THE OPEN UNIVERSITY OF SRI LANKA

FACULTY OF ENGINEERING TECHNOLOGY
BACHELOR OF TECHNOLOGY – LEVEL 06
FINAL EXAMINATION – 2010

MEX6271 – ROBOTICS

LIBRARY
01 NOV 2011

DATE : ***29 MARCH 2011***
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) What makes an industrial robot different from other types of automated industrial machines? Elaborate on your answer by taking suitable examples.

(1.2) Briefly explain the evolutionary stages in robotics.

(1.3) Distinguish between payload and maximum load with regard to a robots load bearing capacity. *Typically the payload is very much less than the maximum load bearing capacity of a robot.* Why?

(1.4) Explain the different types of methods available for programming an industrial type robot. Taking suitable examples, discuss the applicability of each of the programming methods explained in your answer.

Question 02

(2.1) Briefly explain types of joints in a robot in relation to its nature of motion.

(2.2) Distinguish between a spatial manipulator and a planer manipulator. Describe the degree of freedom in a spatial manipulator in terms of position and orientation.

(2.3) Explain the methodology adopted in determining a robot's work space, empirically and mathematically.

(2.4) Explain the types of reference frames used in jogging a robot.

Question 03

(3.1) Distinguish the difference between kinematics and kinetics.

(3.2) Briefly explain the importance of kinematics in the context of robot manipulators.

(3.3) What is the significance of forward kinematics and inverse kinematics, as applied to robot manipulators?

(3.4) Taking suitable examples, explain the difference between a *path* and a *trajectory*.

Question 04

(4.1) Explain how a point in space is described in;

(i) Frame space notation

(ii) Vector notation

(iii) Vector-matrix notation

(4.2) A moving frame {2} is rotated about a fixed origin with respect to a fixed frame {1}. Describe a point *P* in space, with respect to;

(i) Fixed frame {1}

(ii) Moving frame {2}

(4.3) Show that the rotational transformation matrix $\mathbf{R}$ is independent of the point P.

Question 05

(5.1) A physical coordinate vector is given by $\mathbf{Q} = 4\mathbf{i} + 5\mathbf{j} + 3\mathbf{k}$. Find the homogeneous coordinate vector of $\mathbf{Q}$.

(5.2) Describe the reduced form of a generalized homogenous transform matrix $\mathbf{T}$. Explain the sub-matrices contained in $\mathbf{T}$.

(5.3) A moving frame {2} is rotated with respect to a fixed reference frame {1} about the *z*-axis by an angle 30^0 and translated such that, ${}^1\mathbf{D}_2 = \begin{bmatrix} 4.0 & 2.0 & 6.0 \end{bmatrix}^T$. If ${}^2\mathbf{P} = \begin{bmatrix} 2.0 & 5.0 & 4.0 \end{bmatrix}^T$, find the description of point *P* with respect to frame {1}.

Question 06

(6.1) Show that the rotation of a vector in frame {1} is equivalent to a rotation of the frame by the same angle of rotation but in the opposite direction.

(6.2) Show that the translation of a vector in frame {1} is equivalent to a translation of the frame by the same distance but in the opposite direction.

(6.3) Consider a point P in space. Find the new position of the point, after rotating it by an angle 30^0 about the z-axis and translating it by -1 unit in along the *x*-axis. Pictorially indicate the equivalent frame transformation for this vector transformation.

Question 07

(7.1) Show that the composite transformation from frame {i} to frame {j} is given by, (*i>j*)

$$ {}^{j}\mathbf{T}_{i} = \prod_{k=j}^{i-1} {}^{k}\mathbf{T}_{k+1} $$

(7.2) By using standard notations. Show that ${}^{2}\mathbf{T}_{1} = \left[{}^{1}\mathbf{T}_{2} \right]^{-1}$

(7.3) Given that, ${}^{1}\mathbf{R}_{2} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0.866 & -0.500 \\ 0 & 0.500 & 0.866 \end{bmatrix}$ and ${}^{1}\mathbf{D}_{2} = \begin{bmatrix} 3.0 & 3.0 & 5.0 \end{bmatrix}^{T}$, evaluate ${}^{2}\mathbf{T}_{1}$.

[You may use the relationship obtained in (7.2) above]

Question 08

(8.1) Distinguish between RPY rotations and Euler angle rotations in relation to frame rotations.

(8.2) Two frames, one a fixed frame {1} and the other a moving frame {2} are coincident at the beginning. The following successive rotations are carried out on frame {2} about the axes of the fixed frame {1}.

(i) Rotation about *x*-axis by an angle 45^{0}

(ii) Rotation about *y*-axis by an angle 30^{0}

(iii) Rotation about x-axis by an angle 60^{0}

Obtain the equivalent rotation matrix ${}^{1}\mathbf{R}_{2}$ for the above rotations.

(8.3) Show that the same final orientation can be obtained by performing the same rotations about the moved *xyx*-axes of the moving frame but in the opposite order.

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