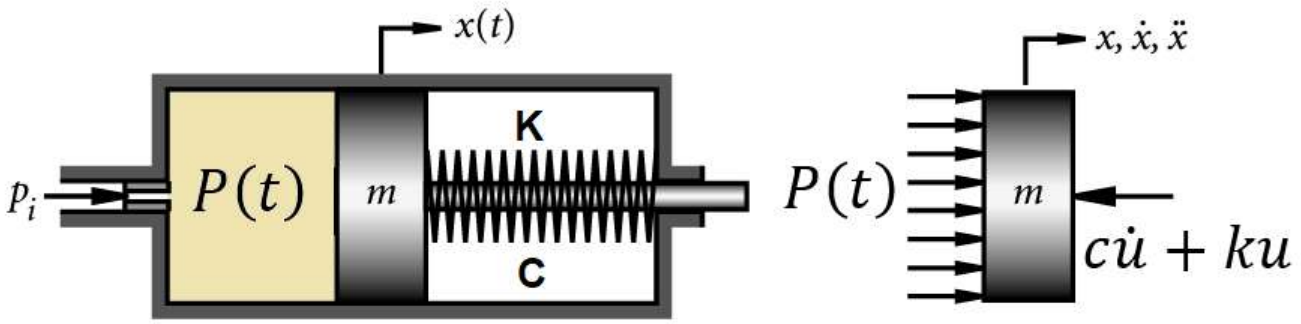
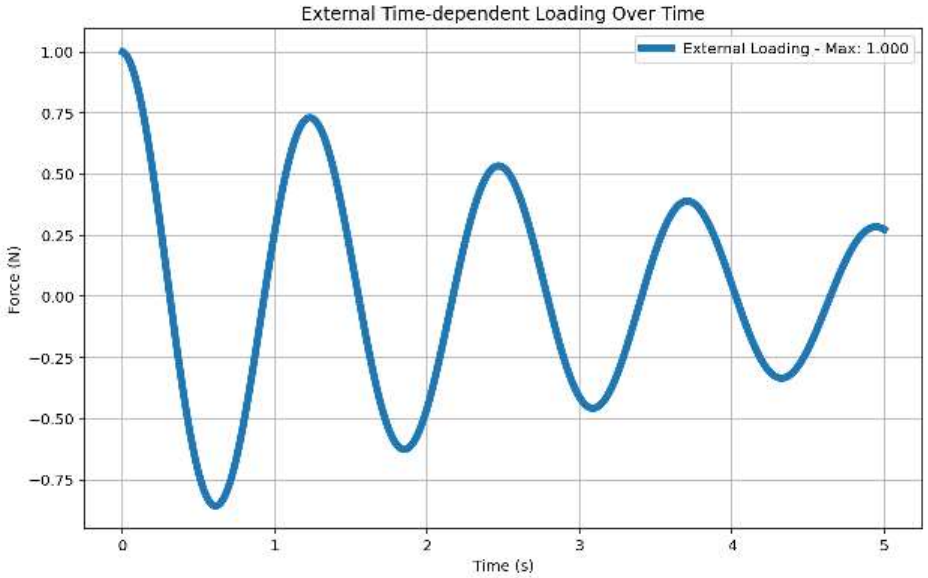
>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

MODELING OF PISTON VIBRATION SDOF STRUCTURE USING OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)





$$P(t) = P_0 e^{-0.05\bar{\omega}t} cos(\bar{\omega}t)$$

$$m\ddot{u} + c\dot{u} + ku = P(t)$$

Spyder (Python 3.12)

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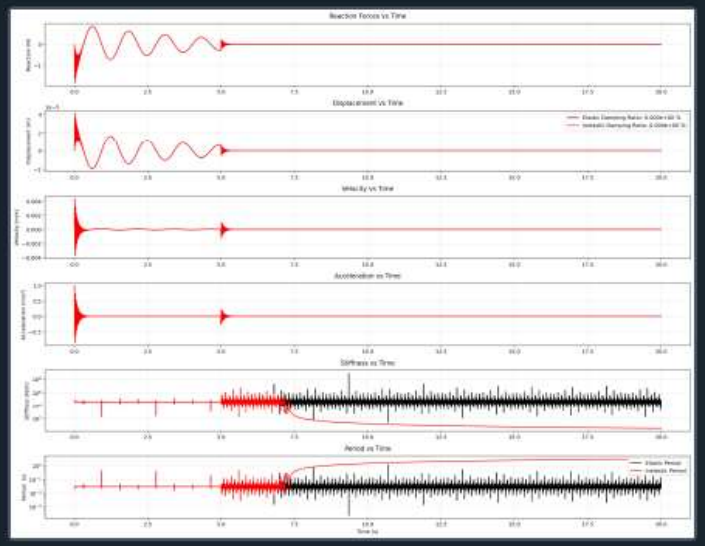
C:\Users\Dell\Desktop\OPENSEES_FILES\+SDOF_PISTON_VIBRATION

C:\Users\Dell\Desktop\OPENSEES_FILES\+SDOF_PISTON_VIBRATION\SDOF_PISTON_VIBRATION.py

