



FA Equipment for Beginners (Industrial Robots)

This is a quick overview of Industrial Robots for beginners.



Introduction Purpose of the Course



This is an introductory course designed to provide beginners, who are new to Industrial Robots, an opportunity to learn the basics of Industrial Robotics.

Introduction **Course Structure**

The contents of this course are as follows.
We recommend that you start from Chapter 1.

Chapter 1 - What are Industrial Robots?





Learn about the basics of Industrial Robots including: purpose, typical uses, sample applications.

Final Test

Passing grade: 60% or higher.

Introduction How to use this e-Learning Tool



Go to the next page		Go to the next page.
Back to the previous page		Back to the previous page.
Move to the desired page		"Table of Contents" will be displayed, enabling you to navigate to the desired page.
Exit the learning		Exit the learning. Window such as "Contents" screen and the learning will be closed.

Introduction **Precautions for Use****Safety Precautions**

Before using the physical hardware, please read the Safety Precautions in the corresponding manuals and follow the relevant safety information contained therein.

Chapter 1 What is an industrial robot?

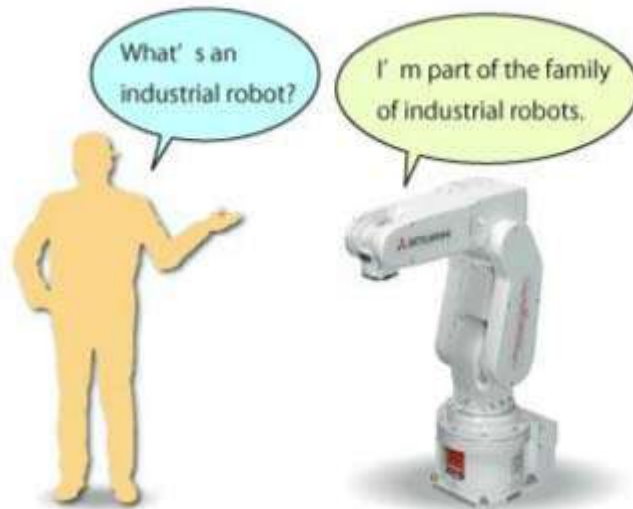
1.1 The Role of an Industrial Robot

The word "robot" generally conjures up images of a humanoids. This is because of the influence of cartoons, anime and pop culture which generally portray robots as futuristic human-like machines.

The type of robot discussed in this course isn't this kind but an industrial robot.

Now, just what is an industrial robot exactly?

- (1) Definition of an industrial robot
- (2) Advantages to using industrial robots
- (3) Safety with industrial robots



1.1

The Role of an Industrial Robot



Definition of an industrial robot

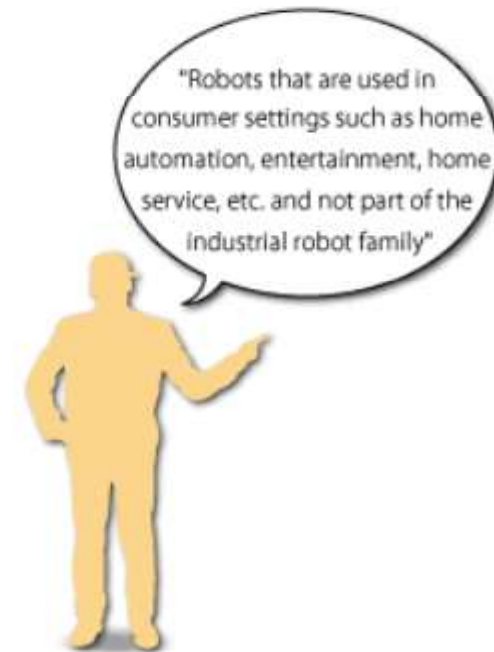
According to ISO (International Organization for Standardization), an industrial robot is defined to be "a programmable manipulator that can be controlled automatically and is programmable in three or more axes."

*The word manipulator used here refers to a device that functions like a human arm to complete different operating tasks.

When people hear the word "industrial robot," most think of robots lined up on a manufacturing line for automotive parts or assembly robots for electronic products like you see on TV.

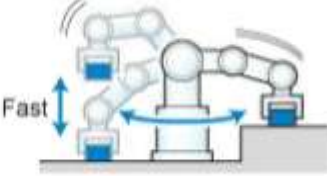
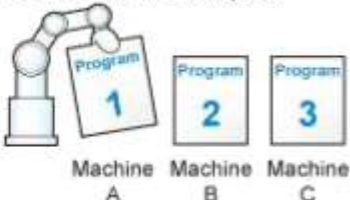
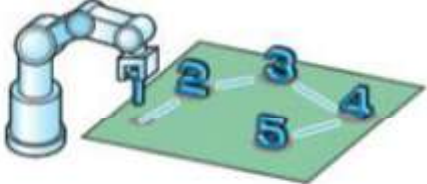
However, according to the definition above, any specialized machine with a crane-like arm controlled by a PLC or similar device is a perfect example of an industrial robot.

These types of robots are differentiated from non-industrial robots (personal robots) like the ones used for daily life tasks or for home automation and amusement.





