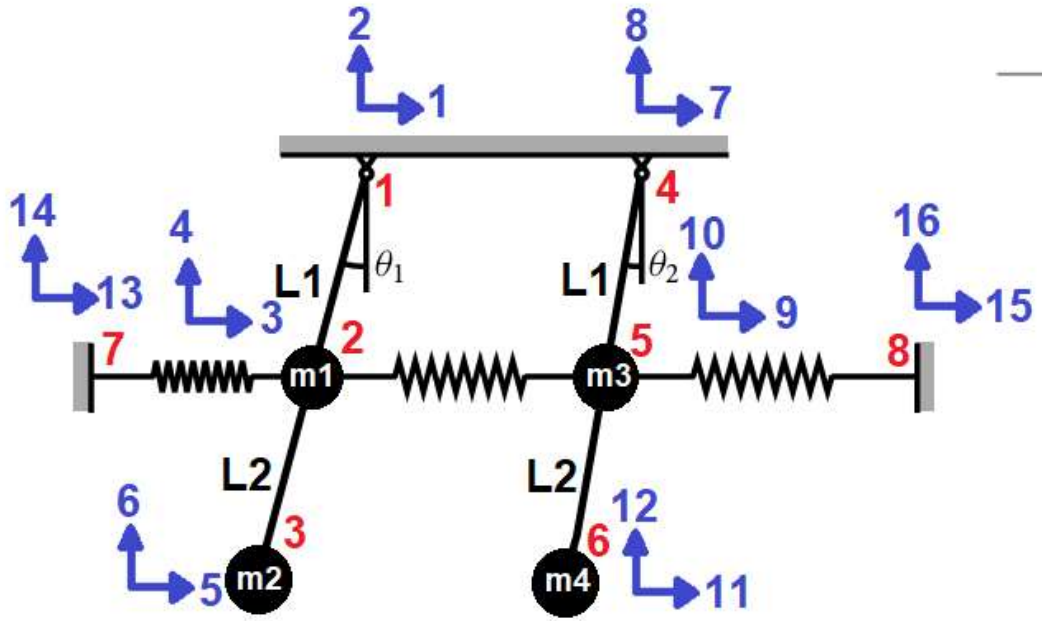
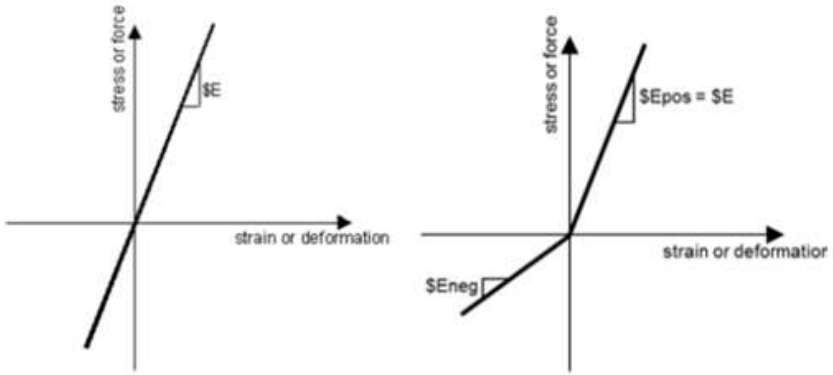
>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

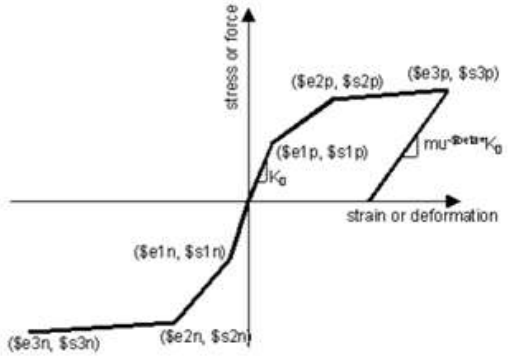
MODELING OF 2D DOUBLE PENDULUM MDOF STRUCTURE USING OPENSEES

THIS PROGRAM WRITTEN BY MICHAEL H. SCOTT AND MODIFIED BY SALAR DELAVAR GHASHGHAEI (QASHQAI)





TRUSS ELEMENT ELASTIC MATERIAL



TRUSS ELEMENT INELASTIC MATERIAL

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

C:\Users\Dell\Desktop\OPENSEES_FILES\PENDULUM\EXAMPLE_04

C:\Users\Dell\Desktop\OPENSEES_FILES\PENDULUM\EXAMPLE_04\MDOF_PENDULUM_FOUR.py

MDOF_PENDULUM_FOUR.py

```
##############################################################################################
#                          >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
#                            MODELING OF 2D DOUBLE PENDULUM MDOF STRUCTURE USING OPENSEES
#---------------------------------------------------------------------------------------------
#                     EVALUATION OF DAMPING FORCE (fD), SPRING FORCE (fS) AND INERTIA FORCE (
#---------------------------------------------------------------------------------------------
#          THIS PROGRAM WRITTEN BY MICHAEL H. SCOTT AND MODIFIED BY SALAR DELAVAR GHASHGHAEI
#                                    EMAIL: salar.d.ghashghaei@gmail.com
##############################################################################################
"""
This code performs nonlinear time history analysis of a 2D double pendulum
 (truss elements) under harmonic base excitation, comparing elastic vs inelastic
 material behavior. It computes dynamic responses (displacement, velocity, acceleration, re
 at each node, extracts time-varying period and stiffness degradation, and calculates
 damping ratios from response histories. The analysis uses corotational truss elements
 with either Elastic or Hysteretic (steel) material models, Newmark integration, and
 accounts for gravity loads and initial geometric imperfections.
 Key outputs include force-displacement hysteresis, damping force-velocity relationships,
 and period elongation due to inelastic action - essential for understanding seismic
 performance and energy dissipation in nonlinear structures.
