UNIT 1

INTRODUCTION

SIA GROUP

PART-A
SHORT QUESTIONS WITH SOLUTIONS

Q1. What are the factors that increase the scope of robotics?

Answer :

The factors that increase the scope of robotics are given below,

1. Flexibility in the output or product obtained.
2. High product quality.
3. Human effort is reduced.
4. Least time consuming process.
5. Increasing demand for product quality and higher production rates.
6. Minimum wastage of products.

Q2. Distinguish between an automated machine and a robot.

Model Paper-I, Q1(a)

Answer :

Differences between an automated machine and a robot.

	Automated Machine		Robot
1.	Output can be obtained by following the working procedures on automated machine.	1.	Output can be obtained by programming. Various number of jobs are produced at different times using different procedures.
2.	During operation, the sequence of steps cannot be changed, as it is fixed according to given procedure.	2.	During operation, the sequence of steps can be reprogrammed or varied.
3.	It does not have sensors and feedback signals.	3.	With the help of sensing and feedback signals, desired output can be obtained.

Q3. Compare a robot with crane.

Answer :

Comparison of Robot and Crane

	Robot		Crane
1.	It is an automated machine which operates based on its programming.	1.	It does not have programming, but it is controlled by an operator.
2.	It varies from a small (single purpose) to large size (various purposes) and is portable.	2.	Cranes are usually installed at the site for specific applications and are less portable.
3.	It can be used for various purposes such as, welding, spray painting, etc.	3.	It is generally used for material handling purposes.
4.	A computer program controls the robot manipulator.	4.	An operator controls the actuators.
5.	A robot cannot judge by itself for various accidental conditions beyond its programming.	5.	An operator can judge and act accordingly in case of accidents and failures.

Q4. Give the comparison of CAD/CAM and robotics.

Model Paper-IV, Q1(a)

Answer :

	CAD/CAM		Robotics
1.	It is defined as the use of computer systems for planning, controlling and optimizing designing and manufacturing activities.	1.	It is defined as a science which deals with designing and manufacturing robots suitable for application in automated manufacturing system.
2.	The equipment used is heavier and less portable. Example : CNC machine.	2.	The equipment used is lighter and more portable. Example : Robotic arm.
3.	Machine tools are controlled by part programming.	3.	Robots are controlled by guiding, teach pendant, off-line or on-line programming.
4.	Less efficient system.	4.	Highly efficient system.
5.	Applications of CAD/CAM are computer integrated manufacturing NC machine tools, etc.	5.	Applications of robotics are Automated Guided Vehicles (AGV), gantry robot, free-standing robot, etc.

Q5. What are the functions of robot and write the advantages of robotics?

Answer :

Functions of Robot

The different functions of a robot are stated as,

(i) **Sensing**

A robot can sense the surrounding environment with the aid of sensors,

Vision, sound, touch, etc.

(ii) **Decision Making**

The signals received by the sensors helps in making decisions.

(iii) **Performance**

Based on decision making, it performs the task.

Advantages of Robotics

(i) Higher flexibility

(ii) Improved performance

(iii) Low cost of production.

Q6. Classify different types of robots.

Model Paper-III, Q1(d)

Answer :

Classification of Robots

Robots are classified into different groups. They are listed below,

(i) **Standard Classification**

(a) Mechanical configuration based robots

(b) Control method based robots.

(ii) **Broad Classification**

(a) Programmable or reprogrammable general purpose robots

(b) Tele-operated or man controlled robots

(c) Intelligent robots.

(iii) **General Classification**

(a) Special purpose robots

(b) General purpose robots.

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Q7. What is the role of an industrial robot in automation?

Model Paper-II, Q1(c)

Answer :

Role of Industrial Robot in Automation

"Industrial robot is defined as a reprogrammable multifunctional manipulator designed to perform various tasks through programmable controls".

Automated manufacturing means an integration of computer control system with the manufacturing unit.

