Mission and vision of the Department

Vision of Mechanical Department

To establish the state of the art learning center in Mechanical Engineering which will impart global competence, enterprising skills, professional attitude and human values in the student.

Mission of Mechanical Department

1. To impart quality technical education to the students.
2. To develop comprehensive competence in the students through various modes of learning.
3. To enable students for higher studies and competitive examinations.
4. To facilitate students and industry professionals for continuous improvement and innovation.

Program Educational Objectives:

[1] Use core competence acquired in various areas of Mechanical Engineering to solve techno-managerial issues for creating innovative products that lead to better livelihoods & economy of resources.

[2] To establish themselves as effective collaborators and innovators to address technical, managerial and social challenges.

[3]To equip students for their professional development through lifelong learning and career advancement along with organizational growth.

[4] Serve as a driving force for proactive change in industry, society and nation.

PROGRAM SPECIFIC OUTCOMES

Student should have

1) An ability to work professionally in mechanical systems including design, analysis, production, measurement and quality control.

2) An ability to work on diverse disciplinary tasks including manufacturing, materials, thermal, automobile, robotics, mechatronics, engineering software tools, automation and computational fluid dynamics.

Jawaharlal Nehru Engineering College

Laboratory Manual

ROBOTICS & INDUSTRIAL APPLICATIONS

For

Final year Students of

Mechanical/Production Engineering

02,Dec 2003- rev 00 – Comp Sc – ISO 9000 Tech Document

LAB MANUAL OF ROBOTICS AND INDUSTRIAL APPLICATIONS

SUBJECT: ROBOTICS AND INDUSTRIAL APPLICATIONS **PRACTICAL:** 2 Hrs/Week.

CLASS: BE (MECH. /PROD) **TERM WORK:** 50 MARKS.

LIST OF EXPERIMENTS:

(1) ASSIGNMENT ON INTRODUCTION TO ROBOT CONFIGURATION

(2) DEMONSTRATION OF ROBOT WITH 2 DOF, 3 DOF, 4 DOF etc.

(3) TWO ASSIGNMENTS ON PROGRAMMING THE ROBOT FOR APPLICATIONS

(4) TWO ASSIGNMENTS ON PROGRAMMING THE ROBOT FOR APPLICATIONS IN VAL II

(5) TWO PROGRAMMING EXERCISES FOR ROBOTS

(6) TWO CASE STUDIES OF APPLICATIONS IN INDUSTRY

(7) EXERCISE ON ROBOTIC SIMULATION SOFTWARE

EXPERIMENT NO: 01

ASSIGNMENT ON INTRODUCTION TO ROBOT CONFIGURATION

AIM: To study an introduction to Robot configuration.

THEORY:

(1) Introduction & Definition of Industrial Robots:

“An industrial robot is an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes.”

The field of industrial robotics may be more practically defined as the study, design and use of robot systems for manufacturing (a top-level definition relying on the prior definition of robot).

Typical applications of industrial robots include welding, painting, ironing, assembly, pick and place, palletizing, product inspection, and testing, all accomplished with high endurance, speed, and precision.

The most commonly used robot configurations for industrial automation include articulated robots, SCARA robots and gantry robots.

In the context of general robotics, most types of industrial robots would fall into the category of robot arms.

(2) Robotics and Automation:

Robotics is the science of designing and building robots suitable for real-life applications in automated manufacturing and other non-manufacturing environments. Robot are the means of performing multifarious activities for man’s welfare in the most planned and integrated manner, maintaining their own flexibility to do any work, effecting enhanced productivity, Guaranteeing quality, assuring reliability and ensuring safety to the workers. When the early man started settling in villages, they invented many innovative implements and left behind inscriptions to communicate many of their ideas.

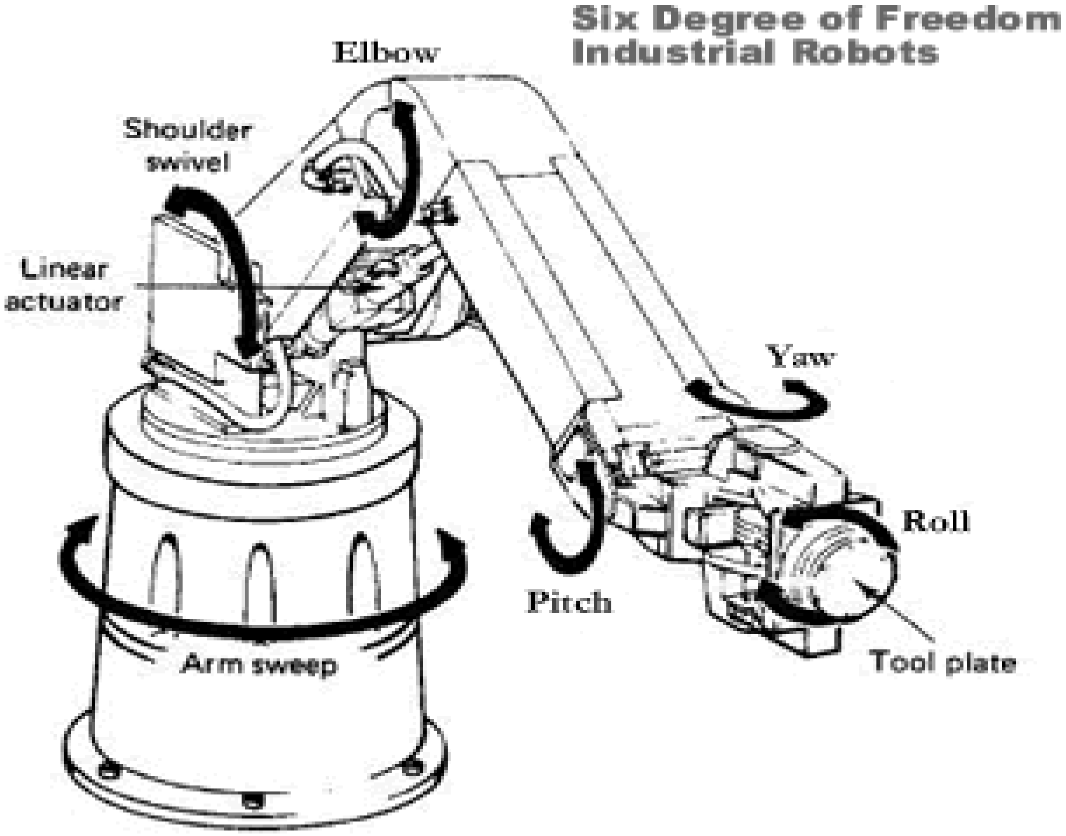
To facilitate the manufacture of products, attempts were made to reduce human and animal labour, and to employ efficient machines run by exploiting other direct or converted natural energy sources. Meanwhile, the economic rule of demand and supply became operative. To produce more goods in a reasonably shorter period of time, the speed of production emerged as a factor of paramount importance. For the given five-M inputs (Man, machines, materials, money and motivation), more outputs at faster speed became imperative to raise the level of productivity. Gradually, the degree of mechanization in real life increased by employing more machines in place of direct labour. Higher heights of mechanization achieved every century, decade or year rendered the newer machines indispensable.

