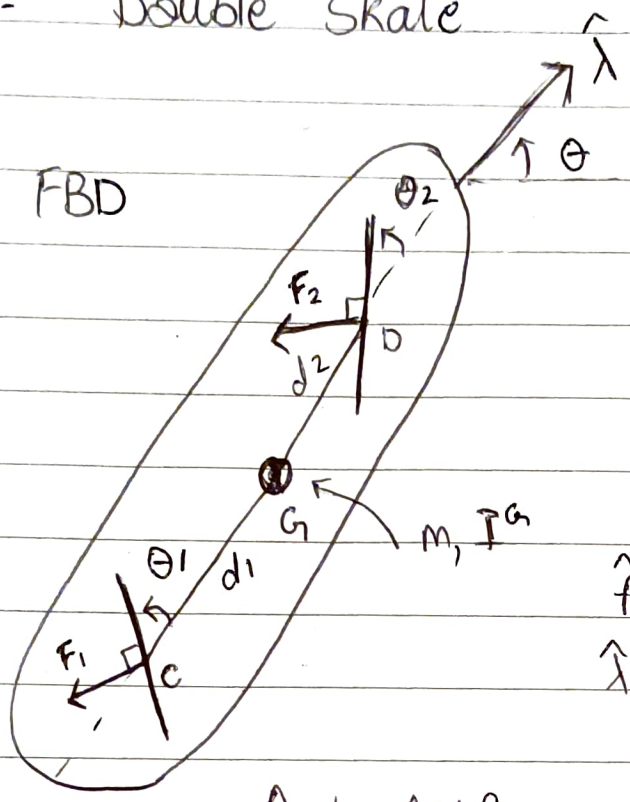
Q39- Double Skate



FBD

Apply LMB

$$\Sigma \vec{F} = m\vec{a}$$

$$F_1 \hat{f_1} + F_2 \hat{f_2} = m\ddot{x}\hat{i} + m\ddot{y}\hat{j}$$

$$\hat{f_1} = -\sin(\theta+\theta_1)\hat{i} + \cos(\theta+\theta_1)\hat{j}$$
$$\hat{f_2} = -\sin(\theta+\theta_2)\hat{i} + \cos(\theta+\theta_2)\hat{j}$$
$$\hat{\lambda} = \cos(\theta)\hat{i} + \sin(\theta)\hat{j}$$

Apply AMB

$$\Sigma \vec{M}_{/G} = \dot{\vec{H}}_G$$
$$\Rightarrow \{(-d_1\hat{\lambda} \times \hat{f_1}F_1) + (d_2\hat{\lambda} \times \hat{f_2}F_2) = I\ddot{\theta}\hat{k}\} \cdot \hat{k}$$

AMB & LMB give us 3 equations

There are 5 unknowns for DAE: $\ddot{x}, \ddot{y}, \ddot{\theta}, F_1, F_2$

($\ddot{x}, \ddot{y}, \ddot{\theta}$: accelerations; F_1, F_2: constraint forces)

2 equations come from constraints at C, D.

Skate constraint at C:

$$V_C = V_{C/G} + V_G = \dot{\theta}\hat{k} \times (-d_1\hat{\lambda}) + (\dot{x}\hat{i} + \dot{y}\hat{j})$$
$$V_C \cdot \hat{f_1} = 0$$

Skate constraint at D:

$$V_D = V_{D/G} + V_G = \dot{\theta}\hat{k} \times (d_2\hat{\lambda}) + (\dot{x}\hat{i} + \dot{y}\hat{j})$$
$$V_D \cdot \hat{f_2} = 0$$