Eastern Mediterranean University
Faculty of Engineering
Department of Electrical and Electronic Engineering

Course Code : EE 428 **Date :** 2nd June, 2000
Course Title : Introduction to Robotics **Time allowed**: 100 min.
Lecturer : M. K. Uyguroğlu

Second Midterm Examination

1. Given a coordinate frame

$$\mathbf{T} = \begin{bmatrix} 0 & -1 & 0 & 2 \\ 0 & 0 & 1 & 5 \\ -1 & 0 & 0 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

a) What is the differential transformation dA corresponding to a differential translation $d = 0i + 1j + 2k$ and rotation $\delta = 0.1i + 0j + 0k$ made with respect to **T**. (20 pts.)

b) What is the equivalent translation and rotation with respect to base coordinate frame? (15 pts.)

2- Consider the R-P-R manipulator shown in Fig. 1 (R-P-R specifies the type and order of the joints. R: Revolute, P: Prismatic joint). Find the Jacobian of the manipulator

a) using Paul's method (20 pts.)
b) using vector-cross product method. (20 pts.)

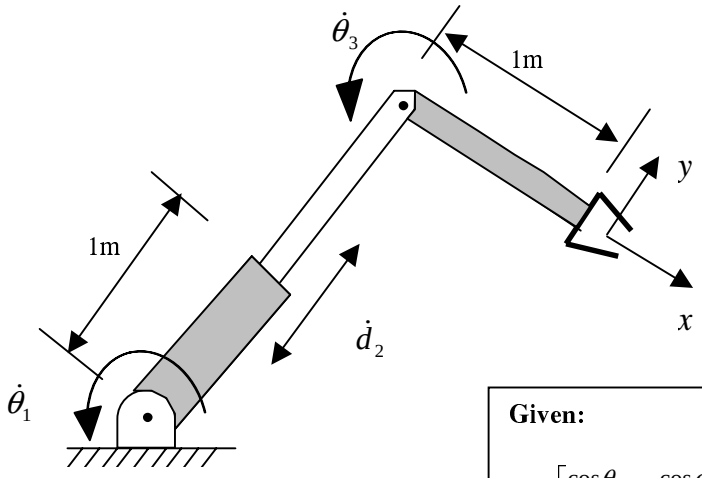

Figure 1

Given:

$$A_i = \begin{bmatrix} \cos\theta_i & -\cos\alpha_i \sin\theta_i & \sin\alpha_i \sin\theta_i & a_i \cos\theta_i \\ \sin\theta_i & \cos\alpha_i \cos\theta_i & -\sin\alpha_i \cos\theta_i & a_i \sin\theta_i \\ 0 & \sin\alpha_i & \cos\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3- The three-link manipulator shown in Fig. 1 is applying a force ${}^3F = [100 \;\; 0 \;\; 0]^T$ and moment ${}^3M = [0 \;\; 0 \;\; 0]^T$ with its end-effector (consider this force to be acting at the origin of the end-effector frame). If $\theta_1 = 60^o$, d_2 = 0.9 m, and $\theta_1 = 30^o$ then find the required joint torques(forces). (25 pts.)