

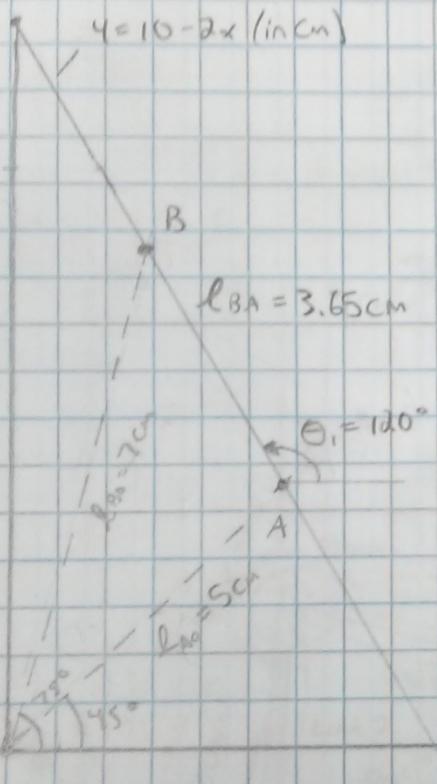
Hw3 Problem 4-1

a. $10e^{j50^\circ} = 10\cos 50 + j10\sin 50$
 $10e^{j50^\circ} = \boxed{7.66 + 6.43j}$ ✓

b. $5(e^{j45^\circ} - 1) = 5e^{j45^\circ} - 5$
 $5e^{j45^\circ} = 5\cos 45 + j5\sin 45$
 $= 3.54 + 3.54j$ Must subtract 5 from real part
 $5e^{j45^\circ} - 5 = \boxed{-1.46 + 3.54j}$ ✓

c. $(3e^{j30^\circ}) * (2e^{j180^\circ}) = 6e^{j(210^\circ)}$
 $= 6(\cos(210) + j6\sin(210))$
 $(3e^{j30^\circ}) * (2e^{j180^\circ}) = \boxed{-5.20 - 3j}$ ✓

HW2 Problem 4-4



a. $R_{AO} = 5e^{j45^\circ} \text{ - Polar}$

$R_{AO} = 3.54 + j3.54 \text{ - Cartesian}$

b. $R_{BO} = 7e^{j75^\circ} \text{ - Polar}$

$R_{BO} = 1.81 + j6.76 \text{ - Cartesian}$

c. $R_{AO} + R_{BA} + R_{BO} = 0$

$\Rightarrow R_{BA} = R_{BO} - R_{AO}$

$R_{BA} = (1.81 + j6.76) - (3.54 + j3.54)$

$R_{BA} = -1.73 + j3.22$

d. $R_{BA} = 3.65 e^{j120^\circ}$

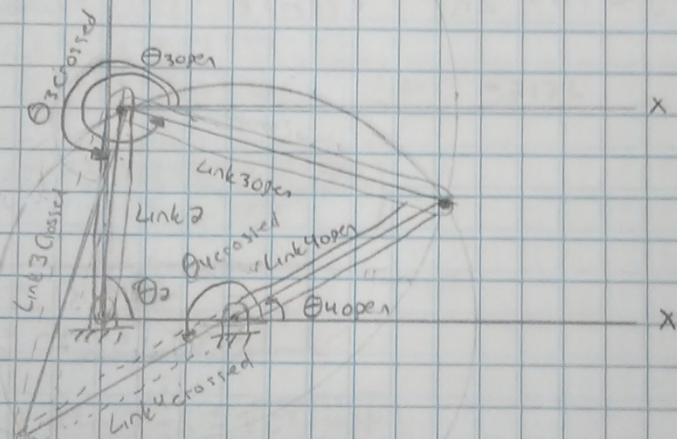
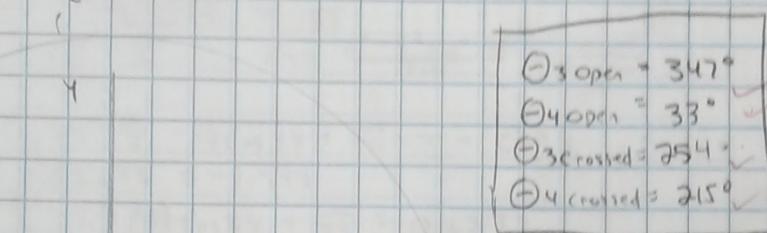
$R_{BA} = -1.83 + j3.16$

