Course Hand Out

Subject Name: ROBOTICS

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Year, Semester, Regulation: IV Year- I SEM (R16)

Unit-I: INTRODUCTION

Important points / Definitions:

- ✓ "**Robot**" today to mean any man-made machine that can perform work or other actions normally performed by **humans**, either **automatically** or by **remote control**.
- ✓ Robots can be made from a variety of **materials** including **metals** and plastics.
- ✓ The **Controller** - also known as the "brain" which is run by a computer program. Often, the program is very detailed as it give commands for the moving parts of the robot to follow
- ✓ **Mechanical parts** - motors, pistons, grippers, wheels, and gears that make the robot move, grab, turn, and lift. These parts are usually powered by air, water, or electricity
- ✓ **Sensors** - to tell the robot about its surroundings. Sensors allow the robot to determine sizes, shapes, space between objects, direction, and other relations and properties of substances
- ✓ **Artificial intelligence** has given robots more ability to process information and to "learn."
- ✓ **Robots** are machines with **programed movements** that allow them to move in certain directions or sequences.
- ✓ **Automation** technology, there have been significant achievements in such areas as communications, **service industries**, and consumer products.
- ✓ The other important aspects of automation, including its effect on **productivity**, economic competition.
- ✓ Higher output and increased productivity have been two of the biggest reasons in justifying the use of **automation**.

Short Questions

1. Define a robot and give its applications? (Apr/May-14)
2. What are the future applications of Robot?(Dec-10)
3. Discuss the history of robots?(June-09,Dec-10)
4. Explain the three types of powers used by Robots?(Dec-12)
5. What are the potential benefits achieved by introducing robots?(Apr/May-14,Dec-10)
6. What is work envelope of a robot? (Apr/May-09)
7. Distinguish an automation and a robot?(Dec-10,Dec-11)
8. What are the various types of joints used in robots?(Jun-09)
9. Explain degrees of freedom of a manipulator?(Apr/May-09,Jun-10,Dec-10)
10. Explain the vacuum cups of grippers?(Dec-10,Apr/May-14)

Long Questions

1. Explain the basic definition and operation of mechanical Grippers?(Dec-10,Apr/May-09,Dec-12)
2. Compare an articulated robot and Cartesian robot with respect to work envelope, manipulative ability and ease of control? (Jun-09)
3. Sketch and explain some linkage mechanisms for mechanical Grippers?(Dec-11)
4. What is compliant gripper? Why are complaint fingers used?(Dec-10)
5. Distinguish between two-point and three-point centering of robot grippers?(Dec-11)
6. Discuss suitable design of robot end effectors to grip objects like shafts, Rings, Flanges?(Dec-10,Apr/May-13)
7. Classify the coordinate system and control system with respect to robotics?(Apr/May-13,Dec-14)
8. Sketch any four of the following robots indicating the joints and degrees of freedom?
   a) polar robot b)cylindrical robot c)cartesisan robot d)scara robot e)Gantry robot f)jointed arm robot (Dec-11,Apr/May-09,10)
9. With the help of a line diagram show basic components of a robot connected to a system?
10. What is the error in the control loop and how can it be eliminated? (Dec-11)

Fill in the Blanks / Choose the Best:

1. The main advantages of robotics include **RELIABILITY AND FLEXIBILITY**

2. **Cartesian** configurations have three mutually perpendicular axes?
3. **YAW** terms refer to the left - right movement of a robot arm?
4. **Isaac Asimov** wrote the three laws of robotics
5. Based on finger movement, Mechanical gripper can be classified as **pivoting movement or translational movement**
6. **Pneumatic** drive is used for lighter class of Robot.
7. Robotic First Law states that **may not injure a human being through interaction**
8. Pitch motion enables **UPAND DOWN MOTION**
9. **Infinite** Number of occurrences of the event must be possible in the interval of the robot.
10. **PITCH** terms refer to the forward movement of a robot arm?