Programmable automation uses information technology and numerical engineering to provide coordination, machine control and communication through computers in the most effective way.af attempts to bridge the gap between consistency and flexibility.

An example of the Programmable automation technology is the robot. The robot is an essential component of CAM and CIM technologies. The name robot came from the

Czechoslovakin word Robota which means a worker or a slave doing heavy work. The protoplasm of modern industrial robots is formed of hydraulics, pneumatics, electrical drives and silicon chips. Today's robots are therefore, to a great extent, as smart and intelligent as the robots conceived in fiction. Present-day industrial robots can work efficiently in both structured and unstructured environments. So, robots with their sensory capabilities and artificial intelligence (AI) are more advanced than the conventional and automated machines in all respects.

(3) Specifications of Robots:



(a) Accuracy:

How close does get the robot to the desired point? When the robot's program instructs the robot to move a desired point, it does not actually performed as per specified. The accuracy measures such as variance. That is the distance between the specified position that a robot is trying to achieve (programming point), and the actual x, y, and z resultant position of the robot end effecter.

(b) Repeatability:

The ability of a robot to return to repeatedly to a given position. It is the ability of the robotic system or mechanism to repeat the same motion or achieve the same position. Repeatability is a measure of error or variability when repeatedly reaching for a single position. Repeatability is often smaller than accuracy.

(c) Degree of Freedom (DOF):

Each joint or axis on the robot introduces a degree of freedom. Each DOF can be a slider, rotary, or other type of actuator. The number of DOF that a manipulator possesses thus is the number of independent ways in which a robot arm can move. Industrial robots typically have 5 or 6 degrees of freedom. 3 of the degrees of freedom allow positioning in 3D space (X, Y, Z), while the other 2 or 3 are used for orientation of the end effector (yaw, pitch and roll). 6 degrees of freedom are enough to allow the robot to reach all positions and orientations in 3D space. 5 DOF requires a restriction to 2D space, or else it limits orientations. 5 DOF robots are commonly used for handling tools such as arc welders.

(d) Resolution:

The smallest increment of motion or distance that can be detected or controlled by the robotic control system. It is a function of encoder pulses per revolution and drive (e.g. reduction gear) ratio. And it is dependent on the distance between the tool center point and the joint axis.

(e) Reach:

The maximum horizontal distance from the center of the robot base to the end of its wrist.

(f) Maximum Speed:

A robot moving at full extension with all joints moving simultaneously in complimentary directions at full speed. The maximum speed is the theoretical values which does not consider under loading condition.

(g) Payload:

The maximum payload is the amount of weight carried by the robot manipulator at reduced speed while maintaining rated precision. Nominal payload is measured at maximum speed while maintaining rated precision. These ratings are highly dependent on the size and shape of the payload due to variation in inertia.

(h) Envelope:

A three-dimensional shape that defines the boundaries that the robot manipulator can reach; also known as reach envelope.

(i) Maximum envelope:

The envelope that encompasses the maximum designed movements of all robot parts, including the end effector, workpiece and attachments.

(j) Restricted envelope:

Restricted envelope is that portion of the maximum envelope which a robot is restricted by limiting devices.

(k) Operating envelope:

The restricted envelope that is used by the robot while performing its programmed motions.

(4) Basic configurations of Industrial Robots with their applications:

Industrial robots come in a variety of shapes and sizes. They are capable of various arm manipulations and they possess different motion systems. This section discusses the various basic physical configurations of robots.

The following four basic Configurations can be combined in various ways to produce a variety of robotic combinations.

a) Cartesian Configuration:

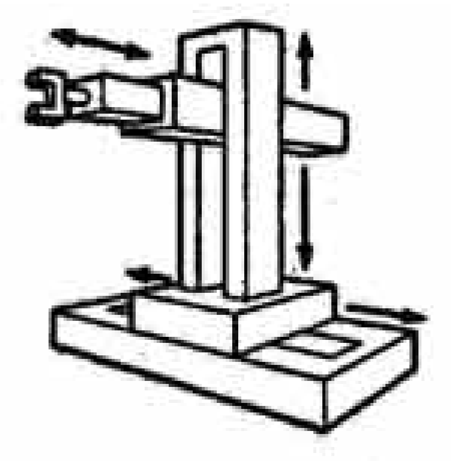


Fig: Cartesian Configuration

Cartesian robot is form by 3 prismatic joints, whose axes are coincident with the X, Y and Z planes.

In the Cartesian coordinate configuration shown in figure, the three orthogonal directions are X,Y and Z. X-coordinate axis may represent left and right motion; Y- coordinate axis may describe forward and backward motion; Z-coordinate axis may be used to represent up and down motions. Motions in any coordinate axis can be imparted independently of the other two. The manipulator can reach any point in a cubic volume of space. It allows three DOFs (x, y, z) in translation only.

Advantages:

1) 3 linear axes.

2) Easy to visualize, ability to do straight line insertions into furnaces.

3) Most rigid structure for given length.

4) Easy computation and programming.

Disadvantages:

1) Can only reach front of it.

2) Requires large floor space.

3) Axes hard to seal.

Applications:

Pick and Place operations, Assembly and Sub-Assembly (Mostly Straight), automated loading CNC Lathe and Milling operations, Nuclear Material handling, Welding etc.

b) Spherical Configuration:

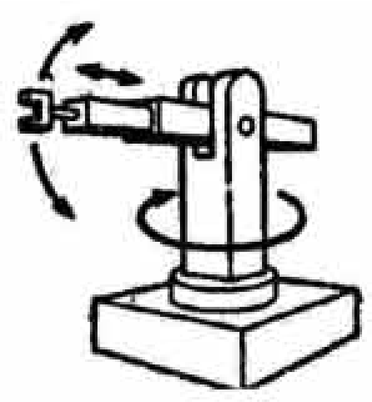


Fig: Spherical Configuration

In the Spherical coordinate configuration shown in figure, the robot has one linear and two angular motions. The linear motion, r corresponds to a radial in or out translation, the first angular motion corresponds to a base rotation, and second angular motion ,is one that rotates about an axis perpendicular to the vertical through the base and is sometimes termed as elbow rotation. The two rotations along with the in or out motion enable the robot to reach an specified point in the space bounded by an outer and inner hemisphere. Sometimes, the spherical coordinate system is referred to as polar coordinate system.

It is still in the research laboratory, the Spherical robot is actually a spherical shape robot, which has an internal driving source.