 Very helpful Website for better learning:
 https://portwooddigital.com/2025/09/08/double-inverted-pendulum/
"""
#%%-------------------------------------------------------------------------
# WIKIPEDIA:
'https://en.wikipedia.org/wiki/Pendulum'
# YOUUBE: Simple Pendulum
'https://www.youtube.com/watch?v=fnvGVsxPuLs'
# YOUTUBE: Everything You Need To Know About Pendulums: Physics Help Room
'https://www.youtube.com/watch?v=0q0L7Fj4dk8'
# YOUTUBE: How a Giant Pendulum Made Taipei101 Possible
'https://www.youtube.com/watch?v=mGe9zjwK2gQ'
# BOOK: Differential Equations for Engineers - Wei-Chau Xie - CAMBRIDGE
'https://www.cambridge.org/core/books/differential-equations-for-engineers/1B8F1A62BF6F98EB
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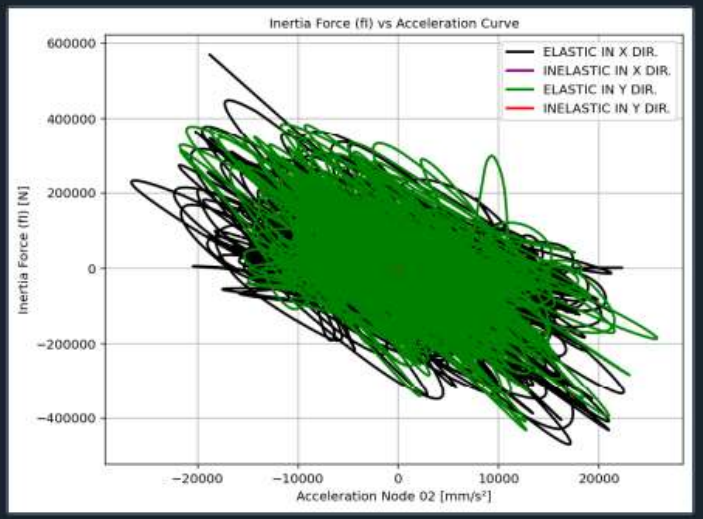
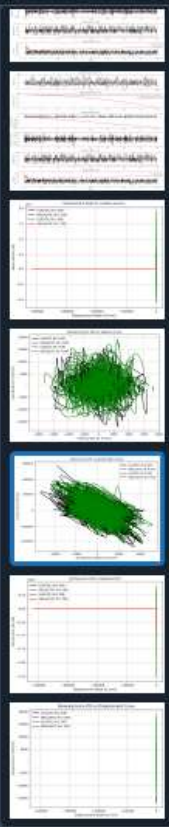
