

Start Up



Figure 1: Overall Configuration of the Robot

This robot arm is only available to students in the CIM lab. It will not be connected for remote control.

Before turning ON the power, be sure to check that nobody is near the manipulator. To start the robot do the following steps in order:

1. Connect compressed shop air
The gripper of this robot requires shop air for operation. Make sure the hose is properly connected and the valve at the wall outlet turned on.
2. Turn ON the main power.
Turn ON the main power switch located on the front of the controller. The control power supply in the controller is turned on and the playback box and the programming pendant become operable.
The initial display on the left appears. However, the manipulator is not operable at this time.
3. Turn ON the servo power.

Depress either [servo power] on the playback box or the programming pendant. Depressing either button supplies power to the manipulator servo motors.

Movements

Robot Arm Articulation

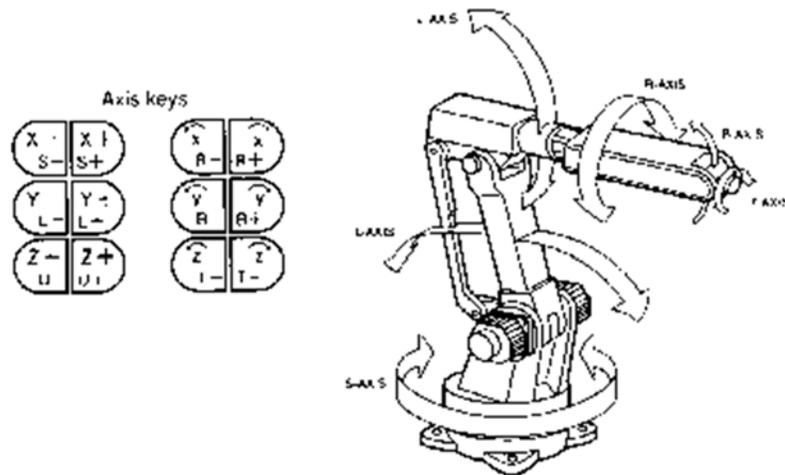


Figure 2: Arm Configuration

The Motoman robot is an articulated arm with six (6) degrees of freedom. That means the arm has six joints

connecting the rigid links of the arm. Starting from the base, the joints are:

1. Waist - connecting the base to the rotary head. This is a twisting joint (S) with a range of $\pm 170^\circ$ in the horizontal plane.
2. Shoulder - connecting rotary head and lower arm. This is a rotary joint (L) with a range of 240° in the vertical plane.
3. Elbow - connecting lower and upper arms. This is a rotary joint (U) with a range of 260° in the vertical plane.
4. Wrist roll - connecting upper arm and wrist. This is a twisting joint (R) allowing a maximum roll of 360° .
5. Wrist pitch/yaw - within the wrist. This is a rotary joint (B) allowing 270° of rotation.
6. Wrist twist - connecting the wrist to the tool adaptor flange. This is a twisting joint (T) allowing a maximum twist of 400° .

The arm is powered with electric motors giving it a maximum pay load capacity of 3 kg (6.6 lb). Its repetitive positioning accuracy is ± 0.1 mm. The maximum reach of the arm defines its work space. This is shown in Figure 3.

Coordinate Systems

1) Joint Coordinate System

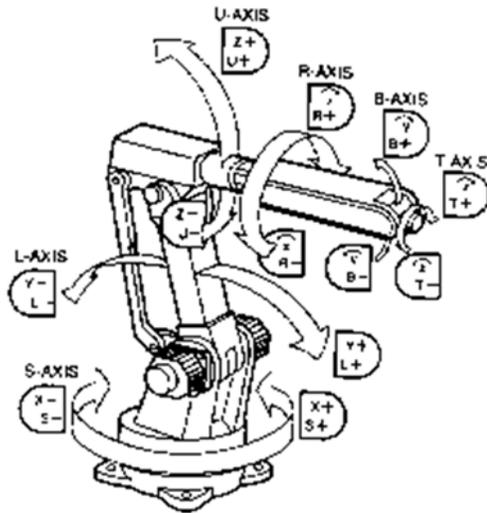


Figure 4: Joint Coordinate System (Articulated Motion)

- In the Joint Coordinate System a position of the robot hand in space is defined by the angles of rotation of six joints of the arm. The first three axes (waist, shoulder, and elbow) are used to position the endeffector, while the three axes of the wrist are used to orient the hand.