While R_{BA} for c and d are not exactly the same, they are extremely close and could be off due to drawing errors.

HW2 Problem 4-6

$$\text{Link 1} = 4 \quad \text{Link 2} = 6 \quad \text{Link 3} = 10 \quad \text{Link 4} = 7 \quad \theta_7 = 88^\circ$$

Circle off radius 10



Circle off radius 7

Grashof: $S + l < P + q$

$$4+10 < 7+6$$

14 \neq 13 \rightarrow Grashof not satisfied

HW 2 - Problem 4-7

Same Drawing as 4-6

$$\theta_2 = 88^\circ \quad \text{Link 1: } d=4 \quad \text{Link 2: } a=6 \\ \text{Link 3: } b=10 \quad \text{Link 4: } c=7$$

$$K_1 = \frac{d}{b} = \frac{4}{3} \quad K_2 = \frac{d}{c} = \frac{4}{7} \\ K_3 = \frac{a^2 + b^2 - c^2 + d^2}{2abc} = \frac{16}{84} \\ K_4 = \frac{d}{b} = \frac{4}{3} \quad K_5 = \frac{c^2 + d^2 - a^2 - b^2}{2ab} = \frac{-16}{120}$$

$$A = \cos 88 - \frac{2}{3} - \frac{4}{7} \cos 88 + \frac{1}{84} = -0.6398$$

$$B = -2 \sin 88 = -1.999$$

$$C = \frac{2}{3} + \left(\frac{4}{7} + 1\right) \cos 88 + \frac{1}{84} = 0.6737$$

$$D = \cos 88 - \left(\frac{4}{3}\right) + \frac{2}{3} \cos 88 + \frac{-10^2}{120} = -1.476$$

$$E = -2 \sin 88 = -1.999$$

$$F = \frac{2}{3} + \left(\frac{4}{3} - 1\right) \cos 88 + \frac{-10^2}{120} = -0.2126$$

