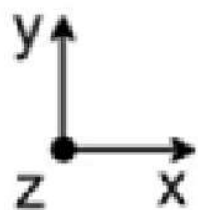
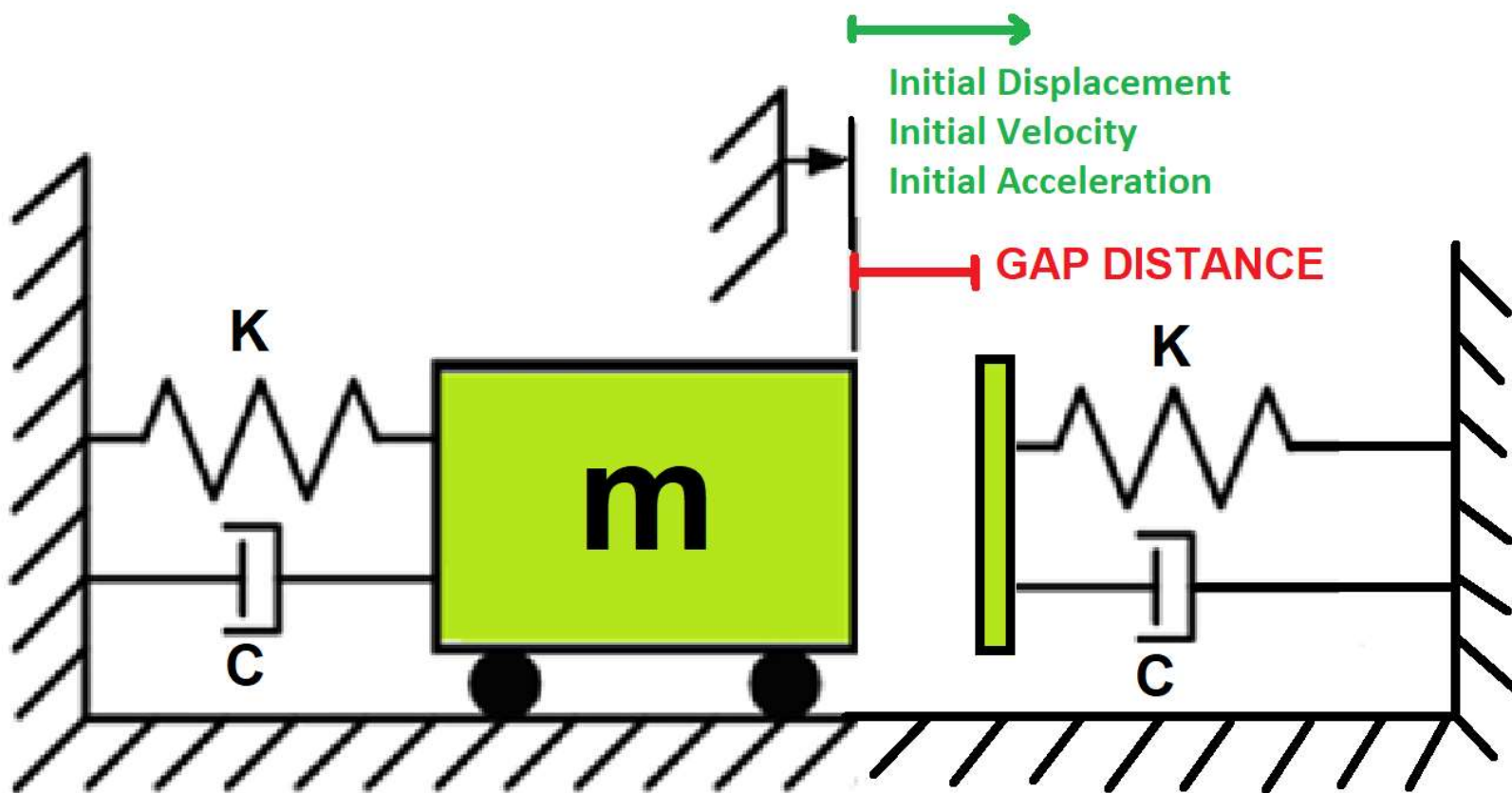


