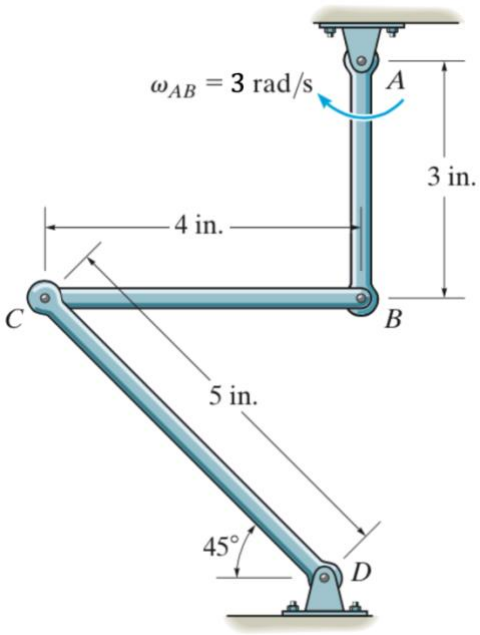
Quiz 13: Chapter 18

Due: Friday 15 Mar 2024

Examine the solved problem below. There are five errors. Your task is to locate and identify any mistakes, then correct them and calculate the proper result. If the same error occurs more than once, only count it as a single error, even if you have to correct it in more than one instance.

Each correctly identified error is worth 3 points, and the re-calculated results are worth 5 points. You must save your work in pdf format and submit via the Quiz 13 Assignment in the Chapter 18 in the Quizzes folder of the Online Classroom in Blackboard. Please do not use any other file format than pdf.

At the instant shown, link AB has an angular velocity $\omega_{AB} = 3\frac{\text{rad}}{\text{s}}$. If each link is considered as a uniform slender bar with a weight of $0.25\frac{\text{lb}}{\text{in}}$, determine the total kinetic energy of the system.



A) Separate the links and sketch the velocity of each:

See diagrams below.

B) Write the equations for the velocities:

Link AB: $v_B = \omega_{AB} r_{AB} = \left(3\frac{\text{rad}}{\text{s}}\right)(3\text{in}) = 9\frac{\text{in}}{\text{s}}$

Link BC: $v_B = \omega_{BC} r_B$
3-4-5 geometry: $r_B = 3\text{in}$
$v_B = \omega_{BC}(3\text{in})$

$9\frac{\text{in}}{\text{s}} = \omega_{BC}(3\text{in})$
$\omega_{BC} = 3\frac{\text{rad}}{\text{s}}$

Link BC: $v_G = \omega_{BC} r_G$

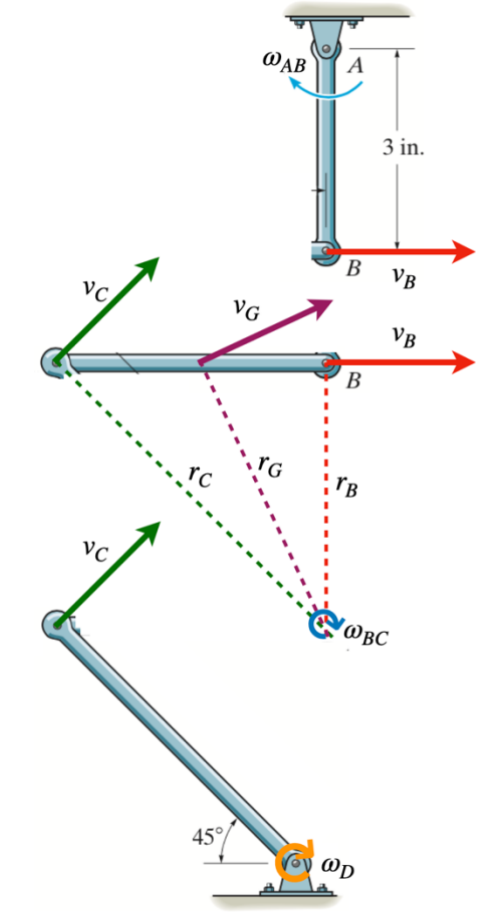
$$r_G = \sqrt{r_B^2 + \left(\frac{r_{BC}}{2}\right)^2} = \sqrt{(3\text{in})^2 + (2\text{in})^2} = 3.61\text{in}$$

$$v_G = \omega_{BC}(3.61\text{in}) = \left(3\frac{\text{rad}}{\text{s}}\right)(3.61\text{in}) = 10.82\frac{\text{in}}{\text{s}}$$

