Class: EML6281

Assignment: Homework 6

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In [2]:
```
from IPython.display import Image

Image('img.JPG', width=700)
```

Out[2]: HW 6 - Chap 7 ; problem 7.3, complete by Monday, 24 Oct 2022 ; solution

3. A planar representation of a group 1 spatial closed-loop mechanism with link a_{71} fixed to ground is shown in Figure 7.8.

(a) Assuming that all constant mechanism parameters are known and that the angle θ_7 is given as an input angle, explain how to solve for the angle θ_1. How many values for θ_1 can be found?

(b) Assuming that you have successfully solved for θ_1, explain how you would solve for the angle θ_4.

(c) Assuming that you have successfully solved for θ_1 and θ_4, explain how you would solve for the angle θ_5.

(d) Finally, assuming that you have successfully solved for θ_2, θ_4, and θ_5, explain how you would solve for the slider displacements S_2, S_3, and S_6.

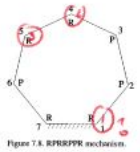

Figure 7.8. RPRRPPR mechanism.

$$Z_{67123} = C_{45}$$

a) Since $\theta_6, \theta_7, \theta_2, \& \theta_3$ are known, the fundamental equation $Z_{67123} = C_{45}$ can be used to solve for θ_1

$Z_{67123} = C_{45}$ $\quad A = S_{12} Y_5 \quad B = S_{12} C_5 \quad D = C_{12} Z_5 - \bar{Z}_3$

$$\Rightarrow S_{34}(X_{6712} S_3 + Y_{6712} C_3) + C_{34} Z_{6712} - C_{45}$$

$$X_{6712} = X_{671} C_2 - Y_{671} S_2$$

$$Y_{6712} = C_{23}(X_{671} S_2 + Y_{671} C_2) - S_{23} Z_{671}$$

$$Z_{6712} = S_{23}(X_{671} S_2 + Y_{671} C_2) + C_{23} Z_{671}$$

$$X_{671} = X_{67} C_1 - Y_{67} S_1$$

$$Y_{671} = C_{71}(X_{67} S_1 + Y_{67} C_1) - S_{71} Z_{67}$$

$$Z_{671} = C_{71}(X_{67} S_1 + Y_{67} C_1) - C_{71} Z_{67}$$

$A = S_{34} Y_{6712} \quad B = S_{34} X_{6712} \quad D = C_{34} Z_{6712} - C_{45}$

then solve $A C_1 - B S_1 + D = 0$ for θ_1

The definitions for expressions with four subscripts in increasing order are written as

$$X_{ijkl} = X_{kl} c_{ij} - Y_{kl} s_{ij}. \tag{6.69}$$
$$X^*_{ijkl} = X_{kl} s_{ij} + Y_{kl} c_{ij}. \tag{6.70}$$
$$Y_{ijkl} = c_{kl}(X_{ij} s_{kl} + Y_{ij} c_{kl}) - s_{kl} Z_{ij}. \tag{6.71}$$
$$Z_{ijkl} = s_{kl}(X_{ij} s_{kl} + Y_{ij} c_{kl}) + c_{kl} Z_{ij}. \tag{6.72}$$

and the definitions for expressions with four subscripts in decreasing order are

$$X_{ijkl} = X_{ij} c_{kl} - Y_{ij} s_{kl}. \tag{6.73}$$
$$X^*_{ijkl} = X_{ij} s_{kl} + Y_{ij} c_{kl}. \tag{6.74}$$
$$Y_{ijkl} = c_{ij}(X_{ij} s_{kl} + Y_{ij} c_{kl}) - s_{ij} Z_{kl}. \tag{6.75}$$
$$Z_{ijkl} = s_{ij}(X_{ij} s_{kl} + Y_{ij} c_{kl}) + c_{ij} Z_{kl}. \tag{6.76}$$

The definitions for expressions with five subscripts in increasing order are written as

$$X_{klij} = X_{klij} c_1 - Y_{klij} s_1. \tag{6.77}$$
$$X^*_{klij} = X_{klij} s_1 + Y_{klij} c_1. \tag{6.78}$$
$$Y_{klij} = c_{kl}(X_{klij} s_1 + Y_{klij} c_1) - s_{kl} Z_{klij}. \tag{6.79}$$
$$Z_{klij} = s_{kl}(X_{klij} s_1 + Y_{klij} c_1) + c_{kl} Z_{klij}. \tag{6.80}$$

and the definitions for expressions with five subscripts in decreasing order are

$$X_{klij} = X_{klij} c_1 - Y_{klij} s_1. \tag{6.81}$$
$$X^*_{klij} = X_{klij} s_1 + Y_{klij} c_1. \tag{6.82}$$
$$Y_{klij} = c_{kl}(X_{klij} s_1 + Y_{klij} c_1) - s_{kl} Z_{klij}. \tag{6.83}$$
$$Z_{klij} = s_{kl}(X_{klij} s_1 + Y_{klij} c_1) + c_{kl} Z_{klij}. \tag{6.84}$$

b) To solve for θ_4, the "Buddy Equations" should be used.

$$X_{67123} = S_{45} S_4$$
$$Y_{67123} = S_{45} C_4$$

} Solve for θ_4 * everything else is known

c) To solve for θ_5, the following equations can be used:

$$X_{32176} = S_{45} S_5$$
$$Y_{32176} = S_{45} C_5$$

} Solve for θ_5 * everything else is known

D) To solve for S_2, S_3, S_6, the vector loop equation should be used.

$$S_1 S_1 + a_{12} a_{12} + S_2 S_2 + a_{23} a_{23} + S_3 S_3 + a_{34} a_{34} + S_4 S_4 + a_{45} a_{45} + S_5 S_5 + a_{51} a_{56}$$
$$S_6 S_6 + a_{67} a_{67} + S_7 S_7 + a_{71} a_{71}$$

Using Set 1, a system of 3 equations with 3 unknowns can be formed and S_2, S_3 & S_6 can be solved for.

Set 1	S_1 (	0,	0,	1	)	$\bar{a}_{12}$ (	1,	0,	0)
	S_2 (	0,	$-s_{12}$,	c_{12}	)	$\bar{a}_{23}$ (	c_3,	$s_3 c_{12}$,	U_{23})
	S_3 (	X_3,	Y_3,	Z_3	)	$\bar{a}_{34}$ (	W_{32},	$-U^*_{321}$,	U_{321})
	S_4 (	X_{32},	Y_{32},	Z_{32}	)	$\bar{a}_{45}$ (	W_{432},	$-U^*_{4321}$,	U_{4321})
	S_5 (	X_{432},	Y_{432},	Z_{432}	)	$\bar{a}_{56}$ (	W_{5432},	$-U^*_{54321}$,	U_{54321})
	S_6 (	X_{5432},	Y_{5432},	Z_{5432}	)	$\bar{a}_{67}$ (	W_{65432},	$-U^*_{654321}$,	U_{654321})
	S_7 (	X_{65432},	Y_{65432},	Z_{65432}	)	$\bar{a}_{71}$ (	c_1,	$-s_1$,	0)