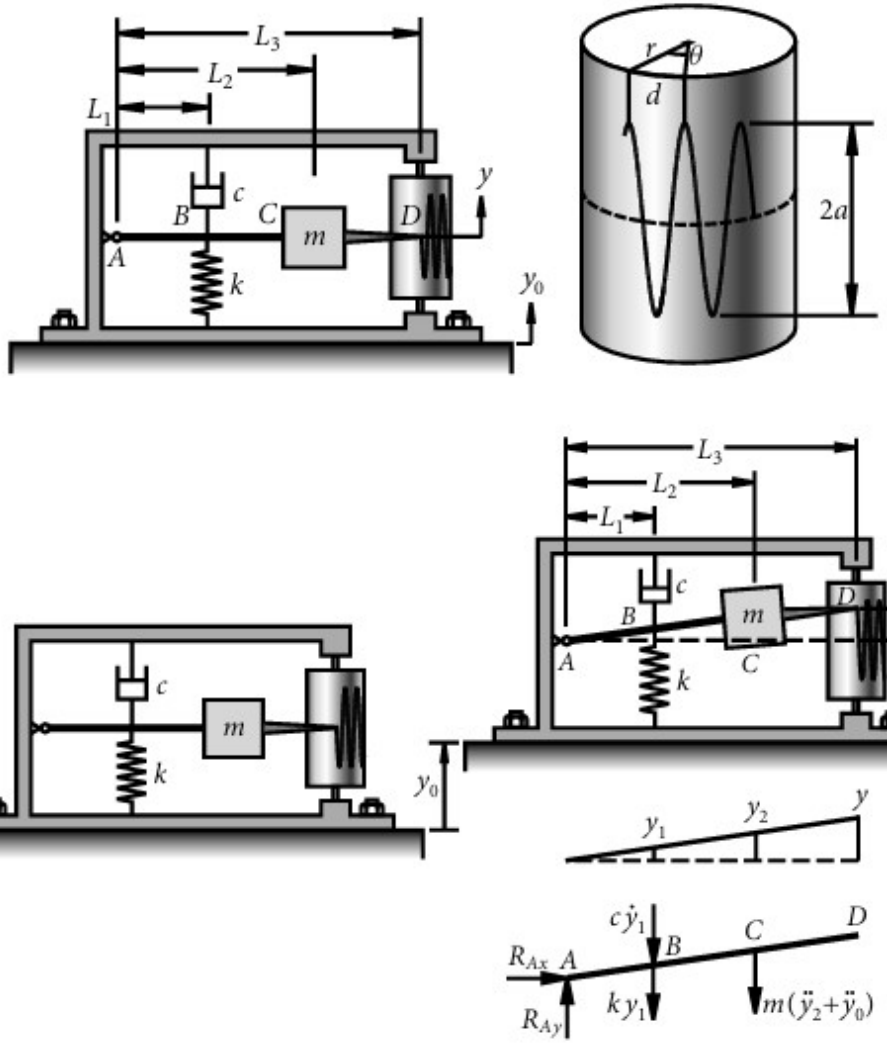
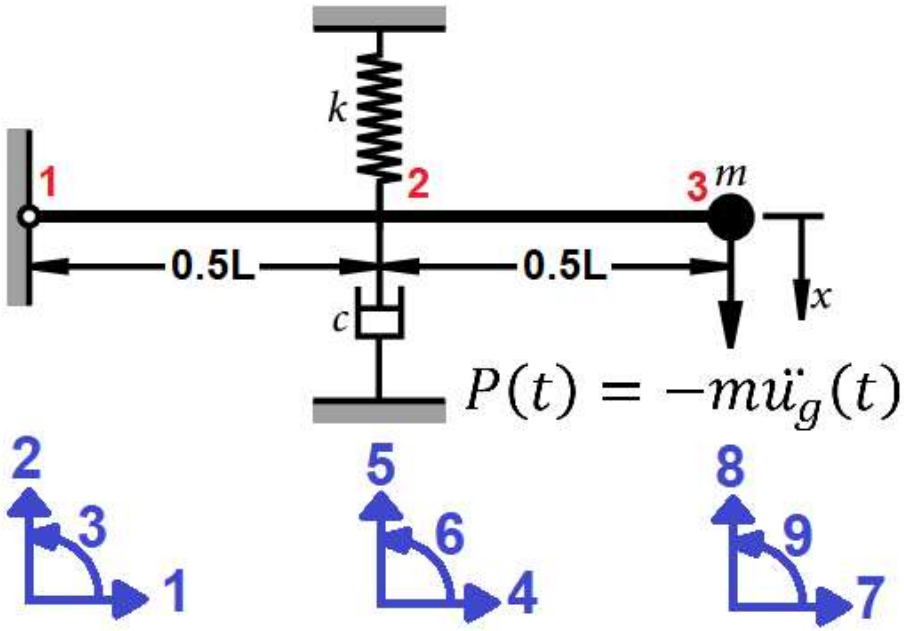
