FREE-VIBRATION ANALYSIS OF SDOF STRUCTURE USING OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

Initial Displacement
Initial Velocity
Initial Acceleration

K

C

M

y

z   x
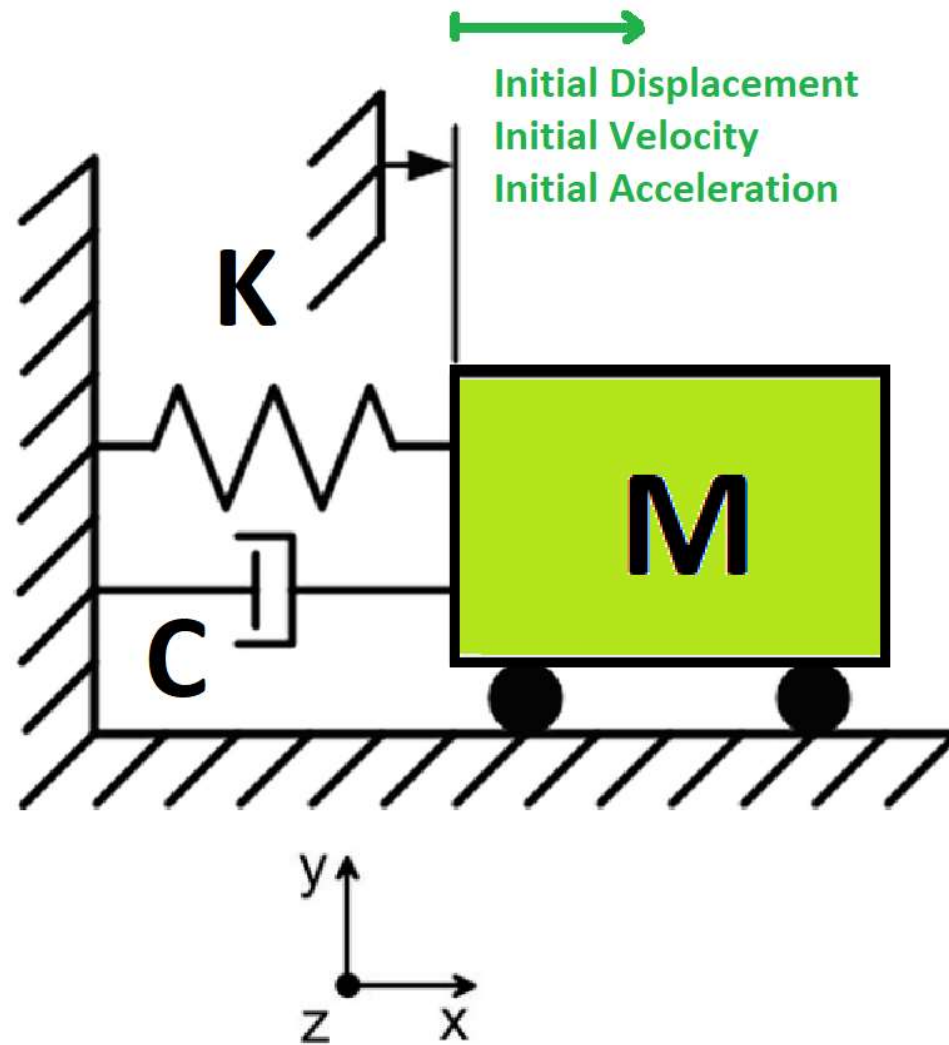
Spyder (Python 3.12)