1.1 The Role of an Industrial Robot

Advantages to using industrial robots

Benefits	Robot functions	Compared to human operators	Compared to specialized machines
<p>They can be used to improve productivity.</p>	<p>Robots can be used to move objects from one location to another. // Unlike a human robots can operate without taking a break 24 hours a day 7 days a week. // Robots are capable of repeatedly and consistently moving objects at very high speeds.</p> 	<p>⊙ (excellent)</p> <p>Need a legend to define the meaning of triangle, circle, 2 circles, etc</p>	<p>△(relatively poor)</p> <p>However, it is ⊙ (excellent) for specialized robots for welding, sealing, and related processes.</p> <p>○</p>
<p>Offer High level of flexibility</p>	<p>They can store programs for multiple models. They enable instantaneous switching of operations when models are changed. They can be used to handle complex operations.</p> 	<p>○ (good)</p> <p>Operators have the added hassle of having to learn different operations for each model.</p>	<p>⊙(excellent)</p> <p>Custom-made special purpose machines are not flexible. They work well when they are dedicated to handling just one part.</p>
<p>Can be easily upgraded or redeployed</p>	<p>Robot movements can be freely changed as desired.</p> 	<p>○ (good)</p>	<p>⊙(excellent)</p> <p>It is very expensive to retrofit Custom-made special purpose machines to perform different functions.</p>

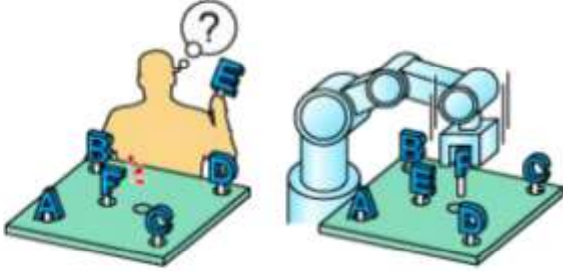
1.1 The Role of an Industrial Robot

Benefits	Robot functions	Compared to human operators	Compared to specialized machines
<p>Systems can be started up quickly.</p> <p>Startup adjustment times can be shortened as there are few startup problems.</p>	<p>It is a general-purpose model with a high degree of freedom.</p> <p>They offer high reliability substantiated through its record boasting installation of several models previously.</p> 	<p>△ (relatively poor)</p>	<p>◎ (excellent)</p> <p>Specialized machines are special-order models that take longer to design and produce.</p>
<p>They help to protect workers from the risk of industrial accidents.</p>	<p>They move as the hands and arms of an operator.</p> <p>(They can handle more complicated movements.)</p> 	<p>◎ (excellent)</p>	<p>Same</p>

1.1

The Role of an Industrial Robot



Benefits	Robot functions	Compared to human operators	Compared to specialized machines
They grant freedom from simple operations and enable more complex ones.	They will continue running without complaint exactly as they were instructed. However, they are not as versatile.	⊙ (excellent) It can be difficult to improve efficiency in operators working continuously on simple tasks.	Same
They can be used to raise product quality.	They always operate in the same way, eliminating the possibility of part assembly errors and other problems. 	○ (good) It is very difficult to completely eliminate operator errors even with experienced operators.	Same

1.1

The Role of an Industrial Robot



Industrial robot safety

Industrial robots operate by swinging their arms back and forth.

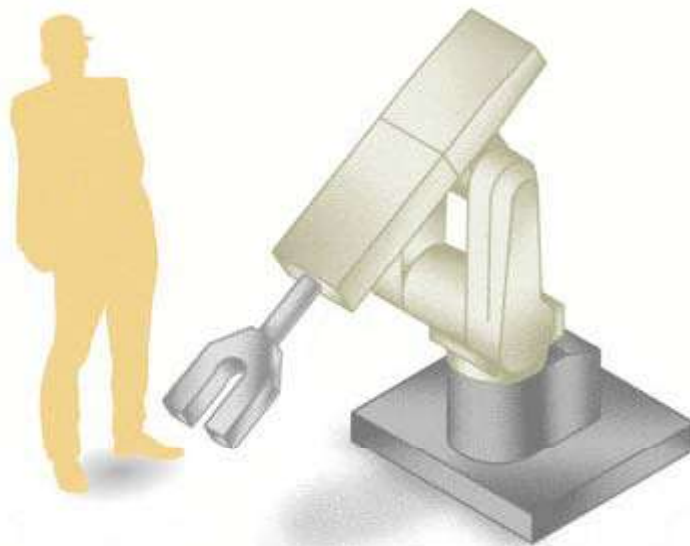
It can be difficult to predict how they will move upon first glance.

Robots operate in conjunction with peripheral safety devices.

During the teaching phase of the robot installation operators will have to get very close to the robot in order to program it. There have been industrial accidents in the past in which operators were struck by, sandwiched by, or otherwise harmed by an industrial robot while carrying out such operations.

In recent years, operations involving industrial robots (for details, see "Industrial Robot Teaching and Similar Operations" and "Industrial Robots Test Operations") have been designated as dangerous or toxic operations requiring operators to complete specialized training before working with them.

It has become required by law that companies install protective devices such as fences to prevent contact with equipment; to formulate, adopt, and strictly observe operating standards; to thoroughly utilize warning messages and inspections; and to implement other safety precautions for management purposes. (In Japan)



1.2

Types of and usage methods for industrial robots



Types of industrial robot

The main types of industrial robots can be classified as outlined below.

- (a) Classification based on Mechanical
- (b) Design and Application

It is becoming more difficult to classify robots into simple categories currently as they have become more complex.

For this reason, actual products use "(b) Mechanical structure" and the "product series name" in their product names. For example, product names for Mitsubishi Electric robots use Vertically Articulated Robot RV-SQ/SD Series and Horizontally Articulated Robot RH-SQH/SDH Series.

Robots that are based on specified applications may also be grouped into series based on the defined field of use, as well.

Example of those are the "Pallet and Case Robot series" and the "Clean Room Robot series."



