EME 152 Discussion 9

November 24, 2021

Agenda

- Derivation of slider velocity
- Input/output torque example
- Three-position synthesis example

Derivation of Slider Velocity

Input/output Torque Example

- Setting US/SI units is now very important!
  - Set the unit system with `uscUnit(true)` for US units and `false` for SI units.
- In the `CFourbar` class:
  - Use the function `setGravityCenter()` to set the gravity center properties (including r_g and delta) of links 2, 3, and 4.
  - Use the function `setInertia()` to set inertial properties of links 2, 3, and 4.
  - Use the function `setMass()` to set the masses of links 2, 3, and 4.
  - Use the functions `forceTorque()`, `forceTorques()`, and `plotForceTorques()` to calculate or plot forces on joints in the four bar linkage mechanism.
- Visit the Ch Mechanism Toolkit file in *C-STEM Studio > My Workspace > LearnMechanism > chmechanism.pdf* for the parameters and return value of these functions.

01_forceTorque.ch

02_plotForceTorques.ch

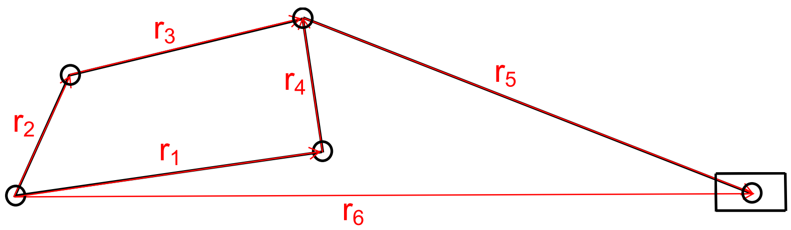
Four Bar Linkage Position Synthesis

- Need to have phi_1, phi_2, phi_3 and psi_1, psi_2, psi_3 in radians.
- In the `CFourbar` class:
  - The function `synthesis()` requires an empty array for the length of links `r[1:4]`, an array of the input angles `phi[1:3]`, and an array of the output angles `psi[1:3]`. This function synthesizes the four bar linkage and generates the array `r[1:4]` which you can then use in the function `setLinks()`.
  - After using `setLinks()`, you can treat the CFourbar class like a normal four bar mechanism and you can call any other function (e.g. calculating forces and torques, animating, etc.)

03_synthesis.ch

Thank you!

Questions? Email!



Fourbar Slider Acceleration Derivation

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March 22, 2010

1 Derivation

$$\vec{r_6} = \vec{r_2} + \vec{r_3} + \vec{r_5} \tag{1}$$

$$r_6 e^{i\theta_6} = r_2 e^{i\theta_2} + r_3 e^{i\theta_3} + r_5 e^{i\theta_5} \tag{2}$$

$$\dot{r_6} = r_2 i\omega_2 e^{i\theta_2} + r_3 i\omega_3 e^{i\theta_3} + r_5 i\omega_5 e^{i\theta_5} \tag{3}$$

The unknowns in the previous equation are $\dot{r_6}$ and ω_5. We assume that ω_3 has already been found, since it is part of the four-bar mechanism. If we use the equality $i = e^{i\pi/2}$ in the above equation, we may rewrite it as

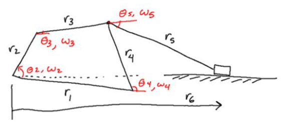
$$\dot{r_6} = r_2\omega_2 e^{i(\theta_2+\pi/2)} + r_3\omega_3 e^{i(\theta_3+\pi/2)} + r_5\omega_5 e^{i(\theta_5+\pi/2)} \tag{4}$$

The above equation may be readily solved with `complexsolve()`, or using analytical methods discussed in previous discussions.

Taking a derivative one more time, we get

$$\ddot{r_6} = r_2 i e^{i\theta_2}(\alpha_2 - i\omega_2^2) + r_3 i e^{i\theta_3}(\alpha_3 - i\omega_3^2) + r_5 i e^{i\theta_5}(\alpha_5 - i\omega_5^2) \tag{5}$$

Again, we assume the only unknowns in the above equation are $\ddot{r_6}$ and α_5, since we found ω_5 in the last step. We assume all other angular velocities and accelerations have been solved for during the analysis of the fourbar part of the mechanism.



$$\underbrace{r_6 = r_2 + r_3 + r_5} \quad = r_1 + r_4 + r_5$$

$$r_6 \cancel{e^{i\theta_6}} = r_2 e^{i\theta_2} + r_3 e^{i\theta_3} + r_5 e^{i\theta_5} \qquad \theta_6 = 0 \quad e^{i\theta_6} = 1$$

complexsolvePR $\rightarrow r_6, \theta_5$

$$r_6 =$$

$$\dot{\theta}_2 = \omega_2 \quad \dot{\theta}_3 = \omega_3 \quad \dot{\theta}_5 = \omega_5$$

$$v_6 = \dot{r}_6 = r_2 i \omega_2 e^{i\theta_2} + r_3 i \omega_3 e^{i\theta_3} + r_5 i \omega_5 e^{i\theta_5}$$

$$i = e^{i\frac{\pi}{2}} \qquad e^a e^b = e^{a+b}$$

$$\dot{r}_6 = r_2 \omega_2 e^{i(\theta_2 + \frac{\pi}{2})} + r_3 \omega_3 e^{i(\theta_3 + \frac{\pi}{2})} + r_5 \omega_5 e^{i(\theta_5 + \frac{\pi}{2})}$$

angularVel

angularPos

$$\dot{r}_6 = Z_1 + Z_2 + M e^{i\theta}$$

$$\dot{r}_6 = Z_3 + \dot{M} e^{i\theta}$$

complexsolvePR $\rightarrow \dot{r}_6, \omega_5$

$$\dot{r}_6 = r_2 \omega_2 e^{i(\theta_2 + \frac{\pi}{2})} + r_3 \omega_3 e^{i(\theta_3 + \frac{\pi}{2})} + r_5 \omega_5 e^{i(\theta_5 + \frac{\pi}{2})}$$

$$\dot{\omega}_5 = \alpha_5$$

$$\ddot{r}_6 = a_6 = r_2 i e^{i\theta_2}(\alpha_2 - i\omega_2) + r_3 i e^{i\theta_3}(\alpha_3 - i\omega_3^2) + r_5 i e^{i\theta_5}(\alpha_5 - i\omega_5^2)$$

angularAccel

complexsolvePR $\rightarrow a_6, \alpha_5$

$$\ddot{r}_6 = Z_1 + Z_2 + \alpha_5 r_5 i e^{i\theta_5} \underbrace{- i\omega_5^2 i e^{i\theta_5}}_{Z_3}$$

$$\ddot{r}_6 = Z + \dot{M} e^{i\theta_5}$$

com . . . PR $\rightarrow \ddot{r}_6, M$

$M \rightarrow \alpha_5$