Advantages:

1) 1 linear + 2 rotating axes.

2) Large working envelops.

Disadvantages:

1) Can’t reach around obstacles.

2) Low accuracy.

3) Complex coordinates more difficult to visualize, control, and program.

Applications:

Die Casting, Dip Coating, Forging, Glass Handling, Heat Treating, Injection Moulding, Machine Tool Handling, Material Transfer, Parts cleaning, Press Loading etc.

c) Cylindrical Configuration:

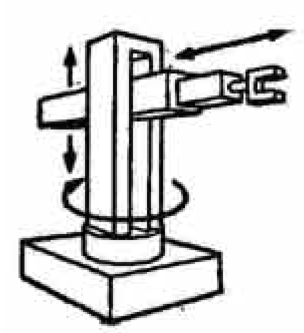


Fig: Cylindrical Configuration

Cylindrical robot is able to rotate along his main axes forming a cylindrical shape.

In the cylindrical coordinate configuration shown in figure, Consists of a vertical column, relative to which an arm assembly is moved up or down. The arm can be moved in or out relative to the column. A cylindrical robot has a two orthogonal prismatic axes of movement (horizontal and vertical) and one revolute axis, forming a cylindrical coordinate system. It is capable of higher horizontal plane speeds vs. cartesian systems due the revolute base. However horizontal, straight line motion is more complex to calculate and tends to be slower. The resolution of the positioning of the end effector is not constant, but depends on the degree of extension along the horizontal axis. If a monomast construction is used for the horizontal element, clearance behind the robot must be accounted for when retracted

Advantages:

1) 2 linear axes +1 rotating.
2) Can reach all around itself.
3) Reach and height axes rigid.
4) Rotational axis easy to seal.
5) Relatively easy programming.

Disadvantages:

1) Can’t reach above itself.

2) Base rotation axis as less rigid.

3) Linear axes are hard to seal.

4) Won’t reach around obstacles.

Applications:

Assembly, Coating Applications, Conveyor Pallet Transfer, Die Casting, Forging Applications, Inspection Moulding, Investment Casting, Machine Loading and Unloading etc.

d) Jointed arm Configuration:

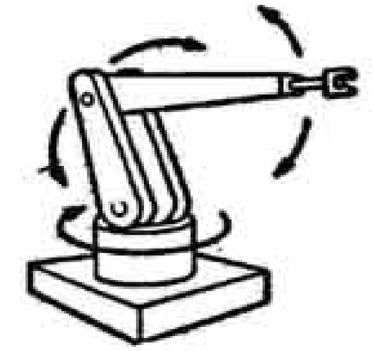


Fig: Jointed arm Configuration

Jointed arm Configuration robots are mechanic manipulator that looks like an arm with at least three rotary joints. The workspace of an articulated arm is complex, often a three-dimensional crescent. With all joints revolute, this type of robot requires the most complex kinematic calculations. An articulated configuration can most closely approximate an anthropomorphic, or human-arm motion, and thus offers a high degree of flexibility for accessing objects, devices or workstations within it's work envelope. Articulated robots may have two or more joints, with highly complex examples having as many as ten joints. A higher degree of flexibility comes at the cost of higher overall complexity, slower speed and higher cost. The resolution of the positioning of the end effector is not constant throughout the workspace.Positional repeatability can be more effected by gravity and load weight than other types because of the joints are oriented orithoginal to gravity.

Advantages:

1) All rotary joints allows for maximum capacity.

2) Any point in total volume can be reached.

3) All joints can be sealed from the environment.

Disadvantages:

1) Extremely difficult to visualize, control, and program.

2) Low accuracy.

Applications:

Assembly operations, Welding, Spray painting, Weld sealing etc.

e) SCARA:

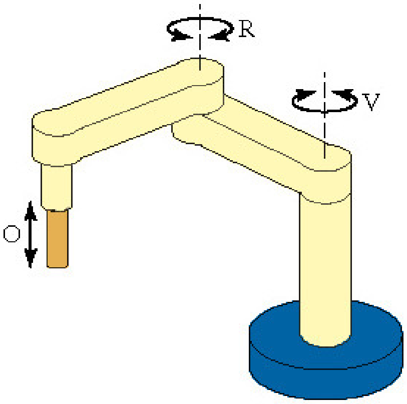


Fig: SCARA

SCARA stands for Selectively Compliant Assembly Robot Arm.

Similar to jointed-arm robot except that vertical axes are used for shoulder and elbow joints to be compliant in horizontal direction for vertical insertion tasks. It consists of two or more revolute joints and one prismatic, all of which operate parallel to gravity, easing the mechanical burden. As the name indicates, this configuration has been designed to offer variable compliance in horizontal directions, which can be an advantage in assembly tasks. The kinematics of this configuration are quite complex and the vertical component of movement is generally rather limited.Thus, it can reach around objects in the workspace, but not over them. The resolution of the positioning of the end effector is not constant throughout the workspace, but these robots do have a high degree of positional repeatability. They are generally faster and more expensive than cartesian systems.

Advantages:

1) 1 linear + 2 rotating axes.

2) Height axis is rigid.

3) High Speed.

4) Large work area for floor space.

5) Moderately easy to program.

Disadvantages:

1) Difficult to program off-line.

2) Highly complex arm.

3) 2 ways to reach point.

4) Limited Applications.

Applications:

Assembly operations, Pick and Place work etc.

CONCLUSION:

Hence, we have studied the Robot Configurations.

EXPERIMENT NO: 02

DEMONSTRATION OF ROBOT WITH 2 DOF, 3 DOF, 4 DOF

AIM: Study of ROBOT With 2DOF,3DOF & 4DOF.

