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The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	: Bachelor of Technology Honours in Engineering
Name of the Examinatior	:	: Final Examination
Course Code and Title	:	: **MEX6271 - ROBOTICS**
Academic Year	:	: 2016/2017
Date	:	: 21st November 2017
Time	:	: 1.30pm – 4.30pm
Duration	:	: 3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 8 questions. All questions carry equal marks.
3. Answer any 5 questions only.

Question 01

(a) What makes an industrial robot different from other types of automated industrial machines? Elaborate on your answer by taking suitable examples.

(b) Briefly explain the evolutionary stages in robotics.

(c) 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?

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

Question 02

(a) 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?

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

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

(d) What are the types of reference frames used in jogging a robot? Explain with an aid of a neat sketch.

Question 03

(a) Derive a mathematical expression for composite transformation of frames with regard to robotic manipulators.

(b) Two frames, {1} and {2} which are initially coincident are subjected to several predetermined motion. The motions of frame {2} with respect to frame (1) are as follows.

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

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

Question 04

(a) 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. Do you agree with the statement? Justify your answer.

(b) 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.

(c) Consider a point **Q** in space. Find the new position of the point, after rotating it by an angle 60^0 about the z-axis and translating it by -3 units in along the x-axis. Pictorially indicate the equivalent frame transformation for this vector transformation.

Question 05

(a) Distinguish between Fixed angle representation vs. Eular angle representation in relation to fundamental rotation matrices.

(b) Show that the order of rotations for XYZ and ZYX are equivalent in fixed angle representation of rotation matrices.

(c) On a neatly drawn sketch, represent roll, pitch and yaw with respect to a robot end-effector.

Question 06

(a) Describe the following terms in relation to trajectory planning.

(i) Path
(ii) Trajectory
(iii) Via points

(b) Distinguish between Joint space vs. Cartesian space in relation to trajectory planning in robotics.

(c) A single-link robot with a rotary joint is motionless at $\Theta = 15$ degrees. The joint is to be moved in a smooth manner to $\Theta = 75$ degrees in 3 seconds.

(i) Find the equation of the polynomial which best describes the motion.

(ii) Plot the position, velocity and acceleration of the joint, indicating their respective values, as a function of time.

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Question 07

(a) In robotics, the often practice to assign standard names for frames associated with a robot and its work-space. Name and explain five such frames associated with robotics, indicating them clearly on a neatly drawn sketch.

(b) An end-effector of a robot is rotated about fixed axes starting with a yaw of $-\pi/2$, followed by a pitch of $-\pi/2$. Determine the resulting rotation matrix.

(c) Show that the rotational transformation matrix **R** is independent of any point P.

Question 08

(a) Briefly explain the parameters that are taken into consideration when developing a kinematic model for a link.

(b) Discuss taking a suitable example, the Denavit-Hartenberg (DH) notation in developing a kinematic model for a robotic manipulator.

END