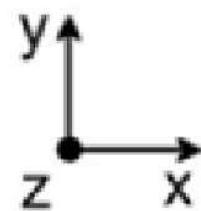
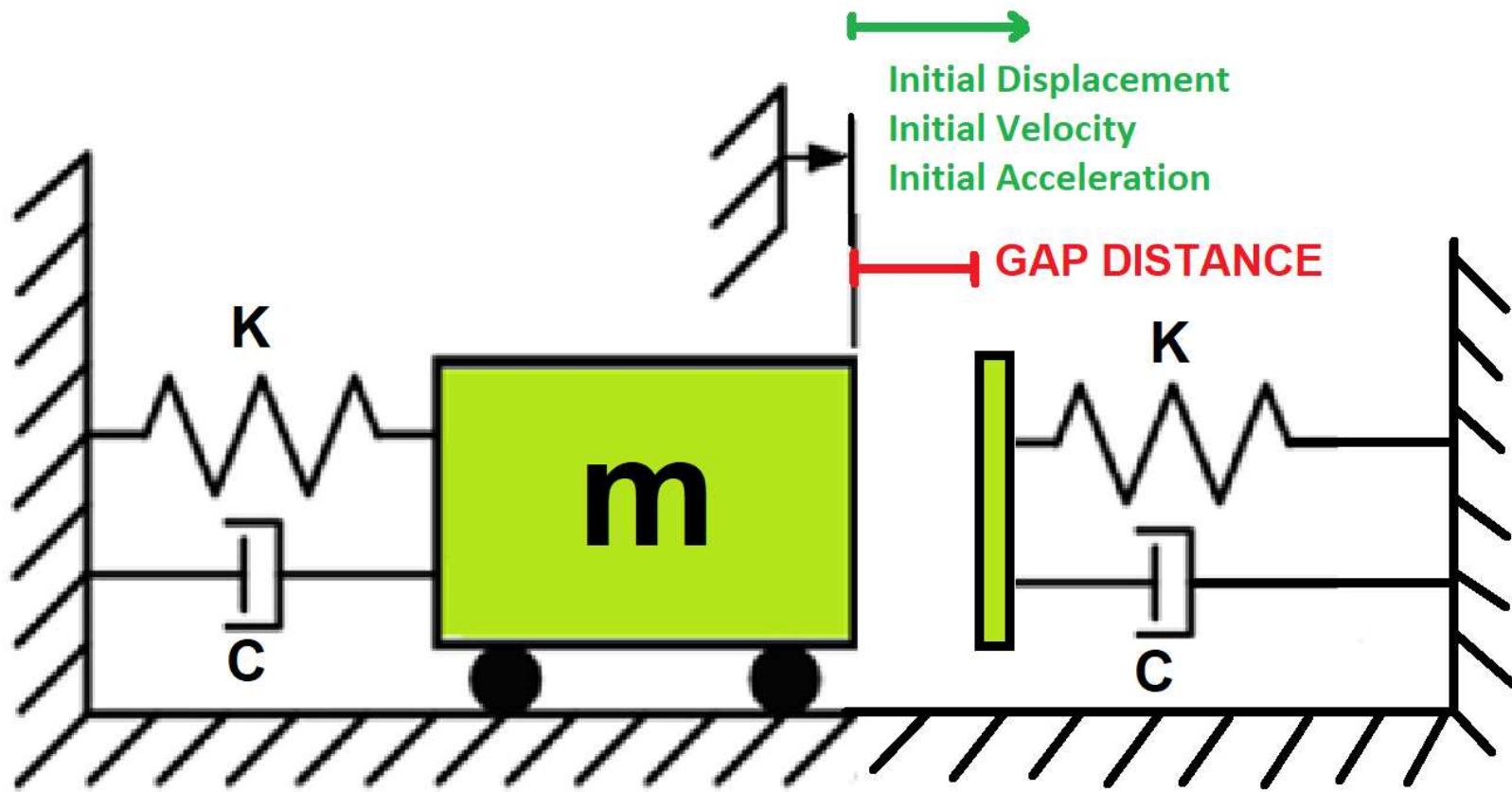
