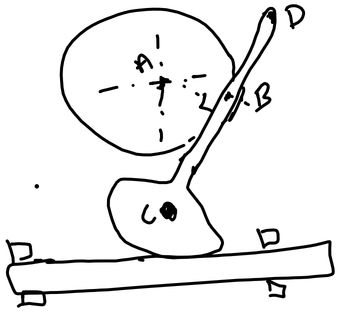
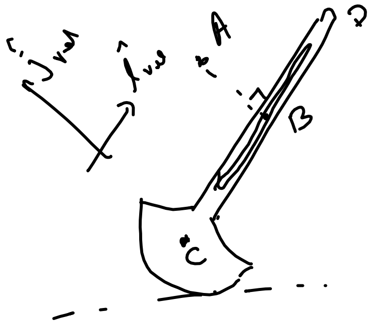


find ω_{CD} when $AB \perp CD$.

$\vec{r}_{B/C} = r_{B/C}\,\hat{i}_{rel}$



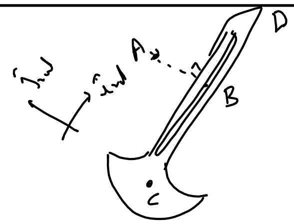
$\hat{j}$ $\hat{i}$

$$\vec{V}_B^{A} = \cancel{\vec{V}_A}^{\,0} + \vec{V}_{B/A}$$
$$= \vec{\omega}_{AB} \times \vec{r}_{B/A}$$
$$= \omega_{AB}\hat{k} \times r_{B/A}(-\hat{j}_{rel})$$
$$= \omega_{AB} r_{B/A}\,\hat{i}_{rel}$$

$$\vec{V}_B^{C} = \vec{V}_C + \vec{V}_{B/C}$$
$$= \vec{0} + \dot{\vec{\rho}}_{rel} + \vec{\omega} \times \vec{\rho}_{rel}$$
$$= \dot{r}_{B/C}\,\hat{i}_{rel} + (\omega_{CD}\hat{k} \times r_{B/C}\,\hat{i}_{rel})$$
$$= \dot{r}_{B/C}\,\hat{i}_{rel} + \omega_{CD} r_{B/C}\,\hat{j}_{rel}$$

equating velocity from A&C origins

$$\vec{V}_B^{A} = \vec{V}_B^{C}$$
$$\Rightarrow \omega_{AB} r_{B/A}\,\hat{i}_{rel} = \dot{r}_{B/C}\,\hat{i}_{rel} + \omega_{CD} r_{B/C}\,\hat{j}_{rel}$$
$$\Rightarrow \dot{r}_{B/C} = \omega_{AB} r_{B/A}$$
& $$0 = \omega_{CD} r_{B/C}$$
$$\Rightarrow \omega_{CD} = 0$$



→ calculate $\vec{a}_B^C$ & $\vec{a}_B^A$

→ equate $\vec{a}_B^C$ to $\vec{a}_B^A$

→ solve

$\hat{j}$, $\hat{i}$

$$\vec{a}_B^A = \vec{a}_A + \vec{a}_{B/A}$$
$$= \vec{0} + \vec{\alpha}_{AB} \times \vec{r}_{D/A} + \vec{\omega}_{AB} \times (\vec{\omega}_{AB} \times \vec{r}_{B/A})$$
$$= \cancel{\vec{\alpha}_{AB}}^{\,0} \times \vec{r}_{B/A} - |\vec{\omega}_{AB}|^2 \vec{r}_{B/A}$$
$$= -\omega_{AB}^2 \, r_{B/A} (-\hat{j}_{rel})$$
$$= \omega_{AB}^2 \, r_{B/A} \, \hat{j}_{rel}$$