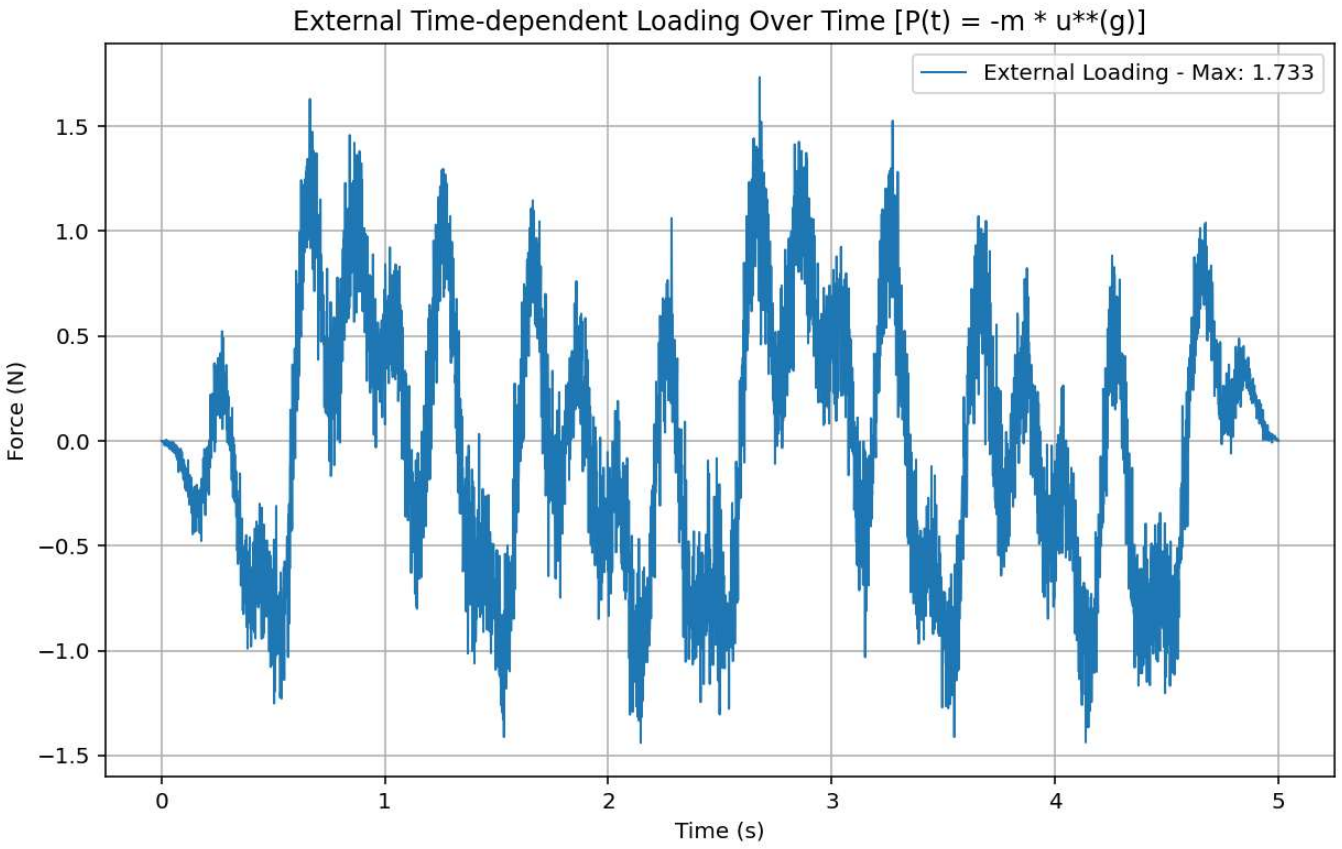
>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

