Newton–Euler

$\sum \vec{F} = m\vec{a}$
$\sum \vec{M}_p = I_p \vec{\alpha}$ (about fixed point or CG)

Lagrange's Eqn

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_i}\right) - \frac{\partial T}{\partial q_i} + \frac{\partial U}{\partial q_i} = Q_i$$

Logarithmic Decrement

$\delta = \ln\left(\frac{x_j}{x_{j+1}}\right)$

$$\zeta = \frac{\delta/2\pi}{\sqrt{1 + (\delta/2\pi)^2}}$$

If $\zeta \ll 1,\ \zeta \approx \frac{\delta}{2\pi}$

SDOF

$m\ddot{x} + c\dot{x} + kx = 0$
$\ddot{x} + 2\zeta\omega_n\dot{x} + \omega_n^2 x = 0$
$2\zeta\omega_n = \frac{c}{m},\ \omega_n^2 = \frac{k}{m}$
$x(t) = e^{-\zeta\omega_n t}(C\cos\omega_d t + S\sin\omega_d t)$ if $0 \leq \zeta \leq 1$

Linearized Lagrange's Eqns

$[M]\ddot{\vec{z}} + [C]\dot{\vec{z}} + [K]\vec{z} = \vec{0}$
$\vec{z} = \vec{q} - \vec{q}_0$
$M_{ik} = (m_{ik})_{\vec{q}_0},\ M_{ik} = M_{ki}$
$C_{ik} = (\partial^2 R/\partial\dot{q}_i\partial\dot{q}_k)_{\vec{q}_0}$
$K_{ik} = (\partial^2 U/\partial q_i \partial q_k)_{\vec{q}_0} = K_{ki}$

Power/Work–Energy

$T + U = T_0 + U_0 + W^{nc}$
$\dot{W}^{nc} = \frac{dT}{dt} + \frac{dU}{dt}$