UNIT I Fundamentals of Robots
Part-A Questions

1. **Define a Robot.**
   RIA defines a robot as a -programmable, multifunction manipulator designed to Move materials, parts, tools or special devices through variable programmed motions for the performance of the variety of tasks .

2. **Explain the types of rotary joint notations**
   - Rotational joint (type R)
   - Twisting joint (type T)
   - Revolving joint (type V)

3. **What is meant by Work space?**
   The space in which the end point of the robot arm is capable of operating is called as workspace in other words reach ability of robot arm is known as workspace.

4. **What is meant by accuracy of robot?**

   The robot's ability to reach a reference point within the robot's full work volume is known as accuracy of robot.

5. **What are the benefits of industrial robots?**
   - Increased Productivity
   - Significant Savings
   - Improved Quality
   - Better Safety
   - Competitive Edge

6. **What is repeatability of robot?**
   Repeatability refers to robot's ability to return to the programmed point when it is commanded to do so.

7. **What is meant by pitch, yaw and roll?**
   Pitch is rotation around the X axis, yaw is around the Y axis, and roll is around the Z axis. Yaw is side to side swinging around an axis. Pitch is up and down movement about an axis and roll is rotatory motion about an axis.

8. **What is work volume?**
   The volume of the space swept by the robot arm is called work volume.

9. **What is meant by quality of robot?**
   A Robot is said to be high quality when the precision and accuracy is more.

10. **What is meant by robot anatomy?**
    Study of structure of robot is called robot anatomy. Manipulator is constructed of a series of joints and links. A joint provides relative motion between the input link and the output link.

11. **What are the three degrees of freedom associated with the arm and body motion?**
    - Right (or) left movement (X-axis motion)
    - In and out movement (Y-axis motion)
    - Vertical movement (Z-axis motion)

12. **Define an Industrial Robot.**
    An industrial robot is an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes. A programmable mechanical device that is used in place of a person to perform dangerous or repetitive tasks with a high degree of accuracy.

13. Define payload capacity of Robot?

   The maximum load which can be carried by the manipulator at low or normal speed.

14. Define base and tool Coordinate system.

   A tool coordinates definition system capable of easily obtaining a transformation matrix for defining a tool coordinates system of a robot. The tool coordinates system at the 0° position of the robot is rotated around each axis so that the tool coordinates system becomes parallel to a base coordinates system.

15. Name the important specifications of an industrial robot.

- Accuracy
- Repeatability
- Degree of Freedom
- Resolution
- Envelope

16. What are the four basic robot configurations available commercially?

- Cartesian coordinate system
- Cylindrical coordinate system
- Polar or spherical coordinate system
- Revolute coordinate system

17. Define the term work envelop?

   The work envelop is described by the surface of the work space.

18. List out the robot major components?

   1. Robot arm
   2. End of arm
   3. Power source   4. Controller
   5. Sensor   6. Actuator
   7. Actuator

19. What is an end effector? Give examples?

   It is a device that is attached to the end of the wrist arm to perform specific task. e.g Tools, Welding equipments , End of arm tooling

20. What is meant by work space and work volume?

   The space in which the end point of the robot arm is capable of operating (or) the reach Ability of robot arm is known as workspace. The volume of the space swept by the robot arm is called work volume.

Part-B

1. Briefly explain the different types of robots.
2. Sketch and explain the four basic robot configurations classified according to the coordinate system.
3. Write short notes on Joint Notation Scheme.
4. Write short notes on technical specification in Robotics.
5. Explain various parts of robots with neat sketch
6. Explain the main Robot anatomy with neat sketch.
7. Describe the types of joints used in robots.
8. Discuss the four types of robot controls
9. Briefly explain the needs of robots in insustries.
10. Classify robots according to the coordinates of motion. With a sketch and an example, Explain the features of each type.

Part-A Questions

1. What is actuator?

Device used for converting hydraulic, Pneumatic or electrical energy into mechanical Energy. The mechanical energy is used to get the work done.

