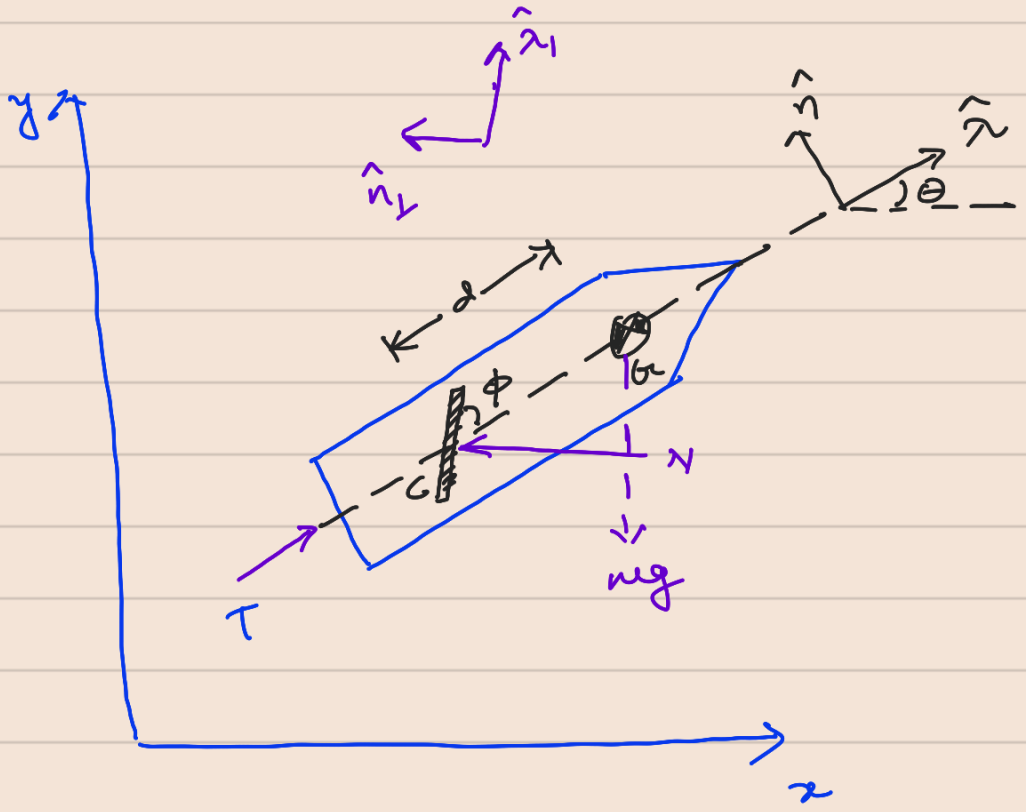
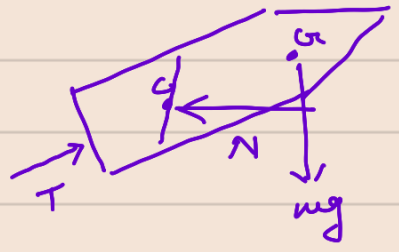
(1)



LMB:

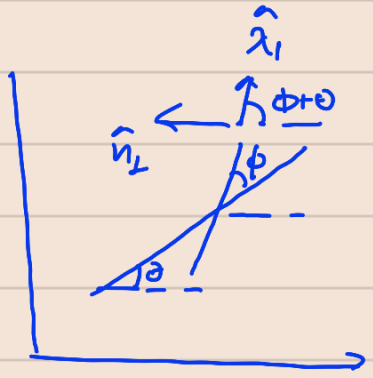


$$\vec{T} + \vec{N} + m\vec{g} = m\vec{a}_G$$

$$T\hat{\lambda} + N\hat{n}_\perp - mg\hat{j} = m\vec{a}_G \quad \text{—(1)}$$

$\hat{\lambda} \rightarrow \cos\theta\,\hat{i} + \sin\theta\,\hat{j}$

$$\hat{n}_\perp = -\sin(\theta+\phi)\,\hat{i} + \cos(\theta+\phi)\,\hat{j}$$



(1) · $\hat{i}$:

$$T\hat{\lambda}\cdot\hat{i} + N\hat{n}_\perp\cdot\hat{i} - mg\,\hat{j}\cdot\hat{i} = m\vec{a}_G\cdot\hat{i}$$