SDOF_PISTON_VIBRATION.py

```
1  ##########################################################################################
2  #                          >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
3  #                             MODELING OF PISTON VIBRATION SDOF STRUCTURE USING OPENSEES
4  #                                          P(t) = P0 cos(wt)
5  #                                      P(t) = P0 exp(-0.05wt) cos(wt)
6  #----------------------------------------------------------------------------------------
7  #                      EVALUATION OF DAMPING FORCE (fD), SPRING FORCE (fS) AND INERTIA FORCE (
8  #----------------------------------------------------------------------------------------
9  #                                  THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
10 #                                       EMAIL: salar.d.ghashghaei@gmail.com
11 ##########################################################################################
12 """
13 1. This code models a single-degree-of-freedom (SDOF) piston-spring-damper system using non
14 2. The system is excited by harmonic and exponentially decaying harmonic external forces (
15 3. Both elastic and inelastic (hysteretic) material behaviors are considered for the spring
16 4. Inelastic behavior captures yielding, post-yield hardening, stiffness degradation, and e
17 5. The model is implemented in OpenSees using a zeroLength element to isolate material resp
18 6. Time integration is performed with the Newmark-β method, ensuring numerical stability fo
19 7. Displacement, velocity, and acceleration responses are recorded at every time step.
20 8. The total resisting force is decomposed into inertia, damping, and spring forces to veri
21 9. Instantaneous stiffness and natural period are continuously updated, showing period elon
22 10. The results allow advanced evaluation of nonlinear vibration behavior, damping mechanis
23 """
24 #%%-------------------------------------------------------------------------------
25 # BOOK: Differential Equations for Engineers - Wei-Chau Xie - CAMBRIDGE
26 'https://www.cambridge.org/core/books/differential-equations-for-engineers/1B8F1A62BF6F98EB
27 #%%-------------------------------------------------------------------------------
28 import openseespy.opensees as ops
29 import numpy as np
30 import matplotlib.pyplot as plt
31 import time as TI
32 import ANALYSIS_FUNCTION as S01
33 import PERIOD_FUN as S02
34 import DAMPING RATIO FUN as S05
```

17 %



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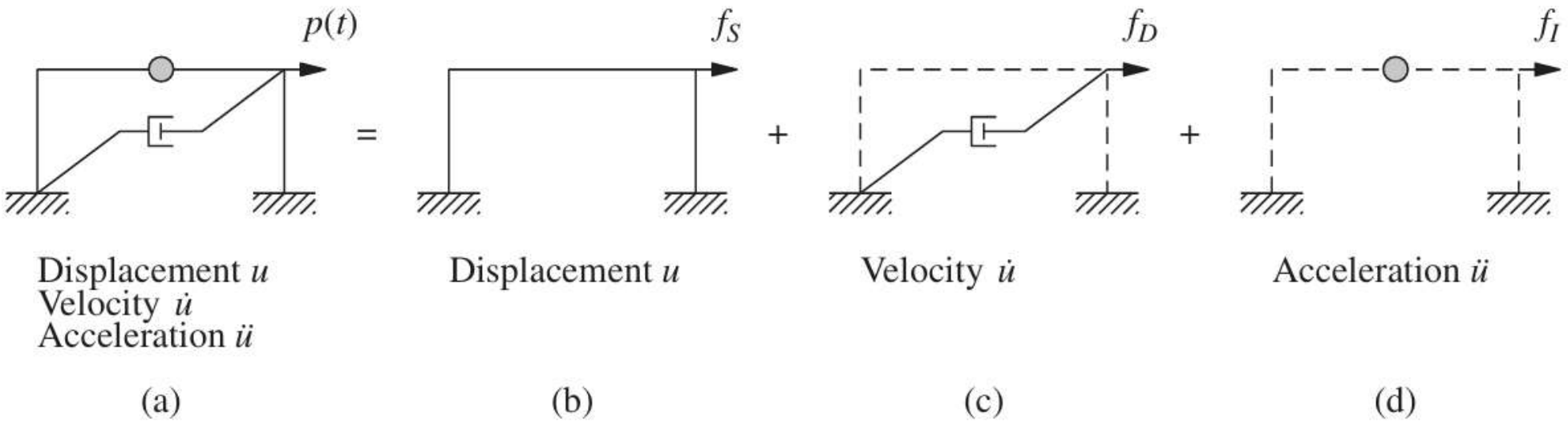
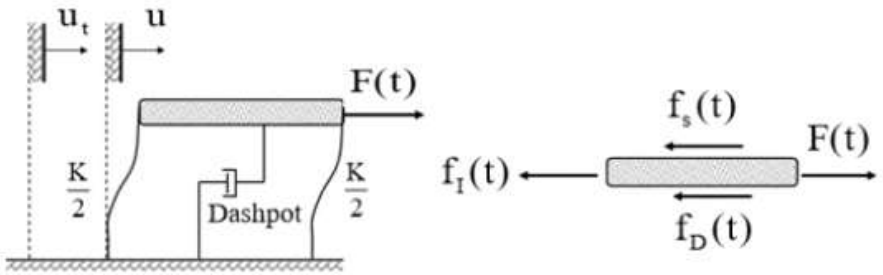
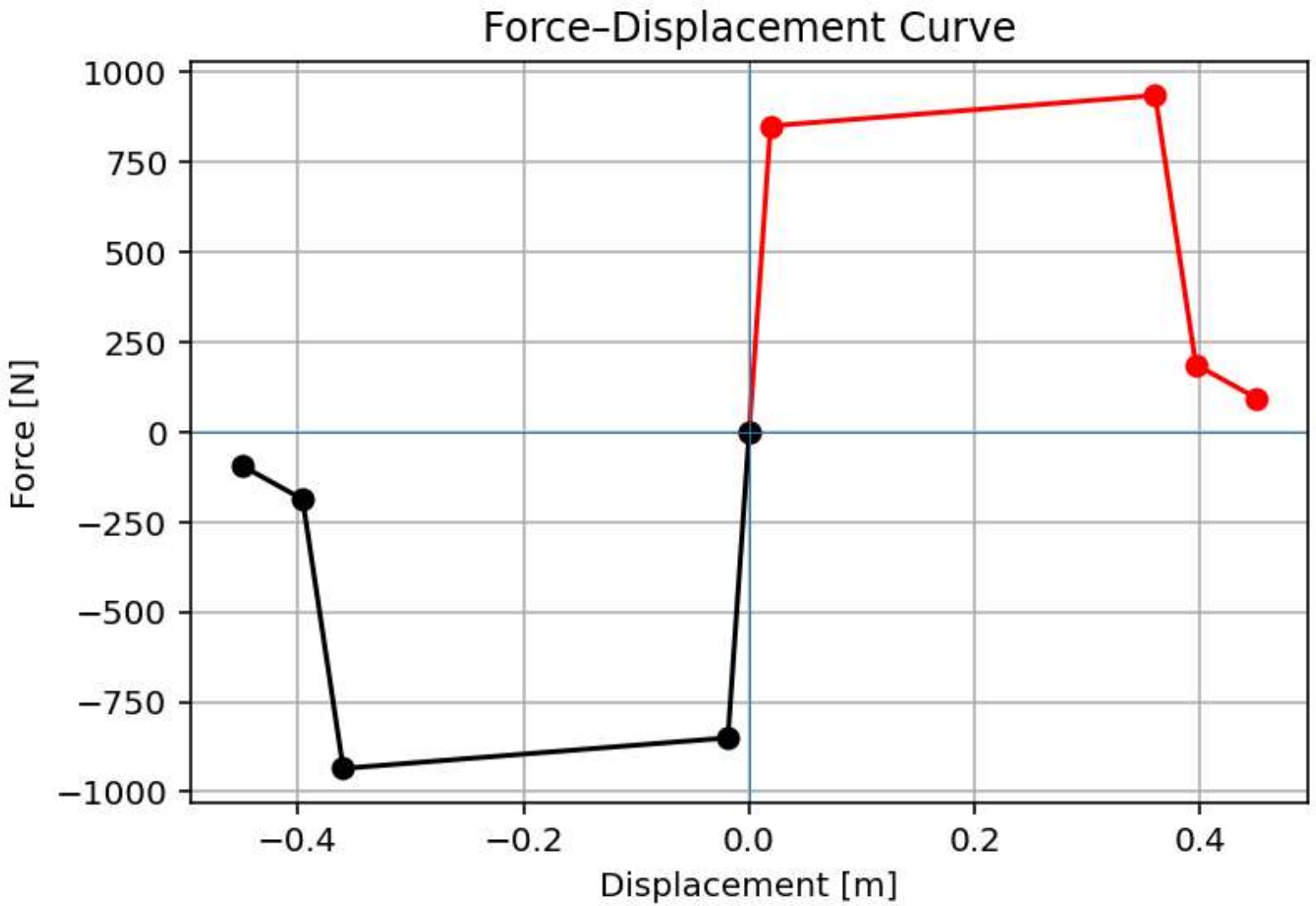
Save file