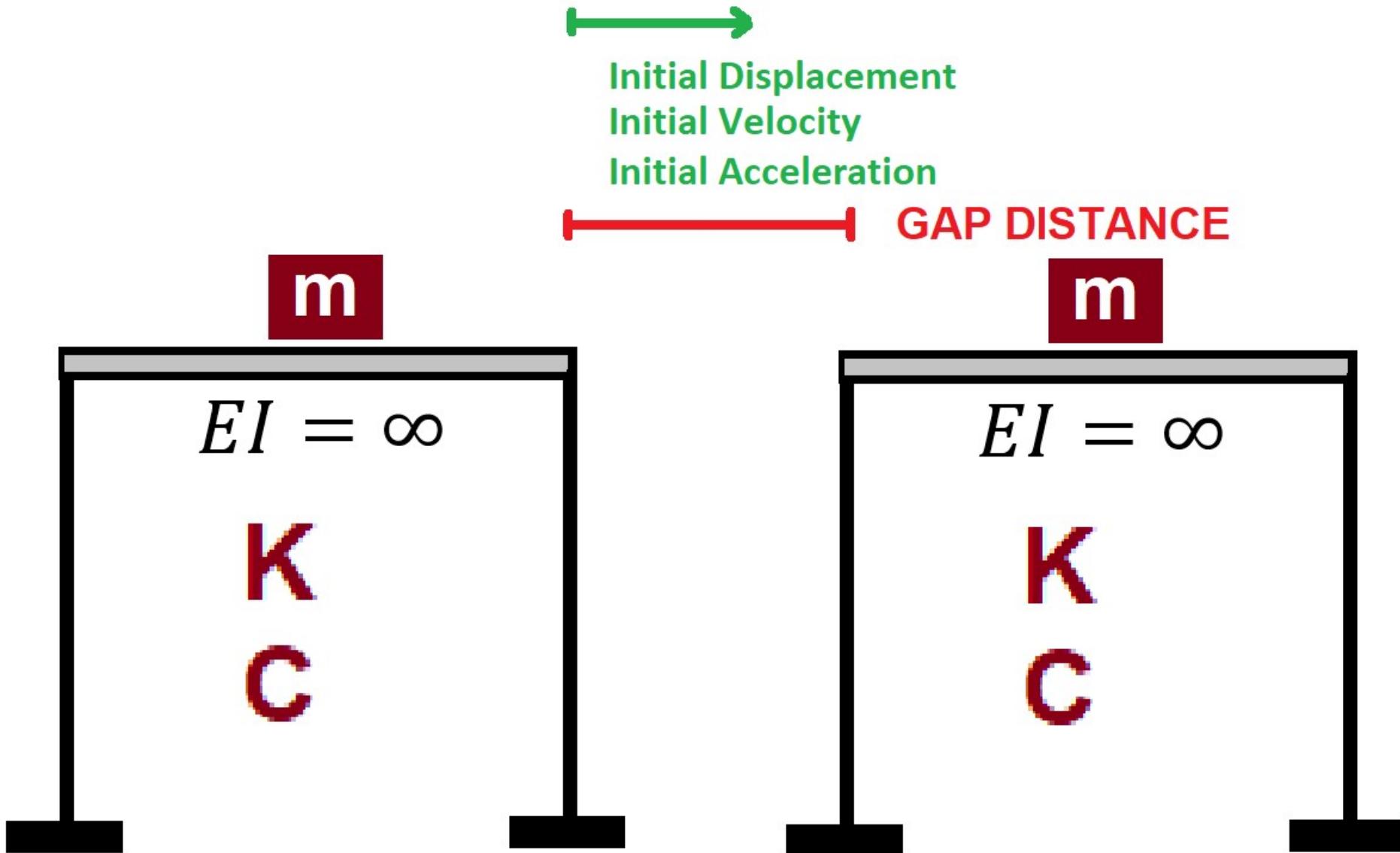


