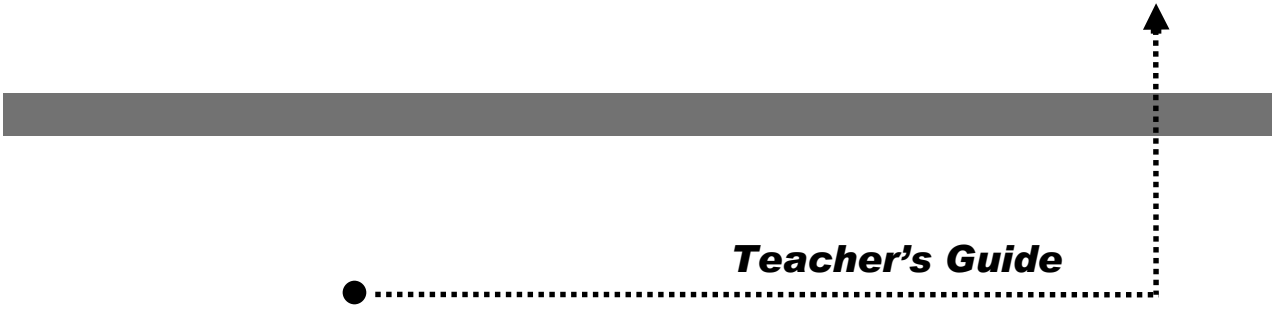
tekLINK

ROBOTICS AND MATERIALS HANDLING 2

RoboCell for SCORBOT-ER 4u



Teacher's Guide

Catalog #100357 Rev.01

PRELIMINARY EDITION

intelitek

Catalog No. 100357 Rev. 01
September 2002

Robotics and Materials Handling 2 (SCORBOT-ER 4u) Teacher's Guide

Intelitek Inc.
444 East Industrial Park Drive
Manchester, NH 03109-5317
USA
Tel: 603-625-8600
Tel: 800-777-6268
Fax: 603-625-2137

website: www.intelitek.com
email: info@intelitek.com

Table of Contents


intelitek
your direction to successful
Advanced Manufacturing Technology
50 quality tekLINKs in 9 manufacturing segments...
FIBER OPTICS
PID CONTROL TECHNOLOGY
HYDRAULICS TECHNOLOGY 2
MasterCAM
PLASTIC THERMO FORMING
MICRO PROCESSORS 2
AUTOMATIC IDENTIFICATION SYSTEMS
MicroCIM
PLC TECHNOLOGY 2 (2 programs)
HYDRAULICS TECHNOLOGY 1
spectraCAM TURNING
AUTOMATED WELDING
MICRO PROCESSORS 1
MACHINE VISION & QC
ANALOG PROCESS CONTROL
FLEXIBLE MANUFACTURING SYSTEM (FMS) (2 programs)
PLC TECHNOLOGY 1 (2 programs)
PNEUMATICS TECHNOLOGY 3 (2 programs)
spectraCAM MILLING
CNC ROUTER
ELECTRONICS TECHNOLOGY 3
INTERNET APPLICATIONS IN MANUFACTURING
COMPUTERIZED DATA ACQUISITION
MATERIALS TESTING (2 PROGRAMS)
ROBOTICS & MATERIAL HANDLING 2 (2 programs)
SENSOR TECHNOLOGY
PNEUMATICS TECHNOLOGY 2 (2 programs)
AutoCAD LT
CNC LATHE (2 programs)
ELECTRONICS TECHNOLOGY 2
VIRTUALCIM
MECHANICAL MEASUREMENT & QC
MECHANISMS
ROBOTICS & MATERIAL HANDLING 1 (2 programs)
ELECTRICAL SYSTEMS
PNEUMATICS TECHNOLOGY 1 (2 programs)
spectraCAD ENGRAVING
CNC MILL (2 programs)
ELECTRONICS TECHNOLOGY 1
tekLINKS
SEGMENTS
COMPUTER APPLICATIONS IN MANUFACTURING
QUALITY CONTROL
INDUSTRIAL MAINTENANCE
AUTOMATION
ELECTRICAL CONTROL
FLUID POWER
DESIGN
PRODUCTION PROCESS
ELECTRONICS
Intelligent Technologies for Manufacturing Education
www.intelitek.com

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 2 tekLINK

The Robotics and Materials Handling 2 tekLINK simulates a real robotic workcell. In this Robotics and Materials Handling 2 tekLINK, you will learn to program a robot using the SCORBASE programming language. After programming, you will use a simulation software, *RoboCell*, to see how a virtual robot performs your program commands.

RoboCell software will enable you to test programs you wrote and then check execution of those programs by a virtual robot. Such simulation capabilities will help reduce the cost in planning your final system, as well as significantly reduce the chance of accidents or failures.

RoboCell is a software package which integrates the SCORBASE robotic software with a graphic display module. It also includes an interactive graphic cell setup module.

- **SCORBASE** is a full-featured robotics control software package, which provides a user-friendly tool for robot programming and operation.
- **Cell Setup** allows you (or the student) to create and modify new and existing simulated robotic cells. The cell may contain the actual elements and connections of a real robotic installation, or it may be a virtual cell.
- **Graphic Display** provides simulation and 3D animation of the robot and other devices in the workcell during position teaching and execution of the SCORBASE programs.

Every project in RoboCell is composed of two files (usually bearing the same name with a different extension):

- A file with the **SBP** extension is a SCORBASE program file, containing the robot program and positions. The program can be used to run both real and virtual robots.
- A file with the **3DC** extension containing the data regarding the robot workcell. After loading the cell file, a window displays a graphic image of the cell and other equipment. When the SCORBASE program is executed, the virtual robot will move within the defined workcell, according to the program commands.

Materials Needed for the Activities

The Activities in this tekLINK require the following components, which are *supplied* in the Robotics lab station:

- Robotics and Materials Handling 2 Activities Book
- Robotics and Materials Handling 2 Student Worksheets
- Pre-Test and Pre-Test Answer Sheet
- Post-Test and Post-Test Answer Sheet
- Personal computer with RoboCell software

In addition, students will need the following materials, which are *not supplied* with the station:

- Personal diskette or hard drive subdirectory for each student/team
- Pencil or pen

tekLINK Requirements

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

- Computer: Hardware Requirement: 80486 66Mhz or higher (Pentium recommended); one free 8-bit or 16-bit AT ISA slot; at least 8 MB RAM; at least 10 MB available disk space; VGA or better graphics display adapter; mouse or other pointing device; printer (optional).
- Software Requirements: DOS 6.2 or later; Windows 3.11 (Windows for Workgroups) or Windows 95.
- Table for computer and controller.
- Table for robot and devices.
- AC power supply. (A power outlet strip with on/off switch is recommended.)
- AC-12/24VDC adapter (for photoelectric sensor).

Safety

The student will work off-line in the Robotics and Materials Handling 2 tekLINK so safety should not be an issue. However should your laboratory also include robotics and materials handling hardware, it is imperative that you make sure that the robotics and materials handling is off-line before students begin the tekLINK. Previous users may have left the system on-line which could cause a potentially dangerous environment for both the human operators and equipment.

Installation

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.

RoboCell Software Installation and Activation

Software Installation

The RoboCell software is supplied on a CD-ROM. 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 RoboCell for ER 4u as they appear on the screen.

The following figures show the installation process:

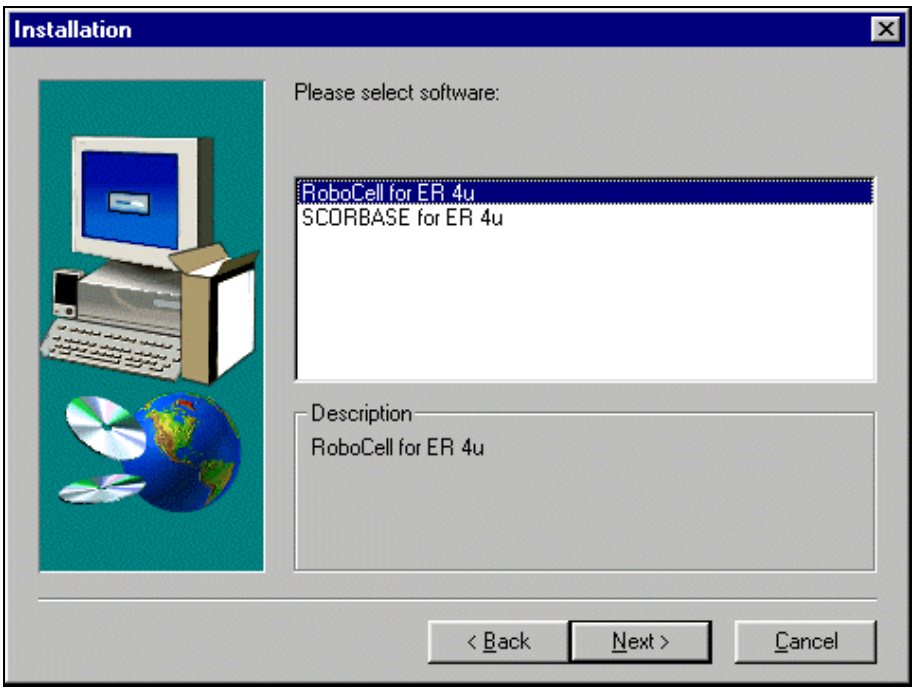


Figure 1

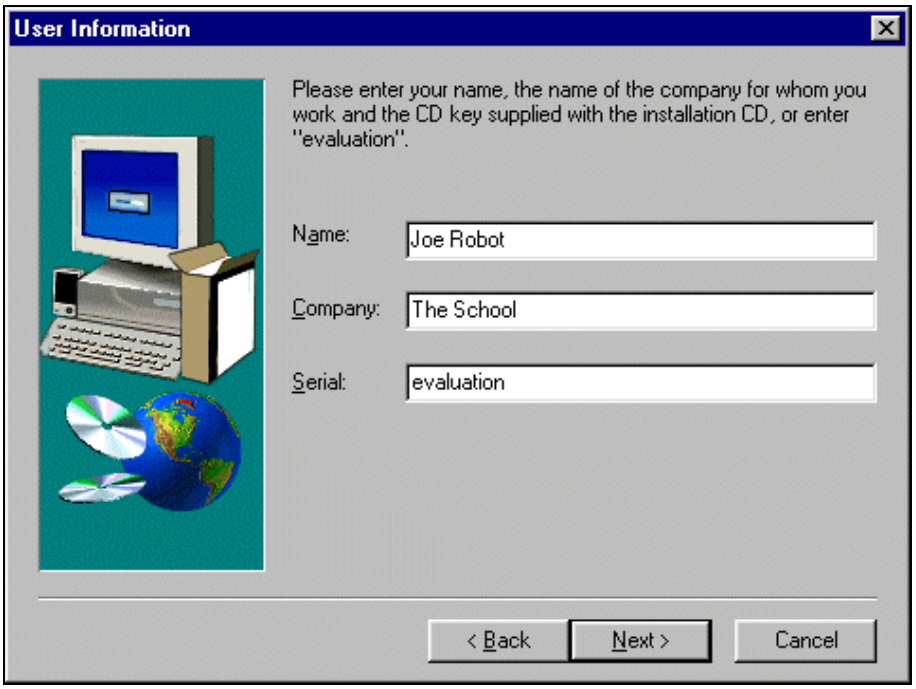


Figure 2

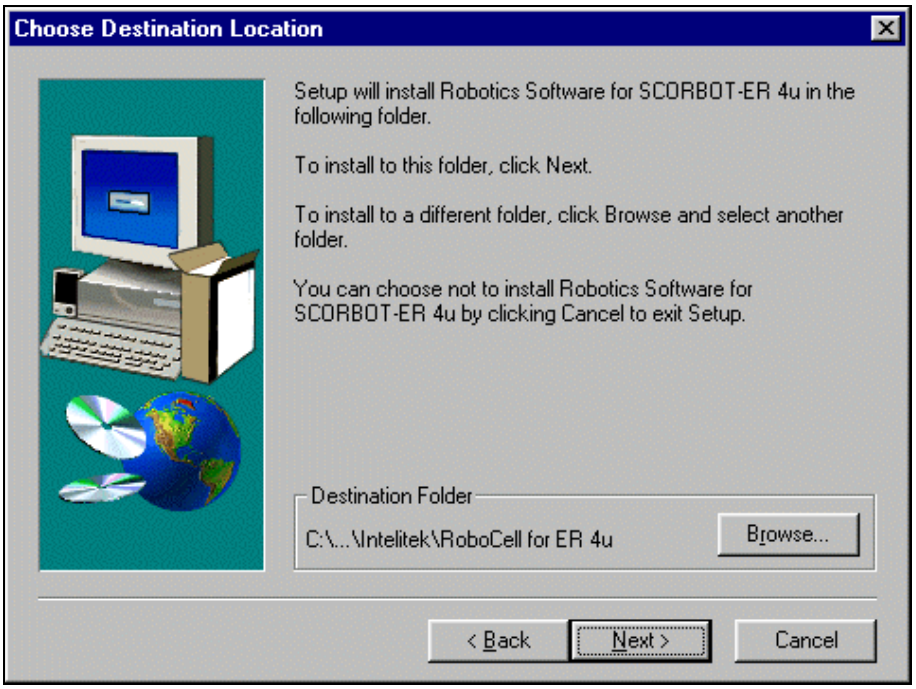


Figure 3

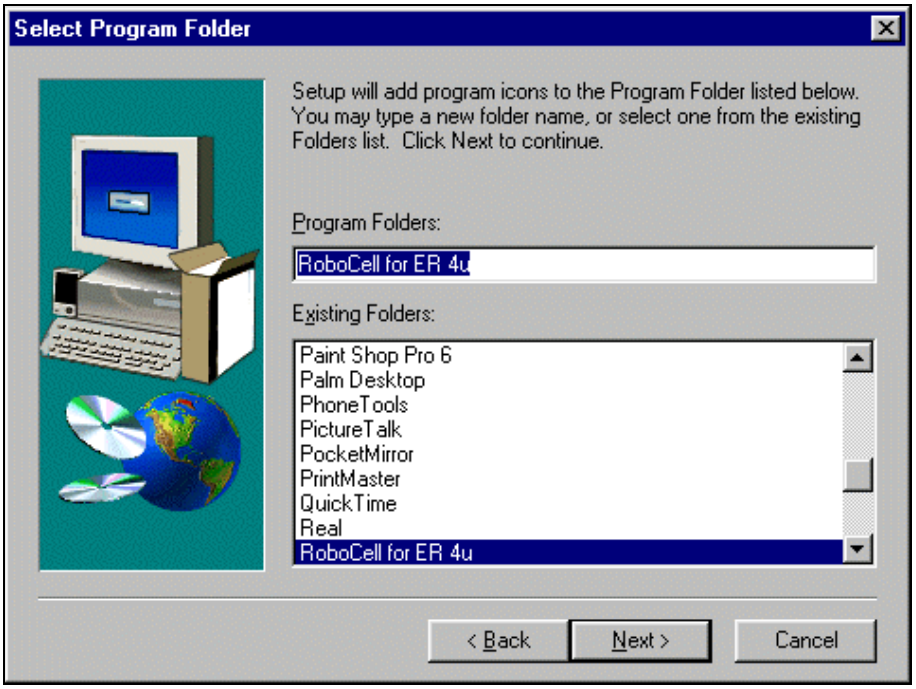


Figure 4

6 When installation is complete, a program group window will appear, similar to the one shown in Figure 5.

Figure 5

Uninstalling the Software

To uninstall RoboCell, do one of the following:

- Select **Start | Programs | RoboCell 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 RoboCell, 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 | RoboCell for ER 4u**.

  Select the SCORBASE for ER 4u command.

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

The RoboCell application window will appear.

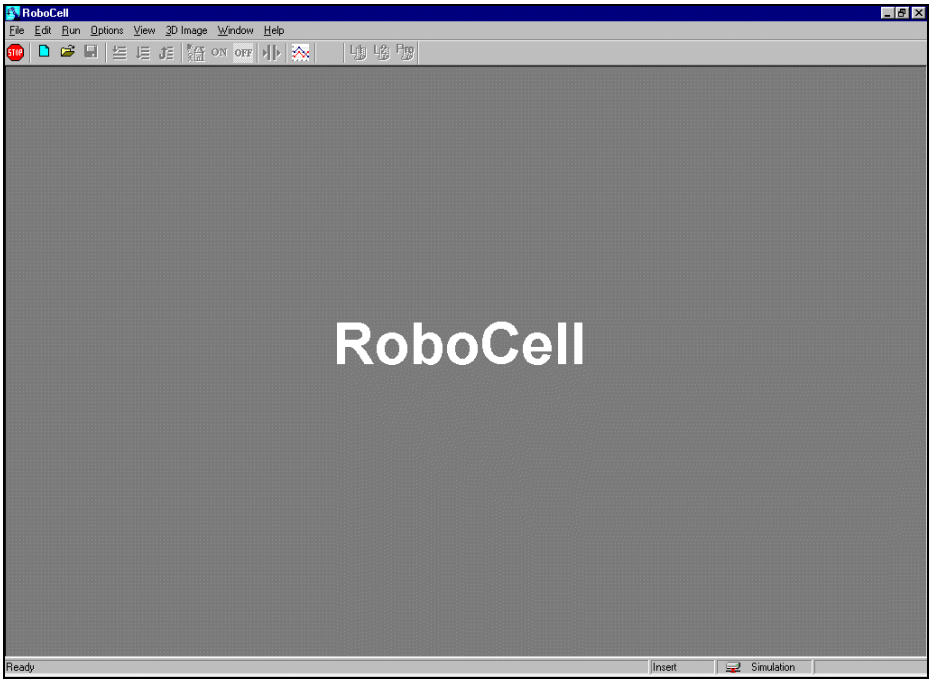


Figure 6: RoboCell Opening Window

Quitting the Software

1. Stop RoboCell 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.

intelitek Software Licensing

The software is protected by a licensing agreement. Once installed, you can use the fully operational software for a 30-day evaluation period. To continue using the software after this period, you need an **unlock code** from Intelitek.

To obtain an unlock code, you need to complete three steps:

3. Install the software from the CD.
4. Send the CD key and the PC-specific code to intelitek.
5. Upon receipt of the unlock code, enter it in the Registration dialog box.

Register your software and receive a unlock code.

During the software installation, you will be prompted to enter the **CD key**. This number is found on the CD case. (Make sure to keep the CD key in a safe place.)

The installation procedure generates a **PC-specific code**. This code is found in the Registration dialog box.

6 To receive the **unlock code** for the software you installed, you must send intelitek both the CD key and the PC-specific code. The Registration dialog box provides several methods for obtaining the unlock code.

- **Automatic email** (uses intelitek's automated software licensing service). In the Registration dialog box, select Get Unlock Code and select By Email.
  - If email is available on the PC, a new email message containing all required details will open. Fill in the requested user information (optional), and click Send. The automatic licensing service will send back an unlock code within minutes.
  - If you have email service, but not on the same computer on which the software is installed, a Notepad window containing all required details will open. Fill in the requested user information (optional), and then transfer the text/file to your email program.

    Send to: info@intelitek.com
    Subject line: intelitek Software License

    To ensure automatic processing, use this exact subject line and do not edit the automatically generated text in the message. You may add text and comments to the end of the message.
- **intelitek Website** (uses intelitek's automated software licensing service):
  - In the Registration dialog box, select Get Unlock Code and select From Our Website.

    Your Internet browser will open at http://www.intelitek.com/support/software-licenses/index.html
  - Follow the onscreen instructions. The unlock code will be displayed automatically.
- **Fax or Phone**: If you do not have Internet or Email service, select Get Unlock Code and select By Fax or Phone. A Notepad window containing all required details will open. Fill in the requested user information (optional), and then print out the document. Contact your local dealer or intelitek with the printed information.

7 When you receive the unlock code, enter it in the Registration dialog box and select Unlock.

Protect Your License

Every unlock code is unique. It will become invalid (and cause the software to stop functioning) when you change a physical component in your PC (e.g., hard disk, network card, CPU), format your disk, or install a new operating system.

- If you want to upgrade your PC and keep your software operational, you must first transfer the license (unlock code) to another PC.
- Once you have upgraded your system, reinstall the software (if necessary) and transfer the license back.

If you do not have a PC available for the temporary transfer operation, return the license to intelitek. You will be able to retrieve the license by following the standard procedure for obtaining the unlock code.

Transfer a License from One PC (Source) to Another PC (Target)

1. On the target PC, do the following:
   - Install the software.
   - Get the PC-specific code from the Registration dialog box.
2. On the source PC, do the following:
   - Open the Registration dialog box.
   - Enter the PC-specific code of the target PC.
   - Select Transfer.

     The software on the source PC will generate a new unlock code for the target PC and will remove the license from the source PC.
3. On the target PC, enter the new unlock code in the Registration dialog box.

Return a License to intelitek for Future Retrieval

Use this procedure when you need to remove a software license and do not have a target PC available.

1. From the Registration dialog box, select Remove the License and click Remove.

   The software will generate a unique Remove code.
2. Send the Remove code and your CD key to intelitek using one of the methods described above (email, website, fax/phone). We will confirm the codes and update our licensing registration records.
3. When you are ready to retrieve your license, install the software (if necessary) and follow the instructions for obtaining an unlock code.

FAQs – Frequently Asked Questions

- ***What is a CD key?***

  This is the code on a label on the CD. It allows intelitek to track software that has been purchased.

- ***What do I do if I do not have a CD key?***

  When prompted to enter the CD key during the software installation, enter the word "evaluation". This will allow you to install the software for a trial period.

- ***What is a PC-specific code?***

  This is a code generated by the software. It is unique for each PC and each installation of the software. This code allows intelitek to generate the unlock code for the PC on which you installed the software. The PC-specific code is displayed in the Registration dialog box.

- ***What is an unlock code?***

  This is a code that allows you to use the software after the evaluation period expires. You need to send your CD key and PC-specific code to intelitek. We will reply with the unlock code for the software you purchased.

- ***How do I install and register the software on more than one PC?***

  Repeat the procedure for obtaining an unlock code as many times as necessary. Alternately, install the software on all PCs and make a note of the PC-specific code generated on each PC. You can then send us one email or fax listing all the PC-specific codes. You will receive unlock codes for each PC. (Note: this will be handled manually by our technical support and may take several days).

- ***Why should I give you my personal details when I request the unlock code?***

  This will allow us to keep you informed about products, upgrades and services available for your system and software. It will also allow us to help you in case of a lost license .

- ***How can I recover the unlock code after a disk crash or other system failure?***

  Once you have restored and reactivated your PC, reinstall the software. If it resumes operation in Evaluation mode, follow the procedure for obtaining an unlock code. Include a comment explaining why you need a new unlock code. (Note: this will be handled manually by our technical support and may take several days).

- ***How can I extend the evaluation period?***

  The 30-day evaluation period begins as soon as the software is installed. Reinstalling the software on the same PC will not renew the evaluation period.

  Under certain circumstances we will extend your evaluation period. Use the Get unlock code option in the Registration dialog box to request a time extension. Be sure to send us your CD key, PC-specific code, and the reason for your request.

  After approving your request we will send you an unlock code that will extend the evaluation period for another 15 days. When you receive the unlock code, do the following

  - Enter it in the Registration dialog box.
  - Select the option to Extend the Evaluation Period.
  - Select Unlock.

Inspection

Take time to familiarize yourself with the safety instructions in the user manuals supplied with the software.

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

Solutions

Solutions Diskette

The Solutions Diskette contains all of the correct program and position files that the student should have saved throughout the tekLINK (saved USER#).

Using options from the RoboCell software, you can review the students' programs to make sure they are correct. Additionally, you can use the List Positions option (select View | List Positions from the SCORBASE menu) to verify that the student saved the correct robot/peripheral positions.

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 from the Solutions Diskette.

Printing Programs

To print a program, do the following:

1. From the SCORBASE menu, select **File | Print**.
2. Click **Print**.

   The Print dialog box will open (Figure 2).

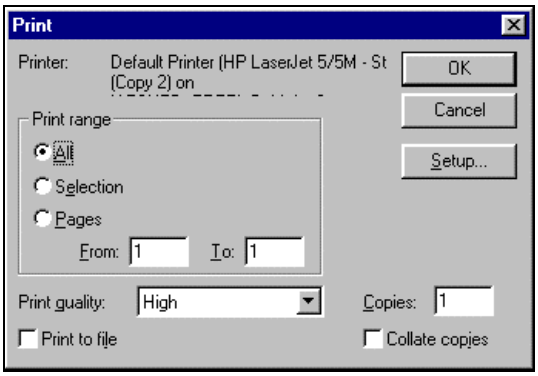


Figure 7

   Make sure that the default **All** is selected.

3. Click **Setup**.

   The Print Setup dialog box opens (Figure 3)

Make sure that **Portrait** is selected in the Orientation field (as shown in Figure 2).

Click OK to close the Setup dialog box.

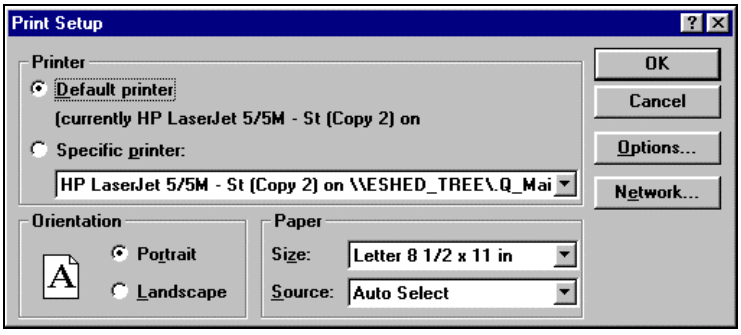


Figure 8

4 Click OK in the Print dialog box to print.

Printing Positions Lists

To print the list of positions, do the following:

1 Click Print.

2 The Print dialog box will open.

Make sure that the default ALL is selected.

3 Click Setup.

Make sure that **Landscape** is selected in the Orientation field.

4 Click OK to close the Setup dialog box.

5 Click OK in the Print dialog box to print.

Pre-test

1 The path traveled by a robot's tool is known as its:

a) Trajectory.

b) Route.

c) Envelope.

d) TCP.

2 TCP stands for:

a) Total Counted Positions.

b) Tool Center Point.

c) Tool Created Path.

d) Tool Center Position.

3 The most efficient SCORBASE command to move the TCP in an arc from one position to another is:

a) Go Circular.

b) Go Position.

c) Go Linear.

d) Jump To.

