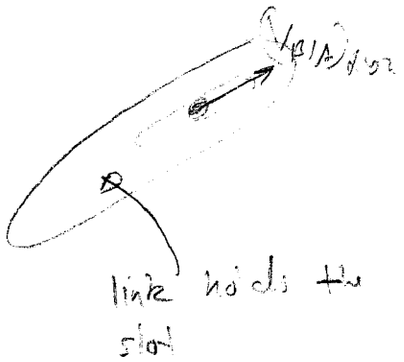
# 20.4 Relative Motion Analysis Using Rotating & Translating axes.

Points on the same body have relative motion

⇒ The same as chapter 16.5. (section)




Attach $x,y,z$ to the body that contains the relative motion

$\vec{\Omega}$ is the angular velocity of $(x,y,z)$ which is the same as $\vec{\omega}$ of the body.

Velocity

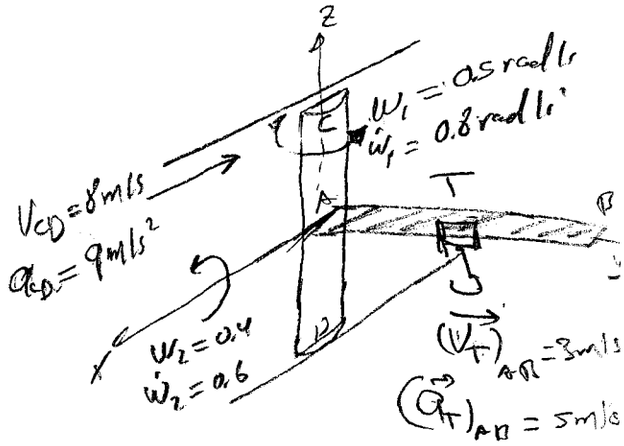
$$\Rightarrow \vec{V}_B = \vec{V}_A + \vec{\Omega} \times \vec{r}_{B/A} + (\vec{V}_{B/A})_{xyz}.$$

acceleration

$$\vec{a}_B = \vec{a}_A + \vec{\Omega} \times \vec{r}_{B/A} + \vec{\Omega} \times (\vec{\Omega} \times \vec{r}_{B/A}) + 2\vec{\Omega} \times (\vec{V}_{B/A})_{xyz} + (\vec{a}_{B/A})_{xyz}.$$

Problem 20-47

$\vec{V}_T$ ? $\vec{a}_T$




$\vec{v}_C = \vec{v}_D = \vec{v}_A = -8\,\vec{i}$ m/s

$\vec{a}_C = \vec{a}_D = \vec{a}_A = -9\,\vec{i}$ m/s²

$\vec{V}_T = \vec{V}_C + \vec{\Omega}_{AB} \times \vec{r}_{T/A} + (\vec{v}_{T/A})_{xyz}$

$\vec{\Omega}_{AB} = \vec{\omega}_1 + \vec{\omega}_2 = 0.5\,\vec{k} + 0.4\,\vec{i}$

$\Rightarrow \vec{V}_T = -8\,\vec{i} + (0.4\,\vec{i} + 0.5\,\vec{k}) \times 8\,\vec{j} + 3\,\vec{j}$

$= -8\,\vec{i} + 1.2\,\vec{k} - 1.5\,\vec{i} + 3\,\vec{j} = (-9.5\,\vec{i} + 3\,\vec{j} + 1.2\,\vec{k})$ m/s

$\vec{a}_T = \vec{a}_A + \vec{\Omega}_{AB} \times \vec{r}_{T/A} + \vec{\Omega}_{AB} \times (\vec{\Omega}_{AB} \times \vec{r}_{T/A}) + (\vec{a}_{T/A})_{xyz} + 2\vec{\Omega}_{AB} \times (\vec{v}_{T/A})_{xyz}$

$\vec{\Omega}_{AB} = \vec{\Omega}_1 + \vec{\Omega}_2 = (\vec{\omega}_1)_{xyz} + (\vec{\omega}_2)_{xyz} + \vec{\omega}_1 \times \vec{\omega}_2 = 0.8\,\vec{k} + 0.6\,\vec{i} + \underbrace{(0.5\,\vec{k} \times 0.4\,\vec{i})}_{0.2\,\vec{j}}$

$\Rightarrow \vec{a}_T = -9\,\vec{i} + (0.6\,\vec{i} + 0.2\,\vec{j} + 0.8\,\vec{k}) \times (8\,\vec{i}) + (0.4\,\vec{i} + 0.5\,\vec{k}) \times (7.5\,\vec{i} + 1.2\,\vec{k}) + 3\,\vec{j} + 2(9\,\vec{i} + 0.3\,\vec{k}) \times 8\,\vec{j}$

$= -9\,\vec{i} + 1.8\,\vec{k} - 2.4\,\vec{i} - 0.48\,\vec{j} - 0.75\,\vec{j} + 5\,\vec{j} + 2.4\,\vec{k} - 3\,\vec{i}$

$= (-9 - 2.4 - 3)\,\vec{i} + (-0.48 - 0.75 + 5)\,\vec{j} + (1.8 + 2.4)\,\vec{k}$

$= -14.4\,\vec{i} + 3.77\,\vec{j} + 4.2\,\vec{k}$