ED 353 484 CE 062 991

AUTHOR Campbell, Rob, Comp.
TITLE Introduction to Robotics for Industrial Technology Education. Curriculum Guide.
INSTITUTION Idaho State Dept. of Education, Boise. Div. of Vocational Education.
REPORT NO Vo-Ed-265
PUB DATE 92
NOTE 75p.
PUB TYPE Guides - Classroom Use - Teaching Guides (For Teacher) (052) -- Guides - Classroom Use - Instructional Materials (For Learner) (051)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Behavioral Objectives; *Competency Based Education; *Computer Assisted Manufacturing; *Electromechanical Technology; Electronic Control; *Electronics; High Schools; Mathematical Applications; Postsecondary Education; *Robotics; Science and Society; State Curriculum Guides; Technological Advancement; Trade and Industrial Education
IDENTIFIERS Idaho

ABSTRACT

This document consists of teacher's and student's guides for approximately 10 days of instruction that introduces robotics. The teacher's guide contains the following: an introduction; a daily lesson plan outline; a pretest; answers to the pretest and posttest; a list of student competencies; unit objectives and terms; definitions of terms; transparency masters on identifying robot parts and types of robots; information for discussions on end-effectors and on pick and place; information on how to conduct student activities on building a low-cost sorting robotic arm and transporting objects using pneumatic and hydraulic power; questions for class discussions on the social and environmental impact of robots; lesson plans on point-to-point function, continuous path function, and maintenance; a posttest; and 19 references. Contents of the student guide are as follows: (1) module instructions; (2) a list of 27 competencies; (3) a student information sheet that covers defining robotics, terms, related careers, what a robot is, why and how robots developed, types of industrial robots, parts of the robot, and issues surrounding robots; (4) a student review worksheet; (5) information on how to use a programming sheet; (6) information on student activities designed to show students how to determine, for instance, degrees of freedom and the horizontal and vertical reach of the robot arm; and (7) information and student worksheets on robotic coding. (CML)

CURRICULUM GUIDE FOR INTRODUCTION TO ROBOTICS FOR INDUSTRIAL TECHNOLOGY EDUCATION

Invest in Success

IDAHO VTE
VOCATIONAL TECHNICAL EDUCATION

STATE DIVISION OF VOCATIONAL EDUCATION

1992

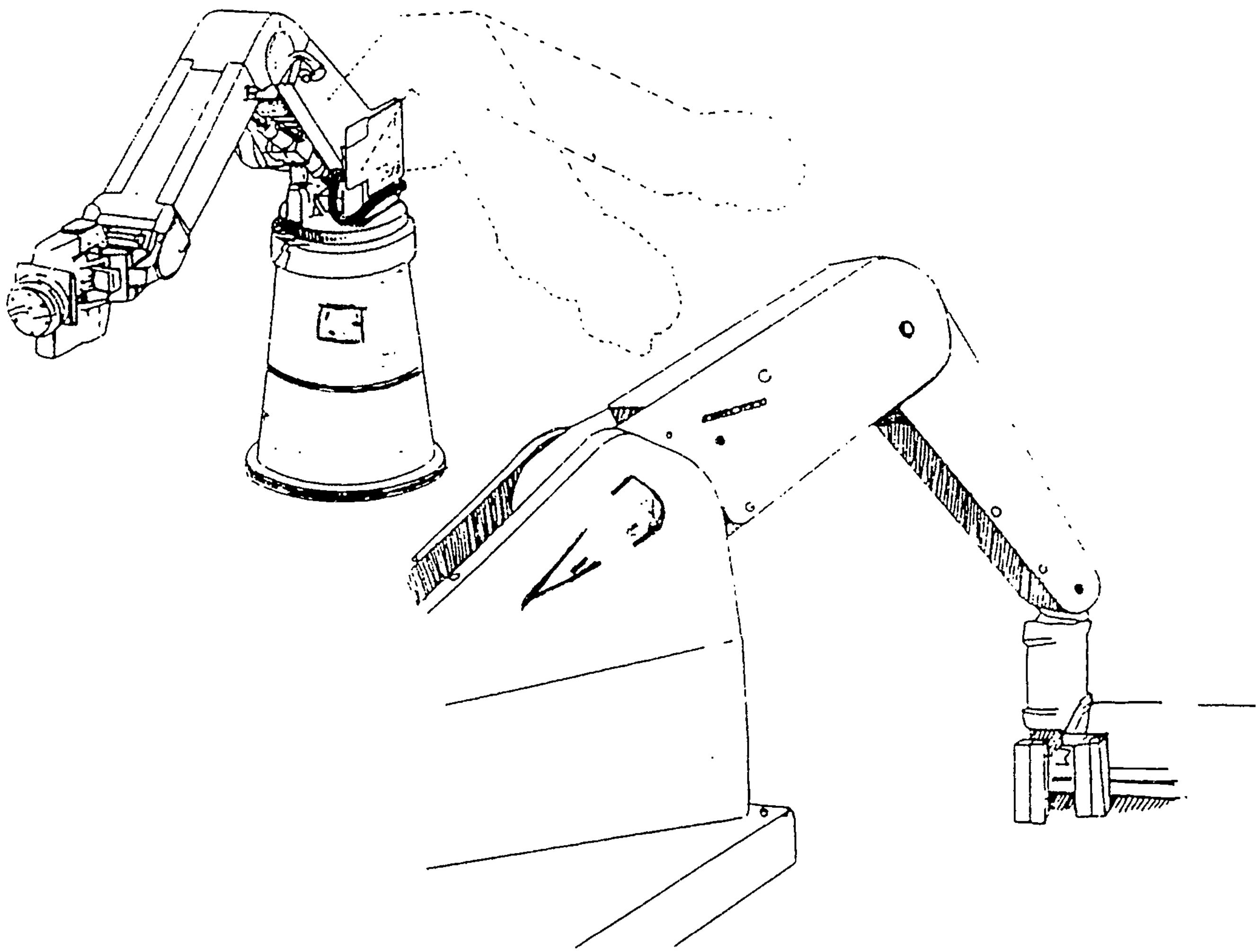
Guide # VE-265

INTRODUCTION TO ROBOTICS

FOR

INDUSTRIAL TECHNOLOGY EDUCATION

TEACHER'S GUIDE



Compiled by Rob Campbell
State Supervisor for Industrial Technology Education
Division of Vocational Education

Costs associated with this publication are available from the Idaho Division
of Vocational Education in accordance with Section 60.202, Idaho Code.
9/92/265/100/010000

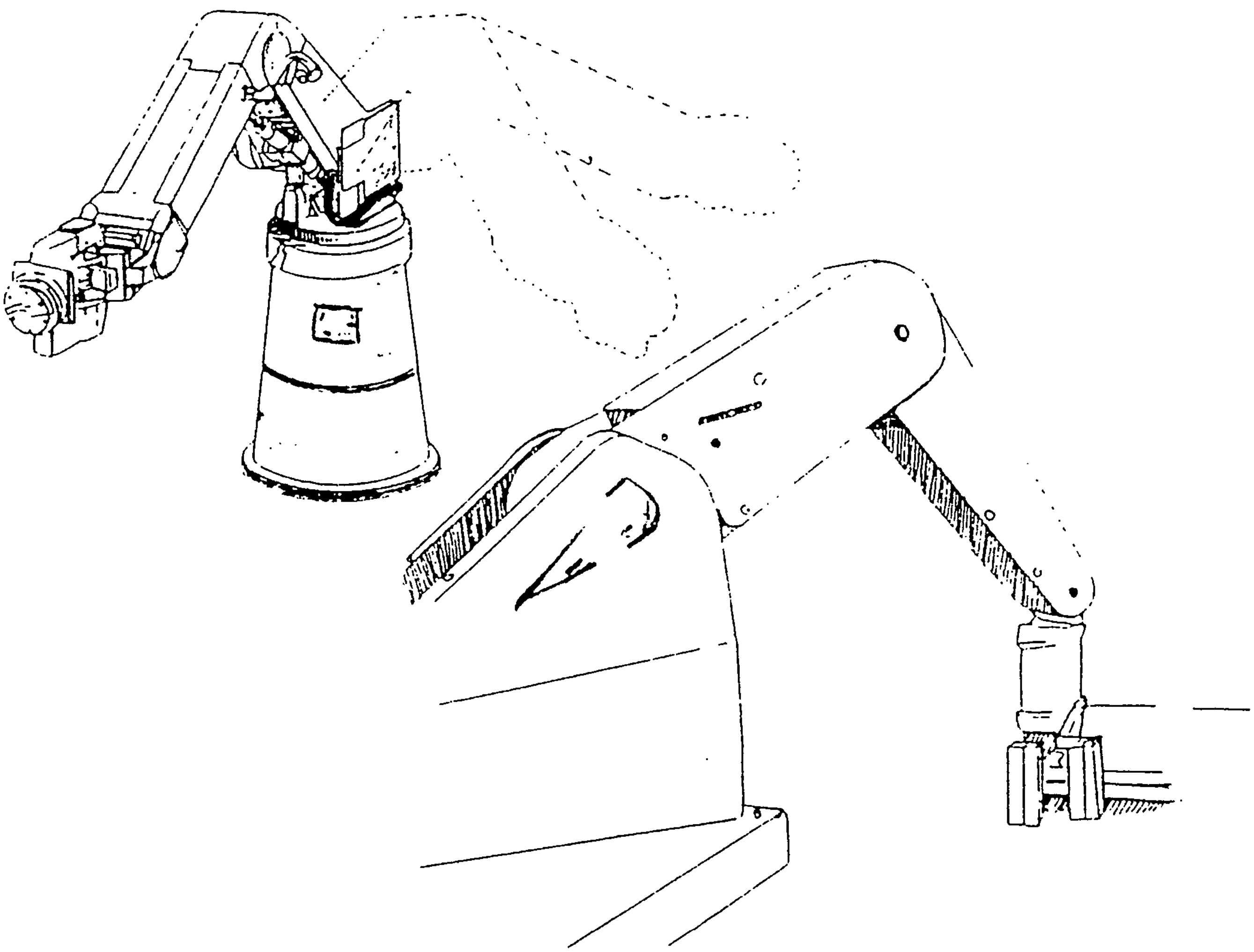
Guide # VE-265

INTRODUCTION TO ROBOTICS

FOR

INDUSTRIAL TECHNOLOGY EDUCATION

TEACHER'S GUIDE



Compiled by Rob Campbell
State Supervisor for Industrial Technology Education
Division of Vocational Education

Costs associated with this publication are available from the Idaho Division of Vocational Education in accordance with Section 60.202, Idaho Code.
9/92/265/100/010000

Acknowledgement:

The Idaho Division of Vocational Education would like to acknowledge the following organizations for their input and use of their curriculum materials and information in compiling this document.

Utah State Office of Public Instruction, Robotic Technology, Balistrer, 1985.

Michigan Industrial Arts Curriculum, Robotics, 1984.

ITEA, the Technology Teacher, Meys, February, 1988.

School Shop, Construct a Robot Simulator, Neddeyriep, 1982.

Mississippi State Department of Education, Diversified Technology, Module 5, Introduction to Robotics.

TEACHER'S GUIDE
INDEX

TABLE OF CONTENTS

Introduction:

This activity is designed to combine, design, fabrication and operation procedures as applied to robots. Robots work within a restricted envelope. Most operate on three axes: ***X, Y, and Z***. Arms move from one side to the other on the X axis, in and out on the Y axis and up and down on the Z axis. It is recommended that the instructor integrate this activity with ongoing classroom presentations with math, science and history teachers. Other activities involved include: pre and post tests, safety instruction, demonstration of robotic processes and programming, automation and manufacturing processes.

Safety Considerations:

General safety concerns apply to the small instructional robots typically found in school technology laboratories. Construction of a robot, however, will involve laboratory tools, so specific safety precautions will need to be observed for each tool or piece of equipment. One special note: It is recommended that only clean new syringes without attached needles be used when constructing syringe operated robots.

INTRODUCTION TO ROBOTICS

TEACHERS LESSON PLANS

TIME IN DAYS	TEACHER	STUDENT
1/2	1. Pass out pre-test/show robotics video Introduce student hand book and assignments.	1. Take pre-test. (nongraded) View video and take notes.
1/2	2. Discuss student profile sheet (pages 2-3) and reading assignments (objectives, terms, activities). Assign reading, Introduction to Robots, pages 4-7.	2. Read Introduction to Robots information, pages 4-7, and start on the terms **(home work assignment)**.
3-4	3. Discuss What is a Robot? Student pages 4-7. Students read pages 7-10, Why and How Did Robots Develop and Types of Robots. Review and discuss Development and types (overhead) (Spherical, Cylindrical, Rectangular, Jointed Arm). Pop Quiz on reading. Reading assignment, pages 10-14. Identify robot parts and demonstrate their operation. (overhead) Discuss controlling mechanisms and uses. Ask students how the parts of the robot (manipulator) are controlled. Ask students to identify different uses of robots in industry. (Welding, painting, materials handling, die casting, end effector, etc.). Reading assignment, pages 14-15 Issues.	3. Take part in the discussion and take notes. Read pages 7-10 - Why and How Did Robots Develop and Types of Robots. Identify as many uses of robots as possible. Take part in discussion. Take notes. Read pages 10-14 - parts of a Robot. Take part in discussion, take notes. Describe how robotic arm (manipulator) is controlled. Identify as many uses of robots as possible. Class discussion. Read Issues, pages 14-15. Complete Review Activity Sheet.
1	4. Discuss Issues. Lecture on End Effectors, Pick and Place Functions. Discuss Programming Sheet, pages 17-18.	4. Read How to Operate a Robot, pages 16-17. Complete Manual Programming Sheet, page 18.