4 The robot's work envelope defines:

a) The list of all the tasks the robot must perform during a particular program.

b) The positions the TCP can reach.

c) The envelope that restricts the robot flexibility.

d) The trajectory within a plane - envelope.

5 After a subroutine has been executed, the program pointer returns to:

a) The first line of the program.

b) The last line of the program.

c) The last line executed in the program before calling the subroutine.

d) The line following the last line of the subroutine.

6 In the XYZ coordinate system, every position is defined by a unique coordinate.

a) True.

b) False.

7 Which of the following would be a position relative to the point (100,100,50) with a X-offset of -25 mm?

a) 125,100,50

b) 100,100,50

c) 75,100,50

d) -25,100,50

8 In order to send the robot and the peripheral equipment to particular positions at the same time, you must define how many positions?

a) One.

b) Two.

c) Three.

d) Four.

9 The advantage of a rotary table is that:

a) It can efficiently hold a lot of different cylinders in the workcell.

b) It helps move objects in and out of the robot's work envelope.

c) It facilitates in position recording.

d) It helps move objects in and out of the robot's trajectory.

10 The rotary table is known as what kind of device:

a) Extra.

b) Peripheral.

c) Stand-alone.

d) Tool-based.

11 A degree of freedom is defined as:

a) The number of axes about which the robot arm can independently rotate or move.

b) Reasonable error in recording positions using encoder values.

c) The ability of the robot to perform a wide range of tasks.

d) The points within the robot arm's reach.

12 The task of an encoder is:

a) To define the secret code needed to enable robotic actions.

b) To sense the robot position.

c) To encode the commands between the computer and the controller.

d) To allocate different codes for different robotic tasks.

13 The quickest way to send a robot 100 mm above a selected objected would be to use the:

a) Send Robot To Object option.

b) Send Robot Above Point option.

c) Send Robot To Point option.

d) Manual Movement dialog box to guide the TCP.

14 When the robot TCP moves up in a straight line,

a) The base does not move.

b) The arm moves.

c) The shoulder moves.

d) All of the above.

15 When **1** is clicked in the Manual Movement dialog box, the robot will:

a) Turn its base only.

b) Move *to* position #1.

c) Move *from* position #1.

d) The robot gripper will be opened.

16 A cylinder whose height is 30 millimeter is placed on the table in a position recorded as position #1. To place another cylinder on top of that cylinder the robot should take it to a position:

a) With an X-offset of 30 millimeter to position #1.

b) With a Y-offset of 30 millimeter to position #1.

c) With a Z-offset of 30 millimeter to position #1.

d) With a R-offset of 30 millimeter to position #1.

17 When the pointer reaches a Label command during program execution:

a) Program execution is halted for a pre-defined time.

b) The pointer moves immediately to the following command.

c) The pointer jumps to a matching Go To command.

d) Program execution is moved to a subroutine.

18 The conveyors always moves the object placed on it:

a) In a straight line.

b) At a constant speed.

c) To the robot gripper.

d) Away from the robot gripper.

19 To increase accuracy, the robot gripper should be:

a) Open.

b) Closed.

c) Open - unless an object is clamped within the gripper's jaw.

d) Gripper position does not effect accuracy.

20 The number of a relative position located above position #1 (which is on the table):

a) Must be position #11.

b) Must have two digits.

c) Can be any number.

d) Can be any number except for 1.

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

Name: _____

Class: _____ **Date:** _____

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**

1 The path traveled by a robot's tool is known as its:

a) **Trajectory.**

b) Route.

c) Envelope.

d) TCP.

2 TCP stands for:

a) Total Counted Positions.

b) **Tool Center Point.**

c) Tool Created Path.

d) Tool Center Position.

3 The most efficient SCORBASE command to move the TCP in an arc from one position to another is:

a) **Go Circular.**

b) Go Position.

c) Go Linear.

d) Jump To.

4 The robot's work envelope defines:

a) The list of all the tasks the robot must perform during a particular program.

b) **The positions the TCP can reach.**

c) The envelope that restricts the robot flexibility.

d) The trajectory within a plane - envelope.

5 After a subroutine has been executed, the program pointer returns to:

a) The first line of the program.

b) The last line of the program.

c) **The last line executed in the program before calling the subroutine.**

d) The line following the last line of the subroutine.

6 In the XYZ coordinate system, every position is defined by a unique coordinate.

a) **True.**

b) False.

7 Which of the following would be a position relative to the point (100,100,50) with a X-offset of -25 mm?

a) 125,100,50

b) 100,100,50

c) **75,100,50**

d) -25,100,50

8 In order to send the robot and the peripheral equipment to particular positions at the same time, you must define how many positions?

a) **One.**

b) Two.

c) Three.

d) Four.

9 The advantage of a rotary table is that:

a) It can efficiently hold a lot of different cylinders in the workcell.

b) **It helps move objects in and out of the robot's work envelope.**

c) It facilitates in position recording.

d) It helps move objects in and out of the robot's trajectory.

10 The rotary table is known as what kind of device:

a) Extra.

b) **Peripheral.**

c) Stand-alone.

d) Tool-based.

11 A degree of freedom is defined as:

a) **The number of axes about which the robot arm can independently rotate or move.**

b) Reasonable error in recording positions using encoder values.

c) The ability of the robot to perform a wide range of tasks.

d) The points within the robot arm's reach.

12 The task of an encoder is:

a) To define the secret code needed to enable robotic actions.

b) **To sense the robot position.**

c) To encode the commands between the computer and the controller.

d) To allocate different codes for different robotic tasks.

13 The quickest way to send a robot 100 mm above a selected objected would be to use the:

a) Send Robot To Object option.

b) **Send Robot Above Point option**.

c) Send Robot To Point option.

d) Manual Movement dialog box to guide the TCP.

14 When the robot TCP moves up in a straight line,

a) The base does not move.

b) The arm moves.

c) The shoulder moves.

d) **All of the above.**

15 When **1** is clicked in the Manual Movement dialog box, the robot will:

a) **Turn its base only.**

b) Move *to* position #1.

c) Move *from* position #1.

d) The robot gripper will be opened.

16 A cylinder whose height is 30 millimeter is placed on the table in a position recorded as position #1. To place another cylinder on top of that cylinder the robot should take it to a position:

a) With an X-offset of 30 millimeter to position #1.

b) With a Y-offset of 30 millimeter to position #1.

c) **With a Z-offset of 30 millimeter to position #1.**

d) With a R-offset of 30 millimeter to position #1.

17 When the pointer reaches a Label command during program execution:

a) Program execution is halted for a pre-defined time.

b) **The pointer moves immediately to the following command.**

c) The pointer jumps to a matching Go To command.

d) Program execution is moved to a subroutine.

18 The conveyors always moves the object placed on it:

a) **In a straight line.**

b) At a constant speed.

c) To the robot gripper.

d) Away from the robot gripper.

19 To increase accuracy, the robot gripper should be:

a) Open.

b) Closed.

c) Open - unless an object is clamped within the gripper's jaw.

d) **Gripper position does not effect accuracy**.

20 The number of a relative position located above position #1 (which is on the table):

a) Must be position #11.

b) Must have two digits.

c) Can be any number.

d) **Can be any number except for 1.**

Post-test

1 The path traveled by a robot's tool is known as its:

a) Trajectory.

b) Route.

c) Envelope.

d) TCP.

2 TCP stands for:

a) Total Counted Positions.

b) Tool Center Point.

c) Tool Created Path.

d) Tool Center Position.

3 The most efficient SCORBASE command to move the TCP in a line from one position to another is:

a) Go Circular.

b) Go Position.

c) Go Linear.

d) Jump To.

4 The most efficient SCORBASE command to move the TCP in an arc from one position to another is:

a) Go Circular.

b) Go Position.

c) Go Linear.

d) Jump To.

5 The robot's work envelope defines:

a) The list of all the tasks the robot must perform during a particular program.

b) The positions the TCP can reach.

c) The envelope that restricts the robot flexibility.

d) The trajectory within a plane - envelope.

6 In RoboCell, which of the following tools can be attached to the robot's end effector:

a) Welding tool.

b) Painting tool.

c) Screwing tool.

d) No tools can be added. The robot always has a gripper attached to its end effector.

7 After a subroutine has been executed, the program pointer returns to:

a) The first line of the program.

b) The last line of the program.

c) The last line executed in the program before calling the subroutine.

d) The line following the last line of the subroutine.

8 Another name for the XYZ coordinate system is the:

a) Cartesian coordinate system.

b) Dewey coordinate system.

c) Triple coordinate system.

d) 3-D coordinate system.

9 In the XYZ coordinate system, every position is defined by a unique coordinate.

a) True.

b) False.

10 Which of the following would be a position relative to the point (10,40,0) with a Y-offset of +35 mm?

a) 45,40,0

b) 10,75,0

c) 10,40,35

d) -25,40,10

11 Which of the following would be a position relative to the point (100,100,50) with a X-offset of -25 mm?

a) 125,100,50

b) 100,100,50

c) 75,100,50

d) -25,100,50

12 In order to send the robot and the peripheral equipment to particular positions at the same time, you must define how many positions?

a) One.

b) Two.

c) Three.

d) Four.

13 A position based on the coordinates of a different position with an offset in one of the five axes is known as a:

a) Offset position.

b) Sub-position.

c) Relative position.

d) Recorded position.

14 The advantage of a rotary table is that:

a) It can efficiently hold a lot of different cylinders in the workcell.

b) It helps move objects in and out of the robot's work envelope.

c) It facilitates in position recording.

d) It helps move objects in and out of the robot's trajectory.

15 The rotary table is known as what kind of device:

a) Extra.

b) Peripheral.

c) Stand-alone.

d) Tool-based.

16 A degree of freedom is defined as:

a) The number of axes about which the robot arm can independently rotate or move.

b) Reasonable error in recording positions using encoder values.

c) The ability of the robot to perform a wide range of tasks.

d) The points within the robot arm's reach.

17 The task of an encoder is:

a) To define the secret code needed to enable robotic actions.

b) To sense the robot position.

c) To encode the commands between the computer and the controller.

d) To allocate different codes for different robotic tasks.

18 In the List Positions dialog box, positions are displayed only in their encoder values.

a) True.

b) False.

19 The Cell Reset option:

a) Homes everything located in the robotic cell (robot, peripheral devices, objects, etc.).

b) Homes the robot.

c) Is similar to an Undo option -- it undoes the last command ordered.

d) Is similar to a Redo option -- it repeats the last command ordered.

20 The quickest way to send a robot 100 mm above a selected objected would be to use the:

a) Send Robot To Object option.

b) Send Robot Above Point option.

c) Send Robot To Point option.

d) Manual Movement dialog box to guide the TCP.

21 When the robot TCP moves up in a straight line,

a) The base does not move.

b) The arm moves.

c) The shoulder moves.

d) All of the above.

22 When **1** is clicked in the Manual Movement dialog box, the robot will:

a) Turn its base only.

b) Move *to* position #1.

c) Move *from* position #1.

d) The robot gripper will be opened.

23 Recording a position is important to:

a) Reset and readjust the robot controller.

b) Reset and readjust the robot encoders.

c) Enable the robot to return to the same position during execution.

d) Statistics.

24 A cylinder whose height is 30 millimeter is placed on the table in a position recorded as position #1. To place another cylinder on top of that cylinder the robot should take it to a position:

a) With an X-offset of 30 millimeter to position #1.

b) With a Y-offset of 30 millimeter to position #1.

c) With a Z-offset of 30 millimeter to position #1.

d) With a R-offset of 30 millimeter to position #1.

25 A recorded position's coordinates may change throughout execution if:

a) It is an absolute position.

b) It is recorded as relative to current position.

c) It is a Cartesian position.

d) There are at least six recorded positions.

26 When the pointer reaches a Label command during program execution:

a) Program execution is halted for a pre-defined time.

b) The pointer moves immediately to the following command.

c) The pointer jumps to a matching Go To command.

d) Program execution is moved to a subroutine.

27 By inserting the command "Wait 100" in a program:

a) The robot will stop for 100 seconds.

b) The robot will stop for 1 second.

c) Program execution will be halted for 100 seconds.

d) Program execution will be halted for 1 second.

28 The conveyors always moves the object placed on it:

a) In a straight line.

b) At a constant speed.

c) To the robot gripper.

d) Away from the robot gripper.

29 A sensor connected to the controller will:

a) Sort objects with different properties.

b) Distinguish between different objects.

c) Inform the controller if a given property is detected.

d) Separate green and red cylinders.

30 The motor of the rotary table is a:

a) Controller input.

b) Controller output.

c) Robot input.

d) Robot output.

31 The conveyor motor is a:

a) Controller input.

b) Robot input.

c) Controller output.

d) Robot output.

32 To increase accuracy, the robot should move in a:

a) Slow speed.

b) High speed.

c) Average speed.

d) Speed does not effect accuracy.

33 To increase accuracy, the robot gripper should be:

a) Open.

b) Closed.

c) Open - unless an object is clamped within the gripper's jaw.

d) Gripper position does not effect accuracy.

34 Before placing an object at a target position on the table, you ordered the robot to take the object to a position *above* the target position in order to:

a) Ensure that the object will reach the position accurately.

b) Ensure that the robot will not collide with the table.

c) Enable easy programming.

d) Improve the system performance.

35 The ability to rotate about the Z-axis is known as Roll.

a) True.

b) False.

36 A position is recorded when:

a) The robot is in that position and the Record button is clicked.

b) The position coordinates are entered in the Teach Positions dialog box and the Record button is clicked.

c) The relative coordinates of the positions are entered in the Teach Positions dialog box and the Record button is clicked.

d) Recording a position is done only during program execution.