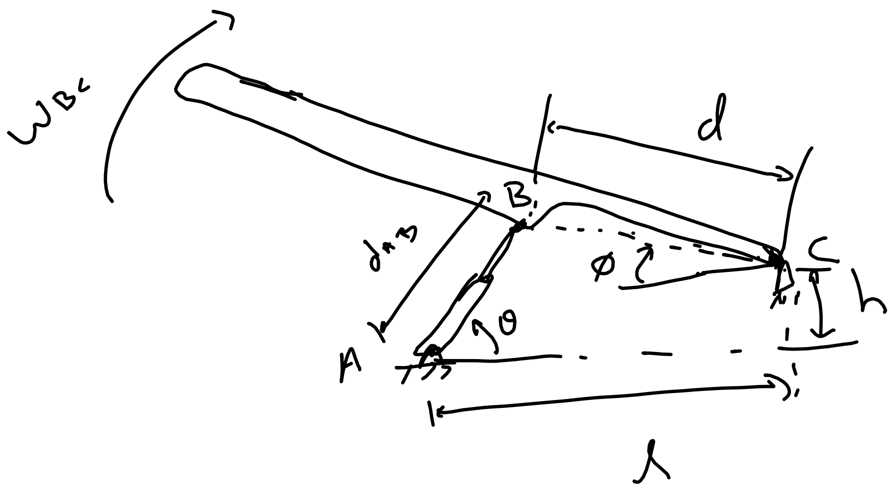
$$\vec{a}_B^C = \vec{a}_C + \vec{a}_{B/C}$$
$$= \vec{0} + \ddot{\vec{\rho}}_{rel} + 2(\vec{\omega} \times \dot{\vec{\rho}}_{rel}) + \vec{\alpha} \times \vec{\rho}_{rel} + \vec{\omega} \times (\vec{\omega} \times \vec{\rho}_{rel})$$
$$= \underbrace{\ddot{\vec{\rho}}_{rel}}_{\text{Radial}} + \underbrace{2(\vec{\omega} \times \dot{\vec{\rho}}_{rel})}_{\text{Coriolis}} + \underbrace{\vec{\alpha} \times \vec{\rho}_{rel}}_{\text{Tangential}} + \underbrace{\vec{\omega} \times (\vec{\omega} \times \vec{\rho}_{rel})}_{\text{Centripetal}}$$
$$= \ddot{r}_{B/C}\,\hat{i}_{rel} + 2(\omega_{CD}\hat{k} \times \dot{r}_{B/C}\,\hat{i}_{rel}) + \alpha_{CD}\hat{k} \times r_{B/C}\,\hat{i}_{rel} + \omega_{CD}\hat{k} \times (\omega_{CD}\hat{k} \times r_{B/C}\,\hat{i}_{rel})$$
$$= \ddot{r}_{B/C}\,\hat{i}_{rel} + 2\omega_{CD}\dot{r}_{B/C}\,\hat{j}_{rel} + \alpha_{CD} r_{B/C}\,\hat{j}_{rel} - \omega_{CD}^2 r_{B/C}\,\hat{i}_{rel}$$
$$= (\ddot{r}_{B/C} - \omega_{CD}^2 r_{B/C})\,\hat{i}_{rel} + (2\omega_{CD}\dot{r}_{B/C} + \alpha_{CD} r_{B/C})\,\hat{j}_{rel}$$

$\omega_{CD} = 0$

$$\Rightarrow \vec{a}_B^C = \ddot{r}_{B/C}\,\hat{i}_{rel} + \alpha_{CD} r_{B/C}\,\hat{j}_{rel}$$
$$\vec{a}_B^A = \omega_{AB}^2 r_{B/A}\,\hat{j}_{rel}$$

equating $\hat{i}$ & $\hat{j}$ components

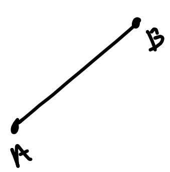
$$\ddot{r}_{B/C} = 0$$
$$\alpha_{CD} r_{B/C} = \omega_{AB}^2 r_{B/A}$$
$$\Rightarrow \boxed{\alpha_{CD} = \frac{\omega_{AB}^2 r_{B/A}}{r_{B/C}}}$$



find $\dot{d}_{AB}$ when $\phi = 0$, $\ddot{d}_{AB}$

1) No arrow for vectors

$$\vec{r}_B = \vec{r}_A + \vec{r}_{B/A} \quad \Big| \quad r_A = r_B + r_{B/A}$$

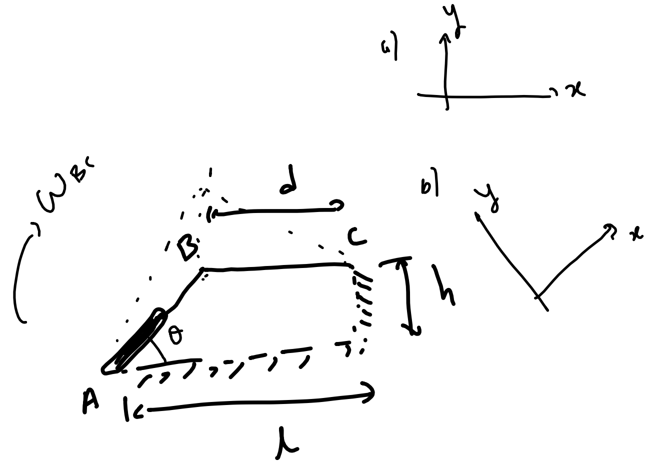


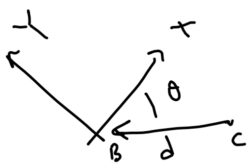
$$\vec{V}_B = \vec{V}_A + \vec{V}_{B/A}$$

$$= \vec{V}_A + \dot{r}_{B/A}\,\hat{u}_{r_{B/A}} + \vec{\omega} \times \vec{r}_{B/A}$$

