ROBOTICS AND AUTOMATION

UNIT I – BASIC CONCEPTS
PART – A

1. **Define a Robot? (Apr 2014)**

   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 task".

2. **What is meant by automation and what are its types?**

   Automation is a technology that is concerned with the use of electronic mechanical and computer based system in the operation control and production.

   Various types of automation:

- Fixed automation
- Programmable automation
- Flexible automation

3. **Why a robot used?**

   a. To reduce production cost
      - Fast
      - Accurate
      - Difficulties in human nature

   b. To avoid 3-D jobs
      - Dirty
      - Dangerous
      - Difficult

4. **What is meant by robot anatomy?(Nov 2013)**

   Robot anatomy means study of structure of robot. Manipulator is constructed of a series of joints & links. A joint provides relative motion between the input link and the output link. Each joint provides the robot with one degree of freedom.

5. **Write are the Benefits of industrial automation? (Apr 2014)**
   - Improved product quality
   - Improved safety
   - Increased manufacturing flexibility
   - Improved operation reliability
   - Improved decision making

6. **Write Asimov's laws of robotics?(Nov 2013)**

   Three rules written by science fiction author Isaac Asimov and later expanded upon. These rules are built in to almost all positronic robots appearing in his fiction and cannot be bypassed. The rules are introduced in his 1942 short story *Runaround* although they were foreshadowed in a few earlier stories.

   The Three Laws of Robotics are as follows:

   I. A robot may not injure a human being or, through inaction, allow a human being to come to harm.

   II. A robot must obey any orders given to it by human beings, except where such orders would conflict with the First Law.

   III. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

7. **Classify the motion control of Robot arm?**
   - Limited sequence control
   - Point to point control
   - Continuous path control
   - Intelligent control

8. What are the Advantages and disadvantages of robot?

Advantages

- Greater flexibility, reprogrammability, adjustable kinematics dexterity
- Greater response time to inputs than humans
- Improved product quality
- Maximize capital intensive equipment in multiple work shifts.

Disadvantages

- Replacement of human labour
- More unemployment
- Significant retraining costs for both unemployed and users of new technology
- Advertising technology does not always disclose some of the hidden disadvantages

9. Write about origin of robot.(Dec 2012)

The word robot was not even in the vocabulary of industrialists, let alone science fiction writers, until the 1920s. In 1920, Karel C˘ apek (1890–1938) wrote the play, Rossum's Universal Robots, commonly known as R.U.R., which premiered in Prague in 1921, played in London in 1921, in New York in 1922, and was published in English in 1923. As C˘ apek wrote his play, he turned to his older brother, Josef, for a name to call these manmade workers. Josef replied with a word he coined—robot.

10. What is degree of freedom? (Dec 2012)

It is described as one of the variables required to define the motion of a body in space. Each joint in a robotic system gives the robot one degree of freedom.

PART B

1. Sketch and explain two views to indicate the work envelope of a (Nov 2013)

i) Cartesian robot.ii) Polar robot. iii) Cylindrical robot iv) Anthropomorphic robot

2. Explain in detail about robot specifications? Discuss the various generations of robots. **(May 2013)**

3. Sketch and explain the various robot configurations and with help of sketch describe pitch, yaw and roll motion of a robot wrist

4. Explain a robot structure with a sketch. What are the various types of joints used in robots?**(Dec 2014)**

UNIT II – POWER SOURCES AND SENSORS

PART A

1. Define micro machines in robotics.

It deals with the controlled manipulation of objects with micrometer scale dimensions. Micromanipulation is most effective process. It is concerned with construction and programming of robots with overall dimensions at the microscale.

2. State the advantages and limitation of a hydraulic drive? (Nov 13)

Advantages:

- It gives greater speed and strength
- It gives highest power to weight ratio
- It is used for heavy pay loads
- It can be used for large working envelope
- It is safe and reliable to work in wet and dirty conditions
- It can be used in hazardous environment.