37 If the robot joints were lengthened, then:

a) The robot work envelope would be increased.

b) The robot's accuracy would be reduced.

c) The load on the motors would be increased.

d) All of the above.

38 When the Run a Single Line icon is clicked:

a) Only one line of the program will be executed and the program pointer will return to the first line.

b) Only one line of the program will be executed and the program pointer will return to the last line.

c) Only one line of the program will be executed and the program pointer will move to the next line.

d) Only one line of the program will be executed and the program pointer will remain on the executed line.

39 The number of a relative position located above position #1 (which is on the table):

a) Must be position #11.

b) Must have two digits.

c) Can be any number.

d) Can be any number except for 1.

40 The coordinates of an Absolute position never change.

a) True.

b) False.

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

Name: _____

Class: _____ **Date:** _____

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

1 The path traveled by a robot's tool is known as its:

a) **Trajectory.**

b) Route.

c) Envelope.

d) TCP.

2 TCP stands for:

a) Total Counted Positions.

b) **Tool Center Point.**

c) Tool Created Path.

d) Tool Center Position.

3 The most efficient SCORBASE command to move the TCP in a line from one position to another is:

a) Go Circular.

b) Go Position.

c) **Go Linear.**

d) Jump To.

4 The most efficient SCORBASE command to move the TCP in an arc from one position to another is:

a) **Go Circular.**

b) Go Position.

c) Go Linear.

d) Jump To.

5 The robot's work envelope defines:

a) The list of all the tasks the robot must perform during a particular program.

b) **The positions the TCP can reach.**

c) The envelope that restricts the robot flexibility.

d) The trajectory within a plane - envelope.

6 In RoboCell, which of the following tools can be attached to the robot's end effector:

a) Welding tool.

b) Painting tool.

c) Screwing tool.

d) **No tools can be added. The robot always has a gripper attached to its end effector.**

7 After a subroutine has been executed, the program pointer returns to:

a) The first line of the program.

b) The last line of the program.

c) **The last line executed in the program before calling the subroutine.**

d) The line following the last line of the subroutine.

8 Another name for the XYZ coordinate system is the:

a) **Cartesian coordinate system.**

b) Dewey coordinate system.

c) Triple coordinate system.

d) 3-D coordinate system.

9 In the XYZ coordinate system, every position is defined by a unique coordinate.

a) **True.**

b) False.

10 Which of the following would be a position relative to the point (10,40,0) with a Y-offset of +35 mm?

a) 45,40,0

b) **10,75,0**

c) 10,40,35

d) -25,40,10

11 Which of the following would be a position relative to the point (100,100,50) with a X-offset of -25 mm?

a) 125,100,50

b) 100,100,50

c) **75,100,50**

d) -25,100,50

12 In order to send the robot and the peripheral equipment to particular positions at the same time, you must define how many positions?

a) **One.**

b) Two.

c) Three.

d) Four.

13 A position based on the coordinates of a different position with an offset in one of the five axes is known as a:

a) Offset position.

b) Sub-position.

c) **Relative position.**

d) Recorded position.

14 The advantage of a rotary table is that:

a) It can efficiently hold a lot of different cylinders in the workcell.

b) **It helps move objects in and out of the robot's work envelope.**

c) It facilitates in position recording.

d) It helps move objects in and out of the robot's trajectory.

15 The rotary table is known as what kind of device:

a) Extra.

b) **Peripheral.**

c) Stand-alone.

d) Tool-based.

16 A degree of freedom is defined as:

a) **The number of axes about which the robot arm can independently rotate or move.**

b) Reasonable error in recording positions using encoder values.

c) The ability of the robot to perform a wide range of tasks.

d) The points within the robot arm's reach.

17 The task of an encoder is:

a) To define the secret code needed to enable robotic actions.

b) **To sense the robot position.**

c) To encode the commands between the computer and the controller.

d) To allocate different codes for different robotic tasks.

18 In the List Positions dialog box, positions are displayed only in their encoder values.

a) True.

b) **False.**

19 The Cell Reset option:

a) **Homes everything located in the robotic cell (robot, peripheral devices, objects, etc.).**

b) Homes the robot.

c) Is similar to an Undo option -- it undoes the last command ordered.

d) Is similar to a Redo option -- it repeats the last command ordered.

20 The quickest way to send a robot 100 mm above a selected objected would be to use the:

a) Send Robot To Object option.

b) **Send Robot Above Point option**.

c) Send Robot To Point option.

d) Manual Movement dialog box to guide the TCP.

21 When the robot TCP moves up in a straight line,

a) The base does not move.

b) The arm moves.

c) The shoulder moves.

d) **All of the above.**

22 When **1** is clicked in the Manual Movement dialog box, the robot will:

a) **Turn its base only.**

b) Move *to* position #1.

c) Move *from* position #1.

d) The robot gripper will be opened.

23 Recording a position is important to:

a) Reset and readjust the robot controller.

b) Reset and readjust the robot encoders.

c) **Enable the robot to return to the same position during execution.**

d) Statistics.

24 A cylinder whose height is 30 millimeter is placed on the table in a position recorded as position #1. To place another cylinder on top of that cylinder the robot should take it to a position:

a) With an X-offset of 30 millimeter to position #1.

b) With a Y-offset of 30 millimeter to position #1.

c) **With a Z-offset of 30 millimeter to position #1.**

d) With a R-offset of 30 millimeter to position #1.

25 A recorded position's coordinates may change throughout execution if:

a) It is an absolute position.

b) **It is recorded as relative to current position.**

c) It is a Cartesian position.

d) There are at least six recorded positions.

26 When the pointer reaches a Label command during program execution:

a) Program execution is halted for a pre-defined time.

b) **The pointer moves immediately to the following command.**

c) The pointer jumps to a matching Go To command.

d) Program execution is moved to a subroutine.

27 By inserting the command "Wait 100" in a program:

a) The robot will stop for 100 seconds.

b) The robot will stop for 1 second.

c) Program execution will be halted for 100 seconds.

d) **Program execution will be halted for 1 second.**

28 The conveyors always moves the object placed on it:

a) **In a straight line.**

b) At a constant speed.

c) To the robot gripper.

d) Away from the robot gripper.

29 A sensor connected to the controller will:

a) Sort objects with different properties.

b) Distinguish between different objects.

c) **Inform the controller if a given property is detected**.

d) Separate green and red cylinders.

30 The motor of the rotary table is a:

a) Controller input.

b) **Controller output.**

c) Robot input.

d) Robot output.

31 The conveyor motor is a:

a) Controller input.

b) Robot input.

c) **Controller output.**

d) Robot output.

32 To increase accuracy, the robot should move in a:

a) **Slow speed.**

b) High speed.

c) Average speed.

d) Speed does not effect accuracy.

33 To increase accuracy, the robot gripper should be:

a) Open.

b) Closed.

c) Open - unless an object is clamped within the gripper's jaw.

d) **Gripper position does not effect accuracy**.

34 Before placing an object at a target position on the table, you ordered the robot to take the object to a position *above* the target position in order to:

a) Ensure that the object will reach the position accurately.

b) **Ensure that the robot will not collide with the table.**

c) Enable easy programming.

d) Improve the system performance.

35 The ability to rotate about the Z-axis is known as Roll.

a) **True.**

b) False.

36 A position is recorded when:

a) The robot is in that position and the Record button is clicked.

b) The position coordinates are entered in the Teach Positions dialog box and the Record button is clicked.

c) The relative coordinates of the positions are entered in the Teach Positions dialog box and the Record button is clicked.

d) Recording a position is done only during program execution.

37 If the robot joints were lengthened, then:

a) The robot work envelope would be increased.

b) The robot's accuracy would be reduced.

c) The load on the motors would be increased.

d) **All of the above.**

38 When the Run a Single Line icon is clicked:

a) Only one line of the program will be executed and the program pointer will return to the first line.

b) Only one line of the program will be executed and the program pointer will return to the last line.

c) **Only one line of the program will be executed and the program pointer will move to the next line**.

d) Only one line of the program will be executed and the program pointer will remain on the executed line.

39 The number of a relative position located above position #1 (which is on the table):

a) Must be position #11.

b) Must have two digits.

c) Can be any number.

d) **Can be any number except for 1.**

40 The coordinates of an Absolute position never change.

a) **True.**

b) False.

Name: _____

Class: _____Date: _____

Activity 1 - Worksheets

Getting Started

Task 1-2: Identifying Important Aspects of RoboCell Software

1 From the following figure, identify the following in the RoboCell software screen and label them on the picture shown below:

- SCORBASE window
- SCORBASE toolbar
- SCORBASE menu
- Graphic Display window
- Graphic Display menu
- Program window
- Manual Movements dialog box
- Teach Positions dialog box

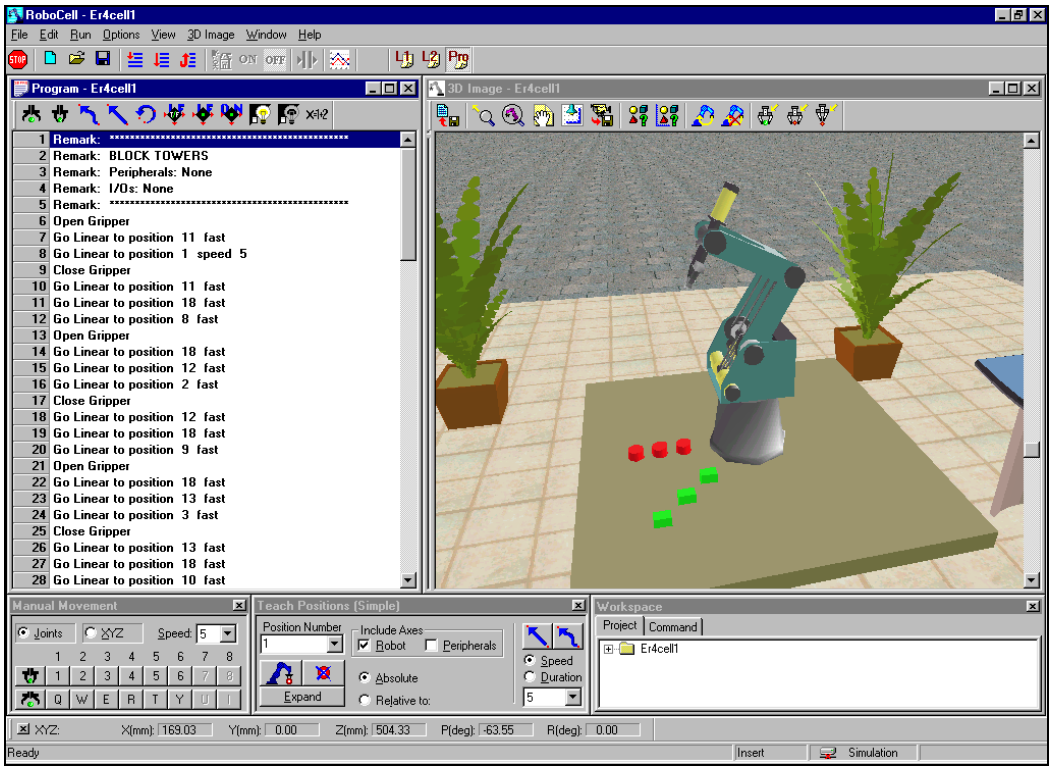


Figure 1

Name: _____

Class: _____ **Date:** _____

Task 1-3: Running a Program

Q *Describe what the robot does with the grey cylinders.*

_____

_____

_____

_____

_____

_____

_____

Q *Describe what the robot does with the green cubes.*

_____

_____

_____

_____

_____

_____

Q *Describe what the robot then does with the green cubes and grey cylinders.*

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Q *Describe what the robot does after placing the last cube in place.*

_____

_____

Q *What will the robot do if Run a Continuous Cycle execution mode was selected?*

_____

_____

_____

_____

Task 1-5: Team Discussion and Review

Q *The only viewing tool not discussed in this activity is the "Follow-Me Camera" feature. What do you think will happen if this feature is selected?*

Hint: After selecting this tool, click on one of the objects in the window (cylinder or cube) and run the program.

