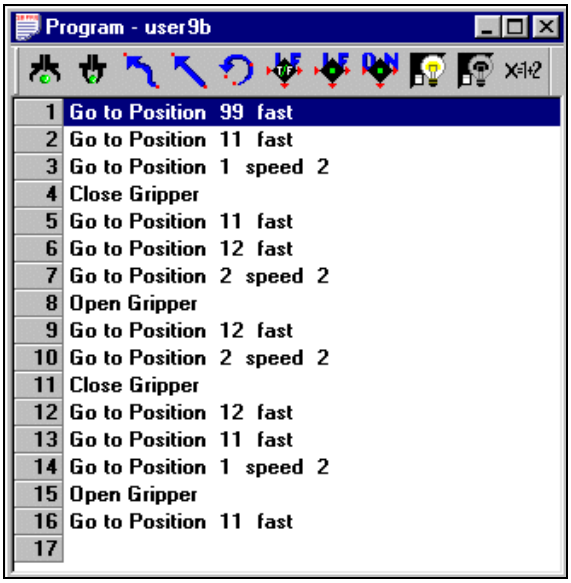
Program – 8B



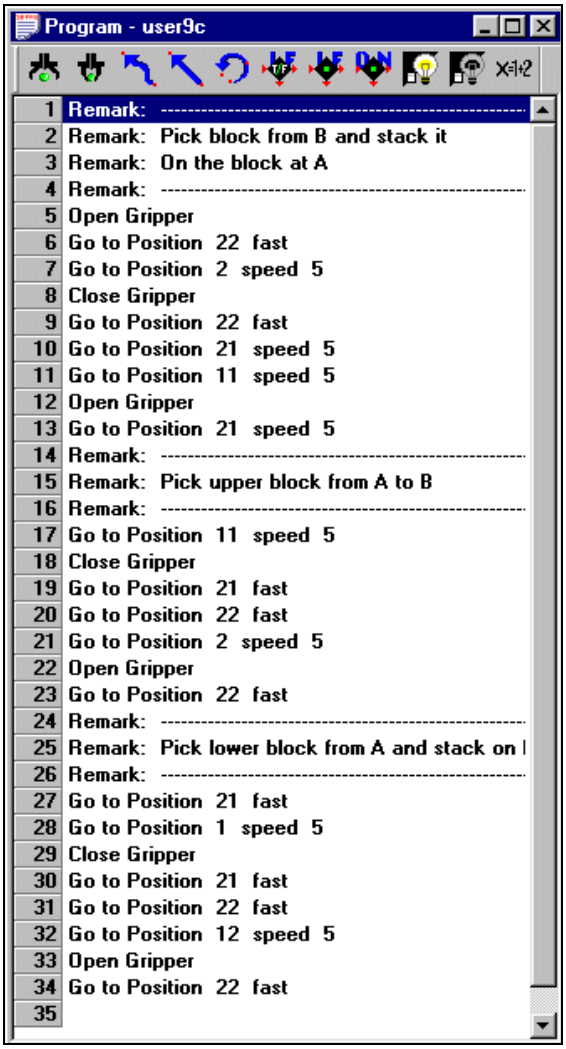
Program – 8C



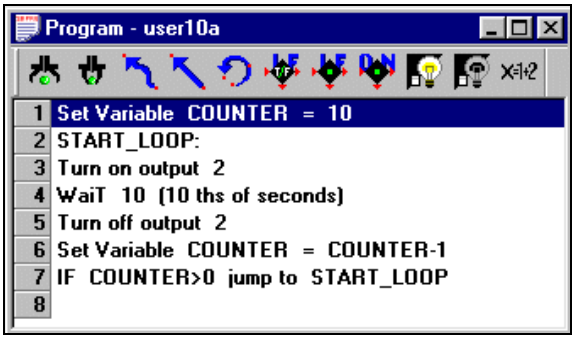
Program – 9A



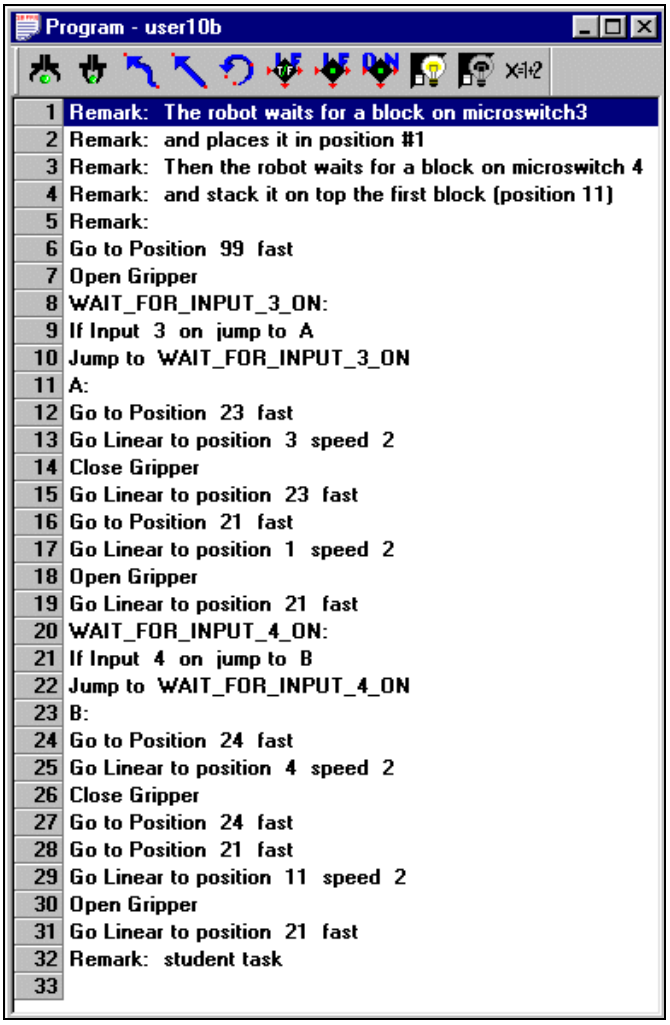
Program – 9B



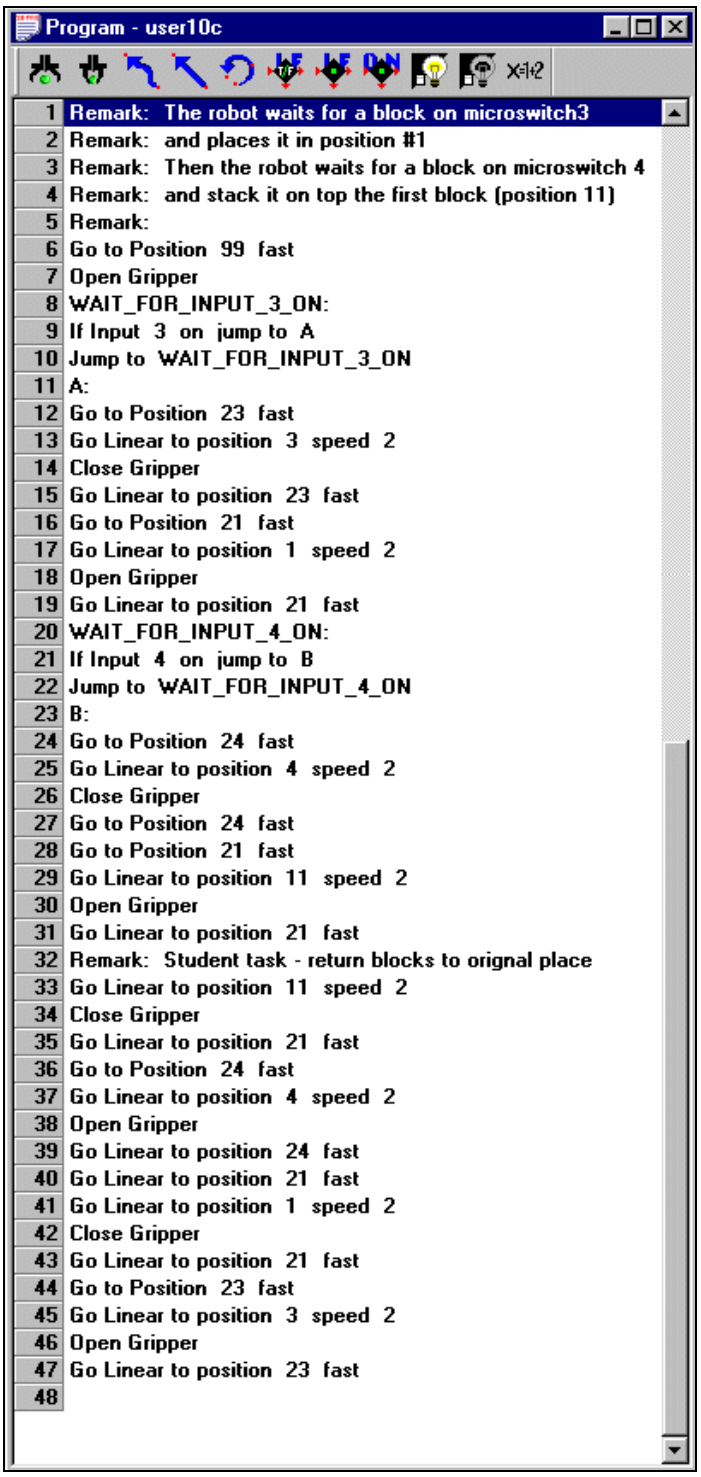
Program – 9C



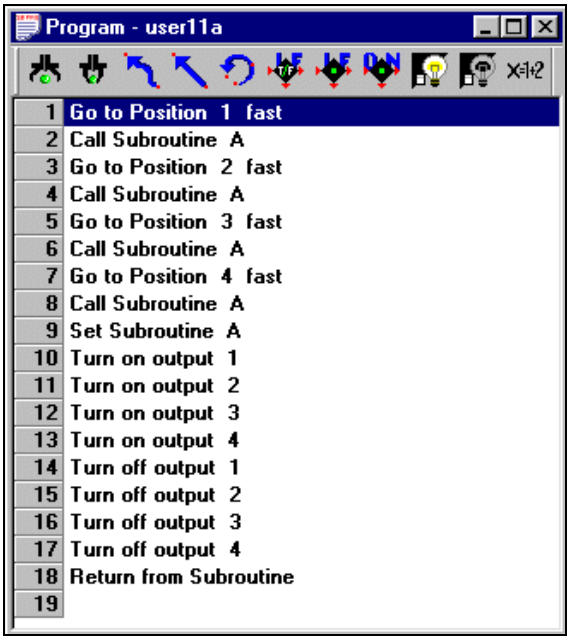
Program – 10A


Program - user10b
1 Remark: The robot waits for a block on microswitch3
2 Remark: and places it in position #1
3 Remark: Then the robot waits for a block on microswitch 4
4 Remark: and stack it on top the first block (position 11)
5 Remark:
6 Go to Position 99 fast
7 Open Gripper
8 WAIT_FOR_INPUT_3_ON:
9 If Input 3 on jump to A
10 Jump to WAIT_FOR_INPUT_3_ON
11 A:
12 Go to Position 23 fast
13 Go Linear to position 3 speed 2
14 Close Gripper
15 Go Linear to position 23 fast
16 Go to Position 21 fast
17 Go Linear to position 1 speed 2
18 Open Gripper
19 Go Linear to position 21 fast
20 WAIT_FOR_INPUT_4_ON:
21 If Input 4 on jump to B
22 Jump to WAIT_FOR_INPUT_4_ON
23 B:
24 Go to Position 24 fast
25 Go Linear to position 4 speed 2
26 Close Gripper
27 Go to Position 24 fast
28 Go to Position 21 fast
29 Go Linear to position 11 speed 2
30 Open Gripper
31 Go Linear to position 21 fast
32 Remark: student task
33