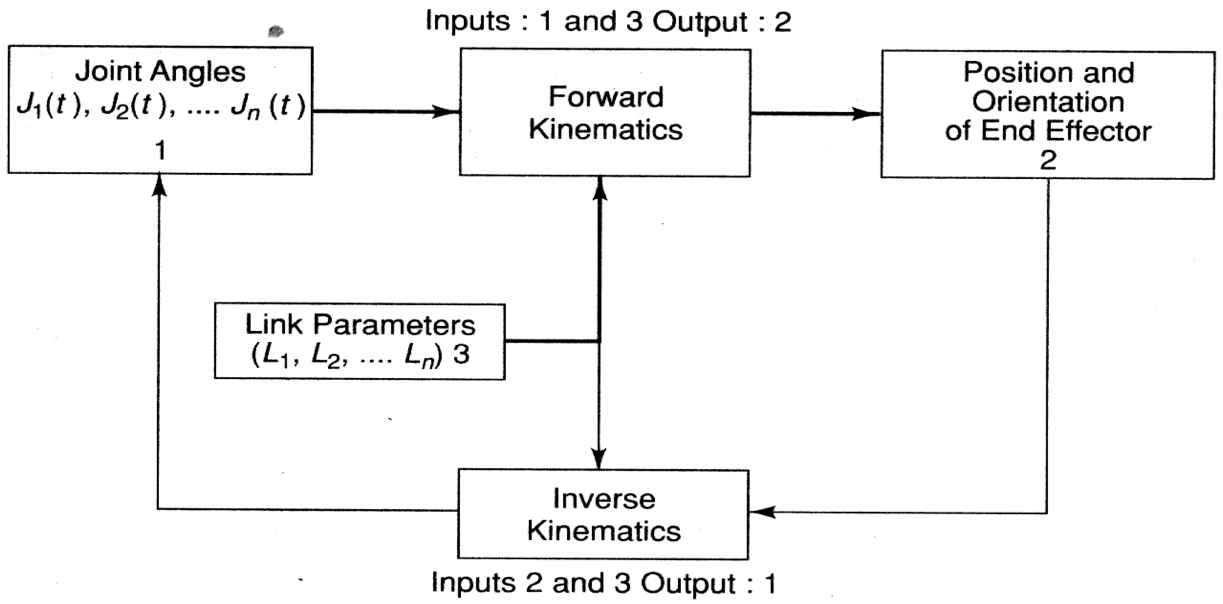

Inputs : 1 and 3 Output : 2
Joint Angles
$J_1(t), J_2(t), \ldots\ldots J_n(t)$
1
Forward
Kinematics
Position and
Orientation
of End Effector
2
Link Parameters
$(L_1, L_2, \ldots\ldots L_n)$ 3
Inverse
Kinematics
Inputs 2 and 3 Output : 1

FIG. 2.1 *Forward and inverse kinematics scheme*

2.2 FORWARD AND REVERSE KINEMATICS (TRANSFORMATION) OF THREE DEGREES OF FREEDOM ROBOT ARM

Forward Transformation

The position and orientation of the end-effector shown in Fig. 2.3 in world space can be determined from the joint angles and the link parameters by the following equations,

$$x_3 = l_1 \cos \theta_1 + l_2 \cos (\theta_1 + \theta_2) + l_3 \cos (\theta_1 + \theta_2 + \theta_3) \tag{2.3}$$

$$y_3 = l_1 \sin \theta_1 + l_2 \sin (\theta_1 + \theta_2) + l_3 \sin (\theta_1 + \theta_2 + \theta_3) \tag{2.4}$$

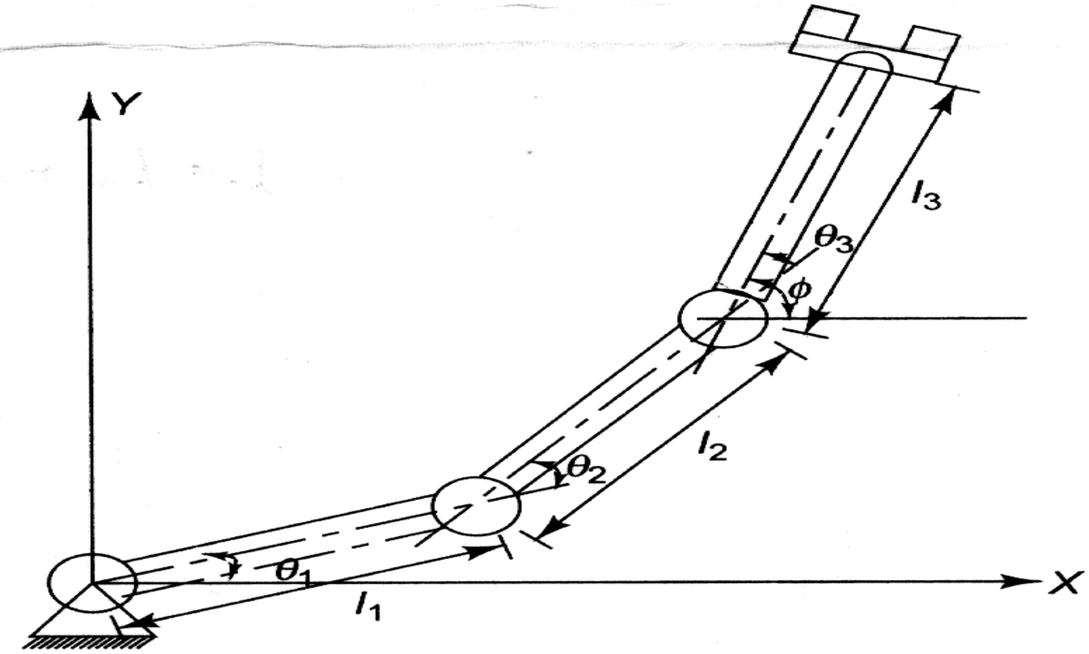
$$\phi = (\theta_1 + \theta_2 + \theta_3) \tag{2.5}$$

Reverse Transformation

The joint angles can also be determined from the end-effector position (x_3, y_3) and the orientation (ϕ), using reverse transformation in the following way

$$x_2 = x_3 - l_3 \cos \phi \tag{2.6}$$

$$y_2 = y_3 - l_3 \sin \phi \tag{2.7}$$



Three DOF 2-D manipulator

From the given geometry,

$$x_2 = l_1 \cos\theta_1 + l_2 \cos\theta_1 \cos\theta_2 - l_2 \sin\theta_1 \sin\theta_2 \quad (2.8)$$

$$y_2 = l_1 \sin\theta_1 + l_2 \sin\theta_1 \cos\theta_2 + l_2 \cos\theta_1 \sin\theta_2 \quad (2.9)$$

Squaring and adding Eqs (2.8) and (2.9),

$$\cos\theta_2 = \frac{x_2^2 + y_2^2 - l_1^2 - l_2^2}{2l_1 l_2} \quad (2.10)$$

Substituting the value of θ_2 in Eqs (2.8) and (2.9), we obtain the value of θ_1. Finally, the value of θ_3 can be obtained using the following relation:

$$\theta_3 = \phi - (\theta_i + \theta_2) \quad (2.11)$$

2.3 FORWARD AND REVERSE TRANSFORMATION OF A FOUR DEGREES OF FREEDOM MANIPULATOR IN 3-D

A 4-degrees of freedom manipulator in 3-D is illustrated in Fig. 2.4. Joint 1 allows rotation about the z-axis, joint 2 allows rotation about an axis perpendicular to the z-axis, joint 3 is a linear joint and joint 4 allows rotation about an axis parallel to the joint 2 axis.

