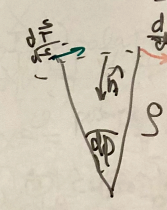
1) single mass point : $m, \vec{r}(t) \rightarrow \vec{v} = \frac{d\vec{r}}{dt} = \frac{d\vec{r}}{ds} \cdot \underbrace{\frac{ds}{dt}}_{= \text{speed} = |\vec{v}|}$

$$\rightarrow \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2} = \vec{a} = \frac{d}{dt}\left(\frac{d\vec{r}}{ds}\right) + \underbrace{\frac{d\vec{r}}{ds} \cdot \frac{d^2s}{dt^2}}_{\vec{a}_{\parallel}} \qquad ds = \sqrt{(d\vec{r})^2}$$

$$\vec{a}_{\perp} = \hat{n}\frac{v^2}{\rho}$$



$\frac{d\hat{r}}{dt} = \frac{ds/dt \, \varphi}{\rho}$

$d\varphi = \frac{a\text{-}/dt}{\rho}$

$\vec{p} = m \cdot \vec{v}$ $\quad \underline{\vec{L} = \vec{r} \times \vec{p}}$ (depends on O)

[Newton: $m \cdot \vec{a} = \frac{d\vec{p}}{dt} = \sum \vec{F}$; $\vec{N} = \sum \vec{r} \times \vec{F}$ torque $= \frac{d\vec{L}}{dt}$

Work $= \int_{path} \vec{F} \cdot d\vec{s} \rightarrow \Delta \text{Work} = \Delta \frac{m}{2}\vec{v}^2 \rightarrow$ kin En.. T_{kin}

if ↑ is independent) $\rightarrow V_{pot}(r) = -\int_{0}^{\vec{r}} \vec{F} \cdot d\vec{s} \Rightarrow E = T_{kin} + V_{pot} = \text{const.}$

2) System of mass points : $\vec{r}_i, m_i \rightarrow \vec{R} = \frac{\sum m_i \vec{r}_i}{M = \sum m_i}$ center of mass

$$\vec{V} = \frac{d}{dt}\vec{R} \qquad \vec{P} = M\vec{V} = \sum \vec{p}_i$$

$$M\frac{d\vec{V}}{dt} = \frac{d\vec{P}}{dt} = \sum_i^{\text{all masses}} \vec{F}_i = \sum \vec{F}_i^{ext} + \frac{1}{2}\underbrace{\sum_{i,j} \vec{F}_{ij}}$$

$$\frac{1}{2}\sum \underbrace{\vec{F}_{ij} + \vec{F}_{ji}}_{=0}$$

weak equivalence

$$\sum F_i^{ext} = 0 \Rightarrow \vec{R}(t) = \vec{R}_0 + \vec{V} \cdot t$$

def.: $\vec{r}_i{}' = \vec{r}_i - \vec{R}$ $\quad [\sum \vec{r}_i{}' = 0]$

$$\vec{L}_{tot} = \sum (\vec{r}_i \times \vec{p}_i) = \sum \vec{r}_i{}' \times \vec{p}_i{}' + \sum R \times \vec{p}_i = \vec{R} \times \vec{P}$$

$$\frac{d\vec{L}}{dt} = \vec{N} = \sum \vec{r}_i \times \vec{F}_i = R \times \sum F_i^{ext} + \sum_{ij} \vec{r}_i{}' \times \vec{F}_{ij} \quad \frac{1}{2}\sum (\vec{r}_i{}' - \vec{r}_j{}') \times \vec{F}_{ij}$$

Strong equivalence

$$T_{kin} = \frac{1}{2}\sum_i m_i \vec{v}_i^2 = \frac{M}{2}\vec{V}^2 + \frac{1}{2}\sum m_i \dot{\vec{r}}_i{}'^2 \qquad \vec{v}_i = \dot{\vec{R}} + \dot{\vec{r}}_i{}'$$

$$V_{pot} = V_{pot}^{ext} + \frac{1}{2}\sum_{i,j} V(|\vec{r}_i - \vec{r}_j|)$$