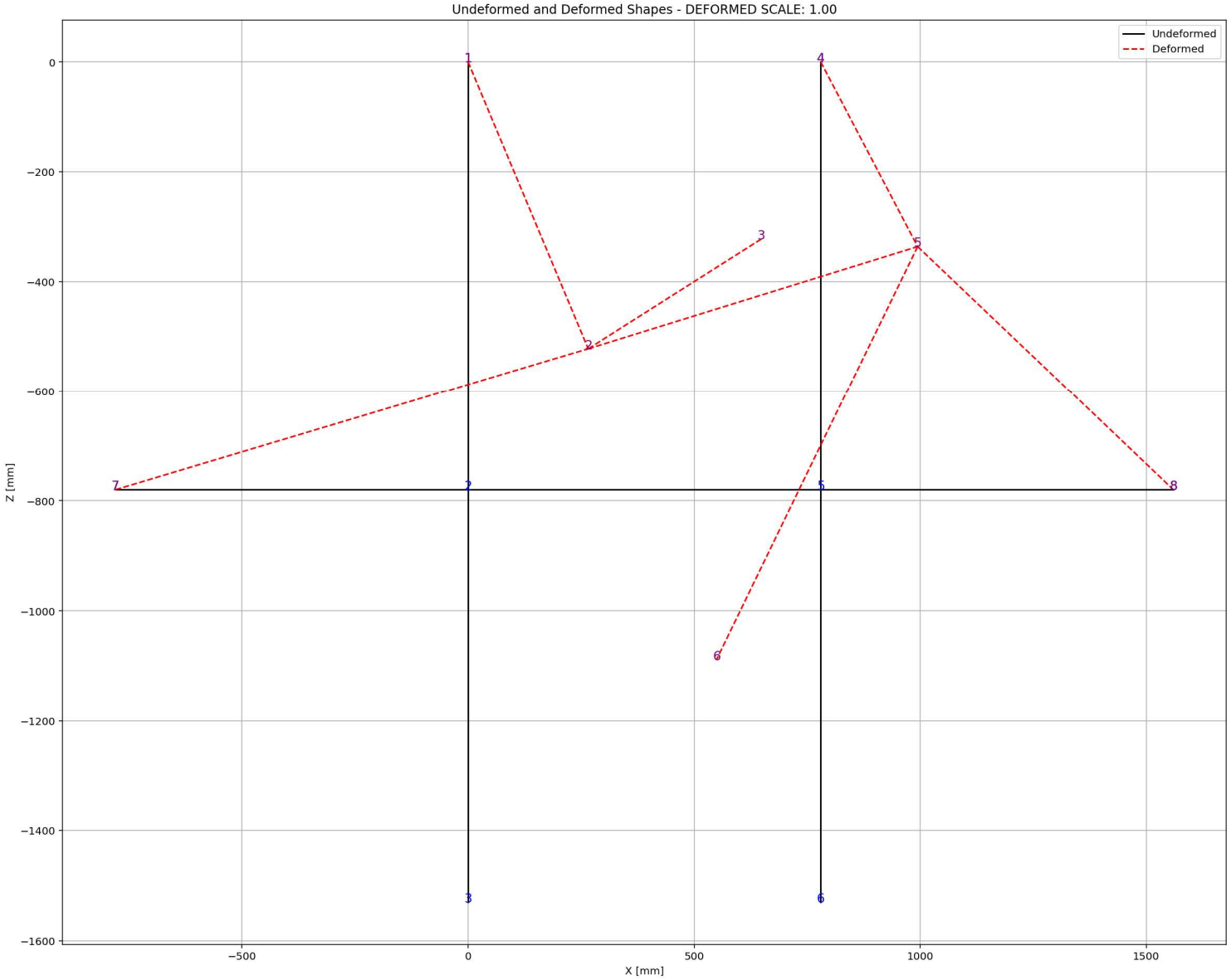
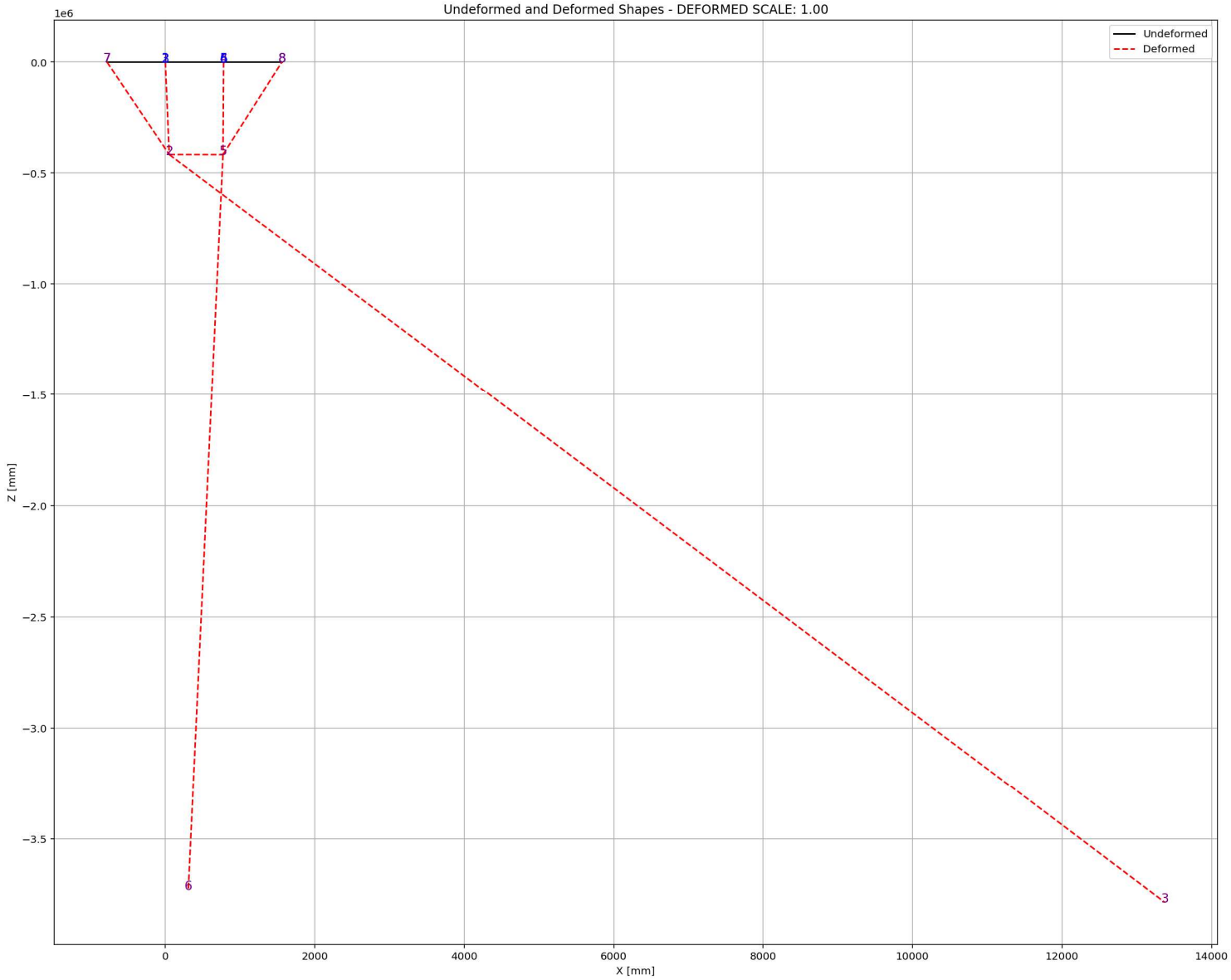




IPython Console | Files | Help | Variable Explorer | Debugger | Plots | History

Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 246, Col 55 UTF-8 CRLF RW Mem 54%


Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
−200
−400
−600
−800
−1000
−1200
−1400
−1600
−500
0
500
1000
1500
1
2
3
4
5
6
7