MODELING OF DISPLACEMENT METER FOR MDOF STRUCTURE USING OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)


L_3
L_2
L_1
c
B
C
m
D
y
A
k
y_0
r
θ
d
$2a$
L_3
L_2
L_1
c
B
m
D
y
A
k
C
c
m
k
y_0
y_1
y_2
y
$c\dot{y}_1$
B
C
D
R_{Ax}
A
ky_1
$m(\ddot{y}_2+\ddot{y}_0)$
R_{Ay}


k
1
2
3
m
0.5L
0.5L
x
c
$P(t) = -m\ddot{u}_g(t)$
2
3
1
5
6
4
8
9
7


External Time-dependent Loading Over Time [P(t) = -m * u**(g)]
External Loading - Max: 1.733
Force (N)
Time (s)
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
0
1
2
3
4
5

Spyder (Python 3.12)

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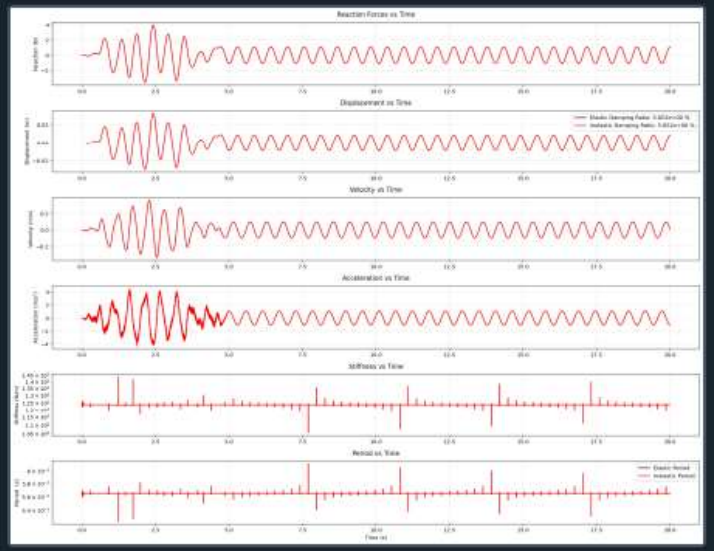
C:\Users\Dell\Desktop\OPENSEES_FILES\+DISPLACEMENT_METER

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

DISPLACEMENT_METER.py

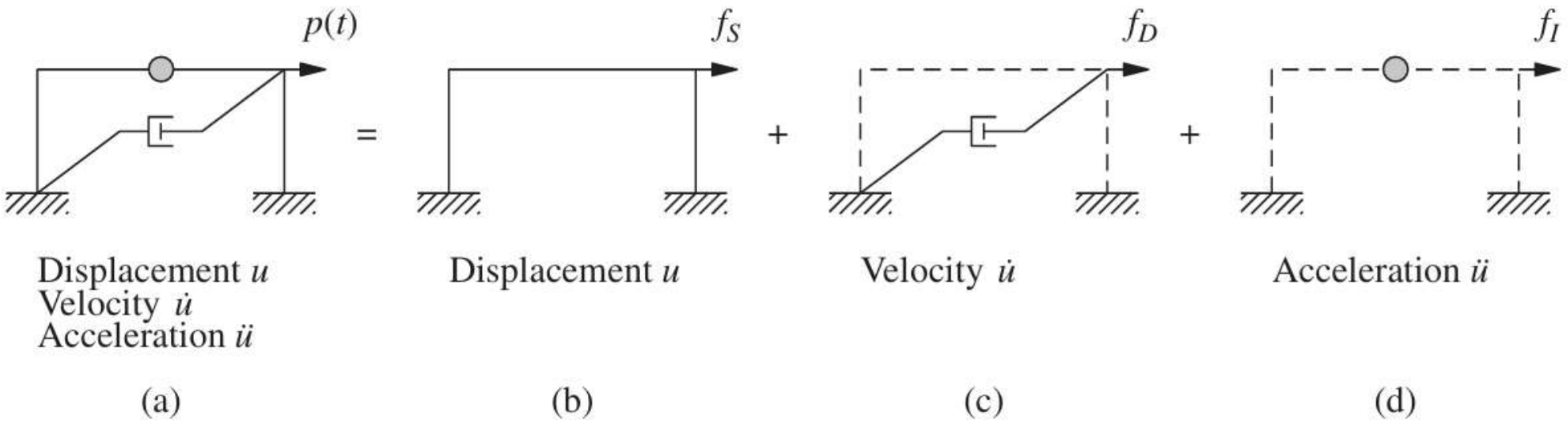
```
1  ##########################################################################################
2  #                          >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <
3  #                            MODELING OF DISPLACEMENT METER MDOF STRUCTURE USING OPENSEES
4  #                                              P(t) = -m * ug**(t)
5  #----------------------------------------------------------------------------------------
6  #                       EVALUATION OF DAMPING FORCE (fD), SPRING FORCE (fS)AND INERTIA FORCE
7  #----------------------------------------------------------------------------------------
8  #                                THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
9  #                                        EMAIL: salar.d.ghashghaei@gmail.com
10 ##########################################################################################
11 """
12 Performs time-dependent loading analysis of a Multi Degree of Freedom (SDOF)
13  structure using OpenSeesPy, comparing elastic and inelastic spring behavior.
14  Key features include:
15
16 1. Implements both elastic (linear) and hysteretic (nonlinear) material models for
17  structural springs.
18 2. Supports initial conditions for displacement, velocity, and acceleration.
19 3. Uses Newmark's method for time integration with Newton-Raphson iteration.
20 4. Calculates damping ratios using logarithmic decrement from response peaks.
21 5. Generates force-displacement backbone curves for inelastic material.
22 6. Tracks and plots time-history responses (displacement, velocity, acceleration, reaction
23 7. Compares elastic vs inelastic system performance.
24 8. Includes convergence checks and analysis stability monitoring.
25 9. Outputs model data in JSON format for post-processing.
26 10. Provides theoretical validation through natural frequency calculations.
27
28 Particularly useful for earthquake engineering applications,
29 allowing evaluation of structural response under time-dependent loading
30  with different material nonlinearities and damping characteristics.
31  The hysteretic material model captures energy dissipation
32  inelastic deformation, while the elastic case serves as a reference for linear behavior.
33 """
34 import openseespy.opensees as ops
```