Disadvantages

- It occupies more space
- Maintenance should be done regularly

3. What are the types of hydraulic actuator? (May 14)

The types of hydraulic actuators are

- Linear hydraulic actuator
  - I. Single acting cylinder
  - II. Double acting cylinder
  - III. Double acting double rod cylinder
- Hydraulic rotary actuator
  - I. Gear motor
  - II. Vane motor
  - III. Piston motor

4. **What is thresholding? What is segmentation?**
   Thresholding is a binary conversion technique in which each pixel is converted into a binary value either black or white.
   Segmentation is the method to group area of an image having similar characteristics or features into distinct entities representing part of the image.
5. **Describe the functions of machine vision system.**
   Sensing and digitizing image data
   Image processing and analysis
   Application
6. **List out the basic lighting devices used in vision system.**
   Diffuse surface device
   Condenser projectors
   Flood or spot projectors
   Collimator
   Imagers
7. **List out the applications of micro robots.**
   Medical field in surgery
   Mining in hard core areas
   Surveillance in border security
   To monitor the dangerous microorganism in ocean
8. **What is the role of tactile sensor? (May/June 2013)**
   Tactile sensors are employed wherever interactions between a contact surface and the environment are to be measured and registered. Tactile sensors are useful in a wide variety of applications for robotics and computer hardware and even security systems.
9. **What is gear ratio? (May/June 2013)**
   The gear ratio of a gear train, also known as its speed ratio, is the ratio of the angular velocity of the input gear to the angular velocity of the output gear. The gear ratio can be calculated directly from the numbers of teeth on the gears in the gear train.
10. **What are the desirable features of sensors? (Nov 13/May 14) What are the basic classifications of sensors?**
    i. Accuracy
    ii. Precision
    iii. Operating Range
    iv. Speed of response
    v. Calibration
    vi. Reliability
    vii. Cost and ease of operation

    Classifications of sensors

    i. Tactile sensors
    ii. Proximity sensors
    iii. Range sensors
    iv. Voice sensors etc

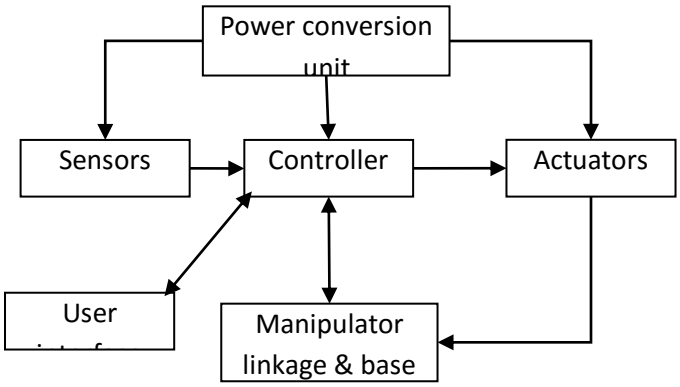
PART – B

1. With a neat block diagram, describe the different stages of machine vision system. **(May/June 2013)**
2. Describe electronic drive system for robots. What are the merits and demerits of DC motors? **(May/June 2013).**
3. Discuss in detail about the various types of sensors used in robotics. Distinguish between tactile and non-tactile sensors. Sketch and explain the working of an acoustic sensor (**May 14)**
4. Sketch and explain pneumatic and hydraulic manipulator drives used for robots. (**Nov 13)**

UNIT III – MANIPULATORS, ACTUATORS AND GRIPPERS

PART - A

1. Draw the block diagram of manipulator and mention its building blocks.



2. List the advantages of electronic control circuit of manipulator.

The electronics control system has following advantages

Very compact and small in size
Consumes very less power
Very fast in response
Much more accurate and efficient than conventional system
Wide control ranges
Economical, since maintenance cost is minimum
Highly protective.

3.List the advantages of pneumatic control circuit of manipulator.