UNIT –II

MOTION ANALYSIS AND MANIPULATOR KINEMATICS

KEY POINTS:

- **Kinematics** pertains to the motion of bodies in a robotic mechanism without regard to the forces/ torques that causes **motion**.
- Robot kinematics also deals with motion planning, **singularity avoidance**, **collision avoidance**, as well as the kinematic synthesis of robots
- kinematics is the most fundamental aspect of **robot design, analysis, control**, and simulation
- **Motion planning** (also known as the navigation problem or the piano mover's problem) is a term used in **robotics** is to find a sequence of valid configurations that moves the **robot** from the source to destination.
- The robotics community has focused on efficiently applying different **representations** of **position** and **orientation** and their derivatives with respect to time to solve foundational kinematics problems
- The reverse process that computes the joint parameters that achieve a specified position of the end-effector is known as **inverse kinematics**.
- **Forward kinematics** specifies the joint parameters and computes the **configuration** of the chain. For serial manipulators this is achieved by direct substitution of the **joint** parameters into the forward kinematics equations for the serial chain.
- The geometry of the robot arm with respect to a reference coordinate system, while the end-effector moves along the prescribed path .
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SHORT QUESTIONS:

1. What is joint coordinates?.

2. What is the difference between forward kinematics and inverse kinematics?.

3. Define Manipulator? .

4. Discuss about planar two link Manipulator?.

5. What is homogeneous transformation?.

6. What is manipulator kinematics?

7. Define DH parameter?.

8. Differentiate world coordinates and joint coordinates? .

9. Explain the importance of Homogeneous transformation?

10. Write a short notes on inverse kinematics.

LONG QUESTIONS:

1. Explain about Homogeneous transformation in robotics Kinematics?(May-13)

2. Draw and explain with an example the composite homogeneous transformation (Dec2011,Dec-10).

3. Explain about the world coordinate system?(Apr/May-09).

4. Find the coordinates of point $P(2,3,4)^T$ relative to the reference frame after a rotation of 45^0 about the axis?.(Dec-10,dec-11)

5. verify the rotation matrices about the reference frame axes follow the required constraint equations set by orthogonally and length requirements of directional unit vectors?(Dec-11/Jul-09).

6. State the importance of Denavit-Hartenburg D-H convention?(Apr/May-06,Jun-06,Dec-10,Dec-11).

7. Write and explain the arm matrix of SCARA robot?(Dec-10,Dec-11).

8. Define and explain about inverse Homogeneous Transformations?(Dec-10).

9. Explain yaw-pitch-roll (YPR) Transformation with an example?(Apr/May-09).

10. Explain about the Forward Kinematics?(Jun-09).

FILL IN THE BLANKS:

1. Pitch motion enables **UP AND DOWN MOTION**.

2. Kinematic equations of a robot to compute the position of **END EFFECTOR .**

3 Mechanical errors arise due to which of the following causes **BACKLASH** .

4. **CARTESIAN** coordinate systems are used to find Forward Kinematics and Inverse Kinematics equation for position analysis..

5. In **FORWARD** Kinematics we used to determine where the robot's hand is

6. Robot kinematics applies geometry to the study of the movement of **MULTI DEGREE** of freedom**.**

7. A manipulator with 6 DOF is **SPATIAL MANIPULATOR**.

8. A commonly used convention for selecting frames of reference in robotics applications is **D-H CONVENTION.**.

9. **Newton-Euler** method can solve dynamic equations of motion of manipulators..

10. **D-H** model of representation is a very simple way of modeling robot links and joints that can be used for any robot configuration, regardless of its sequence or complexity.

UNIT –III

DIFFERENTIAL KINEMATICS AND ROBOT DYNAMICS

KEY POINTS:

- **Robot dynamic** is concerned with the relationship between the forces acting on a robot mechanism and the accelerations they produce.

- The robot mechanism is **modelled** as a **rigid-body system**, in which case robot **dynamics** is the application of rigid-body dynamics to robots.