Industrial robot plays a significant role in automated manufacturing, to perform different kinds of applications such as, material transfer or handling, assembly operations, inspection, etc. The industrial robots are important in automated manufacturing due to the following advantages,

(i) Reduced production cost

(ii) Improved productivity

(iii) Better quality and quantity of production

(iv) More safety and less effect of hazardous tasks.

Q8. State the advantages and disadvantages of robots.

Answer :

Advantages

1. A robot can perform tasks even in unfavourable conditions
2. Precise or consistent manufacturing is possible
3. Accurate results can be obtained
4. High product quality and efficiency
5. It can transport heavy products or components from one place to other.

Disadvantages

1. High installation cost
2. Lack of response during emergency cases.

PART-B

ESSAY QUESTIONS WITH SOLUTIONS

1.1 AUTOMATION AND ROBOTICS, CAD/CAM AND ROBOTICS – AN OVERVIEW OF ROBOTICS, PRESENT AND FUTURE APPLICATIONS, CLASSIFICATION BY COORDINATE SYSTEM AND CONTROL SYSTEM

Q9. Define robotics and discuss the history of robotics.

Answer : Model Paper-IV, Q4(b)

Robotics

The science that deals with the design and construction of robot used in different applications in an automated manufacturing and other industries, is called robotics.

History of Robotics

In 1958, a subsidiary of Condec. corporation made a licensed agreement of industrial robot with devol. Later in 1959, the planet corporation presented pick-and-place robot. In 1961, the Unimation Inc. introduced first industrial robot. INTEL introduced microprocessor technology in 1963 and different robots were developed by AMF-Versatran.

During 1969, an automobile motor company installed the robot for spot welding operation, for the first time. The first computer controlled robot in 1974 was introduced by Cincinnati Milacron T^3. Then, in the period of 1983-84, many developments had made in robotics such as, 6-axes multipurpose robot, microprocessor based pick-and-place robot, the first man carrying computer controlled walking machine, two-legged walking machine, etc.

The four robot generations are grouped based on the robot capabilities. They are.

1st generation (Since 1960's)	These are repeating, non-servo, pick-and-place and point-to-point type robots. Their service life is longer and 80% of present robots used by industries are 1st generation type.
2nd generation (Since 1980's)	They possess path-control capabilities.
3rd generation (Since 1990's)	High-speed processing robots. They are self-learning, decision making and have artificial intelligence, vision, etc.
4th generation (Since 2000's)	This group comprises of a true android or an artificial biological robot or super humanoid robot.

Q10. What are the Laws of robotics? What are the Thumb Rules on the decision of a robot usage?

[May/June-14, Set-3, Q1(a) | Model Paper-II, Q4(a)]

Answer :

Laws of Robotics

The three laws proposed by Issac Asimov on Robots are,

(i) **First Law**

A robot should not cause any harm to a human operator or should not by negligence, allow one to be harmed.

(ii) **Second Law**

A robot must execute the instructions given by an operator, unless it disagrees with first law.

(iii) **Third Law**

A robot must protect its own existence, unless that disagrees with the first and second laws.

Thumb Rules

The thumb rules on the decision of robot usage are as follows,

1. It must be well known with four D's i.e., dirty, dull, difficult or dangerous. The robots should be used in place of human, where they are not efficient to perform the job.
2. The use of robots should not make the human jobless.
3. It must be used, based on short-term and long-term economic aspects.
4. The robots should not be used unnecessarily, instead of human.

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Q11. What is automation? Explain different types of automation.

[Nov.-11, Set-3, Q1(a) | Model Paper-I, Q4(a)]

Answer :

Automation

Automation is defined as the technology related to the application of mechanical, electronic and computer based systems to control and operate the production.

Types of Automation

Automation is categorized into three types. They are,

(i) Fixed automation

(ii) Programmable automation

(iii) Flexible automation.

(i) Fixed Automation

It is the automation, in which the sequence of processing or assembly operations to be carried out are fixed by the equipment configuration. In fixed automation, a single set of sequence of operations are integrated in an equipment. Therefore, it is difficult to automate changes in the design of the product.