2. What are the factors which must be considered while choosing the drive system for robots?

a) Accuracy	b) Repeatability
c) Degree of freedom	d) Mobility
e) Coordinate systems	f) Gravitational and acceleration force
g) Backlash, friction and thermal effects	h) Weight
i) Power-to-weight ratio	j) Operating pressure

3. **List the advantages and dis-advantages of hydraulic drive?** Advantages:
1. Precision motion control over a wide range of speeds and loads
2. Robust
3. Greater

Strength Disadvantages:
1. Expensive
2. High maintenance
3. Not energy efficient
4. Noisy
5. Not suited for clean-air environment

4.**List the advantages and disadvantages of pneumatic actuators?**
Advantages:
1. Compact 2. Control is simple 3. It is cheapest form of all actuators 4.Individual components can be easily interconnected
Disadvantages:

1. More noise and vibration 2. Not suitable for heavy loads 3. If mechanical stops are used resetting the system can be slow

5. **List the advantages and dis-advantages of Electrical actuator?** Advantages:
1. High power conversion efficiency 2. No pollution of working environment 3. They are
easily maintained and repaired4. Light weight 5. The drive system is well suited for electronic control Disadvantages:
1. Poor dynamic response 2. Conventional gear driven create backlash 3. Alarger and heavier
motor must be used which must be costly

6. What are the elements of the closed loop control system ?
1. Comparison element
2. Control element
3. Correction element
4. Process element
5. Measurement element

7. What is a stepper motor?

It is a device which transforms electrical pulses into equal increments of rotary shaft motion called steps

8. What are the different types of stepper motor?

1. Permanent magnet stepper motor
2. Variable reluctance stepper motor
3. Hybrid stepper motor

9. What are the advantages and disadvantages of Stepper motor?

Advantages:

1. The rotation angle of the motor is proportional to the input pulse
2. The motor has full torque at standstill
3. Precise positioning and repeatability of movement since good stepper motors have an accuracy of 3-5% of a step and this error is non-cumulative from one step to the next.
4. Excellent response to starting

Disadvantages:

1. Resonance can occur if not properly controlled
2. Not easy to operate at extremely high speeds
3. Very low torque to weight ratio
4. Torque decreases with increase in the stepping frequency
5. For sufficiently high stepping speeds the stepper motor may skip steps due to overshoot.

10. What are the characteristics of servomotor?

1. Linear relationship bet. The speed and electric control signal
2. Steady state stability
3. Wide range of speed control
4. Linearity of mechanical characteristics throughout the entire speed range.
5. Low mechanical and electrical inertia 5.Fast response

11. Write about various types of motion convention?

1) Rotary – i) Belts and pulleys ii) Gear trains iii) Harmonic drives iv) Chains
2) Rotary to Linear motion conversion -i) Rack and pinion ii) Lead screw
3) Linkages- i) Four bar linkage ii) crank and rocker iii) Slider crank

12. Write about the balls screw?

Wherever the rack and pinion and hydraulic ram are not quite accurate, the linear screw and ball screws provide accurate movements , which are necessary in automated microscopes.

13. Why servomotors are preferred with stepper motor in robot applications?

Servomotors are easy to control compared to the stepper motors.

14. What are the parts used in harmonic drive?

1. Elliptical wave generator 2.Flex spline with external teeth 3. Rigid circular spline with Internal teeth

17. Define End effector and Gripper?

End effector is a device that is attached to the end of the wrist arm to perform specific task Gripper is the end effector which can hold or grasp the object

18. What are the types of grippers?
1. Mechanical
2. Hooking
3. Vaccum
4. Fragile object
5. Magnetic (i) permanent (ii) Temporary Grippers

19. What is a stripping device?
A device used to remove work piece from the magnetic gripper

20. What are the elements of end arm tooling?
1. Mounting plate
2. Power for actuation of tooling motion
3. Mechanical linkage 4.Sensors

Part-B Questions
1. Explain Mechanical drives system.
2. Explain Pneumatic actuators system with neat sketch.
3. Explain various types of Gripper mechanisms.
4. Write note on Gripper selection and design
5. Write a note on Magnetic Grippers.
6. Explain the various drive system used with an industrial robot and compare their features, merits and
   demerits.
7. Explain the working of a stepper motor.
8. (i) With a neat sketch, explain the working of a stepper motor.
   (ii) Describe robot kinematics with suitable illustrations.
9.With a neat sketch explain the working of any two robot actuator.
10. Describe any two feed back devices used in robots.

Part-A Questions

1. What is the common imaging device used for robot vision systems?

    Black and white videocon camera, charge coupled devices, solid-state camera, charge injection devices.