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FREE-VIBRATION_U0_VO_A0_TWO.py ×

```python
###############################################################################
#                  >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
#                  FREE-VIBRATION ANALYSIS OF SDOF STRUCTURE USING OPENSEES
#-----------------------------------------------------------------------------
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###############################################################################
"""
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.
9. Outputs model data in JSON format for post-processing.
10. Provides theoretical validation through natural frequency calculations.

Particularly useful for earthquake engineering applications,
allowing evaluation of structural response under free vibration
 with different material nonlinearities and damping characteristics.
 The hysteretic material model captures energy dissipation
 inelastic deformation, while the elastic case serves as a reference for linear behavior.
"""
import openseespy.opensees as ops
import numpy as np
import matplotlib.pyplot as plt
import time as TI
```
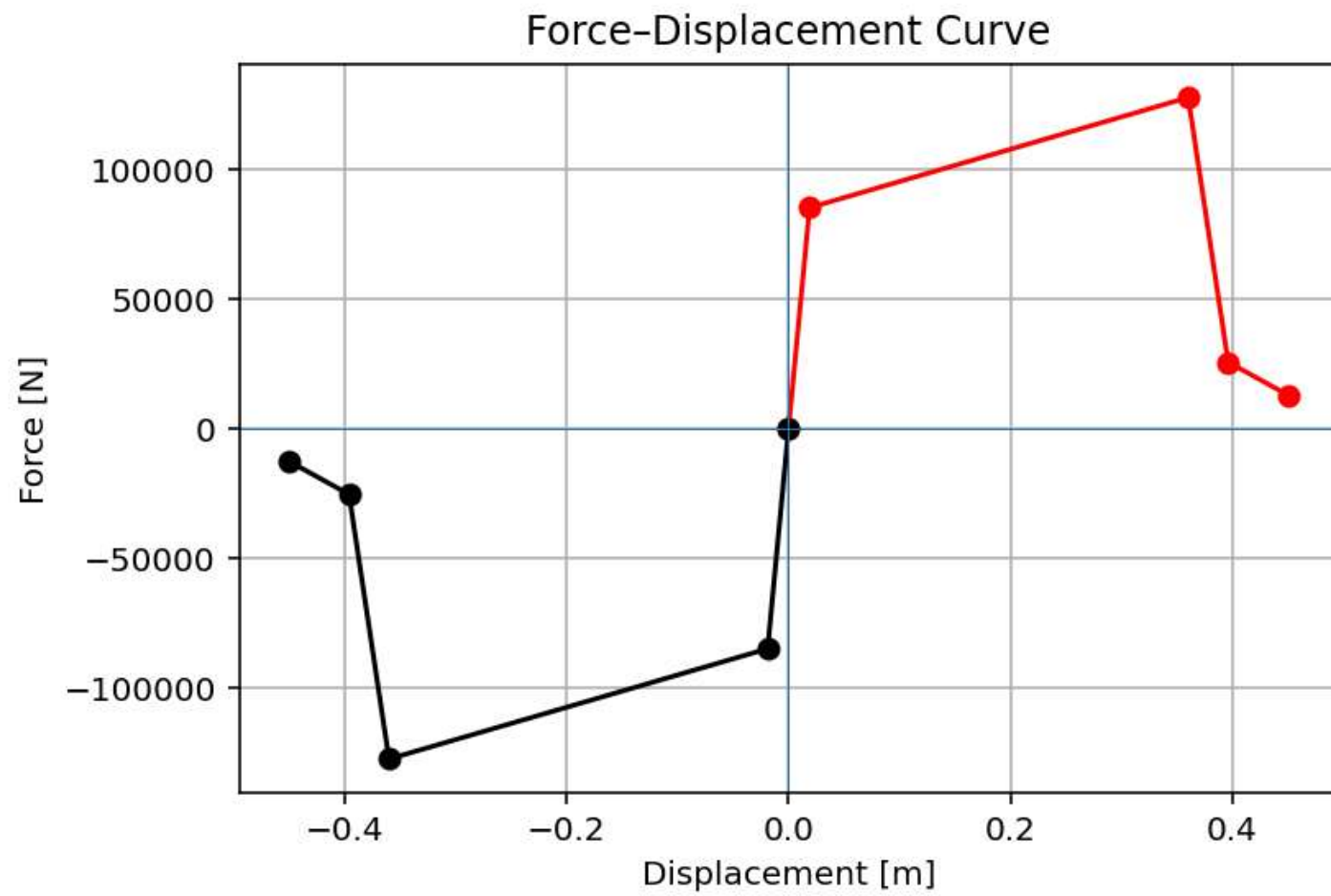
Force-Displacement Curve

IPython Console   Files   Help   Variable Explorer   Debugger   Plots   History

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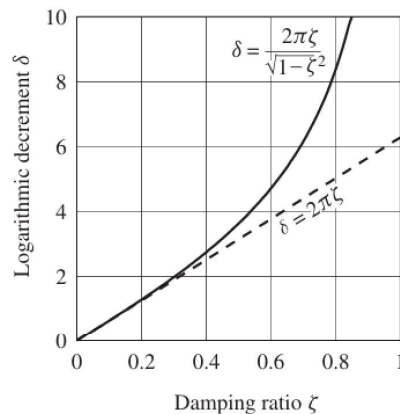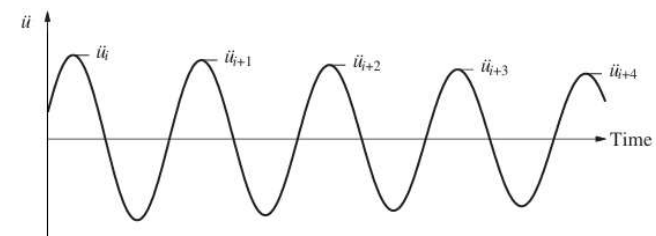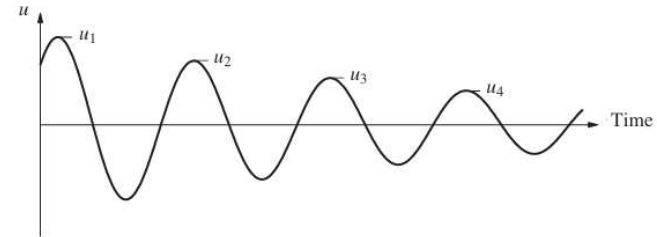
Force–Displacement Curve

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

Reaction Forces vs Time

Displacement vs Time

Velocity vs Time

Acceleration vs Time

Stiffness vs Time

Period vs Time