RO2102: Dynamics and Simulation

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Homework-1

Problem 2 Due : 16 - Jan - 2025 Time Spent : 2.5 Hours

Given: $\bar{r}_A, \bar{r}_B, \bar{r}_C, \bar{r}_D, \bar{F}$

(a) **To Find:** Shortest Distance between AB and CD.

$$\boxed{d = \bar{r}_{C/A} \cdot \frac{(\bar{r}_{B/A} \times \bar{r}_{C/D})}{|\bar{r}_{B/A} \times \bar{r}_{C/D}|}}$$

Reference: Ruina - Pratap Sample 1.23

(b) **To Find:** End Points of shortest line segment

In the calculation of d $\bar{r}_{C/A}$ was "dotted" with the normal vector,

i.e, the line from AC was projected to the normal vector, which would start somewhere on line AB, and end at C.

This makes C one of the end points.

For the other point, say some distance "a" from A,

$$d \frac{(\bar{r}_{B/A} \times \bar{r}_{C/D})}{|\bar{r}_{B/A} \times \bar{r}_{C/D}|} + a \frac{\bar{r}_{B/A}}{|\bar{r}_{B/A}|} = \bar{r}_{C/A}$$

$$\Rightarrow \boxed{a \frac{\bar{r}_{B/A}}{|\bar{r}_{B/A}|} = \bar{r}_{C/A} - d \frac{(\bar{r}_{B/A} \times \bar{r}_{C/D})}{|\bar{r}_{B/A} \times \bar{r}_{C/D}|}}$$

where, $a \frac{\bar{r}_{B/A}}{|\bar{r}_{B/A}|}$ is the other end point of the line segment.

(c) To Find : Volume of tetra hedron ABCD

$$\text{Volume of a parallelopiped} = \bar{r}_{A/D} \cdot (\bar{r}_{B/D} \times \bar{r}_{C/D}) = 6 \times \text{Volume of Tetrahedron}$$

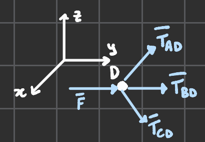
[Reference: Ruina-Pratap 1.3: Mixed Triple Product]

$$\Rightarrow \boxed{\text{Volume of ABCD} = \frac{1}{6}\, \bar{r}_{A/D} \times (\bar{r}_{B/D} \cdot \bar{r}_{C/D})}$$

(d) To Find: Tension in bar AD

Assume static equillibrium,

FBD : Joint D



$$\sum \bar{F} = \bar{0}$$

$$\Rightarrow \boxed{\bar{T}_{AD} \frac{(\bar{r}_{A/D})}{|\bar{r}_{A/D}|} = \bar{F} + T_{BD} \frac{\bar{r}_{D/B}}{|\bar{r}_{D/B}|} + T_{CD} \frac{\bar{r}_{D/C}}{|\bar{r}_{D/C}|}}$$

From the above equation, 3 scalar equations are obtained. When solved simultaneously, the three unknowns : T_{AD}, T_{BD}, T_{CD} can be found.