WINTER– 2022 EXAMINATION
Model Answer

Subject Name: Industrial Robotics **Subject Code:** 22587

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.
8) As per the policy decision of Maharashtra State Government, teaching in English/Marathi and Bilingual (English + Marathi) medium is introduced at first year of AICTE diploma Programme from academic year 2021-2022. Hence if the students in first year (first and second semesters) write answers in Marathi or bilingual language (English +Marathi), the Examiner shall consider the same and assess the answer based on matching of concepts with model answer.

Q. No.	Sub Q.N.	Answer	Marking Scheme
Q. 1.		**Attempt any FIVE of the following.**	**10**
	a) Ans:	**State functions of sensors.** The function of Sensors is to sense and measure physical properties of the environment, e.g., temperature, luminance, resistance to touch, weight, size, etc.	**02**
	b) Ans:	**List various methods of robot programming.** 1) Walk-through method 2) Lead-through method 3) Off-Line programming 4) Robot Simulation	**02** (1/2 mark each)
	c) Ans:	**List different robot specifications.** Work envelope, Payload Capacity, Repeatability, Precision, Reach, Speed, Stroke, Operating Environment, Tool orientation etc.	**02** (1/2 mark each for any 4)
	d) Ans:	**List various applications of robots (any Four).** a) **Industrial Applications:** - Material Handling, Machine Loading and unloading, Palletizing etc. b) **Processing Applications:** - Arc Welding, Spot Welding, Spray Painting c) **Assembly Operations:** - Automated assemblies in industry. d) **Inspection Applications:** - Part Inspection e) **Non-Industrial Applications:** - Home sector, Health Sector, Service Sector, Agriculture & Research	**02** (1/2 mark each for Any 4 application)
	e) Ans:	**State any four End effector commands.** OPEN, CLOSE, HOPEN, HCOLSE, OPENI, CLOSEI, MOVEST, MOVET, GRASP, MOVE, TOOL	**02** (1/2 mark each for any 4 command)

	f) **Ans:**	**List various future technologies of robot.** Robot intelligence, Advanced sensor capabilities (3D Vision), Telepresence and related technologies, Mechanical design features (Direct Drive robot, Multiple arm coordinate robot), Mobility, locomotion and navigation, Universal hand, System integration and network.	**02** (1/2 mark each for any 4 technology Name)
	g) **Ans:**	**State functions of proximity sensor.** It is used to sense the presence of object within a specified distance.	**02**
Q. 2.		**Attempt any THREE of the following.**	**12**
	a) **Ans:**	**State different considerations in gripper selection.** **a) Actuation Selection/Types of actuations:** - Mechanical, Pad Shape selection, Vacuum actuation, Magnetic Grasping, Expandable Bladder **b) Drive Selection/Types of Drive**: - Pneumatic, Hydraulic, Electric **c) Protection Selection/Types of Protection: -** Heat Shield, Force cooling, Heat Resistance. **d) Process Selection/Types of Process:** - Actuate processing method for figures, Interchangeability, Shape compatibility, ease of access **OR** • The part surface to be grasped must be reachable. • The size variation of the part must be accounted for, and how this might influence the accuracy of locating the part. • The gripper design must accommodate the change in size that occurs between part loading and unloading. • Consideration must be given to the potential problem of scratching and distorting the part during gripping, if the part is fragile or has delicate surfaces. • If there is a choice between two different dimensions on a part, the larger dimension should be selected for grasping. • Gripper fingers can be designed to conform to the part shape by using resilient pads or self-aligning fingers.	**04** (1 Mark for each consideration)
	b) **Ans:**	**Explain edge detection and its procedure.** • Edge detection an effective technique used for segmentation of images in robot vision system. • In edge detection technique, the outline boundary of an object within an image is equivalent to identifying the edges of the object that separate the object from background. • The algorithms to identify whether an image pixel lies on the edges of an object or not, are known as "edge detection algorithms. • A common method is based on the intensity change or intensity discontinuity that occurs in adjacent pixels at the boundary or edge of an object. • The idea underlying most of edge detection algorithms is the computation of local gradient of image intensity. • The magnitude of the first derivative of intensity function can be used to detect edges in the image. • It helps to separate the image from background.	**04** (1 Mark each for 1 valid point)

	c) **Ans:**	**List requirements of good programming language.** **Various requirement of good programming language are as follows: -** ● World Modelling ● Position Specifications. ● Motion Specification ● Sensory Control ● Programming Support ● Flow of Execution	**04** (1 Mark each for 1 requirement)
	d) **Ans:**	**Explain applications of Robot in automated assemblies** ● Automated assembly applications involve both material-handling and the manipulation of a tool. ● They typically include components to build the product and to perform material handling operations. ● Assembly operation traditionally labor-intensive activities in industry and are highly repetitive and boring. Hence are logical candidates for robotic applications. ● **Automated assembly operations are classified as:** Batch assembly: As many as one million products might be assembled. The assembly operation has long production runs. Low-volume: In this a sample run of ten thousand or less products might be made. ● **Advantages of Robotic Assembly:** Increased productivity Improved efficiency Increased product quality ● **Application of Robotic Assembly** Part identification Part sorting Bin picking Tool changing Part fastening or joining **(Note: - Student may explain any relevant application of automated assembly)**	**04** (1 Mark each for 1 valid point)
Q. 3.		**Attempt any THREE of the following.**	**12**
	a) **Ans:**	**Write short note on teach pendant** ● There are various methods of robot programming out of which Lead through programming method requires a Teach Pendant. ● Teach Pendants are handheld devices that that may be wired or wireless and allows control of each manipulator joint and control over many functions including emergency stop. ● Robotic teach pendants are the most common device use to program industrial robots. Teach pendants are a vital component of a robotic system. ● Teach pendants are connected to controller of robotic system. They may contain several buttons or switches or feature a touchscreen display as is the case with newer models. ● They also feature a display which shows the robot's commands and allows for editing of those commands. ● In addition, the display can be used to recall the command history of the robot. Pendants utilize a keyboard for task input and easy programming. ● Another common feature of pendants is a large red button, which is the emergency stop button of the robotic system.	**04** (1 mark for diagram & 3 marks for any 6 valid point)