It is used where high volume of production is required. Production rate of fixed automation is high. In this automation, no new or modified products are processed for a given sequence of assembly operations.

(ii) Programmable Automation

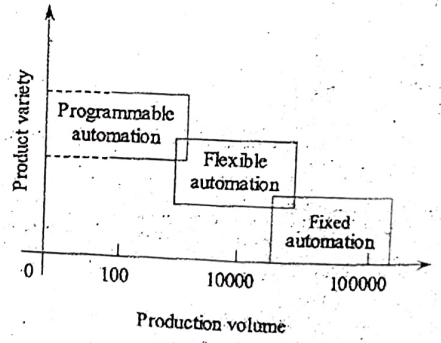
It is the automation, in which the equipment is designed to accommodate various product configurations in order to change the sequence of operations or assembly operations, by means of control program. Different types of programs can be loaded into the equipment to produce products with new or modified configurations.

It is employed for batch production of low and medium volumes. For each new batch of different products, a new control program corresponding to the new product is loaded into the equipment. This automation is relatively economic for small size batch production.

(iii) Flexible Automation

A computer integrated manufacturing system which is an extension of programmable automation is referred as flexible automation. It is developed to minimize the time loss between the change over of the batch production from one product to another. The program for new products and changing the sequential steps, enable production of different products with no loss of time.

This automation is more flexible in interconnecting work stations with material handling and storage systems. A central computer is necessary to route the various components of appropriate workstations, in order to control the different processing activities or operations in the system. It is used for medium production rate and for a continuous production of various products with flexibility. The relation between the three automations as a function of production volume and product variety is plotted in the graph below.



Graph

Q12. Differentiate between fixed and flexible automation.

Answer : [Nov.-11, Set-2, Q1(c) | Model Paper-III, Q2(a)]

The differences between fixed automation and flexible automation are as follows,

	Fixed Automation		Flexible Automation
1.	It is defined as, the automation in which the sequence of processing or assembly operations to be carried out are fixed by the equipment configuration.	1.	It is defined as a computer integrated manufacturing system, which is an extension of programmable automation.
2.	In this, a fixed sequence of simple operations are integrated in an equipment.	2.	In this, different types of programs can be loaded into the equipment to produce products with new or modified configurations and with no loss of time.
3.	It is used for high volume production.	3.	It is used for batch production of medium volume.
4.	No new products are processed for a given sequence of assembly operations.	4.	The production of new products is possible.
5.	It is not flexible to accommodate changes in the design of the product.	5.	It is flexible to accommodate variations in the design of the product.
6.	If product life cycle completes, the equipment becomes obsolete.	6.	A continuous production of various products can be processed on the equipment.
7.	Production rate is high.	7.	Production rate is moderate.
8.	The cost of unit is low.	8.	The cost of unit is high.

Q13. Compare programmable automation with flexible automation.

Answer :

Differences between Programmable Automation and Flexible Automation

	Programmable Automation		Flexible Automation
1.	It is defined as, the automation in which the equipment is designed to accommodate various product configurations, in order to change the sequence of operations by means of control program.	1.	It is defined as a computer integrated manufacturing system which is an extension of programmable automation.
2.	In this, different types of programs can be loaded into the equipment to produce products with new configurations.	2.	In this, also different types of programs can be loaded into the equipment to produce products with new configurations and with no loss of time.
3.	It is used for batch production of low and medium volumes.	3.	It is used for batch production of medium volume.
4.	The production of new products requires a long setup time.	4.	The production of new products requires a short setup time.
5.	The products are produced in batches and after completion of one batch, the equipment is reprogrammed and re-setup for next batch.	5.	A continuous production of various products can be processed on the equipment with less setup time.
6.	Its production rate is low.	6.	Its production rate is moderate.
7.	The cost of unit is high, compared to fixed automation.	7.	The cost of unit is high, compared to programmable automation.