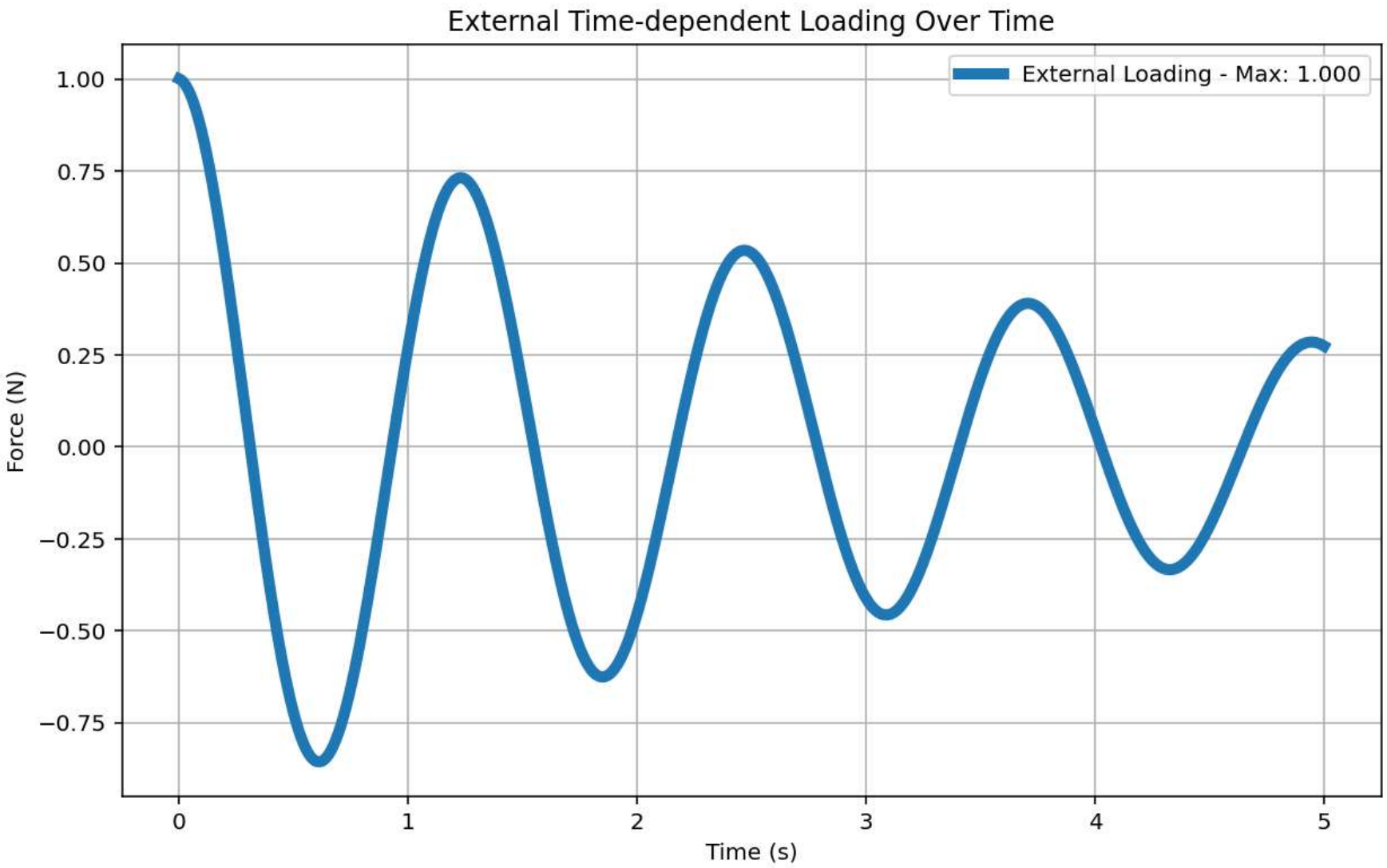
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 22, Col 119 UTF-8 CRLF RW Mem 47%