Vertically Articulated
Robot RV-SQ/SD Series



Horizontally Articulated
Robot RH-SQH/SDH Series

1.2

Types of and usage methods for industrial robots



General industrial robot models

General model

Number	Term	JIS definition	Overview	
2110	Sequence robot	A robot with a control system that works to generate a new operating status when the previous one ends by advancing machine operating status according to a set sequence and set conditions.	A robot that advances to subsequent operating stages in sequential order according to information set in advance (sequences, conditions, ranking, etc.).	
2120	Playback robot	A robot that can be used to repeatedly execute a task program stored by a teaching program.	A robot that is taught operating sequences, conditions, rankings, and other information according to how the robot is moved by an operator and advances operations while replicating the information.	
2130	Numerical control robot	A robot that is taught operating sequences, conditions, rankings, and other information based on numerical, language, and other data and not according to how the robot is moved by an operator and works to complete operations based on that information.	A robot that is programmed with operating sequences, conditions, rankings, and other information written in a specialized language, or that accepts input of numerical position coordinates, and that operates based on the programmed information.	
2140	Intelligent robot	A robot that can independently determine how to behave using artificial intelligence.	A robot that possess artificial intelligence, which means that exhibits cognitive abilities, a capacity for learning, abstract thinking abilities, the ability to adapt to its environment, and other abilities artificially.	
	2141	Sensory control robot	A robot that controls operation using sensor information.	A robot that inputs sensory information from the sensors to determine how to operate.
	2142	Adaptive control robot	A robot that is equipped with adaptive control functions.	A robot that is equipped with adaptive control functions, which are control functions that can be used to change control and other properties to meet certain conditions in response to environmental changes and other factors.
	2143	Learning control robot	A robot that is equipped with learning control functions.	A robot that is equipped with learning control functions, which are control functions that are used to reflect operating experience and related information to complete operations as appropriate.

1.2

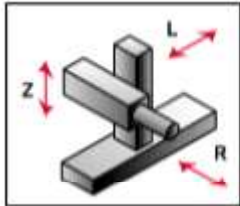
Types of and usage methods for industrial robots



Mechanical structure of an industrial robot (1)

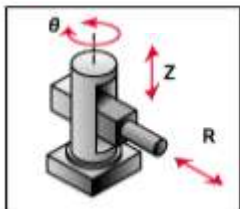
Features of mechanical structures and their applications

Cartesian coordinate robot



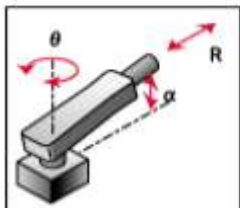
Definition	A Cartesian coordinate robot has an arm that has a mechanical structure with three linear joints arranged along Cartesian coordinates.
Overview	They have high rigidity and positioning accuracy, making them easy to control. Their movement speeds are not so high. They have a smaller operating range than the area they occupy. They are optimal for attachment/detachment of workpieces(*) to/from line processing machines, operations requiring XY positioning, palletizing operations, and operations requiring high precision. *: "Workpiece" refers to the object that is to be processed.

Cylindrical coordinate robot



Definition	A cylindrical coordinate robot has an arm that has a mechanical structure with at least one rotatable joint and one linear joint arranged along cylindrical coordinates.
Overview	The operating range extends not only to the front but to both sides; however, movement is restricted along the upper and lower diagonals, making it difficult to use for complex operations such as wraparound operations. They have high rigidity and positioning accuracy and are relatively easy to control. They have faster linear speeds at the tip due to their swivel joints. They are optimal for handling operations such as attachment of workpieces to machines and insertion of objects into boxes.

Polar coordinate robot



Definition	Cylindrical and Spherical robots are obsolete so don't have to be discussed
Overview	The operating range extends in the up and down directions, enabling the robot arms to be swiveled up and down in positions that are lower or higher than the robot body. Wraparound operations can also be completed to an extent. They cannot be used to transport as heavy a weight as other types of robots. They are optimal for use in operations performed in relatively complex areas such as spot welding or painting and in phase contouring. (Robots with this type of structure are not being used much currently.)

1.2

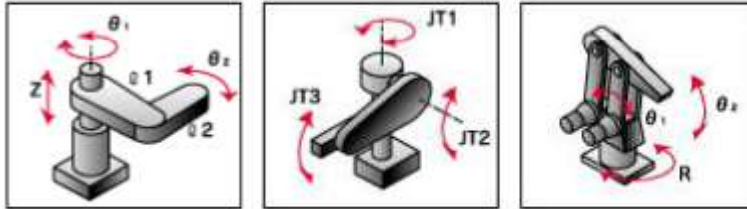
Types of and usage methods for industrial robots



Mechanical structure of an industrial robot (2)

Features of mechanical structures and their applications

Articulated robot



Definition	An articulated robot has an arm with a mechanical structure that has at least three rotatable joints.
Overview	<p>The wraparound ability is high enough to allow a person to wrap their hand around the back of the object, and the operating area over which complex operations can be completed is larger than the space they occupy.</p> <p>They are optimal for high-speed operations in which the arms run in a circular motion.</p> <p>They are used in assembly operations, for tracking along complex curved surfaces, and for similar tasks.</p>

Some of the robots most commonly used as industrial robots are the articulated robots listed below.

Vertically articulated robots

Example: Vertically Articulated Robot RV-SQ/SD Series family of robots from Mitsubishi Electric

Robots referred to as simply articulated robots are usually this type of robot.

Their arm structures resemble the human arm, which makes them have the most reasonable form to use as substitutions for human beings.

Horizontally articulated robots

Example: Horizontally Articulated Robot RH-SQH/SDH Series family of robots from Mitsubishi Electric

Their arms move horizontally with the tip of the arm moving up and down along the sliding axis only. **They are also referred to as scalar robots.**

They have high rigidity in the vertical direction (with little rattling) but can be moved flexibly in the horizontal direction.

They are optimal for use in assembly operations such as insertion of parts or tightening of screws.

Operation/Programming

As shown above, there is a very wide variety of industrial robots available.
There is not enough space available here to describe every single type.

Below, an overview will be given on operation and programming for controlling robot configurations using Mitsubishi Electric industrial robots as examples.