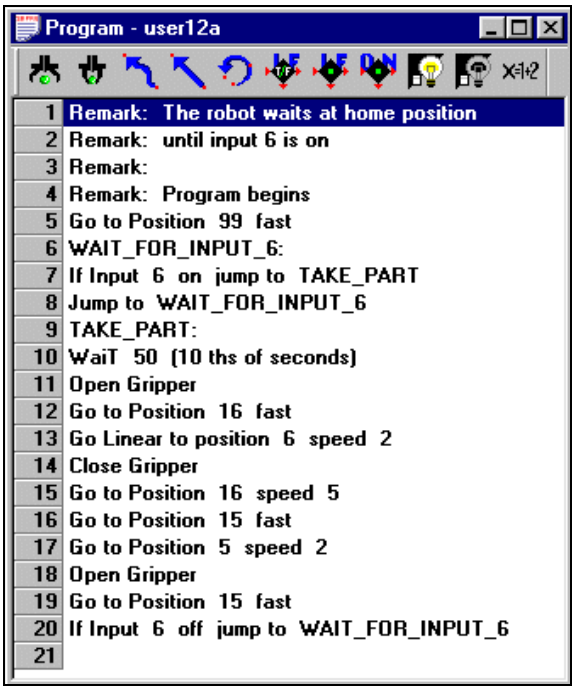
Program – 10B


Program - user10c
1 Remark: The robot waits for a block on microswitch3
2 Remark: and places it in position #1
3 Remark: Then the robot waits for a block on microswitch 4
4 Remark: and stack it on top the first block (position 11)
5 Remark:
6 Go to Position 99 fast
7 Open Gripper
8 WAIT_FOR_INPUT_3_ON:
9 If Input 3 on jump to A
10 Jump to WAIT_FOR_INPUT_3_ON
11 A:
12 Go to Position 23 fast
13 Go Linear to position 3 speed 2
14 Close Gripper
15 Go Linear to position 23 fast
16 Go to Position 21 fast
17 Go Linear to position 1 speed 2
18 Open Gripper
19 Go Linear to position 21 fast
20 WAIT_FOR_INPUT_4_ON:
21 If Input 4 on jump to B
22 Jump to WAIT_FOR_INPUT_4_ON
23 B:
24 Go to Position 24 fast
25 Go Linear to position 4 speed 2
26 Close Gripper
27 Go to Position 24 fast
28 Go to Position 21 fast
29 Go Linear to position 11 speed 2
30 Open Gripper
31 Go Linear to position 21 fast
32 Remark: Student task - return blocks to orignal place
33 Go Linear to position 11 speed 2
34 Close Gripper
35 Go Linear to position 21 fast
36 Go to Position 24 fast
37 Go Linear to position 4 speed 2
38 Open Gripper
39 Go Linear to position 24 fast
40 Go Linear to position 21 fast
41 Go Linear to position 1 speed 2
42 Close Gripper
43 Go Linear to position 21 fast
44 Go to Position 23 fast
45 Go Linear to position 3 speed 2
46 Open Gripper
47 Go Linear to position 23 fast
48

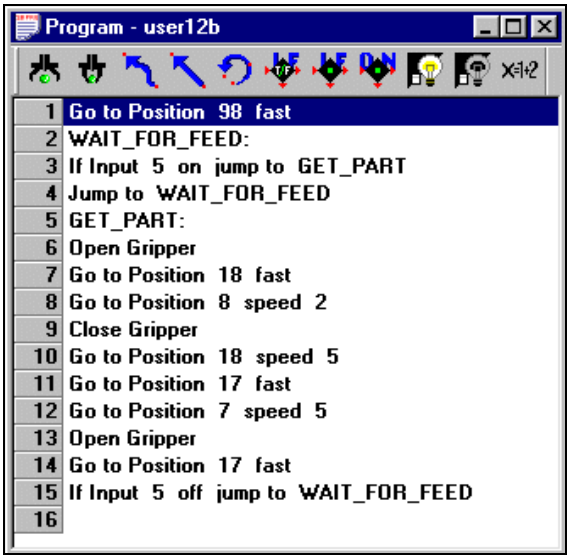
Program – 10C



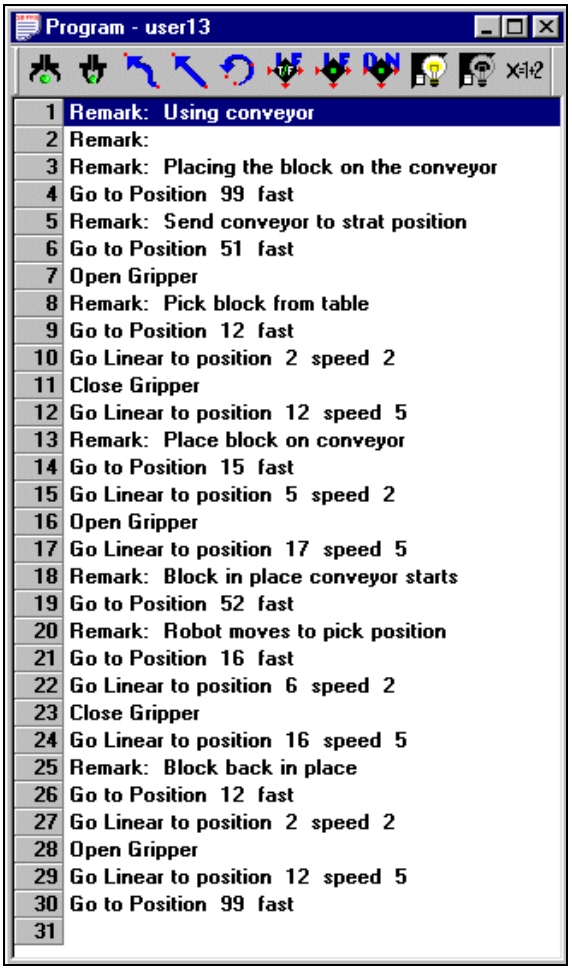
Program – 11A



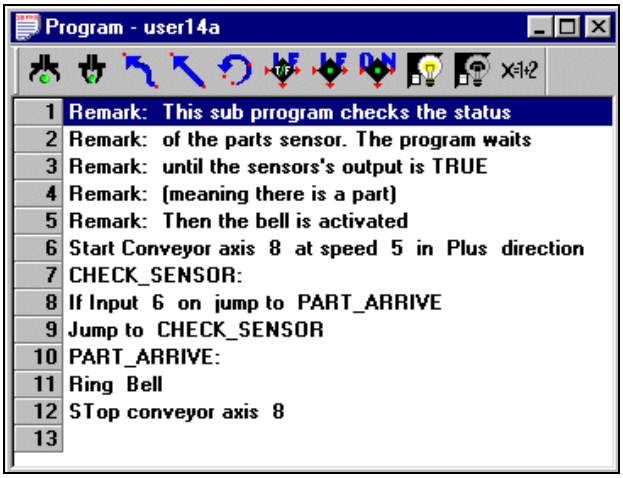
Program – 12A



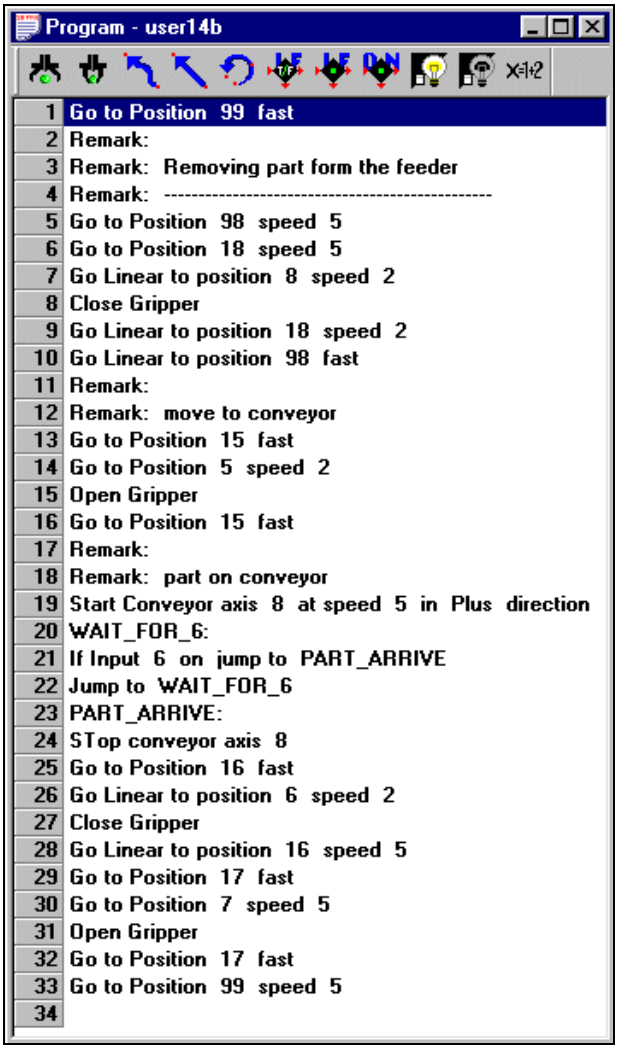
Program – 12B



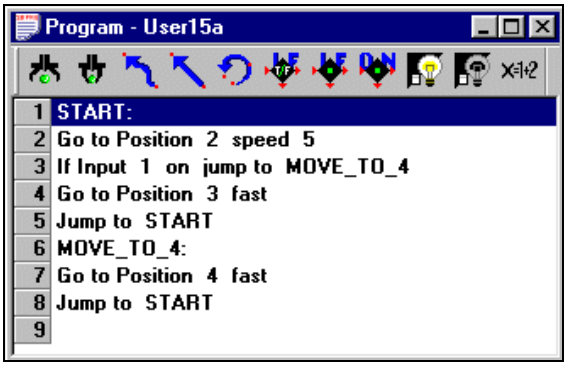
Program – 13



Program – 14A



Program – 14B


Program - User15a
1 START:
2 Go to Position 2 speed 5
3 If Input 1 on jump to MOVE_TO_4
4 Go to Position 3 fast
5 Jump to START
6 MOVE_TO_4:
7 Go to Position 4 fast
8 Jump to START
9

Program – 15A

Name: _____

Class: _____ **Date:** _____

Pre-test Answer Sheet

1	a	b	c	d
2	a	b	c	d
3	a	b	c	d
4	a	b	c	d
5	a	b	c	d
6	a	b	c	d
7	a	b	c	d
8	a	b	c	d
9	a	b	c	d
10	a	b	c	d
11	a	b	c	d
12	a	b	c	d
13	a	b	c	d
14	a	b	c	d
15	a	b	c	d
16	a	b	c	d
17	a	b	c	d
18	a	b	c	d
19	a	b	c	d
20	a	b	c	d

Pre-test

1 What is the function of the robot controller?

a) To monitor and control the action of the mechanical arm.

b) To write programs for the robot.

c) To place the workpieces where the robot can reach them.

d) To monitor and control the action of the operator.

2 What is the function of the robot manipulator?

a) To turn on outputs.

b) To move the end effector to the proper positions.

c) To turn on the controller.

d) To move the conveyor belt.

3 Which device is not a robotic end effector?

a) Gripper.

b) Screwdriver.

c) Drill.

d) Output terminal.

4 Why do robots have internal sensors?

e) To enable the operator to locate objects.

f) To enable the robot controller to locate objects.

g) To enable the operator to determine the robot's position.

h) To enable the robot controller to monitor the robot's position.

5 Why do robotic systems often include external sensors?

a) To enable the robot to locate objects.

b) To enable the operator to locate objects.

c) To read input signals.

d) To send output signals.

6 Which of the following devices produces a controller input signal?

a) A buzzer.

b) A microswitch.

c) A lamp.

d) A LED.

7 The controller sends an output signal to which device?

a) A lamp.

b) A robot axis.

c) A servo gripper.

d) A microswitch.

8 What are the main components of a manipulator arm?

a) Links and joints.

b) Links and end effector.

c) Base and end effector.

d) Controller and robot.

