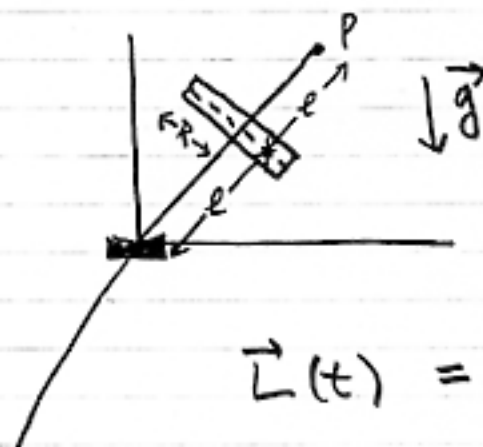


Dragt 91

DCM1.16



$\vec{r}_p$  = vector from 0 to P

$$\vec{r}_p(t) = 2l \cos \theta \hat{e}_z + 2l \sin \theta (\hat{e}_x \cos \Omega t + \hat{e}_y \sin \Omega t)$$

Since  $\omega \gg \Omega$  the angular momentum is

$$\vec{L}(t) = \frac{\vec{r}_p}{2l} \omega I \quad I = \text{flywheel moment of inertia} = \frac{MR^2}{2}$$

$$\frac{d\vec{L}}{dt} = \omega \Omega I \sin \theta (-\hat{e}_x \sin \Omega t + \hat{e}_y \cos \Omega t)$$

But torque  $\vec{N} = \left(\frac{\vec{r}_p}{2}\right) \times \vec{F}$  w/  $\vec{F} = -Mg\hat{e}_z$

$$\vec{N} = Mgl \sin \theta (\hat{e}_y \cos \Omega t - \hat{e}_x \sin \Omega t)$$

Thus  $\frac{d\vec{L}}{dt} = \vec{N}$  gives  $\omega \Omega I = Mgl$

or, solving for  $\Omega$ ,

$$\Omega = \frac{Mgl}{\omega I} = \frac{2gl}{\omega R^2}$$

$$M \ddot{\vec{r}}_{cm} = \vec{F}_{total} = -Mg\hat{e}_z + \vec{F}_{cup \rightarrow top}$$

$$\vec{F}_{cup \rightarrow top} = \frac{1}{2} M \ddot{\vec{r}}_p + Mg\hat{e}_z$$

$$\vec{F}_{cup \rightarrow top} = -Ml\Omega^2 \sin \theta (\hat{e}_x \cos \Omega t + \hat{e}_y \sin \Omega t) + Mg\hat{e}_z$$

with  $\Omega$  given above.