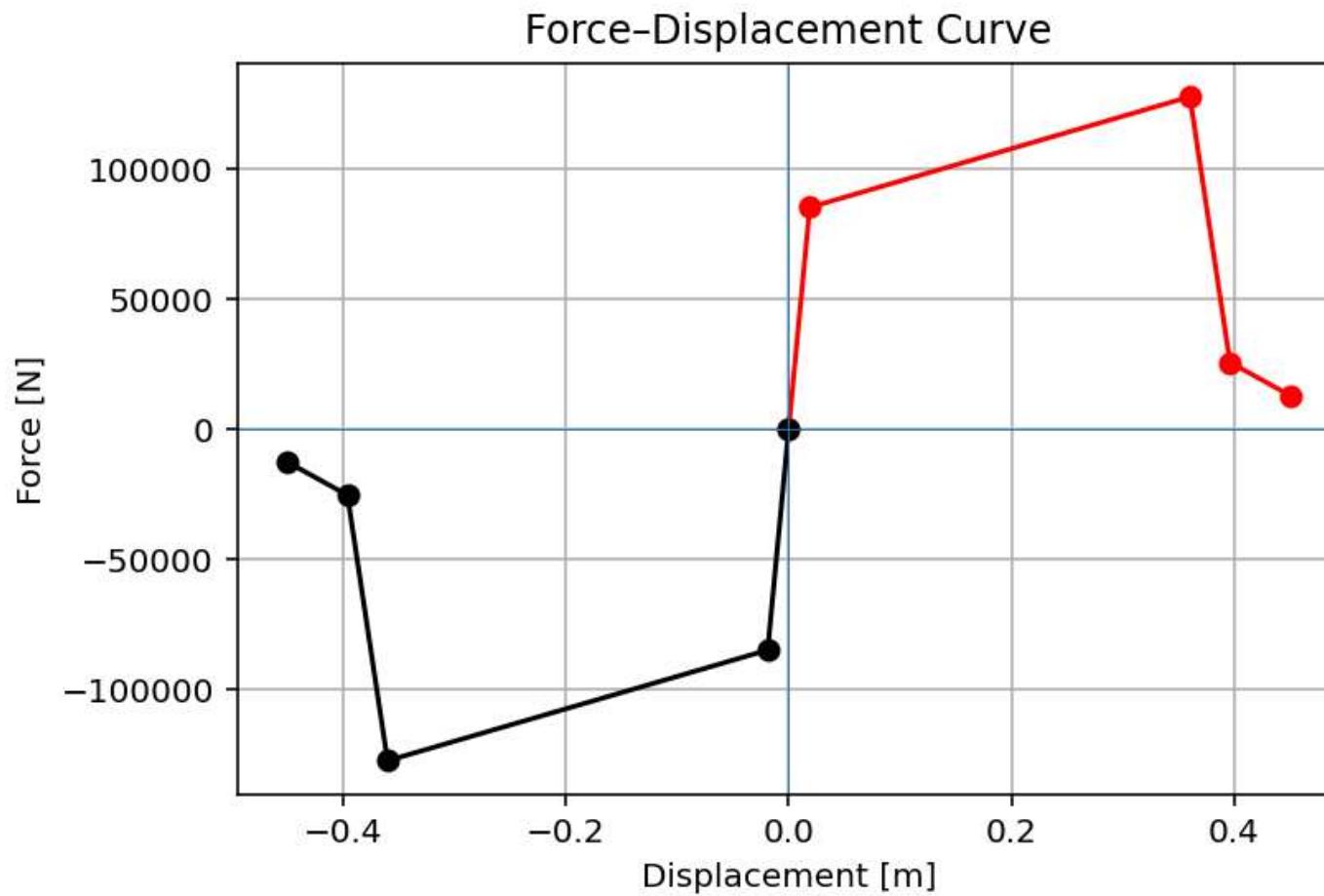
>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