8


Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
1e6
Undeformed
Deformed
Z [mm]
X [mm]
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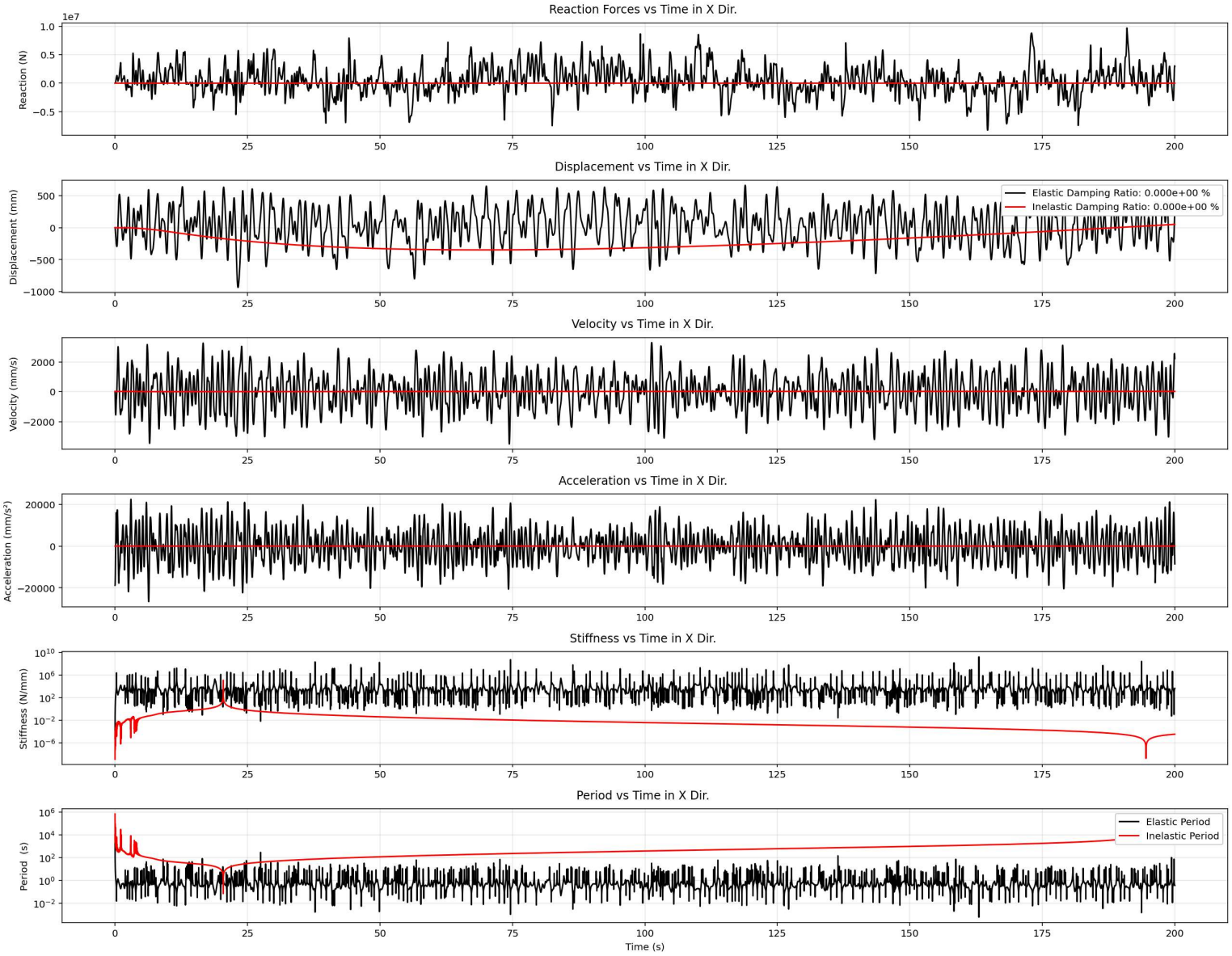
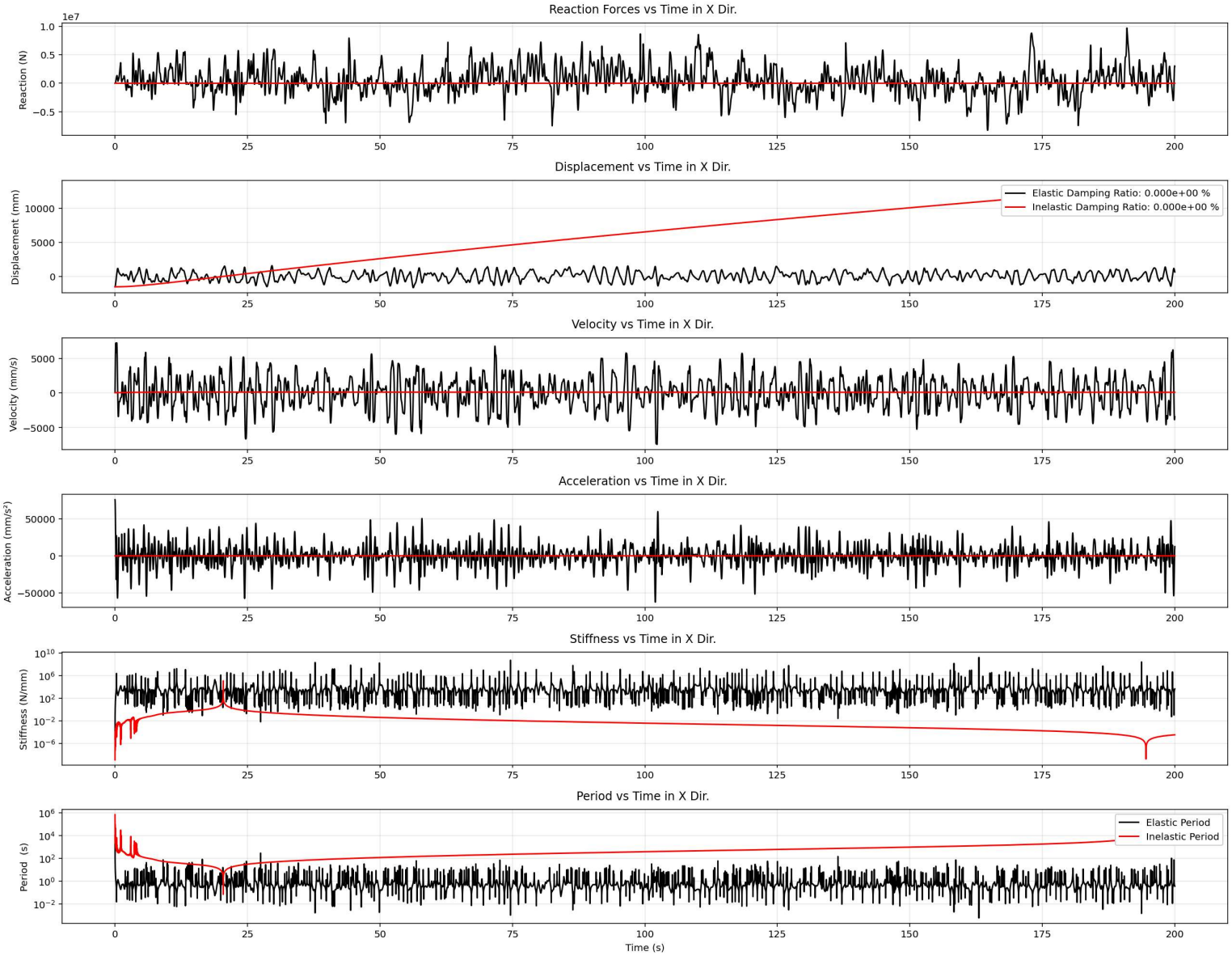
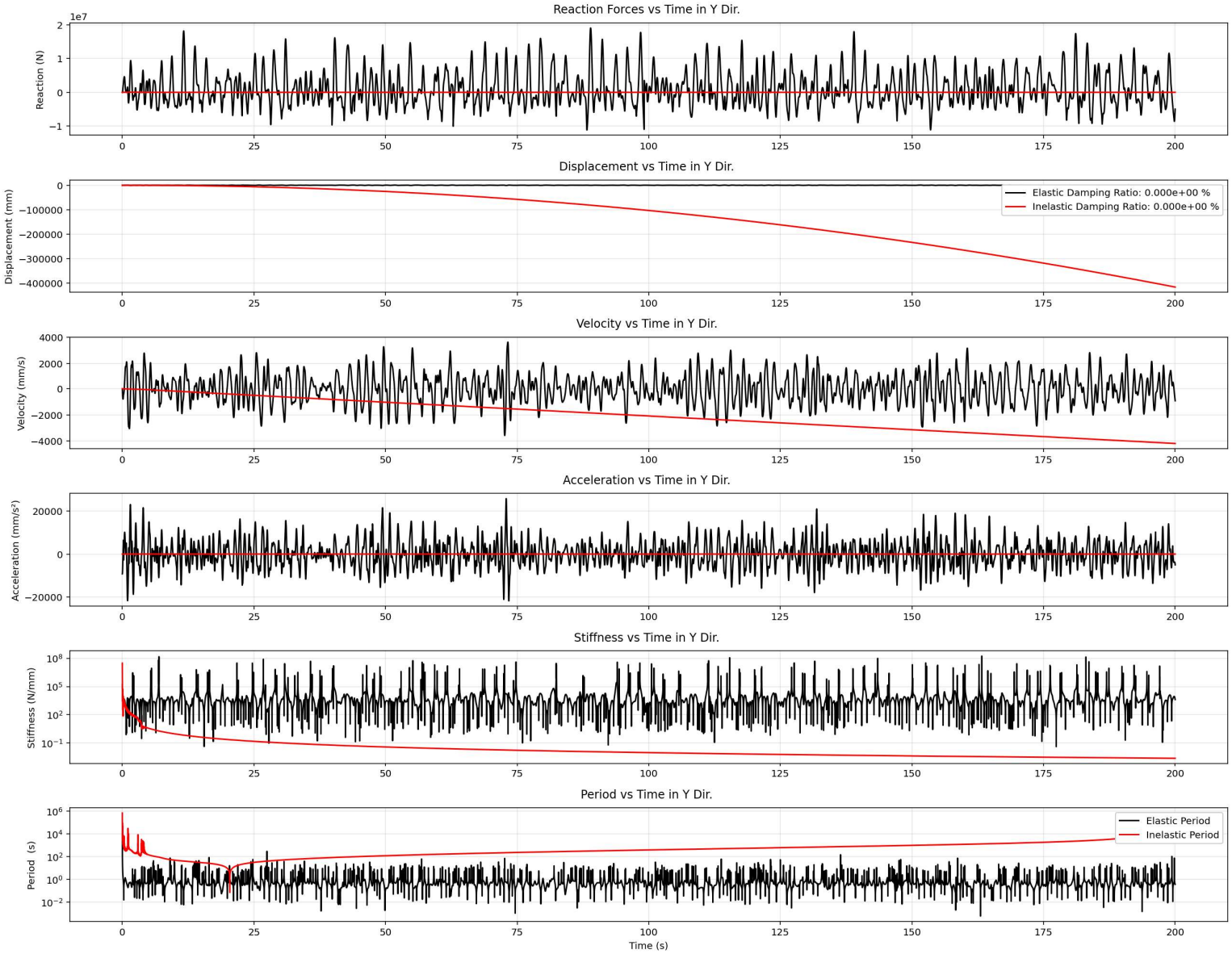
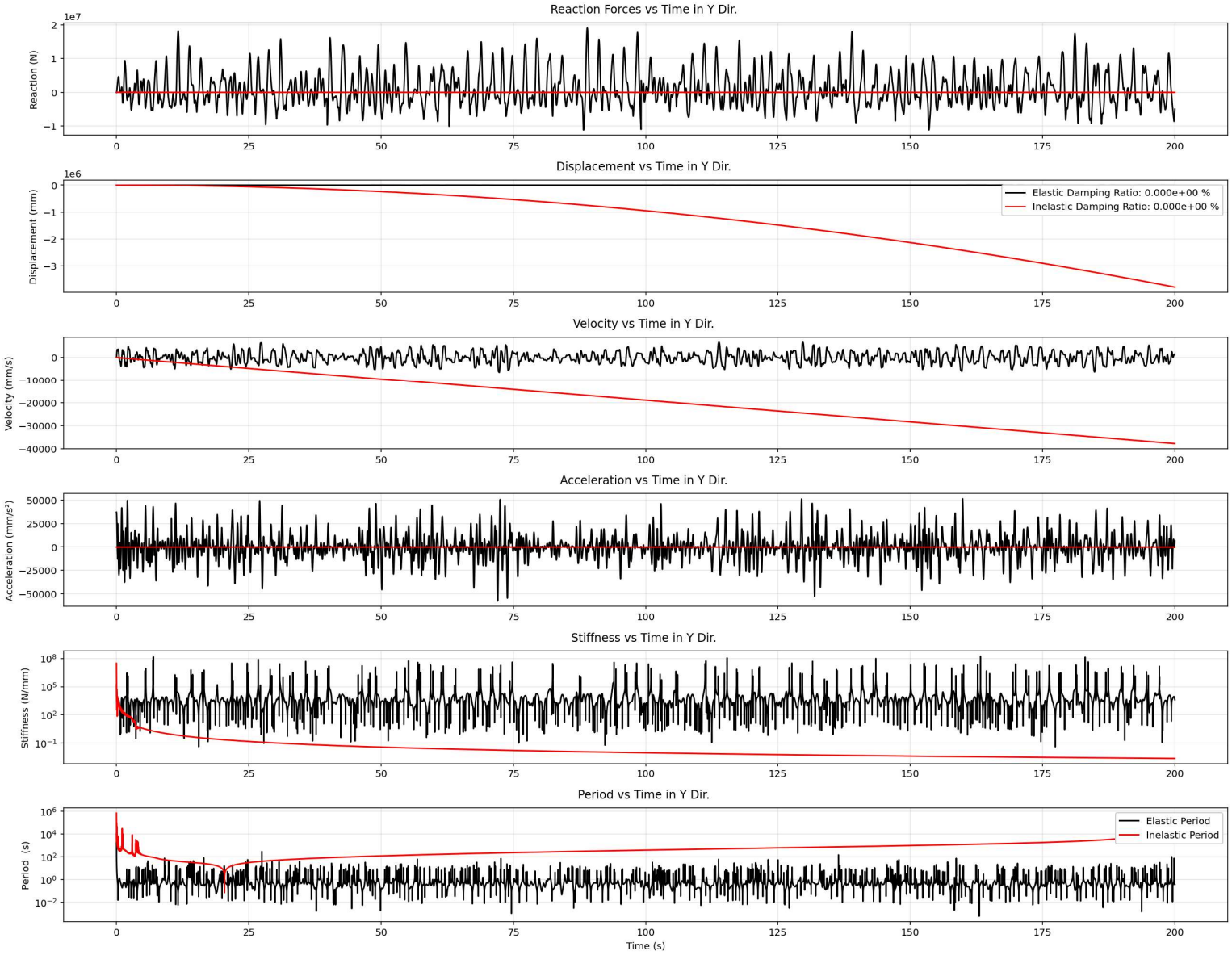
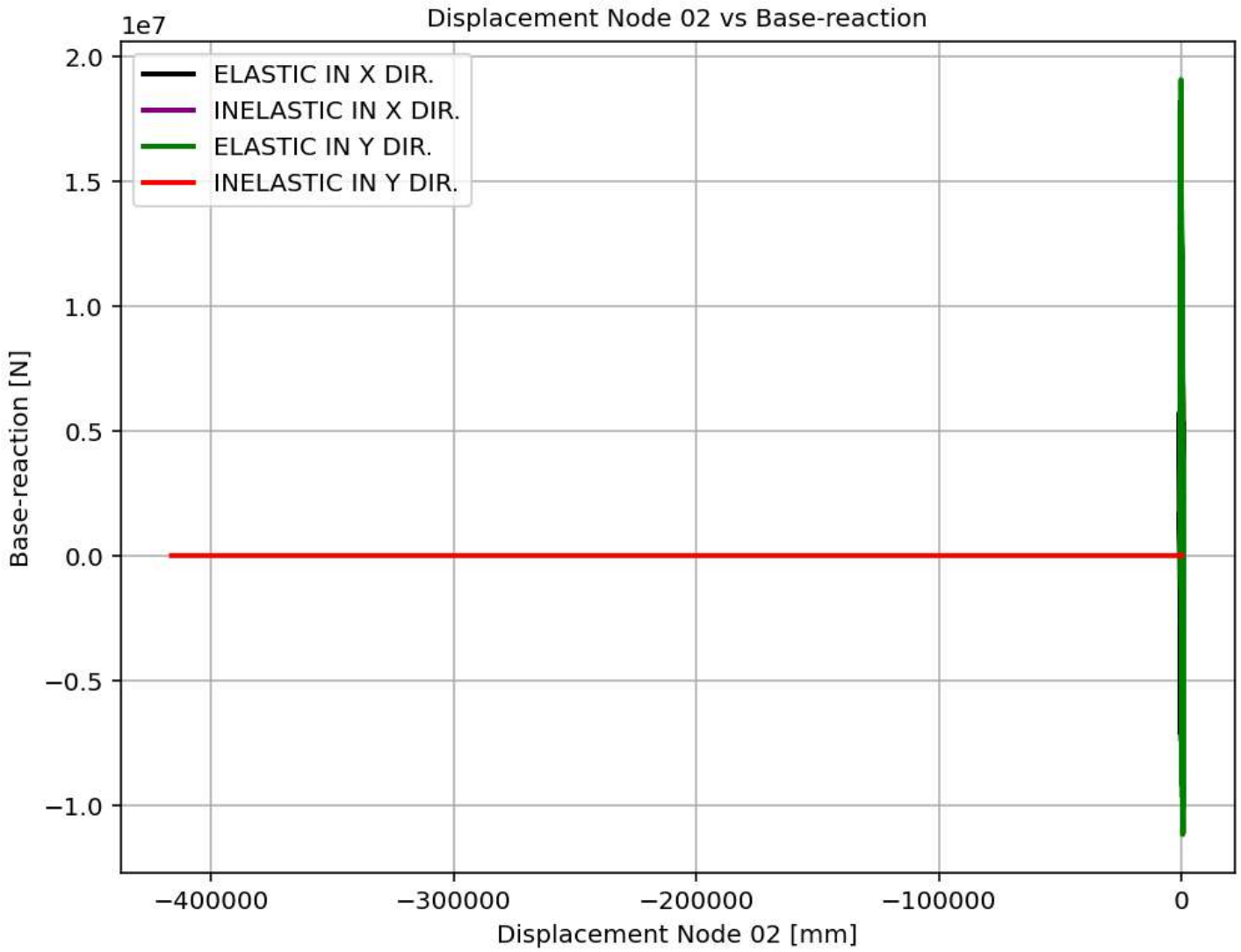
−0.5
−1.0
−1.5
−2.0
−2.5
−3.0
−3.5
0
2000
4000
6000
8000
