$\vec{r}\cdot\vec{s} = rs\cos\theta$ $\quad \vec{r}\times\vec{s} = det\begin{bmatrix}\hat{x} & \hat{y} & \hat{z}\\ r_x & r_y & r_z\\ s_x & s_y & s_z\end{bmatrix}$ $\quad \vec{F} = m\ddot{\vec{r}}$ $\quad Constant\ a{:}\ x(t) = x_0 + v_0 t + \frac{1}{2}at^2;\ v(t) = v_0 + at;\ v_f^2 - v_i^2 = 2a\Delta x$ $\quad \vec{f} = -f(v)\hat{v}$ $\quad f(v) = bv + cv^2$

$\vec{F} = q(\vec{E} + \vec{v}\times\vec{B})$ $\quad m\dot{v} = -\dot{m}v_{ex} + F^{ext}$ $\quad v - v_0 = v_{ex}\ln\frac{m_0}{m}$ $\quad \vec{R} = \frac{1}{M}\sum_{\alpha=1}^{N} m_\alpha \vec{r}_\alpha$

$\vec{R} = \frac{1}{M}\int \vec{r}\, dm = \frac{1}{M}\int \rho\,\vec{r}\, dV$ $\quad \vec{\ell} = \vec{r}\times\vec{p}$ $\quad \vec{L} = \sum_{\alpha=1}^{N}\vec{r}_\alpha\times\vec{p}_\alpha$ $\quad \dot{\vec{L}} = \vec{\Gamma}^{ext}$ $\quad \Delta T = T_2 - T_1 = \int_1^2 \vec{F}\cdot d\vec{r} = W(1\to 2)$ $\quad T = mv^2/2$ $\quad U(\vec{r}) = -W(\vec{r}_0\to\vec{r}) = -\int_{\vec{r}_0}^{\vec{r}}\vec{F}(\vec{r'})\cdot d\vec{r'}$

$\vec{\nabla}\times\vec{F} = 0$ $\quad \vec{F} = -\vec{\nabla}U$ $\quad E = T + U_1 + \cdots + U_n$ $\quad \Delta E = W_{nc}$ $\quad t = \sqrt{\frac{m}{2}}\int_{x_0}^{x}\frac{dx'}{\sqrt{E-U(x')}}$

$\vec{F}(\vec{r}) = f(\vec{r})\hat{r}$ $\quad U = U^{int} + U^{ext} = \sum_\alpha\sum_{\beta>\alpha}U_{\alpha\beta} + \sum_\alpha U_\alpha^{ext}$ $\quad Net\ force\ on\ particle\ \alpha = -\nabla_\alpha U$ $\quad T + U = constant$ $F = -kx \leftrightarrow U = \frac{1}{2}kx^2$ $\quad \ddot{x} = -\omega^2 x \leftrightarrow x(t) = A\cos(\omega t - \delta)$

$\ddot{x} + 2\beta\dot{x} + \omega_0^2 x = 0 \leftrightarrow x(t) = Ae^{-\beta t}\cos(\omega_1 t - \delta)\ (assuming\ \beta < \omega_0), \beta = \frac{2b}{m}, damping\ force = -bv, \omega_0 = \sqrt{\frac{k}{m}}, \omega_1 = \sqrt{\omega_0^2 - \beta^2}$ $\quad F(t) = mf_0\cos(\omega t), x(t) = A\cos(\omega t - \delta), where\ A^2 = \frac{f_0^2}{(\omega_0^2-\omega^2)^2 + 4\beta^2\omega^2}$ $\quad \delta = \tan^{-1}\left(\frac{2\beta\omega}{\omega_0^2-\omega^2}\right)$ $\quad S = \int_{x_1}^{x_2} f[y(x), y'(x), x]dx,\ \frac{\partial f}{\partial y} - \frac{d}{dx}\frac{\partial f}{\partial y'} = 0$

$S = \int_{u_1}^{u_2} f[x(u), y(u), x'(u), y'(u), u]du, \frac{\partial f}{\partial x} = \frac{d}{du}\frac{\partial f}{\partial x'}, and\ \frac{\partial f}{\partial y} = \frac{d}{du}\frac{\partial f}{\partial y'}$ $\quad \mathcal{L} = T - U$

$\frac{\partial\mathcal{L}}{\partial q_i} = \frac{d}{dt}\frac{\partial\mathcal{L}}{\partial\dot{q}_i}\ [i = 1, \dots n]$ $\quad p_i = \frac{\partial\mathcal{L}}{\partial\dot{q}_i}$ $\quad \mathcal{H} = \sum_{i=1}^{n} p_i\dot{q}_i - \mathcal{L}$ $\quad \vec{r} = \vec{r}_1 - \vec{r}_2$ $\quad \mu = \frac{m_1 m_2}{m_1 + m_2}$

$U_{eff} = U(r) + U_{cf}(r) = U(r) + \frac{\ell^2}{2\mu r^2}$ $\quad u''(\varphi) = -u(\varphi) - \frac{\mu}{\ell^2 u(\varphi)^2}F$

$r(\varphi) = \frac{c}{1+\epsilon\cos\varphi}\ for\ F = -\frac{\gamma}{r^2}, with\ c = \frac{\ell^2}{\gamma\mu}$ $\quad E = \frac{\gamma^2\mu}{2\ell^2}(\epsilon^2 - 1)$