_____

_____

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Shut Down	
Item	**End of Session**
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____Date: _____

Activity 2 - Worksheets

Recording XYZ Positions

Task 2-2: Recording Positions

Position #	X	Y	Z
1			
11			
2			
12			

Table 1

Q *How do the coordinates shown in this dialog box compare with the coordinates you recorded in Table 2-1?*

_____

_____

_____

_____

_____

Q *What other types of information does the dialog box present?*

_____

_____

Name: _____

Class: _____ **Date:** _____

Q *Why can't you order the robot to move straight from position #1 to #2?*

Task 2-5: Team Discussion and Review

Q *What would happen if you clicked the Run Single Cycle icon again, without resetting the cell setup?*

Name: _____

Class: _____ **Date:** _____

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____ **Date:** _____

Name: _____

Class: _____Date: _____

Activity 3 - Worksheets

Programming a Continuous Cycle

Task 3-2: Running and Modifying Previous Program

Line #	Command
1	
2	
3	
4	
5	
6	
7	
8	
9	

Table 2

Q *Should you record more positions if you want the robot to return the cube to positions #1?*

_____

_____

Name: _____

Class: _____Date: _____

Q *How can you modify the program so that the robot will return the cube to its initial position?*

_____

_____

_____

_____

Line #	Command
10	
11	
12	
13	
14	
15	
16	

Table 3

Task 3-4: Modifying the Positions

Q *What will happen if you will run the program USER2 with this new cell?*

_____

_____

_____

_____

Q *Describe the robot actions.*

_____

_____

Name: _____

Class: _____ **Date:** _____

_____

_____

_____

_____

Q *Count the changes that should be made in the position coordinates so that the robot will move the cube from the current position back 100 mm.*

_____

_____

_____

_____

Q *Should you program a new program?*

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Task 3-6: Team Discussion and Review

Q *Why does the cube move when you close the gripper at position #1?*

_____

_____

_____

_____

_____

_____

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____Date: _____

Activity 4 - Worksheets

Recording Positions by Sending the Robot to Objects

Task 4-2: Recording Positions

Q *Observe the coordinates for positions #13 (Get Position) and explain how the coordinates were calculated based on the cylinder's dimensions.*

_____

_____

_____

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Q *Observe the coordinates for position #23 and explain how the coordinates were calculated based on the cylinder's dimensions.*

_____

_____

_____

_____

_____

_____

_____

_____

Task 4-5: Team Discussion and Review

Q *Assume that the three cylinders in the cell you just worked with are replaced with three cubes. Will the robot stack the cubes one on top of the other such that the cube bases will overlap one another? If no, suggest a solution.*

_____

_____

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____ **Date:** _____

Name: _____

Class: _____ **Date:** _____

Activity 5 - Worksheets

Defining Roll and Pitch Axes

Task 5-2: Running RoboCell and Loading Previously Saved Files

Q *Describe the relative position in which cube #1 is placed on top of cube #3.*

_____

_____

_____

_____

Q *Describe the angle between the gripper jaw and cube #2.*

_____

_____

_____

_____

Q *Describe the relative position in which cube #2 is placed on top of cube #1.*

_____

_____

_____

_____

Q *What is the reason for the misalignment of the cubes?*

_____

Name: _____

Class: _____ **Date:** _____

_____

_____

_____

_____

_____

_____

Q *Count the positions whose angles must be changed.*

_____

_____

_____

_____

Q *How many degrees should the gripper be rotated in position #13 so that cube #1 will be aligned with cube #3?*

_____

Q *How many degrees should the gripper be rotated in position #23 so that cube #2 will be aligned with cube #1 and cube #3?*

_____

Name: _____

Class: _____ **Date:** _____

Task 5-4: Running the Program

Q *Describe the relative position in which cube #1 is placed on top of cube #3.*

_____

_____

_____

_____

Q *Describe the angle between the gripper jaw and cube #2.*

_____

_____

_____

_____

Q *Describe the relative position in which cube #2 is placed on top of cube #1.*

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Task 5-5: Team Discussion and Review

Q *Calculate the necessary Roll angle for position #2.*

Q Hint: Use the following figure:

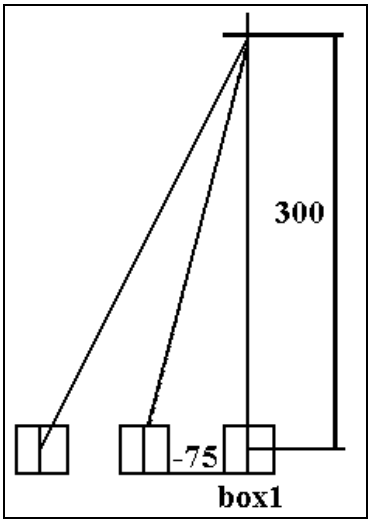


Figure 2

_____

_____

_____

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____Date: _____

Activity 6 - Worksheets

Recording Relative Positions

Task 6-2: Recording Positions

Q *What would happen if you clicked again on the Go Position button?*

_____

_____

_____

Q *What information does this dialog box provide?*

_____

_____

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Task 6-3: Programming

Q *How will you now order the robot to return to its initial position?*

_____

_____

_____

_____

_____

Task 6-5: Team Discussion and Review

Q *The production procedure of another product requires that the product will be dipped in tank A. B and D (skip dipping in C). Modify the program accordingly.*

Q Save the program and positions as USER6A.

_____

Shut Down	
Item	**End of Session**
Files saved.	
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____ **Date:** _____

Activity 7 - Worksheets

Recording More Relative Positions

Task 7-2: Recording Positions

Q *Why is the robot ordered to lift the cylinder 40 mm?*

_____

_____

_____

_____

Q *Why should the cylinder be lowered 50 mm to the template.*

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Task 7-4: Team Discussion and Review

Q *According to Figure 7-3, the distance between the center of the two cylinders placed on the template is 80 mm. This value was used to calculate the distance from position #1 to position #2.*

Q However, in industry, it customary for positions to be recorded relative to given data, rather than recalculating the coordinates.

Q How would you record position #2 as a relative position based on the above data?

_____

_____

_____

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____ **Date:** _____

Activity 8 - Worksheets

Recording Positions for Peripheral Devices

Task 8-1: Running RoboCell and Loading the Setup

Q *Which cylinders does it reach?*

_____

_____

_____

Q *Which doesn't it reach? What message appears in the status bar of the Graphic Display window?*

_____

_____

_____

_____

_____

Q *What does that say about the work envelope of the robot?*

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Q *Is it possible to perform this task without a rotary table?*

_____

_____

_____

_____

_____

_____

Q *What is the advantage of using a rotary table?*

_____

_____

_____

_____

_____

Task 8-2: Recording Positions for the Robot and Peripheral Equipment

Q *How will you load the blue cylinder?*

_____

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Task 8-5: Team Discussion and Review

Q *In this activity, the program you wrote can be easily modified to increase the efficiency of the process. By examining the process, you can see that after placing the cylinder, the robot moves to a position above the table (position #11) and only then the table turns to place the next cylinder under it.*

Q Modify the program to increase productivity by cutting down the time.

Hint: You can record a single position for the robot and the peripheral equipment.

Save the file as USER8A.

Name: _____

Class: _____ **Date:** _____

Shut Down	
Item	**End of Session**
Files saved.	
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____Date: _____

Activity 9 - Worksheets

Recording Positions Using Encoder Values

Task 9-1: Running RoboCell and Opening Cell Setup File

Q *Are the cylinders aligned in their stacked tower?*

_____

_____

Q *What should be the encoder value for the blue cylinder to be located exactly in the initial position of the green cylinder?*

_____

_____

_____

_____

Task 9-4: Running the Program

Q *Compare the efficiency of the new program with the previous one.*

_____

_____

_____

_____

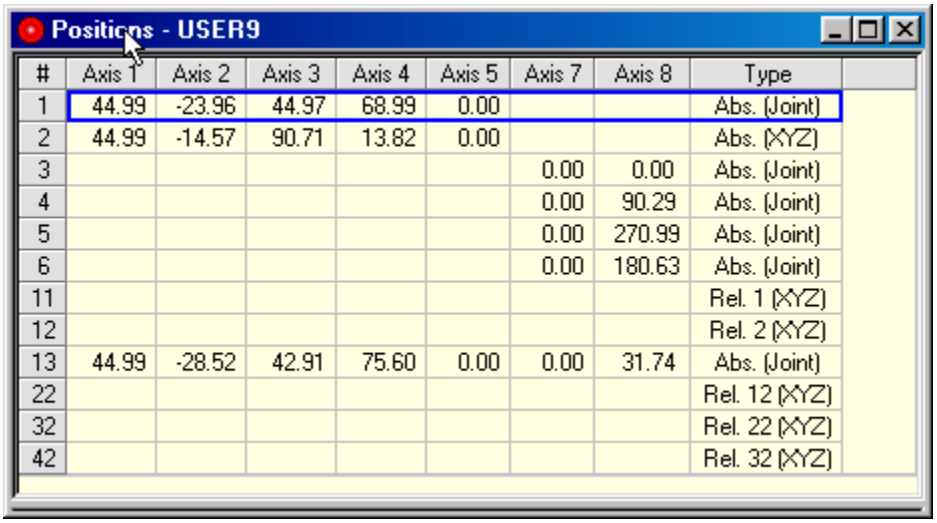
_____

Name: _____

Class: _____ **Date:** _____

Task 9-5: Team Discussion and Review

Q *The following figure shows the encoder values before you performed Task 9-3. What will be the encoder values of the newly recorded positions (#13, #14, #15 and #16)?*



Positions - USER9

#	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 7	Axis 8	Type
1	44.99	-23.96	44.97	68.99	0.00			Abs. (Joint)
2	44.99	-14.57	90.71	13.82	0.00			Abs. (XYZ)
3						0.00	0.00	Abs. (Joint)
4						0.00	90.29	Abs. (Joint)
5						0.00	270.99	Abs. (Joint)
6						0.00	180.63	Abs. (Joint)
11								Rel. 1 (XYZ)
12								Rel. 2 (XYZ)
13	44.99	-28.52	42.91	75.60	0.00	0.00	31.74	Abs. (Joint)
22								Rel. 12 (XYZ)
32								Rel. 22 (XYZ)
42								Rel. 32 (XYZ)

Figure 3

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____ **Date:** _____

Name: _____

Class: _____Date: _____

Activity 10 - Worksheets

Programming the Robot to Execute Linear Movement

Task 10-2: Recording Two End Positions and Running the Program

Q *Describe the TCP path.*

_____

_____

_____

_____

Q *Describe the TCP speed during program execution.*

_____

_____

_____

Task 10-3: Recording a Middle Position and Running the Program

Q *Describe the TCP path.*

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Q *Is the TCP path in this program closer to a straight line than in the previous program?*

_____

Q *Describe the TCP speed during program execution.*

_____

_____

_____

Task 10-4: Recording a Relative Position, Sending the Robot to this Position Repeatedly and Running the Program

Q *Describe the TCP path.*

_____

_____

_____

Q *Is the TCP path closer to a straight line this time?*

_____

Q *Describe the TCP speed during program execution.*

_____

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Task 10-5: Using the Go Linear Command and Running the Program

Q *Describe the TCP path.*

_____

_____

_____

Q *Describe the TCP speed during program execution.*

_____

_____

_____

Task 10-6: Team Discussion and Review

Q *Add to your program an instruction to go to position #1. Then run the program with the Encoder Counts dialog box open. Note that when the TCP moves from position #2 to position #1, only the encoder values for encoder 1 changed. However when the TCP moves from position #1 to position #2, all the encoder values changed.*

Q How can you explain this?

_____

_____

_____

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____Date: _____

Activity 11 - Worksheets

Programming the Robot to Execute Circular Movement

Task 11-4: Running the Program

Q *Rerun the program to determine if the letter B is completed after moving from position #1 to position #8 through all the intermediate positions (when the robot completes line #7)?*

_____

_____

_____

_____

Task 11-5: Team Discussion and Review

Q *Using all the points recorded in this activity, write a program that draws the number "3".*

Q Save the program as USER11A.

_____

_____

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____Date: _____

Activity 12 - Worksheets

Programming with Subroutines

Task 12-5: Team Discussion and Review

Q *Load the cell setup file ACT12_1. This robotic cell is similar to the one used in this activity except that the sensor that can detect blue was replaced with a sensor that can detect red.*

Q Do the program and/or positions need to be modified in order to now sort the red cylinders? If yes, then save the new program and positions as file USER12A.

_____

_____

_____

_____

_____

_____

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____ **Date:** _____

Name: _____

Class: _____ **Date:** _____

Activity 13 - Worksheets

More Programming with Conditional Branching

Task 13-4: Team Discussion and Review

Q *Print the program (or copy it) and then draw lines that describe the program flow.*

Name: _____

Class: _____ **Date:** _____

Q *Describe the robot response.*

_____

_____

_____

_____

_____

Q *Give reasons for the robot response.*

_____

_____

_____

_____

_____

_____

_____

Q *Describe the task of the Disable input Interrupt 1 command.*

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____ **Date:** _____

Name: _____

Class: _____Date: _____

Activity 14 - Worksheets

Advanced Use of Subroutines

Task 14-3: Team Discussion and Review

Q *Modify the program you wrote in this activity as follows.*

- Change the conveyor speed to fast (speed #10)
- Set the speed of the robot movement to position #13 to slow (speed 1).

Q *Run the modified program.*

Q What happened?

_____

_____

_____

_____

Q *Give reasons why you think this happened and suggest a way to correct this bug.*

_____

_____

_____

_____

_____

Name: _____

Class: _____ **Date:** _____

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Name: _____

Class: _____Date: _____

Activity 15 - Worksheets

Conclusion

Task 15-1: Final Projects

Do as many of the following projects as you can in the time that remains:

A Load the cell setup file **ACT15A.3DC** in which two cylinders (height = 35 mm) are placed on a table.

Program the robot to stack the cylinders on the table at (220,0). Note that the cylinders' contact areas should overlap.

Save the program and positions in file **USER15A**.

B Load cell setup file **ACT15B.3DC**. This cell is similar to the first cell except that the cylinders were replaced with cubes (height = 35 mm). By using the Show Object Positions options, you can see the cubes are placed exactly in the same positions where the cylinders were.

Program the robot to stack the cubes on the table at (220,0). Note that the cubes' contact area should overlap.

Hint: Modify the program you just wrote.

Save the program and positions in file **USER15B**.

C Load the cell setup file **ACT15C.3DC**. This cell is also similar to the two previous cells except that the cylinders/cubes were replaced with two prisms (height = 35 mm; length = 35 mm; width = 50 mm). The prisms are placed exactly where the cylinders/cubes were.

