# MAE 4345 Exercise 1
# Samuel Law & Rhys Miller
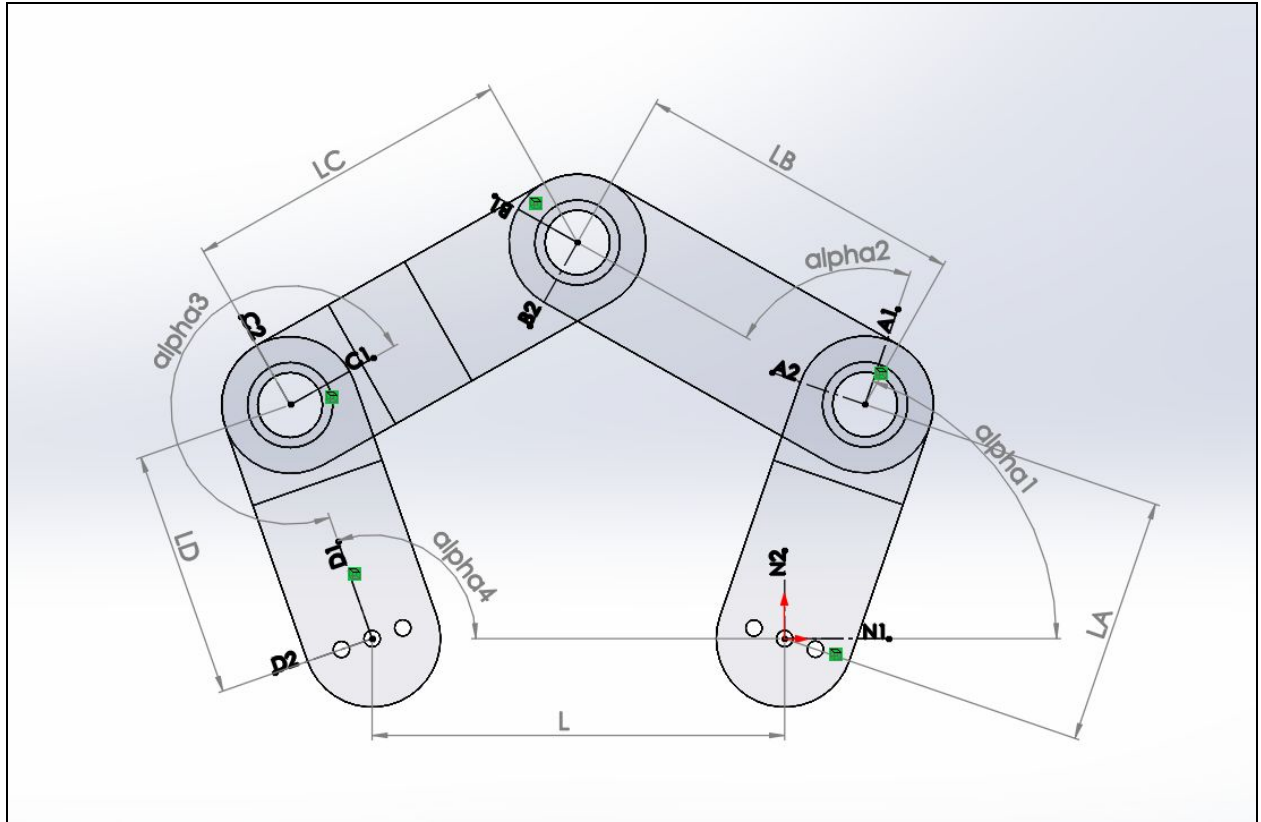
Figure 1. Linkage with Frames, Lengths, and Angles
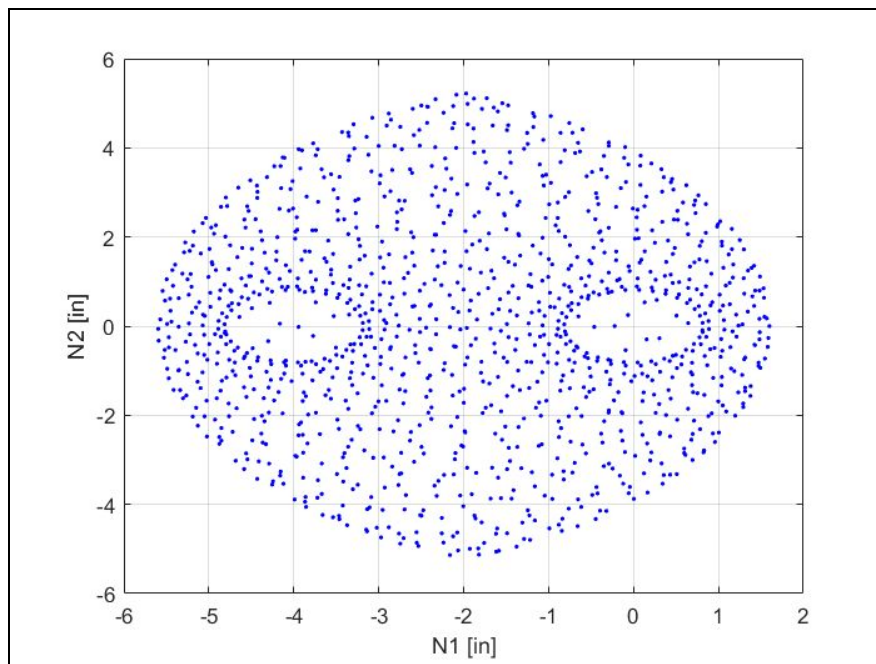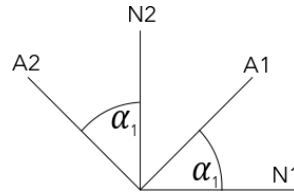


