Internal Assessment Test 1 – Sept. 2018

Solutions key

Sub:	Automation & Robotics					Sub Code:	15ME563	Branch:	Mech
Date:	11.09.18	Duration:	90 min's	Max Marks:	50	Sem / Sec:	V/A&B		OBE

1.	**Types of Automation** Automated manufacturing systems can be classified into three basic types. 1. Fixed automation 2. Programmable automation 3. Flexible automation ***Fixed automation*** is a system in which the sequence of processing (or assembly) operations is fixed by the equipment configuration. Each of the operations in the sequence is usually simple, involving perhaps a plain linear or rotational motion or an uncomplicated combination of the two; for example, the feeding of a rotating spindle. It is the integration and coordination of many such operations into one piece of equipment that makes the system complex. Typical features of fixed automation are: • high initial investment for custom-engineered equipment • high production rates • relatively inflexible in accommodating product variety The economic justification for fixed automation is found in products *that* are produced in very large quantities and at high production rates. The high initial cost of the equipment can be spread over a very large number of units, thus making the unit cost attractive compared with alternative methods of production. Examples of fixed automation include machining transfer lines and automated assembly machines. In ***programmable automation***. the production equipment is designed with the capability to change the sequence of operations to accommodate different product configuration. The operation sequence is controlled by a *program,* which is a set of instructions coded so that they can be read and interpreted by the system. New programs can be prepared and entered into the equipment to produce new products. Some of the features that characterize programmable automation include • high investment in general purpose equipment • lower production rates than fixed automation • flexibility to deal with variations and changes in product configuration • most suitable for batch production Programmable automated production systems are used in low- and medium-volume production. The parts or products are typically made in batches. To produce each new batch of a different product. The system must be reprogrammed with the set of machine instructions that correspond to the new product. The physical setup of the machine must also be changed. Tools must be loaded. Fixtures must be attached to the machine table and the required machine settings must be entered. This changeover procedure takes time. Consequently, the typical cycle for a given product includes a period during which the setup and reprogramming takes place, followed by a period in which the hatch is produced. Examples of programmable automation include numerically controlled (NC) machine tools, industrial robots, and programmable logic controllers. ***Flexible Automation*** is an extension of programmable automation. A flexible automated system is capable of producing a variety of parts (or products) with virtually no time lost for changeovers from one part style to the next. There is no lost production time while reprogramming the system and altering the physical setup (tooting, fixtures, machine settings). Consequently, the system can produce various combinations and schedules of parts or products instead of requiring that they be made in batches.
2	***1. Specialization of operations*** The first strategy involves the use of special-purpose equipment designed to perform one operation with the greatest possible efficiency. This is analogous to the concept of labor

specialization, which is employed to improve labor productivity.

2. ***Combined operations***

Production occurs as a sequence of operations. Complex parts may require dozens, or even hundreds, of processing steps. The strategy of combined operations involves reducing the number of distinct production machines or workstations through which the part must be routed. This is accomplished by performing more than one operation at a given machine, thereby reducing the number of separate machines needed. Since each machine typically involves a setup, setup time can usually be saved as a consequence of this strategy. Material handling effort and non operation time are also reduced. Manufacturing lead time is reduced for better customer service.

3. ***Simultaneous operations***

A logical extension of the combined operations strategy is to simultaneously perform the operations that are combined at one workstation. In effect, two or more processing (or assembly) operations are being performed simultaneously on the same work part thus reducing total processing time.

4. ***Integration of operations***

Another strategy is to link several workstations together into a single integrated mechanism, using automated work handling devices to transfer parts between stations. In effect, this reduces the number of separate machines through which the product must be scheduled with more than one workstation. Several parts can be processed simultaneously, thereby increasing the overall output of the system.

5. ***Increased flexibility***

This strategy attempts to achieve maximum utilization of equipment for job shop and medium-volume situations by using the same equipment for a variety of parts or products, It involves the use of the flexible automation concepts. Prime objectives are to reduce setup time and programming time for the production machine. This normally translates into lower manufacturing lead time and less work-in-process.

6. ***Improved material handling and storage***

A great opportunity for reducing nonproductive lime exists in the use of automated material handling and storage systems. Typical benefits include reduced work-in-process and shorter manufacturing lead times.

7. ***Online inspection***

Inspection for quality of work is traditionally performed after the process is completed. This means that any poor-quality product has already been produced by the time it is inspected. Incorporating inspection into the manufacturing process permits corrections to the process as the product is being made. This reduces scrap and brings the overall quality of the product closer to the nominal specifications intended by the designer.