TIME IN DAYS	TEACHER	STUDENT
1 (cont.)	(Optional Discussion). Point to point, Continuous Path, Maintenance. Identify each degree of freedom. (Should identify six). Reading assignment, pages 19-22. Discuss Degrees worksheet and handout graph paper and data recording sheet.	Identify each degree of freedom. Read pages 19-22 and complete degrees of freedorn worksheet handout and page 24. Ask teacher for handouts.
2-3	5. Explain procedure sheet how to build a low cost robot. Cover safety procedures for all tools and equipment used. Assign students into groups to perform robotic code laboratory experiment.	5. Assist the teacher in building a syringe robotic arm. Conduct robot code experiment, pages 25-29.
1/2	6. Discuss robot work cells and their impact on quality and efficiency. Discuss the impact of robots on workers and productivity. Social/environmental impact.	6. Discuss negative and positive impacts of robots.
1/2	7. Hold discussion on advantages and disadvantages of robots.	7. Identify advantages and disadvantages of robots.
	8. Have students define the terms listed at the first of the unit. Review as needed. Discuss Career Report.	8. Complete definition for terms or notebook paper. Complete Career Report.
1/2	9. Pass out Post-Test.	9. Take Post-Test.

OPTIONAL ADVANCED DISCUSSION MATERIALS

1. Point-to-Point Functions
2. Continuous Path Functions
3. Maintenance

Date: ____________ Class: ______________ Name: __________________________

#1 ROBOTICS PRE-TEST

Instructions: Circle the letter of the correct answer.

1. A robot is a/an:

    a. programmable machine
    b. multipurpose machine
    c. electromechanical machine
    d. all of the above

2. Robots are used for work that is:

    a. boring
    b. repetitious
    c. dangerous
    d. all of the above

Instructions: Fill in the blanks with the correct answers.

3. Name the four components of typical robot systems:

    a. ______________________________
    b. ______________________________
    c. ______________________________
    d. ______________________________

4. The three most used power sources for robot systems are:

    a. ______________________________
    b. ______________________________
    c. ______________________________

5. Manipulator movements are either ________________ or ____________.

PRE-TEST ANSWERS

1. d

2. d

3. The following in any order:

   a. manipulator b. controller c. power sources

   d. end effectors

2. The following in any order:

   a. electric b. pneumatic c. hydraulic

3. Servo controlled or non-servo controlled:

POST-TEST ANSWERS

1. d

2. g

3. Cartesian

4. The following in any order:

   a. spray painting b. welding c. loading/unloading

   d. handling materials e. assembling

5. 1. cylindrical coordinate robot
   2. rectangular coordinate robot
   3. spherical coordinate robot
   4. jointed-arm coordinate robot

6. 1. pick and place
   2. point to point
   3. continuous path

7. Microprocessor control

8. F
9. E
10. D
11. C
12. B
13. A

STUDENT PROFILE SHEET

Robotic Competencies

Activity Objective: The purpose of this activity is to develop student capabilities in making and using robots suitable for a variety of manufacturing processes. Student activities include design, planning, fabrication, programming and utilization of robots.

Lap Competencies:

1. Define and recognize various potential hazards and the safety considerations
2. associated with such hazards.
3. Be able to practice safe attitudinal and operational habits when working with the robot.
4. Identify capabilities and/or potential uses for the low-medium- and high-technology level categories of robots.
5. Define various basic terms associated with a robot's coordinate-system movements.
6. Identify various features and capabilities associated with the rectilinear, cylindrical, spherical and anthropomorphic robotics coordinate systems.
7. Define various basic terms applicable to the most significant structural parts of the robot.
8. Identify and provide the functions of various parts of the robot.
9. Be able to identify potential problems and to take corrective actions toward keeping a robotic system in good working order.
10. Be able to perform simple maintenance work on the robotic system as directed by the instructor.
11. Define types and features and potential uses of various robotics and end-effectors.
12. Determine various parameters, e.g., opening, force, attachments, etc., of end-effector(s) on the robot which you are using.
13. Define the dimensional planes involved in the working envelopes of robots in general.
14. Determine and sketch the size and shape of the working envelope being used, through use of the teach pendant.
15. Define/describe basic terms and potential applications for robotics pick-and-place operations.
16. Design a simple pick-and-place routine for the robot.

17. Use the teach pendant's modes and program a robot to execute a pick-and-place operation.

18. Define/describe basic terms and potential applications for robotics point-to-point movement operations.

19. Design a simple point-to-point routine for the robot.

20. Define/describe basic terms and potential applications for robotics continuous-path operations.

21. Design a simple (simulated) continuous-path routine for the robot.

22. Use the teach pendant's modes and program a robot to carry out a simulated continuous-path operation.

23. Identify and describe the essential features of the equipment used in manufacturing technology and describe the major types and systems of robots.

24. Apply hand, mechanized and automated processes in operating robots to perform simulated manufacturing tasks.

25. Devise a plan of procedures and operations for repetitive and quantity fabrication of products or components and construct a simple robot to work with it.

26. Read technical and working drawings and prints to secure needed information.

27. Solve simulated industrial design or planning problems in the construction of a robotic arm that demonstrates each coordinate system.

28. Discuss production technology breakthroughs and future trends in the design and operation of robots and programming methods.

UNIT OBJECTIVES

After completing this instructional unit, you will be able to do the following:

1. Define a robot in one sentence.
2. Describe how and why robots developed.
3. Define robotics in one sentence.
4. Describe the parts or components of a robot.
5. Describe three types of industrial robots.
6. Give several uses of robots in the workplace.
7. Discuss the pros and cons of robot development.
8. Operate a robot using a manual Pendant.
9. Operate a robot using a micro computer.
10. Construct a working model of an industrial robot.

FOR TEACHER USE ONLY

LESSON PLAN TERMS

DEFINITIONS

ACTUATOR:	A device which converts electrical, hydraulic, or pneumatic energy into mechanical linear or rotary motion.
ANDROID:	A robot which is made to look human or has some human resemblance.
ANTHROPOMORPHIC, OR REVOLUTE COORDINATES:	All movements are rotational. Anthropomorphic means resembling human shape or characteristics. It describes the ability of a robot arm to move in a fashion similar to the human arm.
ARTIFICIAL INTELLIGENCE:	Ability to perceive and solve problems.
AUTOMATION:	The technique of making a process, usually in manufacturing, automatic, self-moving, or self-controlling.
AXIS:	A basic motion or plane of travel.
COMPONENT PACKAGING:	The way the controller, programming equipment and power supply are placed in the robot system; either integrated components (a part of the robot itself) or separate components interfaced to the robot by cables.
CONTINUOUS PATH:	Non-stop action, providing a smooth flow of motion.
CONTROLLER:	The "brain" of the robot, used to direct motion, store program data and interface with other equipment.
COORDINATE SYSTEM:	A method of defining the directions and dimensions of the space through which a robot's end-effector can move.
CUSTOM-MADE:	Made to order, according to the customer's specifications.
CYLINDRICAL COORDINATES:	The movement in two planes is linear (straight line) and in the third it is rotational.
DEGREES OF FREEDOM:	The total number of different movements, about axes, through which the robot can function. It is equal to the number of axes built into the robot.
EFFECTORS:	The parts of the robot that are moved by the gears, motors or hydraulic pressure, the (arms, hands, legs, etc., of a robot).
ENCODER:	Device that converts the motion o the arm into string of numbers, used in programming by a computer.

INDUSTRIAL ROBOT: Robots that gear their efforts towards the application of industrial tasks; like welding, lifting, painting, etc.

MANIPULATOR: A mechanism, usually consisting of a series of segments jointed or sliding relative to one another, for the purpose of grasping and moving objects, usually in several degrees of freedom.

POINT-TO-POINT: Moving through a sequence of steps defined by a large number of discrete locations.

PROGRAM: A sequence of instructions to be executed by the computer or robot controller to control a machine or a process.

RECTILINEAR COORDINATES: The movements are linear (straight line, one in each of the three planes X, Y and Z.

REPROGRAMMABLE: Capable of having operational instructions changed as the tasks of the robot change.

ROBOT: A reprogrammable multifunctional manipulator, designed to move materials, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks.

SENSORS: Parts which act like a person's senses and detect not only objects, but also heat, light, odors, and translates these objects into symbols.

SERVO CONTROLLED: A robot where the controlling system continuously checks the location of all the moving parts of the robot.

SPHERICAL COORDINATES: The movement in one plane is linear (straight line), while in the other two planes it is rotational.

WORK ENVELOPE: The total space reached by the robot arm during its operation; the maximum reach of the robot in all directions.

TEACHERS LESSON PLAN

Identifying Robotic Part

The major segments of the robot will be identified and briefly described. (You may want to demonstrate the movements using a student and overhead.) Only the major, or most important segments will be discussed.

They are as follows:

1. Base -- the base is that part which is fastened to the table or floor. It contains the waist axis of rotation.

2. Torso, or Shoulder Assembly -- The torso, or shoulder assembly, is that part which contains the bicep flex axis of rotation.

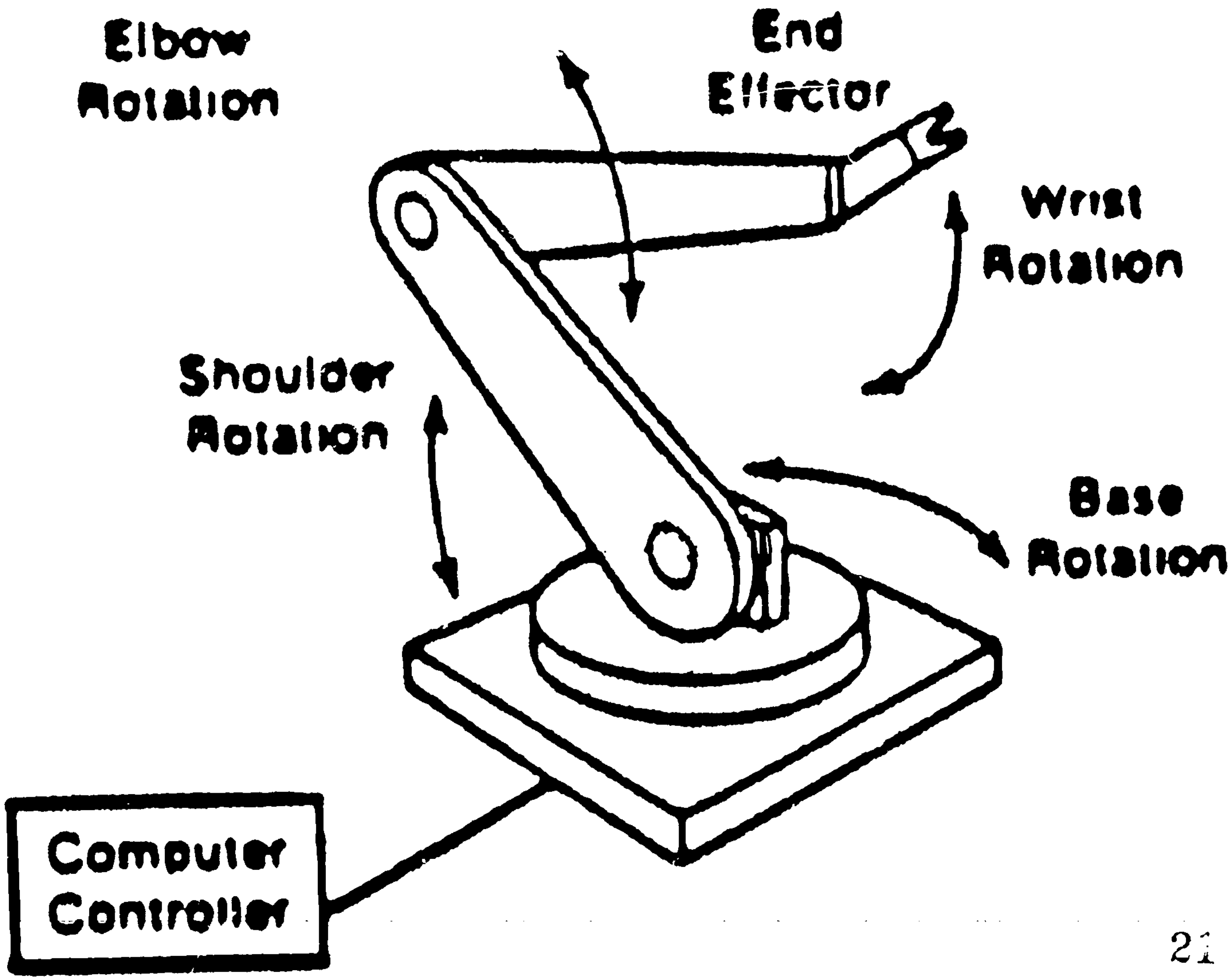
3. Bicep, or Upper Am -- The bicep constitutes part of the extension capability of the robot. Its length is from the bicep axis to the elbow axis.

4. Forearm -- The forearm constitutes another part of the extension capability of the robot. Its length is from the elbow axis to the wrist axis.

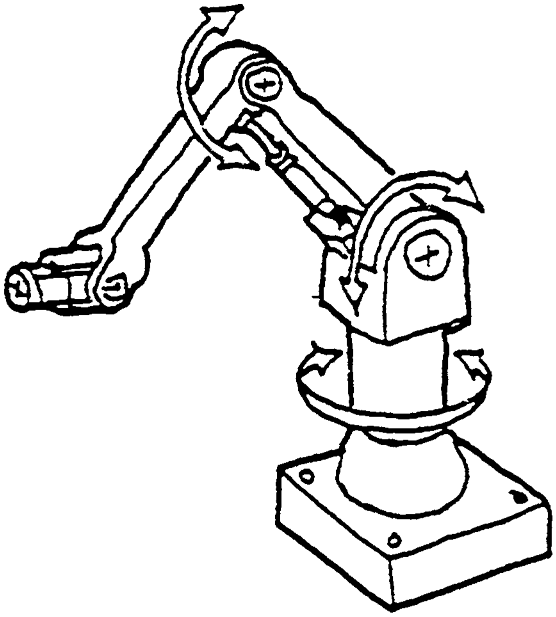
5. End-Effector -- The end-effector assembly is often referred to as the "business end" of the robot. It flexes about the wrist flex, axis. It has pitch (up and down motion) as well as rotational motion.

