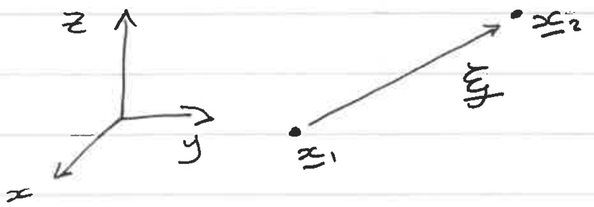
3)



$$\ddot{\underline{x}}_i = -\frac{GM\underline{x}_i}{|\underline{x}_i|^3} \qquad \underline{\xi} = \underline{x}_2 - \underline{x}_1$$

and define $\underline{d} = \frac{1}{2}(\underline{x}_1 + \underline{x}_2)$

thus ~~x~~ $\underline{d} = \frac{1}{2}(\underline{x}_1 + \underline{x}_1 + \underline{\xi})$

$$\underline{x}_1 = \underline{d} - \frac{1}{2}\underline{\xi} \qquad \underline{x}_2 = \underline{d} + \frac{1}{2}\underline{\xi}$$

it follows that $|\underline{x}_1|^2 = d^2 - \underline{d}.\underline{\xi} + \frac{\xi^2}{4} \qquad |\underline{x}_2|^2 = d^2 + \underline{d}.\underline{\xi} + \frac{\xi^2}{4}$

and $\xi \ll d$ so $|x_1| \approx d\left(1 - \frac{\underline{d}.\underline{\xi}}{d^2}\right)^{1/2} \quad |x_2| \approx d\left(1 + \frac{\underline{d}.\underline{\xi}}{d^2}\right)^{1/3}$

~~Therefore~~ $\cancel{\ddot{\underline{\xi}} = \ddot{\underline{x}}_2 - \ddot{\underline{x}}_1 = \frac{-GM(\underline{d} - \frac{1}{2}\underline{\xi})}{d\left(1 - \frac{\underline{d}.\underline{\xi}}{d^2}\right)}}$

$$\left.\begin{aligned} |x_1| &\approx d\left(1 - \tfrac{1}{2}\underline{d}.\underline{\xi}/d^2\right) \\ |x_2| &\approx d\left(1 + \tfrac{1}{2}\underline{d}.\underline{\xi}/d^2\right) \end{aligned}\right\} \begin{aligned} &\text{Binomial approximation} \\ &(1+b)^\alpha \approx 1 + \alpha b \end{aligned}$$

Therefore $\ddot{\underline{\xi}} = \ddot{\underline{x}}_2 - \ddot{\underline{x}}_1$

$$= \frac{-GM(\underline{d} + \frac{1}{2}\underline{\xi})}{d^3(1 + \frac{1}{2}\underline{d}.\underline{\xi}/d^2)^3} + \frac{GM(\underline{d} - \frac{1}{2}\underline{\xi})}{d^3(1 - \frac{1}{2}\underline{d}.\underline{\xi}/d^2)^3}$$

which rearranges to $\ddot{\underline{\xi}} = \frac{-GM}{d^3}\left(\underline{\xi} - (3\underline{\xi}.\underline{d}/d^2)\underline{d}\right)$