$$\theta_{41,2} = 2 \tan^{-1} \left(\frac{-B \pm \sqrt{B^2 - 4AC}}{2A} \right)$$

$$\boxed{\theta_{41} = 31.47^\circ}$$

$$\boxed{\theta_{42} = -147.3^\circ = 212.7^\circ}$$

$$\theta_{31,2} = 2 \tan^{-1} \left(\frac{-E \pm \sqrt{E^2 + 4DF}}{2D} \right)$$

$$\boxed{\theta_3 = -13^\circ = 346.7^\circ}$$

$$\boxed{\theta_{32} = -102^\circ = 257.99^\circ}$$

These values are very close
to those found in 4-6

Graphically

$$\theta_{31} = 347^\circ$$

$$\theta_{32} = 254^\circ$$

$$\theta_{41} = 33^\circ$$

$$\theta_{42} = 215^\circ$$

Numerically

$$\theta_{31} = 346.7^\circ$$

$$\theta_{32} = 257.9^\circ$$

$$\theta_{41} = 31.47^\circ$$

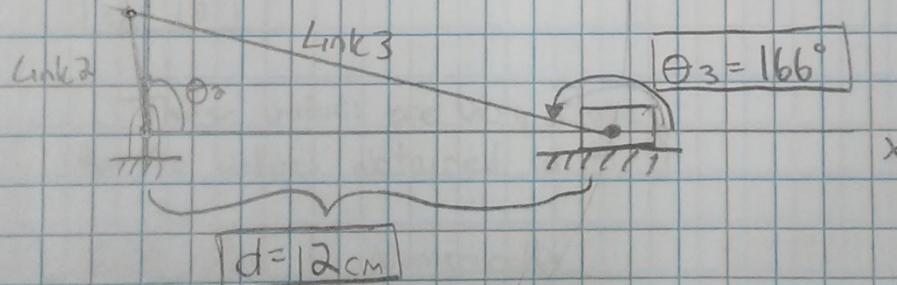
$$\theta_{42} = 212.7^\circ$$

HW 2 Problem 4-9

$$\text{Link } 2 = 3 \quad \text{Link } 3 = 13 \quad \text{Offset} = 0 \quad \theta_2 = 100^\circ$$

Circle of radius 13 (in cm)

Scale 2:1



Homework 2 - Problem 4-10

Same drawing as 4-9

$$\begin{array}{ll} \theta_2 = 100^\circ & \text{Link 2: } a = 3 \\ \theta_4 = 90^\circ & \text{Offset: } c = 0 \end{array}$$

$$\theta_{31} = \sin^{-1} \left(\frac{-a \sin(\theta_2) + c}{b} \right) + 180^\circ$$

