EC2024 –ROBOTICS AND AUTOMATION

QUESTION BANK

UNIT-I

PART-A

1. Write a brief note on sensors in robotic application. (April 2010)

Position sensors, LVDT, Velocity sensors, Acceleration sensors, force and pressure sensors

2. Briefly write on the drives in robotic application. (April 2010)

Electric motors, Servo motors, Stepper motors, Direct drive Electric motors, Hydraulic actuators, Pneumatic actuators, Magnetostrictive actuators

3. 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 ".

4. Name the commonly used robot configuration system?

Cartesian coordinate system, cylindrical coordinate system, Polar or spherical coordinate system, Revolute coordinate system

5. What are Asimov's law of Robotics

Robot may not injure a human being or, through inaction, allow a human being to come to harm.

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

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

6. What is the classification of Robots?

1. Manual-handling Devicxe
2. Fixed-Sequence Robot
3. Variable-sequence Robot
4. Playback Robot
5. Numerical Control Robot
6. Intelligent robot

7. What are the advantages of robots?

1. Increase in Productivity, Safety, Efficiency, quality and consistency of products
2. It can work in Hazourdous environment
3. No environmental comfort such as lightening, air conditioning
4. It can work continuously without boredom, hangovers
5. More accurate than human

8. What do you understand by degree of freedom?

The number of independent motion in which the end effector can move, defined by the number of axes of motion of the manipulator.

9. What are the disadvantages of robots

Inappropriate or wrong responses , A lack of decision-making power ,A loss of power Damage to the robot and other devices ,Human injuries , Costly due to initial cost, installation cost, need for pheripherals, training, programming

10. What are Robot Coordinates

Cartesian coordinate, Cylindrical coordinate, Spherical coordinate, Articulated/Anthromorphic, Selective Compliance Assembly Robot Arm (SCARA)

11. What are Robot Reference frames

1.World Reference frame (x,y,z axes) or universal coordinated frame

2.Joint Reference frame, 3.Too, reference frame

12. What are Robotic Characteristics?

1. Payload, Reach, Precision (Validity), Repeatability(Variability)

13. What is robot work space?

Depending on their configuration and size of their links and wrist joints, robots can reach a collection of points called a workspace

14. What are the Robot Applications?
Machine Loading, Pick and Place operations, Welding, Painting, Inspection, Samplig, Assembly, Manufacturing, Survielance, Medical Applications, Hazardous environments
15. What are the different types of wrists used in a robot?
The different types of wrist used in a robot are Pitch, Yaw, and Roll.
16. Distinguish between hard & flexible automation.

Sl. No:	Hard automation	Flexible automation
1	The volume of production is high	The volume of production is low.
2	The product variety is less	More product variety.
3	Initial cost is high.	Initial cost is low.
4	The equipment is designed for one product, can't be used for other.	The equipment is used for different product and it can be used for other batch process.

PART-B

1. What is degree of freedom? Explain with an example.
2. Discuss the different applications of industrial robots
3. Explain the history of robotics from the origin.
4. State and Explain Asimov's law with proof.
5. Describe the classification of robots and explain them

UNIT-II

1. What are the classification of robot layout
Robot centered , In line robot, Mobile robot
2. What are the types of actuators used in Robots
Electric Motors, Hydrualic actuators, Pneumatic actuators, Magenetostrictive actuators
3. What are the types of encoders?
Linear encoder, Rotary encoder, Absolute encoder, Incremental encoder
4. What are the Robotic Components

Manipulator or cover ,End effector ,Actuators ,Sensors ,Controller ,Processor

5. List out the different types of Robot joints
Prosmatic Joints , Revolute joints
6. Define the term path used in robotics.
A path is defined as a sequence of robot configurations in a particular order without regard to the timing of these configurations.
7. Define trajectory.
A trajectory is defined as a sequence of robot configurations in a particular order when each part of the path must be attained, thus specifying timing.
8. Distinguish between path and trajectory.

Path	Trajectory
It is a sequence of robot configurations in a particular order without regard to the time	It is a sequence of robot configurations in a particular order with regard to the time
It does not concerned about velocities and accelerations	It concerned about velocities and accelerations

9. List out various types of trajectories.
Joint space trajectory, Cartesian space trajectory, Bang-bang trajectory, Cubic spine trajectory

10. What is joint space description

    The description of the motion to be made by the robot by its joint values is called joint space description. In this case, although the robot will eventually move to the desired position, the motion between the two points is unpredictable.