- Robotic teach pendants provide a robot operator the ability to program applications and to control the robot's motion remotely.
- Operators can program robots through pendants without needing to be connected to a fixed terminal.
- The remote capability allows operators to program or control robots safely out of reach of their workspace or hazardous environments.
- In addition to programming and controlling robots, pendants can be used for testing and troubleshooting robotic systems.
- Industrial robots are best suited for performing repetitive tasks, making teach pendants ideal programming solutions as they are designed for teach and repeat programming. Through these technique operators' program robots for specific application parameters, these may include the robot speed and range of motion.
- The controls on the pendant allow an operator to relay information to the robot about cycle times, velocity, functionality, and interactions needed with any additional machinery involved.

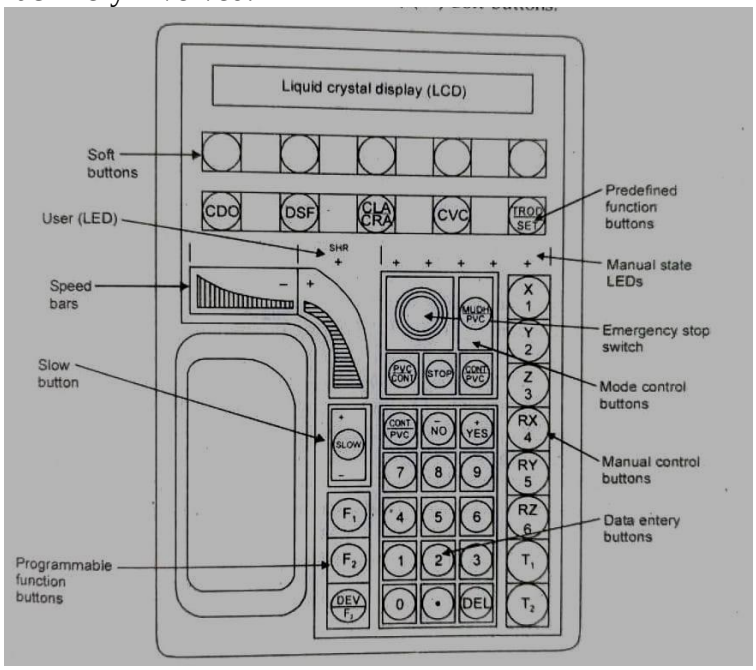


Figure. Teach Pendant

Note- There are variety of teach pendants in market. Any alternative/illustrative diagram should be considered. Students may explain the functions of buttons available on teach pendant.

b) Ans: **Explain Wrist assembly with neat sketch.**

(2 Marks for dig and 2 marks for any 4 valid points)

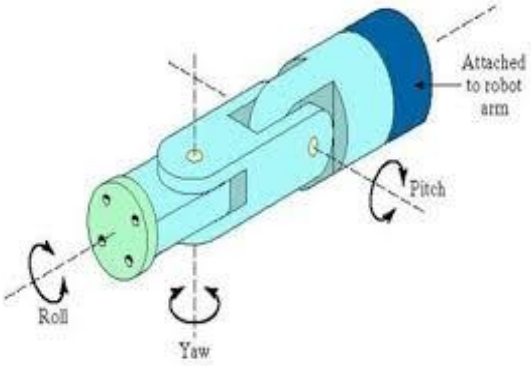


Fig Robot wrist

		• Wrist assembly is attached to the end-of-arm. • End effector is attached to the wrist. • Function of Wrist assembly is to orient the end effector • There are three degrees of freedom located in a wrist viz • Pitch or bend- It is the up and down movement of the wrist. • Yaw- It is the right and left movement of the wrist • Roll or Swivel- Rotation of the wrist mechanism about the arm axis	
	c) Ans:	**State needs of Robot maintenance.** • The main need of maintenance is to maintain the functionality of the robot and to minimize its breakdowns. • Maintenance of robot is needed to ensure safety of operator as well as machines and equipment in the work envelope. • Periodic maintenance of robot will increase useful life of robot. • Robot maintenance is needed to avoid production loss due to sudden breakdown of the robot. • Robot consists of various linear, rotary and twisting joints. Maintenance is necessary for smooth function of these joints. • There should be periodic overhaul of various motors and drives in robot to avoid power loss. • To maintain accuracy of robot the maintenance is necessary. • Robot maintenance ensures lubrication of ball joints and shaft.	**04** (1 mark each for any 4 valid points)
	d) Ans:	**Explain following performance parameters related to robot** **i) <u>Repeatability</u>-** The accuracy with which the particular defined position can be repeatedly achieved by robot is called as repeatability. **or** Repeatability refers to the ability of robot to return to programmed point when commanded to do so. **Or** Repeatability of robot to reposition itself to a position to which it was previously commanded or taught. **ii) <u>Resolution or Precision</u>-** It is the least count of the robot movement into which the work envelop of robot can be divided to represent the incremental of detrimental steps. **Or** Capability of robot controller to divide the range of total movement into closely spaced points that can be identified	**04** (2 mark each)
	e) Ans:	**Explain concept of robot intelligence**. • An intelligent robot is robot which has well developed artificial brain. • This type of robot is capable of arranging actions according to purpose and also has sensors and end effectors. • Currently the intelligent robot is primitive and fully intelligent robot is possible in near future. • The future intelligent robot will be aware about its surrounding environment to take decisions on its own.	**04** (1 mark each for any 4 valid point)