Q14. Discuss the reasons for implementation of automated systems in manufacturing industries.

Answer :

Automation is defined as the technology, in which the operations involved in a process are carried out by automated means such as, open or automatic closed loop control systems.

In automation, different electronic, mechanical and computer based systems are used to operate and control the production. Thus, in automation, manual operation of controls is replaced by programmed or automatic control systems.

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Reasons for Implementation of Automated System

The reasons for the implementation of automated systems in manufacturing industries are as follows,

1. **To Increase the Productivity Rate of Labour**
   Implementation of the automation in manufacturing operations, increases the rate of production and labour productivity. Thus, the use of automation results in very high output per hour for a given labour input.
2. **To Decrease the Cost of Labour**
   Though the automated machines are very expensive, they are economically feasible compared to the increasing labour costs. As the automated machines are more efficient and accurate, it is possible to obtain higher rates of output in a less cost per unit of product. Therefore, manufacturing industries use automation technology.
3. **To Minimize the Effect of Shortage of Labour**
   In some situations, the required number of labour may not be available to work at remote areas of the process. This shortage of labour affects the production rates of the industry. As the automated machines function at remote areas without the need of manual control, automation is implemented in industries. Thus, automation overcomes the effect of labour shortages.
4. **To Obtain High Quality of Products**
   All the equipment used in an automated system are operated and controlled by the programs in which the desired specifications are defined. Hence, the operations of the programmed control systems produce the products of specified quality at faster rates with high consistency.
5. **High Cost is Avoided**
   A non-automated company suffers a lot of disadvantages in various aspects. It requires more number of labour, the time taken for production is high and also the productivity rate is low.
   In this competitive world, the automation offers the advantage of obtaining high quality products, which increase the sales, enhance profits and improves labour co-ordination.
6. **To Decrease the Manufacturing Lead Time**
   An automated manufacturing system provides a benefit for the manufacturer to deliver the order of a customer within a less period of time and have an advantage for future orders, by saving the time and work period.
7. **To Upgrade the Safety of Workers**
   Automation provides safety for workers. As the worker plays a supervisory role rather than performing the operations directly in the field, the work becomes safer and hence, safety of worker is increased.

Q15. Explain the use of computers in industrial manufacturing.

Answer :

In industrial manufacturing, the computers are used because of their powerful multi-functional capabilities. The use of computers in industrial manufacturing is mainly classified into three groups. They are,

(i) Pre-processing support applications
(ii) Monitoring and control
(iii) Post processing support.

(i) Pre-processing Support Applications

This group includes all the support functions, for the efficient and economical manufacturing of a product. The computer provides the support functions as,

(a) Computer aided design and drafting.
(b) Finite element analysis.
(c) Computer aided part programming, process planning, scheduling, tool design and material requirement planning.

A skilled operator is required to perform the various actions, such as, to enter the input to the computer and to interpret the computer output for the system. A computer supports the manufacturing process to enable the functions such as part programming, process planning, production scheduling, instructions and information for the manufacturing system.

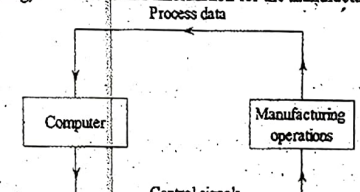


Figure: Pre-processing Support Applications of the Manufacturing System

(ii) Monitoring and Control

In this, the computers are used as direct interface with the manufacturing process for the purpose of monitoring and controlling. The monitoring system implies a direct interface of the computer with the manufacturing process. Monitoring is employed for observing and collecting data from the process. Controlling is employed for control of process based on monitoring.

The software which contains control algorithms delivers command signals to the manufacturing process with the help of computer, to control the manufacturing process.

(iii) Post Processing Support

This contains all the support functions that allow computers to deliver quality product to the market (or) customers. This process consists of computer-aided assembly, inspection, quality control, cost analysis, packing, labelling, analysis of market feedbacks, and billing.