Table 1: Motion on Joint Coordinate System

	axis	axis key	motion
main axes	S-axis	$\begin{matrix} X- \\ S- \end{matrix}$ $\begin{matrix} X+ \\ S+ \end{matrix}$	rotates to left or right
	L-axis	$\begin{matrix} Y- \\ L- \end{matrix}$ $\begin{matrix} Y+ \\ L+ \end{matrix}$	move forward or reverse
	U-axis	$\begin{matrix} Z- \\ U- \end{matrix}$ $\begin{matrix} Z+ \\ U+ \end{matrix}$	moves up or down
wrist axes	R-axis	$\begin{matrix} X- \\ R- \end{matrix}$ $\begin{matrix} X+ \\ R+ \end{matrix}$	rolls to left or right
	B-axis	$\begin{matrix} Y- \\ B- \end{matrix}$ $\begin{matrix} Y+ \\ B+ \end{matrix}$	bends up or down
	T-axis	$\begin{matrix} Z- \\ T- \end{matrix}$ $\begin{matrix} Z+ \\ T+ \end{matrix}$	turns to right or left

- Specifying a new coordinate for one of the joints results in motion of only that one joint; the endeffector (hand or tool) moves on an arc. Movement from some point A to another point B using linear interpolation in these joint coordinates does not result in straight line motion but rather follows a complex curve in three space.
- This is the coordinate system used by the servo-loops of the robot controller. It allows for independent control of each joint.

2) Rectangular Coordinate System

Playback Box

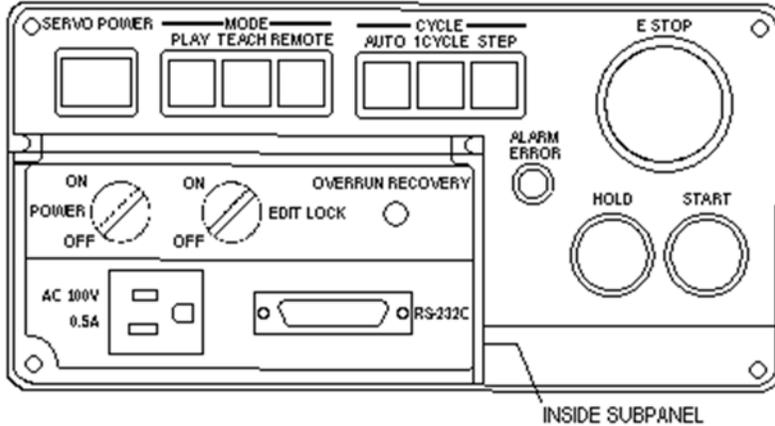


Figure 10: Overview of Playback Box

The Playback Box allows operation of the Motoman robot by shop operators without access to the teach pendant. Depending on the mode selected, the robot can be started and a stored program executed automatically. Program editing from the pendant can be locked out. The following are the major switches and indicators:

E Stop	Turns OFF the servo power
Servo Power	Turns ON the servo power; the lamp is lit while servo power is on.
Mode Selector:	Selects the operating mode: Enters PLAY mode and enables playback operation; its lamp is lit while in PLAY mode;
PLAY -	when teach-lock is ON, PLAY mode cannot be selected.
TEACH -	Enters TEACH mode and enables axes operation and editing with the programming pendant: its lamp is lit while in TEACH mode;
REMOTE -	editing is prohibited when the optional EDIT LOCK switch is ON. Enter REMOTE mode and enables playback operation from an external computer:

Programming Pendant



Using the Programming Pendant:

- From the programming pendant you can control the robot arm for setup and teaching of locations.
- With the pendant you can move the arm in any direction, you can open and close the hand, and change its speed.
- You are able to create programs with the pendant and you will be able to execute an existing program.
- In this tutorial the buttons on the pendant will be explained:
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 - Move the pointer on any group of buttons, and a brief description pops up.
 - Click anywhere else on the pendant and a new window will open and let you simulate the function of the programming pendant.

Instruction Set

The INFORM II instruction set for the Motoman robot can be divided into several subsets depending on the general function an instruction executes. In the following table only those instructions are listed which are deemed necessary for the student to successfully understand this tutorial:

1. Basic Instructions
 - Move Instructions
 - I/O Instructions
 - Control Instructions
 - Operating Instructions
2. Device Instructions (these instruction differ by application)

Basic Instruction Set

Move Instructions:

MOVJ Moves to the taught position by joint interpolation:

VJ = play speed (range: 0.01 to 100.00 %)

- PL = position level (range: 0 to 4)
- UNTIL syntax (see below)
- NWAIT (see below)

example: MOVJ VJ=50.0 PL=2 UNTIL IN#(16)=ON NWAIT

MOVL Moves to the taught position by linear interpolation:

- V = play speed (range: 0.1 to 1500.0 mm/s)
- VR = wrist orientation play speed (range: 0.1 to 180 °/s)
- VE = extended axis play speed (range: 0.01 to 100 %)
- PL = position level (range: 0 to 4)
- UNTIL syntax (see below)
- NWAIT (see below)

example: MOVL V=138.0 PL=0 UNTIL IN#(16)=ON NWAIT

MOVCC Moves to the taught position by circular interpolation:

- V = play speed (range: 0.1 to 1500.0 mm/s)
- VR = wrist orientation play speed (range: 0.1 to 180 °/s)
- VE = extended axis play speed (range: 0.01 to 100 %)
- PL = position level (range: 0 to 4)
- NWAIT (see below)

Shut down

At the end of your lab session the robot system must be shut down properly to avoid damage to the equipment.

1. Turn OFF servo power.
2. Turn OFF main power.