>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

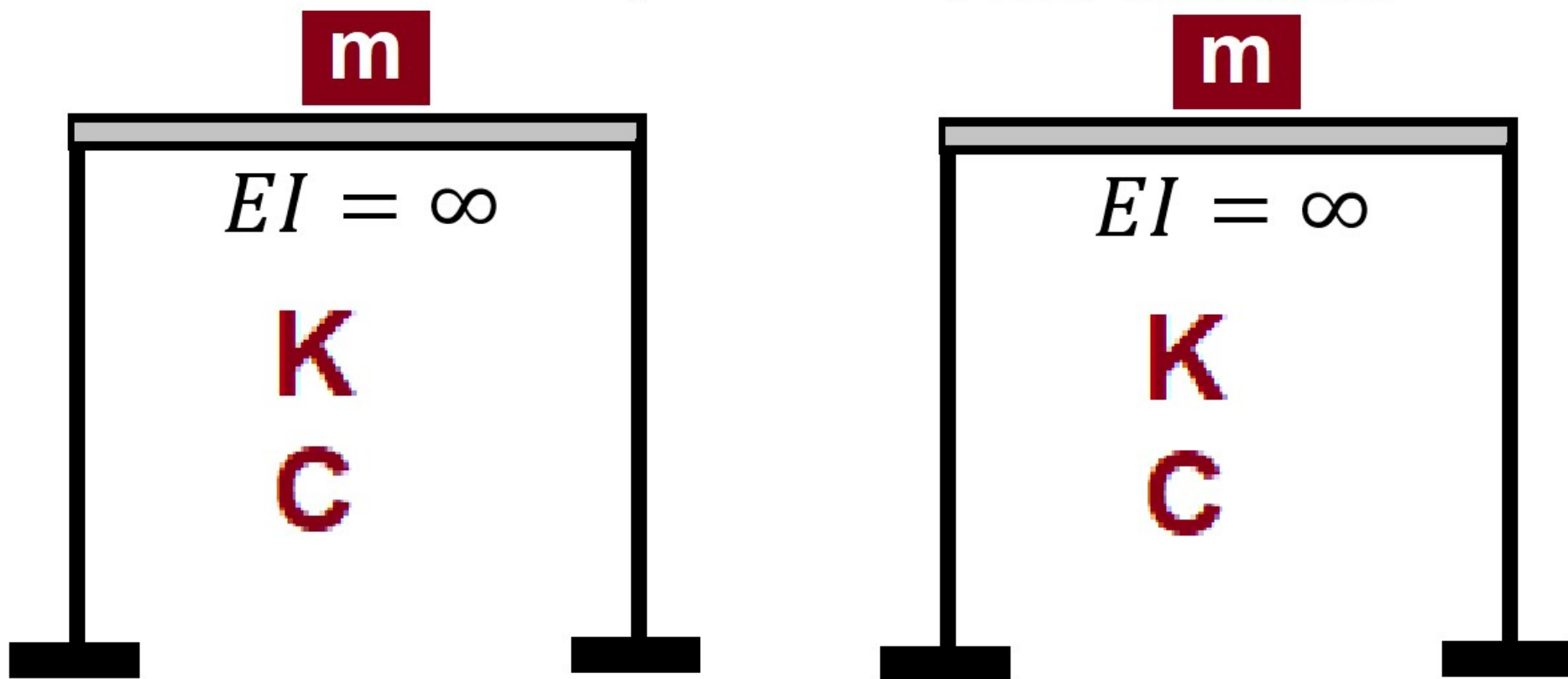
SIMULATE THE FREE-VIBRATION RESPONSE OF A SINGLE-DEGREE-OF- FREEDOM (SDOF) STRUCTURE INCORPORATING A PARALLEL CONTACT/GAP MECHANISM TO MODEL STAGED STIFFNESS ACTIVATION USING OPENSEES