$\vec{F}_{inertial} = -m\vec{A}$ $\quad \vec{\omega} = \omega\hat{u}$ $\quad \vec{v} = \vec{\omega}\times\vec{r}$ $\quad \left(\frac{d\vec{Q}}{dt}\right)_{S_0} = \left(\frac{d\vec{Q}}{dt}\right)_S + \vec{\Omega}\times\vec{Q}$

$m\ddot{\vec{r}} = \vec{F} + \vec{F}_{cor} + \vec{F}_{cf}, with\ \vec{F}_{cor} = 2m\dot{\vec{r}}\times\vec{\Omega}, and\ \vec{F}_{cf} = m(\vec{\Omega}\times\vec{r})\times\vec{\Omega}$

$\vec{g} = \vec{g}_0 + (\vec{\Omega}\times\vec{R})\times\vec{\Omega}$ $\quad N_{oc} = N_{inc}n_{tar}\sigma_{oc}$ $\quad N_{sc}(into\ d\Omega) = N_{inc}n_{tar}\frac{d\sigma}{d\Omega}(\theta,\phi)d\Omega$

$\frac{d\sigma}{d\Omega} = \frac{b}{\sin\theta}\left|\frac{db}{d\theta}\right|$ $\quad \frac{d\sigma}{d\Omega} = \left(\frac{kqQ}{4E\sin^2(\theta/2)}\right)^2$ $\quad \dot{q}_i = \partial\mathcal{H}/\partial p_i$ and $\dot{p}_i = -\frac{\partial\mathcal{H}}{\partial q_i}$ $[i = 1, \dots n]$

$\vec{L} = \vec{L}(motion\ of\ CM) + \vec{L}(motion\ relative\ to\ CM)$

$T = T(motion\ of\ CM) + T(motion\ relative\ to\ CM)$ $\quad \vec{L} = \bar{\bar{I}}\vec{\omega}$

$\bar{\bar{I}} = \begin{bmatrix}I_{xx} & I_{xy} & I_{xz}\\ I_{yx} & I_{yy} & I_{yz}\\ I_{zx} & I_{zy} & I_{zz}\end{bmatrix}$ $\quad I_{xx} = \sum_\alpha m_\alpha(y_\alpha^2 + z_\alpha^2), etc.$ $\quad I_{xy} = -\sum_\alpha m_\alpha x_\alpha y_\alpha, etc.$ $\quad \vec{L} = \lambda\vec{\omega}$

$(\bar{\bar{I}} - \lambda\bar{\bar{1}})\vec{\omega} = 0$ Characteristic equation: $det(\bar{\bar{I}} - \lambda\bar{\bar{1}}) = 0$ $\quad \bar{\bar{I}}' = \begin{bmatrix}\lambda_1 & 0 & 0\\ 0 & \lambda_2 & 0\\ 0 & 0 & \lambda_3\end{bmatrix}$ $\quad \dot{\vec{L}} + \vec{\omega}\times\vec{L} = \vec{\Gamma}$ $\quad \bar{\bar{M}}\ddot{\vec{q}} = -\bar{\bar{K}}\vec{q}$ $\quad T = \frac{1}{2}\sum_{j,k} M_{jk}\,\dot{q}_j\dot{q}_k$ $\quad U = \frac{1}{2}\sum_{j,k} K_{jk}\,q_j q_k$ $\quad \vec{q}(t) = Re(\vec{a}\,e^{i\omega t})$

$\left(\overline{\overline{K}} - \omega^2 \overline{\overline{M}}\right)\vec{a} = 0$ $\ddot{\phi} + 2\beta\dot{\phi} + \omega_0^2 \sin\phi = \gamma\omega_0^2 \cos(\omega t)\,, with\ \gamma = \frac{F_0}{mg}, and\ F(t) = F_0 \cos(\omega t)$ $|\Delta\phi(t)| \sim K e^{\lambda t}$ $\dot{q}_i = \partial\mathcal{H}/\partial p_i$ and $\dot{p}_i = -\frac{\partial\mathcal{H}}{\partial q_i}$ $[i = 1, \dots n]$

$\Delta t = \gamma \Delta t_0$ $\gamma = 1/\sqrt{1-\beta^2},$ $\beta = V/c$ $\ell = \ell_0/\gamma$ $x' = \gamma(x - Vt),$ $y' = y,$ $z' = z,$ $t' = \gamma(t - Vx/c^2)$ $v_x' = \frac{v_x - V}{1 - v_x V/c^2},$ $v_y' = \frac{v_y}{\gamma(1 - v_x V/c^2)},$ $v_z' = \frac{v_z}{\gamma(1 - v_x V/c^2)}$ $q^{(4)'} = \Lambda q^{(4)}$ $x^{(4)} \cdot y^{(4)} = x_1 y_1 + x_2 y_2 + x_3 y_3 - x_4 y_4$ $u^{(4)} = \frac{dx^{(4)}}{dt_0} = \gamma(\vec{v}, c)$ $p^{(4)} = m u^{(4)} = (\gamma m \vec{v}, \gamma m c) = (\vec{p}, E/c)$ $\vec{\beta} = \vec{p}c/E$ $p^{(4)} \cdot p^{(4)} = -(mc)^2$ $E^2 = (mc^2)^2 + (\vec{p}c)^2$

Binomial expansion for $x \ll 1$: $(1+x)^n \cong 1 + nx + \frac{n(n-1)}{2}x^2$

$$\frac{1}{1+x} = 1 - x + x^2 - x^3 + \cdots \quad (x < 1)$$