THE OPEN UNIVERSITY OF SRI LANKA

FACULTY OF ENGINEERING TECHNOLOGY
BACHELOR OF TECHNOLOGY – LEVEL 06
FINAL EXAMINATION – 2011

MEX6271– ROBOTICS

DATE : *20MARCH 2012*
TIME : *1400HRS - 1700HRS*
DURATION : *THREE HOURS*

PLEASE READ THE FOLLOWING INSTRUCTIONS BEFORE ANSWERING THE PAPER

INSTRUCTIONS:

1. *This paper consists of eight questions. Answer any **five questions only.***
2. *Each question carries equal marks.*
3. *Answers should be written on the answer books provided by the Examinations Division.*
4. *Commence to answer each question on a **fresh page***

Question 01

(1.1) Explain the term Robotics in your own words. Site examples to elaborate on your answer

(1.2) Distinguish **fourth generation** robots from **third generation** robots. What makes these robots different from the preceding types of robots when considering the evolution of robots?

(1.3) Briefly discuss four types of robots commonly encountered in the field of robotics.

(1.4) What is a **Stewart platform**? Explain the applications of Stewart platforms in industry or in the area of research.

Question 02

(2.1) *Robotic manipulators are typically considered to be **kinematic chains**.* Explain the term kinematic chain.

(2.2) Explain the role played by joints in achieving motion in robotic manipulators. What are the major three types of movement necessary for a robot manipulator to realize a desired motion?

(2.3) Define the term **Dextrous workspace** in relation to robot workspace.

(2.4) Explain the phenomenon of **singularity of a mechanism** with respect to a robot manipulator.

Question 03

(3.1) *Typically, an inverse kinematic problem is not simple and straight forward as a direct kinematic problem*. Elaborate. You may use a suitable example for explaining your answer.

(3.2) Explain the term **Jacobian** in relation to robotics. Why is it important in robotics?

(3.3) *A robot's **payload** is very much less than its **maximum load carrying capacity**.* Explain.

(3.4) Explain the reason of robotic manipulators often employ hybrid control schemes rather than using a position control or a force feedback scheme.

Question 04

(4.1) Explain the significance of **homogeneous coordinates** and **homogeneous transformations** in relation to modeling of robotic manipulators.

(4.2) Obtain an expression for the **basic homogeneous transformation matrix** with regard to frame transformations.

(4.3) The homogeneous transformation matrices between frames {i} – {j} and frames {i} – {k} are given as;

$$ {}^{j}\mathbf{T}_{i} = \begin{bmatrix} 0.866 & -0.500 & 0 & 10 \\ 0.500 & 0.866 & 0 & 1 \\ 0 & 0 & 1 & 5 \\ 0 & 0 & 0 & 1 \end{bmatrix} \text{ and } {}^{k}\mathbf{T}_{i} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0.866 & -0.500 & 10 \\ 0 & -0.500 & 0.866 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

Determine, ${}^{j}\mathbf{T}_{k}$.

Question 05

(5.1) Obtain a mathematical expression for composite transformation of frames.

(5.2) Two frames, {1} and {2} are initially coincident. Frame {2} is subjected to the following motions with respect to frame (1).

(i) A rotation of 60^0 about the z-axis.
(ii) A translation of 5cm along the z-axis.
(iii) A translation of 10cm along x-axis
(iv) A rotation of 30^0 about the z-axis

Determine the homogeneous transformation matrix after the above motions, describing frame {2} with respect to frame {1}.

Question 06

(6.1) Obtain mathematical expressions for **fundamental rotation matrices** for the three principle axes of a reference frame.

(6.2) What does XYZ fixed angle rotation matrix represent? Show that the order of rotations for XYZ and ZYX are equivalent.

(6.3) Represent **roll, pitch** and **yaw** on a neatly drawn sketch.

Question 07

(7.1) Briefly explain the reduced form of the **generalized homogeneous transformation matrix** used in modeling robotic manipulators. What is the significance of each sub-matrix in the reduced form of the generalized homogeneous transformation matrix?

(7.2) Figure 7.1 shows an object placed on a table. Two frames, frame {0} situated at the base of the table and the other, frame {1} is located at point **A** and oriented as shown below. The points **A**, **B** and **C** have the following coordinates with respect to frame {0}.

$$\mathbf{A}=\begin{bmatrix}5\\4\\2\end{bmatrix} \qquad \mathbf{B}=\begin{bmatrix}5\\2\\0\end{bmatrix} \qquad \mathbf{C}=\begin{bmatrix}5\\4\\0\end{bmatrix}$$

Determine the pose matrix P which represents the position and orientation of frame {1} with respect to frame {0}.

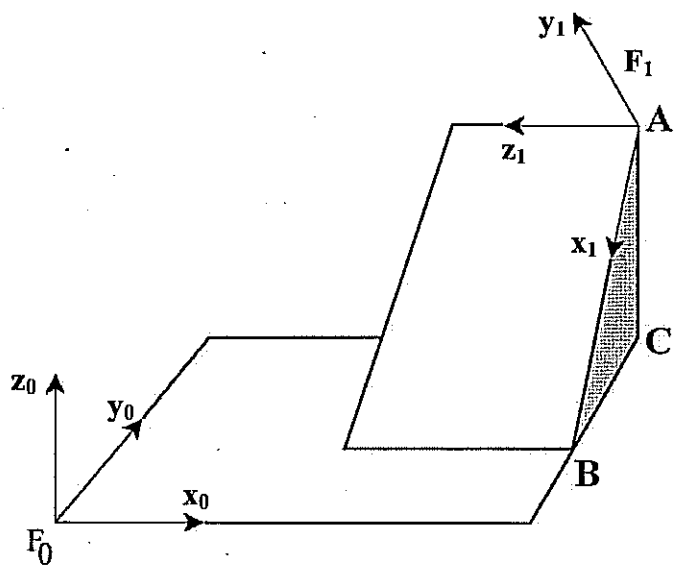


Figure 7.1

Question 08

(8.1) Distinguish a path from a trajectory in relation to robotic manipulators.

(8.2) What are the two most widely used techniques employed in robotic trajectory planning? Explain.

(8.3) The second joint of a SCARA manipulator is expected to move from $\theta_2 = 30^0$ to 150^0 in 5 seconds. Find the cubic polynomial to generate the smooth trajectory for the joint. What is the maximum velocity and acceleration of the joint?

END