Program the robot to stack the prisms on the table at (220,0). Note that the prisms' contact area should overlap.

Hint: Modify the program that you just wrote.

Save the program and positions in file **USER15C**.

Name: _____

Class: _____ **Date:** _____

Shut Down	
Item	**End of Session**
Files saved.	
Exited from RoboCell.	
Computer turned off.	

Activity 1 – Worksheets Answer Key

Getting Started

Task 1-2: Identifying Important Aspects of RoboCell Software

1 From the following figure, identify the following in the RoboCell software screen and label them on the picture shown below:

- RoboCell window
- RoboCell toolbar
- RoboCell menu
- Graphic Display window
- Graphic Display menu
- Program window
- Manual Movement dialog box
- Teach Positions dialog box

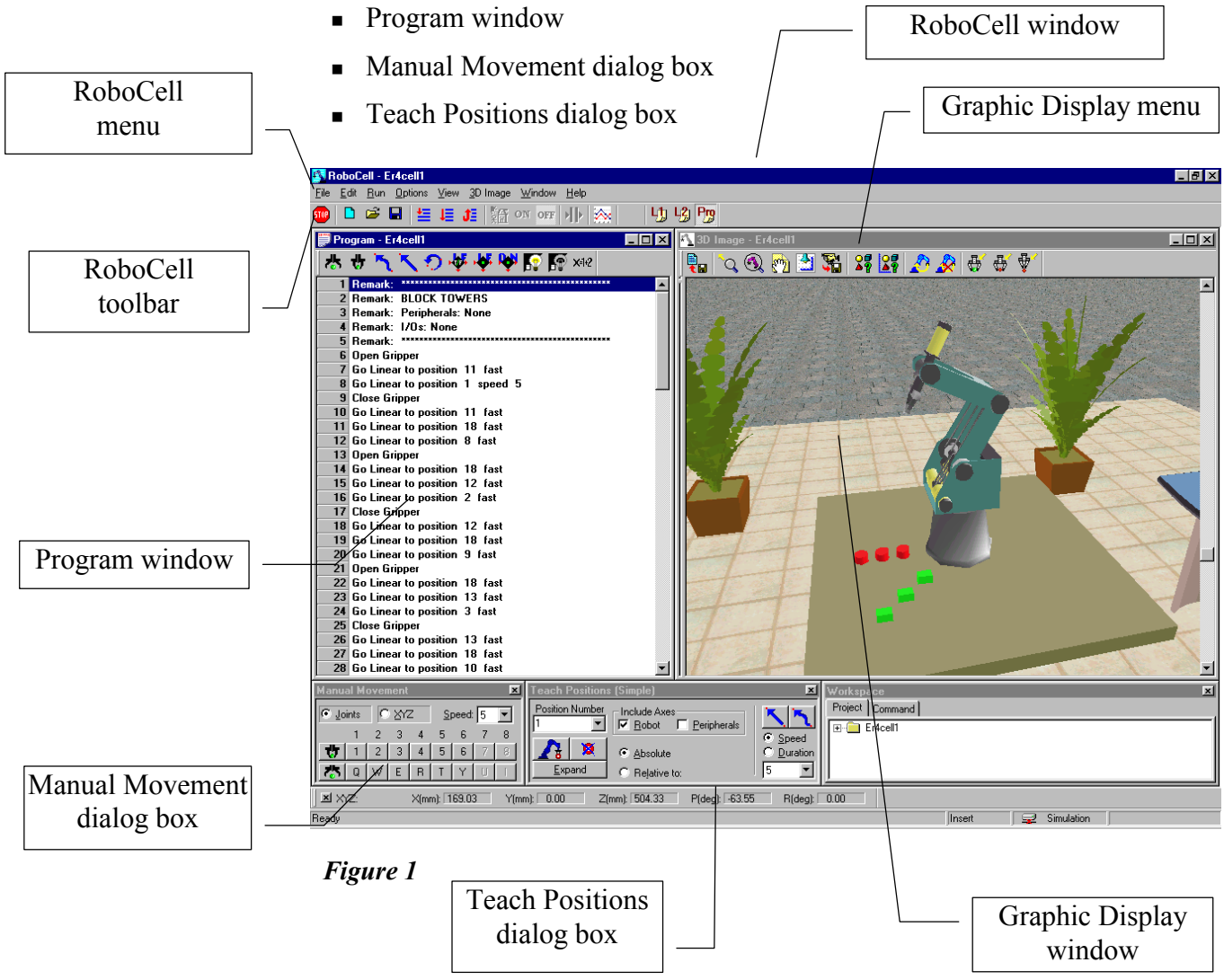


Figure 1

Task 1-3: Running a Program

Q *Describe what the robot then does with the red cylinders.*

> ***THE ROBOT PLACES THE THREE CYLINDERS BACK IN PLACE IN REVERSED ORDER. THE TOP CYLINDER IS PLACED NEXT TO THE ROBOT, THE MIDDLE CYLINDER IN THE MIDDLE AND THE FIRST IS PLACED FARTHER AWAY FROM THE ROBOT.***

Q *Describe what the robot does with the green cubes.*

> ***THE ROBOT RETURNS THE CUBES TO THEIR ORIGINAL POSITIONS.***

Q *Describe what the robot then does with the green cubes and red cylinders.*

> ***THE ROBOT MOVES TO THE CLOSEST CUBE, PICKS IT UP AND PLACES IT ON THE TABLE. THEN IT MOVES TO THE SECOND CUBE, PICKS IT UP AND PLACES IT ON THE FIRST. AFTERWARDS IT PLACES THE THIRD CUBE ON TOP OF THE PREVIOUSLY STACKED TWO CUBES.***

Q *Describe what the robot does after placing the last cube.*

> ***THE ROBOT STOPS BECAUSE THE PROGRAM ENDED.***

Q *What will the robot do if Run a Continuous Cycle execution mode was selected?*

> ***THE ROBOT WOULD HAVE STARTED THE SAME JOB AGAIN (AND AGAIN..).***

Task 1-5: Team Discussion and Review

Q *The only viewing tool not discussed in this activity is the "Follow-Me Camera" feature. What do you think will happen if this feature is selected?*

Hint: After selecting this tool, click on one of the objects in the window (cylinder or cube) and run the program.

> ***THE FOLLOW ME CAMERA TOOL CAUSED THE CAMERA TO FOLLOW THE SELECTED OBJECT (WHICH IS IN THE CENTER OF THE SCREEN). WHEN THE ROBOT MOVES THE OBJECT, THE CAMERA MOVES ALONG WITH IT AND THE OBJECT REMAINS IN THE CENTER OF THE IMAGE.***

Shut Down	
Item	**End of Session**
Exited from RoboCell.	
Computer turned off.	

Recording XYZ Positions

Task 2-2: Recording Positions

Position #	X	Y	Z
1	**400.10**	**0.00**	**10.03**
11	**400.10**	**0.00**	**50.03**
2	**300.10**	**0.00**	**10.03**
12	**300.10**	**0.00**	**50.03**

Table 1

Q *How do the coordinates shown in the window compare with the coordinates you recorded in Table 2-1?*

THE INFORMATION FROM THE LIST POSITIONS DIALOG BOX REGARDING THE XYZ COORDINATES OF THE POSITIONS RECORDED DURING THIS ACTIVITY SHOULD BE IDENTICAL TO THAT FOUND IN TABLE 2-1.

Q *What other types of information does the window present?*

THE COORDINATES ARE LISTED AS ABSOLUTE AND XYZ.

Q *Why can't you order the robot to move directly from position #1 to #2?*

BECAUSE THE TOOL TRAJECTORY IS UNKNOWN (YET) AND FORCING THE TOOL TO PASS THROUGH POSITIONS #11 AND #12 WILL ENSURE THAT THE CUBE WILL NOT COLLIDE WITH THE TABLE.

Task 2-5: Team Discussion and Review

Q *What would happen if you clicked the Run Single Cycle icon again, without resetting the cell setup?*

WHEN A CYCLE IS ENDED, THE CUBE IS IN POSITION #2 (AND NOT IN POSITION #1, AS IT SHOULD BE). THE PROGRAM WILL ORDER THE ROBOT TO MOVE TO POSITION #1 AND CLOSE THE GRIPPER BUT THE GRIPPER WILL ONLY GRASP AIR. WHEN THE GRIPPER APPROACHES POSITION #2, IT WILL BUMP INTO THE CUBE (PLACED THERE DURING THE PREVIOUS CYCLE). YOU WILL RECEIVE AN IMPACT ERROR MESSAGE.

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Programming a Continuous Cycle

Task 3-2: Running and Modifying Previous Program

Line #	Command
1	*Remark: **********
2	*Remark: ACT3*
3	*Remark: Programming a Continuous Cycle*
4	*Remark: **********
5	*Open Gripper*
6	*Go to Position 11 fast*
7	*Go to Position 1 speed 1*
8	*Close Gripper*
9	*Go to Position 11 fast*
10	*Go to Position 12 fast*
11	*Go to Position 2 speed 1*
12	*Open Gripper*
13	*Go to Position 12 fast*

Table 2

Q *Should you record more positions if you want the robot to return the cube to positions #1?*

NO - ALL THE POSITIONS NEEDED ARE ALREADY RECORDED.

Q *How can you modify the program so that the robot will return the cube to its initial position?*

BY ADDING COMMANDS THAT WILL INSTRUCT THE ROBOT TO RETURN THE CUBE TO POSITION #1.

Line #	Command
14	*Go to Position 2 speed 1*
15	*Close Gripper*
16	*Go to Position 12 fast*
17	*Go to Position 11 fast*
18	*Go to Position 1 speed 1*
19	*Open Gripper*
20	*Go to Position 11 fast*

Table 3

Task 3-4: Modifying the Positions

Q *What will happen if you run the current program with this new cell?*

THE ROBOT WILL MOVE AS PLANNED BUT IT WILL NOT MOVE THE CUBE SINCE THE INITIAL POSITION OF THE CUBE IS NOW DIFFERENT.

Q *Describe the robot's actions.*

THE ROBOT MOVES TO THE POSITIONS THAT WERE RECORDED BEFORE. SINCE THE CUBE IS NOT IN ITS ORIGINAL INITIAL POSITION, THE ROBOT LOOKS FOR THE CUBE, DOESN'T FIND IT, AND CONTINUES TO CARRY OUT THE PROGRAM WITH AN EMPTY GRIPPER.

Q *Count the changes that should be made in the position coordinates so that the robot will move the cube from the current position back 100 mm.*

THE Y-COORDINATE OF ALL OF THE POSITIONS (#1, #2, #11 AND #12) SHOULD BE CHANGED FROM ZERO TO 70.

Q *Do you need to write an entirely new program?*

NO! THE PREVIOUSLY SAVED PROGRAM WILL STILL WORK SINCE THE COMMANDS EXECUTION SEQUENCE IS THE SAME.

Task 3-6: Team Discussion and Review

Q *Why does the cube move when you close the gripper at position #1?*

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Recording Positions by Sending the Robot to Objects

Task 4-2: Recording Positions

Q *Observe the coordinates for positions #13 (Get Position) and explain how the coordinates were calculated based on the cylinder's dimensions.*

THE CYLINDER IS LIFTED 100 DUE TO SAFETY REASONS. THE DISTANCE ALONG THE Y AXIS IS 150 MM SINCE THE DISTANCE BETWEEN TWO CYLINDERS IS 75 MM (75+75=150).

THE CYLINDER IS LOWERED 65 MM TO THE UPPER LEVEL OF CYLINDER #3 WHICH IS 35 MM ABOVE THE TABLE. (100-35=65).

Q *Observe the coordinates for position #23 and explain how the coordinates were calculated based on the cylinder's dimensions.*

THE CYLINDER IS LIFTED 100 DUE TO SAFETY REASONS. THE DISTANCE ALONG THE Y AXIS IS 75 MM (THE DISTANCE BETWEEN THE CYLINDERS IS GIVEN) THE CYLINDER IS LOWERED 30 MILLIMETER TO THE UPPER LEVEL OF CYLINDER #1 WHICH IS 70 MM ABOVE TABLE LEVEL (EACH CYLINDER IS 35 MM HIGH). THUS 100-70=30.

Task 4-5: Team Discussion and Review

Q *Assume that the three cylinders in the cell you just worked with are replaced with three blocks. Will the robot stack the blocks one on top of the other such that the cube bases will overlap one another? If no, suggest a solution.*

THE ROBOT WILL STACK THE CUBES ONE ON TOP OF THE OTHER BUT THE CUBE BASES WILL NOT BE ALIGNED PROPERLY BECAUSE THE GRIPPER IS ROTATED WITH THE ROBOT'S BASE. THE SOLUTION WOULD BE TO MODIFY THE ANGLE OF THE GRIPPER.