The advantages of are Pneumatic control circuits are
Exhaust air is released directly into the atmosphere
Most pneumatic circuits employ a centralised compressor as their source of energy.
The input to the circuit is fixed at some conveniently located manifold which leads directly into the FRL (Filter Regulator Lubricator) unit.

4.What are the different methods of speed control of DC motors used in manipulator?

DC motor speed can be controlled using thyristors, some methods are

Armature voltage control methods (also called phase control method of speed control.)

D C chopper speed control (A chopper can give variable D.C at its output)

Speed control by using a dual converter (includes rectifier and inverter.)

5. **Define End effector. (Nov 2013)**

End effector is a device that is attached to the end of the wrist arm to perform specific task.

6. **What is meant by gripper? Mention its classifications.**

Gripper is a End effector which can hold or grasp the object .

Grippers may be classified based on

single and multiple gripper

External gripper, internal gripper

Mechanical grasping devices, magnets, suction cups.

7. **.Briefly explain about mechanical grippers. (May 2014)**

A mechanical gripper is an end effector that uses mechanical fingers actuated by a mechanism to grasp an object.The fingers (jaws) make contact with the object. The fingers are either attached or integral part of the mechanism. Fingers are interchangeable to accommodate different parts. Two fingers are sufficient to hold the work part. Grippers with three or more fingers are less common.

8. **List the advantages and features of suction cup gripper? (May 2014)**

a) Require only one surface of the part for grasping,
b) Applies uniform pressure distribution on the surface of the part,
c) Relatively a lightweight gripper,
d) Applicable to a variety of different material.

9. **What are the merits and demerits of magnetic gripper? (Nov 2013)**

Advantages: Pickup time very fast, Variation in part size can be tolerated, The gripper do not have to be designed for one particular work part, They have ability to handle metal parts with holes, They require only one surface for gripping

Disadvantages: Residual magnetism, Side slippage, More than one sheet will be lifted by magnet from a stack

10. **What is a stripping device? When it is required?**

The device which accomplishes this separation technique is called a stripper or stripping device. Its function is to mechanically detach the part from magnet. Permanent magnets are used for handling tasks in hazardous environments requiring explosion proof apparatus. i.e no electrical circuit is needed to operate the magnet reduces the danger of sparks which cause ignition

11. **List any four considerations in gripper design.**

The part surface to be grasped must be reachable.

The size variation of the part must be accounted.

The gripper design must accommodate the change in size that occurs between part loading and unloading.

The scratching and distorting the part during gripping must considered.

Gripper fingers can be designed to conform to the part shape.

12. **List some top priority guidelines in gripper selection**

Part to be handled, Actuation method, Power and signal transmission, Gripper force, Operating condition, Fabrication materials, etc

PART B

1. What are the different types of gripper mechanism used for robots manipulator? Explain in detail about the magnetic, vacuum grippers, inflated devices and adhesives grippers. **(Nov 2013/May 2015)**

2. Discuss in detail about the construction of a manipulator. ii) Discuss in detail various types mechanical grippers. **(Nov 2013/May 2014)**
3. Explain the different types of speed control methods using electronic components and circuits to control the robot motions? **(May 2015)**
4. What are the design considerations in selection of a gripper? Explain the different types of speed control methods using pneumatic circuits to control the robot motions)**(Nov 2013)**

UNIT IV – KINEMATICS AND PATH PLANNING

PART A

1. **Determine the coordinates of robot having arm length of 300 mm, its initial position is (10,20) and rotates at an angle of 45 deg. Clockwise. (Nov/Dec 2012)**

$$p_{initial} = \begin{bmatrix} 10 \\ 20 \\ 0 \\ 1 \end{bmatrix};$$

unit vector corresponds to 30° rotation in clockwise is $u = \begin{bmatrix} \cos(-45) \\ \sin(-45) \\ 0 \\ 1 \end{bmatrix}$

$$p_{final} = \begin{bmatrix} 1 & 0 & 0 & 0.707 \\ 0 & 1 & 0 & -0.707 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 10 \\ 20 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 10.707 \\ 19.293 \\ 0 \\ 1 \end{bmatrix}$$