11. What is joint Cartesian space description

    The description of the motions of a robot relative to the Cartesian reference frame, as followed by the position and orientation of the robot's hand is called Cartesian space description.
    Distinguish between joint and Cartesian space description.

12. What is a knot point?

    Knot points are intermediate points in trajectory planning which use to move the robot from one segment to another segment

13. What are the two approaches for achieving for path planning?
    a. Cartesian space oriented method
    b. Joint space oriented method

14. What is bounded deviation joint path?

    It is a joint path, which selects enough intermediate points during the preplanning phase to guarantee that the manipulator hand's deviation from the Cartesian straight line path on each motion segmented

15. Give the expression for third order polynomial trajectory planning?

$$\theta(t) = c_0 + c_1 t + c_2 t^2 + c_3 t^3$$
$$\dot{\theta}(t) = c_1 + 2c_1 t + 3c_3 t^2$$

    Where $\theta(t)$ is joint angle and $\dot{\theta}(t)$ is velocity , c_0, c_1, c_2 and c_3 are constants.

16. Give the expression for fifth order polynomial trajectory planning?

    The expression for third order polynomial trajectory planning is

$$\theta(t) = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + c_4 t^4 + c_5 t^5$$
$$\dot{\theta}(t) = c_1 + 2c_2 t + 3c_3 t^2 + 4c_4 t^3 + 5c_5 t^4$$
$$\ddot{\theta}(t) = 2c_2 + 6c_3 t + 12c_4 t^2 + 20c_3 t^3$$

17. What are the assumptions made for trajectory planning?

    The assumptions are the initial condition for trajectory planning

$$\theta(t_i) = \theta_i, \theta(t_f) = \theta_f,$$
$$\dot{\theta}(t_i) = 0, \dot{\theta}(t_f) = 0,$$

    where t_i is initial time anf t_f is final time.

18. Give the expression for linear segment with parabolic blends trajectory planning?

$$\theta(t) = c_0 + c_1 t + \frac{1}{2} c_2 t^2$$
$$\dot{\theta}(t) = c_1 + c_2 t$$
$$\ddot{\theta}(t) = c_2$$

19. How the trajectory planning problem is formulated?

    The trajectory planning problem is formulated as a maximization of the distance between two consecutive Cartesian set points on a given straight line path subject to the smoothness and torque constraints

20. Distinguish between tactile and force sensor

    Tactile sensor is device that indicates the contact between themselves and some other solid objects. Whereas force sensor exhibit decreasing resistance when force is increased

Part B

1. Describe briefly any two actuators used in robots
2. Describe the relative merits of electric, hydraulic and pneumatic actuators?

3. Briefly discuss about the sensors used in robotics
4. Explain in detail about touch and tactile sensors
5. Write short notes on:
    a. trajectory planning for orientation of the end effectors.
    b. Cartesian space trajectory.

Unit III

1. The common methods of teaching a robots

The common methods of teaching robots are

a) Leadthrough teaching, b) Textual teaching

2. Define manipulator

Manipulator is a mechanical device; consist of links and joints driven by actuatorsand composed of a main frame (arm) and a wrist. The robot having the same physical body but it is controlloed by external controller and it can be act as human being.

3. Define the end of arm position in world space & joint space

Pw (x,y), $P\theta(\theta_1 , \theta_2)$

4. Define the motion types in manipulator path control

Slew motion, Straight line motion

5. What are the two methods of lead through programming

Manual lead through, Powered lead through

6. Application of power lead through and manual lead through

Spot welding and spray painting respectively

7. What are the methods of defining the position in space Joint movement?

xyz co- ordinate motion, tool co-ordinate motion

8. What are the two main reasons for defining the points?

To define a working position for the end effector and to avoid obstacles

9. What is meant by straight line interpolation?

The robot controller computes the straight line path between two points and develops the sequence of addressable poits along the path for the robot to pass

10. Explain WAIT

WAIT N – the robot controller should wait at its current location until it receives signal on Line N