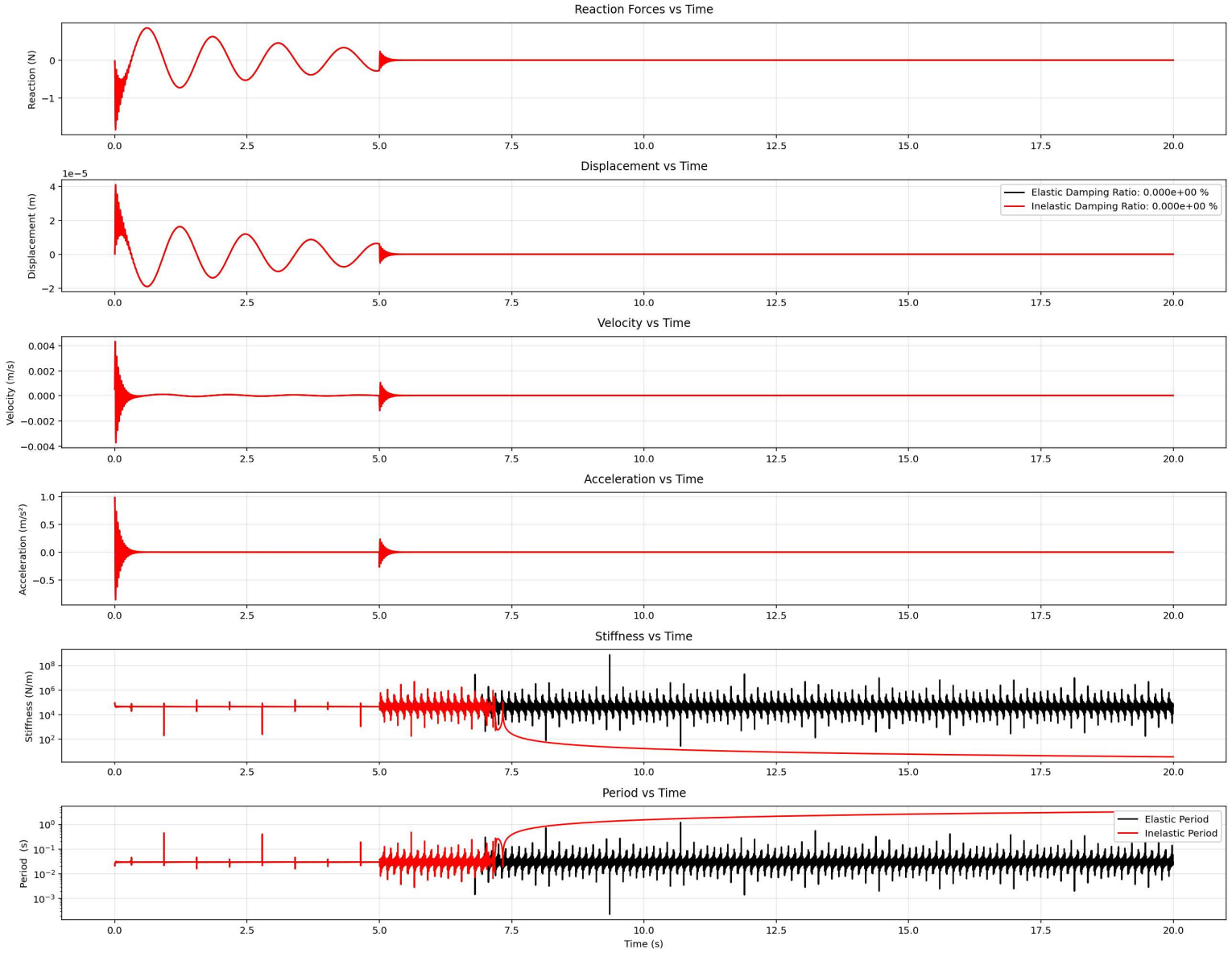


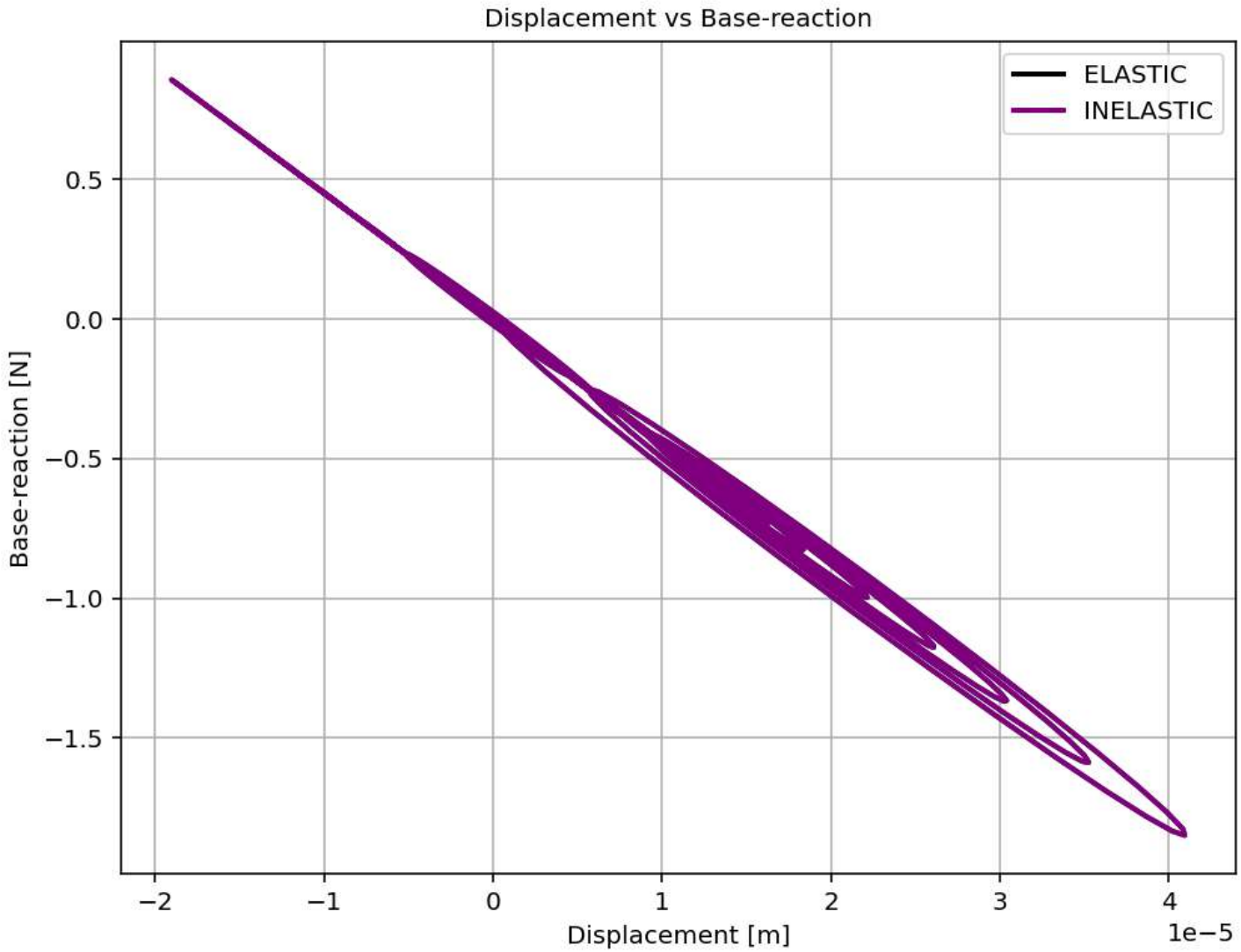
(a) System; (b) stiffness component; (c) damping component; (d) mass component.

