National University of Singapore
Faculty of Engineering

TM4245 **Quiz 1** **12 Feb 1999, 19:00-20:00**

1. Frames A and B are attached to the cuboid as shown in Fig. 1. Determine the relative position and orientation of the two frames, i.e., determine ${}^{B}T_{A}$. **(15 marks)**

2. Complete the frame assignments for Frame 1 in Fig. 2 according to the Denavit Hartenberg convention given in class. Frame 0 is also show in Fig. 2. **(15 marks)**

3. Identify the four kinematic parameters (according to the Denavit Hartenberg convention) that relate Frames 0 and 1 in Fig. 3. (**15 marks)**

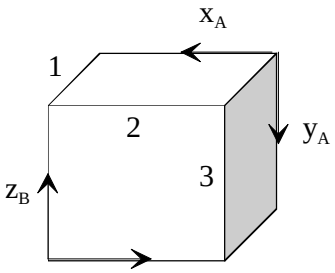

Fig.1

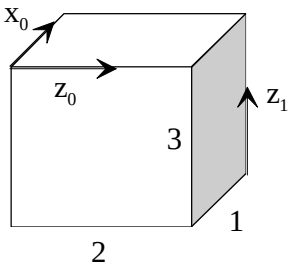

Fig. 2

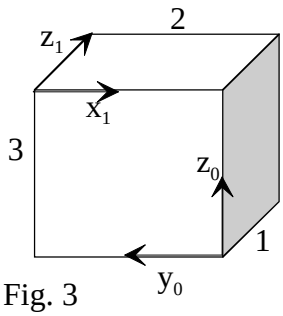

Fig. 3

4. Frames A and B are rigidly attached to a cuboid as shown in Figure 1 with ${}^{B}T_{A}$ known. Let Frames U and V be fixed to the world with ${}^{V}T_{U}$ known. The cuboid is initially at a given ${}^{U}T_{A}$. The cuboid undergoes the following motion in the indicated sequence:
   a. rotation about X_U by 30 degrees
   b. rotation about Z_U by 40 degrees
   c. rotation about Y_A by 50 degrees
   d. rotation about Z_B by 60 degrees
   e. rotation about X_V by 70 degrees

   Find the new position and orientation of Frame A in U, i.e., find ${}^{U}T_{A}$. **(25 marks)**

5. Figure 4 shows a 3-DOF robot with the second joint translational and the first and third joint rotational. The positive direction of the second joint variable q_2 represents the distance from A to B. The positive direction of the first joint variable q_1 is measured from the positive X_0 axis in a counterclockwise direction. The 2nd link AB is fixed at 90 degrees with respect to the first moving link. The third link BE rotates with joint variable q_3 whose positive direction is counterclockwise measured from AB. Frame E is attached to the end-effector as shown. Determine the position and orientation of the end-effector, ${}^{0}T_{E}$ as a function of the three joint coordinates q_1, q_2, and q_3. **(30 marks)**

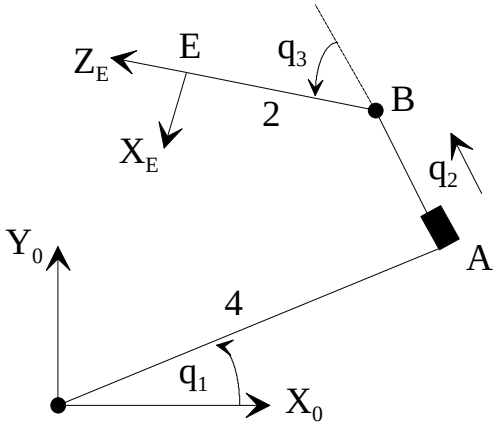

Fig. 4

END OF QUIZ