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Defining Roll and Pitch Axes

Task 5-2: Running RoboCell and Opening the 3D File

Q *Describe the relative position in which cube #1 is placed on top of cube #3.*

> ***CUBE #1 IS ROTATED RELATIVE TO CUBE #3 SO THAT THEIR SIDES ARE NOT FULLY ALIGNED.***

Q *Describe the angle between the gripper jaw and cube #2 before the gripper closed.*

> ***THE GRIPPER IS ROTATED RELATIVE TO CUBE #2. WHEN THE ROBOT GRIPS THE CUBE IT IS ROTATED WHILE RUBBING AGAINST THE TABLE.***

Q *Describe the relative position in which cube #2 is placed on top of cube #1.*

> ***THE UPPER SURFACE OF CUBE #1 IS FULLY ALIGNED WITH THE LOWER SURFACE OF CUBE #2.***

Q *What is the reason for the misalignment of the cubes?*

> ***THESE ANGULAR MISMATCHES RESULT FROM THE WRONG ANGLE OF THE TOOL (GRIPPER). WHEN CYLINDERS WERE USED, THE ANGLE HAD NO MEANING BUT WHEN CUBES ARE USED THE ANGLE DIFFERENCE RESULTED IN AN IMPROPERLY STACKED CUBES.***

Q *Count the positions whose angles must be changed.*

> ***POSITION #2 - LIFTING CUBE #2.***
>
> ***POSITION #13 - PLACING CUBE #1.***
>
> ***POSITION #23 - PLACING CUBE #3.***

Q *How many degrees should the gripper be rotated in position #13 so that cube #1 will be aligned with cube #3?*

> ***THE GRIPPER (AND CUBE #1) SHOULD BE ROTATED -26.57°.***

Q *How many degrees should the gripper be rotated in position #23 so that cube #2 will be aligned with cube #1 and #3?*

> ***THE SAME - THE GRIPPER SHOULD BE ROTATED -26.57°.***

Task 5-4: Running the Program

Q *Describe the relative position in which cube #1 is placed on top of cube #3.*

> ***CUBE #1 IS ROTATED BEFORE IT IS PLACED ON CUBE #3 SO THAT THEIR SIDES ARE FULLY ALIGNED.***

Q *Describe the angle between the gripper jaw and cube #2.*

> ***THE GRIPPER ROTATES AND PICKS 2 WITHOUT RUBBING IT AGAINST THE TABLE.***

Q *Describe the relative position in which cube #2 is placed on top of cube #1.*

> ***THE UPPER SURFACE OF CUBE #1 IS ALIGNED WITH THE BOTTOM SURFACE OF CUBE #2.***

Task 5-5: Team Discussion and Review

Q *Calculate the necessary Roll angle for position #2.*

Q Hint: Use the following figure:

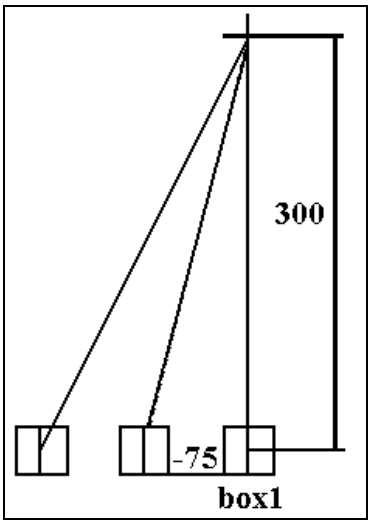


Figure 2

THE TANGENT OF THE ANGLE IS 0.25 (75 DIVIDED BY 300). THE ROLL ANGLE IS THEREFORE 14.04 DEGREES

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Recording Relative Positions

Task 6-2: Recording Positions

Q *What would happen if you clicked again on the Go Position button?*

THE ROBOT WILL MOVE UP AN ADDITIONAL 50 MM.

Q *What information does this dialog box provide?*

THE DIALOG BOX, SHOWN IN THE FIGURE BELOW (ACCESSED BY SELECTING VIEW | LIST POSITIONS) LISTS ALL OF THE POSITIONS RECORDED FOR THE CELL. ADDITIONALLY, IT SHOWS WHETHER THE POSITIONS ARE ABSOLUTE OR RELATIVE. AND IF THEY ARE RELATIVE, ON WHAT POSITION THEY ARE BASED.

Positions - USER6

#	X (mm)	Y (mm)	Z (mm)	Pitch (deg)	Roll (deg)	Ax7 (mm/deg)	Ax8 (mm/deg)	Type
1	250.02	-139.97	60.04	-90.00	0.00			Abs. (Joint)
2	0.00	0.00	-50.00	0.00	0.00			Rel. Curr. (XYZ)
3	0.00	0.00	50.00	0.00	0.00			Rel. Curr. (XYZ)
4	0.00	70.00	0.00	0.00	0.00			Rel. Curr. (XYZ)
11	321.82	11.52	134.10	-90.00	0.00			Abs. (Joint)
12	322.19	-89.17	133.35	-90.00	0.00			Abs. (Joint)
13	301.72	-200.76	60.14	-89.96	-26.57			Abs. (XYZ)
23	301.70	-198.98	110.23	-89.96	-26.57			Abs. (XYZ)
33	301.70	-198.98	110.23	-89.96	0.00			Abs. (Joint)

Figure 3

Task 6-3: Programming

Q *How will you now order the robot to return to its initial position?*

MOVE TO POSITION #1 (THE ABSOLUTE POSITION), TO POSITION #2 (DOWN), OPEN THE GRIPPER, AND THEN MOVE BACK UP (POSITION #3)

Task 6-5: Team Discussion and Review

Q *The production procedure of another product requires that the product will be dipped in tank A, B and D (skip tank C). Modify the program accordingly.*

Q Save the program and positions as USER6A.

NEW POSITIONS ARE NOT NEEDED. THE PROGRAM, SAVED AS USER6A, SHOULD BE MODIFIED TO:

```
1  Remark: ****************
2  Remark: ACT6A
3  Remark: Recording Relative Positions
4  Remark: ****************
5  Open Gripper
6  Go to Position  1  fast
7  Go to Position  2  speed  5
8  Close Gripper
9  Go to Position  3  fast
10 Remark:  START A
11 Go to Position  4  fast
12 Go to Position  2  speed  5
13 WaiT  50  ( 10 ths of seconds )
14 Go to Position  3  fast
15 Remark:  START B
16 Go to Position  4  fast
17 Go to Position  2  speed  5
18 WaiT  50  ( 10 ths of seconds )
19 Go to Position  3  fast
20 Remark:  START D
21 Go to Position  4  fast
22 Go to Position  4  fast
23 Go to Position  2  speed  5
24 WaiT  50  ( 10 ths of seconds )
25 Go to Position  3  fast
26 Go to Position  1  fast
27 Go to Position  2  speed  5
28 Open Gripper
29 Go to Position  3  fast
```

Shut Down	
Item	**End of Session**
Files saved.	
Exited from RoboCell.	
Computer turned off.	

Recording More Relative Positions

Task 7-2: Recording Positions

Q *Why is the robot ordered to lift the cylinder 40 mm?*

> ***THE ROBOT SHOULD BE 40 MM ABOVE THE SURFACE SINCE THE CYLINDER HEIGHT IS 35 MM.***

Q *Why should the cylinder be lowered 50 mm to the template.*

> ***THE TEMPLATE SURFACE IS 20 MM ABOVE TABLE LEVEL WHILE THE GRAVITY FEEDER IS 30 MM ABOVE TABLE LEVEL. IN RELATIVE TERMS, THE TEMPLATE IS 10 MM LOWER THAN THE FEEDER.***

Task 7-4: Team Discussion and Review

Q *According to Figure 7-3, the distance between the center of the two cylinders placed on the template is 80 mm. This value was used to calculate the distance from position #1 to position #2.*

Q In industry, however, it customary for positions to be recorded relative to given data, rather than recalculating the coordinates.

Q How would you record position #2 as a relative position based on the above data?

> ***RECORD POSITION #2 AS RELATIVE TO POSITION #1 (Y=-80).***

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Recording Positions for Peripheral Devices

Task 8-1: Running RoboCell and Loading the Setup

Q *Which cylinders does it reach on the rotary table?*

> ***THE ROBOT CAN REACH ONLY THE GREEN CYLINDER.***

Q *Which doesn't it reach? What message appears in the status bar of the Graphic Display window?*

> ***IT CANNOT REACH THE BLUE, YELLOW AND RED CYLINDERS. THE MESSAGE, "TARGET IS OUT OF THE ROBOT'S REACH," APPEARS.***

Q *What does that say about the work envelope of the robot?*

> ***THAT MEANS THAT ONLY THE GREEN CYLINDER IS WITHIN THE ROBOT'S WORK ENVELOPE.***

Q *Is it possible to perform this task without a rotary table?*

> ***NOT IF ALL THE CYLINDERS REMAIN IN THEIR INITIAL POSITIONS. HOWEVER, WERE THE CYLINDERS TO BE PLACED WITHIN THE ROBOT'S WORK ENVELOPE THEN THE TASK COULD BE CARRIED OUT.***

Q *What is the advantage of using a rotary table?*

> ***THE WORK ENVELOPE IS LESS OCCUPIED AND OTHER OBJECTS, TOOLS, AND ACCESSORIES CAN BE MOVED, AND INTEGRATED, INTO THE SYSTEM.***

Task 8-2: Recording Positions for the Robot and Peripheral Equipment

Q *How will you load the blue cylinder?*

> ***LOADING THE BLUE CYLINDER WILL BE DONE BY SENDING THE ROBOT TO A POSITION ABOVE WHERE THE GREEN CYLINDER IS INITIALLY STANDING (POSITION #11) WHILE SENDING THE TABLE TO POSITION #6. WHEN THE ROBOT IS THEN LOWERED TO POSITION #1, CLOSING THE GRIPPER WILL THUS LOAD THE BLUE CYLINDER.***

Task 8-5: Team Discussion and Review

Q *In this activity, the program you wrote can be easily modified to increase the efficiency of the process. By examining the process, you can see that after placing the cylinder, the robot moves to a position above the table (position #11) and only then the table turns to place the next cylinder under it.*

Q Modify the program to increase productivity by cutting down the time.

Hint: You can record a single position for the robot and the peripheral equipment.

Save the file as USER8A.

> ***1. PLACE THE ROBOT IN POSITION #11 AND THE TABLE IN POSITION #3. THEN RECORD THIS POSITION AS POSITION #13 - ROBOT AND PERIPHERAL.***
>
> ***2. PLACE THE ROBOT IN POSITION #11 AND THE TABLE IN POSITION #4. THEN RECORD THIS POSITION AS POSITION #14 - ROBOT AND PERIPHERAL.***
>
> ***3. PLACE THE ROBOT IN POSITION #11 AND THE TABLE IN POSITION #5. THEN RECORD THIS POSITION AS POSITION #15 - ROBOT AND PERIPHERAL.***
>
> ***4. PLACE THE ROBOT IN POSITION #11 AND THE TABLE IN POSITION #6. THEN RECORD THIS POSITION AS POSITION #16 - ROBOT AND PERIPHERAL.***

5. THEN MODIFY THE PROGRAM BY REPLACING THE TWO LINES WITH ONE. FOR EXAMPLE REPLACE:

```
Go to Position  11  fast
Go to Position  3  fast
```

WITH

```
Go to Position  13  fast
```

THE MODIFIED PROGRAM SHOULD BE SAVED AS USER8A:

```
1  Remark: *************************
2  Remark: ACT8A
3  Remark: Recording Positions for Peripheral Devices
4  Remark: *************************
5  Open Gripper
6  Remark:  STARTING OF RED CYLINDER
7  Go to Position  14  fast
8  Remark:   robot above rotary table
9  Remark:  rotary table in position
10 Go to Position  1  speed  5
11 Close Gripper
12 Go to Position  11  fast
13 Go to Position  24  fast
14 Go to Position  2  speed  5
15 Remark:  cylinder in place
16 Open Gripper
17 Go to Position  24  fast
18 Remark:  STARTING OF BLUE CYLINDER
19 Go to Position  16  fast
20 Remark:  robot above table
21 Remark:  rotary table in position
22 Go to Position  1  speed  5
23 Close Gripper
24 Go to Position  11  fast
25 Go to Position  24  fast
26 Go to Position  21  speed  5
27 Remark:  cylinder in place
28 Open Gripper
29 Go to Position  24  fast
30 Remark:  STARTING OF YELLOW CYLINDER
31 Go to Position  15  fast
32 Remark:  robot above rotary table
33 Remark:  rotary table in position
34 Go to Position  1  speed  5
35 Close Gripper
36 Go to Position  11  fast
37 Go to Position  24  fast
38 Go to Position  22  speed  5
39 Remark:  cylinder in place
40 Open Gripper
```

```
41 Go to Position  24  fast
42 Remark:  STARTING OF GREEN CYLINDER
43 Go to Position  13  fast
44 Remark:  robot above rotary table
45 Remark:  rotary table in position
46 Go to Position  1  speed  5
47 Close Gripper
48 Go to Position  11  fast
49 Go to Position  24  fast
50 Go to Position  23  speed  5
51 Remark:  cylinder in place
52 Open Gripper
53 Go to Position  24  fast
```

Shut Down	
Item	**End of Session**
Files saved.	
Exited from RoboCell.	
Computer turned off.	