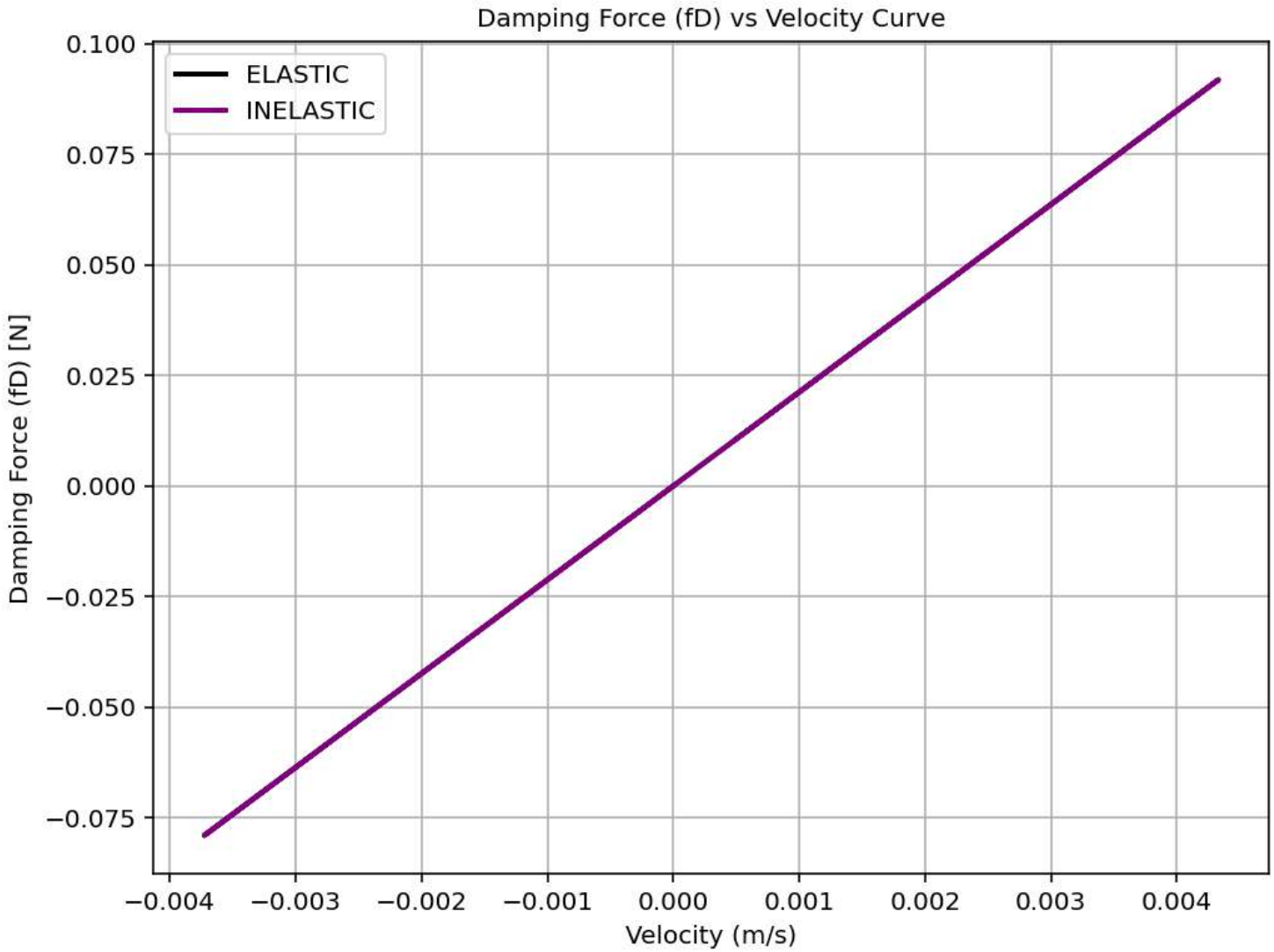


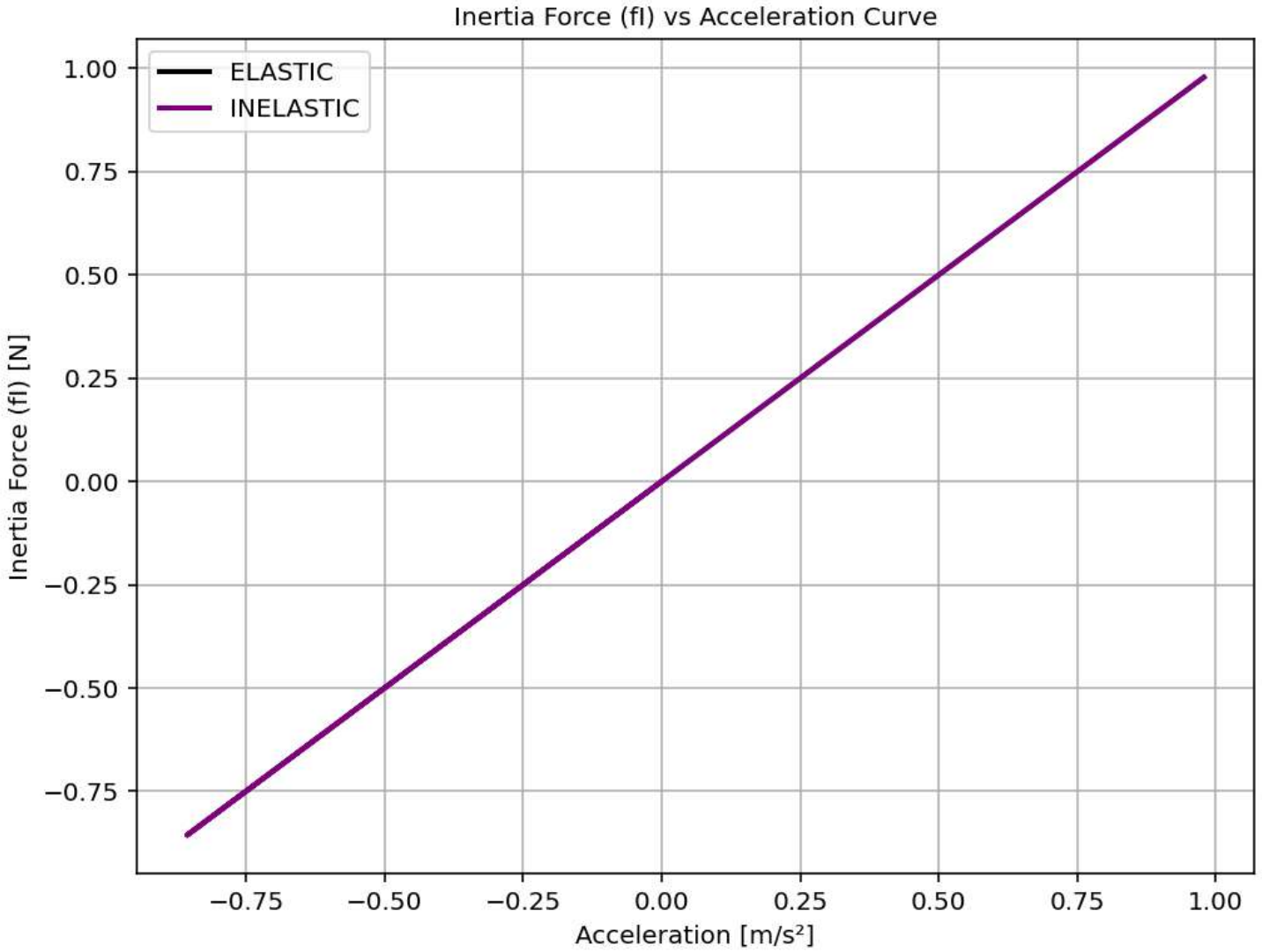

Force–Displacement Curve
1000
750
500
250
0
−250
−500
−750
−1000
Force [N]
−0.4
−0.2
0.0
0.2
0.4
Displacement [m]