In industrial manufacturing, the computers are used as a logical technique to be performed in the entire process of product development and manufacture. To perform the process with the aid of computers, the technologies such as CAD, CAM, computer integrated manufacturing, etc are required. The use of computer in industrial manufacturing increases accuracy of the product and reduces the operating cost and time, wastage of material, effort of human skills, etc.

Q16. Write a note on overview of robotics.

Answer :

"Robotics" is defined as the "science of designing and building robots which are suitable for real life applications in automated manufacturing and other non-manufacturing environments". It has the following objectives,

1. To increase productivity
2. Reduce lead time
3. Minimize labour requirement
4. Enhance quality of the products
5. Minimize loss of man hours, on account of accidents.
6. Ensure reliable and high speed production.

The commonly used robots are classified as,

1. Programmable or re-programmable robots
2. Tele-operated or man controlled robots
3. Intelligent robots.

Robots are used in manufacturing and assembly units for performing operations like,

1. Spot or arc welding
2. Parts assembling
3. Spray painting
4. Material handling
5. Loading and unloading.

The feature and capabilities of the robots are,

1. Intelligence
2. Sensor capabilities
3. Telepresence
4. Mechanical design
5. Mobility and navigation
6. Universal gripper
7. System integration and networking

Q17. Write the main characteristics of robot application in industry.

[May/June-14, Set-2, Q1(b) | Model Paper-II, Q0(b)]

Answer :

Characteristics of work which promote the application of a robot are,

(I) Uncomfortable or Hazardous Working Conditions

In many industries, human operators or workers have to work in uncomfortable or hazardous environment. These hazards include physical dangers, health hazards such as intense heat, radiation, sparks toxicity and use of carcinogenic materials. However, working in places which are not really hazardous but are uncomfortable, unpleasant and undesirable by humans also imparts a high probability of robot application. Some of the applications, based on this factor include spot welding, arc welding, die casting and spray painting.

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(ii) Repetitive Work

Work that has to be performed frequently is known as repetitive work, which is very common in high and medium volume production. Workers performing this kind of operations find it monotonous and degrading. Industrial robots with the capability of repeating a fixed motion without any deviation are ideally suited to such working conditions. Applications include spot arc, pick and place operations, machine loading, unloading and spot welding.

(iii) Handling Difficult Jobs

Another criteria that requires the application of a robot is the operation of handling of difficult-to-hold objects. These objects are difficult to handle, because of their hotness, weight or an irregular shape. Therefore, a robot with sufficient capabilities and appropriate end effector must be used for handling difficult objects.

(iv) Shift Wise Operation

To meet the demand, many manufacturing firms run two to three working shifts. Some processes require very high level continuous operations. Therefore, accomplishing of these process using human workers leads to a higher variable cost. It can be reduced by the substitution of robots, which leads to higher fixed cost and relatively low variable cost. This leads to reduction in total operating costs, since, higher fixed cost can be distributed over the number of shifts.

Q18. What are the important aspects to be considered in deciding the use of robots in,

(i) Manufacturing operation

(ii) Hazardous operation.

Answer :

(i) Manufacturing Operations

The most important aspect to be considered for the use of robots is the knowledge and amount of skill required to accomplish the job.

The following are the considerations in deciding the use of robots in manufacturing process,

1. The use of robots maintains constant speed and quality throughout the production process.
2. A robot neither gets sick nor it needs rest, which works continuously throughout a year and hence, rate of production increases.
3. Robots can be used in various fields of manufacturing process as follows,

   (a) **Loading or Unloading Components**

   - To load and unload parts to or from CNC machine tool.
   - To load components in electron and laser beam welding.
   - To load or unload parts in die casting machine.

   (b) **Welding Operation**

   - It is used for spot welding.
   - It can also be used for arc welding process.
   - Seam welding of variable width.

   (c) **Machining Operation**

   - Robots are used in drilling operation.
   - It is also used for deburring and sanding processes.
   - Other processes include grinding, cutting, forming, etc.