8. ***Process control and optimization***

This includes a wide range of control schemes intended to operate the individual processes and associated equipment more efficiently. By this strategy, the individual process times can be reduced and product quality improved.

9. ***Plant operations control***

Whereas the previous strategy was concerned with the control of the individual manufacturing *process*, this strategy is concerned with control at the plant level. It attempts to manage and coordinate the aggregate operations in the plant more efficiently. Its implementation usually involves a high level

	of computer networking within the factory. ***10. Computer Integrated Manufacturing*** Taking the previous strategy one level higher, we have the integration of factory operations with engineering design and the business functions of the firm, CIM involves extensive use of computer applications, computer data bases, and computer networking throughout the enterprise.
3.	*A flexible manufacturing system* (FMS) is a highly automated OT machine cell consisting of a group of processing workstations (usually CNC machine tools), interconnected by an automated material handling and storage system, and controlled by a distributed computer system. **Materials Handling System of FMS** *Functions of the Handling System.* The material handling and storage system in an FMS performs the fol1owing functions: • ***Random, independent movement of work parts between stations.*** This means that parts must be capable of moving from anyone machine in the system *to* any *other* rnachine to provide various routing alternatives for the different parts and to make machine substitutions when certain stations are busy. •***Handle a variety of workpart configurations.*** For prismatic parts, this is usually accomplished by using modular pallet fixtures in the handling system. The fixture is 10 cated on the top face of the pallet and is designed to accommodate different part configurations by means of common components, quick-change features, and other devices that permit a rapid build-up of the fixture for a given part. The base of the pallet is designed for the material handling system. For rotational parts, industrial robots are often used to load and unload the turning machines and to move parts between stations. • ***Temporary storage***. The number of parts in the FMS will typically exceed the number of parts actually being processed at any moment. Thus, each station has a small queue of parts waiting to be processed which helps to increase machine utilization. **• *Convenient access to loading and unloading work part.*** The handling system must include locations for load/unload stations. • ***Compatible with computer control.*** The handling system must be capable of being controlled directly by the computer system to direct it to the various workstations, load/unload stations, and storage areas. *Material Handling Equipment.* The types of material handling systems used to transfer parts between stations in an FMS include a variety of conventional material transport equipment The material handling function in an FMS is often shared between two systems: (1) a primary handling system and (2) a secondary handling system. The ***prima**ry handling system* establishes the basic layout of the FMS and is responsible for moving work parts between stations in the system. The *secondary handling system* consists of transfer devices, automatic pallet changers and similar mechanisms located at the workstations in the FMS. The function of the secondary handling system is to transfer work from the primary system to the machine tool or other processing station and to position the parts with sufficient accuracy and repeatability to perform the processing or assembly operation. Other purposes served by the secondary handling system include: (1) reorientation of the work part if necessary to present the surface that is to be processed and (2) buffer storage of parts to minimize work change time and maximize station utilization. In some FMS installations, the positioning and registration requirements at the individual workstations are satisfied by the primary work handling system. In these cases, the secondary handling system is not included.

4.

In the *in-line layout,* the machines and handling system are arranged in a straight line. In its simplest form, the parts progress from one workstation to the next in a well-defined sequence, with work always moving in one direction and no back flow. The operation of this type of system is similar to a transfer line.

In the *loop layout*, the workstations are organized in a loop that is served by a part handling system in the same shape, as shown in Figure 16.8(a). Parts usually flow in one direction around the loop, with the capability to stop and be transferred to any station. A secondary handling system is shown at each workstation to permit parts to move without obstruction round the loop. The load/unload stations are typically located at one end of the loop.

The ladder layout consists of a loop with rungs between the straight sections of the loop, on which workstations are located, as shown in Figure 16.9.The rungs increase the possible ways of getting from one machine to the next, and obviate the need for a secondary handling system. This reduces average travel distance and minimizes congestion in the handling system, thereby reducing transport time between workstations.

The *open field layout* consists of multiple loops and ladders and may include sidings as well as illustrated in Figure 16.10 This layout type is generally appropriate for processing a large family of parts. The number of different machine types may be limited, and parts are routed to different workstations depending on which one becomes available first.

The *robot-centered cell* (Figure l6.1) uses one or more robots as the material handling system. Industrial robots can be equipped with grippers that make them well suited for the handling of rotational parts, and robot-centered FMS layouts are often used to process cylindrical or disk-shaped parts.

