# HW Assignment Solution for EML 4806 CH 3

## Problem 1:

| $\alpha_{i-1}$ | $a_{i-1}$ | $d_i$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | $L_1$ | 0 |
| 0 | $L_2$ | 0 |

$$ {}^0_1T = \begin{bmatrix} C_1 & -S_1 & 0 & 0 \\ S_1 & C_1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^1_2T = \begin{bmatrix} C_2 & -S_2 & 0 & L_1 \\ S_2 & C_2 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad {}^2_3T = \begin{bmatrix} C_3 & -S_3 & 0 & L_2 \\ S_3 & C_3 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^0_3T = {}^0_1T\,{}^1_2T\,{}^2_3T = \begin{bmatrix} C_{123} & -S_{123} & 0 & L_1C_1 + L_2C_{12} \\ S_{123} & C_{123} & 0 & L_1S_1 + L_2S_{12} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

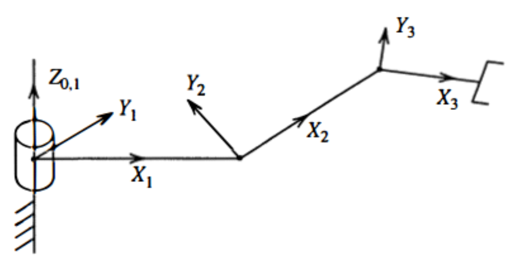
where:

$C_{123} = \cos(\theta_1 + \theta_2 + \theta_3)$

$S_{123} = \sin(\theta_1 + \theta_2 + \theta_3)$, etc.

## Problem 3:

| $\alpha_{i-1}$ | $a_{i-1}$ | $d_i$ |
|---|---|---|
| 0 | 0 | 0 |
| 90° | $L_1$ | 0 |
| 0 | $L_2$ | 0 |




$$ {}^0_1T = \begin{bmatrix} C_1 & -S_1 & 0 & 0 \\ S_1 & C_1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad {}^1_2T = \begin{bmatrix} C_2 & -S_2 & 0 & L_1 \\ 0 & 0 & -1 & 0 \\ S_2 & C_2 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^2_3T = \begin{bmatrix} C_3 & -S_3 & 0 & L_2 \\ S_3 & C_3 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad {}^B_WT = {}^0_3T = {}^0_1T\,{}^1_2T\,{}^2_3T $$

$$ {}^B_WT = \begin{bmatrix} C_1C_{23} & -C_1S_{23} & S_1 & L_1C_1 + L_2C_1C_2 \\ S_1C_{23} & -S_1S_{23} & -C_1 & L_1S_1 + L_2S_1C_2 \\ S_{23} & C_{23} & 0 & L_2S_2 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

**Problem 9:**

$$^0P_{TIP} = {}^0_2T\,{}^2P_{TIP};\ {}^2P_{TIP} = \begin{bmatrix} L_2 \\ 0 \\ 0 \end{bmatrix}$$

$$^0P_{TIP} = \begin{bmatrix} C_1C_2 & -C_1S_2 & S_1 & L_1C_1 \\ S_1C_2 & -S_1S_2 & -C_1 & L_1S_1 \\ S_2 & C_2 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} L_2 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} L_1C_1 + L_2C_1C_2 \\ L_1S_1 + L_2S_1C_2 \\ L_2S_2 \end{bmatrix}$$

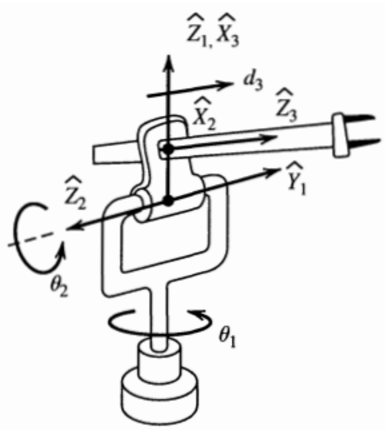
**Problem 17:**

As shown:

$\theta_1 = 0$

$\theta_2 = 90°$

$d_3 = 0$




**Problem 28:**

$$(3.9)\ \text{Same solution except } {}^2P_{TIP} = \begin{bmatrix} 0 \\ L_2 \\ 0 \end{bmatrix}, \text{ which yields}$$

$$^0P_{TIP} = \begin{bmatrix} L_1c_1 - L_2c_1s_2 \\ L_1s_1 - L_2s_1s_2 \\ L_2c_2 \end{bmatrix}$$