

Newton–Euler

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

Lagrange’s Eqn

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

SDOF

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

Logarithmic Decrement

$$\begin{aligned}\delta &= \ln \left(\frac{x_j}{x_{j+1}} \right) \\ \zeta &= \frac{\delta/2\pi}{\sqrt{1 + (\delta/2\pi)^2}} \\ \text{If } \zeta \ll 1, \quad \zeta &\approx \frac{\delta}{2\pi}\end{aligned}$$

Power/Work–Energy

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

Linearized Lagrange’s Eqns

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