- (a) Industrial robot configuration
- (b) Manual operation and operation by teaching pendant
- (c) Operation using programming

1.2

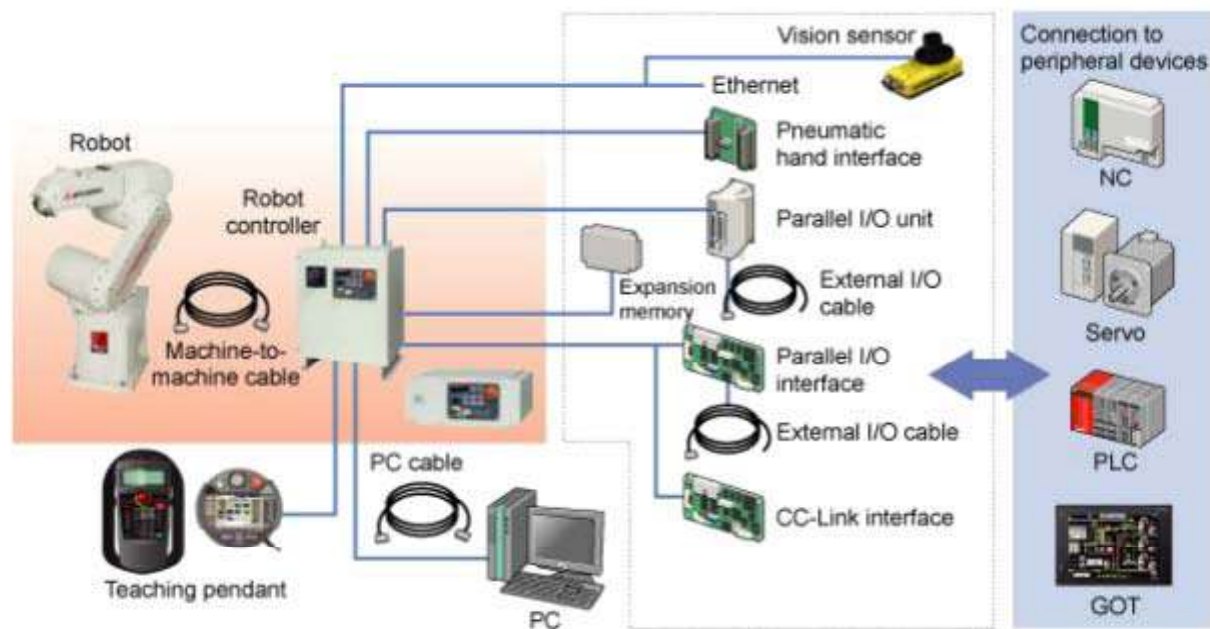
Types of and usage methods for industrial robots



Industrial robot configuration

The standard structure of an industrial robot is as shown below.

- (1) Robot body
- (2) Robot controller
- (3) Teaching pendant (A control pendant used to run a robot and teach it positions)
- (4) Machine-to-machine cable (A cable used to connect robots together)
- (5) Tools for operations (Hands, etc.)
- (6) Other
 - PC for completing programming/connection cable
 - Solenoid valves, air hoses, and other parts for moving hands, etc.
 - I/O cables, interfaces, etc. for linking robots to peripheral devices



1.2

Types of and usage methods for industrial robots



Manual operation and operation by teaching pendant

In general, teaching for robot operating points (positions, poses) is completed using a teaching pendant. The latest teaching pendant can be used to not only teach position but also to create new programs.

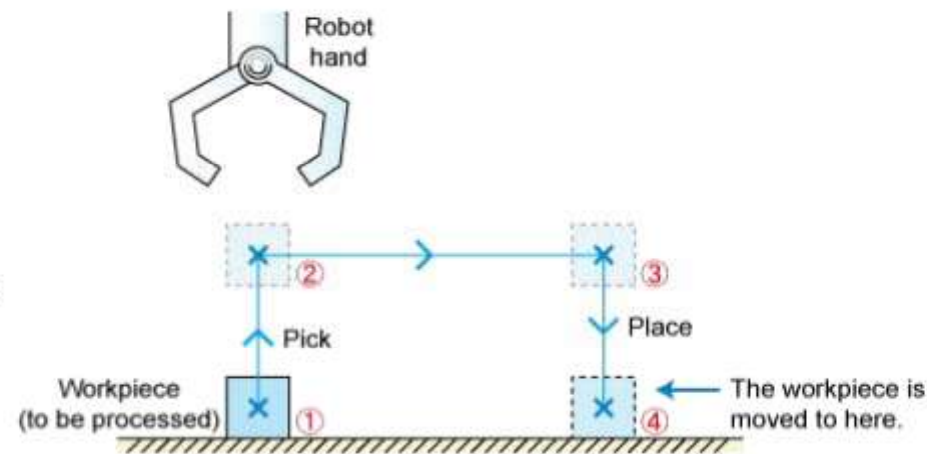
With operations performed using a teaching pendant, operators often approach the robot to complete the specified operations.

This is why teaching pendants are equipped with safety features for different models.

<Example with Pick & Place Operations>



Mitsubishi Electric Teaching Box
(Model name R32TB)



Procedures

- Teaching pendants are used to teach operating points in the correct order of operation. That is, teaching pendants are used to add/save points through manual operation (jog operation).
- They are used to set operating conditions (opening/closing of hands, operating speed, etc.) for each operating point.

1.2

Types of and usage methods for industrial robots



Operations based on robot language

Robot languages differ by robot manufacturer.

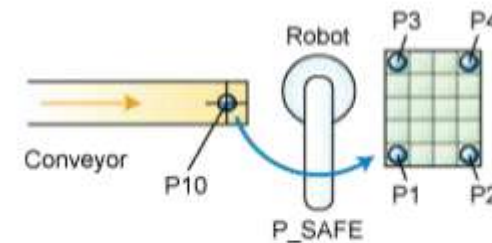
They may also differ by field of usage, model series, or other reason even within the same manufacturer.

In order to let participants imagine and get a better feel for robot languages, we will present examples of programming completed for palletizing operations using MELFA-BASIC, a robot language used by Mitsubishi Electric robots.

