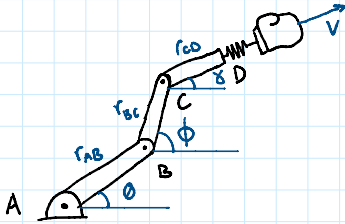


20-R-KM-DK-19 Intermediate Rotating Frame

Inspiration: 16-42 Hibbeler



A very funny engineer has attached her prank punching machine to a robotic arm. If the boxing glove moves at a maximum 1 m/s constant velocity, relative to the link CD, what is the velocity and acceleration of the glove at the instant shown?

The lengths of the linkage arms are given as $r_{AB} = 0.3 \text{ m}$, $r_{BC} = 0.6 \text{ m}$, and $r_{CD} = 0.4 \text{ m}$.

The angles are given as $\theta = 30 \text{ degrees}$, $\phi = 50 \text{ degrees}$, and $\gamma = 15 \text{ degrees}$.

Arm BC is rotating at $\omega_{BC} = 2 \text{ rad/s}$ and $\alpha_{BC} = 1 \text{ rad/s}^2$, while arm CD is rotating at $\omega_{CD} = -0.25 \text{ rad/s}$ and $\alpha_{CD} = 0.25 \text{ rad/s}^2$.

$$\begin{aligned}\vec{V}_D &= \vec{V}_B + \vec{\omega}_{BC} \times \vec{r}_{CD} = 0 + 2\hat{k} \times (0.6\cos 50^\circ \hat{i} + 0.6\sin 50^\circ \hat{j}) \\ &= 1.2\cos 50^\circ \hat{j} - 1.2\sin 50^\circ \hat{i}\end{aligned}$$

$$\begin{aligned}\vec{a}_C &= \vec{a}_B + \vec{\alpha}_{BC} \times \vec{r}_{CB} - \omega_{BC}^2 \vec{r}_{CB} = 0 + 1\hat{k} \times (0.6\cos 50^\circ \hat{i} + 0.6\sin 50^\circ \hat{j}) - 4(0.6\cos 50^\circ \hat{i} + 0.6\sin 50^\circ \hat{j}) \\ &= 0.6\cos 50^\circ \hat{j} - 0.6\sin 50^\circ \hat{i} - 2.4\cos 50^\circ \hat{i} - 2.4\sin 50^\circ \hat{j}\end{aligned}$$

$$\begin{aligned}\vec{V}_D &= \vec{V}_C + \vec{\omega}_{CD} \times \vec{r}_{DC} + (\vec{V}_{D/C})_{xyz} = 1.2\cos 50^\circ \hat{j} - 1.2\sin 50^\circ \hat{i} + (-0.25\hat{k}) \times (0.4\cos 15^\circ \hat{i} + 0.4\sin 15^\circ \hat{j}) + (\cos 15^\circ \hat{i} + \sin 15^\circ \hat{j}) \\ &= -1.2\sin 50^\circ \hat{i} + 1.2\cos 50^\circ \hat{j} - 0.1\cos 15^\circ \hat{j} + 0.1\sin 15^\circ \hat{i} + \cos 15^\circ \hat{i} + \sin 15^\circ \hat{j} \\ &= \boxed{0.072554399 \hat{i} + 0.433571594 \hat{j}}\end{aligned}$$

$$\begin{aligned}\vec{a}_D &= \vec{a}_C + \vec{\omega}_{CD} \times \vec{r}_{DC} + 2\vec{\omega}_{CD} \times (\vec{V}_{D/C})_{xyz} - \omega_{CD}^2 \vec{r}_{DC} + (\vec{a}_{D/C})_{xyz} \\ &= -0.6\sin 50^\circ \hat{i} - 2.4\cos 50^\circ \hat{j} - 2.4\sin 50^\circ \hat{j} + 0.6\cos 50^\circ \hat{i} + (0.25\hat{k}) \times (0.4\cos 15^\circ \hat{i} + 0.4\sin 15^\circ \hat{j}) + 2(-0.25\hat{k}) \times (\cos 15^\circ \hat{i} + \sin 15^\circ \hat{j}) - (0.25)^2(0.4\cos 15^\circ \hat{i} + 0.4\sin 15^\circ \hat{j}) + 0 \\ &= -0.6\sin 50^\circ \hat{i} - 2.4\cos 50^\circ \hat{j} - 2.4\sin 50^\circ \hat{j} \\ &= \boxed{-1.422937457 \hat{i} - 1.4456749 \hat{j}}\end{aligned}$$