PENNSTATE Berks

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HW3

Assume the mechanism shown below has the following parameters

$$r_{O_2B} = 3.5cm, \quad \dot{\theta}_2 = 125rpm(CCW)$$

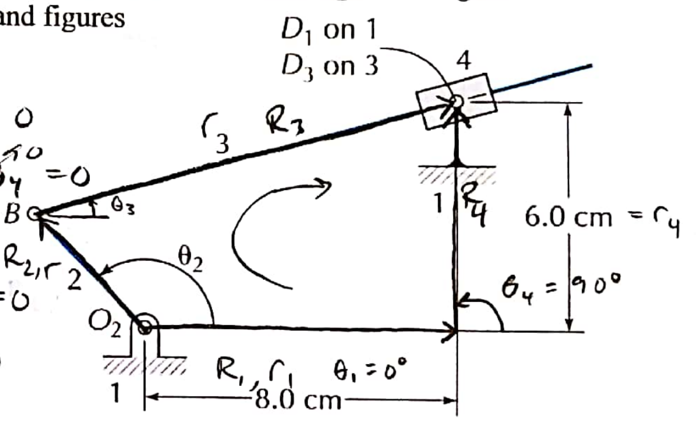
For this mechanism:

a) Determine the position of point D_3 with respect to point B as a function of θ_2 and plot your results using values of θ_2 from 0 to 2π in increments of 0.001 radians.

b) Determine the angular position and velocity of link 3 as a function of θ_2 and plot your results using values of θ_2 from 0 to 2π in increments of 0.001 radians. You may use a numerical derivative to determine the angular velocity.

c) What is the angular velocity when θ_2 = 75 degrees?

Feel free to start your solution on this page, and add additional pages as necessary. Please include a print out of your MATLAB source code as well as the requested figures using the MATLAB "Publish" feature to print your code and figures



(1) $-R_1 + R_2 + R_3 - R_4 = 0$

$-r_1\cos\theta_1 + r_2\cos\theta_2 + r_3\cos\theta_3 - r_4\cos\theta_4 = 0$

(2) $-r_1 + r_2\cos\theta_2 + r_3\cos\theta_3 = 0$

$-r_1\sin\theta_1 + r_2\sin\theta_2 + r_3\sin\theta_3 - r_4\sin\theta_4 = 0$

(3) $+r_2\sin\theta_2 + r_3\sin\theta_3 - r_4 = 0$

a) $\theta_2 = [0, 2\pi]$ increments of 0.001 rad

$r_1 = 8.0$ cm (constant)

$r_4 = 6.0$ cm (constant)

$r_2 = 3.5$ cm (constant)

$\dot{\theta}_2 = 125$ rpm (ccw)

unknown Variables

$\theta_2, \theta_3, r_3, \dot{r}_3, \dot{\theta}_3$

(2a) $r_2\cos\theta_2 = r_1 - r_3\cos\theta_3$, $r_3 = \dfrac{r_1 - r_2\cos\theta_2}{\cos\theta_3}$ (2d), θ_3 found with (4c)

(3a) $r_2\sin\theta_2 = r_4 - r_3\sin\theta_3$

(2b) $= \dfrac{d}{dt}[(2a)] = \dot{r}_2\cos\theta_2 - r_2\dot{\theta}_2\sin\theta_2 = \dot{r}_1 - \dot{r}_3\cos\theta_3 + r_3\dot{\theta}_3\sin\theta_3$

(3b) $= \dfrac{d}{dt}[(3a)] = \dot{r}_2\sin\theta_2 + r_2\dot{\theta}_2\cos\theta_2 = \dot{r}_4 - \dot{r}_3\sin\theta_3 - r_3\dot{\theta}_3\cos\theta_3$

(2c) $r_3\dot{\theta}_3\sin\theta_3 = \dot{r}_3\cos\theta_3 - r_2\dot{\theta}_2\sin\theta_2$

(3c) $r_3\dot{\theta}_3\cos\theta_3 = -\dot{r}_3\sin\theta_3 - r_2\dot{\theta}_2\cos\theta_2$

(4a) $= \dfrac{(2c)}{(3c)} = \tan\theta_3 = \dfrac{\dot{r}_3\cos\theta_3 - r_2\dot{\theta}_2\sin\theta_2}{-\dot{r}_3\sin\theta_3 - r_2\dot{\theta}_2\cos\theta_2}$ See pg 2 for r_3 eqn

rearrange (2a) & (3a) and solve for $\tan\theta_3$

(4b) $\tan\theta_3 = \dfrac{r_4 - r_2\sin\theta_2}{r_1 - r_2\cos\theta_2} \Rightarrow$ (4c) $\theta_3 = \tan^{-1}\left[\dfrac{r_4 - r_2\sin\theta_2}{r_1 - r_2\cos\theta_2}\right]$

Solving (4a) for $\dot{r}_3$

$$-\tan\theta_3 \dot{r}_3 \sin\theta_3 - \tan\theta_3 r_2 \dot{\theta}_2 \cos\theta_2 = \dot{r}_3 \cos\theta_3 - r_2 \dot{\theta}_2 \sin\theta_2$$

$$\dot{r}_3(\cos\theta_3 + \tan\theta_3 \sin\theta_3) = r_2\dot{\theta}_2 \sin\theta_2 - \tan\theta_3 r_2 \dot{\theta}_2 \cos\theta_2$$

$$\dot{r}_3\left(\frac{\cos^2\theta_3 + \sin^2\theta_3}{\cos\theta_3}\right) = r_2\dot{\theta}_2(\sin\theta_2 - \tan\theta_3 \cos\theta_2)$$

$$\dot{r}_3 \sec\theta_3 = r_2\dot{\theta}_2(\sin\theta_2 - \tan\theta_3\cos\theta_2)$$

$$\dot{r}_3 = r_2\dot{\theta}_2(\sin\theta_2\cos\theta_3 - \sin\theta_3\cos\theta_2)$$

(5) $$\dot{r}_3 = r_2\dot{\theta}_2 \sin(\theta_2 - \theta_3)$$

plugging (5) into (2c) and solve for $\dot{\theta}_3$

(6) $$\dot{\theta}_3 = \frac{r_2\dot{\theta}_2\sin(\theta_2-\theta_3)\cos\theta_3 - r_2\dot{\theta}_2\sin\theta_2}{r_3\sin\theta_3}$$

vector equation for Link 3:

(2e) $$\vec{R}_3 = \langle r_3\cos\theta_3,\ r_3\sin\theta_3\rangle$$