1. For the robot shown in Fig. 1:

(a) Set up coordinate systems of all joints based on the procedure you observed in the class, and then determine **Denavit–Hartenberg** parameters! (10)

(b) Generate ***Homogenous Transformation*** for each joint and finally calculate $T^0_{n=4}$. (20)

(c) Then derive the **Jacobian Matrix** of the robot. (**50**)

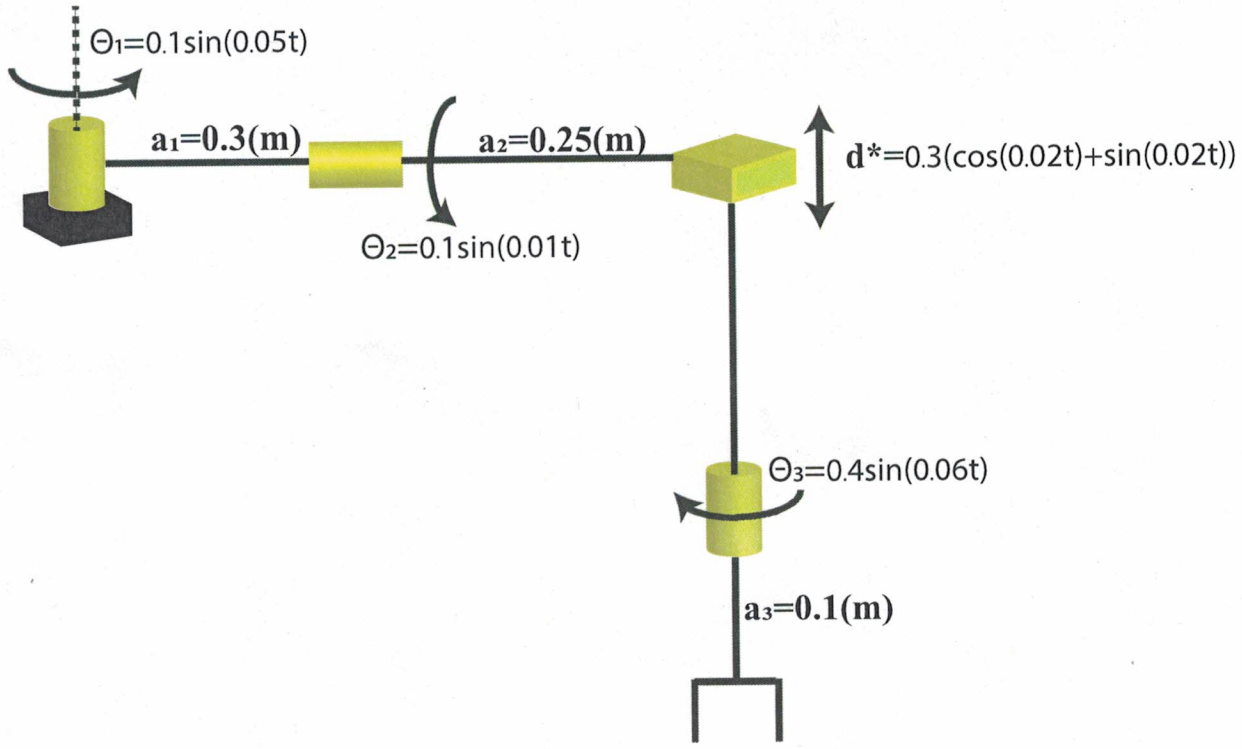

Figure 1: A 3D robot

(d) Using MATLAB and the numerical values of $\theta_1(t)$, $\theta_2(t)$, $\theta_3(t)$, and $d^*(t)$ at t=5s, shown in Fig. 1, calculate the **position and orientation** of the end-effector. Also plot **the position** (x, y, and z) of the end-effector vs. time for $0 \leq t \leq 6s$. (10)

(e) Derive the **Pseudoinverse Jacobian** (J^+) of the robot. (10)

Please do not forget to write your full name and RED ID! Please return the exam sheet along with your solutions! Please provide your detailed solutions and do not jump to final answers.