45 %

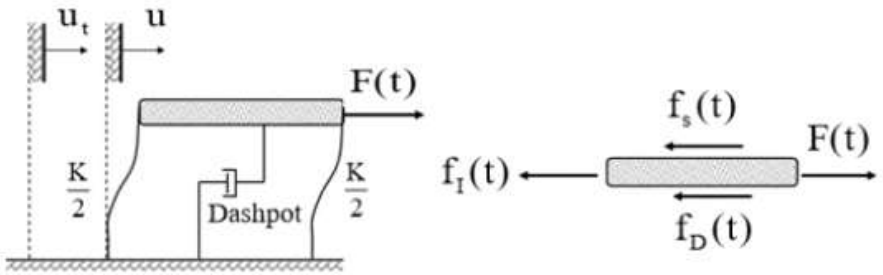


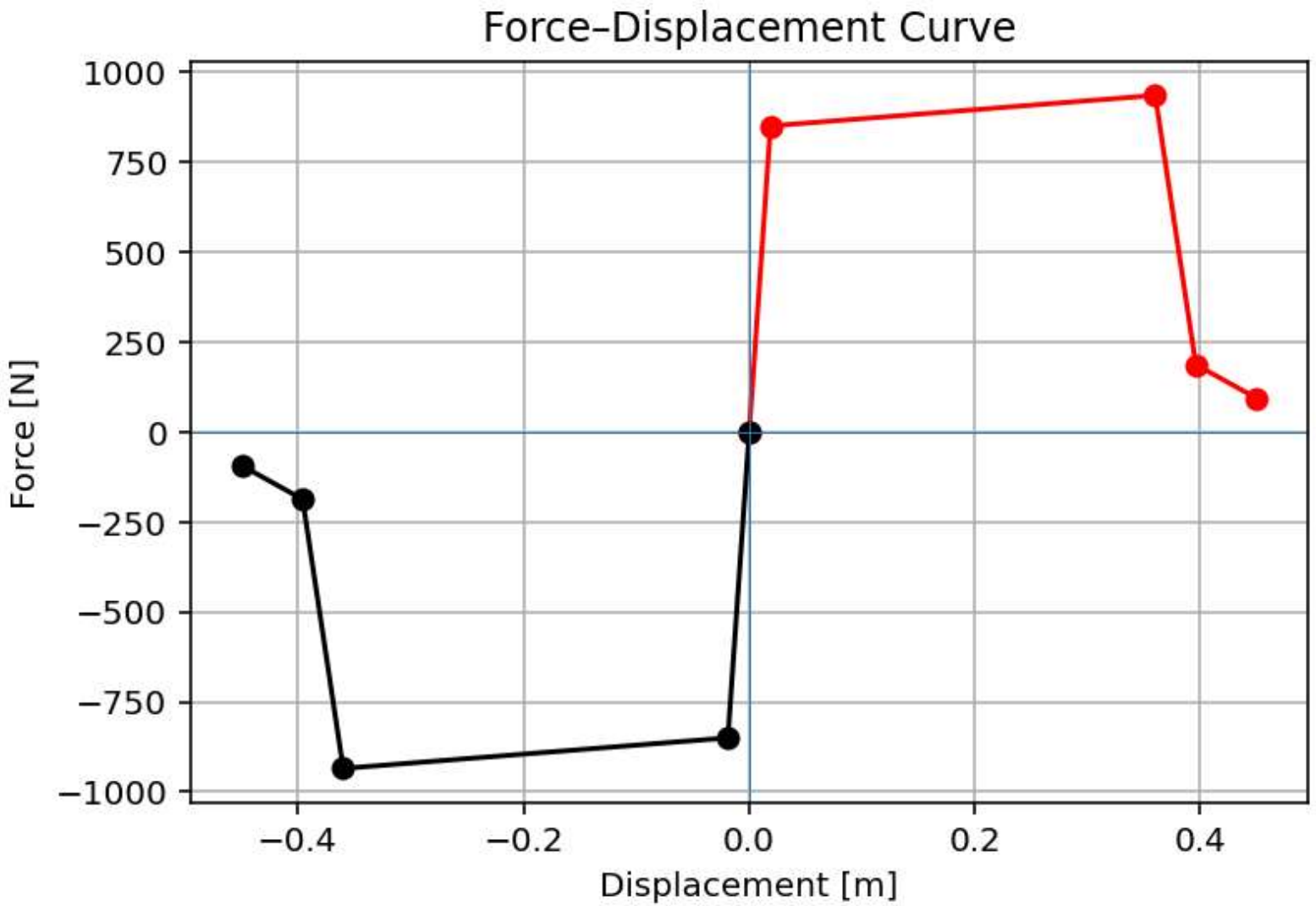
IPython Console | Files | Help | Variable Explorer | Debugger | Plots | History