9 Which is not a method for manipulating the robot arm?

a) Using a hand-held control box.

b) Using the terminal or computer keyboard.

c) Using controller outputs.

d) Using robotic software.

10 What is the robot home?

a) The factory which produced the robot.

b) The robot's work environment. c

c) A fixed reference position.

d) A specific position defined by the operator.

11 What is a robot position?

a) A set of coordinates which define the robot's home.

b) A set of coordinates which define the robot's location in space.

c) XYZ.

d) Joints.

12 What is the function of a parts feeder?

a) To put parts in the robot's gripper.

b) To sort the parts which the robot will handle.

c) To discard the parts which have failed inspection.

d) To supply parts to the robotic workcell.

13 What is the function of a conveyor belt?

a) To take parts to and from the robotic workcell.

b) To sort the parts which the robot will handle.

c) To move the robot axes.

d) To carry the manipulator arm.

14 When can the robot open the gripper?

a) When the robot is at its home position.

b) When there is an object in the gripper.

c) When there is no object in the gripper.

d) All of the above.

15 After robot positions have been recorded, what should you do?

a) Turn off the controller.

b) Delete the program.

c) Home the robot.

d) Save the positions.

16 What are the two required stages in programming the robot?

a) Writing the program and recording the positions.

b) Operating the robot and recording positions.

c) Writing the program and saving the program.

d) Recording the positions and saving the positions.

17 What is a robot program?

a) A set of commands which the robotic system will perform.

b) A series of robot movements.

c) A set of robot positions.

d) The SCORBASE software.

18 What is the safest way to stop the robot system in an emergency?

a) Press the red Emergency button.

b) Turn off the computer.

c) Turn off the controller.

d) Pull the plug out of the socket.

19 What drives (actuates) the joints on the robot arm?

a) Encoders.

b) Motors.

c) The controller.

d) The operator.

20 Why might the operator need to press the Emergency stop button?

a) The program has a bug in it.

b) A part to be handled is in the wrong position.

c) The robot is in the wrong position. d

d) All of the above.

Pre-test Answer Key

1	**a**	b	c	d
2	a	b	c	**d**
3	a	**b**	c	d
4	a	b	c	**d**
5	a	**b**	c	d
6	a	**b**	c	d
7	a	b	c	**d**
8	a	b	**c**	d
9	a	b	**c**	d
10	**a**	b	c	d
11	a	**b**	c	d
12	a	b	c	**d**
13	a	b	**c**	d
14	a	b	c	**d**
15	**a**	b	c	d
16	a	b	**c**	d
17	a	b	c	**d**
18	a	b	c	**d**
19	**a**	b	c	d
20	a	b	c	**d**

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b) Screwdriver.

c) **Drill.**

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f) To enable the robot controller to locate objects.

g) To enable the operator to determine the robot's position.

h) **To enable the robot controller to monitor the robot's position.**

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c) **Using controller outputs.**

d) Using robotic software.

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d) **Save the positions.**

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d) Recording the positions and saving the positions.

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b) **Motors.**

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d) The operator.

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a) The program has a bug in it.

b) A part to be handled is in the wrong position.

c) The robot is in the wrong position. d

d) **All of the above.**

Name: _____

Class: _____ **Date:** _____

Post-test Answer Sheet

1	a	b	c	d
2	a	b	c	d
3	a	b	c	d
4	a	b	c	d
5	a	b	c	d
6	a	b	c	d
7	a	b	c	d
8	a	b	c	d
9	a	b	c	d
10	a	b	c	d
11	a	b	c	d
12	a	b	c	d
13	a	b	c	d
14	a	b	c	d
15	a	b	c	d
16	a	b	c	d
17	a	b	c	d
18	a	b	c	d
19	a	b	c	d
20	a	b	c	d

21	a	b	c	d
22	a	b	c	d
23	a	b	c	d
24	a	b	c	d
25	a	b	c	d
26	a	b	c	d
27	a	b	c	d
28	a	b	c	d
29	a	b	c	d
30	a	b	c	d
31	a	b	c	d
32	a	b	c	d
33	a	b	c	d
34	a	b	c	d
35	a	b	c	d
36	a	b	c	d
37	a	b	c	d
38	a	b	c	d
39	a	b	c	d
40	a	b	c	d
41	a	b	c	d
42	a	b	c	d

Post-test

1 Why do robots have internal sensors? [Activity 1]

a) To enable the operator to locate objects.

b) To enable the robot controller to locate objects.

c) To enable the operator to determine the robot's position.

d) To enable the robot controller to monitor the robot's position.

2 What is a series of commands separate from the main robot program? [Activity 11]

a) Input.

b) Output.

c) Subroutine.

d) Remark.

3 Which of the following devices produces a controller input signal? [Activity 6]

a) A buzzer.

b) A microswitch.

c) A lamp.

d) A LED.

4 When can the robot open the gripper? [Activity 2]

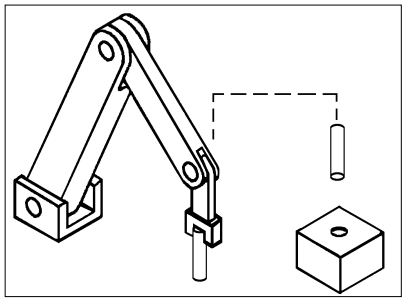
a) When the robot is at its home position.

b) When there is an object in the gripper.

c) When there is no object in the gripper.

d) All of the above.

5 What kind of task is this robot performing? [Activity 5]



a) Drilling.

b) Assembly.

c) Sensing.

d) Loading.

6 What is the robot home? [Activity 2]

a) The factory which produced the robot.

b) The robot's work environment.

c) A fixed reference position.

d) A specific position defined by the operator.

7 What does on-line programming mean? [Activity 4]

a) Program has one main routine.

b) Robot is taught positions in the workcell.

c) Positions are taught in a line.

d) Programmer makes a diagram of the task.

8 What is a robot position? [Activity 3]

a) A set of coordinates which define the robot's home.

b) A set of coordinates which define the robot's location in space.

c) XYZ.

d) Joints.

9 Which of the following is not found in a robot program? [Activity 4]

a) Input command.

b) Robot arm movement command.

c) Home position.

d) Remark.

10 What is the function of the robot controller? [Activity 1]

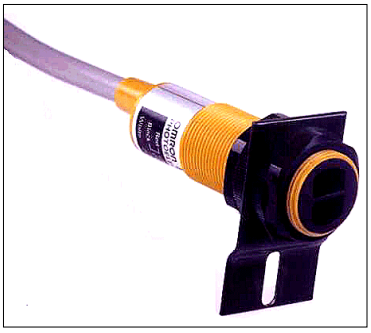
a) To monitor and control the action of the mechanical arm.

b) To write programs for the robot.

c) To place the workpieces where the robot can reach them.

d) To monitor and control the action of the operator.

11 What is this device? [Activity 12]



a) A gripper.

b) A microphone.

c) A sensor.

d) An encoder.

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a) A position near the robot home.

b) A set of coordinates which defines the robot's location in space.

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d) A set of coordinates which defines an offset from another position.

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b) To enable the operator to locate objects.

c) To read input signals.

d) To send output signals.

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a) To put parts in the robot's gripper.

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c) To discard the parts which have failed inspection.

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a) Buzzer.

b) Photoelectric sensor.

c) Microswitch.

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16 What are the main components of a manipulator arm? [Activity 1]

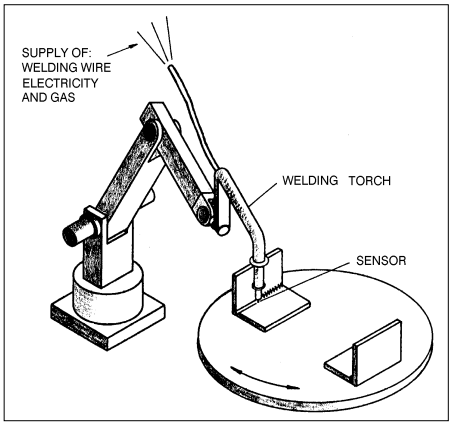
a) Links and joints.

b) Links and end effector.

c) Base and end effector.

d) Controller and robot.

17 What is this robot doing?



a) Sensing.

b) Painting.

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b) Using the terminal or computer keyboard.

c) Using controller outputs.

d) Using robotic software.

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b) Delete the program.

c) Home the robot.

d) Save the positions.

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a) Writing the program and recording the positions.

b) Operating the robot and recording positions.

c) Writing the program and saving the program.

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b) As slow as possible.

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b) Elbow

c) Base

d) Shoulder

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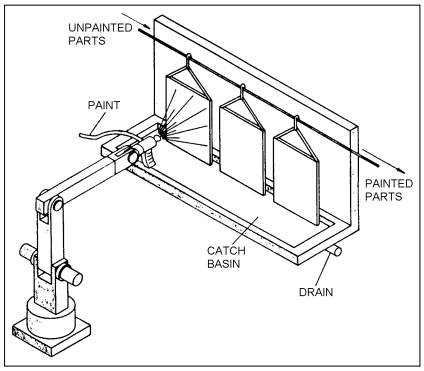

a) Drilling.

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c) Cutting.

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b) Usually

c) Rarely

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a) The robot can assemble different parts simultaneously.

b) The robot can have different models.

c) The robot can be used for different manufacturing tasks.

d) The robot can be taught different positions.

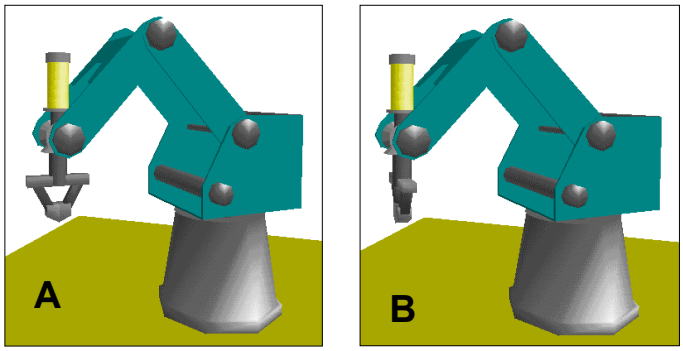
28 To move the robot from position A to position B, which joint must move? [Activity 2]

a) Elbow

b) Base

c) Wrist

d) Gripper



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a) A set of commands which the robotic system will perform.

b) A series of robot movements.

c) A set of robot positions.

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a) To take parts to and from the robotic workcell.

b) To sort the parts which the robot will handle.

c) To move the robot axes.

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a) A lamp.

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b) Non-contact.

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d) All of the above.

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a) Press the red Emergency button.

b) Turn off the computer.

c) Turn off the controller.

d) Pull the plug out of the socket.

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a) To avoid damaging materials or equipment.

b) To make sure the robot can perform the operation without damaging materials.

c) To measure the time it takes to perform the operation.

d) All of the above.

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b) Motors.

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a) Quicker to complete program cycle.

b) Operation is more predictable.

c) Robot is responsive to workcell signals.

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a) Delete a robot position.

b) Change the program name.

c) Count the number of times a routine has been completed.

d) Notify the operator that the program has changed.

39 Which of the following is not likely a task for a robot?

a) Painting with an air brush.

b) Welding with a welding gun.

c) Cutting with a scissors.

d) Placing parts into a sorting bin.

40 Which device is not a robotic end effector? [Activity 1]

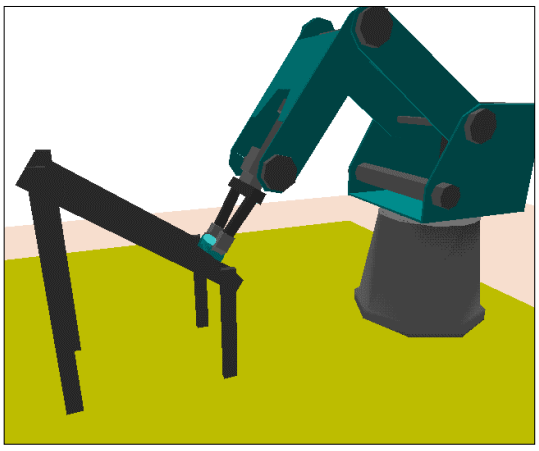
a) Gripper.

b) Screwdriver.

c) Drill.

d) Output terminal.