		● To accomplish this decision-making task robot should receive high level instructions that are expressed as commands to do general task, and translate those instructions into a set of actions that must be followed to accomplish the task. ● To improve the real time control of robot that will be capable of responding with respect to environment the National bureau of standards has developed a frame work that can be represented in following figure. ● Robots used for robot human interaction will be able to respond to human commands (voice, gesture etc.) Such robots could also exhibit human behavior such as happiness and sadness etc. ● **Advantages –** Reduction in human errors Zero risks 24*7 availability Digital assistance New inventions Unbiased decisions Perform repetitive tasks Use in risky operations	
Q. 4.		**Attempt any THREE of the following.**	**12**
	a) Ans:	**State the need of telepresence and related technologies** ● Telepresence is a technology that involves use of remote-control manipulators or teleoperators to perform certain tasks. ● This type of technology is used for handling hazardous products like handling of radioactive materials. ● Telepresence capability is the ability to communicate information about its environment (which may be unsafe for human) back to a remote safe location where humans will be able to make judgments and decisions about actions that should be taken by the robot. ● They may be controlled via smartphones, screens and video cameras. ● Telepresence robot will put the operator in an environment without the need for them to physically be there. ● It is anticipated that future robot will have sophisticated teleoperators, combining their intelligence with robot. ● Telepresence helps robot to work in a complicated environment and replaces human assistance with intelligent system called telepresence. ● In complex environment the robot needs two-way communication with human like gathering information from sensors and transmits to human and again robot will receive complex information from human. This can be achieved using Speech synthesis (talking robots) and voice programming. ● Voice programming enables the human or teleoperator to program the robot from remote place without physically appearing in the complex work envelope of Robot.	**04** (1 mark each for any 4 valid points)

- Thus, speech synthesis and voice programming represent the possible techniques of telepresence and helps in gathering information of robot environment with the help of advance sensors, give feedback to remote location about information and display this information in a manner that human can easily understand.
- The rapid growth of technologies such as 4G & 5G have made stable audio-visual data transmission possible. Virtual and augmented reality technologies are also integral to the design of reliable and commercially viable telepresence robots alongside hardware components.
- Essentially, telepresence technologies are assistive devices that mimic and replicate the sense of human operator, allowing them to interact with them as if they were there.
- The function of telepresence are:
  - Information acquisition using advanced sensor technologies
  - Feedback of this information to remote location
  - Display of this information in a manner that facilitates interpretation by humans.

b) Ans: **Differentiate between preventive maintenance and predictive maintenance.** — **04** (1 mark each for any 4 valid points)

Preventive Maintenance	Predictive Maintenance
Preventive maintenance is usually performed to prevent robot/machine from unexpected failures.	Predictive maintenance is usually performed to predict failures that might occur so that it can be prevented from occurrence.
This maintenance is performed on whether needed or not i.e. whether potential failure is identified or not. This is done on regular basis.	This maintenance is performed whenever needed i.e. whenever any potential failure is identified. This is not done on regular basis.
One needs to increase downtime of robot/equipment to carry out maintenance i.e., one need to stop primary functions of robot/machine to carry out maintenance action.	No downtime of robot/machine is required i.e., one does not need to stop primary functions of robot/machine as this maintenance can be performed while robot/machine are performing their regular functions.
In this, maintenance occurs even if potential failures are not identified.	In this, maintenance occurs only when potential failures are identified.
It is less complex process and simple than predictive maintenance.	It is more complex and difficult than preventive maintenance.
This maintenance action is more costly than predictive maintenance as regular maintenance requires more investment.	This maintenance action is less costly than preventive maintenance as one can simply reduce avoid maintenance that is not necessary and thus reduce maintenance costs.
It is more time consuming because in this type of maintenance, one need to perform inspection and maintenance on regular basis.	It is less time consuming as in this type of maintenance, one need to perform inspection and maintenance only when required.

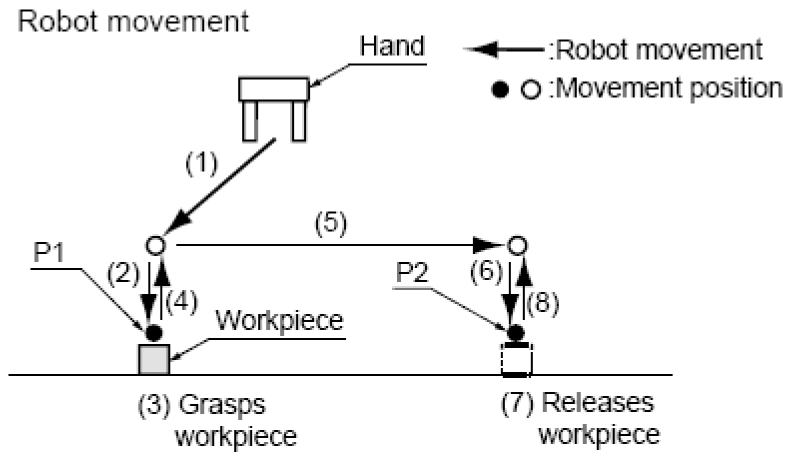
c) Ans:

Write a program for PNP (Pick and Place) activity.