$$T\cos\theta - N\sin(\theta+\phi) = m\ddot{x}_G \quad \text{— (2)}$$

(1) · $\hat{j}$:

$$T\hat{\lambda}\cdot\hat{j} + N\hat{n}_\perp\cdot\hat{j} - mg\,\hat{j}\cdot\hat{j} = m\vec{a}_G\cdot\hat{j}$$

$$T\sin\theta + N\cos(\theta+\phi) - mg = m\ddot{y}_G \quad \text{— (3)}$$

AMB: $\sum \vec{M}_G = \dot{\vec{H}}_G$ H → Angular momentum

$$\Rightarrow \vec{r}_{GC} \times \vec{N} = \underline{I}^G\ddot{\theta}\,\hat{k} \quad \text{— (4)}$$

Constraint: $\vec{v}_c \cdot \hat{n}_\perp = 0$

$\Rightarrow \frac{d}{dt}(\vec{v}_c \cdot \hat{n}_\perp) = 0 \Rightarrow \frac{d}{dt}(f(\theta, \phi, v_{Gx}, v_{Gy}, \dot{\theta}, \dot{\phi})$

$\Rightarrow \dot{\vec{v}}_c \cdot \hat{n}_\perp + \vec{v}_c \cdot \dot{\hat{n}}_\perp = 0$

$v_c = v_G + \vec{v}_{c/G}$

$v_G \rightarrow \begin{bmatrix} \dot{x}_G \\ \dot{y}_G \end{bmatrix}$

$\vec{v}_{c/G} \rightarrow \vec{\omega} \times \vec{r}_{c/G}$

$\vec{\omega} \rightarrow \dot{\theta}\hat{k}$

$\vec{r}_{c/G} \rightarrow d\hat{\lambda}$

$\hat{n}_\perp = -\sin(\theta+\phi)\,\hat{i} + \cos(\theta+\phi)\,\hat{j}$

Dynamics:

$x = (r_G, \theta, v_G, \dot{\theta}), \quad y = \phi$

$u = [T, \dot{\phi}], \quad z = [x, y]$

$\dot{x} = f(x, u), \quad \dot{y} = g(u)$

$\dot{z} = \begin{bmatrix} f(x, u) \\ g(u) \end{bmatrix}$

} coded using symbolic methods

Dyn Eqn from notes:

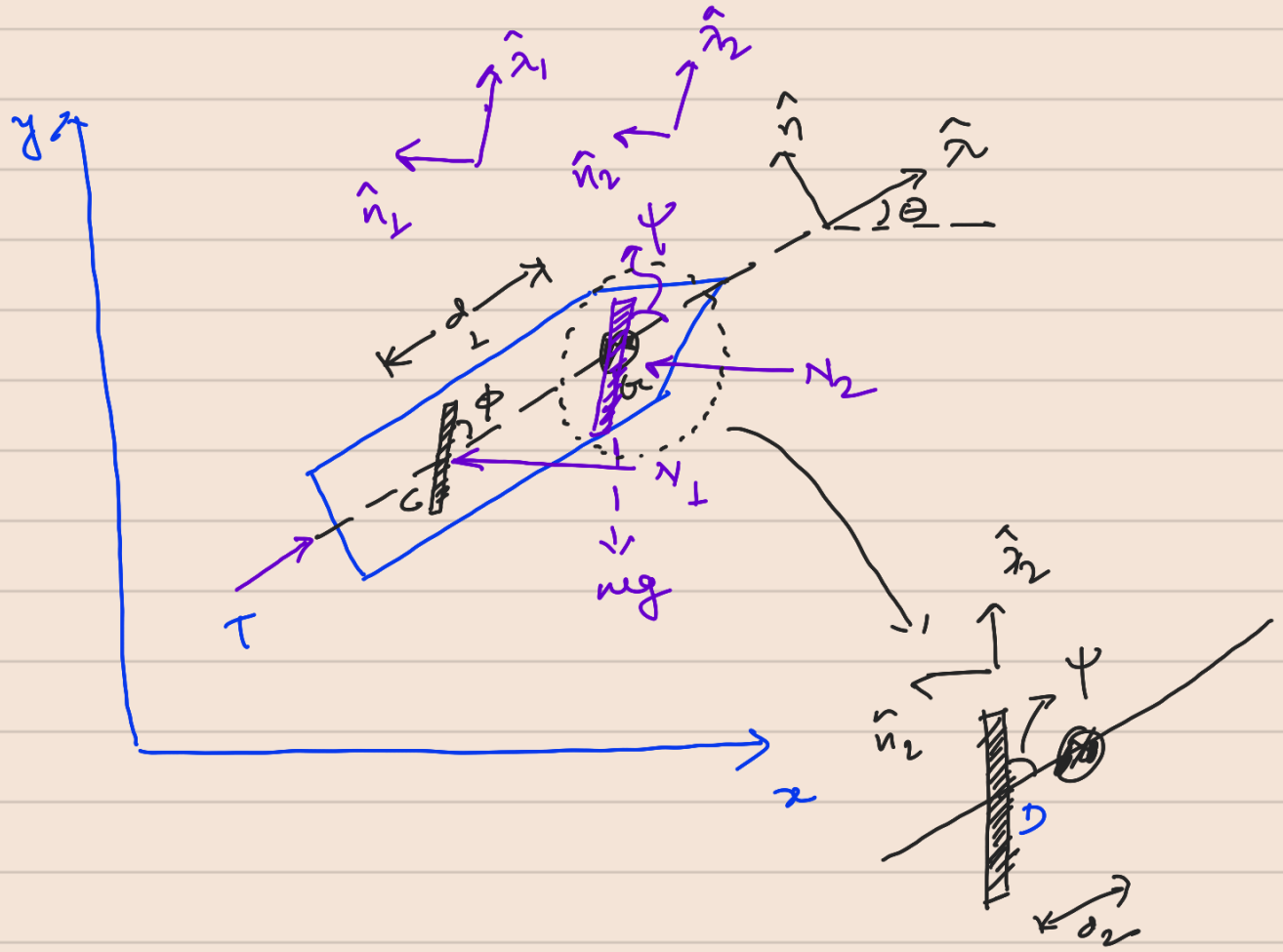
$T\cos\theta - N\sin(\phi+\theta) = m\ddot{x}$

$T\sin\theta + N\cos(\phi+\theta) - mg = m\ddot{y}$

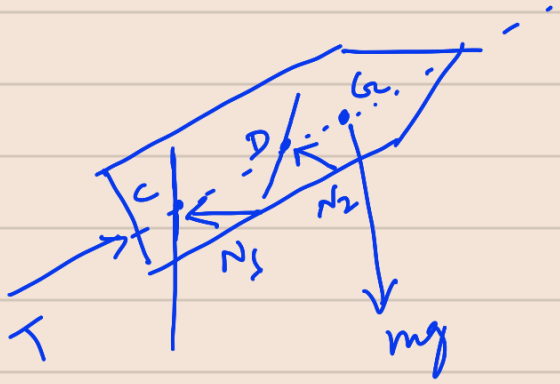
$-Nd\cos(\phi+\theta)\cos\theta - Nd\sin(\phi+\theta)\sin\theta = I_G\ddot{\omega}$

$\ddot{y} + c(\phi+\theta) - \ddot{x}\sin(\phi+\theta) - \omega\dot{x}\cos(\phi+\theta) - \dot{\phi}\dot{x}\cos(\phi+\theta)$
$- \alpha d\cos\phi - \omega\dot{y}\sin(\phi+\theta) - \dot{\phi}\dot{y}$

(2)



FBD



$$\hat{n}_1 = -s(\theta+\Phi)\,\hat{i} + c(\theta+\Phi)\,\hat{j}$$

$$\hat{n}_2 = -s(\theta+\psi)\,\hat{i} + c(\theta+\Phi)\,\hat{j}$$

LMB:

$$\vec{T} + \vec{mg} + \vec{N}_1 + \vec{N}_2 = m\vec{a}_{Gx}$$

$$\Rightarrow T\hat{\lambda} + mg(-\hat{k}) + N_1\hat{n}_1 + N_2\hat{n}_2 = m\vec{a}_G \quad \text{——(1)}$$

AMB: $\vec{r}_{GC} \times N_1 + \vec{r}_{GD} \times N_2 = I_G\,\ddot{\theta}\,\hat{k}$

Constraint: $\vec{v}_C \cdot \hat{n}_1 = 0$

$\vec{v}_D \cdot \hat{n}_2 = 0$