6. Controller -- The robot controller contains controlling and motor drive circuitry for the robot. It forms the major link between the teach pendant or computer and the robot.

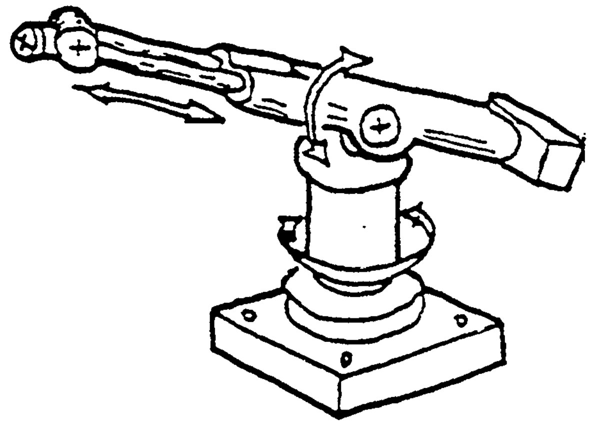
7. Teach Pendant -- A teach pendant is a hand-held computer, usually attached to the robot controller, with which the operator can guide the robot through a series of points or in a motion pattern. Typically, a teach pendant can also be used to record the robot's moves for subsequent automatic actions by the robot.


Elbow Rotation
End Effector
Wrist Rotation
Shoulder Rotation
Base Rotation
Computer Controller

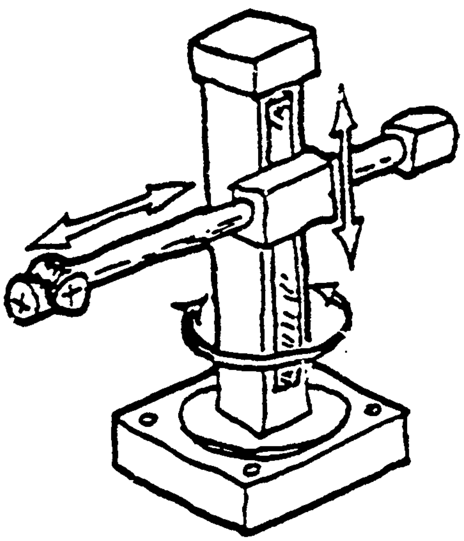
BASIC CONFIGURATIONS



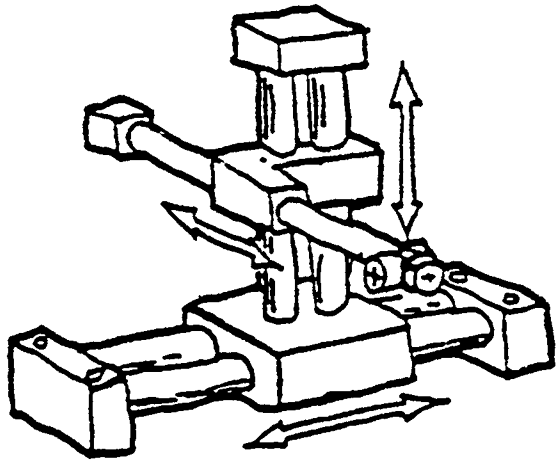
JOINTED ARM



SPHERICAL



CYLINDRICAL



RECTANGULAR

LESSON PLAN
End-Effector

Introduction

As stated, the end-effector is the "business end" of a robot. An end-effector may be defined as any actuator, gripper, or mechanical device which is attached at the wrist joint of a robot for the purpose of picking up, moving, or positioning an object. In this case, the object, which constitutes the payload, could be any of many things such as a workpiece to be machined, a part to be assembled, or the wire which comes out of the nozzle of a wire-feed welder. The end-effector is what "handles" that object.

The design and manufacture of end-effector is a somewhat specialized area within the field of robotics. This is because of the many applications wherein robots perform a wide variety of tasks. For example, a robot used to insert and remove parts from a lathe may require a differently shaped end-effector for each type of part machined on that lathe. Thus, the end-effectors must be easily interchangeable for the different parts production runs done on that lathe.

The design of end-effectors is as varied as the robot applications themselves. A few broad categories of end-effectors are shown in Figure 1. Notice that they may be pneumatically (vacuum), electrically, or mechanically driven. Also, they may be a power tool, measure device, or some sort of gripper. The gripping-type end-effector is the most often used because it can be made to be able to grasp a wide variety of shapes and sizes of objects.

Grippers can usually be classified as two-finger or three-finger, and each can be made to grasp an object internally (hollow object) or externally. The three-finger gripper is often used where the object is circular or spherical and where the object must be centered between the fingers.

Gripper-Type End-Effector-Measurands

Generally, there are three things which can be measured on a gripper. They are:

1. **Jaw Size or Finger Width** - This refers to the diameter of an internal gripper when closed, or to the contact distance along the width of a finger.

2. **Opening or Span** - This opening is the distance between fingers when fully opened. Span refers to both the minimum and maximum opening, and must be given by stating two values, e.g., ⅛" to 1-¼".

3. **Pinch Force** - This is the force which the gripper fingers can apply to the object being grasped.

For many robot applications, the end-effector must move to very specific locations within the robot's total cycle of movements. For example, accurate end-effector placement might be necessary when the robot is used for assembly of parts or for loading and unloading of parts an a near-by machine such as a lathe. In other applications, such as grinding or deburring operations, the robot might have to move the end-effector by very small increments.

These two examples indicate that end-effector placement can be very important in the performance of a robot.

End-Effector Placement Specifications

Three end-effector placement specifications can be of concern for a robot. Each of the three can be considered to inter-relate with the others. The three are described as follows:

1. **Accuracy** - A measurement of the difference between the end-effector taught location point, due to the command from the controller, and the played-back location. Accuracy will depend on the precision of manufacture of segments or parts of the robot itself, the feedback control system, and possibly on the accuracy of the command.

2. **Repeatability** - A measurement of the difference between an original played-back position and those of subsequent cycles. In other words, the extent to which the end-effector comes to the same location time after time. Thus, repeatability can be effected by variations of payload and velocity and by the precision of manufacture of the robot.

3. **Resolution** - The smallest increment (distance) by which the end-effector can be moved. This specification is not often used for two reasons. First, the accuracy specification Is more meaningful and useful. Second, for a revolute axis (anthropomorphic) robot only the increments of angular movements are constant. Any straightline movement involves two or more joints, which causes straightline movements to depend upon the angles at which those joints are being used.

LESSON PLAN

Pick and Place Functions

Introduction

Robots can be classified by the function(s) which they perform. One such classification is the "pick-and-place" PNP) function. Early robots of the 1950s and 1960s could perform this function.

The more sophisticated medium- and high-technology robots can perform these and many additional functions as well. A pick-and-place robot operates to pick up an object (payload), most often using a gripper-type and end-effector, and to move that object to a new location. The path which the end-effector follows between pick-up and set-down of the object will depend upon the particular application being considered.

Applications

The applications for which a pick-and-place robot is suited, or the tasks which it can perform, include:

1. **Machine loading and unloading.** Examples could include the insertion of parts into and retrieval of parts from a lathe, a milling machine, a punch press, or a forming press. Simple assembly of parts is also possible, where a part is taken from a loading chute or tube and placed in a particular location in or on another part.

2. **Pelletizing or stacking of parts.** An example would be the placement of parts into a shipping carton as that carton moves along a conveyor belt.

3. **General materials handling tasks**, such as the movement of a die, a jig, or a fixture which holds a part on which operations are performed.

INSTRUCTOR INFORMATION

Low Cost Syringe Operated Robotic Arm

Needed Materials

1. Supplies

Bolts and nuts	Materials for fabrication	String
Cans	Paper fasteners	Syringes (new)
Caps	Paper	Thread spools
Counterweights	Pencil	Toilet paper rolls
Glue	Pipe cleaners	Tubes
Hinges	Plastic hose	Water
Hard wood	Poster board	Wire
Knobs	Small boxes	Wood

2. Equipment (cover safely procedures before using power equipment)

Bandsaw	Radial Arm saw	Whole punch
Drill press	Scissors	
Goggles	Table Saw	

3. Form 4-5 member corporation, decide on a robotic idea by drawing several thumbnails. Select the best and build a prototype.

4. Have the group design a company logo, business card, etc.

5. Have each group keep a folder containing their: business cards, company logo, <u>all</u> the robot sketches, work duties (who did what), work envelope details, simulated price list for their robot, and everything relating to the corporation.

   Rules governing robots include that the robot must have:

   a. at least three moving axes.

   b. an end-effector for at least one "stated" industrial application.

   c. logo must appear on robot (thermal screen printing).

   d. its controlling a components must be a part of the robots base or along side it, connected by tubing, wiring or cables.

   e. a small sign must be attached to the base describing what industrial applications this robot is capable of doing.

Key Instructional Suggestions:

1. **Safety**

   General safety concerns are involved in the operation of small school robots. The building of a robot, however, requires all the normal safety precautions typically used in laboratory work.

2. **Motivation**

   A. The instructor should display all the projects in a school display for one week and/or enter them into a science technology fair or other appropriate contest.

3. **Prerequisite Information**

   Previous reading assignments, pages 1-25, and learning activities, safety and use of hand and power tools.

4. **Reinforcement**

   Interact with the school's mathematics/geometry instructors to cooperatively work on the coordinate systems and geometry principles necessary to program robots.

5. **Attitudes**

   - Encourage safety attitudes.
   - Encourage students to consider applications other than traditional ones for robots.

6. **Remediation/Enrichment**

   Remediation: If slower students fall behind in programming, work with math and special needs instructors to take advantage of their resources for bringing geometry capabilities up to the needed levels.

   Enrichment: Have advanced students build more complicated robots; consider a research paper or slide show on emerging robot technology; build models of different types of robots.

Advanced Application

1. Add more axis to your robot to make it more functional.
2. Add replaceable end effectors to make your robot more marketable.
3. Visit a factory or community college that has a robotics program.
4. Construct a robotic arm using electric motors, pulleys and gear, etc.

INSTRUCTOR INFORMATION

Basic Steps in Building a Low Cost (Syringe Operated) Robotic Arm

Step 1: Build the Base and Power Supply (Syringe) Board e.g.

1. Square base and power supply board.
2. Glue a block to the base for spring support.
3. Position it approximately centered on the base.
4. Bore a hole centered from the back edge of the base.
5. Cut acrylic tubing to the required length and the required length from the end.
6. Cut a notch to required length around the tube a.
7. Glue the acrylic tube into the hole.

Step 2: Build an Upper Arm and Forearm Assembly e.g.

1. Cut the upper arm from the dowel rod.
2. Cut forearm from a hardwood.
3. Join forearm and upper arm at elbow by cutting slot in top of ¾" dowel.
4. Secure the joint with 1/4" dowel pin for the joint to pivot.

Step 3: Construct the Gripper e.g.

1. Cut a piece of ¼" plywood into T-shape. The cross of the T should match the shape of the hinge.
2. Bolt the short side of the off set chest hinge to the T-shaped plywood.
3. Drill a hole in the exposed part to attach a gripper linkage.
4. Bolt the long side of the chest hinge to the end of the forearm.
5. Glue sandpaper to the inside of the gripper faces to give the jaws more holding ability.

Step 4: Attaching Syringes e.g. (Notice: Use only clean, new syringes)

1. Determine syringe size of each application, e.g., 6 cc through 20 cc syringes for the power supply and cc through 6 cc for drive syringes (1, 2, & 3).

2. Cut light-gauge sheet metal to size and shape around syringe body.

3. Secure to the power supply board with wood screw.

4. To mount drive syringe #1, (which controls the vertical movement of the forearm, cut a piece of sheet metal to the size.

5. Bend the form yoke.

6. Fasten the sheet metal yoke to the upper arm.

7. Mount drive syringe #2, which controls base rotation. Position drive syringe #2 so that when the handle is pulled out, it will align with the back of the acrylic tubing.