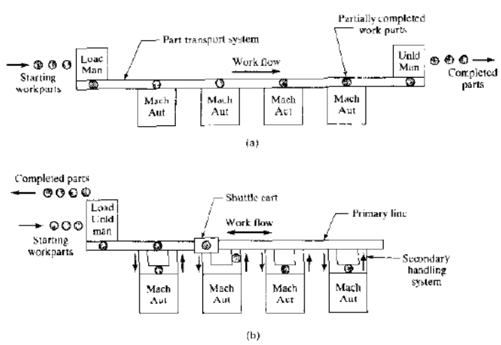


Figure 16.7 In-line FMS layouts: (a) one direction flow similar to a transfer line and (b) linear transfer system with secondary part handling system at each station to facilitate flow in two directions. Key: Load = parts loading station, UnLd = parts unloading station, Mach = machining station, Man = manual station, Aut = automated station.

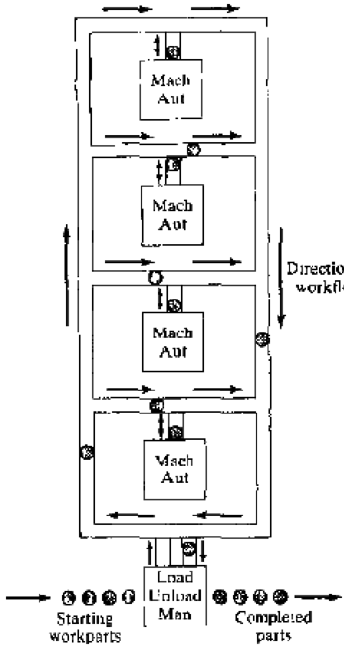


Figure 16.9 FMS ladder layout. Key: Load = parts loading station, UnLd = parts unloading station, Mach = machining station, Man = manual station, Aut = automated station.

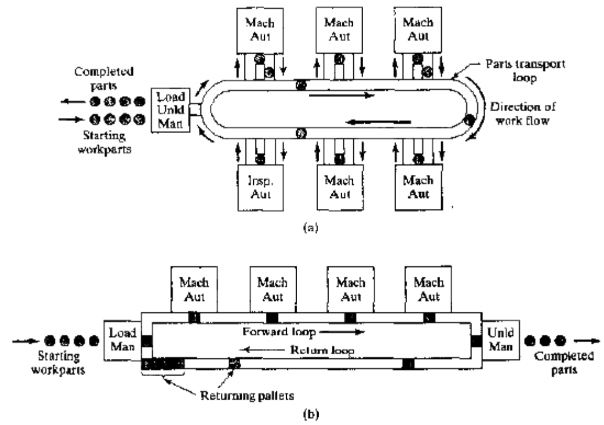


Figure 16.8 (a) FMS loop layout with secondary part handling system at each station to allow unobstructed flow on loop and (b) rectangular layout for recirculation of pallets to the first workstation in the sequence. Key: Load = parts loading station, UnLd = parts unloading station, Mach = machining station, Man = manual station, Aut = automated station.

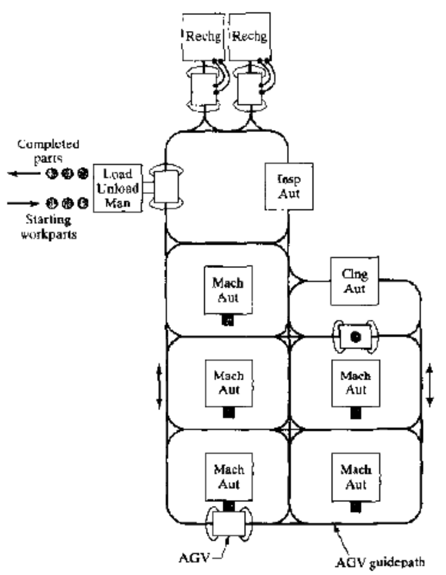
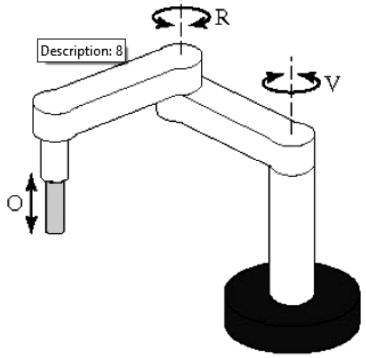
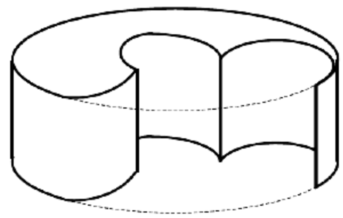


Figure 16.10 Open field FMS layout. Key: Load = parts loading, UnLd = parts unloading, Mach = machining, Clng = cleaning, Insp = inspection, Man = manual, Aut = automated, AGV = automated guided vehicle. Rechg = battery recharging station for AGVs.

