In-class Examples for Chapter 2: Position Analysis

1) Robot Arms

What is the position of point D with respect to point O if BC and CD are horizontal?
2) Door Close Mechanism

Through what range of motion does the damper arm need to move (relative to the door) as the door is opened from $\theta_2 = 0^\circ$ to $\theta_2 = 180^\circ$? Specifically, what is the change in the angle of link 3 relative to link 2 (i.e., what is $\Delta \theta_{3/2}$)?

Given:

<table>
<thead>
<tr>
<th>Link</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>10&quot;</td>
</tr>
<tr>
<td>BC</td>
<td>11&quot;</td>
</tr>
<tr>
<td>CD</td>
<td>12&quot;</td>
</tr>
<tr>
<td>DA</td>
<td>13&quot;</td>
</tr>
</tbody>
</table>

Find: $\Delta \theta_{3/2} = \theta_{3/2} - \theta_{3/2} = (\theta_3 - \theta_2) - (\theta_3 - \theta_2)$

Solution:

Vector Diagrams

Open Position

Closed Position

Using cosine law

$$\theta_2 = \theta_{RBA} ; \ \theta_3 = \theta_{RCD} ; \ \theta_4 = \theta_{RCD}$$

$$\theta_2 = \theta_{RBA} ; \ \theta_3 = \theta_{RCD} ; \ \theta_4 = \theta_{RCD}$$

Using cosine law

$$12^2 = 11^2 + 3^2 - 2 \times 11 \times 3 \times \cos \theta_3$$

$$\theta_3 = 102^\circ$$

$$\Delta \theta_{3/2} = (0 - 180) - (102 - 0) = -282^\circ$$

Link 3 is moving c.w. w.r.t. link 2
2) Door Close Mechanism (b)

What are the angles of Links 3 and 4 when the door is open 45°?

Given:

\[ R_{BA} = 10'' \]
\[ R_{CB} = 11'' \]
\[ R_{DC} = 12'' \]
\[ R_{AD} = 13'' \]

\[ \Theta_{BA} = \Theta_2 = 45° \]
\[ \Theta_{AD} = 180° \]

Find: \[ \Theta_3 = \Theta_{CB} \], \[ \Theta_4 = \Theta_{DC} + 180° \]

Solution:

\[ \vec{R}_{BA} + \vec{R}_{CB} + \vec{R}_{DC} + \vec{R}_{AD} = 0 \]
\[ \vec{R}_{CB} + \vec{R}_{DC} = - (\vec{R}_{BA} + \vec{R}_{AD}) \]

For case 4:

\[ \Theta_A = \Theta_C \pm \cos^{-1} \frac{C^2 + A^2 - B^2}{2AC} \]
\[ \Theta_B = \Theta_C \pm \cos^{-1} \frac{C^2 + B^2 - A^2}{2BC} \]

For the configuration drawn above, need to use \[ \Theta_{CB} = 22.15° \] and \[ \Theta_{DC} = -110.79° \].

\[ \Theta_3 = \Theta_{CB} = 22° \]
\[ \Theta_4 = \Theta_{DC} + 180° = -110.79° + 180 = 69° \]

This is Case 4 with

\[ \bar{C} = - (\vec{R}_{BA} + \vec{R}_{AD}) \]
\[ = -(10\cos 45° + 10\sin 45°) + (-13\sin 45°) \]
\[ = 5.929 \pm 7.071 \]
\[ = 9.228'' \angle -50.02° \]

Homework 3.11 & 3.15 Position Analysis Only