8. Drill a hole in the end of the base rotation syringe handle and insert the head end of the finish nail.

9. To mount drive syringe #3, (which controls the gripper), cut a piece of ¾" pine to the required size, diagonally.

10. Glue the block.

11. Secure drive syringe #3 with epoxy glue to the diagonally cut block.

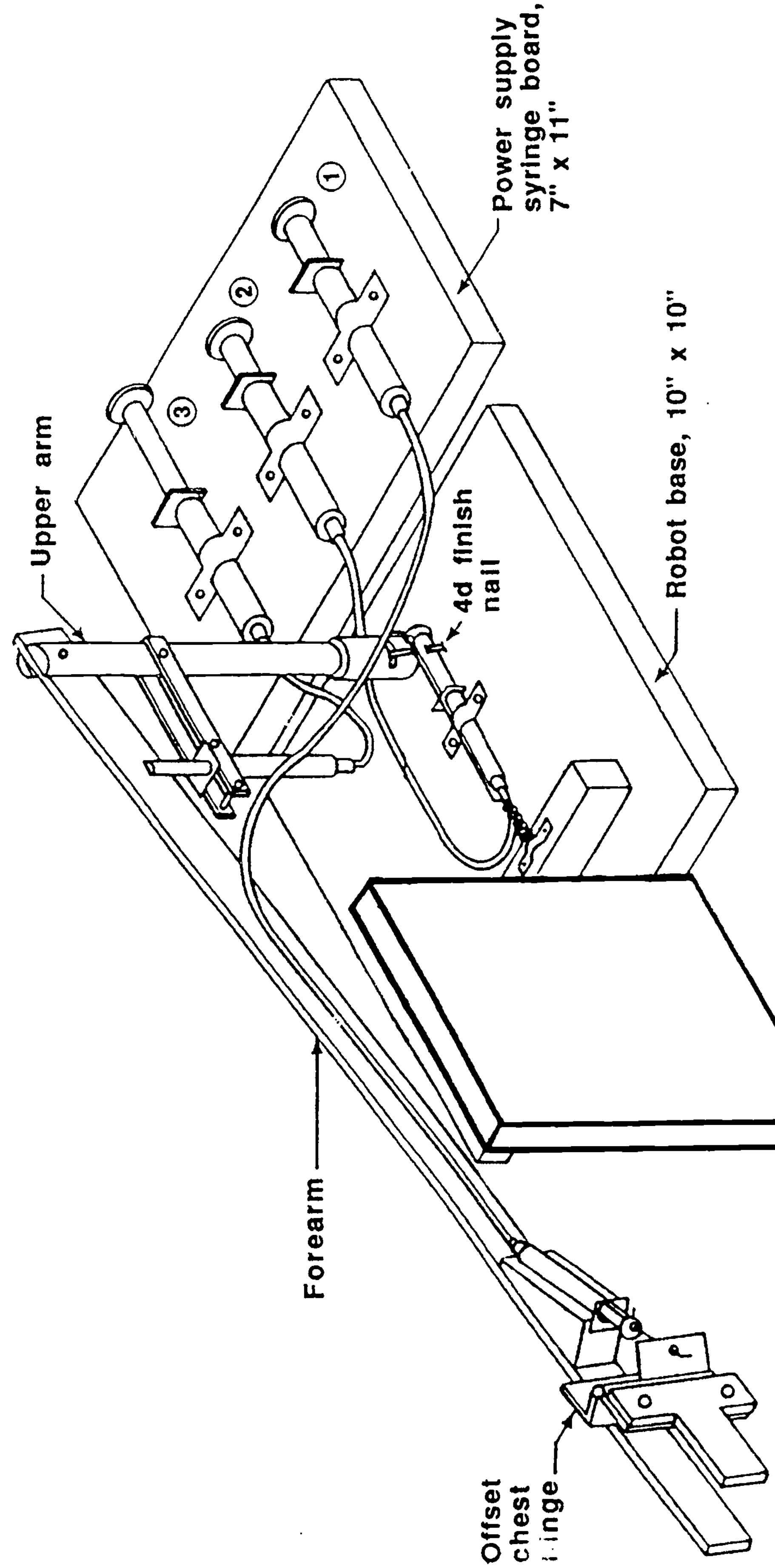
12. Use light-gauge wire to secure the syringe handles to the hole in the sheet metal so the gripper can be driven.

Step 5: Connecting Hoses e.g.

1. Aquarium hose 3/16" should fit tightly over the end of the syringe. If care is taken by making movements smoothly, the power supply syringes will easily drive the robot mechanism.

Step 6: Testing and Painting e.g.

1. After completing the construction, the students should test the function of each moving part. Make any necessary corrections and adjustments. Mask off all the unwanted area not to be painted, then spray the paint on the exposed parts.



Upper arm
Power supply
syringe board,
7" x 11"
1
2
3
4d finish
nail
Robot base, 10" x 10"
Forearm
Offset
chest
hinge

30

TRANSPORTING OBJECTS USING PNEUMATIC AND HYDRAULIC POWER

Student Activity for Low Cost Robotic Arm

Experiment with a mechanical arm using pneumatic and hydraulic power, and use numerical codes to actually program a mechanical arm to transport an object.

Activity Summary

In this activity, students get a chance to use simple mechanical arms, powered by a simple pneumatic and hydraulic system. After becoming familiar with the mechanical arms students will write a program, using a special code, that will allow the mechanical arm to get around an obstacle and pick up a small container and return to its starting position.

Objectives

- To understand the use of pneumatics and hydraulics
- To experiment with a mechanical arm
- To gain an understanding of the use of numerical codes
- To write a program using numerical codes

Vocabulary/Concepts Reinforced

- Pneumatics
- Hydraulics
- Numerical codes
- Mechanical arm Robotics
- Power systems
- Transportation systems

Equipment/Supplies

- Mechanical arm
- Small container of water or other fluid
- Small film container, or other object about 1" in diameter
- Small wall 8" in height

Teaching Tips

1. It would be nice to have two simple mechanical arms, one for pneumatics and one for hydraulics, but if that is not possible, you can have the students experiment with air in the system and then replace the air with water or another type of fluid.

2. This activity is designed to give the students some idea of how some mechanical areas can be powered. It will show the students the difference in using pneumatics and hydraulics. Students will also gain an understanding of how numerical codes will aid in the programming of machines and robots. Students will be allowed to write their own program and also have the opportunity to see whether someone else's program will do the job it is designed to do. Before this unit is begun, each group could be assigned the task of maintaining a mechanical arm.

Introduction

During this activity, you will be experimenting with a mechanical arm using pneumatic and hydraulic power. After experimenting, you will write a program to transport a small container from one spot to another. When you are finished writing a program, you will be given someone else's program and you will use it to move the container from one spot to another. When this activity is over, you should be able to see one of the roles energy plays in industry.

Instructional Strategy

Programming the Robot (stimulating on-line programming)

1. You should conduct this activity in a place when it will not hurt to get wet because the hoses occasionally will slip off the end of the syringes and could get things a little wet.

2. At the start of this activity, you will be given a mechanical arm. This mechanical arm will have three basic motions. During the first part of this activity, you will be powering your mechanical arm by using pneumatics. You will see six syringes on your mechanical arm. Three of these syringes will be large, and three will be small. On each syringe the markings show cubic centimeters (cc) as a measuring device. The larger syringes have more markings than the smaller ones.

3. The first step will be to experiment with the mechanical arm. Push in and pull out the plunger of the large syringes that are mounted on the base of the mechanical arm. As you experiment with each of the mounted syringes, pay close attention to how each syringe affects the movement of the mechanical arm. Take notes so you can refer to them later. You will find that one syringe moves the whole mechanical arm horizontally, one moves the arm up and down, and the last one controls the gripper. Practice trying to move the container from one place to the other. After practicing with pneumatics, replace the air with water or another type of fluid. This is now what you call hydraulics. Experiment with the mechanical arm again, and pay close attention to the differences between the two types of power. By the end of this section, you should be aware of the relationship of moving the plungers of the large syringes with the plungers of the small syringes.

4. After you feel good about using the mechanical arm, you are ready to proceed to the next step. Student Support Sheet I gives you some codes for the actual movements of the large plungers. It does not tell you how it affects the smaller plungers. Your notes should have the relationships documented. As you look at the sheet, it will give you a code for the forward or backward movement of the plunger, a code for which plunger will be moved, and a code for how far the plunger will be moved. Your mechanical arm should be set up with a wall as an obstacle and a place for a container to sit on each side of the wall. After becoming familiar with the numerical codes, take the programming sheet (Student Support Sheet 2) and start writing a program that will transport the container from a specific spot on one side of the wall to a specific spot on the other side of the wall.

5. When you are through writing the program, another student will read his/her program to you. Without any help from your code sheet or from another person, you will see if you can successfully follow this program and move the container. If the program doesn't work, and time permits, give it back to the programmer and see if he/she can correct the errors.

Evaluation

Students will turn in their program along with a short evaluation of the program that they used. You will be evaluated on your knowledge of the numerical codes found on Student Support Sheet 1. This will be done by someone reading his/her program to you to see if you can follow the numerical codes.

CLASS DISCUSSION ISSUES

Social/Environmental Impact

1. Discuss the impacts of a total factory run by robots with very little human intervention.

2. Discuss what type of jobs robots are best suited for.

3. Discuss safety systems robots are using to keep people from getting hurt.

4. Discuss in detail the pros and cons of robotics and how they will effect your students' job market of the future.

5. Have a class debate on the pros and cons of robots in society.

LESSON PLAN

Point-to-Point Function

The previous lesson plan concerned the pick-and-place functional classification of robots. You may recall that the PNP robot function had only two locations of major concern, the pick up and the set down locations.

How it moved from one to the other could vary, depending on the application. In this lesson we are concerned with what is called the "point-to-point."

(PTP) classification of function, which can be far more complex and have many more applications. A point-to-point robot moves from one point to another. This sounds simple, but bear in mind that the robot's total cycle may involve hundreds of points which must be reached in a designated sequence. Obviously then, the memory in which these points and movements are to be stored must have considerable capacity. Because of this, the point-to-point robot came into use when computers having sufficient memory became cost affective for robot control.

Applications

The applications for which the point-to-point robot is suited, or the tasks which it can perform, require more computer memory than the PNP robot and include the following:

1. **Spot welding operations.** The robot can move the spot welder tips along the adjoining parts to be welded, such as on an automobile body, and at each point stops long enough to weld one spot. The robot may even twist the tips lightly before opening so that the tips themselves make a cleaner break away from the metal.

2. **Deburring operations.** The robot can move the deburring tool, such as a small grinder, along edges of cast or other parts to remove sharp edges and protrusions. The tool may have to move along different edges at different angles as-well an along both internal and external edges of the part.

3. **Mass assembly operations.** The robot, for exar. ple, may be used to insert specific integrated circuits, which are fed from different chutes, into the pre-punched holes of a printed circuit board. Each integrated circuit may have to be rotated before insertion at a specific location on the board.

Many other applications such as drilling and gluing operations could be described. However, they would all involve a specific sequence of point-to-point moves and stops.

LESSON PLAN

Continues Path Function

Introduction

The pick-and place and the point-to point functional classifications of robots were covered earlier. In both of those functional classifications, the robot's movements were from or to specific points or location within its cycle. Reaching these points in a particular sequence was the primary objective, so long as the robot cleared any. obstructions, i.e., didn't bump into objects, which might be between the points.

In this lesson, we are concerned with a third classification, the "continuous path" (CP) function. The unique characteristic of the CP robot is that the path which the end-effector must follow is critical, even though the end-effector still as from one point to the next, the next, etc. The three-dimensional sketches in the overhead will aid in explanation of this. In both sketches let's assume that the object to be moved must reach points a, b, and c. However, the paths between these points are very different. The sketch in the future could be that of a point-to-point function robot. Notice that a total of only nine points are used to define the path.

A far more critical path is illustrated in the curved sketch. Points a, b, and c are still reached and the end-factor still moves in the X, Y, and Z axes directions. In this case, however, a total of 31 points are used to define the path, and many more could be added to cause the end-effector to trace an even smoother curve. From this illustration, one should realize that the more critical the path, the greater the umber of points needed to accurately define it. Also, the greater the number of points needed, the larger the memory capacity needed.

Applications

The continuous path functional robot often has greater computer memory capacity and may be built for greater precision than the PNP or PTP robots. These two factors, and other possible features, enable the CP robot to handle critical-path applications. Some of these applications are:

1. **Paint spraying operations.** For best paint application, the robot should move the sprayer's nozzle at a constant velocity, at a fixed distance from, and always at the some angle to the surface to be sprayed. Since one of the robot's major movements in this case is the base swivel or waist rotate, the robot's bicep, elbow and wrist flex, and a possible wrist yaw, need to be moved as the sprayer's nozzle sweeps past the surface.

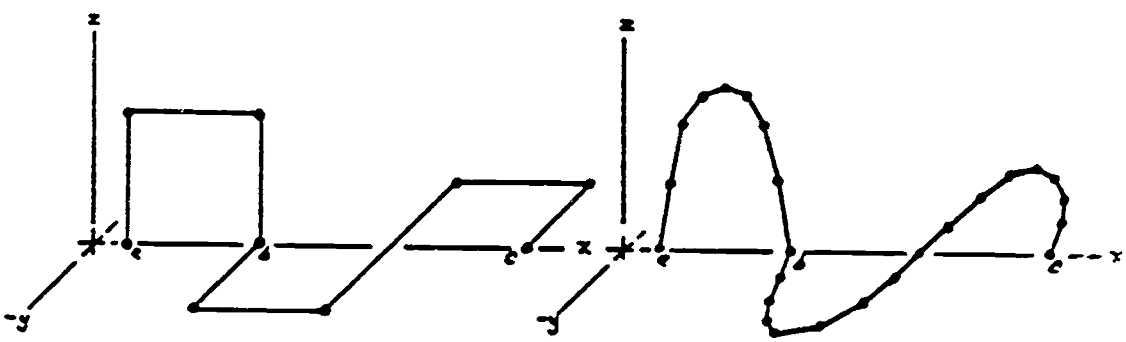


Illustration of a) Point-to-Point, and b) Continuous-Path Programming Entries for End-Effector Movement

2. Seam or arc welding. Many welds are of considerable length and they are often along a curved path. For arc welding, the length of arc (distance-from feed wire to parent material) is important toward determining the quality of the finished weld. Also important is the angle at which the weld bead is deposited. The continuous path functional robot can be programmed, typically using a teach pendant, to maintain the arc length and angle at the proper values.

3. Cutting operations. The acetylene torch, the laser, and other devices can be used to make both straight and curved cuts in a wide variety of materials. The pieces or parts which are cut from the stock material may be very intricate. Such cutting requires the entry into memory of many points along the path. Thus, the continuous path functional robot may be used to nova the cutting tool.

4. Inspection operations. The end-effector of a robot may be equipped with a variety of sensors and then used to inspect parts. The sensors might slide along the part's surface to determine its dimensions, its smoothness, the accuracy of features on the part, cr to identify the part. Signals from these sensors are sent to a computer where they are compared with one or more prescribed values. This comparison enables the computer to make decisions regarding the acceptance or rejection of the part being inspected.