2) Not drawing axis

3) Not drawing simplified scenario.





$$\vec{V}_B^{\,c} = \vec{V}_c + \vec{V}_{B/c}$$

$$= \vec{0} + \cancel{\dot{r}_{B/c}}^{\,0}\,\hat{u}_{r_{B/c}} + \vec{\omega}_{BC} \times \vec{r}_{B/c}$$

$$= \vec{\omega}_{BC} \times \vec{r}_{B/c}$$

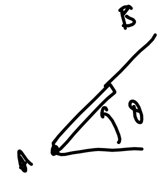
$$= (-\omega_{BC}\hat{k}) \times (-d\cos\theta\,\hat{i} + d\sin\theta\,\hat{j})$$

$$= (-\omega_{BC}\hat{k}) \times (-d\cos\theta\,\hat{i}) + (-\omega_{BC}\hat{k}) \times (d\sin\theta\,\hat{j})$$

$$= \omega_{BC} d\cos\theta\,(\hat{k}\times\hat{i}) - \omega_{BC} d\sin\theta\,(\hat{k}\times\hat{j})$$

$$= \omega_{BC} d\cos\theta\,\hat{j} + \omega_{BC} d\sin\theta\,\hat{i}$$

$$\vec{V}_B^{\,c} = \omega_{BC} d\sin\theta\,\hat{i} + \omega_{BC} d\cos\theta\,\hat{j}$$



$$\vec{V}_B^A = \vec{V}_A + \vec{V}_{B|A}$$

$$= \vec{0} + \dot{r}_{B/A}\hat{u}_{r_{B/A}} + \vec{\omega}_{AB} \times \vec{r}_{B/A}$$

$$= \vec{0} + \dot{\vec{\rho}}_{B/A,rel} + \vec{\omega}_{AB} \times \vec{\rho}_{B/A,rel}$$

$$\vec{V}_B^A = \dot{r}_{B/A}\hat{u}_{B/A} + \vec{\omega}_{AB} \times \vec{r}_{B/A}$$

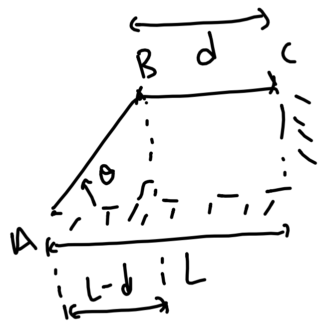
$$= \dot{d}_{AB}\hat{i} + (\omega_{AB}\hat{k}) \times (d_{AB}\hat{i})$$

$$\vec{V}_B^A = \dot{d}_{AB}\hat{i} + \omega_{AB} d_{AB}\hat{j}$$

$$\vec{V}_D^C = \omega_{BC} d \sin\theta\,\hat{i} + \omega_{BC} d \cos\theta\,\hat{j}$$

$$\dot{d}_{AB} = \omega_{BC} d \sin\theta$$

$$\omega_{AB} = \frac{\omega_{BC} d \cos\theta}{d_{AB}}$$



$$\tan\theta = \frac{h}{L-d}, \quad \cos\theta = \frac{L-d}{\sqrt{h^2 + (L-d)^2}}$$

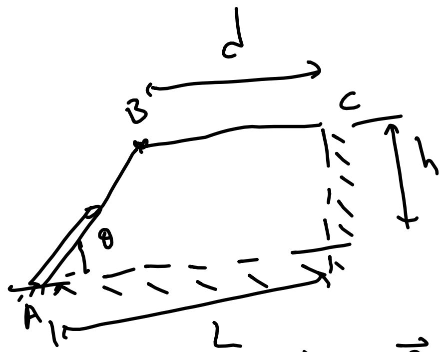
$$\sin\theta = \frac{h}{\sqrt{h^2 + (L-d)^2}}, \quad d_{AB} = \sqrt{h^2 + (L-d)^2}$$

$$\dot{d}_{AB} = \omega_{BC} d \sin\theta$$

$$\dot{d}_{AB} = \frac{\omega_{BC} d h}{\sqrt{h^2 + (L-d)^2}}$$

$$\omega_{AB} = \frac{\omega_{BC} d \cos\theta}{d_{AB}} = \frac{\omega_{BC} d (L-d)}{h^2 + (L-d)^2} \quad //$$

$$\ddot{d}_{AB}\ ,\quad \omega_{AB} = \frac{\omega_{BC}\, d(L-d)}{h^2 + (L-d)^2}$$