(Palletizing refers to a stacking operation in which workpieces from the conveyor are stacked together onto pallets according to specified standards.)

<Programming conditions>

- The stopping position for when workpieces come out from the conveyor is set to be P10.
- The input signal IN8 is to be input to the robot when a workpiece is at the stopping position.
- Robot operates are to start and stop at the safe point P_SAFE.
- The four corners of the pallet are to be designated P1, P2, P3, and P4.
- The length of approach to the workpiece attachment/detachment point is to be 50 mm (1.97 in.).
- The linear interpolation speed is to be 300 mm/s (11.8 in./s) and other operations are to move at the maximum speed.



1.2

Types of and usage methods for industrial robots



Number	Program	Comment
1	DEF PLT 1,P1,P2,P3,P4,4,5,1	The first row is the definition of a pallet, with Pallet 1 (PLT1) being made up of P1 to P4 over an area of 4x5 (20 different pallets). The last line is along the data index direction (direction in which the counter proceeds)
2	MOV P_SAFE	MOV refers to the joint interpolation operation.
3	SPD 300	The linear interpolation speed is 300 mm/s (11.8 in./s).
4	HOPEN 1	HOPEN1 and HCLOSE1 are open/close commands for Hand 1.
5	M1=1	The pallet counter settings are initialized.
6	*LOOP	Label settings (repeated positioning)
7	WAIT M_IN(8)=1	The system waits until Input Signal 8 is input.
8	MOV P10,-50	MOV P10, -50 moves the arm 50 mm (1.97 in.) to the front of P1.
9	MVS P10	MVS refers to the linear interpolation operation.
10	DLY 0.2	The timer is to be set to 0.2 s.
11	HCLOSE 1	
12	DLY 0.3	
13	MVS ,-50	MVS, -50 moves the arm 50 mm (1.97 in.) away from the current location.
14	P100=PLT 1,M1	M1 is used as the pallet counter.
15	MOV P100,-50	-50 and other numbers are used to move the arm in the Z-axis direction of the tool coordinates.
16	MVS P100	
17	DLY 0.2	DLY is the timer.
18	HOPEN 1	
19	DLY 0.3	
20	MVS ,-50	
21	M1=M1+1	The counter counts in incremental terms.
22	IF M1<=20 Then *LOOP	The operation is repeated if Counter' (the number of workpieces) is less than 20.
23	MOV P_SAFE	Once the operation is completed, the arm moves to the P_SAFE point.
24	END	

The types of operations that can be completed using industrial robots are determined by the type of machine tool attached to the end of the robot arm.

For example:

- Assembly robots that have a "gripping hand" attached (that resembles a human hand)
- Arc welding robots that have an arc welding torch attached
- Painting robots that have a painting gun attached
- Burr removal robots that have a grinder attached

As well as others.

There are different specialized application software programs and human-machine interfaces available and processing knowledge used depending on the type of operation, and there are currently different fields in established genres for each type of application. (Specialized operation robots)

The type of robot to select is determined according to the posture required for the specific operation in question, the operating range, the amount of weight to be moved by the robot, the operating environment, and other factors.

In general, the greater the number of axes, the more complex the posture can be.

Many horizontally articulated robots use 4-axial specifications and are commonly used in assembly and other operations that are oriented downward.

Many vertically articulated robots use 6-axial specifications and are used for more complex operations.

Below, a number of examples of practical applications for industrial robots will be given.

- (1) Palletizing Application
- (2) Dispensing Application
- (3) Visual Line Tracking Application
- (4) Machine Tending Application
- (5) Cleanroom Application

1.3**Examples of practical applications for Industrial robots****Palletizing Application**

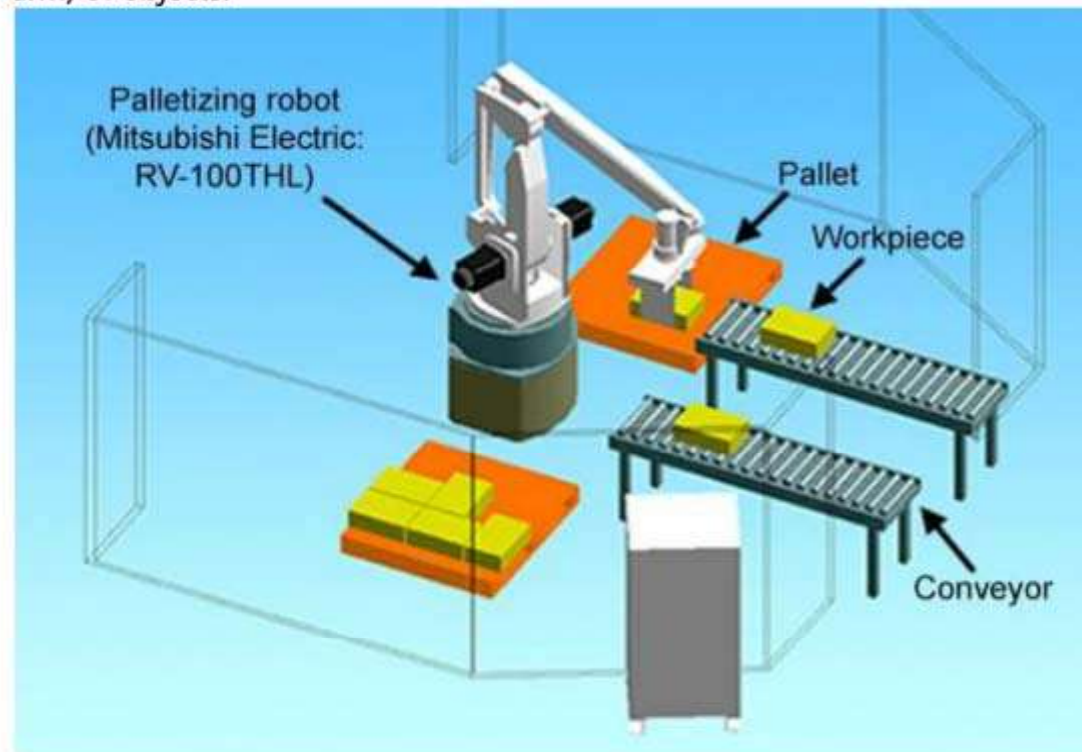
Palletizing operations are used mainly in delivery processes at factories and in warehouses.

