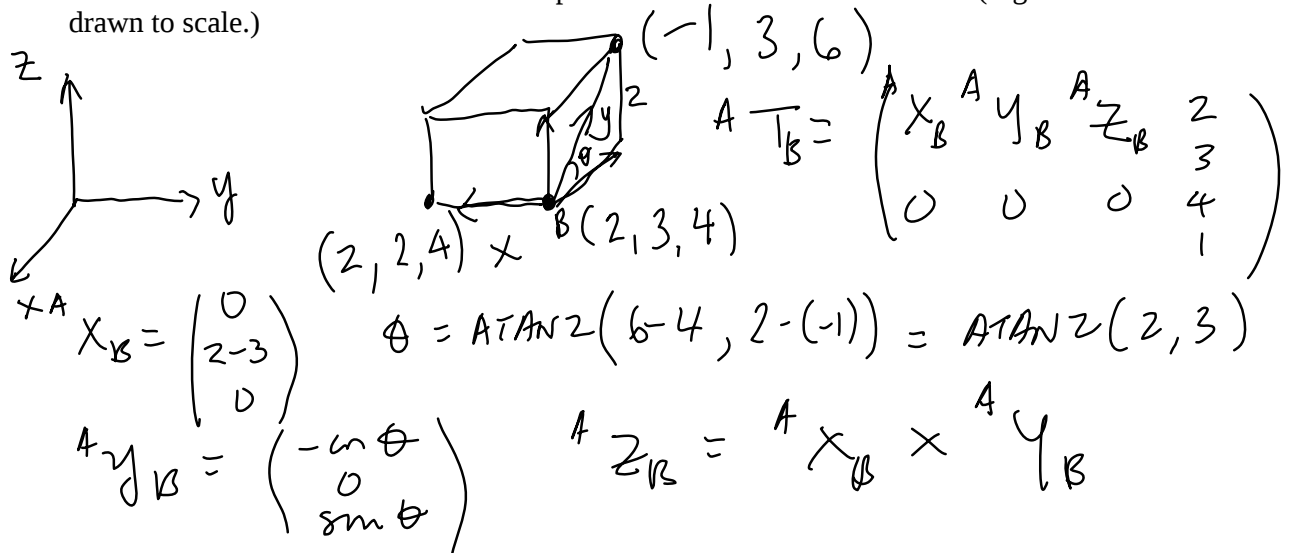


Full Name (as in student ID): _____

1. The rigid body B is positioned and oriented with respect to Frame A according to Fig 1, where the coordinates indicated are expressed in Frame A. Define the 4 x 4 homogeneous transformation matrix that describes the position and orientation of B in A. (Figure not drawn to scale.)



2. Frames D, E, F are fixed to the ground and their relative configurations ${}^D T_E$ and ${}^D T_F$ are known. A point of interest C on a body B has coordinates $(4, 5, 6)$ with respect to Frame B (attached to Body B). B is initially at configuration given by ${}^E T_B$, it then undergoes the following motion in the indicated sequence:

- B_1, C_1 1st) Rotation about Z_E by 30 degrees
 B_2, C_2 2nd) Rotation about X_B by 60 degrees
 B_3, C_3 3rd) Translation along Frame B by $(1, 2, 3)$ m

Find the coordinates of point C with respect to D after the three motions

$${}^B P_C = \begin{pmatrix} 4 \\ 5 \\ 6 \end{pmatrix} \quad {}^D P_{C3} = ?$$

$${}^D P_{C3} = {}^D T_{B3} {}^B P_{C3} \quad \text{When } {}^B P_{C3} =$$

$${}^E T_{B0} = {}^E T_B \rightarrow {}^E T_{B1} = \text{Rot}(Z, 30^\circ) {}^E T_{B0},$$

$${}^E T_{B2} = {}^E T_{B1} \text{Rot}(X, 60^\circ)$$

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos 60 & -\sin 60 & 0 \\ 0 & \sin 60 & \cos 60 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$${}^E T_{B3} = {}^E T_{B2} \text{Trans}(1, 2, 3)$$

$${}^D T_{B3} = {}^D T_E {}^E T_{B3}$$

$$\begin{pmatrix} \cos 30 & -\sin 30 & 0 & 0 \\ \sin 30 & \cos 30 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$\begin{pmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 1 & 3 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$