Solution I :- By Considering VAL Melfa Language (Mitsubishi)

04 (1/2 mark for each must command)

**** Must command represented by BOLD*



1.**DEFINE POINT P1** "Define object pick up point P1"

2. **DEFINE POINT P2** "Define object place point P2"

3.**Mvs P1, -50 *1** "Hand Moves to 50 mm above P1"

4. Ovrd 50 "Hand movement speed reduces to 50%"

5.**Mvs P1** "Hand Moves to P1 with linear interpolation"

6. Dly 0.5 "Hand waits of 0.5 Second"

7.**HClose 1** "Closes hand 1(Grasps workpiece.)"

8. Dly 0.5 "Hand waits of 0.5 Second".

9. Ovrd 100 "Sets movement speed to maximum speed"

10. Mvs P1, -50 *1 "Hand Moves to 50 mm above P1 (Lift the object)"

11.**Mvs P2, -50 *1** "Hand Moves to 50 mm above P2"

12. Ovrd 50 "Hand movement speed reduces to 50%"

13.**Mvs P2** "Hand Moves to P2 with linear interpolation"

14. Dly 0.5 "Hand waits of 0.5 Second".

15.**HOpen 1** "Opens hand 1 (Releases workpiece)"

16. Dly 0.5 "Hand waits of 0.5 Second".

17. Ovrd 100 "Sets movement speed to maximum speed"

18. Mvs P2 , -50 *1 "Hand Moves to 50 mm above P2"

19. End "Ends the program"

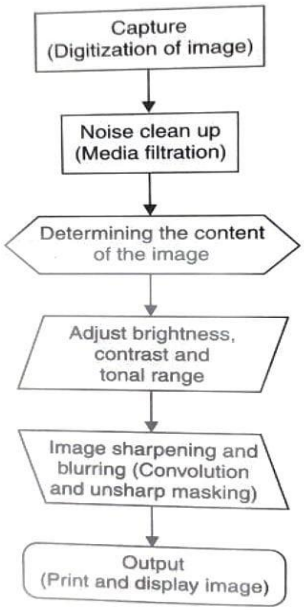
******** Note: - Command justification statements are not expected from students. Only command lines are must.***

*******************************OR**

Solution II :- By Considering VAL KRL Language (Kuka Robot)

Define P1	Pickup point on chute
Define P2	Place or drop Point
MOVE SAFE	Move to starting safe position
APPRO P1, 50	Move to 50 mm above pickup point
WAIT 12	Wait for incoming part to come on chute
OPEN I 100	Signal Gripper to open
MOVES P1, -50	Move to pick up point P1
GRASP x, 100/or CLOSE 100	Grasp the part in gripper/ close the gripper
DEPART P1, 50	Depart above 50 mm from point P1
APPRO P2, 50	Move to drop point 50mm above P2
MOVES P2, -50	Move to drop point P2
OPEN I 100	Open gripper to drop/place the part
DEPART P2, 50	Depart to point 50mm above drop point P2
CLOSE I 100	Close the gripper
STOP	Stop the program

d) Ans: **Explain with block diagram components of digital image processing.**



04 (2 mark for block diagram and 2 marks for explain)

- Digital image processing plays vital role in robot vision system. The components of digital image processing can be explained with the following block diagram.
- **Capture-**The first step consists of capturing an image using a suitable image capturing device like Vidicon or CCD camera followed by digitization.
- **Digitization:** is the process of converting information into a digital (i.e., computer-readable) format or representation of analog information into a numerical (binary) number.
- **Noise clean-up**- Smoothing operations are done to improve quality of the image by reducing noise but on the other hand noise reduction blurs the images and other sharp details.
- **Determining content of Image**- In this step identification of each object in the image is done to find useful information.
- **Adjust brightness, contrast and tonal range-** Tonal range represents the amount of contrast, or detail, in the image and is determined by the image's distribution of pixels, ranging from the darkest pixels (black) to the lightest pixels (white).
- **Image sharpening**- As discussed earlier the noise reduction induces blurriness in image therefore Image sharpening is necessary to process important information.
- **Output**- It is the final step in which the image is displayed or printed.

OR

1) Image data reduction –

In this the objective is to reduce the volume of data. The two methods can be used for image data reduction – digital conversion & windowing. It is done to reduce the bottleneck that can occur from large volume of data in image processing.