Palletizing operations involve delivery and warehouse storage of objects that are stacked in groups onto pallets or into cases.

Stacking and delivery operations carried out by hand for a large number of products are extremely exhausting and very inefficient.

The use of a palletizing robot will allow operators to stack a large number of products by order onto pallets for easy moving in short amounts of time.

For example, Mitsubishi Electric's RV-100TH palletizing robot can be used to move up to 100 kg (or 200 lbs., including the arm) of objects.



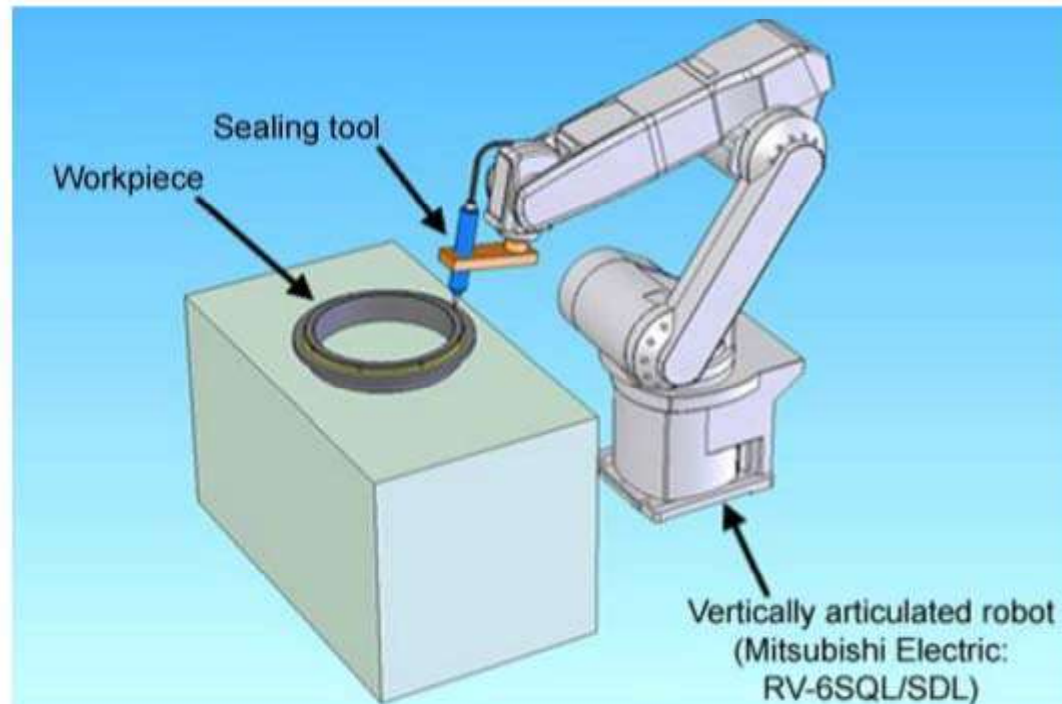
1.3**Examples of practical applications for Industrial robots****Dispensing Application**

Robots are equipped with painting heads attached to their ends and used for painting operations such as application of sealing material, packing material, wax material, and other materials.

Such materials must be applied to the sealing areas uniformly and continuously.

For this reason, sealing operation know-how must be included when the teaching program is written.

For example, such factors must be considered as the timing at which application is to be started or stopped and the securement of tracking accuracy.



1.3

Examples of practical applications for Industrial robots



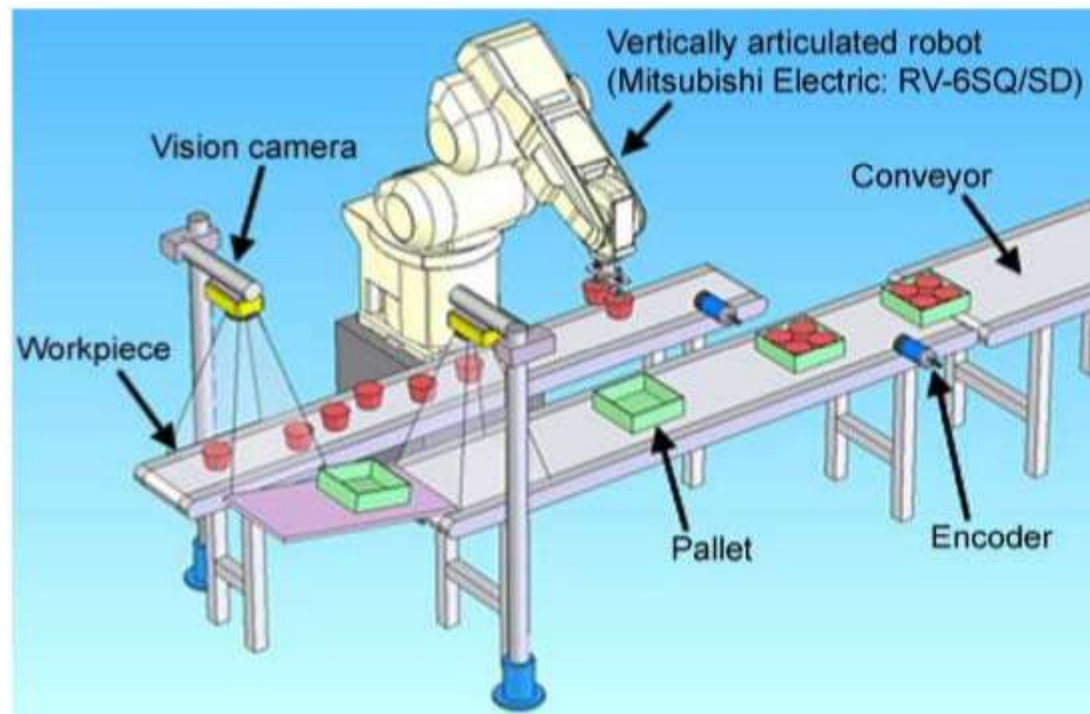
Visual Line Tracking Application

Tracking operations are operations in which workpieces traveling along a conveyor are removed without the conveyor having to be stopped.

