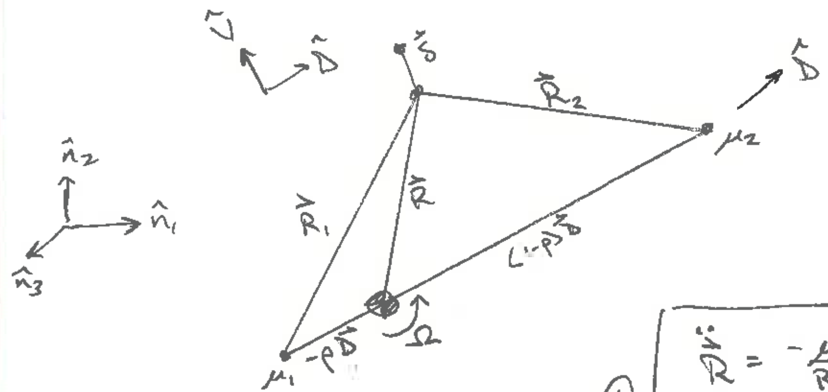

$\vec D = D\hat D$

$\vec r = \vec R + \vec\delta$

$\vec r_1 = \vec R_1 + \vec\delta$

$\vec r_2 = \vec R_2 + \vec\delta$

(1) $$\boxed{\begin{aligned}\ddot{\vec R} &= -\frac{\mu_1}{R_1^3}\vec R_1 - \frac{\mu_2}{R_2^3}\vec R_2 \\ \ddot{\vec r} &= -\frac{\mu_1}{r_1^3}\vec r_1 - \frac{\mu_2}{R_2^3}\vec r_2\end{aligned}}$$ Accelerations due to gravity

$\vec R_1 = \vec R - \rho D\hat D$

$\dot{\vec R}_1 = \dot{\vec R} - \rho\dot D\hat D - \rho D(\Omega\hat\nu)$

(2) $\boxed{\ddot{\vec R}_1 = \ddot{\vec R} - \rho\ddot D\hat D - 2\rho\dot D(\Omega\hat\nu) + \rho D\Omega^2\hat D}$ Moved origin of reference orbit to μ_1 instead of ⊕

(3) $\boxed{\ddot{\vec r}_1 = \ddot{\vec r} - \rho\ddot D\hat D - 2\rho\dot D(\Omega\hat\nu) + \rho D\Omega^2\hat D}$ Same derivation as (2)

$\ddot{\vec r}_1 = -\frac{\mu_1}{r_1^3}\vec r_1 - \frac{\mu_2}{r_2^3}\vec r_2 - \rho\ddot D\hat D - 2\rho\dot D\Omega\hat\nu + \rho D\Omega^2\hat D$

$\ddot{\vec\delta} = \ddot{\vec r}_1 - \ddot{\vec R}_1 = \underbrace{\left[-\frac{\mu_1}{r_1^3}\vec r_1 - \frac{\mu_2}{r_2^3}\vec r_2\right]}_{[\ddot{\vec r}]} - \underbrace{\left[-\frac{\mu_1}{R_1^3}\vec R_1 - \frac{\mu_2}{R_2^3}\vec R_2\right]}_{[\ddot{\vec R}]}$ + (Rotating Frame) − (Rotating Frame)

(4) $\boxed{\ddot{\vec\delta} = \mu_1\left[-\frac{\vec r_1}{r_1^3} + \frac{\vec R_1}{R_1^3}\right] + \mu_2\left[-\frac{\vec r_2}{r_2^3} + \frac{\vec R_2}{R_2^3}\right]}$ Substitute (1) into (3) − (2)
Rotating frame terms cancel

Roy p.202: $\frac{\vec R_k}{R_k^3} - \frac{\vec r_k}{r_k^3} = \frac{\vec R_k}{R_k^3} - \frac{(\vec R_k + \vec\delta)}{r_k^3}$ $k=1,2$

$= \vec R_k\left(\frac{1}{R_k^3} - \frac{1}{r_k^3}\right) - \frac{\vec\delta}{r_k^3}$

$\frac{1}{R_k^3} - \frac{1}{r_k^3} = \frac{r_k^3 - R_k^3}{R_k^3 r_k^3} = \frac{(r_k - R_k)(r_k^2 + r_k R_k + R_k^2)}{R_k^3 r_k^3} = \frac{(r_k^2 - R_k^2)}{R_k^3 r_k^3}\,\frac{(r_k^2 + r_k R_k + R_k^2)}{(r_k + R_k)}$

$\vec\delta\cdot(\vec r_k + \vec R_k) = (\vec r_k - \vec R_k)\cdot(\vec r_k + \vec R_k) = r_k^2 - R_k^2 = \vec\delta\cdot(\vec R_k + \vec\delta + \vec R_k)$

so $r_k^2 - R_k^2 = \delta^2 + 2\vec\delta\cdot\vec R_k$

Let $Q_k = \frac{\delta^2 + 2\vec\delta\cdot\vec R_k}{R_k^3 r_k^3}\,\frac{(r_k^2 + r_k R_k + R_k^2)}{r_k + R_k}$

$$\boxed{\ddot{\vec\delta} = \sum_{k=1}^{2}\mu_k\left[Q_k\vec R_k - \frac{\vec\delta}{r_k^3}\right]}$$ (4) rewritten to avoid subtracting two nearly equal numbers.