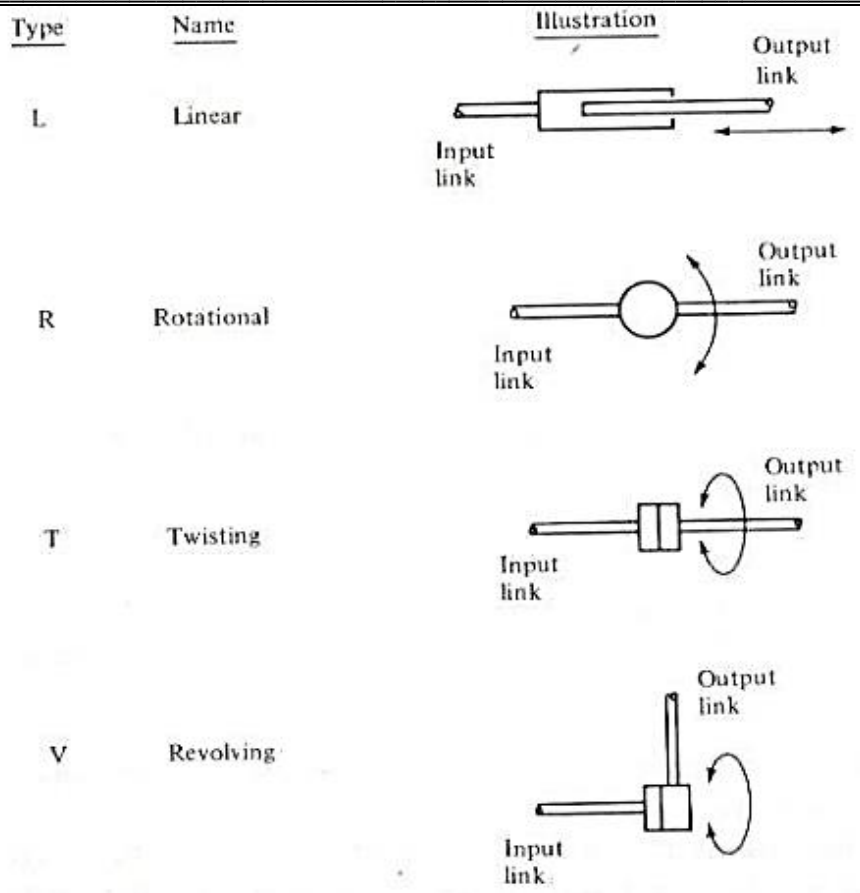
2) Segmentation-

It is the process of identifying a group of related pixels for locating connected regions or areas of image having similar characteristics. This process divides the image into constituent parts.

3) Feature extraction –

It is often necessary to distinguish one object from another. This is usually accomplished by means of features of object that can be used in machine vision

		include area, diameter & perimeter. Several descriptors are simultaneously obtained for a given object and then the object may be identified with good statistical confidence level. **4) Object recognitions –** The object recognition deals with unique identification of each object in the image. For object identification image comparison technique is simple approach.	
	e) Ans:	**Explain various robot motions with neat sketch.** **1. Linear motion (L)-** It involves sliding or translational motion which can be achieved by piston (up and down), telescopic mechanism (in and out). **2.Rotational motion (R)-** one part moving about something other than its centre (arm bending at the elbow) OR It involves the motion where axis of rotation is perpendicular to the axes of input and output links. **3. Twisting motion (T)-** part turns about its center. The output link rotates in relation to the input link. (Turning of a human neck joint). Or It involves the motion where axis of rotation is parallel to the axes of two links. **4. Revolving motion (V)-**the output link axis is perpendicular to the rotational axis, and the input link is parallel to the rotational axes. As like twisting joint, the output link spins about the input link. **Note: - Diagram is illustrated on next page.**	**04** (1 mark for each motion)

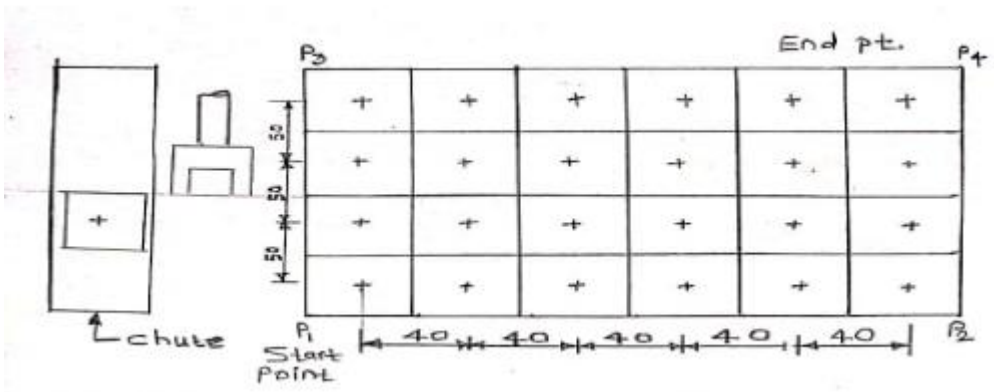
			
Q. 5.		**Attempt any TWO of the following.**	**12**
	a) Ans:	**Explain applications of Robot in automated inspections.** ● Inspections are more accurate when performed by robots, and because robots can operate for long periods of time without breaks, they provide more comprehensive inspections than manual processes, especially in dangerous settings. ● Inspection robots are mobile service robots with advanced vision sensors, typically used for the inspection of critical parts. ● Inspection robots are either semiautonomous, where they've been taught established paths, or fully autonomous, able to navigate themselves. ● Robotics can increase productivity by relocating human resources to value-added tasks and increasing the number of parts and/or dimensions measured, with the ultimate goal of controlling the quality of 100% of dimensions on 100% of parts. ● Inspection of "electronic devices" has also been performed by robots. For example, a printed circuit (PC) board often must be checked for missing or improperly drilled holes before the components are placed on the board. ● The robot can be used in manufacturing sector performing regular inspections on machinery used for manufacturing is crucial to keeping plants up and running. automated tools can accomplish in performing, many of the checks conducted in industrial facilities ● Robots can be used for examine turbine blades for cracks and conduct visual inspections of tanks, vessels, pipes, cooling towers and other equipment components.	**06** (1 mark each for any 6 valid point)

- **Advantages of Robot in automated inspections: -**
  Better safety
  Improved accuracy
  Longer hours
  Flexibility
- Various applications of robot in automated inspections are manufacturing, energy, transportation etc.