Transport of products in the food product field generally need to be transported at short takt times, which is why tracking operations are often used in such applications as the conveyor can run without stopping.

Tracking operations can be used to direct the robot to follow the movement of the conveyor through input of pulse signals to the robot from an encoder installed in the conveyor.

A vision sensor is also used to track the inclination of workpieces on the conveyor and for random layouts.



1.3

Examples of practical applications for Industrial robots



Machine Tending Application

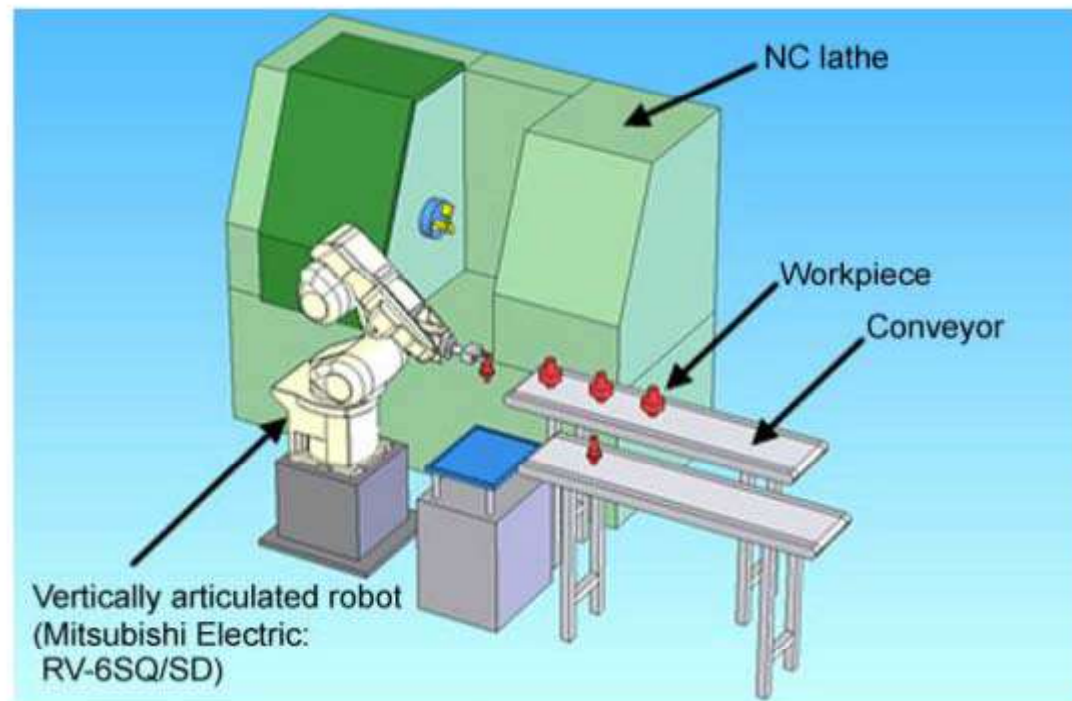
An unprocessed workpiece is attached to the workpiece chuck on a processing machine (NC lathe), and the processed workpiece is then removed after it is processed.

Unprocessed workpieces are transported along on a conveyor.

Processed workpieces are also transported along on a conveyor once they have been stacked onto a pallet.

Workpiece alignment and layout can be a complicated operation that uses a robot with a five- or six-axial degree of freedom.

In this type of application, the type of robot required has a structure that is built to withstand the dust (mist) generated during lathe processes.



1.3

Examples of practical applications for Industrial robots

Cleanroom Application

These robots are used in special areas called "cleanrooms" that require extremely clean environments for processes involving fabrication of semiconductor, liquid crystal, and other parts.

The type of robot used in this type of application is a cleanroom robot.

In simple terms, a clean robot is one equipped with measures to prevent dust from being discharged from the robot.

To produce this type of structure, AC servos are used for all servos, and sealing is applied around all rotating areas.

The dust that collects inside the robot is extracted to external using a vacuum device.

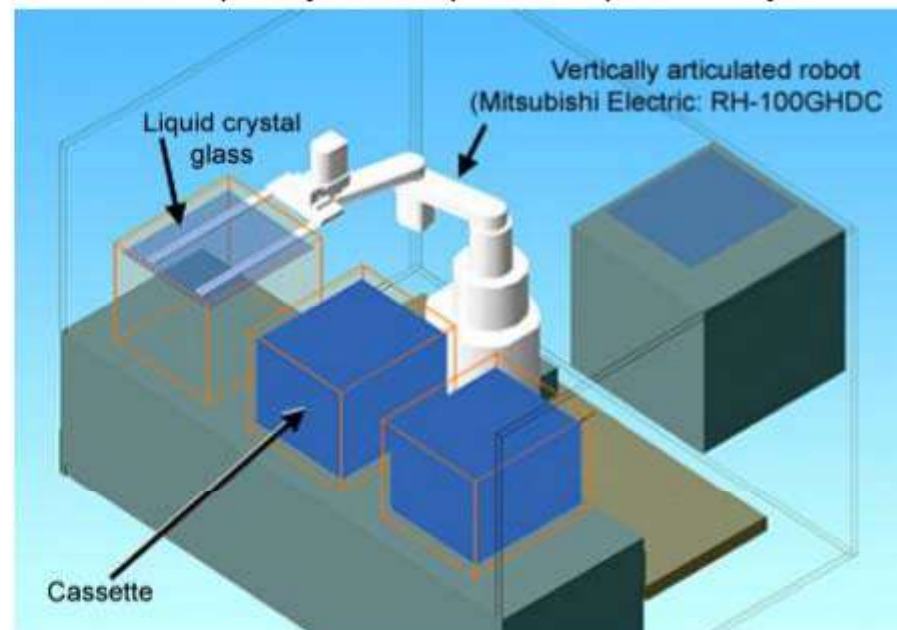
The cleanliness level inside a cleanroom is expressed in terms of "Cleanroom class."