   (d) **Spray Painting**

   - Robots are effectively used in painting of automobiles, especially trucks
   - It can be used for painting of agricultural equipment.
   - Painting of appliance components.

(ii) **Hazardous Operation**

In hazardous environments, robots are very commonly used in order to avoid any type of danger to human life. Some of the hazardous environments, which necessitates the use of robots are as follows,

(a) **Nuclear Operations**

Robots are especially used in nuclear power plants for the maintenance of atomic reactors, which are extremely hazardous to human life.

(b) **Mining Operations**

With the use of robots in mining operations, the human operators are prevented from exposure to dangerous materials, such as, radio active materials.

(c) **Undersea Operations**

Specially designed robots can perform various undersea operations such, as oil or mineral exploration, salvage operations, etc. They can function even in the deepest sea for longer periods, which is highly hazardous for human beings.

(d) **Municipal Services**

Robots are widely used in municipal services, such as, fire fighting, Cleaning of underground locations which are filled with dangerous gases and sewer cleaning.

Q19. Write the present and future applications of robots used in industries.

Answer :

[May/June-14, Set-2, Q1(a) | Model Paper-I, Q5(a)]

Applications of Robots

Present Applications of Robots

Presently robots are being used in the following applications,

(i) Material transfer applications

(ii) Machine loading and unloading

(iii) Processing operations like,

(a) Spot welding

(b) Continuous arc welding

(c) Spray coating

(d) Drilling, reaming and lapping

(e) Grinding, polishing, deburring and wire brushing

(f) Riveting

(g) Laser drilling and cutting, etc.

(iv) Assembly tasks or parts mating.

(v) Inspection and automation.

Future Applications of Robots

The future applications of robots includes the following,

(i) Intelligence

(ii) Sensor capabilities

(iii) Telepresence

(iv) Mobility and navigation

(v) Universal gripper

(vi) System integration and networking

(vii) FMS (Flexible Manufacturing Systems)

(viii) Hazardous and inaccessible non-manufacturing environments

(ix) Underground coal mining

(x) Fire fighting operations

(xi) Robots in space

(xii) Security control

(xiii) Garbage collection and waste disposal operations

(xiv) Household robots

(xv) Medical care and hospital duties, etc.

Q20. Classify robots based on the coordinate system and control system with neat diagrams.

[May/June-14, Set-4, Q1(c) | Model Paper-IV, Q2(c)]

Answer :

Classification of Robots based on Coordinate System

They are divided into four types,

(i) **Cartesian Coordinate Configuration**

It is also called rectangular coordinate configuration or gantry robot, whose axes are perpendicular to each other. The manipulator links move only in linear direction, whereas, the robotic arms are prismatic. It is again sub-divided into cantilevered cartesian and gantry-style cartesian. Cantilevered type are less rigid and can extend from the fixed support upto a limited area. These are accurate and easy to program. Gantry type are used to move excessive loads very accurately and are more rigid.

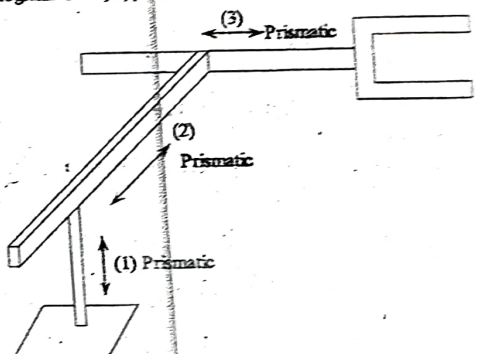


Figure: Cartesian Configuration

2. **Cylindrical Configuration**

It consists of a vertical column and a robot arm which traverses over the column and also, has radial motion with respect to the column.

The arm cannot rotate fully i.e., 360°. It can be extended upto certain limits, as per the requirements. Thus, the work envelope is a portion of cylinder.