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)







Spyder (Python 3.12)

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C:\Users\DELL\Desktop\OPENSEES_FILES\+CONTACT_EXA..0\CONTACT_PROBLEM_SDOF_FREE-VIBRATION_U0_VO_A0.py

CONTACT_PROBLEM_SDOF_FREE-VIBRATION_U0_VO_A0.py

```

1  #####
2  #>>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
3  #>>> SIMULATE THE FREE-VIBRATION RESPONSE OF A SINGLE-DEGREE-OF-FREEDOM (SDOF) STRUCTURE INCORPORATING
4  #>>> CONTACT/GAP MECHANISM TO MODEL STAGED STIFFNESS ACTIVATION USING OPENSEES
5  #
6  # THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
7  # EMAIL: salar.d.ghashghaei@gmail.com
8  #####
9  """
10 This script simulates the nonlinear dynamic response (Free-vibration Analysis) of a single-degree-of-freedom system with a gap mechanism. It compares elastic and inelastic behavior.
11 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.
12
13 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.
14
15 Performs free-vibration analysis of a Single Degree of Freedom (SDOF) structure using OpenSeesPy, comparing elastic and inelastic spring behavior.
16 Key features include:
17
18 1. Implements both elastic (linear) and hysteretic (nonlinear) material models for
19 structural springs.
20 2. Supports initial conditions for displacement, velocity, and acceleration.
21 3. Uses Newmark's method for time integration with Newton-Raphson iteration.
22 4. Calculates damping ratios using logarithmic decrement from response peaks.
23 5. Generates force-displacement backbone curves for inelastic material.
24 6. Tracks and plots time-history responses (displacement, velocity, acceleration, reactions).
25 7. Compares elastic vs inelastic system performance.
26 8. Includes convergence checks and analysis stability monitoring.
27
28
29
30
31
32
33
34

```

Displacement vs Base-reaction

Base-reaction [N]

Displacement [m]