LESSON PLAN
Maintenance

Introduction

Maintenance and troubleshooting of robotic systems, and any related machines which the robot may serve, is a very important part toward determining the performance and cost effectiveness of a robot. This activity covers some of the concepts and considerations pertaining to maintenance and troubleshooting of robots. The following terms and comments do not cover all that may be involved, but should provide you with some understanding of the importance of this topic.

Terms and Definitions

1. **Maintenance Schedule** - A recorded account of all servicing, repairs, and other maintenance performed on a robot. Such a record is important toward determining the cost of up-keep, the maintenance to be anticipated in the future, and any possible improvements regarding the robot or its use.

2. **Payback Period** - The time, typically in years, that is required for the savings attained by using a robot to equal its original cost. This is a very simple definition because other costs such as interest, inflation, etc., are not taken into account in this definition.

3. **Payload Handling Capabilities** - The payload of a robot basically concerns the mass or weight which the robot can grasp, lift, or handle safely. This can be effected by the reach, speed, acceleration/deceleration, etc., with which the robot must handle the load. These, in turn, can effect the reliability and life of the robot.

4. **Sensors** - The type and number of sensors needed for a robotics installation depend upon the individual application. Sensors may be used to determine (sense) the presence/absence of parts which the robot is to handle, the position, direction, speed, etc., of parts and of the robot itself, and/or a wide variety of other conditions. Their calibration, adjustment, and maintenance can greatly effect the robot's performance.

Additional Comments on Maintenance

A wide variety of other maintenance and troubleshooting tasks may be involved in the up-keep of robots and related machines. Several of the possibilities are listed here.

1. Checking for proper positioning of limit switches and other sensors.
2. Checking for wear in joints and other linkages.
3. Adjustment of cable, belt, and/or chain drive tension.
4. Cleaning and lubrication of robot parts.
5. Checking of electrical cables and connections.
6. Checking of hydraulic or pneumatic hoses and connections.
7. Measuring/determining the accuracy and repeatability of end-effector positioning.
8. Checking the security of keys, set screws, and other fastens.

ROBOTICS POST-TEST

Date: ____________ Class: ______________ Name: __________________________

Instructions: Please read each item and circle the letter of the correct answer.

1. The levels of robots can be identified as:

   a. simple
   b. medium
   c. complex
   d. all of the above
   e. none of the above

2. Robots can be classified by:

   a. number of axes of movement
   b. load capacity
   c. cycle time
   d. accuracy
   e. power source
   f. type of controller
   g. all of the above

Instructions: Fill in the blanks with the correct answer.

3. The movement of a robot's manipulator is based on the ________________________ coordinate system.

4. The most common industrial applications of robots are:

   a. ______________________________
   b. ______________________________
   c. ______________________________
   d. ______________________________
   e. ______________________________

5. What are the work envelope classification of robots?

6. There are three major classifications of motion for robots: What are they?

7. What is the most common type of co-trol used for industrial robots?

8-13. Write the correct letter on the blanks beside the numbers.

______	8.	Feedback	A.	Machine intelligence
______	9.	Grippers	B.	The science to designing robots
______	10.	Program	C.	Devices that take in information
______	11.	Sensors	D.	Set of instructions
______	12.	Robotics	E.	A kind of robot hand
______	13.	Artificial Intelligence	F.	Information from the robots sensors
			G.	Area that a robot can reach

REFERENCES:

Barker, R. G. (1984) "Types, Utilization and Application of Robots for Industrial Arts Education." Industrial Education. May/June, pp. 12-14, 17.

Lawrence, P. L. et al. (1986) Industrial Robots and Automation: Book 1, Book 2 and 7 Student Workbook. Benton Harbor, MI: Heath Company. ISBN #0-87119-141-5.

Malcom, D. R. Jr. (1985) Robotics: An Introduction. Boston, MA: Breton Publishers. ISBN #0-534-04752-1.

Radio Shack. Understanding Robots: Using the Armatron.

Waring, R. H. (1984) Robots and Robotology. Blue Ridge Summit, PA: TAB Books, Inc. ISBN #0-8306-1673-X.

Balistreri: P. Jerry (1985) Robotic Technology. Utah State Office of Public Instruction.

Kefrissen, Edward and Stephens Merik (1984) Industrial Robots and Robotics. Restor Publishing

Michigan Industrial Arts Curriculum, "Robotics", 1984.

Robotics Explained (1985). Bergwall Productions, Inc., Box Z38, Garden City, NY 11530.

Robotics Balletique - 16mm film, your WISO.

Anderson, R. & Carter, L (November, 1985). Robot construction using inexpensive materials. Industrial Education. pp. 22-23.

Meys, J. W. (February, 1988). Add robotics - without much expense. The Technology Teacher. pp. 25-28.

Neddenriep, T. (October, 1987). Construct a robot simulator for use in the general shop. School Shop. pp. 20-21.

Potter, T. & Guild, 1. (1983). Robotics. Usborne series in technology. London, UK: Usborne.

Salant, M. A. (1988). Introduction to Robotic. St. Louis, MO: McGraw Hill.

Sheets, E. (1986). Technology Activities. Cleveland, OH: Broadhead Garrett Co. pp. 1-3.

Wright, T. R. (1987). Programming a Robot. CITE Module series. Muncie, IN: Ball State University. pp. 1-8.

Wright, T R. (1987). Teaching Robotics. CITE Module series. Muncie, IN: Ball State University. pp. 1-13.

Mississippi State Department of Education, Diversified Technology Series, Module 5 Introduction to Robotics.

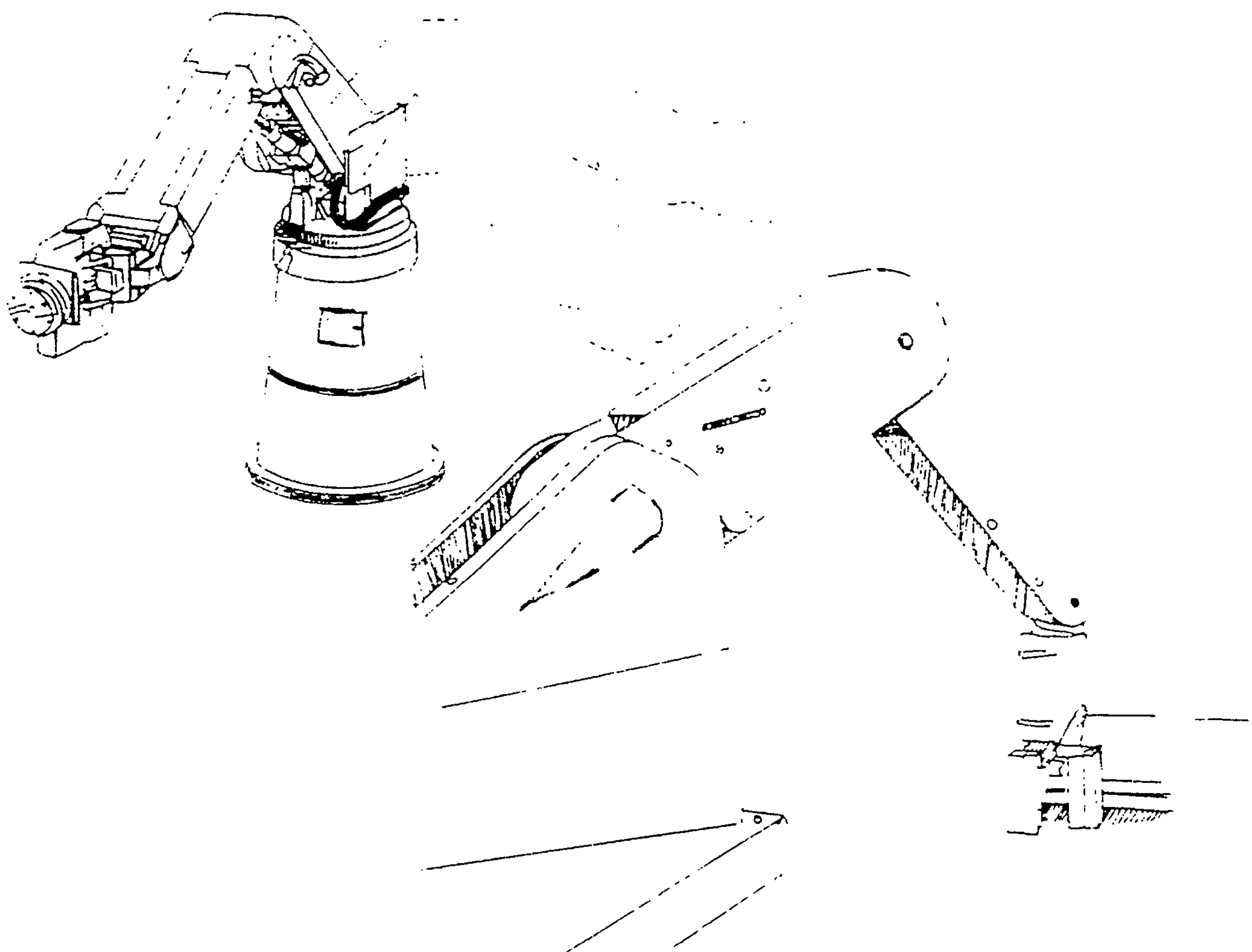
bn tea\ rob gui

INTRODUCTION TO ROBOTICS

FOR

INDUSTRIAL TECHNOLOGY EDUCATION

STUDENT'S GUIDE



Compiled by Rob Campbell
State Supervisor for Industrial Technology Education
Division of Vocational Education

The Idaho Division of Vocational Education is an equal opportunity employer and does not discriminate or deny services on the basis of age, race, religion, color, national origin, sex and/or disability.

INDEX

TABLE OF CONTENTS

MODULE INSTRUCTIONS

Introduction:

This activity is designed to combine, design, fabrication and operation procedures as applied to robots. Robots work within a restricted envelope. Most operate on three axes: ***X, Y, and Z***. Arms move from one side to the other on the X axis, in and out on the Y axis and up and down on the Z axis. It is recommended that the instructor integrate this activity with ongoing classroom presentations with math, science and history teachers. Other activities involved include: pre and post tests, safety instruction, demonstration of robotic processes and programming, automation and manufacturing processes.

Safety Considerations:

General safety concerns apply to the small instructional robots typically found in school technology laboratories. Construction of a robot, however, will involve laboratory tools, so specific safety precautions will need to be observed for each tool or piece of equipment. One special note: It is recommended that only clean new syringes without attached needles be used when constructing syringe operated robots.

STUDENT PROFILE SHEET

Robotic Competencies

Activity Objective: The purpose of this activity is to develop student capabilities in making and using robots suitable for a variety of manufacturing processes. Student activities include design, planning, fabrication, programming and utilization of robots.

Lap Competencies:

1. Define and recognize various potential hazards and the safety considerations associated with such hazards.

2. Be able to practice safe attitudinal and operational habits when working with the robot.

3. Identify capabilities and/or potential uses for the low-medium- and high-technology level categories of robots.

4. Define various basic terms associated with the robot's coordinate-system movements.

5. Identify various features and capabilities associated with the rectilinear, cylindrical, spherical and anthropomorphic robotics coordinate systems.

6. Define various basic terms applicable to the most significant structural parts of the robot.

7. Identify and provide the functions of various parts of the robot.

8. Be able to identify potential problems and to take corrective actions toward keeping a robotic system in good working order.

9. Be able to perform simple maintenance work on the robotic system as directed by the instructor.

10. Define types and features and potential uses of various robotics and end-effectors.

11. Determine various parameters, e.g., opening, force, attachments, etc., of end-effector(s) on the robot which you are using.

12. Define the dimensional planes involved in the working envelopes of robots in general.

13. Determine and sketch the size and shape of the working envelope being used, through use of the teach pendant.

14. Define/describe basic terms and potential applications for robotics pick-and-place operations.

15. Design a simple pick-and-place routine for the robot.

16. Use the teach pendant's modes and program a robot to execute a pick-and-place operation.

17. Define/describe basic terms and potential applications for robotics point-to-point movement operations.

18. Design a simple point-to-point routine for the robot.

19. Define/describe basic terms and potential applications for robotics continuous-path operations.

20. Design a simple (simulated) continuous-path routine for the robot.

21. Use the teach pendant's modes and program a robot to carry out a simulated continuous-path operation.

22. Identify and describe the essential features of the equipment used in manufacturing technology and describe the major types and systems of robots.

23. Apply hand, mechanized and automated processes in operating robots to perform simulated manufacturing tasks.

24. Devise a plan of procedures and operations for repetitive and quantity fabrication of products or components and construct a simple robot to work with it.

25. Read technical and working drawings and prints to secure needed information.

26. Solve simulated industrial design or planning problems in the construction of a robotic arm that demonstrates each coordinate system.

27. Discuss production technology breakthroughs and future trends in the design and operation of robots and programming methods.

INTRODUCTION TO ROBOTICS

Student Reading

DEFINING ROBOTICS

UNIT OBJECTIVES

After completing this instructional unit, you will be able to do the following:

1. Define a robot in one sentence.
2. Describe how and why robots developed.
3. Define robotics in one sentence.
4. Describe the parts or components of a robot.
5. Describe three types of industrial robots.
6. Give several uses of robots in the workplace.
7. Discuss the pros and cons of robot development.
8. Operate a robot using a manual Pendant.
9. Operate a robot using a micro computer.
10. Construct a working model of an industrial robot.

LEARNING PATH

1. Read the text and complete the Progress Reviews.

2. Perform the "Hands-on" Activities.

#3 TERMS

(Write the definitions to these terms in your notebook.)