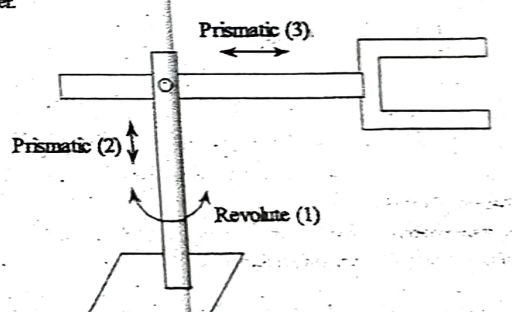


Figure: Cylindrical Configuration

3. Spherical or Polar Configuration

It consists a telescopic arm, which is pin jointed about horizontal axis and rotates about vertical axis. The work envelope of this robot is sphere.

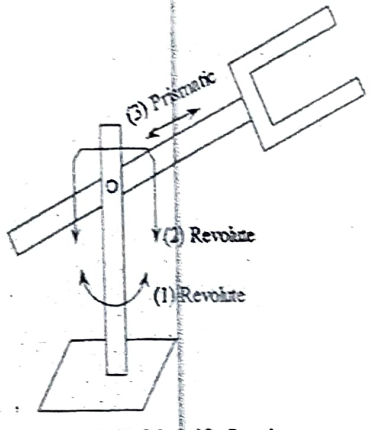


Figure: Spherical Configuration

4. Jointed Arm Configuration (Revolute)

It is similar to a human arm and comprises of number of links and joints, which are referred to as shoulder, arm and wrist joints. These are sub-divided into three types,

(a) Pure spherical

(b) Parallelogram spherical

(c) Cylindrical.

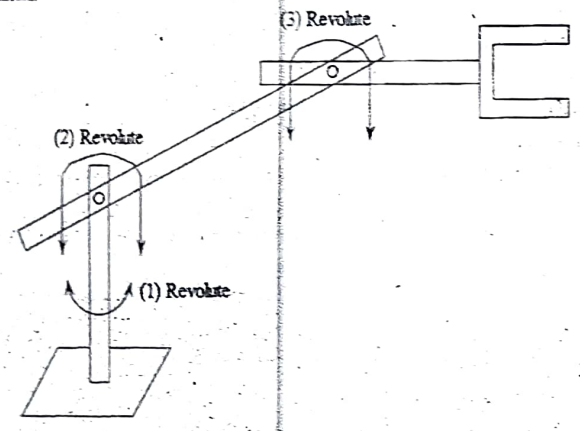


Figure: Jointed Arm Configuration

Classification of Robots Based on Control Systems

Based on control systems, the robots are divided into

(i) Non-servo control

(ii) Servo control

(a) Point-to-point control

(b) Continuous path control.

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(i) Non-servo Control

The arm of these robots follow open loop sequence between end positions with pre-determined trajectories. It is shown in the figure below,

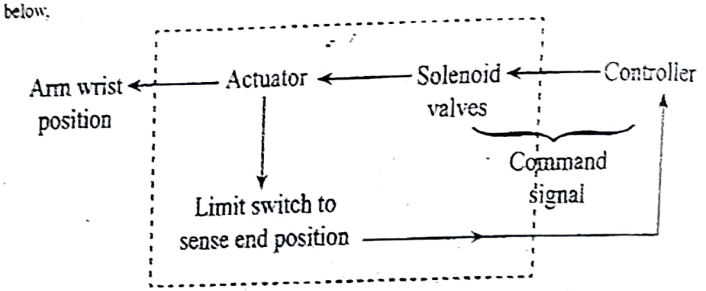


Figure: Non-servo Controlled Robot

(ii) Servo Control

These robots have feedback signalling devices on joints, with which position of axis can be measured. They have good manipulation ability and in these robots, end effectors can be placed at desired locations within the boundary of work envelope.

