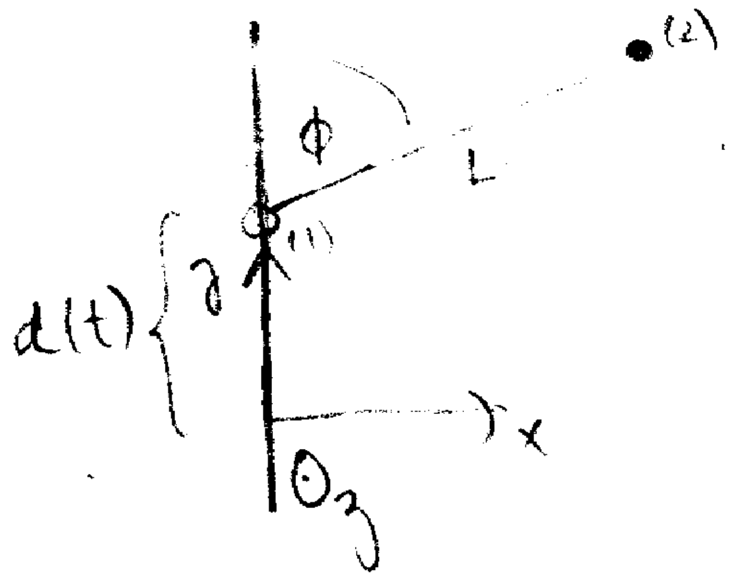
Elijamos el origen del sistema en la posición inicial de (1)



$y_1(t) = d(t) \Rightarrow \dot y_1(t) = \dot d(t)$ (no necesariamente $\dot d(t)$ ...

$y_2(t) = d(t) + L\cos\phi \Rightarrow \dot y_2 = \dot d(t) - L\,\text{sen}\,\phi\,\dot\phi$

$x_2(t) = L\,\text{sen}\,\phi \Rightarrow \dot x_2(t) = L\cos\phi\,\dot\phi$

pero $\dot y_1 = -\dot y_2 \Rightarrow \dot d(t) = -\dot d(t) + L\,\text{sen}\,\phi\,\dot\phi \Rightarrow \dot d(t) = \frac{L\,\text{sen}\,\phi\,\dot\phi}{2}$

$$\frac{dd}{dt} = \frac{dd}{d\phi}\dot\phi = \frac{L\,\text{sen}\,\phi\,\cancel{\dot\phi}}{2} \rightarrow \int_0^d dd = \int_0^\phi \frac{L\,\text{sen}\,\phi}{2}\,d\phi \rightarrow \boxed{d(\phi) = \frac{L}{2}(1-\cos\phi)}$$

Entonces: $\dot y_1(t) = \frac{L\,\text{sen}\,\phi\,\dot\phi}{2}$; $\dot y_2 = -\frac{L\,\text{sen}\,\phi\,\dot\phi}{2}$

$\dot x_2 = L\cos\phi\,\dot\phi$

juntando todo, tenemos hasta ahora:

$\dot y_{cm} = 0 = cte$

$\dot y_1(\phi) = \frac{L\,\text{sen}\,\phi\,\dot\phi}{2}$; $\dot x_2(\phi) = L\cos\phi\,\dot\phi \Rightarrow \ddot x_2(\phi) = -L\,\text{sen}\,\phi\,\dot\phi^2 + L\cos\phi\,\ddot\phi$

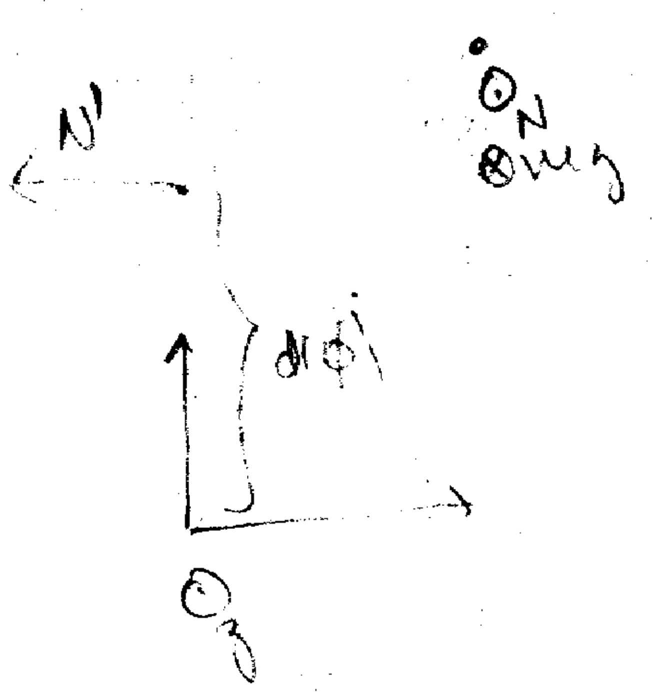
$\dot y_2(\phi) = -\frac{L\,\text{sen}\,\phi\,\dot\phi}{2}$

$x_1 = 0 = cte$

$$N' = -2m\ddot x_{cm} = -\cancel{2m}\left(\frac{m\cdot 0 + m\ddot x_2}{\cancel{2m}}\right) = -m\ddot x_2$$

$$\Rightarrow N'(\phi) = +mL\left(\text{sen}\,\phi\,\dot\phi^2 - \cos\phi\,\ddot\phi\right)$$

Ahora usemos $\sum\vec\tau = \frac{d\vec L}{dt}$, tomando como referencia el origen del sistema de coordenadas.



$$\sum\vec\tau_o = d\,\hat\jmath \times (-N')\hat\imath = N' d\,\hat k$$

$$\vec L_o = md\,\hat\jmath \times \dot y_1\hat\jmath + m\Big(L\,\text{sen}\,\phi\,\hat\imath + \underbrace{\left(\tfrac{L}{2}(1-\cos\phi) + L\cos\phi\right)}_{\frac{L}{2}(1+\cos\phi)}\hat\jmath\Big) \times (\dot x_2\hat\imath + \dot y_2\hat\jmath)$$

$$= mL\,\text{sen}\,\phi\,\dot y_2\,\hat k - \frac{mL}{2}(1+\cos\phi)\dot x_2\,\hat k$$