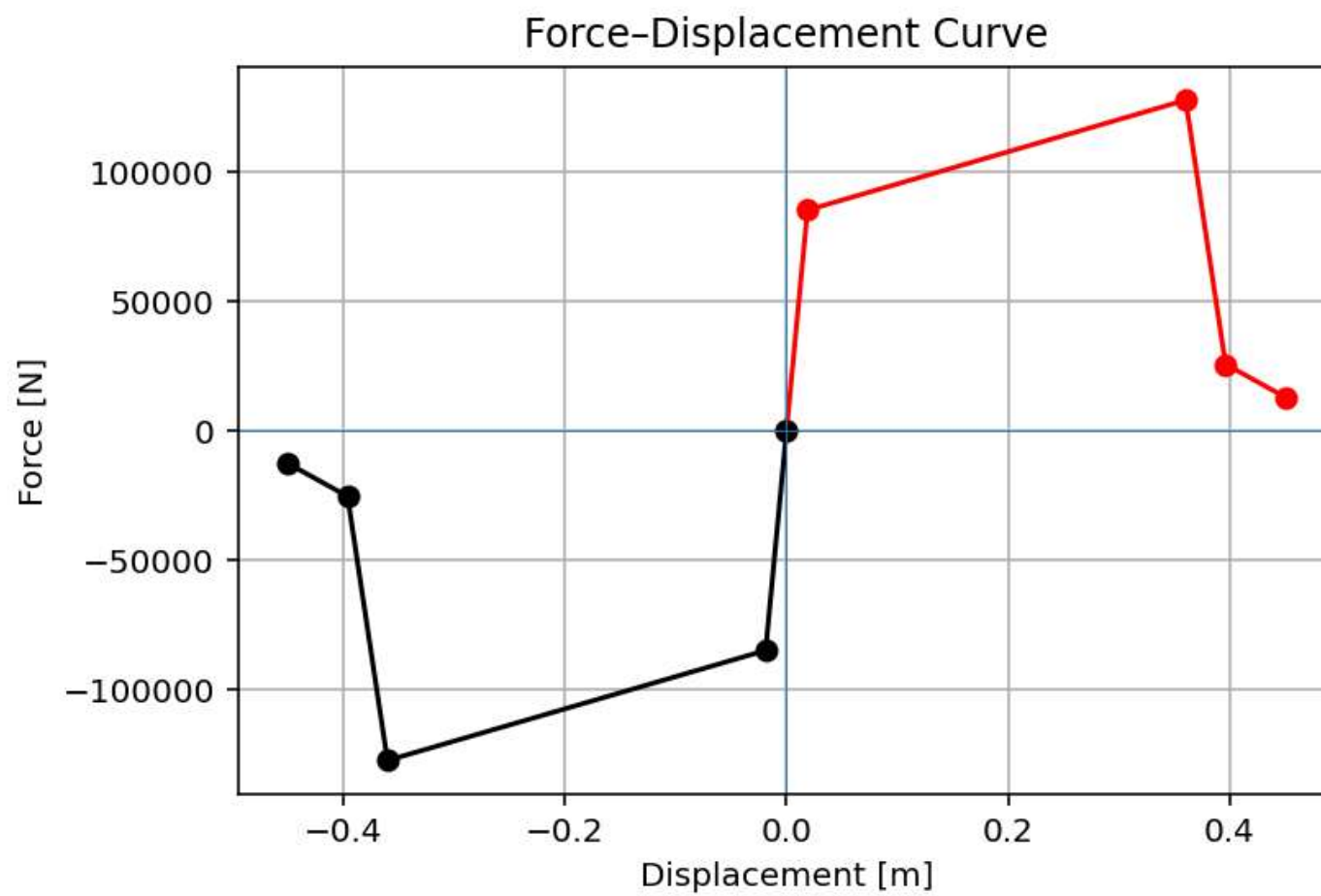
WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)