Let

θ_1 = angle of rotation of joint 1 (base rotation)

θ_2 = angle of rotation of joint 2 (elevation angle)

l = length of the linear joint 3 (extension)
(a combination of l_2 and l_3)

θ_4 = angle of rotation of joint 4 (pitch angle)

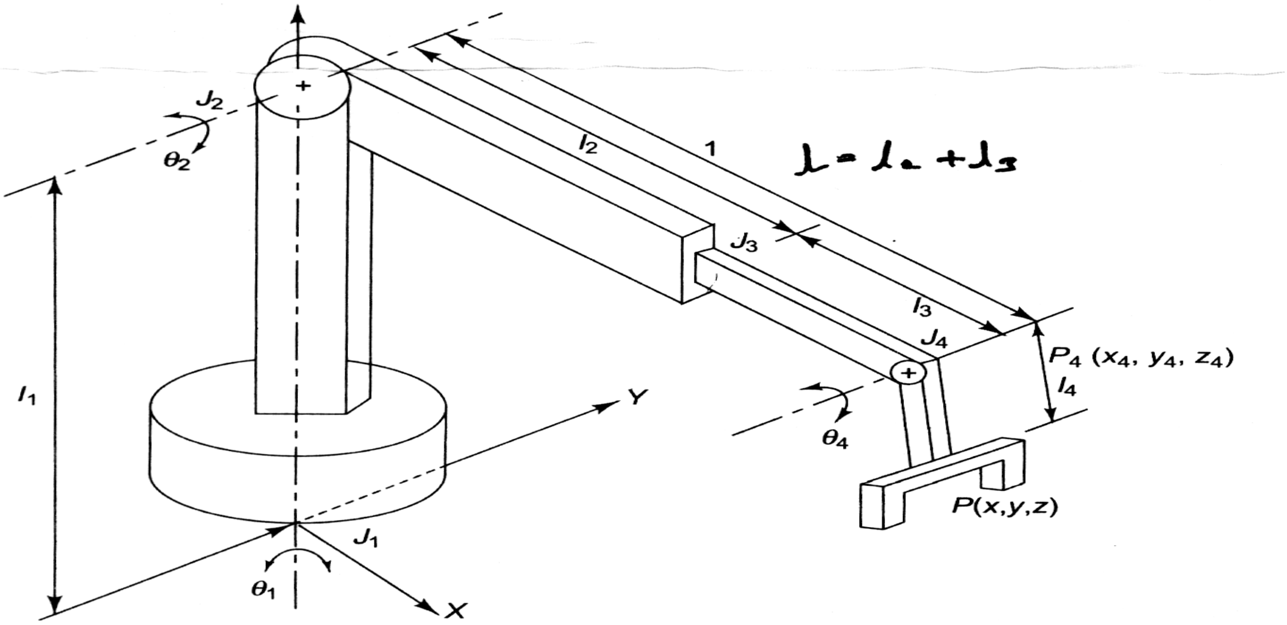


FIG. 2.4 *Four DOF 3-D manipulator*

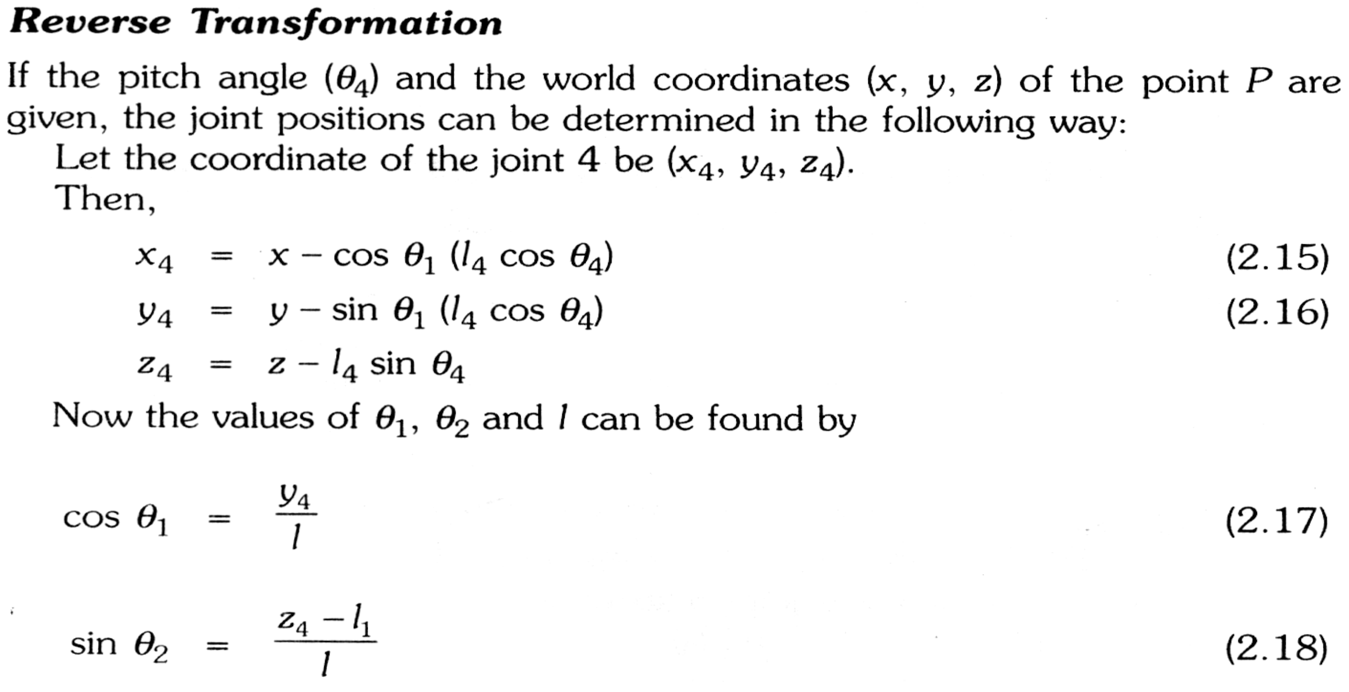
Forward Transformation

The position of the end-effector P in world space is given by

$$x = (l \cos \theta_2 + l_4 \cos \theta_4) \times \cos \theta_1 \tag{2.12}$$

$$y = (l \cos \theta_2 + l_4 \cos \theta_4) \times \sin \theta_1 \tag{2.13}$$

$$z = l_1 + l \sin \theta_2 + l_4 \sin \theta_4 \tag{2.14}$$



Reverse Transformation

If the pitch angle (θ_4) and the world coordinates (x, y, z) of the point P are given, the joint positions can be determined in the following way:

Let the coordinate of the joint 4 be (x_4, y_4, z_4).