10000
12000
14000
7
8
2
5
6
3

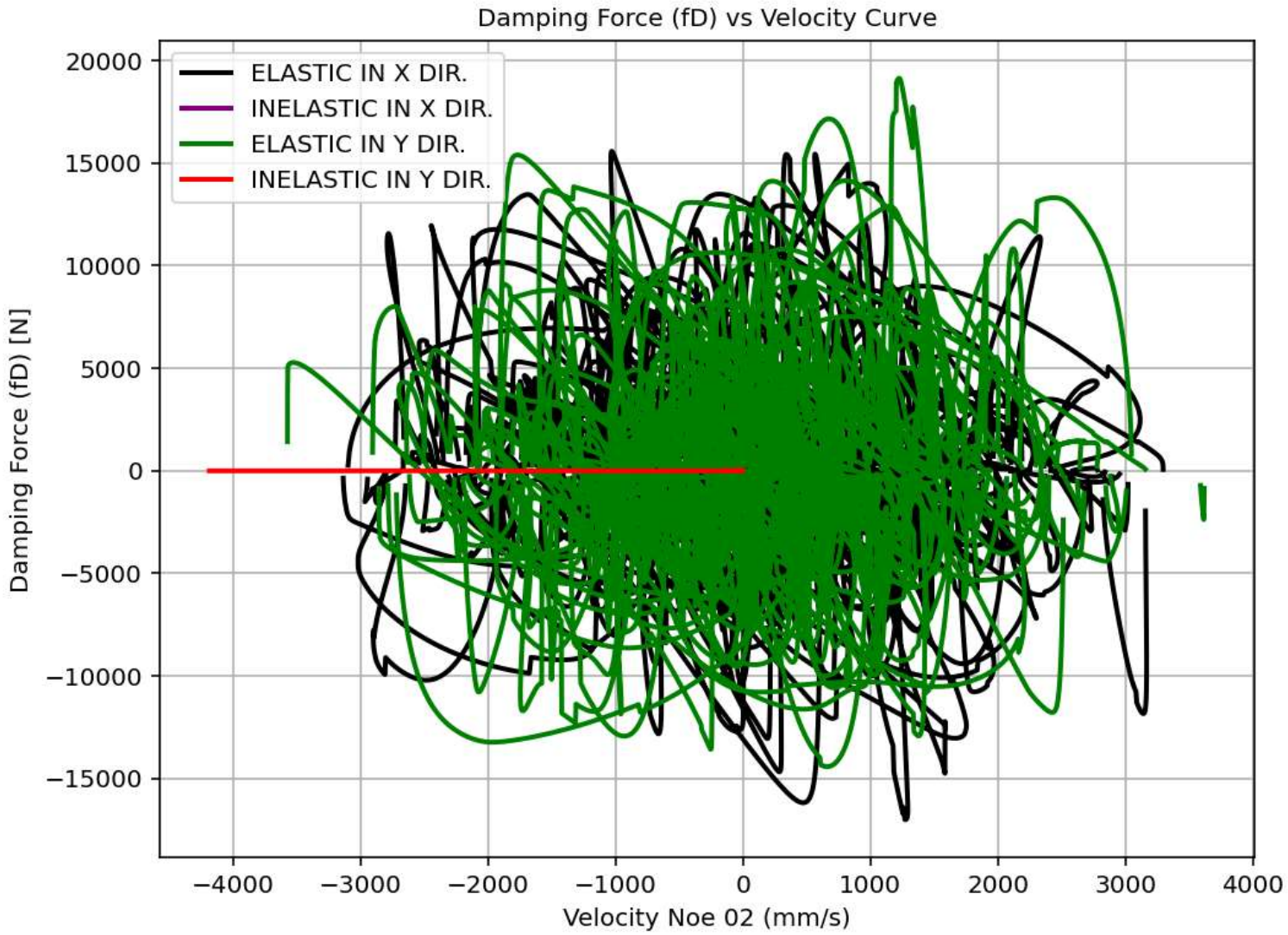

Reaction Forces vs Time in X Dir.
1e7
Reaction (N)
Displacement vs Time in X Dir.
Displacement (mm)
Elastic Damping Ratio: 0.000e+00 %
Inelastic Damping Ratio: 0.000e+00 %
Velocity vs Time in X Dir.
Velocity (mm/s)
Acceleration vs Time in X Dir.
Acceleration (mm/s²)
Stiffness vs Time in X Dir.
Stiffness (N/mm)
Period vs Time in X Dir.