5

A robot is a reprogrammable multi functional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of variety of tasks.





SCARA (Selective Compliance Assembly Robot Arm)

Notation: [**VRL**]: Revolving, Rotational and Linear joint

This configuration consists of 1 prismatic and 2 revolute joint. The important features being the relative motion of all the links at the joints are about vertical axes.

SCARA stands for Selective Compliance Assembly Robot Arm. This joint is 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.

Features:

i) Work volume is **cylindrical** in nature
ii) Most common in assembly robot
iii) Arm consists of two horizontal revolute joints at the wrist and elbow and a one prismatic joint
iv) Can reach at any point within horizontal planar defined by two concentric circles
v) Most assembly operations involve building up assembly by placing parts on top of a partially complete assembly
vi) Floor area is small compare to work area
vii) Rectilinear motion requires complex control of the revolute joints.

6.

Robot End Effectors

An end effector is a device that attaches to the wrist of the robot arm and enables the general-purpose robot to perform a specific task. It is sometimes referred to as the robot‘s “hand.”

Types of end effectors

The End effectors can be divided into two major categories:

1 . Grippers
2. Tools

Grippers are and effectors used to grasp and hold objects. The objects are generally work parts that are to be moved by the robot. These part handling applications include machine loading and unloading, picking parts from a conveyor and arranging parts onto a pallet.

Grippers can be classified as single, double or multiple. The single gripper is distinguished with only one grasping device mounted to the robot’s wrist.

A double gripper has two gripping devices attached to the wrist and is used to handle two separate objects. The two gripping devices can be actuated independently. The double gripper is especially useful in machine loading and unloading applications. To illustrate, suppose that a particular job calls for a raw work part to be loaded from a conveyor onto a machine and the finished part to be unloaded onto another conveyor. With a single gripper, the robot would have to unload the finished part before picking up the raw part. This would consume valuable time in the production cycle because the machine would have to remain open during these handling motions. With a double gripper, the robot can pick the part from the incoming conveyor with one of the gripping devices and have it ready to exchange for the finished part. When the machine cycle is completed, the robot can reach in tor the finished part with the available grasping device, and insert the raw part into the machine with the other grasping device. The amount of time that the machine is open is minimized.

The term multiple gripper is used in the case where two or more grasping devices attached to the wrist. The occasions when more than two grippers would be required are somewhat rare. There is also a cost and reliability penalty which accompanies an increasing number of gripper devices on one robot arm.

Tools are end effectors designed to perform work on the part rather than to merely grasp it. By definition, the tool-type end effector is attached to the robot's wrist. One of the most common applications of industrial robots is spot welding, in which the welding electrodes constitute the end effector of the robot. Other examples of robot applications in which tools are used as end effectors include spray painting and are welding.

Mechanical Grippers

A mechanical gripper is an end effector that uses mechanical fingers actuated by a mechanism to grasp an object. The fingers, sometimes called jaws, are the appendages of the gripper that actually make contact with the object. The fingers are either attached to the mechanism or are an integral part of the mechanism. If the fingers are of the attachable type, then they can be detached and replaced. The use of replaceable fingers allows for wear and 'inter-changeability. Different sets of fingers or use with the same gripper mechanism .can be designed to accommodate different part ' models.

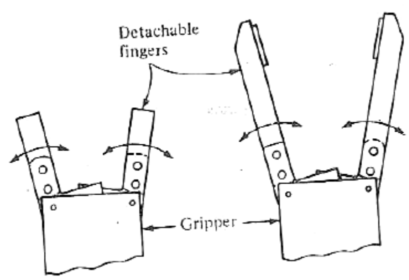


Fig: Interchangeable fingers can be used with the same gripper mechanism

7 a) **Spatial Resolution**

The spatial resolution of a robot is the smallest increment of movement into which the robot can divide its work volume. Spatial resolution depends on two factors: the system's control resolution and the robot's mechanical inaccuracies. It is easiest to conceptualize these factors in terms of a robot with 1 degree of freedom.

