M.TECH/AEIE/3RD SEM/AEIE 6133/2016

ROBOTICS ENGINEERING
(AEIE 6133)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

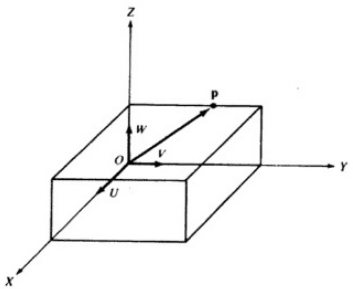
Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Which of the following terms IS NOT one of the five basic parts of a robot?
(a) Peripheral tools (b) End effector
(c) Controller (d) Driver.

(ii) The number of moveable joints in the base, the arm, and the end effector of the robot determines.....?
(a) degrees of f... (b) cost of the robot
(c) payload cap... none of the above.

(iii) SCARA robot is ... operations?
(a) Single Oper... Rotary operation
(c) Assembly O... Translatory Operation.



(iv) The amount of ... alled.
(a) Tonnage Payload
(c) Dead lift Horsepower.

(v) End effectors can be classified into two categories which are
(a) elbows and wrists (b) grippers and end of arm tooling
(c) grippers and wrists (d) end of arm tooling and elbows.

(vi) The type of end of arm tooling you should use on your robot is not based on
(a) the application (b) the work envelope of the robot
(c) gripping force (d) program control.

(vii) Which joint on a robot are we most concerned with when it comes to end of armtooling?
(a) Base (b) Elbow (c) Wrist (d) Shoulder.

(viii) When a welding torch is placed as an end of arm tooling, what type of programming needs to take place to execute the welding process?
(a) Point to point (b) Continuous path
(c) Off-line (d) Palletizing.

(ix) Which one of the following terms refers to the up - down motion of a robot arm?
(a) Yaw (b) Pitch (c) Roll (d) Elevate.

(x) What is the name for the space inside which a robot unit operates?
(a) Work envelop (b) Envelop
(c) Danger zone (d) None of the above.

Group – B

2. (a) For a given manipulator, with joint angle vector $q(t) = (q_1(t), q_2(t), ..., q_n(t))$ describe the direct kinematics problem.

(b) Consider OXYZ as fixed and reference coordinate system with OUVW as rotating coordinate system with respect to OXYZ. Derive the various rotation matrices for rotation in OX, OY and OZ axis.

2 + 10 = 12

3. (a) Derive the rotation matrix for a rotation of 30^o about the OZ axis, followed by a rotation of 60^o about the OX axis, followed by a rotation of 90^o about the OY axis.

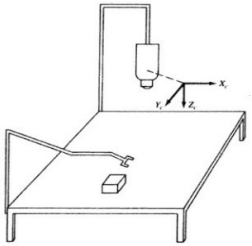
(b) Given two points $a_{uvw} = (4,3,2)^T$ and $b_{uvw} = (6,2,4)^T$ with respect to rotated OUVW coordinate system, determine the corresponding points a_{xyz}, b_{xyz} with respect to reference coordinate system if it has been rotated by 60^oabout the OZ axis.

7 + 5 = 12

Group – C

4. (a) With a suitable circuit diagram, explain how a [illegible] be used as a force-torque sensor. Also describ[illegible]ial conditioning circuitry.

$$T_1 = \begin{bmatrix} 0 & 1 & 0 & 1 \\ 1 & 0 & 0 & 10 \\ 0 & 0 & -1 & 9 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad T_2 = \begin{bmatrix} 1 & 0 & 0 & 10 \\ 0 & -1 & 0 & 20 \\ 0 & 0 & -1 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



(b) State how an IR transmitter-receiver pair [illegible]ed (rpm) measurement of a rotating wheel. Dr[illegible]no circuitry with proper application code.

6 + 6 = 12

What is the position of the center of the cube with respect to the base coordinate system?

5. (a) Determine a T matrix that represents a rotation of α angle about the OX axis, followed by a translation of b unit of distance along the OZ axis, followed by a rotation of ϕ angle about the OV axis.

(b) Assume in the above question the cube is within the arm's reach. What is the orientation matrix [n s a]

9 + 3 = 12

(b) Given two points $a_{xyz} = (4,3,2)^T$ and $b_{xyz} = (6,2,4)^T$ with respect to rotated OUVW coordinate system, determine the corresponding points a_{uvw}, b_{uvw} with respect to reference coordinate system if it has been rotated by 60° about the OZ axis.

Group – E

8. (a) Consider a DC motor driven gear train with 'n' gear ratio, derive the transfer function of the armature voltage to the angular displacement of the motor shaft.

6 + 6 = 12

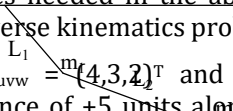
Group – D

(b) State the inverse kinematics problem, list a few ways of solving the said problem.

6. (a) What is the meaning of generalized coordinates of a robot arm? Give two different sets of generalized coordinates for the robot arm shown in the figure below. Draw two separate figures of the arm indicating the coordinate systems you chose.

9 + 3 = 12

9. (a) State the limitations of inverse transformation technique? Show the mathematical changes needed in the above technique to solve for Euler angles in an inverse kinematics problem.



(b) Given two points $a_{uvw} = (4,3,2)^T$ and $b_{uvw} = (6,2,4)^T$ are to be translated by a distance of +5 units along the OX axis and -3 units along the OZ axis. Using the appropriate homogeneous transformation matrix, determine new points a_{xyz} and b_{xyz}.

(b) If the OU, OV and OW coordinate axes were rotated with α angle about the OX axis, what would the representation of the coordinate axes of the reference frame be in terms of the rotated coordinate system OUVW?

1 + 3 + 6 = 12

8 + 4 = 12

7. (a) A robot work station has been setup with a camera as base of coordinate systems. The object to be manipulated is kept on the table. If the local coordinate system has been established at the centre of the cube, the object as seen by the camera can be represented by homogeneous coordinate transformation matrix T1and T2 for camera to base coordinates.