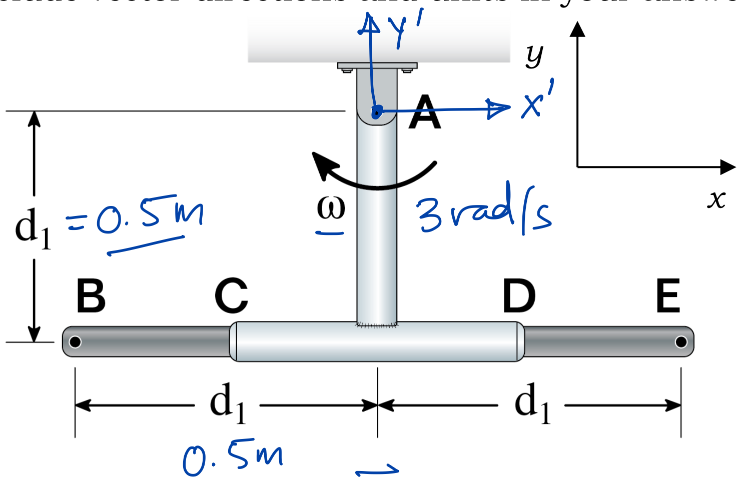
Problem 1 [20 Marks] Body ACD is pinned at A and is rotating with an angular velocity of ω = 3 rad/s (as shown) at this instant. Bar BE slides through tube CD, such that, at this instant, the velocity of B is purely in the $\hat{\jmath}$-direction, and the acceleration of B is zero (as observed from the fixed frame). Find the vectors for the velocity and acceleration of B in the rotating frame, $(\vec{v}_{B/A})_{x'y'z'}$ and $(\vec{a}_{B/A})_{x'y'z'}$, and the angular acceleration of ACD, $\vec{\alpha}$, at this instant. Distance d_1 = 0.5 m. [Reminder – include vector directions and units in your answer].



Known: $(\vec{V}_{B/A})_{x'y'z'} = (\vec{V}_{B/A})_{rel}$

$(\vec{V}_{B/A})_{x'y'z'}$ in x-dir only

$(\vec{a}_{B/A})_{x'y'z'}$ in x-dir only

$\vec{\omega} = -3 \text{ rad/s } \hat{k}$

$\vec{r}_{B/A} = -0.5\hat{\imath} - 0.5\hat{\jmath}$

$\vec{V}_B = V_B \hat{\jmath}$

$\vec{a}_B = 0$

$$\vec{V}_B = \vec{V}_A + \vec{\Omega} \times \vec{r}_{B/A} + (\vec{V}_{B/A})_{x'y'z'}$$

($\vec{V}_A = 0$, $\vec{\Omega} = \vec{\omega}$)

$$V_B\hat{\jmath} = -3\hat{k} \times (-0.5\hat{\imath} - 0.5\hat{\jmath}) + (V_{B/A})_{x'y'z'}\hat{\imath}$$

$$V_B\hat{\jmath} = 1.5\hat{\jmath} - 1.5\hat{\imath} + (V_{B/A})_{x'y'z'}\hat{\imath}$$

Components:

$\hat{\imath}$: $0 = -1.5 + (V_{B/A})_{x'y'z'} \Rightarrow$ $\boxed{(\vec{V}_{B/A})_{x'y'z'} = 1.5 \text{ m/s } \hat{\imath}}$

$\hat{\jmath}$: $V_B = 1.5$ $\quad \vec{V}_B = 1.5 \text{ m/s } \hat{\jmath}$

$$\vec{a}_B = \vec{a}_A + \dot{\vec{\Omega}} \times \vec{r}_{B/A} - \Omega^2 \vec{r}_{B/A} + 2\vec{\Omega} \times (\vec{V}_{B/A})_{x'y'z'} + (\vec{a}_{B/A})_{x'y'z'}$$

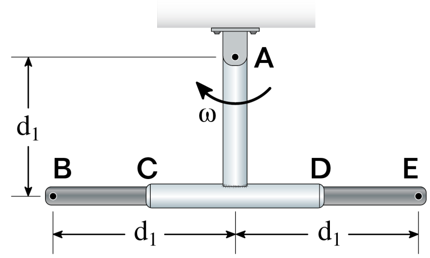
($\vec{a}_B = 0$, $\vec{a}_A = 0$, $\dot{\vec{\Omega}} = \vec{\alpha}$, $\Omega = \omega$, $\vec{\Omega} = \vec{\omega}$)

$$0 = \alpha\hat{k} \times (-0.5\hat{\imath} - 0.5\hat{\jmath}) - (-3 \text{ rad/s})^2(-0.5\hat{\imath} - 0.5\hat{\jmath})$$

$$+ 2(-3 \text{ rad/s } \hat{k}) \times 1.5 \text{ m/s } \hat{\imath} + (a_{B/A})_{x'y'z'}\hat{\imath}$$

$$0 = -0.5\alpha\hat{j} + 0.5\alpha\hat{i} + 4.5\hat{i} + 4.5\hat{j} - 9\hat{j} + (a_{B/A})_{x'y'z'}\hat{i}$$

Problem 1 continued



Components:

$$\hat{i}: \quad 0 = 0.5\alpha + 4.5 + (a_{B/A})_{x'y'z'}$$

$$\hat{j}: \quad 0 = -0.5\alpha + 4.5 - 9$$

$$\Rightarrow 0.5\alpha = -4.5, \quad \alpha = -9$$

$$\boxed{\vec{\alpha} = -9 \text{ rad/s}^2 \, \hat{k}}$$

$$\text{Fr. } \hat{i} \Rightarrow \quad 0 = \cancel{-4.5} + \cancel{4.5} + (a_{B/A})_{x'y'z'}$$

$$\boxed{(\vec{a}_{B/A})_{x'y'z'} = 0}$$