ELASTIC

INELASTIC

IPython Console Files Help Variable Explorer Debugger Plots History

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

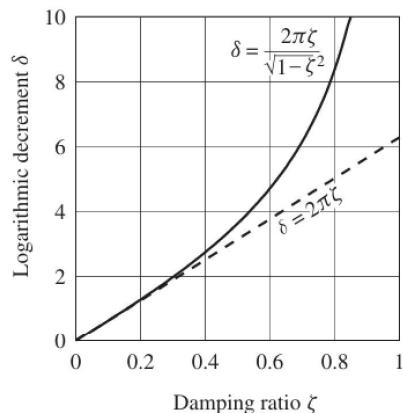
VISCOUSLY DAMPED FREE VIBRATION

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

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

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

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

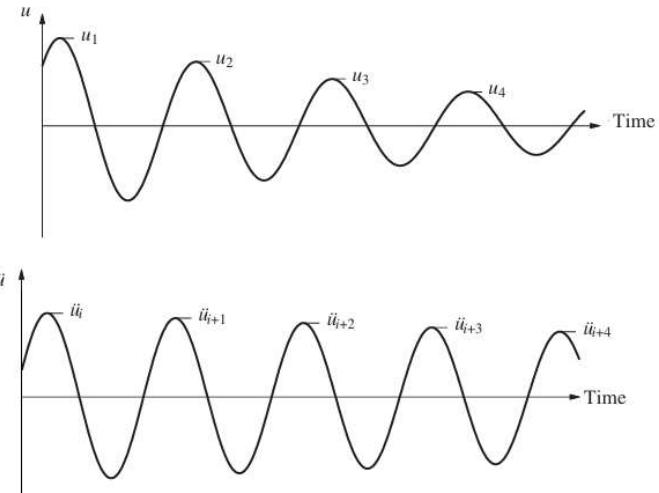


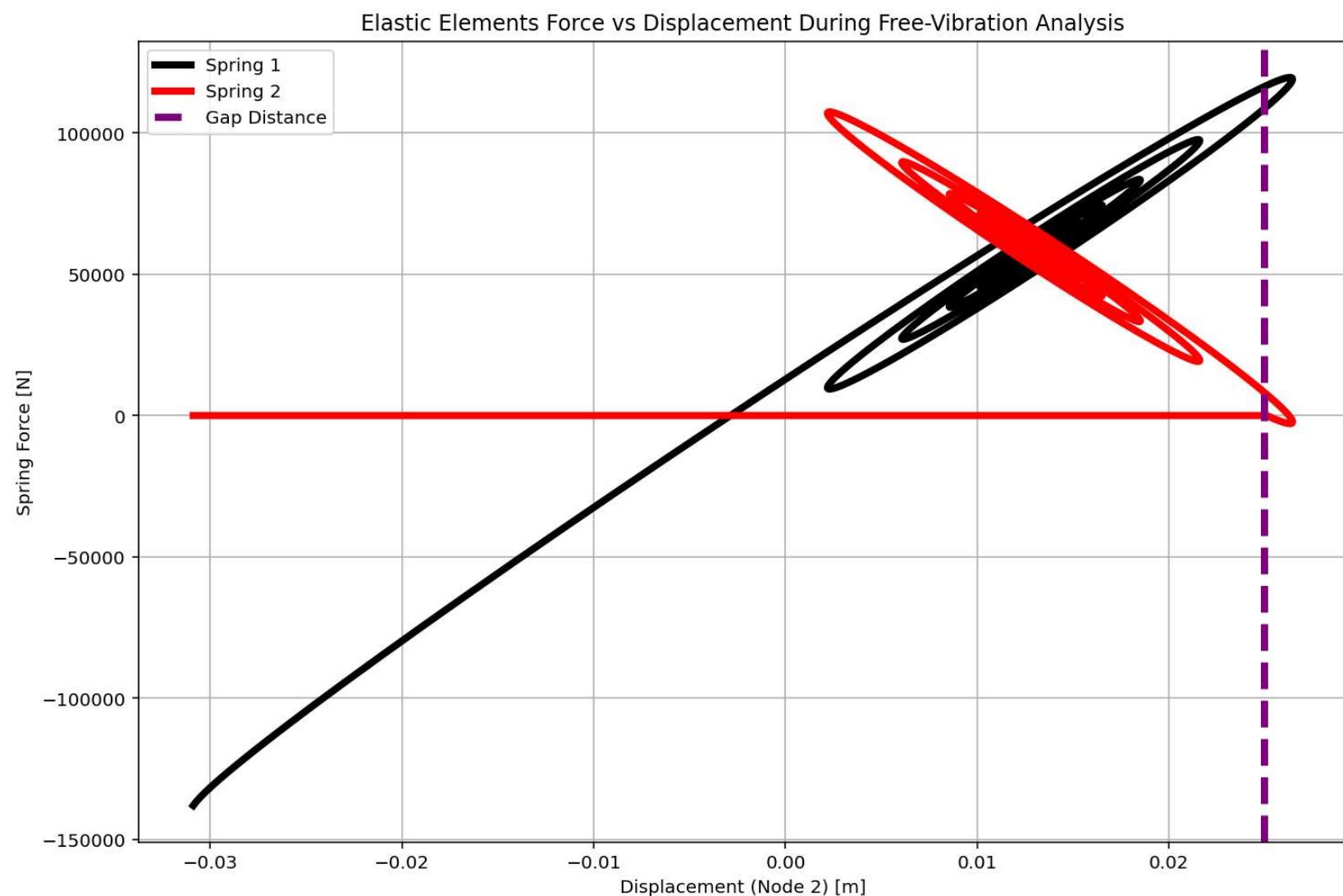
Decay of Motion

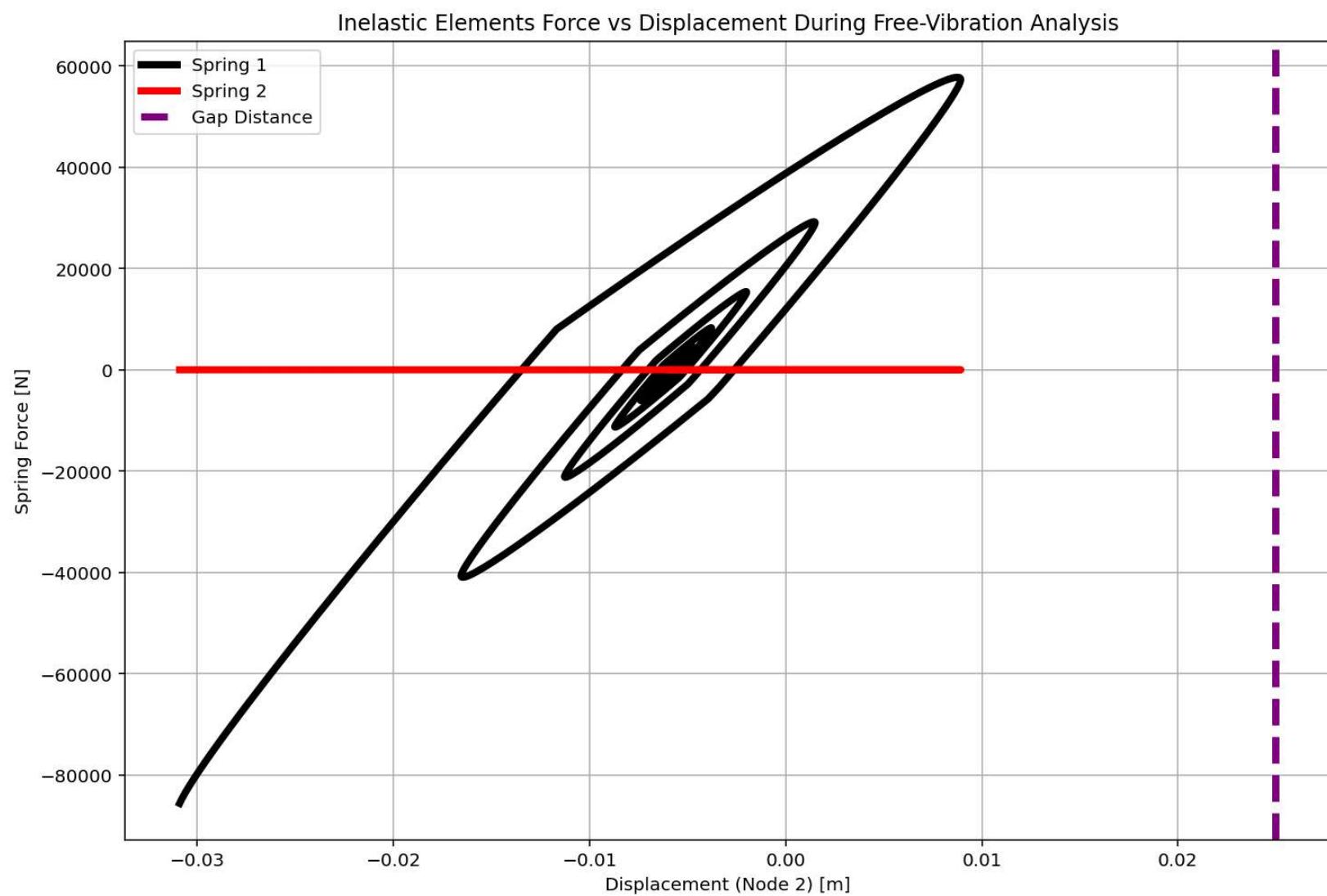
$$\delta = \ln \frac{u_i}{u_{i+1}} = 2\pi \zeta \text{ (APPROXIMATE RELATION)}$$

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

EXACT AND APPROXIMATE RELATIONS BETWEEN LOGARITHMIC DECREMENT AND DAMPING RATIO







Period of Structure vs Displacement During Free-Vibration Analysis