2. **Find out the link length and angle of twist at robot joint if the end effector is located at (0.7, 0.7) (Nov/Dec 2012)**

   $0.7 = L_1\cos\theta_1$ (1)

   $0.7 = L_1\sin\theta_1$ (2)

   eqn 2/eqn1

   $\tan\theta_1 = 0.7/0.7 = 1 \quad \theta_1 = 45$

   $L_1 = 1$

3. **What is forward kinematics and where it can be applied? (May/June 2013)**

   Kinematics is the study of motion without regarding forces that cause it. Forward kinematics is the determination of the position of the robot end effector in the world coordinate system by knowing the joint angles and the link parameter of the robot. It is used to calculate the position and orientation of the end-effector in terms of the joint variables.

4. **What is inverse kinematics?**

   Kinematics is the study of motion without regarding the forces that cause it. Inverse kinematic is the calculation of joint values given the positions, orientations, and geometries of robot links.

5. **What is homogeneous transformation?**

Homogeneous transformation provides the mathematics for describing points with preferred orientations in three dimensional space. Using the homogeneous transformations, a serial links of manipulator may be modeled as a set of reference frames whose relative positions and orientations are determined by the values of the joint variables.

6. **Define jacobian in the field of Robotics.**

The jacobian is a multidimensional form of the derivative. Jacobians are time varying linear transformations. In the field of robotics jacobians relate joint velocities to Cartesian velocities of the tip of the arm.

$$^{\circ}\upsilon = {}^{\circ}J(\theta)\dot{\theta}$$

The number of rows of J(θ)equals the number of degrees of freedom in the Cartesian space being considered. The number of columns is equal to the number of joints of the manipulator.

7. **Write the rotational transformation matrix of a point when it is rotated by an angle θ with respect to x axis, rotated by an angle θ with respect to y axis, rotated by an angle θ with respect to z axis of a three coordinate system**

$$\text{Rot}(x,\theta) = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$\text{Rot}(y,\theta) = \begin{pmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$\text{Rot}(z,\theta) = \begin{pmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ & & 0 & 1 & 0 \\ 0 & & 0 & 0 & 1 \end{pmatrix}$$

8. **Write the overall transformation matrix when both rotation and translation of a point in a three coordinate system.**

$$T = \begin{pmatrix} n_x & o_x & a_x & p_x \\ n_y & o_y & a_y & p_y \\ n_z & o_z & a_z & p_z \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

9. **Brief hill climbing techniques.**

Hill climbing is a mathematical optimization technique which belongs to the family of local search. Hill climbing is used for solving computationally hard problems. It is best used in problems with "the property that the state description itself contains all the information needed for a solution" .The algorithm is memory efficient since it does not maintain a search tree: It looks only at the current state and immediate future states.

10. **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.

11. **Name the basic elements and functions of robot language. (Nov 2013)**

- Constants, variables and other data objects
- Motion commands

- End effector and sensor commands
- Computations and operations
- Program control and subroutines
- Communications and data processing
- Monitor mode commands

12. What are the advantages of off-line robot programming? (May/June 2013)

- Reducing the onsite programming time
- Reducing the downtime of equipment when programming new workpieces/variants
- Programming complex paths (for example, deburring, welding in tight spaces, grinding, polishing, etc, which are highly time consuming

PART B

1. a. Determine the coordinates of end effector point of joint J1,twist by and angle of 50 deg and variable link has length of 500mm. Assume it is a TL robot and coordinate system is defined at joint J2. **(Nov/Dec 2012)**

   b. Discuss about hill climbing technique of robot.**(Nov 2013)**

2. a.In RR robot the origin of the global coordinate system is at J1 has two links of length 800mm. determine the coordinate of the end effector point if the joint rotations are 65 deg at both joints, and determine joint rotations if end effector is locates at (10,20).
   b.Discuss about jacobian work envelope with example. **(Nov/Dec 2012)**

