Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent institution of MAHE, Manipal)

V SEMESTER B.TECH. (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, NOV 2018

SUBJECT: MECHANICS OF ROBOTIC SYSTEMS [MTE 3102]

REVISED CREDIT SYSTEM

(21/11/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Data not provided may be suitably assumed

1A. Define Robot and describe the important parts of a robotic system. Classify Industrial robots based on different configurations. **03**

1B. Define the following: **03**

- Control resolution
- Availability
- Reliability
- All the factors affecting load carrying capacity
- Work volume
- Accuracy

1C. Consider the Fig.1C. A robot is kept $1m$ from a table. The table top is 1 m high and $1m^2$. A frame $o_1x_1y_1z_1$ is fixed to the edge of the table as shown. A cube measuring 20 cm on a side is placed in the center of the table with frame $o_2x_2y_2z_2$ established at the center of the cube as shown. A camera is situated directly above the center of the block 2 meters above the table top with frame $o_3x_3y_3z_3$ attached as shown. **04**

I. Determine the homogeneous transformation relating each of these frames to the base frame $o_0x_0y_0z_0$.

II. Determine the homogeneous transformation relating the frame $o_2x_2y_2z_2$ to the camera frame $o_3x_3y_3z_3$.

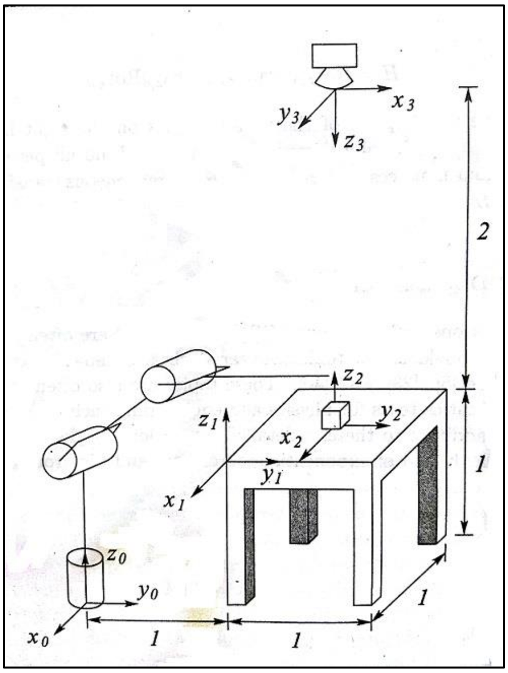

Fig.1C

2A. Determine the position of a point P, attached to frame XYZ which is subjected to the following sequence of operations. **04**

- Rotation of 45˚ OX axis.(T1)
- Rotation of 30˚ about OB axis.(T2)
- Translation of 5 units in OY direction(T3)

If the final position of P is given by [10, 6, -5], calculate its initial position.

2B. Determine the homogeneous transformation matrix $^{A}H_{B}$ and $^{A}H_{C}$ for the co-ordinate frames attached to the corners C and B with respect to A as shown in Fig.2B. **04**

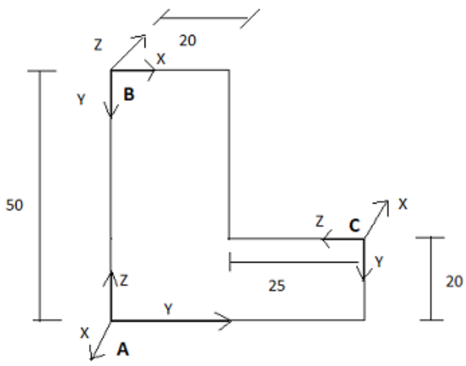

Fig.2B

2C. Prove that the rotational matrices are not commutative in general. **02**

3A. Determine the DH parameters and obtain the direct kinematics for PRP robotic manipulator arm as shown in Fig.3A. **05**

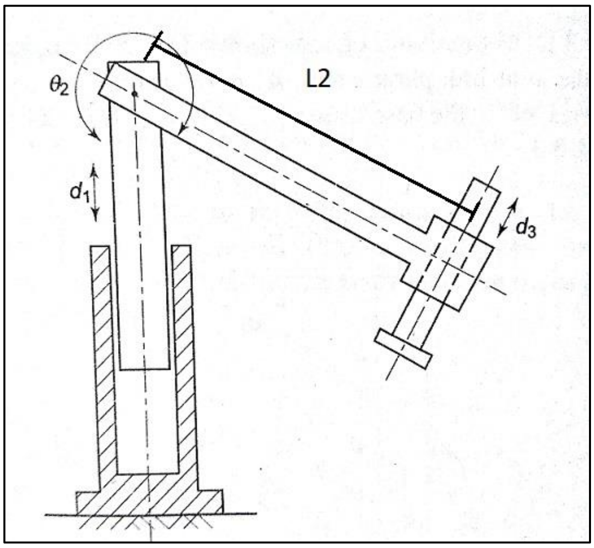

Fig.3A

3B. Calculate the Jacobian Matrix for the Fig.3A. Evaluate the end-effector velocities if joint velocities are given as $[3, 5, 4]^T$, assuming Link Length L_2 as 100 mm. **05**

4A. Formulate the dynamics of the system shown in Fig.4A using Lagrangian method. **05**

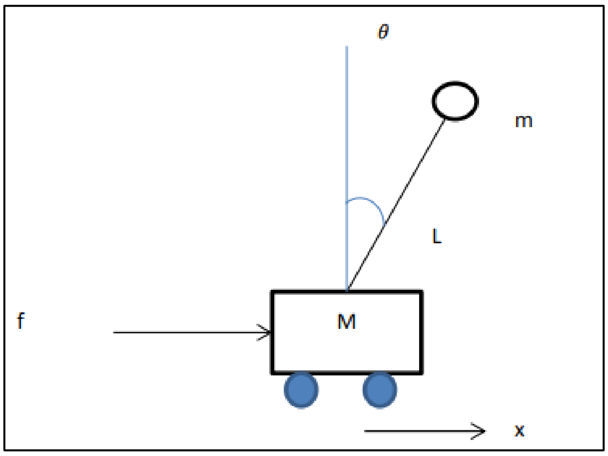

Fig.4A

4B. Obtain the solutions for inverse kinematics of RP manipulator and calculate joint parameters if the final transformation matrix is **05**

$$\begin{bmatrix} 0.866 & 0 & 0.5 & 100 \\ 0.5 & 0 & -0.866 & -173.2 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

5A. Differentiate between: **02**

- Joint space and cartesian space
- Reachable workspace and dexterous workspace

5B. For a RR manipulator, it is given that the initial and final positions for the first joint at time 0 sec is 15°and 75°after 3 sec. respectively. **04**

- Determine expression for position, velocity and acceleration of the joint and plot the results.

- Plot the locus of end effector position if second joint variable θ_2 is fixed to 20° w.r.t. first joint variable θ_1.

5C. The path traced by a joint of a robot manipulator is described by the fifth degree polynomial. The joint has to start from an initial angle of 10° to final angle 20°. The starting acceleration and the ending deceleration 2 deg/sec^2. **04**

The initial and final velocities being zero, find the equation of motion for the joint. The range is covered in 2 seconds.