Actuator
Android
Anthropomorphic/Revolute Coordinates
Artificial Intelligence
Automation
Axis
Component Packaging
Continuous Path
Controller
Coordinate System
Custom-made
Cylindrical Coordinates
Degrees of Freedom
Effectors
Encoder
Industrial Robot
Manipulator
Point-to-Point
Program
Rectilinear Coordinates
Reprogrammable
Robot
Sensors
Servo Controlled
Spherical Coordinates
Work Envelope

RELATED CAREERS

- Electrical Engineer
- Hydraulic Engineer
- Manufacturing Engineer
- Mechanic
- Pneumatic Engineer
- Production Worker
- Production Engineer
- Supervisor
- Technician
- Engineer
- Industrial Technician
- Salesperson
- Scientist
- Trainer
- Programmer
- Robot Distributer
- Designer

MAIN IDEAS

A robot or robot system is a computer controlled machine that can perform a variety of tasks.

Robotics is the design, use, and maintenance of computer-controlled machines to do desired tasks.

Robot systems may include any of the following parts: (1) effectors, (2) sensors, (3) computers, (4) auxiliary parts.

Types of robots including the following: (1) Industrial, (2) Educational, (3) and Personal.

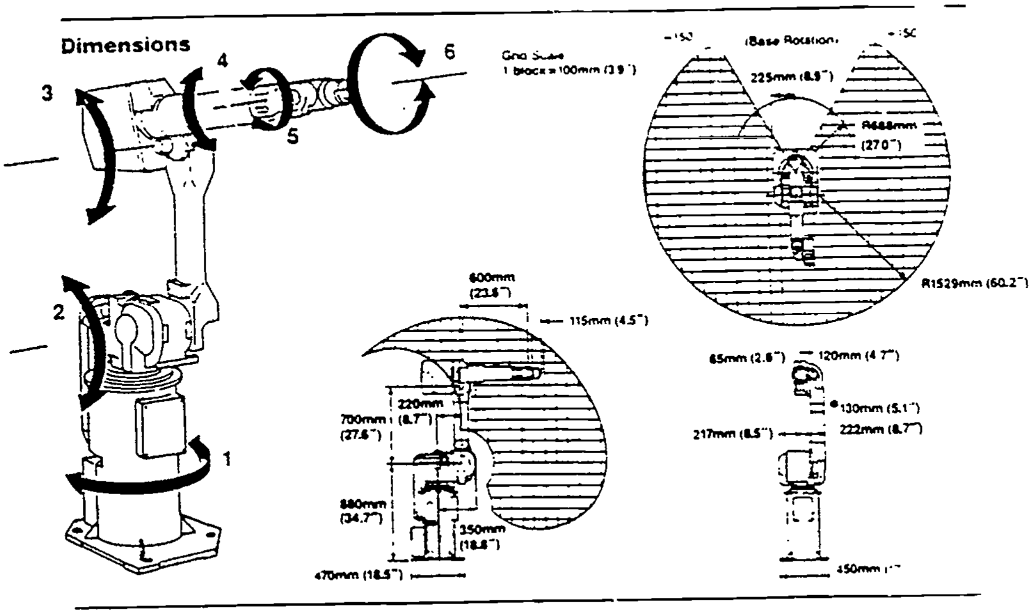
A. What is a Robot?

A robot is a machine or machine system that is controlled by a computer which does some type of work or performs some human chosen task. This task can range from placing bolts in pre-drilled holes to automatically flying an airplane. A robot, also called a robot system, may include any of the following components:

(1) effectors --"arms," "hands," "legs," "feet," (2) sensors--parts which act like a person's senses and detect not only objects, but also heat, light, odors and translates these objects into symbols, (3) computer--set of algorithms or equations controlling robot, and (4) auxiliary equipment--tools and other mechanical fixtures.

The three common types of robots are industrial, personal, and educational. Exhibit 1 shows a typical industrial robot (also known as an industrial robot system).

Exhibit 1. Typical Industrial Robot



Industrial robots, which are the most common type of robots, are machines, usually bolted to the floor, or placed in an overhead position, which pick up parts and move them about. The industrial robot can usually do jobs that human beings consider (1) difficult--lifting heavy loads, (2) dangerous--paint spraying or handling toxic chemicals, or (3) dull--assembly work, placing bolts into holes. Personal robots, or home robots, are the most recent and in some cases the most intelligent type of robots. By intelligent we mean these robots have more sophisticated sensors and are able to perceive conditions that may not have been known beforehand, decide what should be done, and act accordingly. These types of robots are now being tested as toys in the home.

Educational robots are common in schools. These are usually low-cost robots which are designed to help people learn the basics of robotics. (Robotics is the building, use, and upkeep of robots which perform a variety of tasks.) These robots look and act similar to the industrial robot. You will be using an educational robot in this course. (See Exhibit 2.)

Exhibit 2. Educational Robot

Let's recap what we have discussed so far about robotics. Here are a few points to remember:

1. A robot is a computer controlled machine system which performs some desired task.
2. Robot systems may contain either effectors, sensors, computers, or auxiliary parts.
3. The three types of robots are industrial, educational, and personal.
4. Robotics is the design, use, and maintenance of robots.

B. Why and How Did Robots Develop?

Robots are an ancient concept; however, the word robot was invented this century. It comes from the Czechoslovakian word robotnik meaning slave, servant, or forced labor. The word describes automatons or persons who act and work mechanically without thinking for themselves.

People have many misconceptions and also many fears about the development of robots. Most often people envision robots as little creatures like R2D2 in the movie "Star Wars." Some even imagine robots as human-looking machines or pieces of iron that might one day take over the world and destroy all humankind. In his play R.U.R. (Rossum's Universal Robots), the Czech playwright Karel Capek exemplifies this type of science fiction.

In the play, Rossum, the nephew of an eccentric old scientist, invents emotionless robots in a factory. These robots eventually rebel and destroy all humankind. All but two of the robots die. Because these two robots have emotions, they live and reproduce, becoming the new Adam and Eve of the world.

Unlike what science fiction leads us to believe, robots are not required to act or look like humans. They need only to be flexible.

Flexible means having the ability to perform different tasks. Early robot systems performed mere extended or amplified movements of the human hand, arm, and back muscles.

Early model robotics arms were first used in the 1940's to handle radioactive material in atomic laboratories. These machines were called master/slave manipulators and were connected together using mechanical linkages and steel cables. More recent variations of master/slave manipulators were used in wireless communication links and video television.

Even today many chemical laboratories and agencies such as NASA are using robotics devices like the ones described to perform all types of dangerous tasks or to handle dangerous materials.

Push buttons and switches, and later a joystick, were used to move a remote arm manipulator. At Stanford University in the mid 1960's researchers controlled a manipulator arm by removing the master controller and replacing it with a computer.

Joseph Engelberger and George Devoe developed a modern robot in the early 1960's. Their work led to the development of the Unimation company, the early manufacturers of robots. While industrial robots were sold to large companies such as General Motors and recently IBM, they became a major force in industrialization after they had been used extensively in the Japanese automobile industry.

Today, researchers are working on robots with highly developed sensory systems. These robots are able to function as though they have brains. What they actually have is artificial intelligence. Artificial intelligence allows these robots to perceive conditions that may not have been known beforehand, decide what actions should be taken, and perform these actions accordingly.

With new developments increasing steadily, the robot seems revolutionary in nature. It appears to have the potential to replace many people in the manufacturing process and therefore cause major social, economic, and political problems.

In the past, such changes have affected many people, and brought with them major sociological benefits such as shorter working hours and the development of the middle class. It seems probable that the robot revolution will also bring new benefits.

To answer why robots were developed we can go back to the early days of technology to the invention of the wheel, and ask "why invent a wheel?" We can trace new inventions throughout history from the cotton gin to the computer and ask the reason why. We will still come up with the same answer. We invent new things to make people's tasks easier and our lives more convenient.

C. Types of Industrial Robots

Earlier we discussed three types of robots--educational, personal, and industrial. In this section will examine further three categories of the most used robot--the industrial robot.

The three major categories of the industrial robots are servo and nonservo, point-to-point, and servo continuous path robots. A technique for knowing the exact position of a moving object at any time is a "servo" or servomechanism. To determine this position we need to use "feedback." Feedback is a process where we design a machine to include a specific system that tells us the position of each moving part. We can always determine if the target position has been reached by comparing it to the current position and seeing if the difference is zero. If the difference is zero, then the target position or place we wish to move a part has been reached.

A robot where the controlling system continuously checks the location of all the moving parts of the robot, and at any time can make fine adjustments on the locations of the parts, is called a servo controlled robot. A nonservo robot is a machine that has the controlling system tell the parts to move, but it has no way of checking to see that the part actually moved the distance it was told.

For example, the control unit tells the robot arm to move 8 inches. With the servo controlled unit, the next move would not be made until the arm had moved exactly 8 inches. However, with a nonservo unit, the arm might move 7.9 inches and them make its next move. This error destroys any repeatability for the robot.

Let's now examine the first category of industrial robots, servo and nonservo robots. We will begin with nonservo robots.

When you first look at the nonservo system, it seems that it could not possibly work to control a robot. With the evolution of two techniques, however, for specific types of applications, nonservo machines function quite adequately.

The first method give a type of noncontinuous feedback control. This method involves putting a switch or physical stop where a move is to end. Because the switch indicates when the first move has been completed, the machine cannot make the second move until the switch gives an o.k. or feedback signal. The advantage of this process is that the machine can move very fast from one stop to the next and the moves can be quite accurate, because the accuracy depends on the physical placement of the stops. The disadvantage of this type of machine is that because of the required precise arrangements of a complex set of stops, the machines are hard to program.

Having a very reliable drive system that will always move as it is directed is the second method. Some robots use an electric "stepper" motor to accomplish this task. Because the stepper motor moves the precise number of rotations it is told to move, the controller can direct the motor to move 276 steps and the tacks will probably be done. Errors, however, are possible with this procedure. For instance, the stepper motor will slip if the motor is stalled or overloaded. If this happens, all moves after that are out of place and the robot program will be ruined.

Nonservo controlled robots are used where accuracy is needed, the speed of the process is high, and the robot only has to move along three or four axes. (The word "axes" used here simply reverse to the number of independent ways a robot can move.) Also, the tasks should not have a large number of difficult steps, and should not require frequent reprogramming. Since many industrial tasks meet these requirements, companies use pick and place robots a great deal. You will learn more about pick and place robots in a later section but let's now consider servo controlled robots.

Unlike nonservo controlled robots, servo controlled robots operate with constant feedback. A controller continuously sends directions to the parts of the robot and then checks to make sure the parts have moved as they were directed. A high speed computer is needed to send the commands and read the results to obtain any reasonable speed for the machine motion.

Companies use servo controlled robots in complex tasks that required easy programming, a large number of moves, and where they can justify the large cost of a fast controlling computer. (As the cost of micro computer declines, this becomes less a factor.)

The second major category of robots is point-to-point robots. Developers of these robots designed them so that they could be used for spot welding, loading and unloading presses, and moving parts. Developers have also adapted these robots to do many other jobs that need a machine to move through a sequence of steps defined by a large number of discrete locations in a work area. A teaching pendant is used to program this robot.

The third major category of robots is continuous path robots. These robots were developed so that they could be used for spray painting and other types of jobs that require a smooth flowing action by the robot.

Unlike the point-to-point robot that is programmed with the teaching pendant, the continuous path robot is usually programmed with a back-driven device or wand. The wand is constructed so that it has the same number of joints in the exact places as the robot. Because each joint is equipped with an encoder that converts the motion of the wand into a long string of numbers, the robot is able to store and repeat motions. The conversion process is called analog to digital conversion.

While the encoder changes the motion of the arm into numbers so that the computer can store and replay the path, the arm remains an analog or smoothly moving function.

Some robots allow programming in either the point-to-point mode or the continuous path mode. The difference is in how the computer views each mode. Continuous path programming requires much more memory than the point-to-point programming.

D. Parts of the Robot

We mentioned previously in section A **What is a Robot?** -- that a robot system can have any of the following components: effectors,sensors, computers, or auxiliary equipment. In this section, we examine in more detail the parts of an education or industrial robot. As you may recall, most educational robots function the same as industrial robots. The different is in how we use the robot. Instead of using it to work in the factory, we use it as a demonstration item in the classroom.

1. Effectors

We begin with the most obvious part of the robot--effectors. Earlier we said the effectors were the "arms," "hands," "legs," or "feet" that a robot may contain. The most common effector of an industrial robot is some type "arm."

Although a robot arm may be any one of many different designs, it is usually designed to move within a given work "envelope" or area and to lift a maximum weight and move it at some maximum speed. The type of power drives, in addition to the design of the arm, will determine the power and speed characteristics of the arm. The design of a robot arm also determines the amount of movement.

The simplest robot is a two-axis machine. This means the robot can only move parts along two plates, either up and down or in and out. The word "axis" used here simply refers to the number of independent ways the robot can move. It also refers to how many "degrees of freedom" a robot has. Although they can have anywhere from two to ten axes, most robots have five or six axes, or degrees of freedom. In-addition to the axes that occur at the elbow, shoulder, wrist, and grip, the robot base can rotate clockwise or counterclockwise.

2. Auxiliary Parts

The robot hand, also called an end-effector or gripper, serves as an auxiliary part. It is connected to the wrist of the robot arm and is used as a tool for picking up objects. Although the robot arm may be very flexible and adaptable, the end-effector is usually very task specific. For instance, an end of arm gripper designed to handle automobile doors will obviously not be used to pick up car seats or dash boards.

Varying from simple closing vise-like mechanisms to elaborate vacuum suction cups, the end-effectors or end of arm tools may also be spot-welding guns, arc welding torches, wrenches, or any other devices that perform a certain task. Exhibit three illustrates an end or arm tool-the gripper.

The major categories of auxiliary parts include active tools, grippers, gravity operated hooks, vacuum systems, magnetic systems, and automatic tool changing devices.