3. What is robot software? List the advantages and disadvantages of off-line programming? **(Nov 2013/Apr 2014)**

4. a. Discuss the different inputs to an inverse kinematics algorithm. Explain the solution of a simple inverse kinematic algorithm. **(Nov 2014)**

b.. Derive the forward kinematic equation of RR robot. **(May 2015)**

b. A 2D two link robot has length L1=5cm and L2 =4cm and end effectors position at [Xp Yp] is (3.5, 7.5). Find joint angle between link 1 and the ground surface. **(May 2015)**

UNIT V – CASE STUDIES

PART A

1. Write some industrial application of robot?

a). Material handling application

- Material transfer application
- Machine loading/unloading application

b). Processing application

- Welding
- Painting
- Assembly
- Inspection

2. What are the benefits of industrial robot? (April 2014)

Industrial robot offers the following benefits

- Increase productivity
- Improve product quality

- More consistent product quality
- Reduce scrap and waste
- Reduce reworking costs
- Reduce raw goods inventory
- Direct labour cost saving
- Saving in overhead cost such as lighting, heating and cooling

3. **What is palletizing and depalletizing?**

Palletizing is the operation in which the robot picks cartons from conveyor and places them on to a pallet

Depalletizing operation is the reverse of palletizing operation in which the robot removes cartons from the pallet and places them on to conveyor or other location

4. **What are the different types of material handling operation? (Nov 2013)**
   - Picking and placing
   - Palletizing and depalletizing
   - Machine loading and unloading
   - Parts feeding , storage and retrival
   - Sorting of the parts from conveyors
5. **Define the term "CIM". (April 2014)**

The term CIM denotes the use of computer pervasive use of computer system to design the product, plan the product, control the operations and perform the various business related function.

6. **What are parts feeding, storage and retrieval Process?**
   - Parts feeding means feeding the part to the machine
   - Storage means storing different types of object in the pallet
   - Retrieval is the process of taking the object from the pallet
7. **What is assembly? What are the types of assembly operation?**

The term assembly is defined to mean the fitting of two or more discrete parts to form a new subassembly.

- Parts mating
- Parts joining

8. **Define part presentation and Explain bowl feeders?**

In order to perform an assembly task the part that is to be assembled must be presented to robot this is called part presentation

Bowl feeders are devices used for feeding and orienting small parts in automated assembly operations. They are made two main components

- The bowl
- The vibrating base

9. **Explain designing for robot assembly. (Nov 2013)**
   - Certain assembly tasks are very difficult for the robot to perform than others. If possible this difficulty factor should be consider in the design of product
   - Another consideration in the design of an assembly is the direction in which the parts are to be added in the assembly operation
10. **What are the functions of work cell controller? (May/June 2013)**

Robot workcell controller (also known as the *robot workstation controller*) is employed for*controlling* the different activities that take place successively or simultaneously in the workplace. It also includes one important aspect of providing *safety* to the human operators. There are *three types* of tasks carried out by the workcell controller such as:

Sequence Control

Operator Interface

Safety Monitoring

11. **List any four non-manufacturing application areas of robotics. (May/June 2013)**

Navigation, Space, Medical surgery, teaching aids

PART B

1. With suitable diagram, explain industrial application of robot in non-manufacturing field. (**Nov 2014)** Write a detailed note on robot computer interface and robot cell design. **(May/June 2013)**

2. What is spot welding? Describe briefly the operations involved in robotic spot welding. What are advantages of robotic welding over manual welding? **(April 2014)**

3. Static characteristics of work which promote application of robots. Discuss robot application for assembly and inspection. **(April 2014) / (Nov 2014)**

4. Write short notes: **(Apr 2015)**
(i)Robot Cell Layouts.
(ii)Selection of a Robot.

5. What is the need of robots and automation in following applications?(**Apr 2015)**
(i)Welding
(ii)Die casting
(iii)Palletizing