41 What is the robot doing? [Activity 12]



a) Placing a part in a feeder.

b) Taking a part from a feeder.

c) Placing a part on a conveyor.

d) Taking a part from a conveyor.

42 Where should the robot go immediately after it moves away from this position? [Activity 12]

a) To an absolute position.

b) To a relative position.

c) To the home position.

d) To a drop-off position.

Post-test Answer Key

1	a	b	c	**d**
2	a	b	**c**	d
3	a	**b**	c	d
4	a	b	c	**d**
5	a	**b**	c	d
6	a	b	**c**	d
7	a	**b**	c	d
8	a	**b**	c	d
9	a	b	**c**	d
10	**a**	b	c	d
11	a	b	**c**	d
12	a	b	c	**d**
13	**a**	b	c	d
14	a	b	c	**d**
15	a	b	**c**	d
16	**a**	b	c	d
17	a	b	**c**	d
18	a	b	**c**	d
19	a	b	c	**d**
20	**a**	b	c	d

21	**a**	b	c	d
22	a	b	**c**	d
23	a	b	c	**d**
24	a	**b**	c	d
25	a	**b**	c	d
26	a	b	c	**d**
27	a	b	**c**	d
28	a	b	**c**	d
29	**a**	b	c	d
30	**a**	b	c	d
31	**a**	b	c	d
32	a	b	**c**	d
33	a	b	c	**d**
34	**a**	b	c	d
35	a	b	c	**d**
36	a	**b**	c	d
37	a	b	**c**	d
38	a	b	**c**	d
39	a	b	**c**	d
40	a	b	c	**d**
41	a	**b**	c	d
42	a	**b**	c	d

1 Why do robots have internal sensors? [Activity 1]

a) To enable the operator to locate objects.

b) To enable the robot controller to locate objects.

c) To enable the operator to determine the robot's position.

d) **To enable the robot controller to monitor the robot's position.**

2 What is a series of commands separate from the main robot program? [Activity 11]

a) Input.

b) Output.

c) **Subroutine.**

d) Remark.

3 Which of the following devices produces a controller input signal? [Activity 6]

a) A buzzer.

b) **A microswitch.**

c) A lamp.

d) A LED.

4 When can the robot open the gripper? [Activity 2]

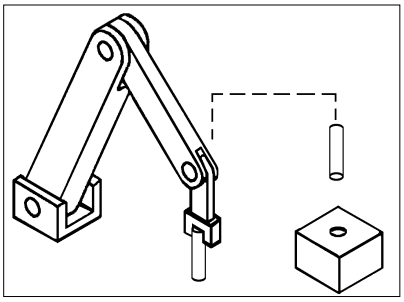
a) When the robot is at its home position.

b) When there is an object in the gripper.

c) When there is no object in the gripper.

d) **All of the above.**

5 What kind of task is this robot performing? [Activity 5]



a) Drilling.

b) **Assembly.**

c) Sensing.

d) Loading.

6 What is the robot home? [Activity 2]

a) The factory which produced the robot.

b) The robot's work environment.

c) **A fixed reference position.**

d) A specific position defined by the operator.

7 What does on-line programming mean? [Activity 4]

a) Program has one main routine.

b) **Robot is taught positions in the workcell.**

c) Positions are taught in a line.

d) Programmer makes a diagram of the task.

8 What is a robot position? [Activity 3]

a) A set of coordinates which define the robot's home.

b) **A set of coordinates which define the robot's location in space.**

c) XYZ.

d) Joints.

9 Which of the following is not found in a robot program? [Activity 4]

a) Input command.

b) Robot arm movement command.

c) **Home position.**

d) Remark.

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a) **To monitor and control the action of the mechanical arm.**

b) To write programs for the robot.

c) To place the workpieces where the robot can reach them.

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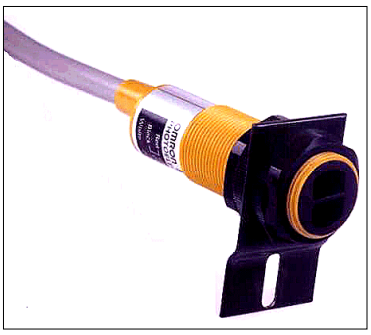

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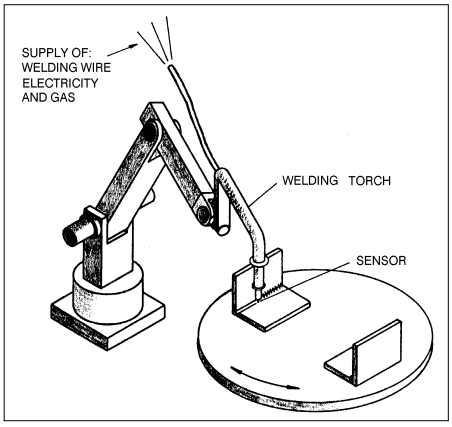

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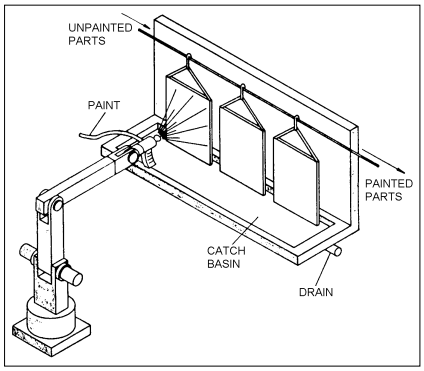

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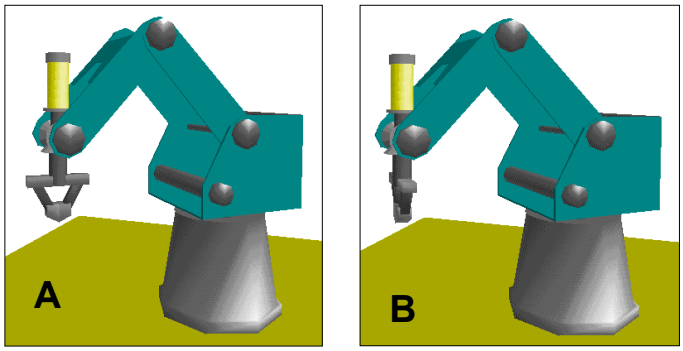

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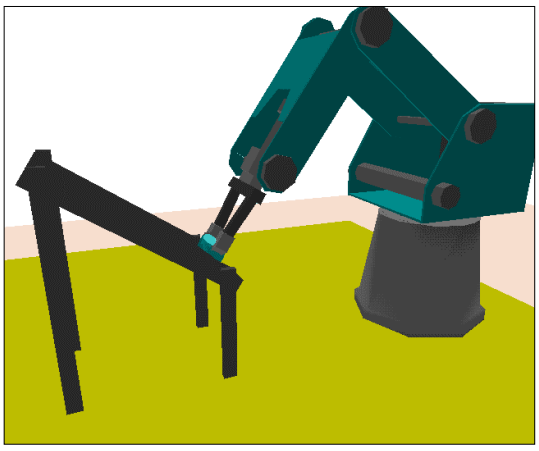

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a) To an absolute position.

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c) To the home position.

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Name: _____

Class: _____Date: _____

Activity 1 - Worksheets

Getting Started

Task 1-1: Introduction to the Robotics and Materials Handling

Q What are the three key elements in the definition of a robot?

_____

_____

_____

_____

_____

Q What are the four most important components in a robotic system?

_____

_____

_____

_____

Q What allows a flexible automation system to perform different operations?

_____

_____

_____

Task 1-2: Safety Guidelines

Q Does your robotic workcell conform with the safety guidelines?

_____

Name: _____

Class: _____ **Date:** _____

Q List points in the system (both the robot and the controller) which are the most dangerous to touch?

_____

_____

_____

Task 1-3: Identifying Robot Components

Refer to the actual SCORBOT-ER 4u robot. In the figure on the worksheet, mark the following parts of the robot:

- Robot Joints: Base, Shoulder, Elbow, Wrist Pitch, Wrist Roll
- Gripper
- Motors and Encoders

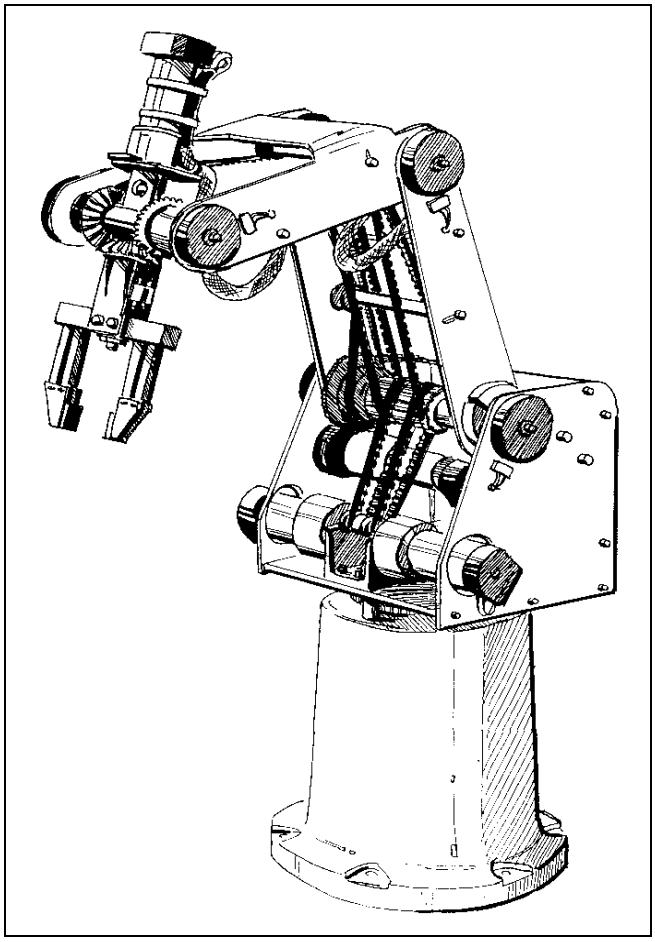


Figure 1

Name: _____

Class: _____ **Date:** _____

Task 1-4: Identifying Controller Components

Refer to the actual Controller-B. In the figure below, mark the following parts of the controller:

- On/Off Power switch (at rear)
- Input and Output terminals and LEDs
- Peripheral Axis (conveyor) connector
- Emergency Button

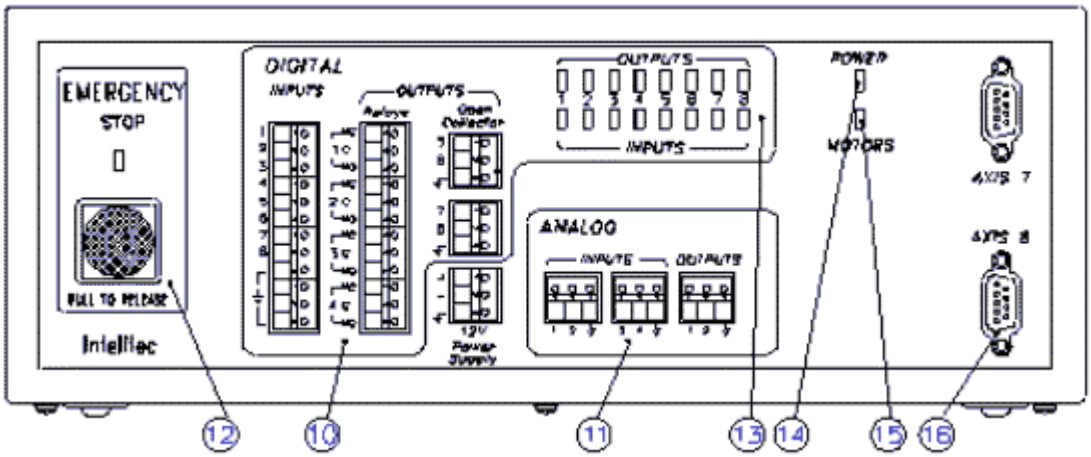


Figure 2

Name: _____

Class: _____ **Date:** _____

Task 1-5: Identifying Workcell Elements

Refer to the lab module. In the figure below, mark the elements found in the workcell:

- Experiment Table: Microswitches; Lamp; Buzzer
- Conveyor Belt: Photoelectric Sensor
- Parts Feeder: Microswitch Sensor
- Parts Bin
- Workpieces

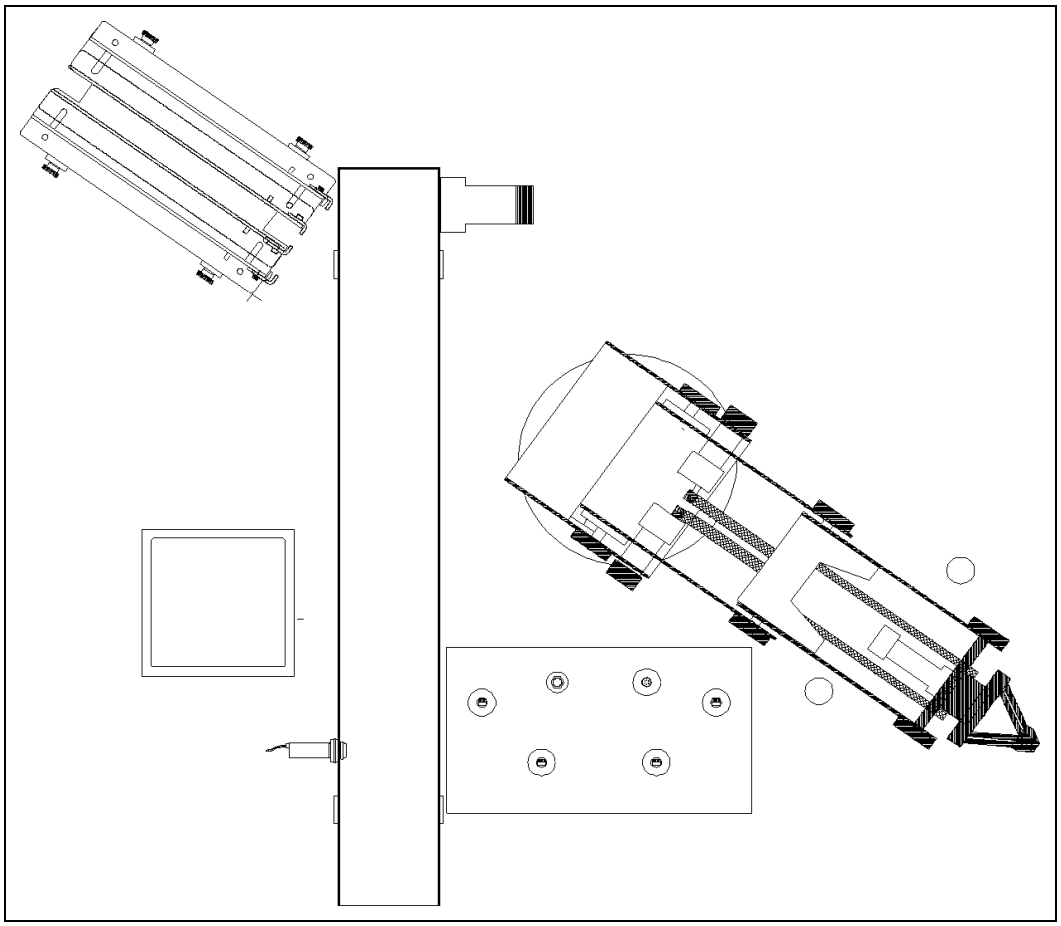


Figure 3

Name: _____

Class: _____Date: _____

Activity 2 - Worksheets

Homing and Moving the Robot

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
2 different blocks (any shape)	
The robotic workcell conforms to safety guidelines	

Task 2-3: Homing the Robot

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

_____

_____

_____

_____

_____

_____

Task 2-5: Robot Working Limits

Q Describe the system response to the encounter between the robot arm and the table.

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Task 2-6: Operating the Gripper

Q What effect does the Close Gripper command have on the gripper?

_____

_____

Q What kind of objects can the SCORBOT gripper grasp?

_____

_____

_____

Task 2-7: Changing Speed Settings

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

_____

_____

Task 2-8: Team Discussion and Review

Q What is the robot home position and why is it needed?

_____

_____

_____

_____

_____

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

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Q How do the robot joints determine the gripper location and orientation?

_____

_____

_____

_____

_____

_____

_____

_____

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	

Name: _____

Class: _____ **Date:** _____

Name: _____

Class: _____Date: _____

Activity 3 - Worksheets

Recording Robot Positions

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 3-8: Team Discussion and Review

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

_____

_____

_____

_____

_____

_____

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

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	

Name: _____

Class: _____Date: _____

Activity 4 - Worksheets

Writing and Running Robot Programs

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 4-9: Team Discussion and Review

Q Modify the program so that the robot returns the object from the Place position to the Pick position. Save the program as USER4B.

Name: _____

Class: _____ **Date:** _____

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	

Name: _____

Class: _____Date: _____

Activity 5 - Worksheets

Pick and Place Programs

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Diskette or personal subdirectory on computer hard drive	
Several blocks (round and square)	
Loose sheet of paper	
Small, self-adhesive squares of paper	
The robotic workcell conforms to safety guidelines	

Task 5-3: Teaching Positions

Position #	X (mm)	Y (mm)	Z (mm)	P (deg)	R (deg)
1					
11			100		
2					
12			100		

Table 5-1: Position table

Name: _____

Class: _____ **Date:** _____

Task 5-9: Team Discussion and Review

Q Describe two or three robotic applications which would require a pick and place sequence similar to the one you programmed in this activity (program USER5).

_____

_____

_____

_____

_____

_____

_____

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	
All other materials returned to supply box or cabinet.	

Name: _____

Class: _____Date: _____

Activity 6 - Worksheets

Inputs and Program Jumps

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Diskette or personal subdirectory on computer hard drive	
Experiment table	
Two blocks (any shape)	
The robotic workcell conforms to safety guidelines	

Task 6-2: Programming with Labels and Unconditional Jumps

Q Describe the system response. What are your conclusions concerning the effectiveness of the Jump to Label command?

_____

_____

_____

_____

_____

Task 6-3: Programming with Inputs and Conditional Jumps

Q Describe the difference between program USER6A and USER6B.

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Task 6-5: Team Discussion and Review

Q Describe the kind of information that is received by the controller inputs.

Q Describe the use of an unconditional jump command.

Q Describe the use of a conditional jump command.

Name: _____

Class: _____ **Date:** _____

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	

Name: _____

Class: _____ **Date:** _____

Name: _____

Class: _____Date: _____

Activity 7 - Worksheets

Outputs

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Experiment Table	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 7-5: Team Discussion and Review

Q Describe the kind of information that is transmitted by the controller outputs.

_____

_____

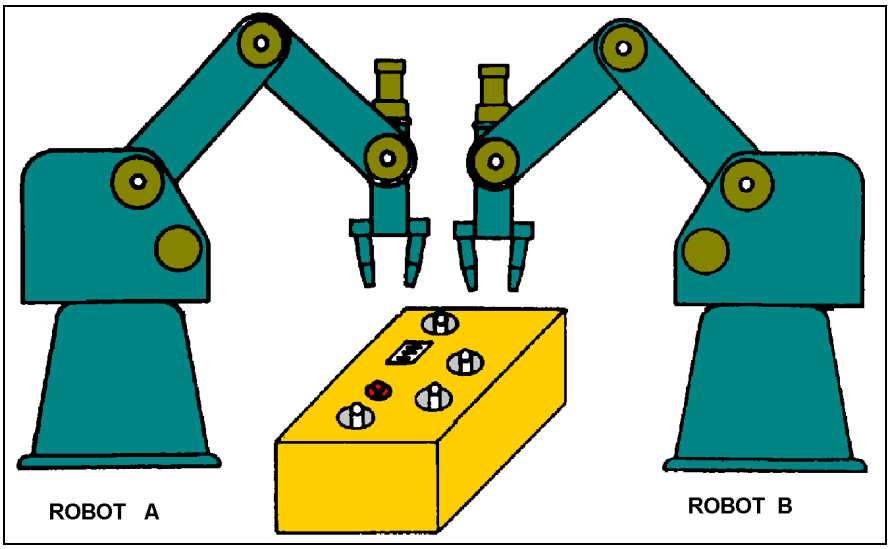
_____

_____

Name: _____

Class: _____Date: _____

Q Describe an application in which two robots are synchronized by means of inputs and outputs. Use the figure to help you with your answer.



Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	

Name: _____

Class: _____Date: _____

Activity 8 - Worksheets

Joint and XYZ Coordinate Systems

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Experiment table	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 8-2: Manipulating the Robot in the XYZ Coordinate System

Q What are your observations? Is it easier to move the TCP along the X and Y axes when in Joints mode or XYZ mode?

_____

_____

_____

_____

Task 8-3: Displaying Position Coordinates

Q Compare the position listings. Can you describe the robot's location just by looking at the list?

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Task 8-8: Team Discussion and Review

Q Describe the differences you observed when using Go Position and Go Linear commands.

_____

_____

_____

_____

_____

_____

Q What kind of robot tasks would require specific linear movement commands?

_____

_____

_____

_____

_____

_____

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	

Name: _____

Class: _____Date: _____

Activity 9 - Worksheets

Relative Positions

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Experiment table	
Diskette or personal subdirectory on computer hard drive	
Two square blocks of equal height	
Metric ruler	
Small, adhesive squares of paper	
The robotic workcell conforms to safety guidelines	

Task 9-2: Teaching Relative Positions (by XYZ Coordinates)

Q Describe what you see in the listings.

_____

_____

Task 9-4: Changing the Reference Position

Q What will happen when you run the program?

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Task 9-6: Team Discussion and Review

Q Summarize the recommended method for recording a relative position (on the Z-axis) for a stacking operation. (hint: refer to Figure 9-6).

_____

_____

_____

_____

_____

_____

Q Describe several manufacturing tasks for industrial robots which would make use of relative positions (for example: loading, stacking).

_____

_____

_____

_____

_____

_____

_____

_____

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	
All other materials returned to supply box or cabinet.	

Name: _____

Class: _____Date: _____

Activity 10 - Worksheets

Program Loops

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Experiment table	
Diskette or personal subdirectory on computer hard drive	
Metric ruler	
Three large round blocks of equal height	
The robotic workcell conforms to safety guidelines	

Task 10-2: Using a Variable Value to Program Conditional Jumps

Q Describe the difference between these two programs.

_____

_____

_____

_____

Q In addition to the LED, what else did you observe when you ran the program?

_____

_____

Q What will happen if you run the program continuously?

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Task 10-3: Stacking Materials Using a Conditional Loop

Q Why does the robot not move?

_____

_____

_____

Q Why does the robot move to Block A, but not go to Block B?

_____

_____

_____

Task 10-5: Team Discussion and Review

Q In this activity the program flow changed as a result of an input signal. Describe an industrial application in which an input signal changes the action in the workcell.

_____

_____

_____

_____

_____

_____

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	
All other materials returned to supply box or cabinet.	

Name: _____

Class: _____Date: _____

Activity 11 - Worksheets

Subroutines

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 11-4: Team Discussion and Review

Q In this Task you wrote a program for a pick and place Task which includes an output on/off subroutine each time the robot puts down the block. Describe an industrial application in which output signals should be sent after a command or operation is executed.