11. Explain the command DELAY.

The robot controller should wait X sec before proceeding to the next step in the program

12. List out any three second generation language

AML, RAIL,MCL

13. Explain any two features of second generation language

Motion control, advanced sensor capabilities

14. What are the basic modes of operation of robot language operating system ?

Monitor mode, Run Mode, Edit Mode

15. What is the acronym of VAL ?

Victor's Assembly Language

16. What is meant by forward transformation ?

Going from joint space to world space is called forward transformation

17. What is meant by reverse transformation ?

Going from world space to joint space is called forward transformation

18. For the vector v=25i+10j+20k perform the translation by a distance of 8 in the X direction 5 in the Y direction and 0 in the z direction

$H = [33\ 15\ 20\ 1\ ]^T$

19. What is the function of the gripper?

The function of gripper is to grasp and hold the objects or workpart

20. Rotate the vector v=5i+3j+8k by an angle 90 deg about X axis

$H = [5\ -8\ 3\ 1\ ]^T$

PART B

1. Obtain the Cartesian & homogenous representations for dot product of the two vectors X & Y.
2. Give an example for transnational transformation.
3. Explain with a sketch the configuration of a controller & its principle of operation.
4. Explain the important characteristics to be added to the existing commercial robots to improve them for using in the factory.
5. Determine a T matrix that represents a rotation through an angle α about the OX axis followed by a translation of 'b' unit of distance along the OZ axis followed by a rotation of ϕ about the OY axis.
6. With a block diagram explain the concept of forward & inverse kinematics scheme.

UNIT IV

Part A

1. Define the term path used in robotics.

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4. List out various types of trajectories.

   Joint space trajectory, Cartesian space trajectory, Bang-bang trajectory, Cubic spline trajectory
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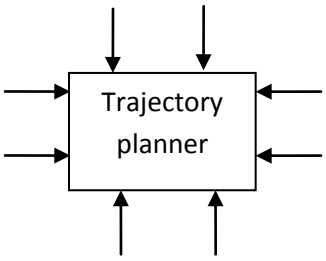
   The description of the motion to be made by the robot by its joint values is called joint space description. In this case, although the robot will eventually move to the desired position, the motion between the two points is unpredictable.
6. What is joint Cartesian space description

   The description of the motions of a robot relative to the Cartesian reference frame, as followed by the position and orientation of the robot's hand is called Cartesian space description.
7. Distinguish between joint and Cartesian space description.

Joint space description	Cartesian space description
It depends only motion of the robot	It depends position and orientation of robot
The joint values directly calculated	The joint values must be repeatedly calculated through inverse kinematic equations

8. What is a knot point?

   Knot points are intermediate points in trajectory planning which use to move the robot from one segment to another segment
9. Draw the block diagram for trajectory planner.



10. Mention the advantages of Cartesian space description.
    a. straightforward concept
    b. certain degree of accuracy is assured along with the desired path
11. Mention the disadvantages of Cartesian space description.
    a. computationally intensive to longer control intervals
    b. transformation of cartisian to joint coordinates is ill-defined
12. What are the methods to realize Cartesian path planning?
    The two methods to realize the Cartesian path planning are
    a. generating a set of knot points in Cartesian coordinates according to some rules along the catresian path
    b. specifying a class of functions to link these knot points according to some ceiteria.
13. What are the two approaches for achieving for path planning?
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14. What is bounded deviation joint path?
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18. Give the expression for linear segment with parabolic blends trajectory planning?

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$$\ddot{\theta}(t) = c_2$$

19. Give the expression to find blending time.
    The blending time t_b can be calculated from the equation

$$t_b = \frac{\theta_i + \theta_f + \omega t_f}{\omega}$$ Where ω is joint velocity

20. Give the expression for velocity constraints.

To minimize the objective function $T = \sum_{i=1}^{n-1} u_i$

Subject to the velocity constraints: $\left|\dot{Q}_{ji}(t)\right| \le V_j \quad \begin{matrix} j = 1,...., N \\ i = 1,.., n-1 \end{matrix}$

21. Give the expression for acceleration constraints.

To minimize the objective function $T = \sum_{i=1}^{n-1} u_i$

Subject to the acceleration constraints : $\left|\ddot{Q}_{ji}(t)\right| \le A_j \quad \begin{matrix} j = 1,...., N \\ i = 1,.., n-1 \end{matrix}$