Period (s)
Elastic Period
Inelastic Period
Time (s)

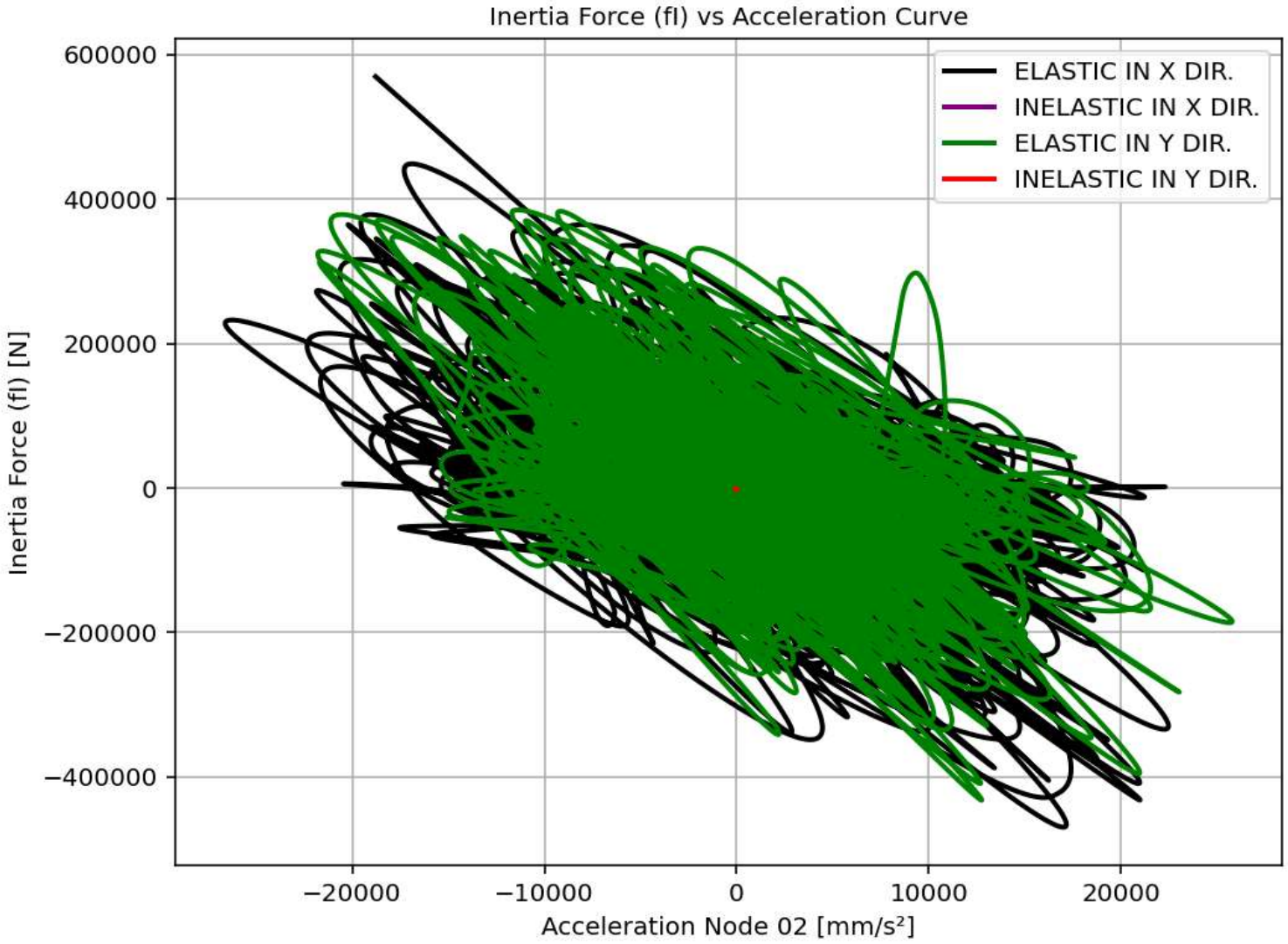

Reaction Forces vs Time in X Dir.
1e7
Reaction (N)
Displacement vs Time in X Dir.
Displacement (mm)
Elastic Damping Ratio: 0.000e+00 %
Inelastic Damping Ratio: 0.000e+00 %
Velocity vs Time in X Dir.
Velocity (mm/s)
Acceleration vs Time in X Dir.
Acceleration (mm/s²)
Stiffness vs Time in X Dir.
Stiffness (N/mm)
Period vs Time in X Dir.
Period (s)
Elastic Period
Inelastic Period
Time (s)

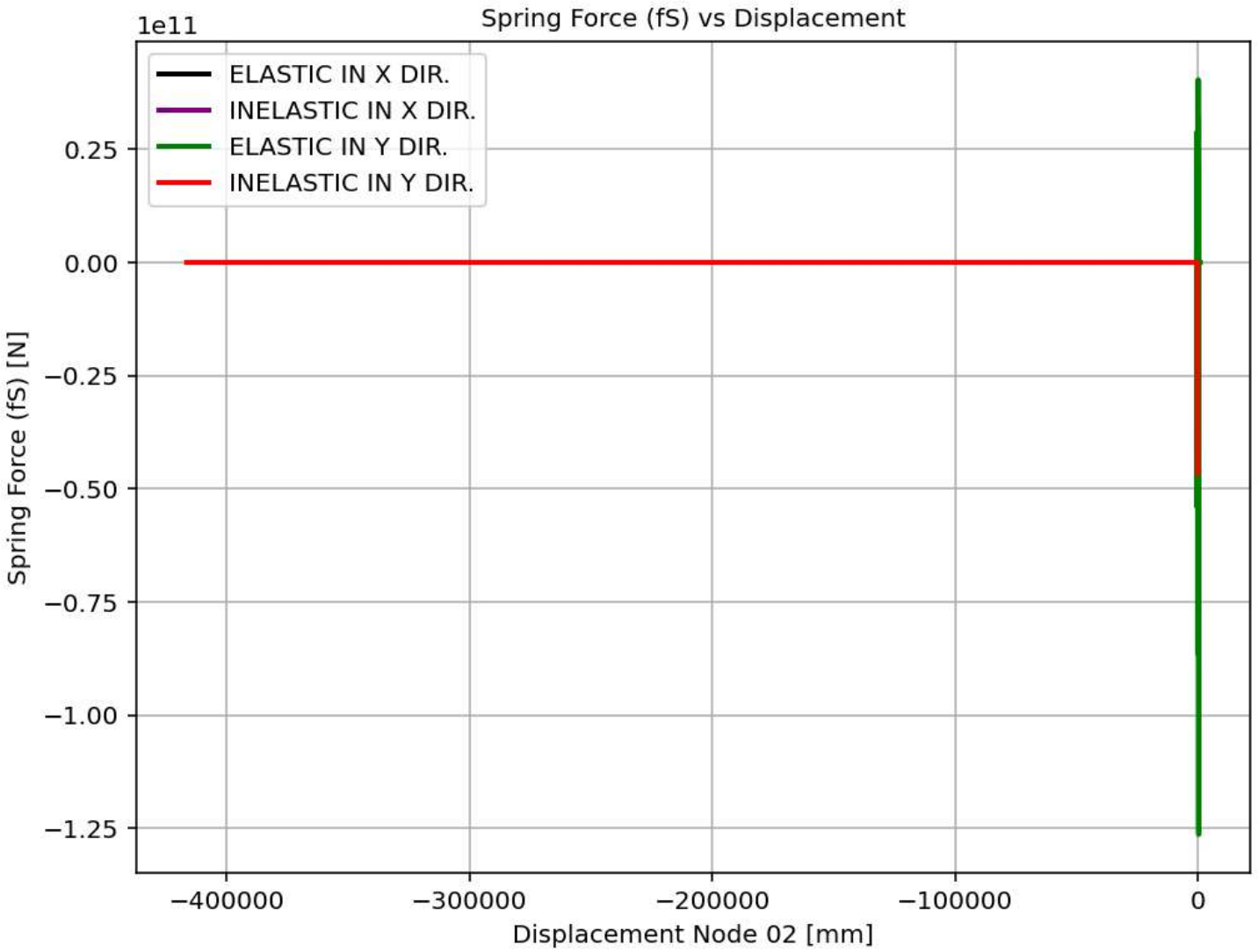

Reaction Forces vs Time in Y Dir.