_____

_____

_____

_____

_____

Q Give several examples of Remarks which you might include in a robotic program.

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	

Name: _____

Class: _____Date: _____

Activity 12 - Worksheets

Contact and Non-Contact Sensors

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Conveyor with photoelectric sensor	
Parts feeder with microswitch	
Parts bin	
Four large round blocks of equal size	
Clear plastic sheet or bag	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 12-2: Activating the Photoelectric Sensor

Q What did you observe in these two steps?

_____

_____

_____

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Task 12-6: Team Discussion and Review

Q In this activity you wrote a program for a pick and place Task which instructs the robot to wait for a part to be available at the feeder and then sends the robot to get the part from the feeder and deliver it to the bin. Describe an industrial application which performs a similar get and deliver task.

_____

_____

_____

_____

_____

_____

_____

_____

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	
All other materials returned to supply box or cabinet.	

Name: _____

Class: _____Date: _____

Activity 13 - Worksheets

Servo Control of the Conveyor

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Conveyor with photoelectric sensor	
Several large round blocks	
A few small stickers (about $1cm^2$)	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 13-5: Team Discussion and Review

Q In this Task you wrote a program in which the robot takes a part and places it on the conveyor near the feeder, waits for the part to arrive at the sensor, and then takes it from the conveyor and returns it to the first position. Describe an industrial application which performs a similar task.

_____

_____

_____

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	
All other materials returned to supply box or cabinet.	

Name: _____

Class: _____Date: _____

Activity 14 - Worksheets

I/O Control of the Conveyor

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Conveyor with photoelectric sensor	
Several round and square blocks	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 14-5: Team Discussion and Review

Q In this activity you wrote a program in which an object moves on a conveyor while the robot waits for it to arrive at the pickup point. Describe an industrial application which performs a similar task.

_____

_____

_____

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	
All other materials returned to supply box or cabinet.	

Name: _____

Class: _____Date: _____

Activity 15 - Worksheets

Conclusion

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Conveyor with photoelectric sensor	
Several round and square blocks	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 15-1: Final Project

Do any one of the following:

1 Write and run a program that will perform the routine shown in the figure below.

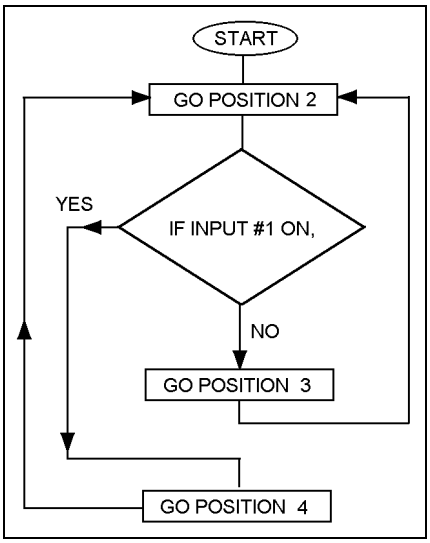


Figure 4

On the other side of the worksheet, present a copy of the program you wrote and describe its function.

Name: _____

Class: _____ **Date:** _____

2 Create a program for the application shown in the figure below.

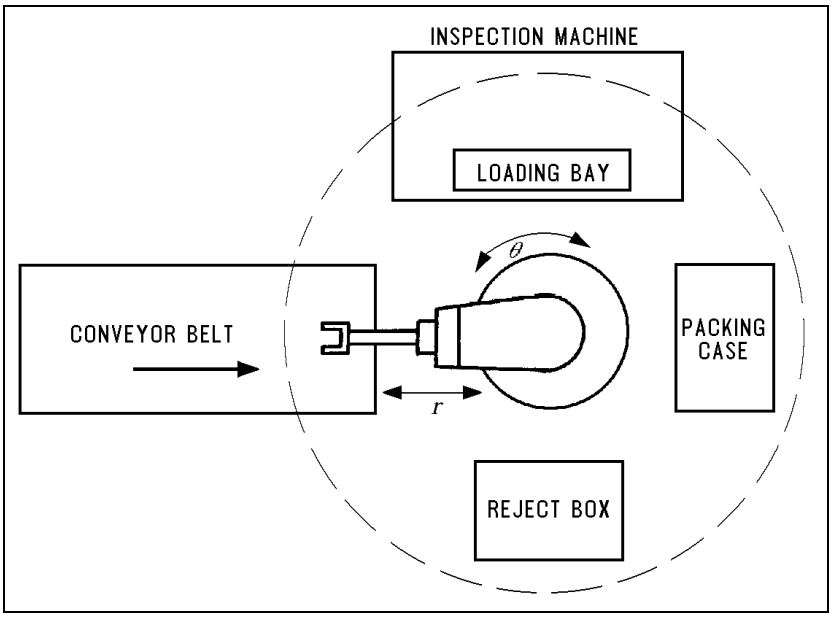


Figure 5

On the other side of the worksheet, describe the application and present a copy of the program you wrote.

Name: _____

Class: _____ **Date:** _____

Name: _____

Class: _____Date: _____

Activity 1 - Worksheets Answer Key

Getting Started

Task 1-1: Introduction to the Robotics and Materials Handling

Q What are the three key elements in the definition of a robot?

> ***(1) THE ROBOT MUST HAVE A MECHANICAL ARM (MANIPULATOR)***
>
> ***(2) THE ROBOT MUST BE REPROGRAMMABLE THROUGH SOFTWARE.***
>
> ***(3) THE ROBOT MUST BE CAPABLE OF PERFORMING DIFFERENT TASKS.***

Q What are the four most important components in a robotic system?

> ***(1) MANIPULATOR***
>
> ***(2) END EFFECTOR***
>
> ***(3) CONTROLLER***
>
> ***(4) COMPUTER / SOFTWARE***

Q What allows a flexible automation system to perform different operations?

> ***CHANGING THE SOFTWARE / PROGRAMS (NOT THE MACHINERY) PRODUCES DIFFERENT OPERATIONS***

Task 1-2: Safety Guidelines

Q Does your robotic workcell conform with the safety guidelines?

> ***THE ANSWER SHOULD BE YES***

Q List points in the system (both the robot and the controller) which are the most dangerous to touch?

> ***GRIPPER, MOVING PARTS (JOINTS), POWER CONNECTORS.***

Task 1-3: Identifying Robot Components

Refer to the actual SCORBOT-ER 4u robot. In the figure on the worksheet, mark the following parts of the robot:

- Robot Joints: Base, Shoulder, Elbow, Wrist Pitch, Wrist Roll
- Gripper
- Motors and Encoders

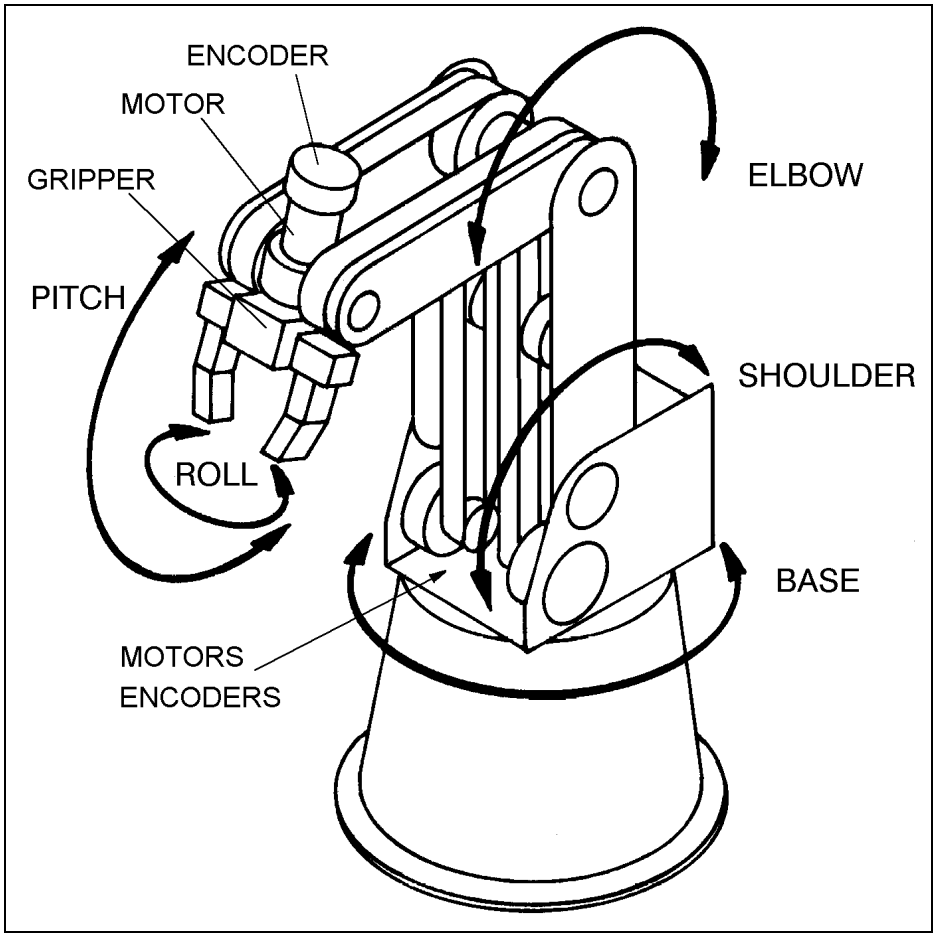


Figure 1

Task 1-4: Identifying Controller Components

Refer to the actual Controller-B. In the figure below, mark the following parts of the controller:

- On/Off Power switch (at rear)
- Input and Output terminals and LEDs
- Peripheral Axis (conveyor) connector
- Emergency Button

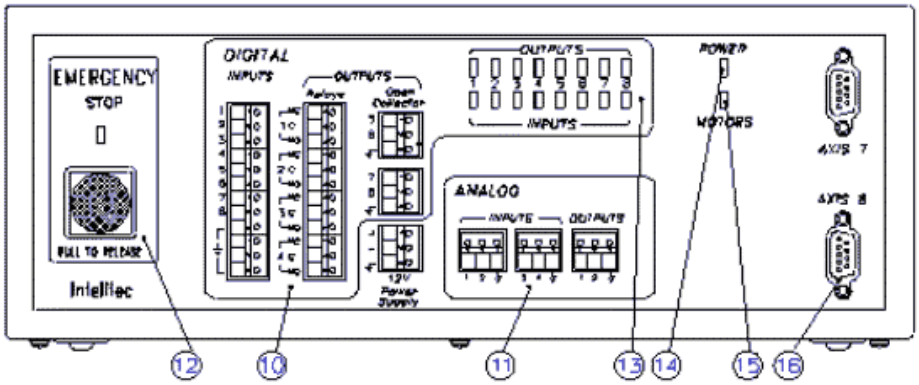


Figure 2

Task 1-5: Identifying Workcell Elements

Refer to the lab module. In the figure below, mark the elements found in the workcell:

- Experiment Table: Microswitches; Lamp; Buzzer
- Conveyor Belt: Photoelectric Sensor
- Parts Feeder: Microswitch Sensor
- Parts Bin
- Workpieces

