Question Paper

Exam Date & Time: 04-May-2019 (02:00 PM - 05:00 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

INTERNATIONAL CENTRE FOR APPLIED SCIENCES
IV SEMESTER B.Sc (Applied Sciences) IN ENGINEERING
END SEMESTER THEORY EXAMINATION APRIL / MAY 2019

INDUSTRIAL ROBOTS [IMET 244]

Marks: 100 **Duration: 180 mins.**

Answer 5 out of 8 questions.

Missing data, if any, may be suitably assumed.

1) Define an Industrial robot and state three laws of robotics. (6)

A)

B) Write a short note on classification of robots with relevant example. (8)

C) Describe on the essential characteristics which a robot should possess with the help of a neat block diagram. (6)

2) (8)

A) Explain the following with a suitable example:
a. Configuration
b. D.O.F
c. Configuration Space
d. Jacobian

B) What is the need of sensors in a Robot? Describe on the working principle of three sensors which we use in a Mobile robots. (6)

C) Define end effector and design an end effector to grasp materials like a bunch of paper, stone and Egg. (6)

3) Write down Grubler formula and identify the degree of freedom of the Figure 1 and Figure 2 using grumbler formula. (8)

A)

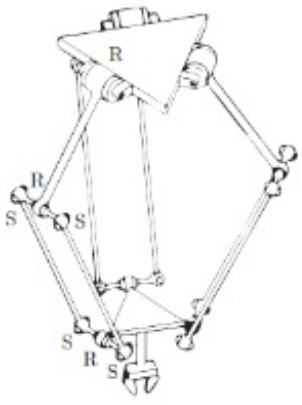

Figure 1

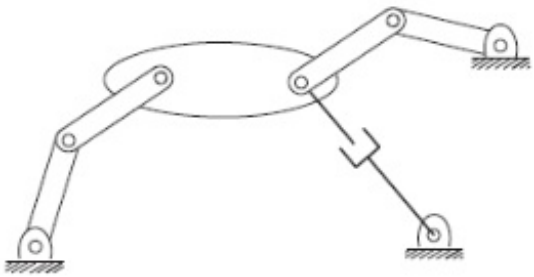

Figure 2

B) Explain the following with a suitable example: (6)

e. Work space
f. Joint space
g. Task space

C) Find the X-Y-Z fixed angle and substitute α = 90,β=60,γ=30 (6)

4) Identify the orientation of the Figure3 end effector using exponential formula. (6)

A)

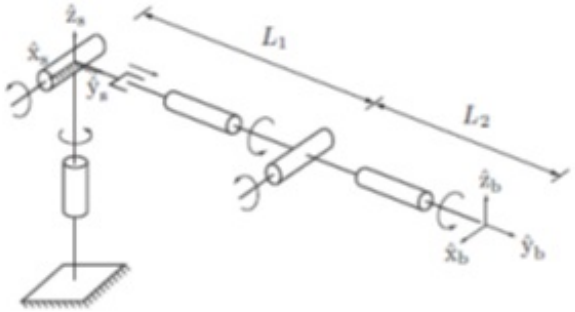

Figure 3

B) Find the D-H parameters of the of the Figure 4 (6)