1e7
Reaction (N)
Displacement vs Time in Y Dir.
Displacement (mm)
Elastic Damping Ratio: 0.000e+00 %
Inelastic Damping Ratio: 0.000e+00 %
Velocity vs Time in Y Dir.
Velocity (mm/s)
Acceleration vs Time in Y Dir.
Acceleration (mm/s²)
Stiffness vs Time in Y Dir.
Stiffness (N/mm)
Period vs Time in Y Dir.
Period (s)
Elastic Period
Inelastic Period
Time (s)

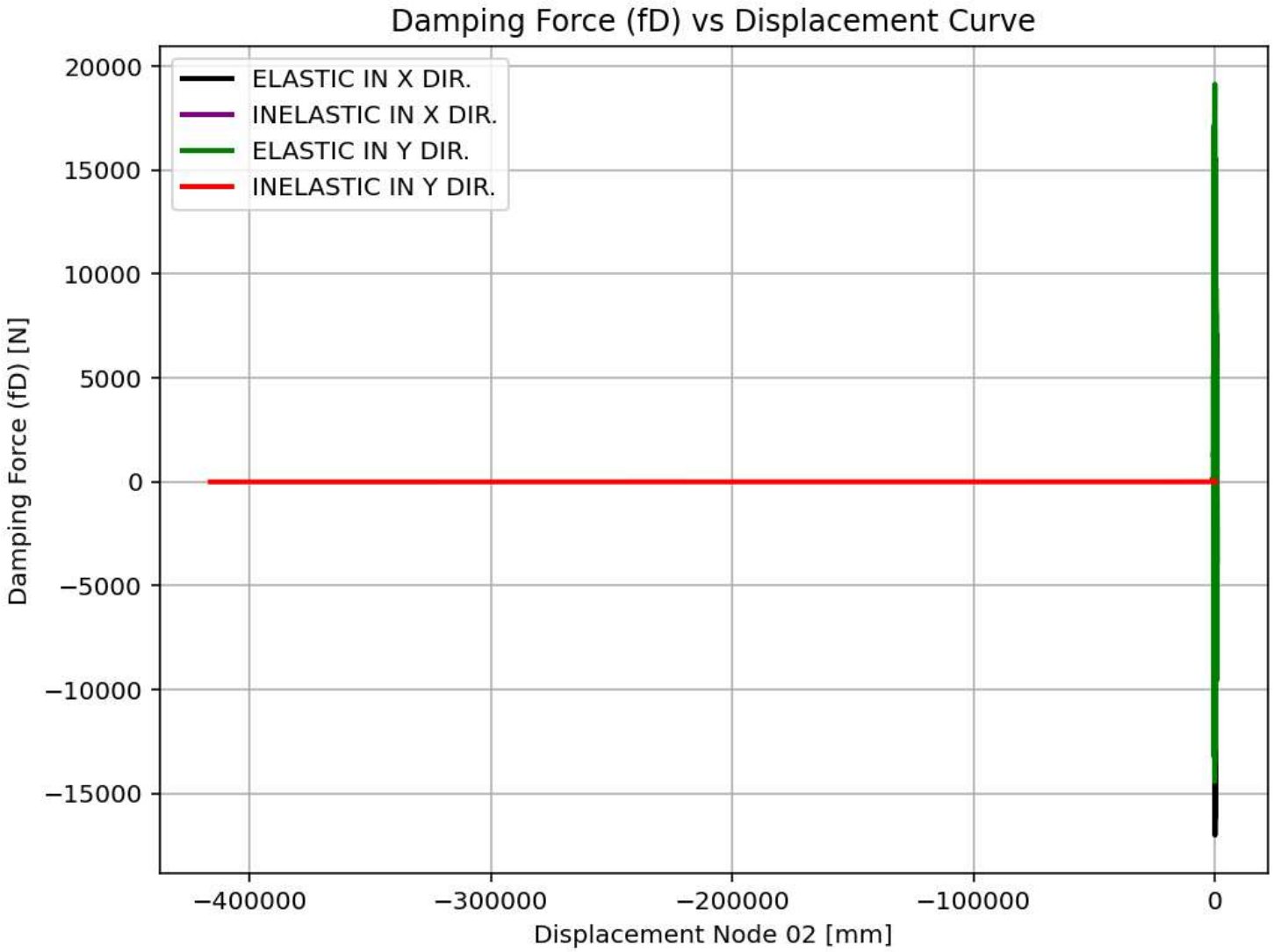

Reaction Forces vs Time in Y Dir.
1e7
Reaction (N)
Displacement vs Time in Y Dir.
1e6
Displacement (mm)
Elastic Damping Ratio: 0.000e+00 %
Inelastic Damping Ratio: 0.000e+00 %
Velocity vs Time in Y Dir.
Velocity (mm/s)
Acceleration vs Time in Y Dir.
Acceleration (mm/s²)
Stiffness vs Time in Y Dir.
Stiffness (N/mm)
Period vs Time in Y Dir.
Period (s)
Elastic Period
Inelastic Period
Time (s)


Displacement Node 02 vs Base-reaction
1e7
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
Base-reaction [N]
ELASTIC IN X DIR.
INELASTIC IN X DIR.
ELASTIC IN Y DIR.
INELASTIC IN Y DIR.
−400000
−300000
−200000
−100000
0
Displacement Node 02 [mm]


Damping Force (fD) vs Velocity Curve
ELASTIC IN X DIR.
INELASTIC IN X DIR.
ELASTIC IN Y DIR.
INELASTIC IN Y DIR.
Damping Force (fD) [N]
20000
15000
10000
5000
0
−5000
−10000
−15000
−4000
−3000
−2000
−1000
0
1000
2000
3000
4000
Velocity Noe 02 (mm/s)


Inertia Force (fI) vs Acceleration Curve
ELASTIC IN X DIR.
INELASTIC IN X DIR.
ELASTIC IN Y DIR.
INELASTIC IN Y DIR.
600000
400000
200000
0
−200000
−400000
Inertia Force (fI) [N]
−20000
−10000
0
10000
20000
Acceleration Node 02 [mm/s²]


Spring Force (fS) vs Displacement
1e11
ELASTIC IN X DIR.
INELASTIC IN X DIR.
ELASTIC IN Y DIR.
INELASTIC IN Y DIR.
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.25
Spring Force (fS) [N]
−400000
−300000
−200000
−100000
0
Displacement Node 02 [mm]


Damping Force (fD) vs Displacement Curve
ELASTIC IN X DIR.
INELASTIC IN X DIR.
ELASTIC IN Y DIR.
INELASTIC IN Y DIR.
Damping Force (fD) [N]
20000
15000
10000
5000
0
−5000
−10000
−15000
−400000
−300000
−200000
−100000
0
Displacement Node 02 [mm]