Figure 2. Point Cloud

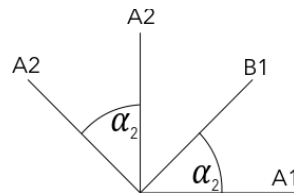$$\mathcal{L}_A = \left\{ P_{NA}, {}^N_A R \right\}$$

$$P_{NA} = L_A \widehat{A_1}$$

$${}^N_A R = \begin{bmatrix} \cos(\alpha_1) & \sin(\alpha_1) & 0 \\ -\sin(\alpha_1) & \cos(\alpha_1) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \hat{N}_1 \\ \hat{N}_2 \\ \hat{N}_3 \end{bmatrix}$$

$$\mathcal{L}_B = \left\{ P_{AB}, {}^A_B R \right\}$$

$$P_{AB} = L_B \widehat{B_1}$$

$${}^A_B R = \begin{bmatrix} \cos(\alpha_2) & \sin(\alpha_2) & 0 \\ -\sin(\alpha_2) & \cos(\alpha_2) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \hat{A}_1 \\ \hat{A}_2 \\ \hat{A}_3 \end{bmatrix}$$
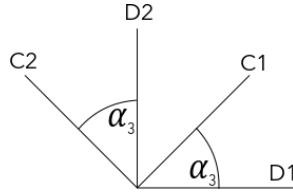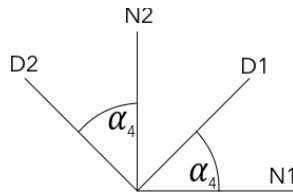
$$\mathcal{L}_C = \{P_{DC}, {}^D_C R\}$$



$$P_{DC} = L_D \widehat{D_1}$$

$${}^A_B R = \begin{bmatrix} \cos(\alpha_3) & \sin(\alpha_3) & 0 \\ -\sin(\alpha_3) & \cos(\alpha_3) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \hat{D}_1 \\ \hat{D}_2 \\ \hat{D}_3 \end{bmatrix}$$

$$\mathcal{L}_D = \{P_{ND}, {}^N_D R\}$$



$$P_{ND} = L\left(-\widehat{N_1}\right)$$

$${}^N_D R = \begin{bmatrix} \cos(\alpha_4) & \sin(\alpha_4) & 0 \\ -\sin(\alpha_4) & \cos(\alpha_4) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \hat{N}_1 \\ \hat{N}_2 \\ \hat{N}_3 \end{bmatrix}$$

$${}^N_B R = {}^N_A R \, {}^A_B R$$

$$P_{NB} = P_{NA} + P_{AB} = P_{ND} + P_{DC} + P_{CB}$$

Img 1. Robot!