2. What is segmentation?

    Segmentation is the method to group areas of an image having similar characteristics or features into distinct entities representing part of the image.

3. What is thresholding?

    Thresholding is a binary conversion technique in which each pixel is converted into a binary value either black or white.

4. What are the functions of machine vision system?
    - Sensing and digitizing image data
    - Image Processing and analysis
    - Application

5. Define sensors and transducer.

    Sensor is a transducer that is used to make a measurement of a physical variable of interest.

    Transducer is a device that converts the one form of information into another form without changing the information content.

6. What are the basic classifications of sensors?
    - Tactile Sensors,
    - Proximity Sensors,
    - Range sensors,
    - Voice sensors etc.,

7. What is a tactile sensor?

    Tactile sensor is device that indicates the contact between themselves and some other solid objects.

8. What is meant by Region growing?

    Region growing is a collection of segmentation techniques in which pixels are grouped in regions called grid elements based on attribute similarities.

9. What is meant by Feature Extraction?

    In vision applications distinguishing one object from another is accomplished by means of features that uniquely characterize the object. A feature (area, diameter, perimeter) is a single parameter that permits ease of comparison and identification.

10. What are the various techniques in image processing and analysis?
    - Image data reduction
    - Segmentation
    - Feature extraction
    - Object recognition

11. Give an application example of a proximity sensor.

- ⬚ Ground proximity warning system for aviation safety
- ⬚ Vibration measurements of rotating shafts in machinery
- ⬚ Sheet break sensing in paper machine.
- ⬚ Roller coasters
- ⬚ Conveyor systems

12. Brief on the working of inductive type proximity sensor.

Inductive proximity sensors operate under the electrical principle of inductance.

Inductance is the phenomenon where fluctuating current, which by definition has a magnetic component induces an electromotive force (emf) is a target object.

To amplify a devices inductance effect, a sensor manufacturer twists wire into a tight coil and runs a current through it.

13. Name some feedback devices used in robotics.
- ⬚ Position Sensors
- ⬚ Velocity Sensors

14. What are the types of encoders?
- ⬚ Incremental encoders
- ⬚ Absolute encoders

15. What is frame grabber?

It is a hardware device used to capture and store the digital image.

16. Classify the position sensors.
- ⬚ Incremental encoders
- ⬚ Absolute encoders
- ⬚ Resistive position sensors
- ⬚ Linear variable differential transformer.
- ⬚ Encoders
- ⬚ Potentiometer
- ⬚ Resolver.

17. What is a tactile array sensor?

Tactile array sensor is a special type of force senor composed of a matrix of force sensing elements.

18. what is meant by feature extraction and pattern recognition?

In vision applications distinguishing one object from another is accomplished by means of features that uniquely characterize the object.A feature (area, diameter,perimeter) is a single parameter that permits ease of comparison and identification. Pattern recognition means classifying an image (region) into one of a number of known classes.

19. What is meant by an object recognition?

The next step in image data processing is to identify the object the image represents. This identification is accomplished using the extracted feature information described. The recognition algorithm must be powerful enough to uniquely identify the object.

20. What is meant by quantitation and morphology?

The transition between continuous values of the image function (brightness) and is digital equivalent is called Quantitation. Morphology is the study of shapes and those methods used to transform or describe shapes of objects

Part-B Questions

1. Briefly explain the characteristics of Sensors.
2. Briefly explain the working principle of position sensors with neat sketch.
3. Briefly explain the working principle of Range sensors with neat sketch.
4. Briefly explain the working principle of Proximity sensors with neat sketch.
5. Explain the Machine vision systems of Robot.
6. Explain the various techniques in Image Processing and Analysis.
7. With suitable applications brief explain the following:
    (i)Optical encoders (ii) Laser range meters (iii) Capacitive type touch sensors
    (iv)Ultrasonic proximity sensors
8. Compare various lighting techniques used in mission vision and image processing analysis.
9. What are robot end effector? How do you classify them.
10. Describe robot end effector interface with example.

Part-A Questions

1. What are the methods of robot programming?
   - Lead through methods
   - Textual robot languages
   - Mechanical Programming

2. What are the ways of accomplishing lead through programming?
   - Powered Lead through
   - Manual Lead through

3. What is teach pendant?

   The teach pendant is usually a small handheld control box with combinations of toggle switches,
   dials and buttons to regulate the robot's physical movements and program capabilities.