3. Robot Controllers

The next part of a robot system is a robot controller. To be flexible, a robot is designed to respond to many external inputs. Usually, these inputs are control signals that may be received from a programmable controller or from single external switches. Since a variety of tooling is tied to robots, the robot controller must also be able to turn on the other devices at precise times. The robot controller coordinates all of these input and output devices. Two devices used as robot controllers are manual pendants and computers.

The manual pendant is a hand-held device that allows you to control the robot yourself. Because using a pendant requires a human to operate it, this method is very limited in a factory. They are, however, used in education to teach students how to operate a robot--an exercise that you will do in a later section.

Unlike pendants, computers are machines that can be programmed to operate the robot. Programming means that a person can give the computer a set of instructions, and it will remember and repeat these instructions independent of a human operator.

Let's take a closer look at computers.

A computer is a machine that follows complex sets of instruction called algorithms at a very high speed. For successful control of a robot, the speed of a computer is essential. Because computers used in robots have a clock rate of 4 million cycles per second, they are able to complete a million or more instructions per second, depending on the type of instructions.

Without this high speed capability, the computer would not be able to give directions to the robot, check to see if the directions are being followed, check on many other aspects of robot operation, and still be able to come back and supervise the original instructions. The computer performs all this while the robot is moving a fraction of an inch.

Programmers must give the computer detailed instructions in order for it to function. To have the computer read in two numbers, add them together, and then save them, may take twenty instructions. Most of the robot instructions are set up in loops--operations that the computer repeats more than once, and these loops are set up in a long program sequence. While progressing through a logical sequence of operations, this structure allows the computer to check on many different activities. A computer that operates a robot is usually called a controller.

The computer, in addition to running the robot, must also turn external conveyor belts, machines and processes on and off to coordinate with the work of the robot. For example, if the robot has vision, the signals from the camera must be interpreted and used to direct the actions of the machines.

The computer functions to control the total process of the robot operation and the production. In some cases, the robot's computer must communicate with other computers or with a programmable controller. A programmable controller is another machine that can control the robot. With the cost of microcomputers decreasing steadily, it appears that robots controlled by computers will be more prevalent in the future.

4. Sensors

Sensors are another part a robot may contain. Robot sensing means perceiving certain objects or conditions such as temperature or light, and converting these conditions into symbols that will make the robot act a certain way.

There are two types of sensing devices, contact and noncontact. Contact sensors detect objects. An example of a contact sensor is a device connected to the hand of the robot arm that feels or detects the grooves on a bolt. This device makes sure that the robots screws nuts on correctly. Noncontact sensors detect things that the human senses detect. Noncontact sensors do things such as register temperature or heat; visualize or detect light; smell odors or sense chemicals; or listen to sounds or respond to voices.

Robots with noncontact sensors that respond to speed give the user an eerie feeling. You can tell the robot to move right, and the robot will move right. Within a small vocabulary, the robot will do what it is told. The computer enables the robot to detect and respond to certain sounds.

Here is how it works: The computer tells you to say "left," then records your pronunciation of he word left. Whenever you say "left" again, the computer directs the robot to move left. With this technique you can speak to the computer in any language--French, English, Spanish or any other. The computer will merely record the sound and store it as a certain command. As long as the same words are used for commands, the robot will follow orders.

Advances in computers are leading to sophisticated vision systems, speech recognition and speech generation, and distance measuring equipment that will broadly expand the capabilities of robots. As these sensing devices are mixed with existing robots, the robots will become more human-like--at least in the way they "think."

The development of artificial intelligence (ability to perceive and solve problems) in computers is having a great impact on robotics. A person can give the robots some rules of motion (or behavior) within a limited space or environment and allow it to move and learn the arrangement of its space. The robot can then do tasks such as stack blocks or arrange objects into certain patterns within this space.

Researchers at the Massachusetts Institute of Technology (MIT) experimented with such robots. They programmed a robot to solve problems. They then gave the robot a variety of shapes of large blocks and told it to turn on a light that it could not reach.

The robot, after some analysis, stacked the blocks so that it could reach the light. This experiment and others strongly suggest that robots will have increased artificial intelligence in the future. The "smarter" these robots become, the more useful they will be to people.

Before we continue with our next section describing how humans use robots, let's recap the major points of this section with a few points to remember:

1. Robot systems may include any of the, following parts: effectors, sensors, robot controllers or computers, auxiliary tools or end-effectors.

2. All these parts are controlled by the robot controller or computer.

3. Two types of sensors are contact and noncontact.

4. Computers with artificial intelligence greatly affect the robotics industry.

E. Applications of Robots

Although you have some basic knowledge about robots, you may be wondering how you can use what you are learning. This section will deal with areas where robots are now being used.

As you may recall, educational robots are used mainly to teach students in the classroom. With these robots, students learn the basics of robotics, potential applications, and management principles. These robots look like industrial robots in appearance and perform some of the smaller tasks. In fact, some companies are using these robots in light manufacturing situations where a larger robot is not practical.

Personal robots make up the variety of machines that are being used as toys in the home. These robots can transport small items, clean an office, or be used for other light-weight operations.

Today, industrial robots are performing a variety of duties in the workplace. The most notable robots, in terms of production, are located in the automobile and manufacturing industries. Let's take a look at what activities a robot performs in the manufacturing industry. Industrial robots are used in the following six areas of factory manufacturing: (1) Design, (2) Testing, (3) Fabrication, (4) Assembly, (5) Inspection, and (6) Materials Handling.

The use of robots in the Design and Testing stages of manufacturing is far from being developed. However, with the use of computers in the factory, the process of developing products is speeding up considerably, and these computers will be able to guide robots in testing new equipment.

Robots are widely used in the fabrication stage of manufacturing. These robots cut and shape parts. Companies like John Deere and General Motors use these robots in their factories all over the country.

Robots are most widely used in the Assembly stage of manufacturing. Pick and place robots are used commonly in this stage. IBM, for instance, uses these robots to assemble typewriters and other machines. Also for the past decade, the Japanese have used robots in assembling cars.

The use of robots in the inspection stage of manufacturing is also being aided by computers. The development of artificial intelligence in computers leads to robots with highly developed sensors. These sensors enable the robot to inspect items and detect malfunctions.

Use of robots in the materials handling stage of manufacturing is also increasing. These robots serve as automatic carts and move items around within the factory.

These are all specific uses of robots within the manufacturing industry. The following are some general areas in which robots are being used:

Brick Loading
Die Casting
Drilling
Fastening
Forging
Glass Making
Grinding
Heat Treating
Machine Loading/Unloading
Machining
Material/Parts Handling
Measuring
Monitoring Radiation
Nut Running
Parts Sorting
Parts Cleaning
Press Loading and Unloading
Profiling
Quality Control
Riveting
Sand Blasting
Spray Painting
Tool Changing
Welding - Arc, Bead, Spot

F. Issues

The increased use of the robot brings with it many topics of discussion or "pros and cons," so to speak. One of the arguments against the development of robots is that they will replace thousands of workers in the factory, and eliminate many other jobs. Its development then has the possibility of causing disastrous social, economic, and political changes in our society.

On the opposite side of the argument are those who believe that the robot could revolutionize the manufacturing industry. They say it could increase productivity, improve quality, and reduce the production and labor costs in industry. They argue that the evolution of the robot has resulted in improved working conditions, and has helped to relieve people from doing jobs that are boring, repetitive, dirty, and dangerous.

To ease tension between employees and companies who have decided to use robots, the employers have started to retrain employees for running a factory with both people and robots. Differences of opinion will probably remain; however, one thing is certain, for good or bad, robots are here to stay.

STUDENT ACTIVITY
Review Worksheet

(Answer the following questions in your notebook.)

1. Define a robot in two sentences or less.

2. Briefly describe how and why robots developed.

3. List the major components of a robot.

4. Which part of the robot controls all the other parts?

   a. Effectors
   b. Computer
   c. Sensors
   d. Auxiliary Tool

5. List three types of robots.

6. List at least six applications of the robot in the workplace.

7. Which of the following reasons does not support further robot development? Future robot development would:

   a. increase productivity in factory.
   b. decrease work hours.
   c. decrease the number of factory workers needed.
   d. improve the quality of products.

Hands-on Activities:

How to Operate a Robot

You should now know what a robot is, how it developed, and you should be familiar with its major parts. You should also know three types of robots ask where they are used. It is now time for you to learn how to operate a robot.

The following are "hands-on" activities that will take you through the steps of operating a robot.

Before you go through any "hands-on" activities, you must first lean how to use a programming sheet.

HOW TO USE A PROGRAMMING SHEET

Before we proceed with this activity, let's first examine the major areas of a programming sheet.

The first area of a programming matrix sheet is the Sequence of Events section. This portion of the programming sheet describes the sequence of actions you will have the robot perform.

The second area of a programming sheet is the program area. This is the area where you will record your commands and sequence events that correspond to the robot's movements. By placing an "X" under the required robot movement in the proper sequence line you will be able to record and remember which movement you want the robot to make.

After determining the process you want the robot to perform--deciding whether you want the robot to pick up or move some object--you can then proceed with this activity.

Items Needed

Manual Programming Matrix Sheet

Steps to be Completed

Step 1. Write a sequence of events--actions you want the robot to perform, in sequence section of your programming sheet.

Step 2. Locate the corresponding movements in the program area of your programming sheet.

Step 3. Mark an "X" under the proper movement and on the proper sequence on your programming sheet.

STUDENT ACTIVITY
Manual Programming Matrix Sheet

Student Name ______________________________

Period ______________________________

Program Date ______________________________

		PROGRAM AREA											
		MOVE FORWARD OR BACKWARDS	SHOULDER EXTEND	SHOULDER RETRACT	BASE ROTATE CW	BASE ROTATE CCW	ELBOW EXTEND	ELBOW RETRACT	WRIST EXTEND	WRIST RETRACT	GRIPPERS UP OR DOWN	GRIPPERS ROTATE	GRIPPERS OPEN OR CLOSE
Step No.	**Sequence of Events**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													
31													
32													

STUDENT ACTIVITY

Degrees of Freedom

This laboratory is designed to have you conduct a variety of experiments with a robot to determine DEGREES OF FREEDOM, the robot SWING, HORIZONTAL AND VERTICAL REACH, VERTICAL STROKE ANGLE, PAYLOAD (lifting) CAPACITY, GRIPPER CAPACITY, REPEATABILITY, and DEGREES OF ROTATION of various joints. Each of these characteristics is important to the application of a robot in a work environment.

Another important concept in robotics applications is the WORK ENVELOPE. A work envelope, or area of influence, is the total three-dimensional, space within which the end effector of a robot can be positioned. Each of the four basic types of robots produces a different shape work envelope.

TOOLS/EQUIPMENT/MATERIALS:

- Robotic Arm
- Protractor
- 6 or 12" Ruler
- Tape Measure
- Incremental Loads (weights)
- Pencil
- Power Supply for Robot
- Graph Paper
- Masking Tape
- Colored Felt Tip Marker
- Procedure Sheet

PROCEDURE:

** NOTE: Stop lifting when robot gears begin to slip and make a clicking sound.

Follow the steps described below. Look at the illustrations and/or refer to the BACKGROUND INFORMATION section robotics concepts that your teacher discussed earlier. Place answers to each step on the attached Robotics Data Recording Sheet. This data sheet is located on the last page of these procedure sheets.

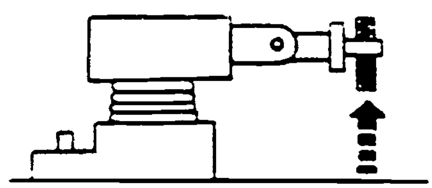
1. What type of robot do you have?

2. What type of power supply provides power to the manipulator?

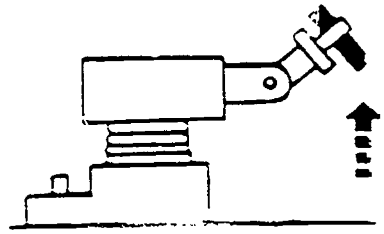
3. Determine the DEGREES OF FREEDOM for this robot.

   a. FORWARD AND BACKWARD

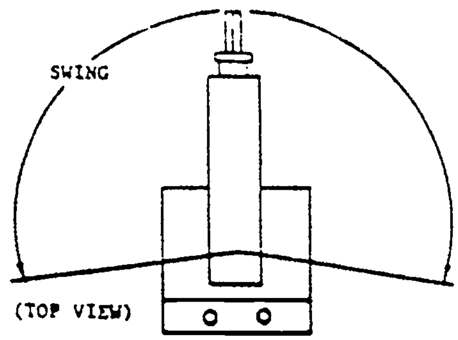
4. Determine the MAXIMUM PAYLOAD CAPACITY at the SHOULDER JOINT with all joints extended. Use the incremental weights that are supplied by the instructor.**



5. Determine the MAXIMUM PAYLOAD CAPACITY at the WRIST JOINT using incremental weights.



6. Determine the MAXIMUM SWING in degree. Place robot in center of paper, and a felt tip pen in the robot gripper with all joints extended. Draw the swing on a piece of graph paper and measure the angle with a protractor. Record the angle on the data recording sheet and label the graph SWING.



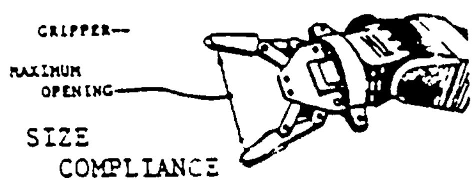
7. Determine the REPEATABILITY of the robot on the swing movement. With pen still in gripper, draw an arc (about 180 degrees) on the graph paper using the swing movement. Label Arc #1. When you reach the end of the arc, reverse the direction and draw the same arc back to the start point. Measure the VARIANCE (largest distance between the two arcs), if any was drawn. Repeat this operation 5 times, measuring and recording the variance each time. Add the five variances and divide by five. This AVERAGE VARIANCE in REPEATABILITY should be recorded on the data sheet. Make sure pen does not move in gripper; tape in place if necessary.