The control resolution is determined by the robot's position control system and its feedback measurement system. It is the controller's ability to divide the total range of movement for the particular joint into individual increments that can be addressed in the controller. The increments are sometimes referred to as "addressable points." The ability to divide the joint range into increments depends on the bit storage capacity in the control memory. The number of
separate, identifiable increments (addressable points) for a particular axis is given by

Number of increments = 2"

where n = the number of bits in the control memory.

For example, a robot with 8 bits of storage can divide the range into 256 discrete positions. The control resolution would be defined as the total motion range divided by the number of increments. We assume that the system designer will make the entire increments equal.

7 b) **Accuracy**

Accuracy refers to a robot's ability to position its wrist end at a desired target point within the work volume. The accuracy of a robot can be defined in terms of spatial resolution because the ability to achieve a given target-point depends on how closely the robot can define the control increments for each of its joint motions. In the worst case, the desired point would lie in the middle between two adjacent control increments.

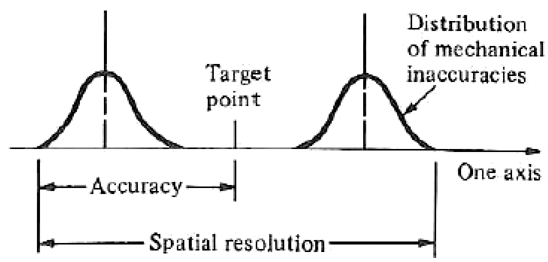


Fig: Illustration of accuracy and spatial resolution in which mechanical inaccuracies are represented by a spatial resolution.

First, the accuracy varies within the work volume, tending to be worse when the arm is in the outer range of its work volume and better when the arm is closer to its base. The reason for this is that the mechanical inaccuracies are magnified with the robot's arm fully extended. The term error map is used to characterize the level of accuracy possessed by the robot as a function of location in the work volume.

Second, the accuracy is improved if the motion cycle is restricted to a limited work range. The mechanical errors will tend to be reduced when the robot is exercised through a restricted range of motions. The robot's ability to reach a particular reference point within the limited work space is sometimes called its local accuracy. When the accuracy is assessed within the robot's full work volume, the term global accuracy is used.

8.a) **Robot Work Volume**

It is the term that refers to the space within which the robot can manipulate its wrist end. The convention of using the wrist end to define the robot's work volume is adopted to avoid the complication of different sizes of end effectors that might be attached to the robot's wrist. The end effector is an addition to the basic robot and should not be counted as part of the robot‘s working space. A long end effector mounted on the wrist would add Significantly to the extension of the robot compared to a smaller end effector.

Also, the end effector attached to the wrist might not be capable of reaching certain points within the robot's normal work volume because of the particular combination of joint limits of the arm.

The work volume is determined by the following physical characteristics of the robot.

The robot's_physical configuration

The sizes of the body, arm, and wrist components

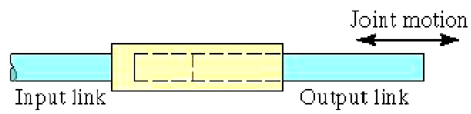
The limits of the robot's joint movements.

8.b) **Types of Joints**

A) **Prismatic joint** - Translational motion

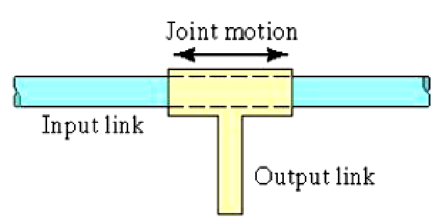
1. Linear joint (type L)

The relative motions between input and output links are linear and axis of the two links and that of joints are parallel.



2 Orthogonal joint (type O)

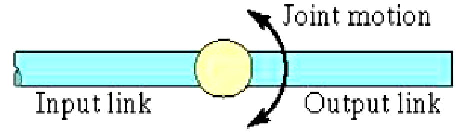
This is also linear motion but input and output links are perpendicular to each other.



B) **Revolute joints** - Rotary motion

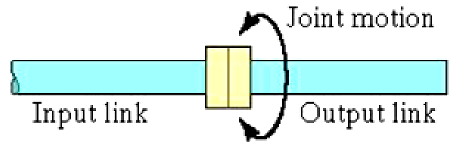
1. Rotational joint (type R)

This gives a rotational motion with axis of rotation perpendicular to both link axes.



2. Twisting joint (type T)

This also gives rotary motion between links and axis of rotation is parallel to both link axes.



3. Revolving joint (type V)

This is also rotary motion. One input link axis is parallel to rotation axis and perpendicular to output link