Initial Displacement
Initial Velocity
Initial Acceleration

GAP DISTANCE





12

Python 3.12

FileEditSearchSourceRunDebugConsolesProjectsToolsViewHelp

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CONTACT_PROBLEM_SD...RATION_U0_VO_A0.py

```
#####
#                               >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
#   SIMULATE THE FREE-VIBRATION RESPONSE OF A SINGLE-DEGREE-OF-FREEDOM (SDOF) STRUCTURE INCORPORATING
#   CONTACT/GAP MECHANISM TO MODEL STAGED STIFFNESS ACTIVATION USING OPENSEES
#-----
#
#   THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
#   EMAIL: salar.d.ghashghaei@gmail.com
#####
"""
This script simulates the nonlinear dynamic response (Free-vibration Analysis) of a single-degree-of-f
contact/gap mechanism. The structure has a primary spring (elastic or hysteretic) that activates
immediately, while a secondary parallel spring engages only when displacement exceeds a specified
gap distance. This models structural components that come into contact only after certain
deformation thresholds, such as gap-opening in masonry infills, pounding between adjacent structures,
or secondary bracing systems activating during strong seismic events.

The analysis tracks force-displacement response, stiffness degradation, and period elongation
as damage accumulates. The eigenvalue analysis at each step captures how the natural period
increases with structural softening, a critical indicator of seismic vulnerability during
progressive damage. Contact activation causes a sudden stiffness increase when the gap closes,
followed by further period evolution as the system yields.

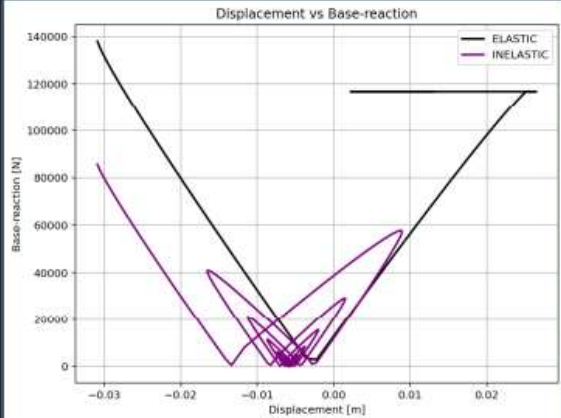
Performs free-vibration analysis of a Single Degree of Freedom (SDOF)
structure using OpenSeesPy, comparing elastic and inelastic spring behavior.
Key features include:

1. Implements both elastic (linear) and hysteretic (nonlinear) material models for
structural springs.
2. Supports initial conditions for displacement, velocity, and acceleration.
3. Uses Newmark's method for time integration with Newton-Raphson iteration.
4. Calculates damping ratios using logarithmic decrement from response peaks.
5. Generates force-displacement backbone curves for inelastic material.
6. Tracks and plots time-history responses (displacement, velocity, acceleration, reactions).
7. Compares elastic vs inelastic system performance.
8. Includes convergence checks and analysis stability monitoring.
```

...CT_EXAMPLES\+CONTACT_PROBLEM_SDOF_FREE-VIBRATION_U0_VO_A0

35 %

Displacement vs Base-reaction



IPython ConsoleFilesHelpVariable ExplorerDebuggerPlotsHistory

Conda: anaconda3 (Python 3.12.7) ✓ LSP: Python Line 261, Col 10 UTF-8 CRLF RW Mem 42%

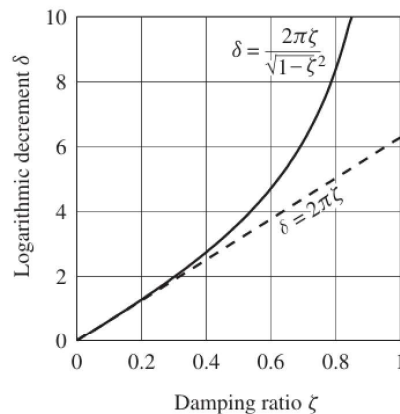
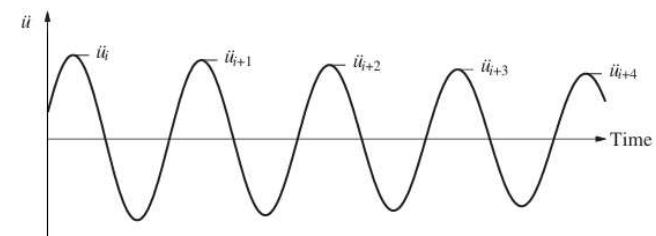
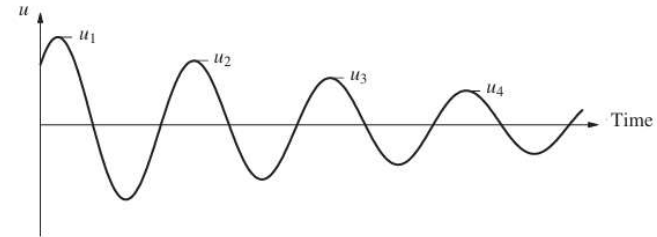
VISCOUSLY DAMPED FREE VIBRATION

$$m\ddot{u} + c\dot{u} + ku = 0$$

$$\ddot{u} + 2\zeta\omega_n\dot{u} + \omega_n^2 u = 0$$

$$\omega_n = \sqrt{k/m} \quad \zeta = \frac{c}{2m\omega_n} = \frac{c}{c_{cr}} \quad \omega_D = \omega_n \sqrt{1 - \zeta^2}$$

$$u(t) = e^{-\zeta\omega_n t} \left[u(0) \cos \omega_D t + \frac{\dot{u}(0) + \zeta\omega_n u(0)}{\omega_D} \sin \omega_D t \right]$$