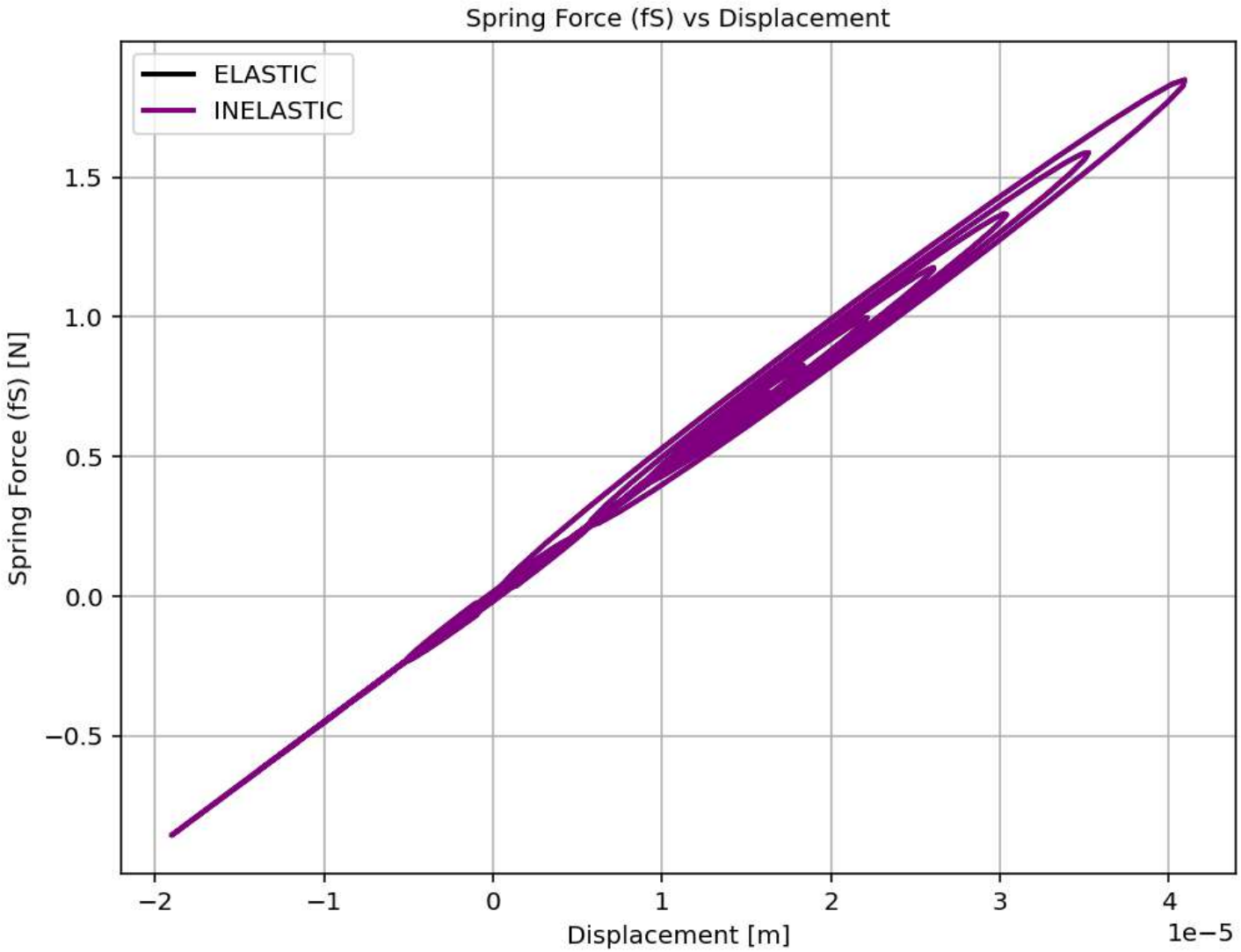

External Time-dependent Loading Over Time
External Loading - Max: 1.000
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
Force (N)
0
1
2
3
4
5
Time (s)