4. What are the methods of teaching?
   - Joint movements
   - X-Y-Z coordinates motions
   - Tool coordinate motions

5. What is robot kinematics?

   Forward kinematics

   It is a scheme to determine joint angles of a robot by knowing its position in the world coordinate system.

   Reverse kinematics

   It is a scheme to determine the position of the robot in the world coordinate system by knowing the joint angles and the link parameters of the robot.

6. What is trajectory planning?

   It is defined as planning of the desired movements of the manipulator.

7. Define degrees of freedom.

   The number of independent ways by which a dynamic system can move without violating any constraint imposed on it, is called degree of freedom. In other words, the degree of freedom can be defined as the minimum number of independent coordinates which can specify the position of the system completely.

8. Explain joint mode of teaching robots.

   The teach pendant has a set of toggle switches (or similar controlled devices) operate each joint either of it to directions until the endeffector has been positioned to the desired point.

9. Explain the reasons for defining points in a program.
   - To define a working position for the endeffector
   - To avoid obstacles

10. What is position representation?

The position of the end of the arm may be represented by the two joint angles q1 and q2.this is known as position representation.

$$P_j = (q1, q2)$$

11. Define servo controlled robots.

Servo controlled robots, which are programmed by lead through an textual language methods tend to actuate all axes simultaneously.

12. What is circular Interpolation?

Circular Interpolation requires the programmer to define a circle in the robot's workspace which is done by specifying three points that lie along the circle.

13. What are irregular smooth motions?

The segments in manual lead though programming are sometimes approximately straight sometimes curved and sometimes back and forth motions. These motions are called irregular smooth motions.

14. What is manual lead through programming?

In manual lead through programming the programmer moves the manipulated wrist to teach spray-painting or arc welding. The movements consist of combination of smooth motion segments.

15. Differentiate between Forward kinematics and reverse kinematics?

Forward kinematics:

1. Given the joint angles, determine the position and orientation of the end effector

2. The outcome of the forward kinematics problem is always unique. There are no multiple solution.

Inverse kinematics:

1. Given the position and the orientation of the end effector, determine the numerical values for the joint variable.

2. This problem is not quite straight forward like the forward kinematic problem

3. It is not possible to obtain closed form solutions due to the non-linear simultaneous equations.

16. Explain redundancy?

Most industrial robots have 6 or less joints, thus, redundancy is not inherent to their design. Some robots, though, do not have a certain joint arrangement in their final orientation joints that can lead to redundancy for certain orientations.

For example, some robots have the final three joint axes (joints 4, 5 and 6 in a six axis Robot) arranged in a roll, pitch, roll sequence.

17. What are the methods of robot programming?

1. Lead through methods
2. Textual robot languages
3. Mechanical programming

18. What is teach pendant?

The teach pendant is usually a small hand held control box with combinations of toggle switches, dials and buttons to regulate the robot's physical movements and program capabilities.

19. Define servo control robots?

Servo control robots, which are programmed by lead through and textual language methods, tend to activate all access simultaneously.

20. Explain joint mode of teaching robots?

The teach pendant has a set of toggle switches (or similar controlled devices) operate each Joint either of it to directions until the end effector has been positioned to the desired point.

Part-B Questions

1. Derive the forward and reverse transformation of 2-Degree of freedom and 3- degree of freedom arm.
2. Briefly explain the Robot Programming Languages in detail.
3. Explain the teach pendant for Robot system
4. Write down the capabilities and limitations of Lead through methods.
5. With an example differentiate forward and inverse kinematics.
6. Derive the expression for direct and inverse kinematics of 4 degrees of freedom robot manipulator.
7. List the commands used in VAL II programming and describe its functions.
8. Explain with neat sketch the fur common robot configuration giving their relative merits and demerits.
9. How do you classify industrial robots based on control system.
10. Discuss the features merits and limitation of various control system.

UNIT V Implementation and Robots Economics
Part-A Questions

1. What are the different types of material handling operation?
    - ⬚ Manually operated devices—hand trucks, powered trucks, cranes, monorails and hoists.
    - ⬚ Automated systems—conveyors, AGV's.
    - ⬚ Miscellaneous systems—industrial robots, transfer mechanisms, elevators, pipelines,containers, dial indexing tables, etc.