- **Differential kinematics** is the most fundamental aspect of **robot design, analysis, control**, and simulation

- The two main problems in robot dynamics are:

  Forward dynamics: given the forces, work out the accelerations.

  Inverse dynamics: given the accelerations, work out the forces

  .

- Dynamic model consists of the following:

  a **kinematic model** of the robot mechanism, and

  a set of inertia parameters.

- **Inertia parameters** are required to define the inertia of a single rigid body (**mass**, location of **center of mass**,and six **inertia paremeters**).

- The **INSTANTANEOUS** motion of the robot is then uniquely characterized by the motion rates in the joints**.**

- The robotics community has focused on efficiently applying different **representations** of **position** and **orientation** and their derivatives with respect to time to solve foundational kinematics problems

- The reverse process that computes the joint parameters that achieve a specified position of the end-effector is known as **inverse kinematics**.

- **Differential kinematics** are **essential** for instantaneous motion analysis

- The geometry of the robot arm with respect to a reference coordinate system, while the end-effector moves along the prescribed path .

SHORT QUESTIONS:

1. What is meant by jacobian?.

2. What do you mean by torque sensor?.

3. What do you mean by Jacobian Matrix? .

4. What id the purpose of differential transformation?.

5. What is Dynamic Modeling?.

6. What are the advantages of Eulers –Lagrange formulation?

7. What is Newton-Euler formulation? Where are its applications?.

8. What is Euler-Lagrange formulation? Where are its applications?

9. Differentiate Between Newton-Euler and Euler-Lagrange?

10. Draw the Block diagram of Jacobian Forward Differential Motion model?.

LONG QUESTIONS:

1. Determine the Jacobian of the 3 DOF Euler wrist and also determine the singularities of the wrist?(Jun-09,Dec-10,Dec-11)

2. For a planar RP manipulator, Derive the Jacobian matrix and find the singularities?(Apr/May-09,Jun-10).

3. Find the Manipulator Jacobian Matrix J(Q) of the five axis spherical coordinate robot?(Apr/May-09,Jun-07).

4. Using Newton-Euler forward equations, Determine the joint torques or forces of a planar PR robotic Manipulator?.(Apr/May-09,Dec-11)

5. Using Lagrange –Euler formulation, Derive the expression for the joint torques of a planar revolute jointed robotic manipulator having unequal links?(Jul-09).

6. For a planar RRmanipulator, Derive the jacobian matrix and find the linear velocity and angular velocity of the end effector? (Dec-11).

7. What do you mean by Jacobian? Derive the Jacobian matrix for a planar 2-link revolute jointed manipulator?(Apr/May-09).

8. Determine the Jacobian of the 2 DOF Euler wrist and also determine the singularities of the wrist?(Dec-10).

9. Establish the dynamic model of a one-axis robot with Lagrangian-Euler Formulation?

10. What are the apparent advantages and disadvantages of the Euler-Lagrange and Newton-Euler formulations?(Jun-09).

FILL IN THE BLANKS:

1. The time derivative of the kinematics equations yields the **JACOBIAN** of the robot .

2. **Newton-Euler** method can solve dynamic equations of motion of manipulators**.**

3 In **FORWARD** Kinematics we used to determine where the robot's hand.

4. **World** coordinate systems are used to find Forward Kinematics and Inverse Kinematics equation for position analysis..

5. Mechanical errors arise due to which of the following causes **BACKLASH** .

6. Robot kinematics applies geometry to the study of the movement of **MULTI DEGREE** of freedom**.**

7. A manipulator with 6 DOF is **SPATIAL MANIPULATOR** in **NEWTON-Eulers** Formulation.

8. A commonly used convention for selecting frames of reference in robotics applications is **D-H CONVENTION.**

9. Kinematic equations of a robot to compute the position of **END EFFECTOR**.in robot dynamics.

10. **D-H** model of representation is a very simple way of modeling robot links and joints that can be used for any robot configuration, regardless of its sequence or complexity.