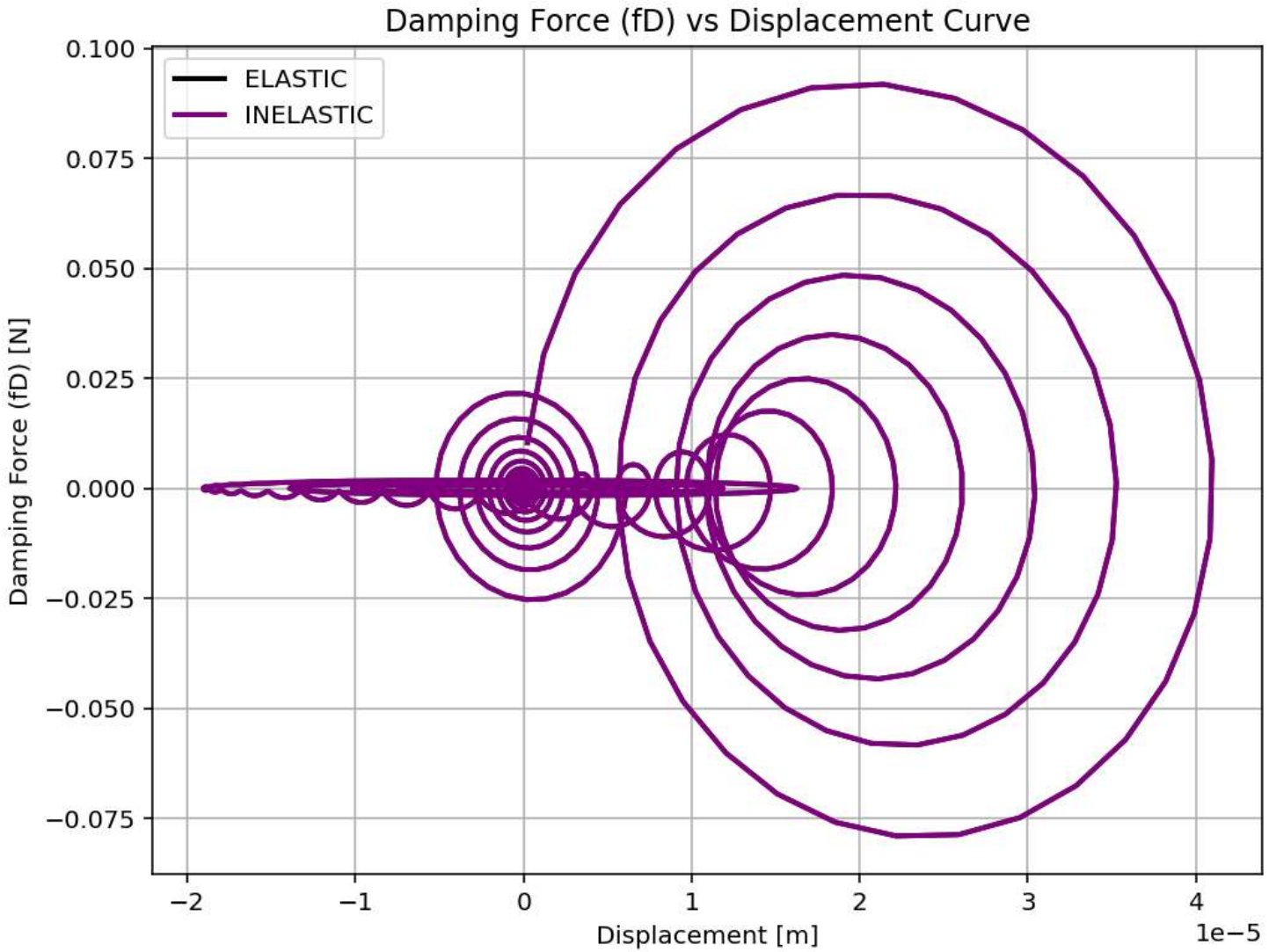

Reaction Forces vs Time
Reaction (N)
Displacement vs Time
1e−5
Displacement (m)
Elastic Damping Ratio: 0.000e+00 %
Inelastic Damping Ratio: 0.000e+00 %
Velocity vs Time
Velocity (m/s)
Acceleration vs Time
Acceleration (m/s²)
Stiffness vs Time
Stiffness (N/m)
Period vs Time
Period (s)
Elastic Period
Inelastic Period
Time (s)


Displacement vs Base-reaction
ELASTIC
INELASTIC
0.5
0.0
−0.5
−1.0
−1.5
Base-reaction [N]
−2
−1
0
1
2
3
4
1e−5
Displacement [m]


Damping Force (fD) vs Velocity Curve
ELASTIC
INELASTIC
Damping Force (fD) [N]
0.100
0.075
0.050
0.025
0.000
−0.025
−0.050
−0.075
−0.004
−0.003
−0.002
−0.001
0.000
0.001
0.002
0.003
0.004
Velocity (m/s)


Inertia Force (fI) vs Acceleration Curve
ELASTIC
INELASTIC
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
Inertia Force (fI) [N]
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
Acceleration [m/s²]


Spring Force (fS) vs Displacement
ELASTIC
INELASTIC
Spring Force (fS) [N]
1.5
1.0
0.5
0.0
−0.5
−2
−1
0
1
2
3
4
Displacement [m]
1e−5


Damping Force (fD) vs Displacement Curve
ELASTIC
INELASTIC
0.100
0.075
0.050
0.025
0.000
−0.025
−0.050
−0.075
Damping Force (fD) [N]
−2
−1
0
1
2
3
4
1e−5
Displacement [m]