Recording Positions Using Encoder Values

Task 9-1: Running RoboCell and Opening Cell Setup File

Q *Are the cylinders aligned in their stacked tower?*

> ***PROBABLY NOT.***

Q *What should be the encoder value for the blue cylinder be to be located exactly in the initial position of the green cylinder?*

> ***WHEN THE ENCODER VALUE WILL BE 3 QUARTERS OF A FULL TURN OR*** $\frac{41{,}000}{4} \cdot 3 = 30750$ ***PULSES, THE BLUE CYLINDER WILL STAND EXACTLY IN THE INITIAL POSITION WHERE THE GREEN CYLINDER.***

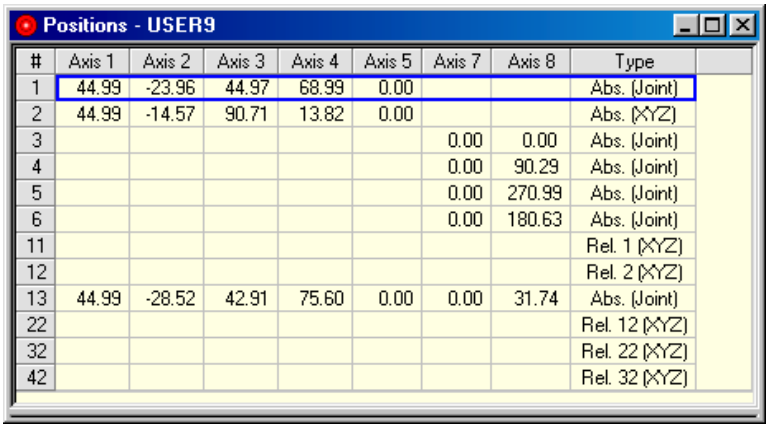
Task 9-4: Running the Program

Q *Compare the efficiency of the new program with the previous one.*

> ***THE NEW PROGRAM RUNS MUCH FASTER THAN THE OLD ONE. INSTEAD OF FIRST THE ROBOT MOVING TO ITS POSITION, AND THEN THE ROTARY TABLE MOVING TO ITS POSITION, THEY BOTH NOW MOVE AT THE SAME TIME AND, THEREFORE, THE RUN TIME IS MUCH SHORTER.***

Task 9-5: Team Discussion and Review

Q *The following figure shows the encoder values before you performed Task 9-3. What will the encoder values be of the newly recorded positions (#13, #14, #15 and #16)?*

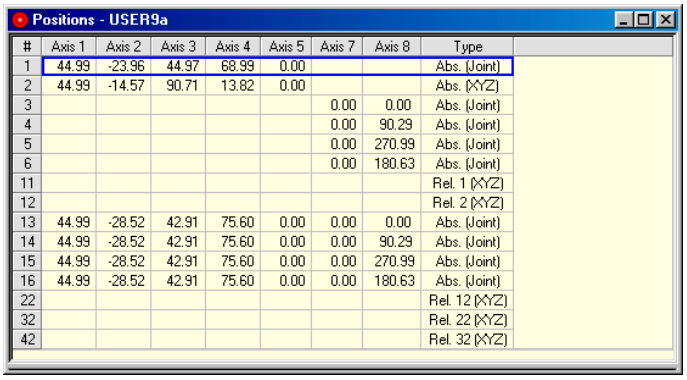


Positions - USER9

#	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 7	Axis 8	Type
1	44.99	-23.96	44.97	68.99	0.00			Abs. (Joint)
2	44.99	-14.57	90.71	13.82	0.00			Abs. (XYZ)
3						0.00	0.00	Abs. (Joint)
4						0.00	90.29	Abs. (Joint)
5						0.00	270.99	Abs. (Joint)
6						0.00	180.63	Abs. (Joint)
11								Rel. 1 (XYZ)
12								Rel. 2 (XYZ)
13	44.99	-28.52	42.91	75.60	0.00	0.00	31.74	Abs. (Joint)
22								Rel. 12 (XYZ)
32								Rel. 22 (XYZ)
42								Rel. 32 (XYZ)

Figure 4

THE FOLLOWING FIGURE ILLUSTRATES THE ANSWER.



Positions - USER9a

#	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 7	Axis 8	Type
1	44.99	-23.96	44.97	68.99	0.00			Abs. (Joint)
2	44.99	-14.57	90.71	13.82	0.00			Abs. (XYZ)
3						0.00	0.00	Abs. (Joint)
4						0.00	90.29	Abs. (Joint)
5						0.00	270.99	Abs. (Joint)
6						0.00	180.63	Abs. (Joint)
11								Rel. 1 (XYZ)
12								Rel. 2 (XYZ)
13	44.99	-28.52	42.91	75.60	0.00	0.00	0.00	Abs. (Joint)
14	44.99	-28.52	42.91	75.60	0.00	0.00	90.29	Abs. (Joint)
15	44.99	-28.52	42.91	75.60	0.00	0.00	270.99	Abs. (Joint)
16	44.99	-28.52	42.91	75.60	0.00	0.00	180.63	Abs. (Joint)
22								Rel. 12 (XYZ)
32								Rel. 22 (XYZ)
42								Rel. 32 (XYZ)

Figure 5

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Programming the Robot to Execute Linear Movement

Task 10-2: Recording Two End Positions and Running the Program

Q *Describe the TCP path.*

> ***THE TCP MOVES IN AN ARC FROM ONE POSITION TO THE OTHER.***

Q *Describe the TCP speed during program execution.*

> ***AT THE MIDDLE POINT, THE TCP MOVES AT A HIGHER SPEED THAN IT DOES NEXT TO THE TWO END POSITIONS.***

Task 10-3: Recording a Middle Position and Running the Program

Q *Describe the TCP path.*

> ***THE ROBOT MOVES IN TWO SMALLER ARCS FROM ONE POSITION TO THE OTHER.***

Q *Is the TCP path in this program closer to a straight line than in the previous program?*

> ***YES.***

Q *Describe the TCP speed during program execution.*

> ***THE ROBOT'S SPEED NEXT TO THE ENDPOINTS IS SLOW AND THE SPEED IN THE MIDDLE OF THE MOVEMENTS IS HIGHER.***

Task 10-4: Recording a Relative Position, Sending the Robot to this Position Repeatedly and Running the Program

Q *Describe the TCP path.*

> ***THE ROBOT MOVES IN A JERKING FASHION (STOPS AND STARTS A LOT). THE PATH IS CLOSE TO A STRAIGHT LINE.***

Q *Is the TCP path closer to a straight line this time?*

> ***YES.***

Q *Describe the TCP speed during program execution.*

> ***THE TCP ACCELERATES AND DECELERATES SIX TIMES BEFORE AND AFTER STOPPING AT THE DESIGNATED POSITIONS. THE SPEED IS OBVIOUSLY NOT AT ALL CONSTANT EVEN THOUGH THE GREEN PATH "CUBES" ARE DRAWN CLOSE TO EACH OTHER.***

Task 10-5: Using the Go Linear Command and Running the Program

Q *Describe the TCP path.*

> ***THE ROBOT MOVES DIRECTLY FROM THE FIRST END POSITION TO THE SECOND. PATH IS CLOSE TO A STRAIGHT LINE.***

Q *Describe the TCP speed during program execution.*

> ***THE TCP MOVES FASTER ON THE CENTER AND SLOWER NEXT TO THE RECORDED ENDPOINTS.***

Task 10-6: Team Discussion and Review

Q *Add to your program an instruction to go to position #1. Then run the program with the Encoder Counts dialog box open. Note that when the TCP moves from position #2 to position #1, only the encoder values for encoder 1 changed. When the TCP moves from position #1 to position #2, however, all the encoder values changed.*

Q *How can you explain this?*

> ***THE DISTANCE OF POSITION #1 AND #2 FROM THE ORIGIN IS EQUAL. WHEN THE ROBOT MOVES FROM POSITION #2 TO POSITION #1, ONLY THE BASE IS MOVING SINCE THIS IS THE FASTEST ROUTE FOR THE ROBOT.***
>
> ***WHEN THE TCP MOVES IN A LINEAR MOTION, HOWEVER, OTHER JOINTS OF THE ROBOT MUST MOVE ALSO SINCE THE DISTANCE OF THE ROBOT PATH FROM THE ORIGIN IS CHANGED DURING MOTION.***

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Programming the Robot to Execute Circular Movement

Task 11-4: Running the Program

Q *Rerun the program line-by-line to determine if the letter B is completed after moving from position #1 to position #8 through all the intermediate positions (up to line #10 of the program)?*

NO. THE LINES THAT CONNECT POSITION #8 AND #1 AND POSITION #1 AND #5 ARE MISSING.

Task 11-5: Team Discussion and Review

Q *Using all the points recorded in this activity, write a program that draws the number "3".*

Q *Save the program as USER11A.*

THE PROGRAM THE STUDENT SHOULD WRITE SHOULD BE:

```
 1   Remark: ************************
 2   Remark: ACT11A
 3   Remark: Programming the Robot to Execute
Circular Movement
 4   Remark: ************************
 5   Go to Position 8  fast
 6   Go Linear to position 7  speed  5
 7   Go Circular to position  5  through  6  speed 5
 8   Go Linear to position 1  speed  5
 9   Go Linear to position 5  speed  5
10   Go Circular to position 3  through  4  speed 5
11   Go Linear to position 2  speed  5
12   Go to Position 9  fast
```

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Programming with Subroutines

Task 12-5: Team Discussion and Review

Q *Load the 3D model file ACT12_1.3. This robotic cell is similar to the one used in this activity except that the sensor that detects blue was replaced with a sensor that detects red.*

Q *Do the program and/or positions need to be modified in order to now sort the red cylinders? If yes, then save the new program and positions as file USER12A.*

THE PROGRAM AND POSITIONS DO NOT NEED TO BE MODIFIED. THE NEW CELL SHOULD SORT RED CYLINDERS WITHOUT MAKING ANY CHANGES AT ALL.

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

More Programming with Conditional Branching

Task 13-4: Team Discussion and Review

Q *Print the program (or copy it) and then draw lines that describe the program flow.*

```
 1    Remark: ********************************
 2    Remark:  ACT13
 3    Remark:  More Programming with Conditional
Branching
 4    Remark: ********************************
 5    On Input Interrupt  1  on jump to  STOP
 6    Open Gripper
 7    Go to Position  11  fast
 8    Go to Position  1  speed  5
 9    Close Gripper
10    Go to Position  11  fast
11    Go to Position  12  fast
12    Go to Position  2  speed  5
13    Open Gripper
14    Go to Position  12  fast
15    Start Conveyor at speed  3 in Minus  direction
16    Go Linear to position  13  fast
17    WaiT  300  ( 10 ths of seconds )
18    STop conveyor
19    Jump to  END
20    STOP:
21    Disable input Interrupt  1
22    STop conveyor
23    Go to Position  3  speed  5
24    Close Gripper
25    Go to Position  13  fast
26    Go to Position  14  fast
27    Go to Position  4  speed  5
28    Open Gripper
29    Go to Position  14  fast
30    Enable input Interrupt  1
31    END:
```

Q *Describe the robot response.*

AFTER REMOVING THE DISABLE INPUT INTERRUPT 1 COMMAND, THE ROBOT STOPS WHILE ATTEMPTING TO PLACE THE OBJECT ON THE TEMPLATE.

Q *Give reasons for the robot response.*

THE REASON IS THAT WHILE MOVING FROM POSITION #3 (ON THE CONVEYOR) UP TO POSITION #13, THE OBJECT MOVES OUT OF THE SENSOR'S SENSING RANGE AND THEN BACK IN. AS A RESULT THE INTERRUPT IS EXECUTED OVER AND OVER AGAIN.

Q *Describe the task of the Disable input Interrupt 1 command.*

THE DISABLE INPUT INTERRUPT 1 COMMAND DISABLES THE INTERRUPT ACTION AFTER STOPPING THE CONVEYOR, THUS PREVENTING REPETITIOUS EXECUTION OF THE INTERRUPT.

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Advanced Use of Subroutines

Task 14-3: Team Discussion and Review

Q *Modify the program you wrote in this activity as follows.*

- *Change the conveyor speed to fast (speed #10)*
- *Set the speed of the robot movement to position #13 to slow (speed 1).*

Q *Run the modified program.*

Q *What happened?*

THE CYLINDER PROBABLY FELL FROM THE CONVEYOR BEFORE THE ROBOT HAD A CHANCE TO PICK IT.

Q *Give reasons why you think this happened and suggest a way to correct this bug.*

A WAY TO FIX THIS WOULD BE TO PLACE THE INTERRUPT BEFORE SENDING THE ROBOT TO POSITION #13 AND REMOVE THE WAIT COMMAND.

Shut Down	
Item	**End of Session**
File saved.	
Exited from RoboCell.	
Computer turned off.	

Conclusion

Task 15-1: Final Projects

Do as many of the following projects as you can in the time that remains:

A Load the cell setup file **ACT15A.3DC** in which two cylinders (height = 35 mm) are placed on a table.

Program the robot to stack the cylinders on the table at (220,0). Note that the cylinders' contact areas should overlap.

Save the program and positions in file **USER15A**.

B Load cell setup file **ACT15B.3DC**. This cell is similar to the first cell except that the cylinders were replaced with cubes (height = 35 mm). By using the Show Object Positions options, you can see the cubes are placed exactly in the same positions where the cylinders were.

Program the robot to stack the cubes on the table at (220,0). Note that the cubes' contact area should overlap.

Hint: Modify the program you just wrote.

Save the program and positions in file **USER15B**.

C Load the cell setup file **ACT15C.3DC**. This cell is also similar to the two previous cells except that the cylinders/cubes were replaced with two prisms (height = 35 mm; length = 35 mm; width = 50 mm). The prisms are placed exactly where the cylinders/cubes were.

Program the robot to stack the prisms on the table at (220,0). Note that the prisms' contact area should overlap.

Hint: Modify the program that you just wrote.

Save the program and positions in file **USER15C**.

Shut Down	
Item	**End of Session**
Files saved.	
Exited from RoboCell.	
Computer turned off.	