2. What is Gantry Robot?

    Cartesian coordinate robots with the horizontal member supported at both ends are sometimes called Gantry robots.

3. Write some applications of AGV?
    - ⬚ Driverless train operations
    - ⬚ Storage distribution system
    - ⬚ Assembly line operation
    - ⬚ FMS

4. List out types of AGV vehicles?
    - ⬚ Towing vehicles
    - ⬚ Unit load vehicles
    - ⬚ Pallet trucks
    - ⬚ Fork trucks
    - ⬚ Light load Vehicles
    - ⬚ Assembly line vehicles.

5. Differentiate palletizing and depalletizing.

    A palletizer or palletiser is a machine which provides automatic means for stacking cases of goods or products on to a pallet.

    A depalletizer machine is any machine that can break down a pallet. Usually, a robot is used for this task, although there are some other forms of depalletizersthat can also break down pallets and move products from one place to another using simple push bars and conveyor belts.

6. What are the steps to be followed by the company in order to implement robot programs in its operations?
    - ⬚ Initial familiarization with the technology
    - ⬚ Plant survey to identify potential applications
    - ⬚ Selection of the application
    - ⬚ Selection of the robot
    - ⬚ Detailed economic analysis and capital authorization
    - ⬚ Planning and engineering the installation
    - ⬚ Installation

7. What are the typical technical features required for material transfer?

    Number of axes: 3to 5

    Control system: limited sequence or point-to-point playback

    Drive system: pneumatic or hydraulic

    Programming: manual, powered lead through

8. What are the different methods of economic analysis?
   1) Payback method
   2) Equivalent uniform annual cost (EUAC) method
   3) Return on investment (ROI) method

9. Write a note on ROI method?
   The return on investment method determines the rate of return for the proposed project based on the estimated cost and revenues.

10. Define EUAC method?
   Equivalent uniform annual cost (EUAC) method converts all of the present and future investments and cash flows into their equivalent uniform cash flows over the anticipated life of the project.

11. Define a deadman switch?
   A dead man switch is a useful control feature during lead through programming. It is a trigger or toggle switch device generally located on the teach pendant which requires active pressure to be applied tom the devices in order to drive the manipulator.

12. What are the general characteristics that make potential robot application technically practical and economically feasible?
   1) Hazardous or uncomfortable working conditions
   2) Repetitive operations
   3) Difficult handling jobs
   4) Multicast operation

13. Define payback period?
   IT is the length of time required for the net accumulated cash flow to equal the initial investment in the project.

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   A deadman switch is a useful control feature during leadthrough programming. It is a trigger or toggle switch device generally located on the teach pendant which requires active pressure to be applied them the devices in order to drive the manipulator.

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16. What are the different methods of cost analysis?
   1. Payback method
   2. Equivalent uniform annual cost (EUAC) method
   3. Return on investment (ROI)method.

17. Define EUAC method?
   Equivalent uniform annual cost method converts all of the present and future investments and cash flows into their equivalent uniform cash flows over the anticipated life of the project.

18. What is image resolution?

The resolution of a digital camera is often limited by the camera sensor (typically a CCD or CMOS sensor chip) that turns light into discrete signals, replacing the job of film in traditional photography. This means that the brighter the image at that point the larger of a value that is read for that Pixel.

19. Define Tracking?

Tracking is defined as the motion of the scene, objects or the camera given a sequence of images Knowing this motion, predict where things are going to project in the next image, so that we don't have so much work looking for them.

20. What are the techniques used in object recognition?
    1. Template matching technique
    2. Structural technique

PART-B Questions

1. Briefly explain AGV and RGV Types of robots in detail.
2. Briefly explain the economic analysis of Robots in detail.
3. Briefly explain the safety sensors and safety monitoring of robots in detail.
4. Briefly explain the workplace design consideration for safety of robots in detail.
5. Briefly explain the various steps involved for implementing the robot in industries.
6. Write a critical note on any two methods for economic analysis of industrial robots.
7. List and explain indirect cost and savings in robot application project.
8. Explain the logical sequence of steps in implementing robotics.
9. Explain working of AGV with component based DCS
10. Briefly explain the workplace design consideration for safety of robots in detail