Link BC: $v_C = \omega_{BC} r_C$
3-4-5 geometry: $r_C = 5\text{in}$
$v_C = \omega_{BC}(5\text{in}) = \left(3\frac{\text{rad}}{\text{s}}\right)(5\text{in}) = 15\frac{\text{in}}{\text{s}}$

Link CD: $v_C = \omega_D (r_{DC} \sin 45°)$
$15\frac{\text{in}}{\text{s}} = \omega_D (5\text{in}) \sin 45°$

$$\omega_D = \frac{\left(15\frac{\text{in}}{\text{s}}\right)}{(5\text{in})\sin 45°} = 4.24\frac{\text{rad}}{\text{s}}$$



C) Write the expression for the kinetic energy:

$T = T_{AB} + T_{BC} + T_{CD}$
Error 04: Uses weight, not mass!

$$T_{AB} = \frac{1}{2} I_A \omega_{AB}^2 = \frac{1}{2}\left(\frac{1}{3} m_{AB} r_{AB}^2\right)\omega_{AB}^2 = \frac{1}{6}\left[\left(0.25\frac{\text{lb}}{\text{in}}\right) r_{AB}\right] r_{AB}^2 \omega_{AB}^2$$

$$T_{AB} = \frac{1}{6}\left(0.25\frac{\text{lb}}{\text{in}}\right)\left[(3\text{in})\left(\frac{1\text{ft}}{12\text{in}}\right)\right]^3 \left(3\frac{\text{rad}}{\text{s}}\right)^2 = (5.895 \times 10^{-3})\text{ft} \cdot \text{lb}$$

$$T_{BC} = \frac{1}{2} m_{BC} v_G^2 + \frac{1}{2} I_G \omega_{BC}^2 = \frac{1}{2} m_{BC} v_G^2 + \frac{1}{2}\left(\frac{1}{12} m_{BC} r_{BC}^2\right)\omega_{BC}^2$$

$$T_{BC} = \frac{1}{2}\left[\left(0.25\frac{\text{lb}}{\text{in}}\right)(4\text{in})\right]\left[\left(10.82\frac{\text{in}}{\text{s}}\right)\left(\frac{1\text{ft}}{12\text{in}}\right)\right]^2 + \frac{1}{24}\left(0.25\frac{\text{lb}}{\text{in}}\right)\left[(4\text{in})\left(\frac{1\text{ft}}{12\text{in}}\right)\right]^3 \left(3\frac{\text{rad}}{\text{s}}\right)^2 = 0.410\text{ft} \cdot \text{lb}$$

$$T_{CD} = \frac{1}{2} I_D \omega_D^2 = \frac{1}{2}\left(\frac{1}{3} m_{CD} r_{DC}^2\right)\omega_D^2 = \frac{1}{6}\left[\left(0.25\frac{\text{lb}}{\text{in}}\right) r_{DC}\right] r_{DC}^2 \omega_D^2$$

$$T_{CD} = \frac{1}{6}\left(0.25\frac{\text{lb}}{\text{in}}\right)\left[(5\text{in})\left(\frac{1\text{ft}}{12\text{in}}\right)\right]^3 \left(4.24\frac{\text{rad}}{\text{s}}\right)^2 = 0.0542\text{ft} \cdot \text{lb}$$

$$T = (5.895 \times 10^{-3} + 0.410 + 0.0542)\text{ft} \cdot \text{lb} = 0.4701\text{ft} \cdot \text{lb}$$