VARIANCE #1 =
VARIANCE #2 =
VARIANCE #3 =
VARIANCE #4 =
VARIANCE #5 =

TOTAL =

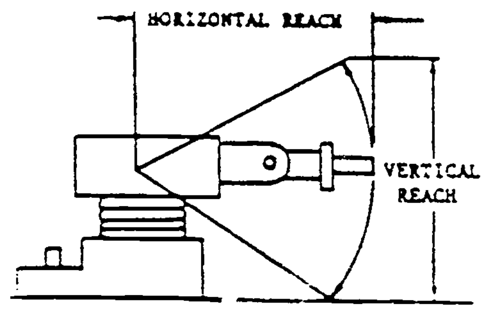
$$\text{AVE. VAR.} = \frac{\text{TOTAL}}{5}$$

8. Measure the maximum opening between the fingers of the end-effector (gripper) and record this dimension on the data sheet. This is the largest SIZE COMPLIANCE for objects to be handled.



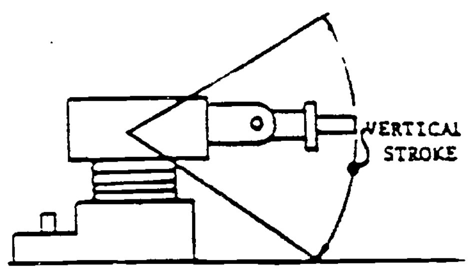
9. Measure the maximum DEGREES OF ROTATION in the wrist joint. This is the total number of degrees that the wrist joint will rotate. (Remember to return wrist back to the original position.)

10. Measure the HORIZONTAL REACH in inches, of the Armatron from the pivot point on the shoulder joint to the end of the closed gripper when all joints are fully extended. Measure with tape measure and record on data sheet.



11. Measure the VERTICAL REACH of the robot in inches also with the tape measure. Measure, with all joints extended, from the lowest point the robot end effector will reach to the highest point.

12. Draw the maximum vertical reach as a vertical line on a piece of graph paper. Draw two horizontal reach lines extending to the left from the top and bottom of the vertical reach line. Show the location of the pivot point in the shoulder joint on the vertical reach line and use a compass to draw an arc which represents the VERTICAL STROKE. Note: Place the compass point in the pivot point location and set the compass radius for the length of the horizontal reach.



13. Using the necessary data from the steps you have just completed and some additional information that you will need to determine, sketch the PLAN (top) and ELEVATION (side) views of the WORK ENVELOPE for the robot in the space provided on this page. Each block in the grid below represents one (1) inch.

NOTE: The VERTICAL STROKE graph that was made in step #12 is a partial PLAN view of the work envelope. The reason that is not a complete plan is that when the manipulator is in its highest point with the arm extended straight out, the end effector can be raised still higher with an WRIST joint movement. This extra arc must also be shown in the plan view.

14. What is the shape of this work envelope called?
(See BACKGROUND INFORMATION section.)

INCLUDE SKELETON OF THE ROBOTIC ARM IN EACH VIEW

PLAN

ELEVATION

ROBOT DATA RECORDING SHEET

Name ______________________ Date __________

1	Type of Robot	
2	Type of Power Supply	
3	Movement Forward/Backward (base)	
4	Shoulder Payload Capacity**	Grams
5	Wrist Payload Capacity**	Grams
6	Maximum swing (base rotation)	Degrees
7	Average Repeatability Variance	Inches
8	Maximum Griper Compliance	Inches
9a	Wrist Degrees of Rotation	Degrees
9b	Degrees in Pitch (up and down)	
10	Horizontal Reach	Inches
11	Vertical Stroke	Degrees
12	Vertical Stroke	Degrees
14	Shape of Work Envelope	Drawing

**NOTE: Stop lifting when gear clicking sound is heard!!

TRANSPORTING OBJECTS USING PNEUMATIC AND HYDRAULIC POWER
ROBOTIC CODING

Student Activity for Low Cost Robotic Arm

Experiment with a mechanical arm using pneumatic and hydraulic power, and use numerical codes to actually program a mechanical arm to transport an object.

Activity Summary

In this activity, you will get a chance to use simple mechanical arms, powered by a simple pneumatic and hydraulic system. After becoming familiar with the mechanical arms write a program, using a special code, that will allow the mechanical arm to get around an obstacle and pick up a small container and return to its starting position.

Objectives

- To understand the use of pneumatics and hydraulics
- To experiment with a mechanical arm
- To gain an understanding of the use of numerical codes
- To write a program using numerical codes

Vocabulary/Concepts Reinforced

- Pneumatics
- Hydraulics
- Numerical codes
- Mechanical arm Robotics
- Power systems
- Transportation systems

Equipment/Supplies

- Mechanical arm
- Small container of water or other fluid
- Small film container, or other object about 1" in diameter
- Small wall 8" in height

Introduction

During this activity, you will be experimenting with a mechanical arm using pneumatic and hydraulic power. After experimenting, you will write a program to transport a small container from one spot to another. When you are finished writing a program, you will be given someone else's program and you will use it to move the container from one spot to another. When this activity is over, you should be able to see one of the roles energy plays in industry.

Instructional Strategy

Programming the Robot (stimulating on-line programming)

You should conduct this activity in a place when it will not hurt to get wet because the hoses occasionally will ship off the end of the syringes and could get things a little wet.

1. At the start of this activity, you will be given a mechanical arm. This mechanical arm will have three basic motions. During the first part of this activity, you will be powering your mechanical arm by using pneumatics. You will see six syringes on your mechanical arm. Three of these syringes will be large, and three will be small. On each syringe the markings show cubic centimeters (cc) as a measuring device. The larger syringes have more markings than the smaller ones.

2. The first step will be to experiment with the mechanical arm. Push in and pull out the plunger of the large syringes that are mounted on the base of the mechanical arm. As you experiment with each of the mounted syringes, pay close attention to how each syringe affects the movement of the mechanical arm. Take notes so you can refer to them later. You will find that one syringe moves the whole mechanical arm horizontally, one moves the arm up and down, and the last one controls the gripper. Practice trying to move the container from one place to the other. After practicing with pneumatics, replace the air with water or another type of fluid. This is now what you call hydraulics. Experiment with the mechanical arm again, and pay close attention to the differences between the two types of power. By the end of this section, you should be aware of the relationship of moving the plungers of the large syringes with the plungers of the small syringes.

3. After you feel good about using the mechanical arm, you are ready to proceed to the next step. Student Support Sheet I gives you some codes for the actual movements of the large plungers. It does not tell you how it affects the smaller plungers. Your notes should have the relationships documented. As you look at the sheet, it will give you a code for the forward or backward movement of the plunger, a code for which plunger will be moved, and a code for how far the plunger will be moved. Your mechanical arm should be set up with a wall as an obstacle and a place for a container to sit on each side of the wall. After becoming familiar with the numerical codes, take the programming sheet (Student Support Sheet 2) and start writing a program that will transport the container from a specific spot on one side of the wall to a specific spot on the other side of the wall.

4. When you are through writing the program, another student will read his/her program to you. Without any help from your code sheet or from another person, you will see if you can successfully follow this program and move the container. If the program doesn't work, and time permits, give it back to the programmer and see if he/she can correct the errors.

Evaluation

Turn in your numerically coded program along with a short evaluation of the program. You will be evaluated on your knowledge of the numerical codes found on Student Support Sheet 1. This will be done by someone reading your program to see if you they follow the numerical codes.

STUDENT SUPPORT SHEET 1

Below you will find a code to use as you plan a program for your mechanical arm to move the container from one side of the obstacle to the other.

The code you will be using will have four numerals. It is important that you remember what each numeral represents.

The first place in the code represents the syringe you are using on the base plate of the mechanical arm. There will be three syringes, so there will be three possible numbers to use in the first place in the code.

1 ... for the first syringe (farthest left)
2 ... for the second syringe
3 ... for the third syringe

The second place in the code represents the direction in which the plunger will be moved.

1 ... for forward movement
2 ... for backward movement

The third and fourth places in the code represents the number of cc that the plunger will be moved. The third place represents the 10s column, and the fourth place represents the ones place. If the number of cc is less than 10 you will use 0 in the 10s column (the third place).

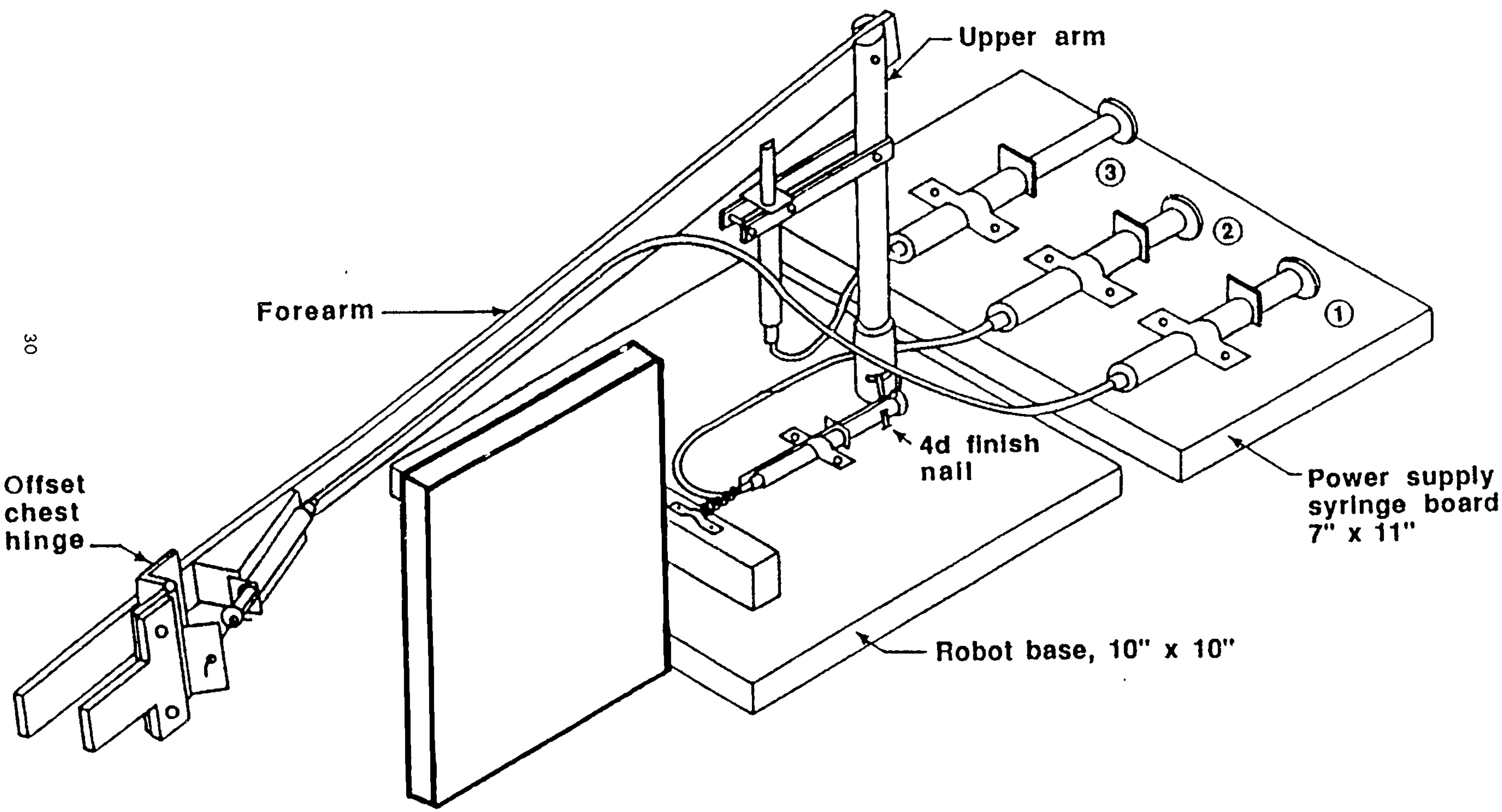
1 ... for moving the plunger 1 cc
0 9 ... for moving the plunger 9 cc
1 1 ... for moving the plunger 1 1 cc

Thus, the code **2 2 0 2** means that the second syringe moved the plunger backwards for 2 cc.

STUDENT SUPPORT SHEET 2

Plan Your Program Below:

1. ____ ____ ____ ____
2. ____ ____ ____ ____
3. ____ ____ ____ ____
4. ____ ____ ____ ____
5. ____ ____ ____ ____
6. ____ ____ ____ ____
7. ____ ____ ____ ____
8. ____ ____ ____ ____
9. ____ ____ ____ ____
10. ____ ____ ____ ____
11. ____ ____ ____ ____
12. ____ ____ ____ ____
13. ____ ____ ____ ____
14. ____ ____ ____ ____
15. ____ ____ ____ ____
16. ____ ____ ____ ____
17. ____ ____ ____ ____
18. ____ ____ ____ ____
19. ____ ____ ____ ____
20. ____ ____ ____ ____
21. ____ ____ ____ ____
22. ____ ____ ____ ____
23. ____ ____ ____ ____
24. ____ ____ ____ ____
25. ____ ____ ____ ____
26. ____ ____ ____ ____
27. ____ ____ ____ ____
23. ____ ____ ____ ____
29. ____ ____ ____ ____
30. ____ ____ ____ ____



Upper arm
Forearm
4d finish nail
Offset chest hinge
Power supply syringe board, 7" x 11"
Robot base, 10" x 10"
1
2
3