20-R-KM-DK-19

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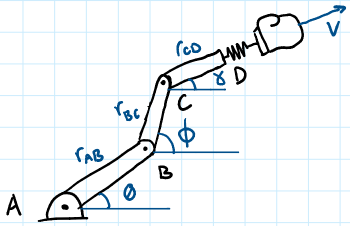
20-R-KM-DK-19 Intermediate Rotating Frame

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 m, r_BC = 0.6 m***, and ***r_CD = 0.4 m.***
The angles are given as ***theta = 30 degrees, phi = 50 degrees***, and ***gamma = 15 degrees***.
Arm BC is rotating at ***omega_BC = 2 rad/s*** and ***alpha_BC = 1 rad/s^2***, while arm CD is rotating at ***omega_CD = -0.25 rad/s*** and ***alpha_CD = 0.25 rad/s^2***. Arm AB is stationary throughout.

$$\vec{v}_C = \vec{v}_B + \vec{\omega}_{BC} \times \vec{r}_{C/D} = 0 + 2\hat{k} \times (0.6\cos 50\,\hat{i} + 0.6\sin 50\,\hat{j})$$
$$= 1.2\cos 50\,\hat{j} - 1.2\sin 50\,\hat{i}$$

$$\vec{a}_C = \vec{a}_B + \vec{\alpha}_{BC} \times \vec{r}_{C/B} - \omega_{BC}^2\,\vec{r}_{C/B} = 0 + 1\hat{k} \times (0.6\cos 50\,\hat{i} + 0.6\sin 50\,\hat{j}) - 4(0.6\cos 50\,\hat{i} + 0.6\sin 50\,\hat{j})$$
$$= 0.6\cos 50\,\hat{j} - 0.6\sin 50\,\hat{i} - 2.4\cos 50\,\hat{i} - 2.4\sin 50\,\hat{j}$$

$$\vec{v}_D = \vec{v}_C + \vec{\Omega}_{CD} \times \vec{r}_{D/C} + (\vec{v}_{D/C})_{x'y'z'} = 1.2\cos 50\,\hat{j} - 1.2\sin 50\,\hat{i} + (-0.25\hat{k}) \times (0.4\cos 15\,\hat{i} + 0.4\sin 15\,\hat{j}) + (\cos 15\,\hat{i} + \sin 15\,\hat{j})$$
$$= -1.2\sin 50\,\hat{i} + 1.2\cos 50\,\hat{j} - 0.1\cos 15\,\hat{j} + 0.1\sin 15\,\hat{i} + \cos 15\,\hat{i} + \sin 15\,\hat{j}$$
$$= \boxed{0.072554399\,\hat{i} + 0.433571594\,\hat{j}}$$

$$\vec{a}_D = \vec{a}_C + \dot{\vec{\Omega}}_{CD} \times \vec{r}_{D/C} + 2\vec{\Omega}_{CD} \times (\vec{v}_{D/C})_{x'y'z'} - \Omega^2\,\vec{r}_{D/C} + (\vec{a}_{D/C})_{x'y'z'}$$
$$= -0.6\sin 50\,\hat{i} - 2.4\cos 50\,\hat{i} - 2.4\sin 50\,\hat{j} + 0.6\cos 50\,\hat{j} + (0.25\hat{k}) \times (0.4\cos 15\,\hat{i} + 0.4\sin 15\,\hat{j}) + 2(-0.25\hat{k}) \times (\cos 15\,\hat{i} + \sin 15\,\hat{j}) - (0.25)^2(0.4\cos 15\,\hat{i} + 0.4\sin 15\,\hat{j}) + 0$$
$$= -0.6\sin 50\,\hat{i} - 2.4\cos 50\,\hat{i} - 2.4\sin 50\,\hat{j}$$
$$= \boxed{-1.922937457\,\hat{i} - 1.4456749\,\hat{j}}$$