Then,

$$x_4 = x - \cos\theta_1\,(l_4 \cos\theta_4) \tag{2.15}$$

$$y_4 = y - \sin\theta_1\,(l_4 \cos\theta_4) \tag{2.16}$$

$$z_4 = z - l_4 \sin\theta_4$$

Now the values of θ_1, θ_2 and l can be found by

$$\cos\theta_1 = \frac{y_4}{l} \tag{2.17}$$

$$\sin\theta_2 = \frac{z_4 - l_1}{l} \tag{2.18}$$

Conclusion: Thus by studying the forward & reverse kinematics for various ROBOT manipulators, we conclude with the demonstration of 2 DOF, 3DOF & 4DOF of ROBOT manipulator

EXPERIMENT NO: 03

TWO ASSIGNMENTS ON PROGRAMMING THE ROBOT FOR APPLICATIONS

AIM: To study the Robot programming for industrial applications.

PROGRAM 1:

Palletizing application using AL.

```
Begin ‘Palletizing sample program’

Frame in-pallet, out-pallet, part;

Comment

The (1, 1) positions of the pallets and grasping position of parts;

Vector del-r1, del-c1;

Vector del-r2, del-c2;

COMMENT relatives’ displacements along the rows and columns;

Scalar r1, c1, ir1, ic1;

Scalar r2, c2, ir2, ic2;

COMMENT COUNTERS;

EVENT in-pallet-empty, in-pallet-replaced;

EVENT out-pallet-full, out -pallet-replaced;

COMMENT

Here insert the frame definition for IN-PALLET and OUT-PALLET and the vector value for displacements along  and recorded using robot

PROCEDURE PICK;

BEGIN

FRAME Pick-frame;

Ir1=ir1+1;

IF ir1 c1Tr1
```

```
THEN
BEGIN
 ir1; =1
ic1; = ic1+1
IF ic1c1Tc1
THEN
BEGIN
SINGAL in-pallet-empty;
WAIT in-pallet-replaced;
ic1; =1;
END;
END;
Pick-frame; = in-pallet+ (ir1-1)*del-r1+( ic1-1)*del-c1
MOVE BEHIND TO PICK FRAME;
CENTRE BARM;
AFFIX PART TO BARM;
END
PROCEDURE PLACE
BEGIN
FRAME PLACE-frame
ir2; = ir2+1
IF ir2c1Tr2
THEN
BEGIN
ir2; = 1;
```

```
ic2; = ic2+1
IF ic2c1Tc2
THEN
BEGIN
SINGAL OUT-Pallet-empty;
WAIT OUT-Pallet-replaced;
ic2; =1;
END;
END;
Place-frame; out-Pallet+(ir2-1)*del-r2+( ic2-1)*del-r2.
MOVE Part To Place-frame.
OPEN BHAND To 3.0*IN
UNFIX PART FROM BARM;
END;
COMMENT THE main Program,
OPEN BHAND To 3.0*IN;
WHILE TRUE DO
BEGIN
PICK;
PLACE;
END;
END;
```

PROGRAM 2:

Palletizing application using KAREL

```
PROGRAM PALLET

---Transfer workpieces from one pallet to another.

---Variables for the input pallet,

BASE 1; position—(1,1) position on pallet.

IR 1, IC 1: integer.

NR1, NC1: integer.

 DR 1, DC 1: vector.

1S1G1, 0S1G1; intger.

--Variables for the output pallet.

BASE 2; Position

IR 2, IC 2: integer.

NR2, NC2: integer.

 DR 2, DC2: vector.

1S1G2, 0S1G2; intger.

ROUTINE PICK

--Pick a workpiece  from the input Pallet.

TARGET: POSITION—targetpose

BEGIN

IR1=IR1+1

If IR1>NR1

Then

I R1=1

IC1=IC1+1
```

```
If  IC1>NC1
Then,
IC1=1
dout (0S1G1)=true
wait for din (1S1G1) +
dout (0S1G1)=false.
End if
End if
TARGET = BASE1
Shift (TARGET, (1R1-1)*DR1+(1C1-1)*DC1
Move near TARGET by 50
Move to TARGET
Close hand 1
Move away 50
and Pick
ROUTINE PLACE
--Place a workpiece on the output pallet var
TARGET:POSITION.
BEGIN
IR2= IR2+1
If IR2>NR2
Then,
IR2=1
IC2=IC2+1
If IC2>NC2
```

```
Then,
IC2=1
dout (0SIG2)=true.
Wait for din (1SIG2)+1
dout (0SIG2)=false.
End if
End if
TARGET=BASE 2
Shift (TARGET, (1R2-1)*DR2+(1C2-1)*DC2
Mover near TARGET by 50
Move to TARGET
Close hand 1
Move away 50
end Place.
```

MAIN PROBLEM

```
BEGIN
IR1=0; IC1=0
IR2=0; IC2=0
--initialize other variable
--BASE 1, NR1, NC1, DR1, DC1, IS1G1, 0S1G1.
--BASE 2, NR2, NC2, DR2, DC2, IS1G2, 0S1G2.
--numerical pose definition omitted here.
Opened hand 1
While true do—loop.
PICK
PLACE
and while
and PALLET.
```

CONCLUSION: Thus, we have studied the Robot programming for industrial applications.

EXPERIMENT NO: 04

ASSIGNMENT ON PROGRAMMING THE ROBOT FOR APPLICATION IN VAL II

AIM: To study the Robot programming application in VAL II.

PROGRAM:

Palletizing application in VAL II

In the VAL II version of Palletizing application, the program transfer parts between two Pallets using the external binary I/O signals to request additional pallets. It communicates with the user via the system terminal asking questions and providing information on system operation. A Pallet location is taught by instructing the operator to move the robot to the corners of pallet. The program then computes all locations in the pallet.

```
PROGRAM Main ( )

;

ABSTRACT:- This is the top level program to move

; Thee parts between two Pallets. It allows the operator

; To teach the Pallet locations if desired & then

; moves parts from one pallet to next

; DATA STRUCTURE

; in. Pallet [.]=An array of location for items on the pallet to be unloaded.

; in. height =approach/depart height for input pallet.

; in. max= The no. of items on a full input pallet.

; in. count= The no. of items left on this I/P pallet.

; out. pallet [ ] = An array of location for items on pallet to be loaded,

; out height = approach/dipalt height for O/P pallet.

; out. max= The no. of items on a full O/P pallet.

; out. count= The no. of items left on this O/P pallet

; #Safe=soft robot location reachable from both pallets

LOCAL sans in count, out count
```

```
Define binary signal no. used to control pallets transfer =1001; input signal TRUE when transfers permitted

in.ready =1002; I/P Signal TRUE when output Pallet ready

out ready =1003; I/P Signal TRUE when O/P Pallet ready
in. Change=4; O/P Signal requests new I/P Pallet
out. Change=5; O/P Signal requests new O/P Pallet
; Ask operator about set up and teach new pallets if desired
 PROMPT “Do you want to define the pallet (Y/N)”Sans
IF Sans ==”Y” THEN
DETACH ( ); Detach robot from program control
TYPE “Use the PENDANT to teach the I/P Pallet location”
CALL set up. Pallet (in. count, in pallet [ ], out. height)
TYPE “Press the comp. button on the PENDANT to continue “
ATTACH ( )
END
; Initialize transfer data
transfer count =0
in. count=0
out count=0
; wait for transfer signal; then start the pallet transfer
MOVES # Safe
TYPE “waiting for transfer signal.......”/S
WAIT SIG (transfer)
```

```
TYPE " starting transfer",/c2
Main, loop transferring one pallet to another, requesting;
;new pallets as necessary; Quit when transfer signal
becomes FALSE
WHILE. SIG (transfer) DO
IF in. count< = 0 THEN
SIGNAL in. change
WAIT SIG (-in. ready)
WAIT SIG (in. ready)
in. count= in. max
END
IF out. Count < 0 THEN
SIGNAL OUT. Change
WAIT SIG (-out. ready)
WAIT SIG (out. ready)
out. count= out. max
END
OPEN
APPROS in Pallet [in. count], in.height.
SPEED 20
MOVES  in. Pallet [in. count]
CLOSE I
DEPARTS in. height
in. count = in. count-1
; Place output part
```

```
APPROS out
SPEED 20
MOVES  out. Pallet [out. count]
OPEN I
DEPARTS out. height
out. count = out. count-1
; Count transfer and display it.
transfer. Count = transfer. Count+1
TYPE N, ”Number of parts transferred,” / I8, transfer. count
 END;
; All done transferring parts, move robots to safe place and quit
MOVES # Safe
END
PROGRAM set up pallet (count. Array [ ],approach)
; INPUT PARM ; NONE
;
;OUTPUT  PARM ; Count = No. of items on their pallet.
array [ ]= Array containing the pallet location
approach = The approach height for their Pallet.
Local r1; 11, 1r, ap, t [], ncol, nrow
Local row, COL.cs, rs, i, frame
Ask operator to teach pallet location
CALL teach. Point (“Upper left pallet location”,Ll)
CALL teach. Point (“Lower left pallet position”, Ll)
CALL teach. Point (“Lower right pallet position”, Lr)
CALL teach. Point (“approach height above pallet”, ap)
PROMPT “Enter the no. of columns (left to right);” ncol
PROMPT “Enter the no. of columns (top to bottom);” nrow
Count = ncol*nrow
; set up to compute pallet location
cs = 0
IF ncol>1 THEN
cs =DISTANCE (ll1lr)/(ncol=1)
END
; Compute frame values
SET frame = FRAME (ll,lr,l1l,l1l)
approach = DZ [ INVERSE (frame);ap]
DECOMPOSE t [1]=l1L
LOOP to compute array value
i =1
For row=0 to nrow-1
For col=0 to ncol-1
SET array [i]= frame.;TRANS ( row*rs, col*cs,0,t[4],t[5],t[6]
  i = i+1
END
END
RETURN
END.
```

CONCLUSION: Thus, we have studied the Robot programming for application in VAL II.

EXPERIMENT NO: 05

TWO PROGRAMMING EXERCISES FOR ROBOTS

AIM: To perform the Robot programming exercise for Pick and Place operation.

THEORY:

Most controllers for industrial robots provide a method of dividing a program into one or more branches. Branching allows the robot program to be subdivided into convenient segments that can be executed during the program. A branch can be thought of as a sub routine that is called one or more times during the program. The subroutine can be executed either by branching to it at a particular place in the program or by testing an input signal line to branch to it. The amount of decision logic that can be incorporated into a program varies widely with controllers. They permit the use of an incoming signal to invoke a branch. Most controllers allow the user to specify whether the signal should be interrupt the program branch currently being executed, or wait until the current branch completes. The interrupt capability is typically used for error branches. An error branch is invoked when an incoming signal indicates that some abnormal event has occurred. Depending on the event and the design of the error branch, the robot will either take some corrective action or simply terminate the robot motion and signal for human assistance.

A frequent use of the branch capability is when the robot has been programmed to perform more than one task. In this case, separate branches are used for indicating which branch of the program must be executed and when it must be executed. A common way of accomplishing this is to mate use of external signals which are activated by sensors or other interlocks. The device recognizes which took must be performed, and provide the appropriate signal to all that branch. This method is frequently used or spray painting robot which have been programmed to paint a limited variety of parts moving post the workstation of a conveyor photoelectric cells are frequently employed to identify the part of to be sprayed by distinguishing between the geometric features of different parts. The photoelectric cells are used to generate the signal to the robot to call the spray painting sub routine corresponding to the particular part.

Robot programs have thus far been discussed as consisting of a series of points in space, where each point is designed as a set of joint coordinate corresponding to the number of degree of freedom of robot. These points are specified as in absolute coordinates. That is when the robot executes program; each point is visited at exactly the same location every time. The new concept involves the use of a relocatable branch.

A relocated branch allows the programmer to specify a branch involving a set of internal points in space that are performed relative to some defined starting point for the branch. This would permit the same motion subroutine to be performed at various locations in the workspace of the robot. Many industrial robots have the capacity to accept reloadable branches as a part of program. The programmer indicates that a relocatable branch will be defined and the controller records relative or Incremental motion points rather than absolute points.

PROGRAM 1:

POINT NAME	EXPLANATION
SAFE	Safe location to start and stop
PICK UP	Location of part pick-up and of chute
INTER	Intermediate point above chute to pass through.
Loc 1	Location of first pallet position
Loc 2	
.	
.	
Loc 24	Location of 24th pallet position
ABOVE 1	Location above 1st pallet position
.	
.	
.	
ABOVE 24	Location above 24th pallet position.

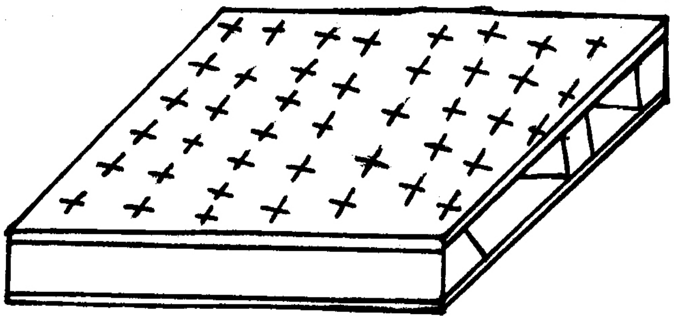


fig :- Pallet with 24 positions used to Illustrate branching in robot program.

Suppose that the operation required the robot to pick up parts from an input chute and place them on a pallet with 24 positions. When a start signal is given, the robot must begin picking up parts and loading them into the pallet, continuing until all 24 positions on the pallet is filled. The robot must then generate a signal to indicate that the pallet is full, and wait for the start signal to being the next cycle. When the robot is directed to go to the point name in the program, it goes to the associated joint coordinates.