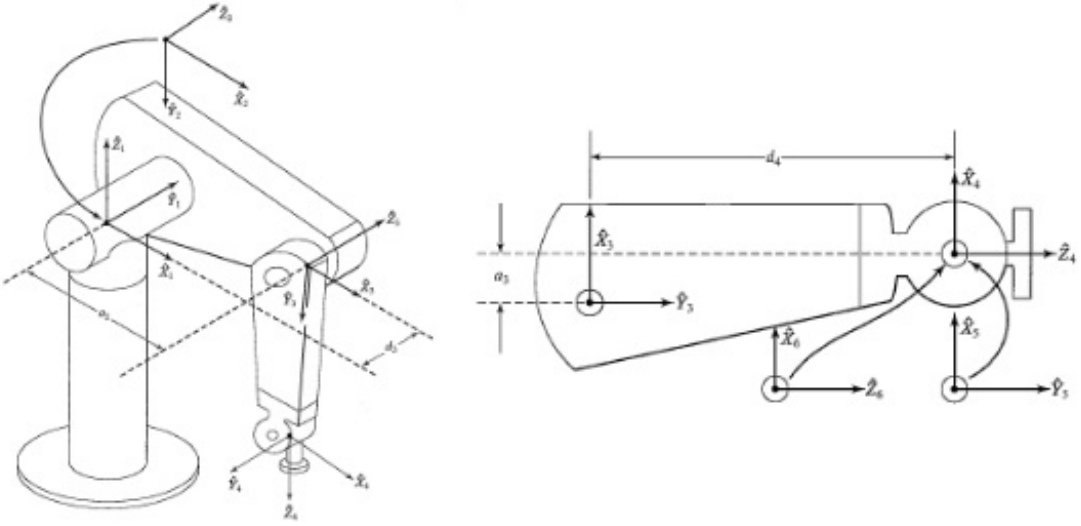

Figure 4

C) Identify the Transformation matrix of Figure 4 (8)

5) Apply the body Jacobian Newton Raphson inverse kinematics algorithm to the 2R robot in Figure 5. Each link is 1 m in length, and we would like to find the joint angles that (8)

A)

$$T_{sd} = \begin{bmatrix} -0.5 & -0.866 & 0 & 0.366 \\ 0.866 & -0.5 & 0 & 1.366 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad M = \begin{bmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad \mathcal{B}_1 = \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \\ 2 \\ 0 \end{bmatrix}, \quad \mathcal{B}_2 = \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \\ 1 \\ 0 \end{bmatrix}.$$

place the tip of the robot at (x; y) = (0:366 m; 1:366 m), which corresponds to θ_d =(30 ^{o}, 90^o) and Our initial guess at the solution is θ^0 = (0, 30^o), and we specify an error tolerance of

ϵ_ω = 0.001 rad (or 0:057^o) and $\epsilon_v = 10^{-4}$ m (100 microns). The progress of the Newton-Raphson method is illustrated in the table below, where only the (ω_{zb}, v_{xb}, v_{yb}) components of the body twist V_b are given since the robot's motion is restricted to the x-y-plane:

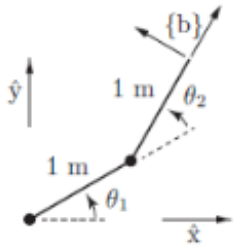

Figure 5

B) Explain Inverse kinematics of a 2R planar open chain using law of cosines with a neat diagram (6)

C) What is newton Raphson method of iteration how can it be useful to identify the Inverse kinematics of an open chain mechanism. (6)

6) Write a short note on the dynamics of manipulator and various methods to identify the dynamics of a mechanical system. (6)

A)

B) Explain newton Euler method with the help of equations (6)

C) Identify the torque equation of a 2R manipulator using Newton Euler equations. (8)

7) Discuss on Lagrangian method (6)

A)

B) Identify the torque equation of the PR manipulator in Figure 6 (8)

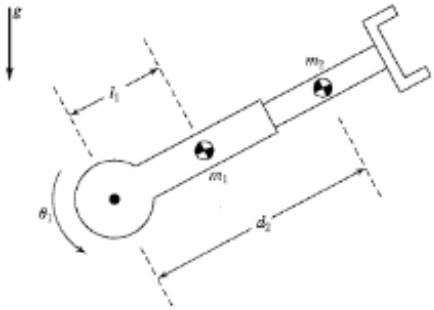

Figure 6

C) Explain how do you identify the twist and wrench of a system if you know force and moment of the system. (6)

8) A single-link robot with a rotary joint is motionless at θ = 15 degrees. It is desired to move the joint in a smooth manner to θ = 75 degrees in 3 seconds. Find the coefficients of a cubic that accomplishes this motion and brings the manipulator to rest at the goal. Plot the position, velocity, and acceleration of the joint as a function of time. (6)

A)

B) Explain detail how can you obtain a trapezoidal motion problems with a neat sketch and identify the position velocity and acceleration. (6)

C) Two link manipulator has to follow a straight line to perform pick and place operation. Discuss on the equation related to follow the given trajectory and how does kinematic singularity affect the performance of the system. (8)

-----End-----