$$\theta_{31} = \sin^{-1} \left(\frac{-3 \sin(100) + 0}{13} \right) + 180$$

$$\boxed{\theta_{31} = 166.9^\circ}$$

$$d = a \cos(\theta_2) + b \cos(\theta_{31})$$

$$d = 3 \cos(100) + 13 \cos(166.9)$$

$$\boxed{d = 12.1}$$

These values are very close
to the values obtained in 4-9

Graphically

$$\theta_{31} = 166^\circ$$

$$d = 12$$

Numerically

$$\theta_{31} = 166.9^\circ$$

$$d = 12.1$$

HW2 Problem 4-18b

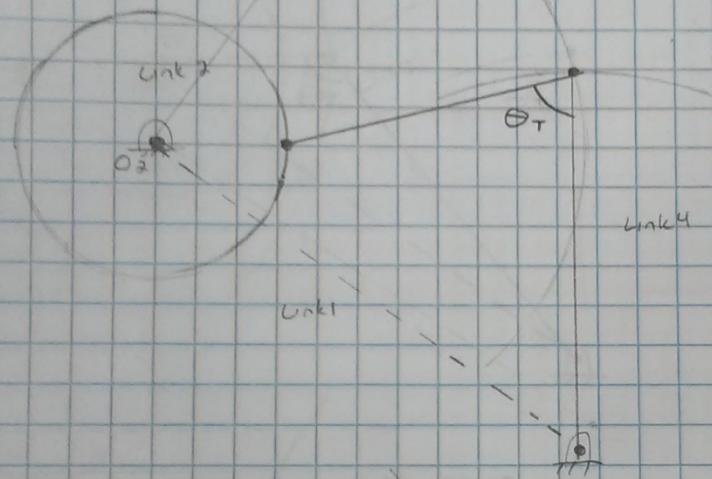
$$L_1 = 16.2$$

$$L_4 = 12.2$$

$$L_2 = 4.0$$

$$L_3 = 9.6$$

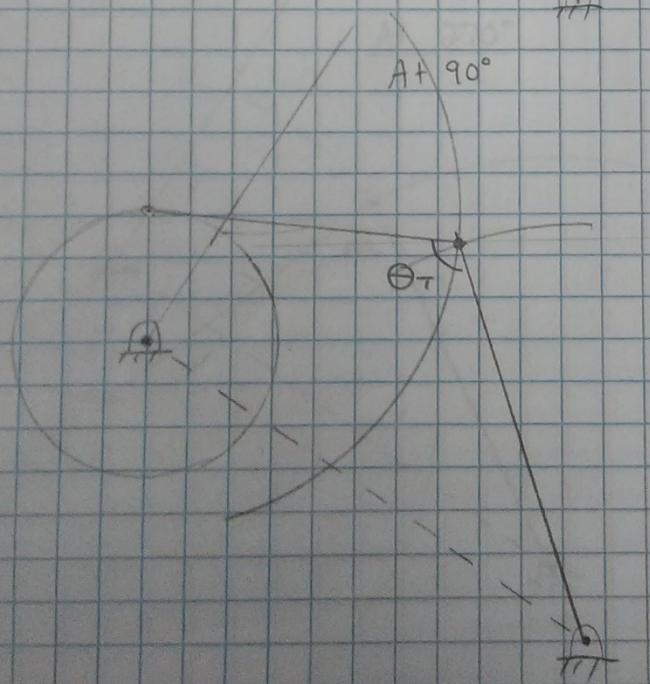
At 0°



$$\theta_{\text{input}} = 0^\circ$$

$$\theta_T = 73^\circ$$

At 90°



$$\theta_{\text{input}} = 90^\circ$$

$$\theta_T = 180 - 111 = 69^\circ$$

H(W) - Problem 4-18b

At 180°

$$\theta_{\text{input}} = 180^\circ$$

$$\theta_f = 54^\circ$$

At 270°

$$\theta_{\text{input}} = 270^\circ$$

$$\theta_f = 80^\circ$$

Hw2 Problem 4-18b

θ_1

90
80
70
60
50
40
30
20
10
0

0

Output

0

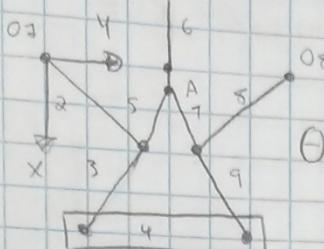
30 60 90 120 150 180 210 240 270 300 330 360

- $\theta_{\text{input}} = 0^\circ \Rightarrow \theta_1 = 71^\circ$
- $\theta_{\text{input}} = 30^\circ \Rightarrow \theta_1 = 50^\circ$
- $\theta_{\text{input}} = 60^\circ \Rightarrow \theta_1 = 31^\circ$
- $\theta_{\text{input}} = 90^\circ \Rightarrow \theta_1 = 16^\circ$
- $\theta_{\text{input}} = 120^\circ \Rightarrow \theta_1 = 64^\circ$
- $\theta_{\text{input}} = 150^\circ \Rightarrow \theta_1 = 51^\circ$
- $\theta_{\text{input}} = 180^\circ \Rightarrow \theta_1 = 54^\circ$
- $\theta_{\text{input}} = 210^\circ \Rightarrow \theta_1 = 57^\circ$
- $\theta_{\text{input}} = 240^\circ \Rightarrow \theta_1 = 64^\circ$
- $\theta_{\text{input}} = 270^\circ \Rightarrow \theta_1 = 80^\circ$
- $\theta_{\text{input}} = 300^\circ \Rightarrow \theta_1 = 71^\circ$
- $\theta_{\text{input}} = 330^\circ \Rightarrow \theta_1 = 71^\circ$
- $\theta_{\text{input}} = 360^\circ \Rightarrow \theta_1 = 71^\circ$

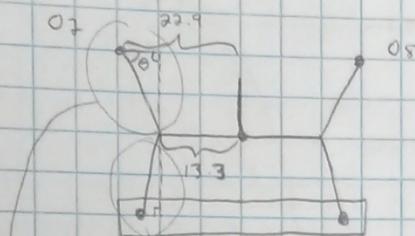
15
75

✓

HW 2 - Problem 4-18 h



$\Theta_2 = 47^\circ$ (Measured w/ Protractor)



$$a = 22.9 - 13.3 = 9.6$$

$$\cos \theta = \frac{a}{b} \Rightarrow \theta = \cos^{-1} \left(\frac{9.6}{19.8} \right) \Rightarrow \theta = 61.0^\circ$$

$$\Theta_2 = 90^\circ - \theta \quad \boxed{\Theta_2 = 29^\circ}$$

$$x_1^2 + 9.6^2 = 19.8^2 \Rightarrow x_1 = 17.3$$

$$b = 82.9 - 4.5 - 13.3 = 5.1$$

$$x_2^2 + 5.1^2 = 19.4^2 \Rightarrow x_2 = 18.7$$

$$\text{Final Length} = 17.3 + 18.7 = 36.02$$

Initial length:

Use Kinematic chain 1, 2, 3, 4 as slider

$$\Theta_{3i} = \sin^{-1} \left(-\frac{a \sin(\Theta_{2i}) - c}{b} \right) + \pi$$

$$a = 9.8 \quad b = 19.4 \quad c = 4.5$$

$$\Theta_{3i} = 147^\circ$$

$$L_0 = a \cos(\Theta_{2i}) - b \cos(\Theta_{3i})$$

$$L_0 = 30.14$$

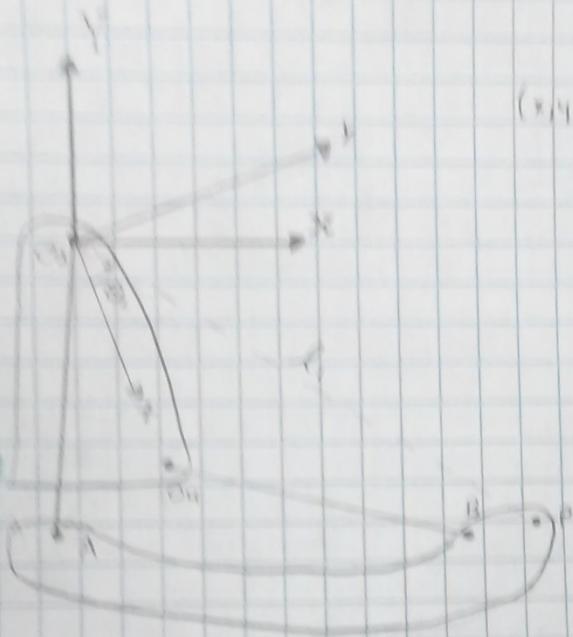
IS
IS

$$\Delta d = L_F - L_0$$

$$\Delta d = 36.02 - 30.14 = \boxed{5.88 \text{ mm}}$$

✓

Hw 3 - Problem 4-3)

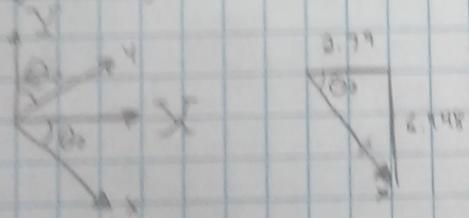


$$(x, y) = (10.316, 10.316)$$

$$l_1 = \sqrt{10.316^2 + 10.316^2} = 16.401$$

$$\theta_1 = \tan^{-1}\left(\frac{10.316}{10.316}\right) = 38.609^\circ$$

X goes along θ_2



$$l_2 \cos \theta_2 = \frac{6.3148}{16.401} \Rightarrow \theta_2 = 63.12^\circ$$

$$\theta_2 - \theta_1 = 27.31^\circ \text{ CW from } X\text{-axis}$$

$$\theta_1 = \theta_2 \text{ (same origin)}$$

$$16.401 = \sqrt{a^2 + b^2} \Rightarrow 268.78 = a^2 + b^2$$

$$-27.31 + 63.12 \left(\frac{b}{a}\right) \Rightarrow -.566a = b$$

$$b^2 = 268.78 - a^2 = 0.3206a^2 \Rightarrow 1.3206a^2 = 268.78$$

$$\Rightarrow a = 14.27 \quad b = -8.078$$

(C)
10

$$(X, Y) = (14.27, -8.078)$$