22. Give the expression for torque constraints.

To minimize the objective function $T = \sum_{i=1}^{n-1} u_i$

Subject to the torque constraints : $\left|\tau_j(t)\right| \le \Gamma_j,\ j = 1,...., N$

23. How the trajectory planning problem is formulated?
The trajectory planning problem is formulated as a maximization of the distance between two consecutive Cartesian set points on a given straight line path subject to the smoothness and torque constraints

Part B

1. It is desired to have the first joint of a six axis robot go from initial angle of 30^o to a final angle of 75^o in 5 seconds. Using a third order polynomial, calculate the joint angles at 1, 2, 3 and 4 seconds. Suppose that the robot arm is to continue to the next point, where the joint is to reach 105^o in another 3 seconds. Draw the position, velocity and acceleration curves for the motion.
2. Write short notes on:
   a. trajectory planning for orientation of the end effectors.
   b. Cartesian space trajectory.
3. Solve for the coefficients of two cubics which are connected in a two-segment spline, with continuous acceleration at the intermediate via point. The initial angle is 0 degrees, the via point is 30 degrees, the goal is 45 degrees. The required time intervals for each segment is 10 seconds.
4. The trajectory of a particular joint is specified as follows: path points in degrees : 10, 25, 35, 10. The duration of these 3 segments should be 2, 1 and 2 seconds, respectively. The magnitude of the default acceleration to use at all blend points is 50 degrees / s^2. Calculate all segment velocities, blend times and linear times.
5. The second joint of a six-axis robot is go from initial angle of 20^o to an intermediate angle of 80^o in 5 seconds and then continue to its destination to 25^0 in another 5 seconds. Calculate the coefficients for third order polynomials in joint space. Plot the joint angles, velocities and accelerations curves.
6. Explain in detail how the trajectory planning is developed for higher order trajectories?

UNIT V

PART -A

1. What are open loop and closed loop control? **(April/may 2010)**

Open loop control:

Control of a process with out feedback .

Closed loop control:

The closed loop system compares the actual output measured by the sensor with the desired output and produces the error signal or actuating signal. The actuating signal is applied to the process so as to influence the output in a manner, which tends to reduce the error.

2. Distinguish palletizing and depalletizing. **(Nov/Dec 2010)**

Palletizing: Placing cartons onto the pallet

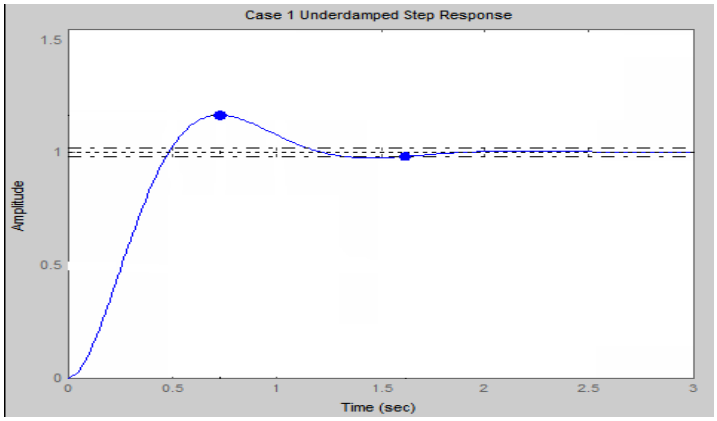
Depalletizing: Reverse of palletizing, i.e. removing of cartons from pallet and placing onto a conveyor

3. Write down a differential equation for a second order under damped system and show typical step response. **(April/may 2010)**

differential equation :

$d^2y / dt^2 + 5\, dy / dt + 25y(t) = 25x(t)$

Step response:



4. Distinguish between continuous and discrete time control. **(Nov/ Dec 2009)**

Continuous time control	discrete time control
Value of actuator force follows continuous function of time.	Value of actuator force follows discrete stair case function of time.

5. What are the different types of second order systems?

Un damped($\zeta = 0$), Under damped ($\zeta < 1$), Critically damped ($\zeta = 1$) and Over damped ($\zeta > 1$)

6. Name few operations done by robots in manufacturing field.

Material handling operations - palletizing / depalletizing, inserting parts into cartons, removing parts from cartons.