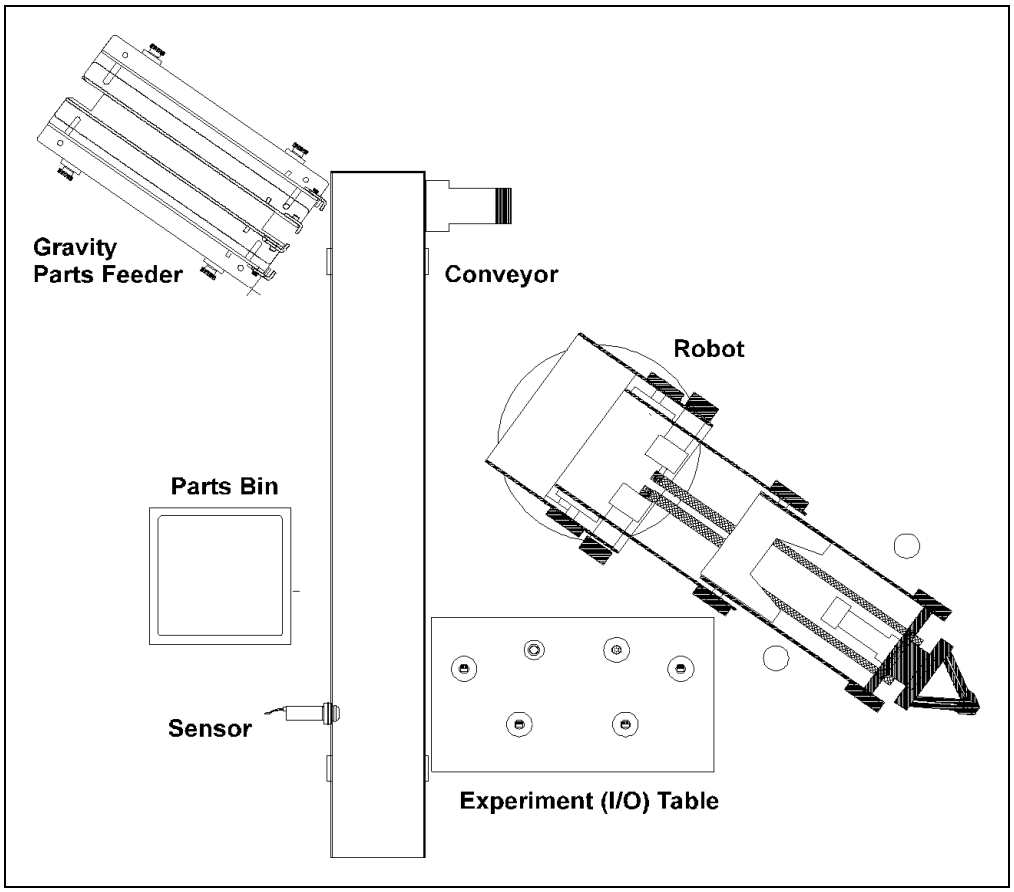


Figure 3

Activity 2 - Worksheets Answer Key

Homing and Moving the Robot

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Two different blocks (any shape)	
The robotic workcell conforms to safety guidelines	

Task 2-3: Homing the Robot

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

SHOULDER (AXIS 2), ELBOW (AXIS 3), PITCH (AXIS 4), ROLL (AXIS 5), BASE (AXIS 1).

THE ROBOT MOVES FAST AT THE START OF THE HOMING FOR EACH JOINT. THE ROBOT MOVES SLOWLY WHEN NEAR HOME ON EACH JOINT.

Task 2-5: Robot Working Limits

Q Describe the system response to the encounter between the robot arm and the table.

SCORBASE ERROR MESSAGE IS DISPLAYED: POSITION ERROR OR IMPACT. THE ROBOT CANNOT BE MOVED.

Task 2-6: Operating the Gripper

Q What effect does the Close Gripper command have on the gripper?

IT CLOSES THE GRIPPER COMPLETELY.

Q What kind of objects can the SCORBOT gripper grasp?

OBJECTS OF DIFFERENT SHAPES, WHICH ARE NOT WIDER THAN THE GRIPPER'S OPENING

Task 2-7: Changing Speed Settings

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

EASIER TO MANIPULATE THE ROBOT AT SLOWER SPEEDS.

Task 2-8: Team Discussion and Review

Q What is the robot home position and why is it needed?

HOME IS A PREDEFINED, SPECIFIC LOCATION IN SPACE. USED AS A REFERENCE POSITION. ENABLES ACCURATE REPETITION OF ROBOT MOVEMENTS AND COMMANDS.

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

ROBOT HITS AN OBSTACLE. ROBOT HITS ITSELF. MOTOR FAILURE. MECHANICAL FAILURE. SOFTWARE OR CONTROLLER FAILURE.

Q How do the robot joints determine the gripper location and orientation?

THE MOVEMENT OF OTHER JOINTS CAUSE THE GRIPPER TO CHANGE ITS POSITION IN SPACE. FOR EXAMPLE: WRIST ROLL ROTATES THE GRIPPER; WRIST PITCH CAUSES GRIPPER TO POINT UP OR DOWN; ELBOW AND SHOULDER JOINTS LIFT AND LOWER THE GRIPPER.

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	

Activity 3 - Worksheets Answer Key

Recording Robot Positions

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 3-8: Team Discussion and Review

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

WHEN DESIRED PATH IS NOT KNOWN IN ADVANCE, PATH CAN BE DEFINED BY RECORDING THE POSITIONS; THEN MOVEMENT COMMANDS CAN BE GIVEN FOR FOLLOWING THIS PATH.

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

WHEN THE ROUTINE OR PATH OF MOVEMENT IS CLEARLY KNOWN AND LOCATION OF POSITIONS CAN BE PREDICTED, MOVEMENT COMMANDS FOR FOLLOWING THE PATH CAN BE WRITTEN BEFORE THE ACTUAL POSITIONS ARE RECORDED.

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	

Writing and Running Robot Programs

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 4-9: Team Discussion and Review

Q Modify the program so that the robot returns the object from the Place position to the Pick position. Save the program as USER4B.

ADD AT THE END OF THE PROGRAM THE FOLLOWING COMMAND LINES:

GO TO POSITION #2 SPEED 1 (MOVE DOWN TO THE PBJECT)

CLOSE GRIPPER

GO TO POSITION #12 FAST

GO TO POSITION #11 FAST (ABOVE PREVIOUS PICK POSITION)

GO TO POSITION #1 SPEED 1

OPEN GRIPPER

GO TO POSITION #11 FAST.

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	

Pick and Place Programs

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Diskette or personal subdirectory on computer hard drive	
Several blocks (round and square)	
Loose sheet of paper	
Small, self-adheseive squares of paper	
The robotic workcell conforms to safety guidelines	

Task 5-3: Teaching Positions

Position #	X (mm)	Y (mm)	Z (mm)	P (deg)	R (deg)
1					
11			100		
2					
12			100		

Table 5-1: Position table

Task 5-5: Team Discussion and Review

Q Describe two or three robotic applications which would require a pick and place sequence similar to the one you programmed in this activity (program USER5).

SAMPLE ANSWERS:

(1) ROBOT TAKES PART FROM FEEDER; DELIVERS IT TO A MACHINE FOR PROCESSING; REMOVES IT FROM THE MACHINE.

(2) ROBOT TAKES PART FROM FEEDER; PLACES IT INTO ANOTHER PART (ASSEMBLY OPERATION); TAKES COMPLETED PART TO CONVEYOR.

(3) ROBOT PICKS UP A COVER/LID; PLACES IT ON A BOX/BOTTLE.

(4) ROBOT PICKS UP A TOOL; USES THE TOOL TO PERFORM AN OPERATION ON AN OBJECT.

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	
All other materials returned to supply box or cabinet.	

Inputs and Program Jumps

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Diskette or personal subdirectory on computer hard drive	
Experiment table	
2 blocks (any shape)	
The robotic workcell conforms to safety guidelines	

Task 6-2: Programming with Labels and Unconditional Jumps

Q Describe the system response. What are your conclusions concerning the effectiveness of the Jump to Label command?

THE JUMP TO STARTA, FOR EXAMPLE, CAUSES A CONTINUOUS LOOP.

THE PROGRAM DOES NOT REACH OR EXECUTE THE LINES THAT COME AFTER THE "JUMP TO STARTA" COMMAND LINE.

Task 6-3: Programming with Inputs and Conditional Jumps

Q Describe the difference between program USER6A and USER6B.

USER6A HAS UNCONDITIONAL JUMP, WHICH CREATES A LOOP.

USER6B HAS A CONDITIONAL JUMP; THE PROGRAM EXECUTION CHANGES ACCORDING TO THE STATE OF INPUT 1.

Task 6-5: Team Discussion and Review

Q Describe the kind of information that is received by the controller inputs.

DEVICES IN THE ROBOTIC WORKCELL INDICATE THEIR STATUS; FOR EXAMPLE: MACHINE READY FOR LOADING/UNLOADING; CONVEYOR STOPPED/STARTED; SENSOR DETECTION OF OBJECT'S PRESENCE/ABSENCE.

Q Describe the use of an unconditional jump command.

PROGRAM EXECUTION IS DIRECTED TO A SPECIFIC PROGRAM LINE (LABEL), REGARDLESS OF THE STATUS OF THE ROBOT OR DEVICES IN THE WORKCELL. FOR EXAMPLE, AS SOON AS AN OPERATION IS COMPLETED (E.G.,LOADING, ASSEMBLY,), THE OPERATION IS REPEATED.

Q Describe the use of a conditional jump command.

PROGRAM EXECUTION IS DIRECTED TO A SPECIFIC PROGRAM LINE (LABEL). THE JUMP CAN BE DETERMINED BY THE STATUS OF THE ROBOT/DEVICES/INPUTS IN THE WORKCELL, OR BY THE NUMBER OF TIMES A ROUTINE MUST BE REPEATED.

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	

Outputs

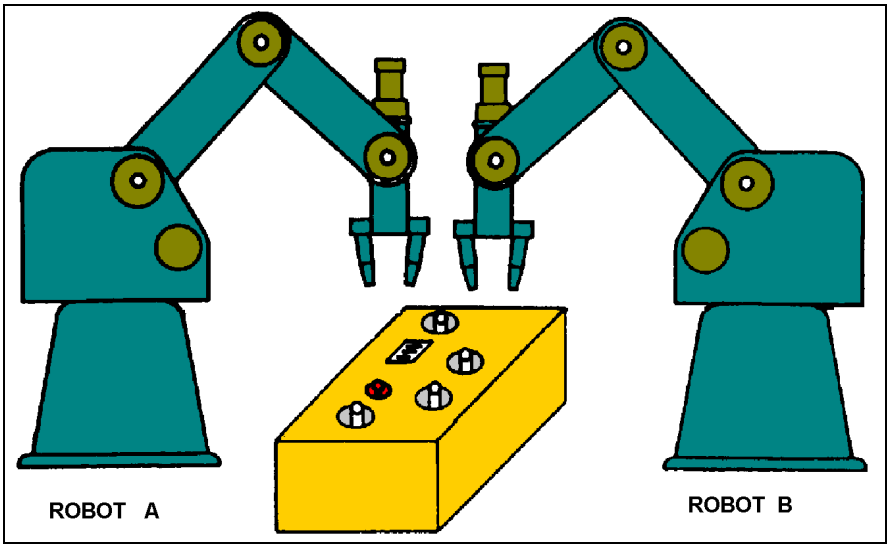
Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Experiment Table	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 7-5: Team Discussion and Review

Q Describe the kind of information that is transmitted by the controller outputs.

INSTRUCTIONS TO DEVICES OR MACHINES IN THE ROBOTIC WORKCELL. FOR EXAMPLE: TURN ON/OFF; START/STOP, SOUND BUZZER, ETC.

Q Describe an application in which two robots are synchronized by means of inputs and outputs. Use the figure to help you with your answer.



SAMPLE ANSWER:

(1) ROBOT A COMPLETES TASK (PLACES BLOCK ON SWITCH 3); OUTPUT SIGNAL TO ROBOT B.

(2) ROBOT B COMPLETES TASKS (PICKS UP BLOCK FROM SWITCH 3 AND PLACES IT ON SWITCH 4); OUTPUT SIGNAL TO ROBOT A.

(3) ROBOT A COMPLETES TASKS (PICKS UP BLOCK FROM SWITCH 4 AND PLACES IT ON SWITCH 3);OUTPUT SIGNAL TO ROBOT B (REPEAT OF #1)

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	

Joint and XYZ Coordinate Systems

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Experiment table	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 8-2: Manipulating the Robot in the XYZ Coordinate System

Q What are your observations? Is it easier to move the TCP along the X and Y axes when in Joints mode or XYZ mode?