In creating robot programs for palletizing operations of this type, the robot is programmed to approach a given part from a direction choose to avoid interference with the other parts.

The speed at which the program is executed should be varied during the program when the gripper is approaching a pick up of drop off point, the speed setting should be at a relatively slow value. When the robot moves larger distance the chute and the pallet, higher speed would be programmed.

PROGRAM 2:

Program for Pick and Place activity:

STATEMENT	STATEMENT DESCRIPTION
BRANCH PICK	The branch of program indicating part picks.
MOVE INTER	Move to an intermediate position chute.
WAIT 12	Wait for an incoming part to chute.
SIGNAL 5	Open gripper fingers (Sensor control)
MOVE PICK-UP	Move gripper and Pick-up the object.
SIGNAL 6	Close the gripper to grasp the object.
MOVE INTER	Depart to intermediate position above chute.
END BRANCH	End of pick-up activity.
BRANCH PLACE	Start of placing activity.
MOVE Z (-50)	Position part and gripper above the pallet .
SIGNAL 5	Open gripper to release the part.
MOVE Z (50)	Depart from the place point.
END BRANCH	End of place activity.

CONCLUSION: Thus, we have studied how to perform Pick and Place operation.

EXPERIMENT NO: 06

TWO CASE STUDIES OF APPLICATIONS IN INDUSTRY

(1) Introduction and general considerations in robot applications.

(2) Case study I: Robot application for Welding.

(3) Case study II: Robot application for Spray painting.

EXPERIMENT NO: 07

EXERCISE ON ROBOTIC SIMULATION SOFTWARE

AIM: To study the Robot path planning using Robotic simulation software.

THEORY:

The locus of points along the path defines the sequence of position through which the robot will move its wrist. In most applications, an end effector is attached to the wrist and program can be considered to be the path in space through which the end effector is to be moved by the robot.

Since, the robot consists of several joint (axes) linked together, the definition of the path in space in effect requires that the robot move its axes through various positions in order to follow that path for a robot with six axes, each point in the path consists of six coordinates value corresponds to the position of one joint. There are basic robot anatomies; Polar, Cylindrical, Cartesian and Jointed Arm.

Each one of three axes associated with the arm and body configuration and two or three additional joints are associated with wrist. The arm and body joint determines the general position in space of the end effector and the wrist determines its orientation. If we think of a joint in space in the robot program as a position and orientation of the end effector, there is usually more than one possible set of joint coordinate values that can be used for the robot to reach that point.

For example, there are two alternative axis configurations that can be used by the jointed arm shown in figure to achieve the target point indicated.

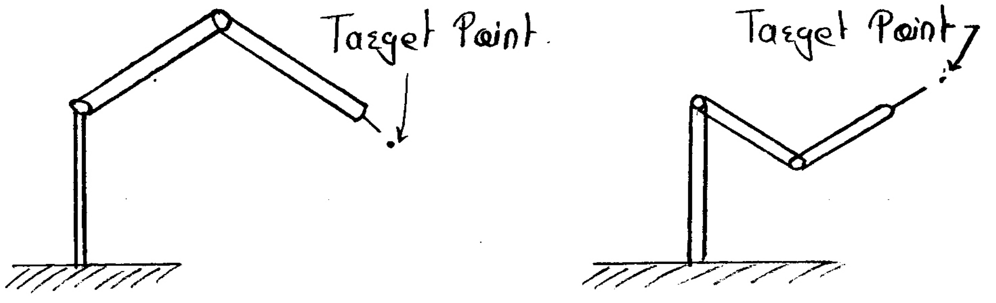


fig (a) → Two alternative axis configurations with end effector located at desired target point.

As shown in figure (a) that; although the target point has been reached by both of alternative axis configurations, there is a difference in the orientation of the wrist with respect to the point. We must conclude from this that the specification of the joint coordinates of the robot does define only one point in a space that corresponds to that set of coordinate values. Point specified in this fashion are said to be joint coordinates. Accordingly, an advantage of defining robot program in this way is that is simultaneously specifies the position and orientation of the end effector at each point in the path.

Let's consider the problem of defining a sequence of points in space. We will assume that these points are defined by specifying the joint coordinates as described above. Although, this method of specification will not affect the issue we are discussing here for a sake of simplicity, lets assume that we are programming a point-to-point Cartesian robot with only two axes and only two addressable point is one of the available points (as determine by the control revolution) that can be commended to go to that point. Figure (b) shows the four points (possible points) in the robot's rectangular space. A program of this robot to start in lower left hand corner and traverse the perimeter of the rectangle could be written as follows;

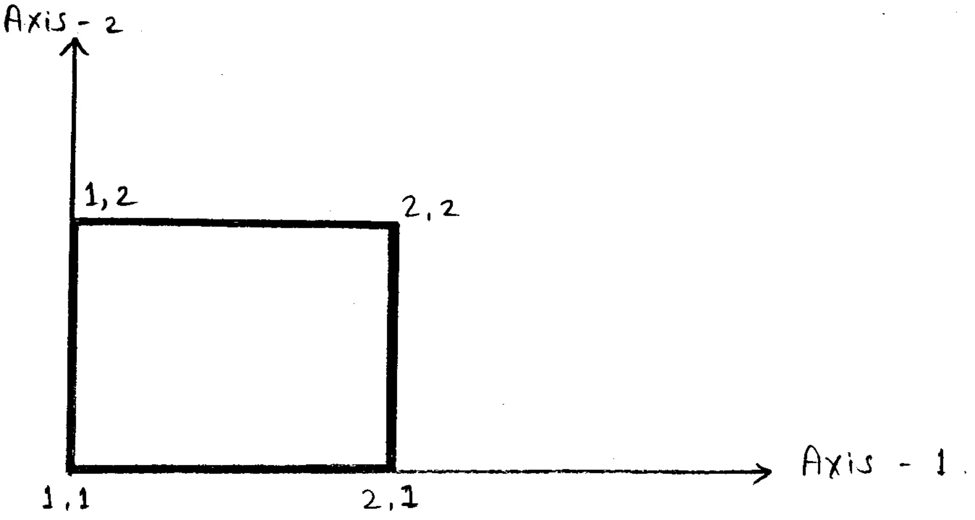


fig (b) - Robot Workspace.

STEP	**MOVE**	**COMMENTS**
1	1, 1	Move to lower left corner.
2	2, 1	Move to lower right corner.
3	2, 2	Move to upper right corner.
4	1, 2	Move to upper left corner.
5	1, 1	Move back to start position.

The point designation corresponds to the x, y- coordinates positions in the Cartesian axis system. In this example, using a robot with two orthogonal slides and only two addressable points per axis, the definition of points in space corresponds exactly with joint coordinate's values.

CONCLUSION: Thus, we have studied the robot path planning using simulation control software.