For example, a Cleanroom Class of 10 ($0.3\ \mu\text{m}$) is used to denote a cleanliness level of less than 10 dust particles with a diameter of $0.3\ \mu\text{m}$ or above in a 1-ft. sq. area.

Semiconductor wafer sizes and liquid crystal glass sizes are becoming bigger and bigger as the fabrication technology becomes more advanced.

This is related to the increased demand for lowered costs due to the ability to obtain a large number of IC chips from a single semiconductor wafer and the increased demand for large liquid crystal panels.

For example, the RH-1000GHDC liquid crystal transport robot produced by Mitsubishi Electric can transport glass sheets 1 m by 1 m in size.



Now that you have completed all of the lessons of the FA Equipment for Beginners (Industrial Robots) Course, you are ready to take the final test. If you are unclear on any of the topics covered, please take this opportunity to review those topics.

There are a total of 8 questions (19 items) in this Final Test.

You can take the final test as many times as you like.

How to score the test

After selecting the answer, make sure to click the **Answer** button. Your answer will be lost if you proceed without clicking the Answer button. (Regarded as unanswered question.)

Score results

The number of correct answers, the number of questions, the percentage of correct answers, and the pass/fail result will appear on the score page.

Correct answers : 3

Total questions : 10

Percentage : 30%

To pass the test, you have to answer **60%** of the questions correct.

Proceed

Review

Retry

- Click the **Proceed** button to exit the test.
- Click the **Review** button to review the test. (Correct answer check)
- Click the **Retry** button to retake the test again.

What is an industrial robot ?

Fill in the blank in the explanation for the definition of an industrial robot with the appropriate terms.

An industrial robot is defined to be a programmable that can be controlled

and is in three or more .

Answer

Back

Advantages to using industrial robots

Select the correct statements regarding advantages to using robots. (More than one may be correct.)

- They can be used to improve productivity.
- They grant people freedom from simple operations.
- They can be used to raise product quality.
- They can be easily operated immediately even by beginners.

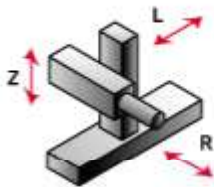
[Answer](#)[Back](#)

Test

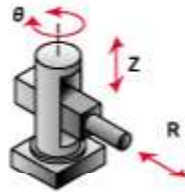
Final Test 3

Structural classifications of industrial robots

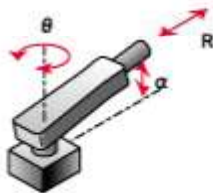
Select the type of industrial robot that corresponds to the structural diagram.



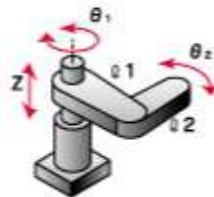
--Select--



--Select--



--Select--



--Select--

Answer

Back

General industrial robot models

Select the type of industrial robot that corresponds to each of the statements below.

A robot that advances to subsequent operating stages in sequential order according to information set in advance (sequences, conditions, position, etc.).

A robot that is taught operating sequences, conditions, rankings, and other information according to how the robot is moved by an operator and works to complete operations based on that information.

A robot that is taught operating sequences, conditions, rankings, and other information based on numerical, language, and other data and not according to how the robot is moved by an operator and works to complete operations based on that information.

Robot structure

Select the parts that correspond to devices making up a robot. (More than one may be correct.)

- Robot
- Robot controller
- Teaching pendant
- Machine-to-machine cable
- Hand
- Main axis mechanism
- Belt conveyer

[Answer](#)[Back](#)

Test

Final Test 6

Robot operating point (Positioning point)

Select the appropriate type of method used most commonly to teach robots operating points.

- Using a teaching pendant
- Using a PC
- Using a PLC

Answer

Back

Robot operation examples

Select the type of robot operation that corresponds to each of the statements below.

--Select--

Products are stacked onto pallets or inserted into cases. Used for product delivery and in warehouse storage.

--Select--

A painting application head is attached to the end of the robot arm and the workpiece is removed once the process is completed.

--Select--

The workpiece attached to the processing machine, and the workpiece is removed once the process is completed.

--Select--

The robot is used in transport and other operations in cleanrooms in processes for semiconductor fabrication, liquid crystal fabrication, and other part fabrication.

Answer

Back

Examples of practical applicaitons for robots

Select the correct feature for robots used in cleanrooms.

- In particular, they are designed to operate at high speed.
- They are equipped with countermeasures to prevent noise during operation in consideration of their surrounding environment.
- They are equipped with countermeasures to prevent dust from being discharged from the robot body.

Answer

Back

You have completed the Final Test. Your results are as follows.
To end the Final Test, proceed to the next page.

Correct answers : 0

Total questions : 8

Percentage : 0%

Proceed

Review

Retry

You failed the test.

You have completed the **FA Equipment for Beginners (industrial Robots)** Course.

Thank you for taking this course.

We hope you enjoyed the lessons and the information you acquired in this course will be useful in the future.

You can review the course as many times as you want.

Review

Close