(Note: - Student may explain any relevant application of automated Inspection)

b) **Write VAL robot program for palletization of parts in pallet having 4 row that are 50 mm apart and 6 column 40 mm apart. The robot must pick parts from an incoming chute and are 25 mm tall.** **06**

Ans: **Solution I :- By Considering VAL Melfa Language (Mitsubishi)**



……. Diagram 1 mark

1. DEFINE P1	"Define Point P1 as a Start Point"	2 Mark
2. DEFINE P10	"Define P10 i.e. Pick up point"	
3. P1=P2	"Copy Coordinates of P1 into P2"	
4. P1=P3	"Copy Coordinates of P1 into P3"	
5. P2*Y=P2*Y+200	"Modify point P2, by moving it right by 200 mm"	
6. P3*X=P3*X-150	"Modify point P3, by moving it upward by 150 mm"	
7. P3=P4	"Copy Coordinates of P3 into P4"	
8. P4*Y=P4*Y+200	"Modify point P4, by moving it right by 200 mm"	
9. DEFINE P1t 1, P1, P2, P3, P4, 6,4,1	"Define Pallet"	
10. M1=1	"Select Numeric variable M1, which acts as a counter"	3 Mark
11. *LOOP	"Designate the loop to repeat the steps in loops"	
12. Mov P10, -50*1	"Hand moves to 50 mm above P10"	
12. Ovrd 50	"Movement speed reduces to 50%"	

14. Prec ON	"Precise movement ON"
15. Mvs P10	"Hand moves to P10"
16. Dly 0.5	"Hand waits for 0.5 second"
17. Hclose 1	"Hand Closes to grasp the object"
18. Dly 0.5	"Hand waits for 0.5 second"
19. Mvs P10, -50*1	"Hand moves to 50 mm above P10"
20. P20=(P1t 1, M1)	"Locate position P20 as first location in Pallet"
21. Mvs P20, -75*1	"Hand moves to 75 mm above P20 as chute is 25 mm above the pallet"
22. Mvs P20	"Hand moves to P20"
23. Dly 0.5	"Hand waits for 0.5 second"
24. Hopen 1	"Hand Opens to release the object"
25. Dly 0.5	"Hand waits for 0.5 second"
26. Mvs P20, -75*1	"Hand moves to 75 mm above P20"
27. M1=M1+1	"Increase the counter by 1"
28. If M1<24 Then *LOOP	"If Count position is less than 24, Loop will get execute repeated"
29. Prec OFF	"Precise movement ON"
30. End	"End of Program"

***** Note: - Command justification statements are not expected from students. Only command lines are must.***

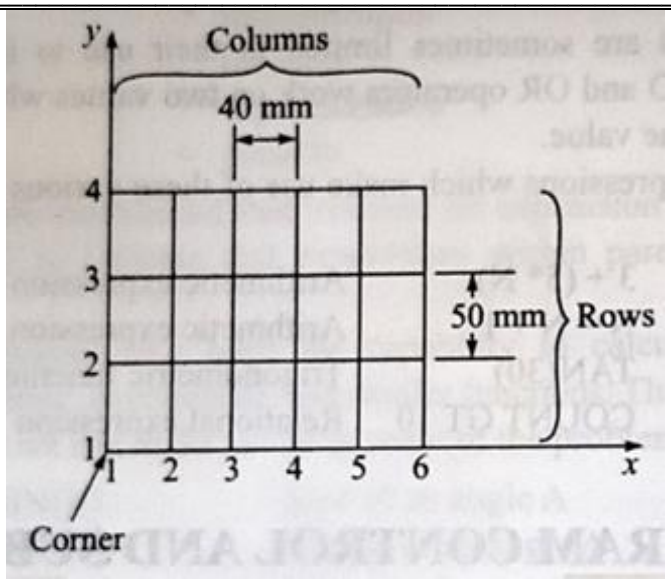
**********OR**********

Solution II :- By Considering VAL KRL Language (Kuka Robot)

Variables:

ROW	The row number (integer value)
COLUMN	The column number (integer value)
X	An x-coordinate value
Y	Ay-coordinate value

06
(1 mark for dig. 1 mark for logic & 4 mark for program



Location constants:

PICKUP The pickup point on the chute

CORNER The corner starting point on the pallet

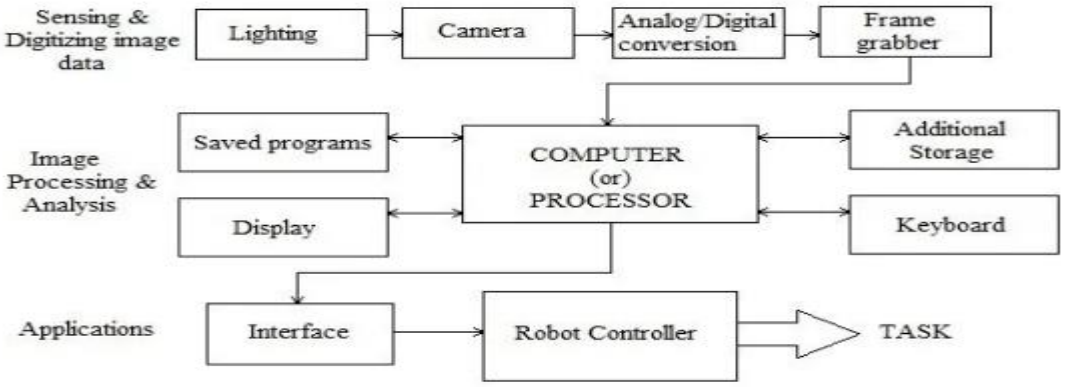
Location variables:

DROP The drop-off point

The program to perform the palletizing operation is as follows:

PROGRAM PALLETIZE	
DEFINE PICKUP = JOINTS (1, 2,3,4,5)	
DEFINE CORNER = JOINTS (1, 2,3,4,5)	
DEFINE DROP = COORDINATES (X, Y)	
OPENI	
ROW = 0	Initialize ROW
Y = ROW *	Compute y for drop-off point
50.0……10	Initialize COLUMN
COLUMN = 0	Compute x for drop-off point
X = COLUMN*	Define DROP for each iteration
40.0……20	Approach 50mm above pickup point
DROP = CORNER + (X, Y)	Move to pickup point
APPRO PICKUP, 50	Close gripper and grasp the object
MOVES PICKUP	Move to 50mm above pickup point
CLOSEI	Move to 50mm above drop point
DEPART 50	Move to drop point
APPRO DROP, 50	Open gripper and drop the part
MOVES DROP	Move 50mm above drop point
OPENI	Increment COLUMN variable
DEPART 50	Check if COLUMN limit reached
COLUMN = COLUMN + 1	Increment ROW variable
IF COLUMN LT 6 GOTO 20	Check if ROW limit reached
ROW = ROW + 1	
If ROW LT 4 GOTO 10	
END PROGRAM	

	c) Ans:	**Explain system integration and networking approach may use in robot.** **a. System Integration** ● Robot Systems Integration ensures that they fit properly in the production process. In order to perform complex and precise tasks, robots rely on skilled human resources to install and maintain them. ● Robotic integration uses robotic systems to provide automated solutions. It's the process of programming these systems to complete specific automated manufacturing tasks. ● A crucial part of robotics systems integration is the integrator. A robotic systems integrator will analyze manufacturing needs, provide custom solutions, design, and then support the robotic system. ● Robotics system integration is an adaptable technology used in many industries, including medical and industrial. Many common industrial uses include assembly, painting, dispensing, palletizing, production inspection, material handling, welding, and production testing. Robotic systems integration is very flexible, scalable, and accurate, providing a significant return on investment. ● It improves accuracy and precision and Increases consistency ● It boosts speed, saves labor cost ● Improves floor utilization with a safer workplace. **b. Networking Approach** ● A 'networked robot' is a robotic device connected to a communications network such as the Internet or LAN. The network could be wired or wireless, and based on any of a variety of protocols such as TCP, UDP. ● While some applications require the use of a single robot to effectively automate and enhance a process, there are others that require using multiple robots working together to achieve certain objectives in more cost-effective or/and efficient manners. ● Multiple robots used for any of these applications can be combined in what is referred to as a Multi-Robot System (MRS). ● It is worth noting that some researchers use the term Multi-Robot Network (MRN). ● Multiple robots can concurrently work on the task to achieve it faster. ● Robots can be heterogeneous in their capabilities to provide a cost-effective solution to achieve a task where each robot handles specific components of the task matching its capabilities. ● Multiple robots can effectively deal with a task that is inherently distributed over a wide area. ● Using multiple robots for achieving a task provides fault tolerance as the presence of multiple robots capable of similar processes can be used to compensate when any of them fails. ● MRS applications includes search and rescue, detection of forest fires, hazardous waste removal, farm operations, mining, constructions, disaster management, warehouse management etc.	**06** (3 mark each for point a and b)

Q. 6.		Attempt any TWO of the following.	12
	a) Ans:	**Explain functions of robotic vision systems and devices with the help of block diagram.**  **Figure:- Components of Machine Vision Systems** Machine vision systems are typically composed of five elements (or components), as discussed below. **1. Lighting and Machine Vision Systems** Lighting is responsible for illuminating the object and highlighting its distinct features to be viewed by the camera. It is one of the critical aspects of machine vision systems; The lighting parameters such as distance of the light source from the camera and object, angle, intensity, brightness, shape, size, and color of lighting must be optimized to highlight the features being inspected. Lighting can be provided by LED, quartz halogen, fluorescent, and xenon etc. **2. Machine Vision Lenses** The lens captures the image and relays it to the image sensor inside the camera in the form of light. Most lenses are equipped with color recognition capability. Lenses are characterized by the following properties, which describes the image quality they can capture Field of view, Depth of field, Depth of focus, Aperture etc. **3. Analog/digital converte**r used to convert analog picture signal to the digital form that is suitable for computer processing. **4. The Frame Grabbe**r is the hardware device is an image storage and computation device which stores a given pixel array. **5. Image Sensor**	**06** (2 mark for diagram and 4 marks for any 4-component explanation)

The image sensor inside the machine vision camera converts light captured by the lens into a digital image. The output of image sensors is a digital image composed of pixels that shows the presence of light in the areas that the lens has observed.

6. Vision Processing Unit

The vision processing unit of a machine vision system uses algorithms to analyze the digital image produced by the sensor. Vision processing involves a series of steps, performed externally (by a computer) or internally (for stand-alone machine vision systems).