IT IS EASIER TO MANIPULATE AND CONTROL LINEAR MOVEMENTS OF THE THE TCP (ALONG X, Y AND Z AXES) WHEN OPERATING IN XYZ MODE.

Task 8-3: Displaying Position Coordinates

Q Compare the position listings. Can you describe the robot's location just by looking at the list?

THE XYZPR VALUES INDICATE THE GRIPPER/TCP LOCATION.

Task 8-8: Team Discussion and Review

Q Describe the differences you observed when using Go Position and Go Linear commands.

GO LINEAR - MOVEMENT IS IN A STRAIGHT LINE.

GO POSITION - MOVEMENT IS NOT NECESSARILY IN A STRAIGHT LINE.

Q What kind of robot tasks would require specific linear movement commands?

WELDING IN A STRAIGHT LINE; GLUING IN A STRAIGHT LINE; ASSEMBLY ("PEG IN A HOLE"); PACKING PARTS INTO COMPARTMENTALIZED CONTAINER; LOADING/UNLOADING

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	

Relative Positions

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Experiment table	
Diskette or personal subdirectory on computer hard drive	
Two square blocks of equal height	
Metric ruler	
Small, adhesive squares of paper	
The robotic workcell conforms to safety guidelines	

Task 9-2: Teaching Relative Positions (by XYZ Coordinates)

Q Describe what you see in the listings.

OFFSET VALUES ONLY.

Task 9-4: Changing the Reference Position

Q What will happen when you run the program?

THE RELATIVE POSITION (WHICH IS LINKED TO THE REFERENCE POSITION) WILL REMAIN AT THE SAME OFFSET FROM THE REFERENCE POINT.

Task 9-6: Team Discussion and Review

Q Summarize the recommended method for recording a relative position (on the Z-axis) for a stacking operation. (hint: refer to Figure 9-6).

AFTER THE REFERENCE POSITION IS RECORDED, MEASURE THE EXACT HEIGHT OF THE OBJECT TO BE STACKED. THE Z-COORDINATE OF THE RELATIVE POSITION IS EQUAL TO THE HEIGHT OF THE OBJECT.

Q Describe several manufacturing tasks for industrial robots which would make use of relative positions (for example: loading, stacking).

STACKING: EACH SUCCESSIVE LAYER CAN BE DEFINED BY OFFSET/RELATIVE POSITION. (Z-AXIS)

PLACEMENT OR REMOVAL OF PART INTO/FROM A COMPARTMENTALIZED BIN EACH COMPARTMENT CAN BE DEFINED BY OFFSET/RELATIVE POSITION. (X AND Y AXES)

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	
All other materials returned to supply box or cabinet.	

Activity 10 - Worksheets Answer Key

Program Loops

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Experiment table	
Diskette or personal subdirectory on computer hard drive	
Metric ruler	
Three large round blocks of equal height	
The robotic workcell conforms to safety guidelines	

Task 10-2: Using a Variable Value to Program Conditional Jumps

Q Describe the difference between these two programs.

FIRST PROGRAM: COUNTER VALUE IS REDUCED

SECOND PROGRAM: COUNTER VALUE IS INCREASED.

Q In addition to the LED, what else did you observe when you ran the program?

BUZZER SHOULD HAVE SOUNDED.

Q What will happen if you run the program continuously?

THE COUNTER VARIABLE WILL BE CONTINUOUSLY RESET, AND THE LOOP WILL REPEAT ENDLESSLY.

Task 10-3: Stacking Materials Using a Conditional Loop

Q Why does the robot not move?

THE ROBOT WILL NOT MOVE TO POSITION 3 UNTIL INPUT 3 TURNS ON.

Q Why does the robot move to Block A, but not go to Block B?

THE ROBOT WILL NOT MOVE TO POSITION 4 UNTIL INPUT 4 TURNS ON.

Task 10-5: Team Discussion and Review

Q In this activity the program flow changed as a result of an input signal. Describe an industrial application in which an input signal changes the action in the workcell.

DEPENDING ON THE STATUS OF THE INPUT SIGNAL, THE ROBOT WILL MOVE TO A PARTICULAR DEVICE/MACHINE/LOCATION.

SAMPLE ANSWERS:

IF INPUT ON, ROBOT WILL PICK UP FINISHED PART.

IF INPUT OFF, ROBOT WILL WAIT FOR PROCESSING.

IF INPUT ON, ROBOT WILL GET RAW MATERIAL.

IF INPUT OFF, ROBOT WILL NOT APPROACH CONVEYOR.

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	
All other materials returned to supply box or cabinet.	

Activity 11 - Worksheets Answer Key

Subroutines

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 11-4: Team Discussion and Review

Q In this Task you wrote a program for a pick and place Task which includes an output on/off subroutine each time the robot puts down the block. Describe an industrial application in which output signals should be sent after a command or operation is executed.

SAMPLE ANSWERS:

(1) ROBOT TAKES PART FROM FEEDER, OUTPUT SIGNALS TO FEEDER TO RELEASE NEXT PART.

(2) ROBOT TAKES PART TO LATHE, WHEN ROBOT MOVES AWAY FROM LATHE, OUTPUT SIGNALS TO LATHE TO CLOSE VISE AND BEGIN MACHINING.

(3) WHEN MILLING OPERATION COMPLETED AND VISE OPEN, THE MACHINE SENDS OUTPUT (ROBOT INPUT) TO INDICATE THAT ROBOT MAY REMOVE PART.

Q Give several examples of Remarks which you might include in a robotic program.

"START ASSEMBLY LOOP"

"ROBOT TAKE PART TO CONVEYOR"

"ROBOT TAKE PART FROM FEEDER"

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	

Contact and Non-Contact Sensors

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Conveyor with photoelectric sensor	
Parts feeder with microswitch	
Parts bin	
Four large round blocks of equal size	
Clear plastic sheet or bag	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 12-2: Activating the Photoelectric Sensor

Q What did you observe in these two steps?

THERE IS NO RESPONSE WHEN THE TRANSPARENT MATERIAL IS PLACED IN FRONT OF THE SENSOR.

INPUT 6 TURNS ON WHEN THE NON-TRANSPARENT MATERIAL IS PLACED IN FRONT OF THE SENSOR.

Task 12-6: Team Discussion and Review

Q In this activity you wrote a program for a pick and place Task which instructs the robot to wait for a part to be available at the feeder and then sends the robot to get the part from the feeder and deliver it to the bin. Describe an industrial application which performs a similar get and deliver task.

> ***SAMPLE ANSWER:***
>
> ***PART ARRIVES ON CONVEYOR AND IS DETECTED BY SENSOR. ROBOT RECEIVES SIGNAL TO PICK UP PART AND TAKE IT TO INSPECTION STATION.***
>
> ***ROBOT WAITS WILL PART IS INSPECTED.***
>
> ***IF PART IS SUCCESSFUL, ROBOT DELIVERS PART TO PACKING CRATE.***
>
> ***IF PART FAILS INSPECTION, ROBOT DELIVERS PART TO REJECTION BIN.***

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	
All other materials returned to supply box or cabinet.	

Servo Control of the Conveyor

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Conveyor with photoelectric sensor	
Several large round blocks	
A few small stickers (about $1cm^2$)	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 13-5: Team Discussion and Review

Q In this task you wrote a program in which the robot takes a part and places it on the conveyor near the feeder, waits for the part to arrive at the sensor, and then takes it from the conveyor and returns it to the first position. Describe an industrial application which performs a similar task.

SAMPLE ANSWER: ROBOT TAKES A PART AND PLACES IT ON A MOVING BELT. AS PART MOVES ON BELT IT UNDERGOES PROCESSING (E.G., PAINTING OR WASHING). WHEN PART REACHES END OF BELT, ROBOT RETURNS PART TO START OF BELT. PART AGAIN MOVES ALONG BELT AND UNDERGOES FURTHER PROCESSING (E.G., DRYING, SECOND COAT OF PAINT)

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	
All other materials returned to supply box or cabinet.	

I/O Control of the Conveyor

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Conveyor with photoelectric sensor	
Several round and square blocks	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 14-5: Team Discussion and Review

Q In this activity you wrote a program in which an object moves on a conveyor while the robot waits for it to arrive at the pickup point. Describe an industrial application which performs a similar task.

SAMPLE ANSWERS:

(1) ROBOT WAITS FOR ANOTHER ASSEMBLY/MANUFACTURING OPERATION TO BE PERFORMED ON THE PART.

(2) ROBOT WAITS FOR PART TO BE SPRAY-PAINTED, WASHED, OR COATED.

(3) ROBOT WAITS FOR PART TO BE INSPECTED.

Inventory Check List	
Item	**End of Session**
SCORBOT-ER 4u robot at home position.	
Controller turned off.	
Computer turned off.	
All blocks returned to supply box or cabinet.	
All other materials returned to supply box or cabinet.	

Conclusion

Inventory and Safety Check List	
Item	**Start of Session**
SCORBOT-ER 4u robot and controller	
Computer with SCORBASE software	
Conveyor with photoelectric sensor	
Several round and square blocks	
Diskette or personal subdirectory on computer hard drive	
The robotic workcell conforms to safety guidelines	

Task 15-1: Final Project

Do any one of the following:

1 Write and run a program that will perform the routine shown in the figure below.

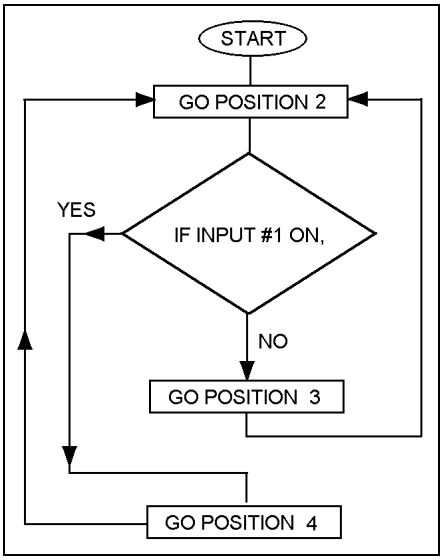


Figure 4

On the other side of the worksheet, present a copy of the program you wrote and describe its function.

2 Create a program for the application shown in the figure below.

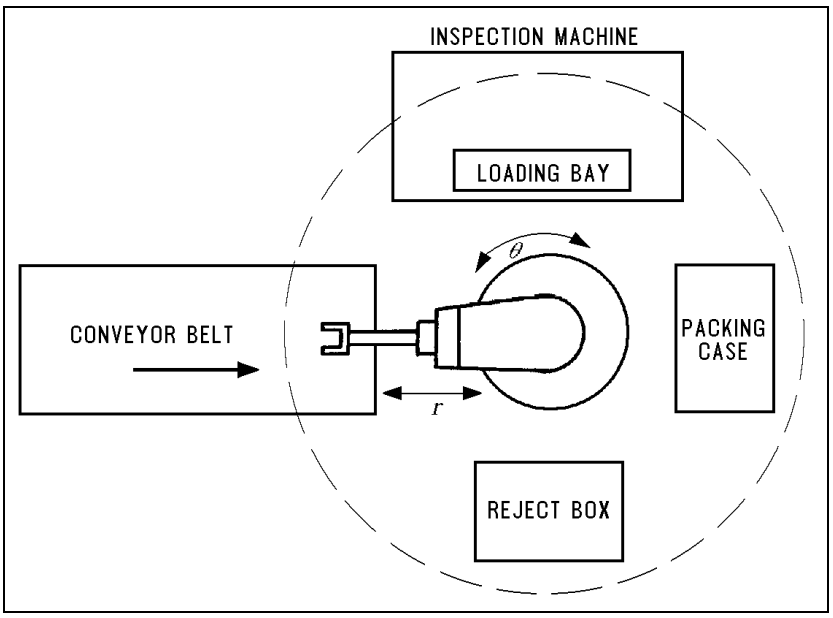


Figure 5

On the other side of the worksheet, describe the application and present a copy of the program you wrote.