$\vec{a}_B^{\,C}$

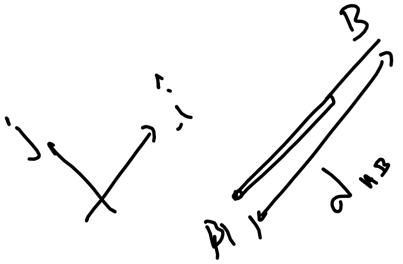
$\vec{a}_B^{\,A}$

$$\vec{a}_B^{\,C} = \vec{a}_C + \vec{a}_{B/C}$$
$$= \vec{0} + \ddot{r}_{B/C}\,\hat{u}_{r\,B/C} + \vec{\alpha}_{BC} \times \vec{r}_{B/C}$$
$$+ \vec{\omega}_{BC} \times (\vec{\omega}_{BC} \times \vec{r}_{B/C})$$
$$+ 2\dot{r}_{B/C}(\vec{\omega}_{BC} \times \vec{u}_{r\,B/C})$$

As $r_{B/C}$ is constant,
$$\vec{a}_B^{\,C} = \vec{\alpha}_{BC} \times \vec{r}_{B/C} + \vec{\omega}_{BC} \times (\vec{\omega}_{BC} \times \vec{r}_{B/C})$$

As $\alpha_{BC} = 0$,
$$\vec{a}_B^{\,C} = \vec{\omega}_{BC} \times (\vec{\omega}_{BC} \times \vec{r}_{B/C})$$

As $\vec{\omega}_{BC} \perp \vec{r}_{B/C}$,
$$\vec{a}_B^{\,C} = -|\vec{\omega}_{BC}|^2\, \vec{r}_{B/C}$$
$$= -\omega_{BC}^2\, \vec{r}_{B/C}$$



$$\vec{a}_B^{A} = \ddot{r}_{B/A}\hat{u}_{r_{B/A}} + \vec{\alpha}_{AB}\times\vec{r}_{B/A} + \vec{\omega}_{AB}\times(\vec{\omega}_{AB}\times\vec{r}_{B/A}) + 2\dot{r}_{B/A}(\vec{\omega}_{AB}\times\hat{u}_{r_{B/A}})$$

$$\vec{a}_B^{A} = \ddot{d}_{AB}\,\hat{i} + (\alpha_{AB}\hat{k}\times d_{AB}\hat{i}) - \omega_{AB}^2(d_{AB}\hat{i}) + 2\dot{d}_{AB}(\omega_{AB}\hat{k}\times\hat{i})$$

$$= (\ddot{d}_{AB} - \omega_{AB}^2 d_{AB})\hat{i} + (\alpha_{AB}d_{AB} + 2\dot{d}_{AB}\omega_{AB})\hat{j}$$

$$\vec{a}_B^{C} = -\omega_{BC}^2\vec{r}_{B/C} = -\omega_{BC}^2(-d\cos\theta\,\hat{i} + d\sin\theta\,\hat{j})$$

Equating 'i' components

$$\ddot{d}_{AB} - \omega_{AB}^2 d_{AB} = \omega_{BC}^2 d\cos\theta$$

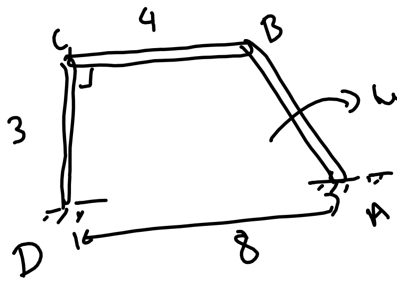
$$\ddot{d}_{AB} = \omega_{BC}^2 d\cos\theta + \omega_{AB}^2 d_{AB}$$

$$= \frac{\omega_{BC}^2 d(L-d)}{\sqrt{h^2+(L-d)^2}} + \left(\frac{\omega_{BC}\, d(L-d)}{h^2+(L-d)^2}\right)^2\sqrt{h^2+(L-d)^2}$$

$$= \frac{\omega_{BC}^2 d(L-d)}{\sqrt{h^2+(L-d)^2}}\left[1 + \frac{d(L-d)}{h^2+(L-d)^2}\right]$$

I.C.

1)

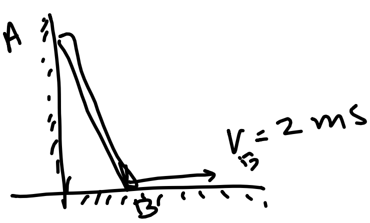


$\omega_{AB} = 1$ rad/s

$\alpha_{AB} = 0$

compute $\vec{V}_c$, $\vec{a}_c$, α_{BC}, ω_{BC}

2)



calculate, $\vec{V}_A$, ω_{AB}, α_{AB}

$\vec{a}_A$