Machine loading and unloading operations

7. Give four Robot applications in processing field.

Spot welding , Continuous arc welding, spray coating and assembly task.

8. Mention few applications of robots in manufacturing field.

Robot are used in Die casting, plastic molding, forging and related operations, machining operations and stamping press operations.

9. What is meant by trajectory following control?

It means in addition to maintaining the block at desired location, controlling the block to follow the trajectory which is given by function of time.

10. What are the advantages of using Robots in arc welding?

Higher productivity, improved safety and quality of work, greater quality of product and process rationalization.

11. What are the benefits of using robots in spray coating?

Removal of operators from hazardous environment, lower energy consumption, consistency of finish, reduced coating material usage and greater productivity.

12. What is an error space in trajectory following control?
    Error space describes the evolution of errors relative to the desired trajectory. If the error space is less, the trajectory will be followed accurately.
13. Give the hierarchy of architecture of an industrial robot controller.
    The hardware architecture is that of a two-level hierarchy with a DEC LSI-11 computer serving as the top level "master" control computer passing commands to six Rockwell 6503 microprocessors.
14. List few robotic applications of machine vision.
    The application of machine vision is Inspection, Identification, Visual serving and Navigation
15. What is meant by "teach pendant"?
    A teach pendant is a hand held button box of the industrial robot PUMA 560, which allows the operator to move the robot around in a variety of modes(joint coordinates or Cartesian coordinates).
16. What are the different configurations are best suited for material loading?
    Polar cylindrical and jointed arm
17. Which configuration is best suited for spray painting?
    Jointed arm
18. Which control system is best suited for Arc welding?
    Continuous path play back method
19. What are the functional blocks of joint control system of PUMA 560?
    Microprocessor(6503), D/A converter, Current amplifier, motor and encoder.
20. What are the functions of LSI-11 of PUMA 560?
    Interpretation of programming commands, when a motion command is interpreted, does the inverse kinematic computations, plans a trajectory and begins generating trajectory via points every 28 milliseconds for the joint controllers.
21. What are the features of the welding robot?
    Work volume and degrees of freedom, motion control system, precision of motion, ability of the robot to work with other equipment.
22. Name two commonly used Robot languages and their significance.

PART -B

1. Describe the linear control of robot manipulation in detail. **(April/may 2010)**

2. Obtain a dynamic model for a single (rotary link)actuated by a DC motor and obtain the transfer function for position control, neglecting armature inductance. **(April/may 2010)**

3. (i) Enumerate with block diagram a robot control system. (8) **(Nov/ Dec 2009)**
(ii) Write in detail about modeling and control of a single joint (8)

4. (i) Enumerate with neat block diagram, the architecture of an industrial robot controller.(**Dec09)**
(ii) Describe a scheme of using a teleoperated robot for the maintenance of a reactor plant. **(6)**

5. Show the block diagram of model based trajectory following controller for a second order system and show that the closed loop system is stable. **(Nov/ Dec 2010)**

6. What are the applications of robots in manufacturing field. Explain any one in detail.
7. What are the applications of robots in processing field. Briefly explain them.
8. Explain how robots are used in assembly and inspection operations.
9. Briefly explain any one industrial application of robots. With suitable diagram.
10. Explain in detail about totally four applications of robot in 4 different fields.
11. A shaft(assumed massless) with a stiffness of 400Nm/radian drives a rotational inertia of 1Kg M^2.
    If the shaft stiffness was neglected in modeling of the dynamics, what is the frequency of this unmodeled resonance?

12. A link of mass 4.347 kg has an end-point lateral stiffness of 3600N/m. Assuming the drive system is completely rigid, the resonance due to the flexibility of the link will limit control gains. What is w_{res}?
13. A steel shaft of length 30cm and diameter 0.2 cm drives the input gear of a reduction of η=8. The rigid output gear drives a steel shaft of length 30 cm and diameter 0.3 cm. What is the range of resonant frequencies observed if the load inertia varies between 1 and 4 kgm².
14. Distinguish the usage of various configurations of electrical drives used in robotic application.
15. Distinguish with a neat sketch use various sensors used for internal and external sensing in robots.