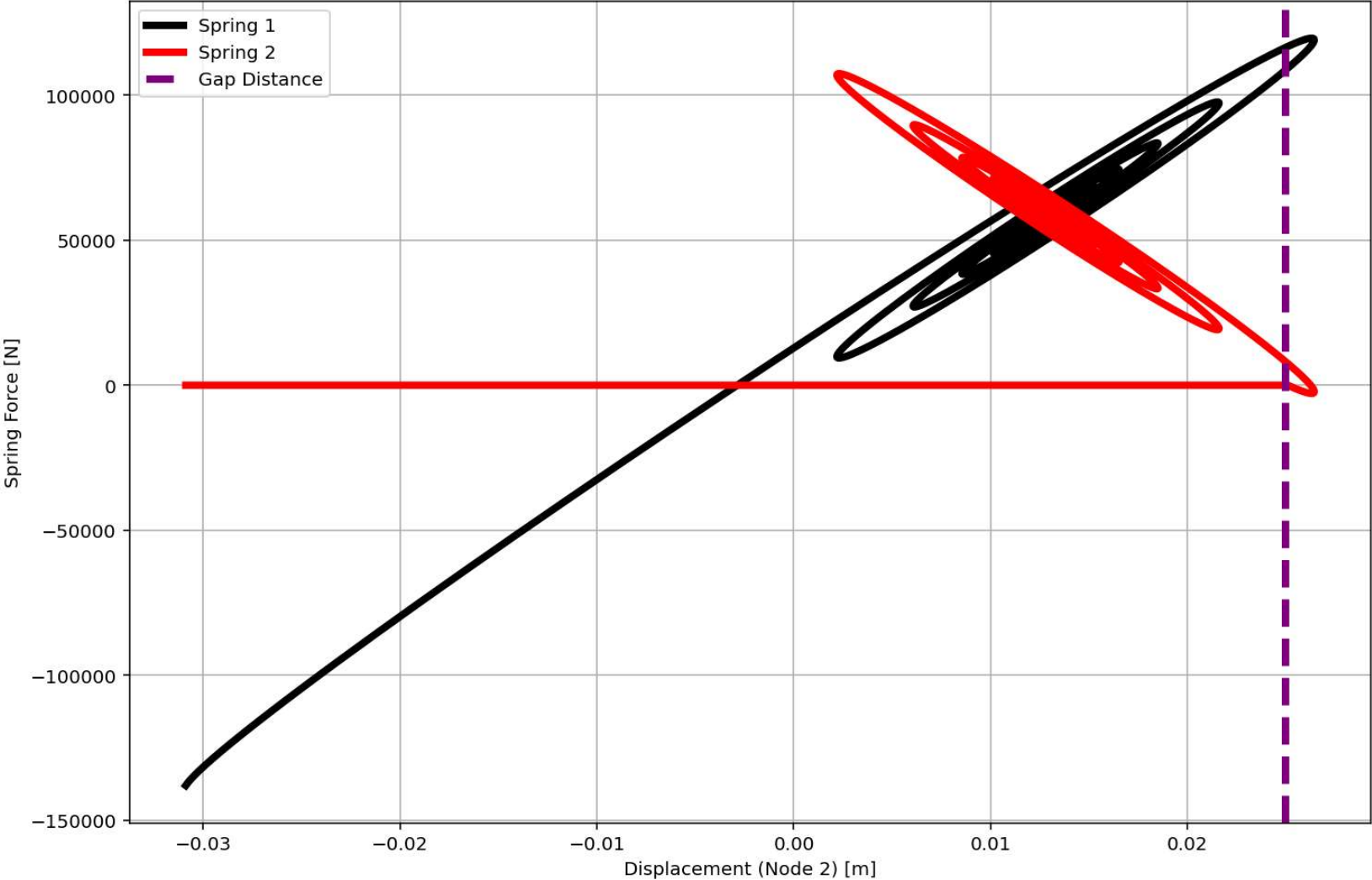
Decay of Motion

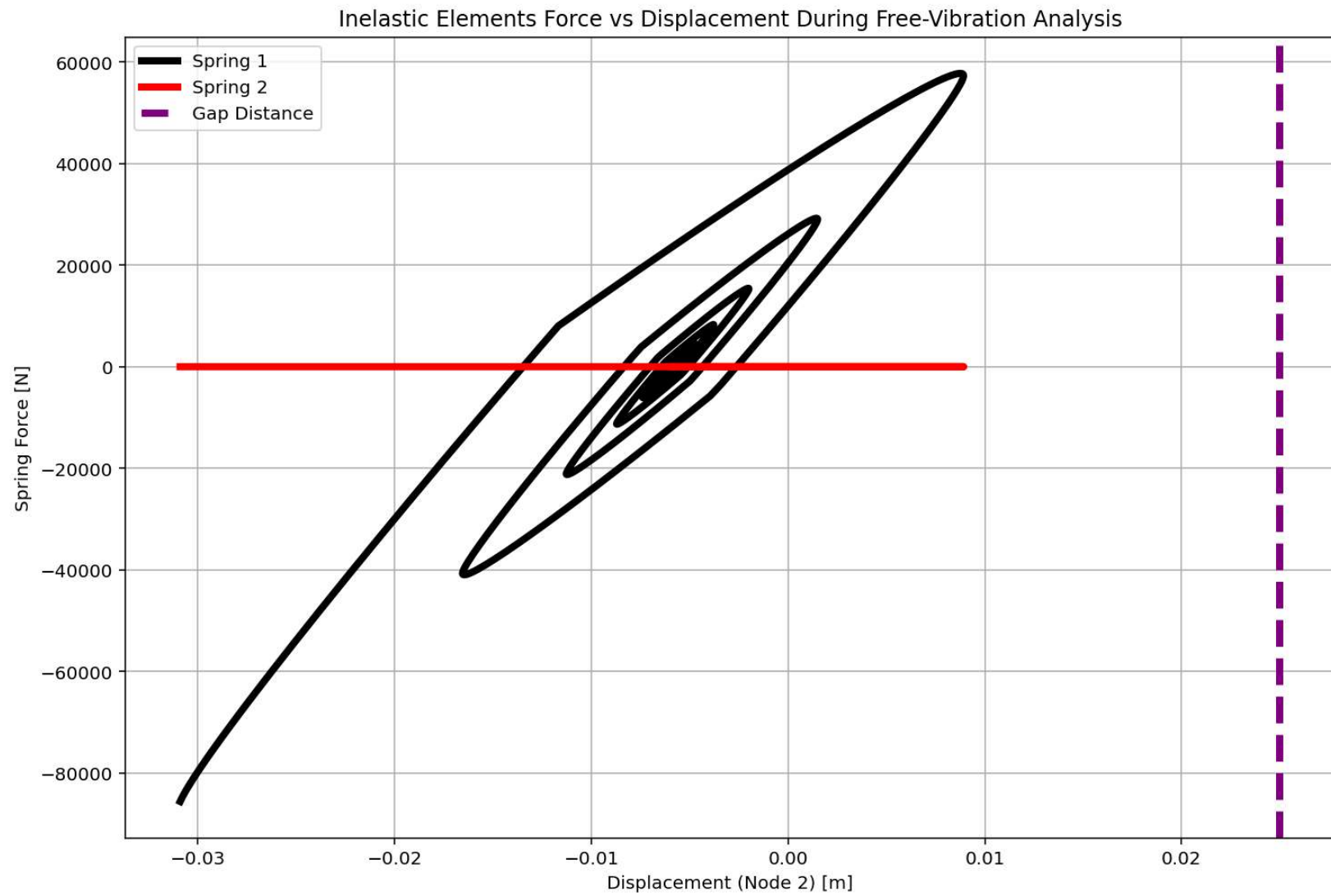
$$\delta = \ln \frac{u_i}{u_{i+1}} = 2\pi\zeta \quad (\text{APPROXIMATE RELATION})$$

$$\delta = \ln \frac{u_i}{u_{i+1}} = \frac{2\pi\zeta}{\sqrt{1-\zeta^2}} \quad (\text{EXACT RELATION})$$

EXACT AND APPROXIMATE RELATIONS BETWEEN LOGARITHMIC DECREMENT AND DAMPING RATIO

Elastic Elements Force vs Displacement During Free-Vibration Analysis





Period of Structure vs Displacement During Free-Vibration Analysis