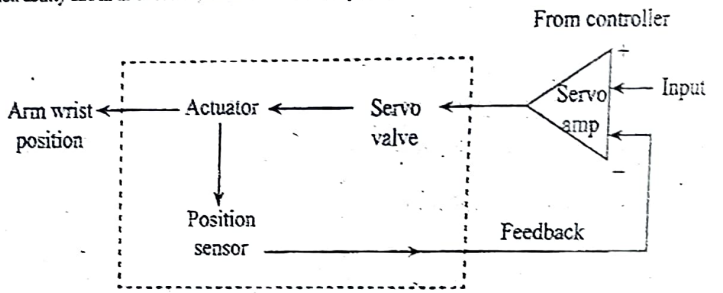


Figure: Servo-controlled Robot

(a) Point-to-Point Control

In this, each joint is moved separately, till the required location of end effector is achieved. This motion of each joint is to be fed and stored in memory device, so that, each joint moves at maximum rate to attain desired position. This system is controlled by sequential joint operation, uncoordianted joint control and terminally coordinated joint control.

Examples: Spot welding, pick and place, loading and unloading, etc.

(b) Continuous Path Control

In this, each joint is moved in a continuous path, which is obtained by interpolating the control variables of the joint. Thus, all the joints are moved in the continuous path, by interpolating their respective control variables, to obtain final position of end effector. The basic techniques of continuous path control are servo control approach, preview control or feed forward control and path planning or trajectory calculation approach.

Examples: Spray painting, arc welding, etc.

Q21. What are special purpose robots? Explain any of them.

Answer : Model Paper-II, Q(5)

Special purpose robots are designed based on requirements of the user and are built as per the specifications provided. Manufacturing of these robots consumes more time and involves high cost. Some of the special purpose robots are.

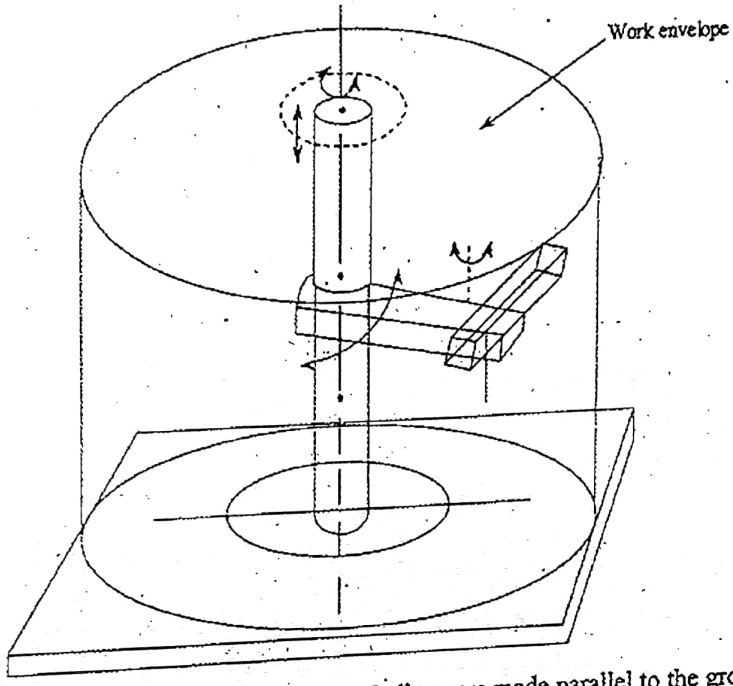
(i) SCARA (Selective Compliance Assembly Robot Arm) type robot.

(ii) Six-axes puma manipulator.

(iii) Automated guided vehicles, etc.

SCARA Type of Robot

It is a jointed-arm configuration type robot. The term SCARA refers to Selective Compliance Assembly Robot Arm. The special feature 'selective compliance' is effectively used in assembling, such as to insert the objects into holes. Even though, it is stiff in vertical direction, lateral compliance exables it to insert the object into holes.



It has four degrees of freedom, in which its shoulder and elbow are made parallel to the ground, whose rotational axes are perpendicular to the ground.

Some of the applications of special purpose robots are welding, painting, assembling, material transfer, casting, etc.

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