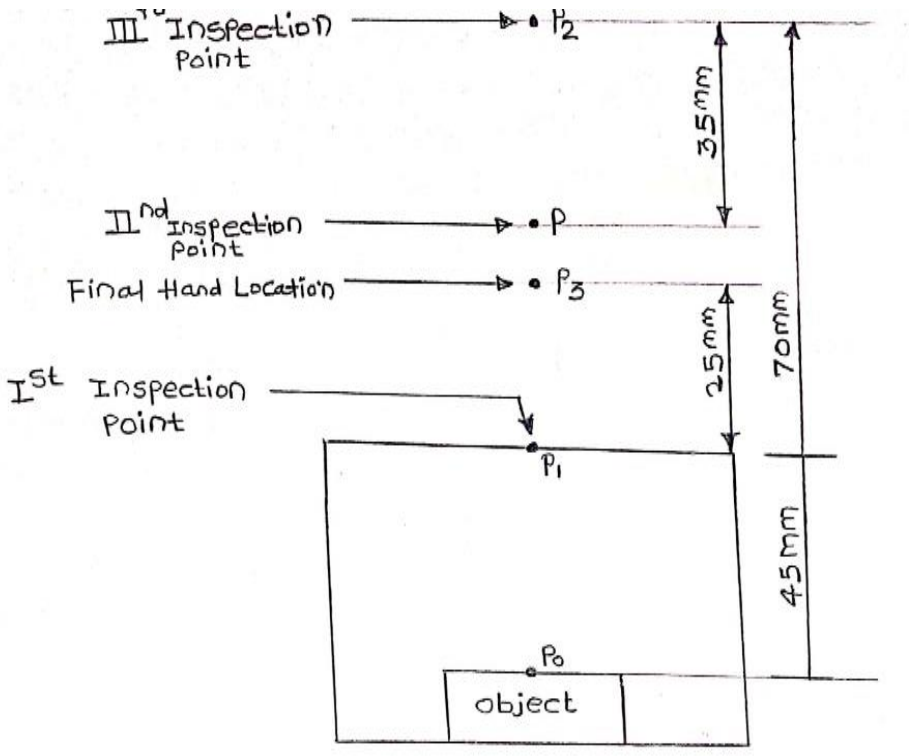
7. Communication System

The communication system quickly passes the decision made by the vision processing unit to specific machine elements. Once the machine elements have received the information (or signal), the machine elements will intervene on and control the process based on the output of the vision processing unit.

b) **Write VAL program for inspecting an OBJECT into a box by approaching 45 mm above the object by moving to an intermediate point 'P' along a straight line and approaching the box 70 mm from above and finally setting the gripper 25 mm above the box.**

06
(1 mark for diagram and 1/2 mark each for must program command)

Ans: **Solution I :- By Considering VAL Melfa Language (Mitsubishi)**



**** Must program command is made **BOLD**

DEFINE P0	Define Point P0
DEFINE CAMERA	Define Camera Variable
Ovrd 50	Movement Speed reduces to 50%
Mov P0, -45*1	Camera Moves 45 mm above P0 (I Inspection Point)
Capture Image	Camera will capture image
Dly 0.5	Hand waits for 0.5 s
Mvs P1, -35*1	Camera Moves 35 mm above P1 (II Inspection Point)
Dly 0.5	Hand waits for 0.5 s
Capture Image	Camera will capture image
Dly 0.5	Hand waits for 0.5 s
Mvs P, -35*1	Camera Moves 35 mm above P (III Inspection Point)
Dly 0.5	Hand waits for 0.5 s
Capture Image	Camera will capture image
Dly 0.5	Hand waits for 0.5 s
Mvs P1, -25*1	Camera Moves 25 mm above P1 (Final Hand Location)
End	End of Program

******** Note: - Command justification statements are not expected from students. Only command lines are must.***

****************************OR**

Solution II :- By Considering VAL KRL Language (Kuka Robot)

DEFINE PO	“Define location of an Object”
DEFINE P	“Define intermediate point”
DEFINE CAMERA	“Assign camera for inspection”
SPEED 50IPS	“Speed reduced to 50%”
APPRO PO, 45 / MOVE P1	“Hand moves to P1”
CAPTURE IMAGE	“Camera will capture image”
WAIT 0.5/Or DELAY 0.5	“Delay 0.5 sec”
MOVES P	“Hand moves to P”
DELAY 0.5	“Delays 0.5 sec”
CAPTURE IMAGE	“Camera will capture image”
DELAY 0.5	“ Delays 0.5 sec”
MOVES P2/ APPRO PO, 115/APPRO P1, 70	“Hand moves to P2”
DELAY 0.5	“Delays 0.5 sec”
CAPTURE IMAGE	“Camera will capture image”
DELAY 0.5	“Delays 0.5 sec”
MOVES P3 / APPRO P1, 25	“Hand moves to P3 from P1”
STOP	“End of program”

(Note – students may use different commands for same operation. Any one command is acceptable. Commands written in bold are must.)

	c) Ans:	**Explain anatomy of a robot.**	**06** (1 mark for diagram and 1 mark for each component)

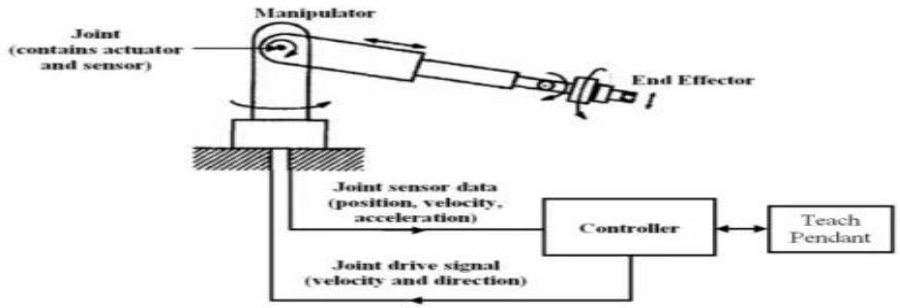


Figure: Anatomy of a Robot.

1. Controller

The controller is the 'brain' of the industrial robotic arm and allows the parts of the robot to operate together. It works as a computer and allows the robot to also be connected to other systems. The robotic arm controller runs a set of instructions written in code called a program.

2. Actuators

Actuators are like the 'muscles' of a robot, the parts which convert stored energy into movement. The most popular actuators are electric motors that spin a wheel or gear, and linear actuators that control industrial robots in factories.

3. Sensors

Sensors are what allow a robot to gather information about its environment. This information can be used to guide the robot's behavior. Some sensors are relatively familiar pieces of equipment.

4. Manipulator

Robots need to manipulate objects; pick up, modify, destroy, or otherwise have an effect. Thus the 'hands' of a robot are often referred to as end effectors, while the 'arm' is referred to as a manipulator.

5. End-Effectors

These are the tools at the end of robotic arms that directly interact with objects in the world. The effectors are the parts of the robot that actually do the work. With the robot arm, the shoulder, elbow, and wrist move and twist to position the end effector in the exact right spot. Each of these joints gives the robot another degree of freedom.