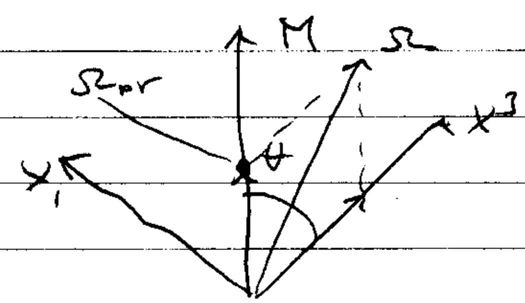
$$\Omega_3 = \frac{M_3}{I_3} = \frac{M\cos\theta}{I_3} \qquad \Omega_1 = \frac{M_1}{I_1} = \frac{M\sin\theta}{I_1}$$

Next we calculate the angular velocity of the precession

$$\vec{v}_{pr} = \vec{\Omega} \times \vec{r} \qquad |\vec{\Omega}_{pr}| = \frac{\Omega\, r \sin\varphi}{\sin\theta}$$

The component of $\vec{\Omega}$ along $\vec{x}_3$ does not contribute to precession $\Rightarrow$ $\vec{\Omega}_{pr}$ is component of Ω along $\vec{M}$.



$$\Omega_{pr} \sin\theta = \Omega_1$$

$$\Omega_{pr} = \frac{M}{I_1}$$

VI g Eqs. of motion of a rigid body §34

Lagrangian: $L = \frac{1}{2}\mu V^2 + \frac{1}{2} I_{ik}\Omega_i\Omega_k - U$

cm coordinates x_1, x_2, x_3

orientation of body ϕ_1, ϕ_2, ϕ_3 $\quad \vec{\Omega}_k = \dot{\phi}_k$

EL eqs $\quad \frac{d}{dt}\frac{\partial L}{\partial \dot{x}_k} - \frac{\partial L}{\partial x_k} = 0$

$$\Rightarrow \dot{p}_k = -\frac{\partial U}{\partial x_k} = F_i$$