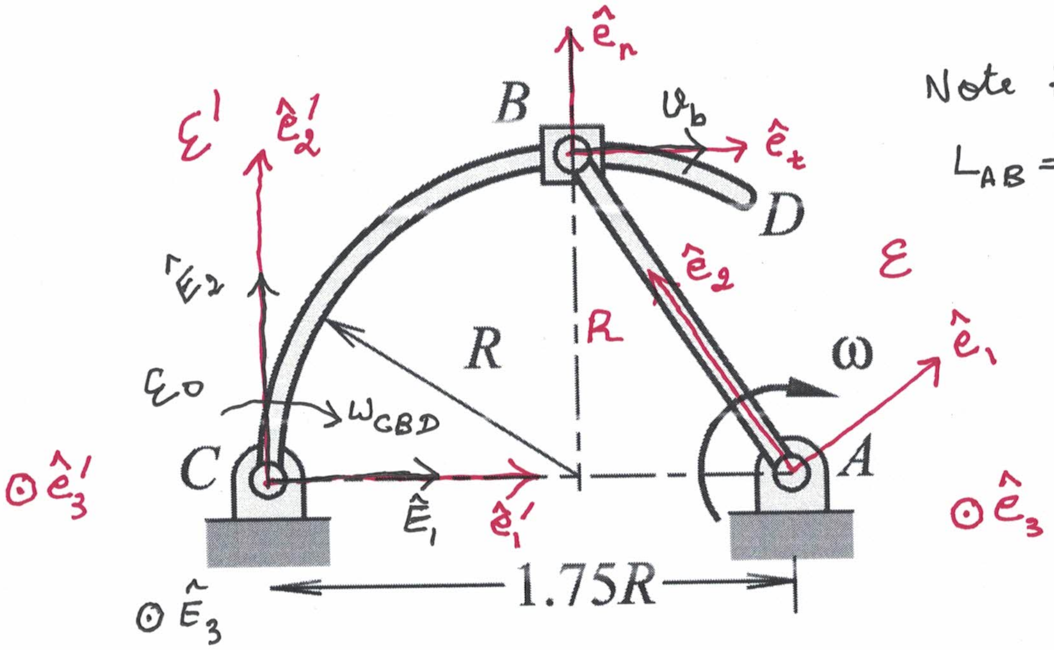
# TUTORIAL-6, PROBLEM-4






Note that $L_{AB} = 1.25R$.

$\mathcal{E}$ frame attached to bar AB with origin at 'A'

$\mathcal{E}'$ frame attached to bar CBD with origin at 'C'.
This frame is fixed to CBD such that $\hat{e}_2'$ is always tangent to CBD at C.

$\mathcal{E}_0$ is the ground frame with origin at 'C'

$$\{\mathcal{E}_0, C, \hat{E}_i\}, \quad \{\mathcal{E}, A, \hat{e}_i\}, \quad \{\mathcal{E}', C, \hat{e}_i'\}$$

Also defining unit vectors attached to B; $\hat{e}_t$ tangent to CBD at B and $\hat{e}_n$ is perpendicular and upwards.

At the instant shown,

$$\hat{e}_1' = \hat{E}_1 = \hat{e}_t \quad \text{------} \quad (1)$$

$$\hat{e}_2' = \hat{E}_2 = \hat{e}_n$$

Given $\underline{\omega}_{\mathcal{E}/\mathcal{E}_0} = \underline{\omega}_{AB} = -\omega\,\hat{e}_3 = -\omega\,\hat{E}_3$

find $\underline{\omega}_{\mathcal{E}'/\mathcal{E}_0} = \underline{\omega}_{CBD} = -\omega_{CBD}\,\hat{e}'_3$

$= -\omega_{CBD}\,\hat{E}_3$.

choosing B as the convenient point to do velocity analysis using

$$\underline{v}^{P} = \underline{v}^{P}_{rel} + \underline{\omega}_{\mathcal{E}/\mathcal{E}_0} \times \underline{r}^{P/G} + \underline{v}^{G/O}$$

(from lectures)

Finding velocity of B as observed from bar AB,

$P \rightarrow B$ $\quad\quad \underline{\omega}_{\mathcal{E}/\mathcal{E}_0} = \underline{\omega}_{AB}$

$G \rightarrow A$

$O \rightarrow C$

i.e., $$\underline{v}^{B} = \underbrace{\cancel{\underline{v}^{B}_{rel}}}_{0} + \underline{\omega}_{AB} \times \underline{r}^{B/A} + \underbrace{\cancel{\underline{v}^{A/C}}}_{0}$$

$$= -\omega\,\hat{E}_3 \times \left(\underline{r}^{B/C} - \underline{r}^{A/C}\right)$$

$$= -\omega\,\hat{E}_3 \times \left(-0.75R\,\hat{E}_1 + R\,\hat{E}_2\right)$$

$$\underline{v}^{B} = 0.75\,R\omega\,\hat{E}_2 + R\omega\,\hat{E}_1 \quad \cdots\cdots (2)$$

Finding velocity of B as observed from bar CBD,

$P \to B$

$G \to C$ $\qquad \underline{\omega}_{\mathcal{E}'/\mathcal{E}_0} = \underline{\omega}_{CBD}$

$O \to C$

i.e., $\underline{v}^B = \underline{v}^B_{rel} + \underline{\omega}_{CBD} \times \underline{r}^{B/C} + \cancel{\underline{v}^{C/C}}_{\to 0}$

$$= \underline{v}^B_{rel} + -\omega_{CBD}\hat{E}_3 \times (R\hat{E}_1 + R\hat{E}_2)$$

$$= \underline{v}^B_{rel} - R\omega_{CBD}\hat{E}_2 + R\omega_{CBD}\hat{E}_1 \qquad \text{-------- (3)}$$

Now note that $\underline{v}^B_{rel} = v_b\,\hat{e}_t$

i.e. the velocity is always along $\hat{e}_t$.

At the given time instant, $\hat{e}_t = \hat{E}_1$

Thus $\underline{v}^B_{rel} = v_b\,\hat{E}_1 \qquad \text{----- (4)}$

Equating (2) & (3) and using (4),

$$0.75R\omega\,\hat{E}_2 + R\omega\,\hat{E}_1 = v_b\,\hat{E}_1 - R\omega_{CBD}\hat{E}_2 + R\omega_{CBD}\hat{E}_1$$

$\hat{E}_2$, $\quad 0.75\cancel{R}\omega = -\cancel{R}\omega_{CBD} \Rightarrow \omega_{CBD} = -0.75\omega$

i.e. $\vec{\omega}_{CBD} = 0.75\,\omega\,\hat{E}_3$

$\hat{E}_1$, $\quad R\omega = v_b + R\omega_{CBD} \Rightarrow v_b = 1.75R\omega$

i.e. $\underline{v}^B_{rel} = 1.75R\omega\,\hat{e}_t$