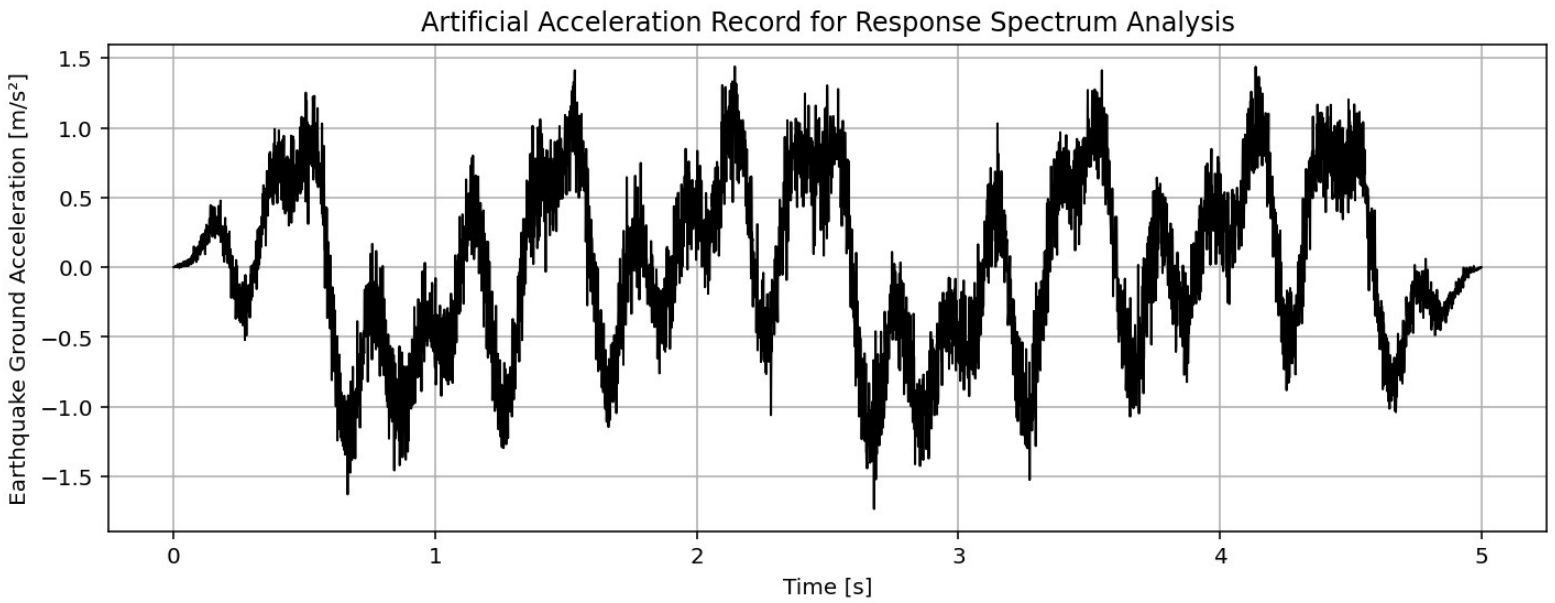
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 12, Col 52 UTF-8 CRLF RW Mem 40%

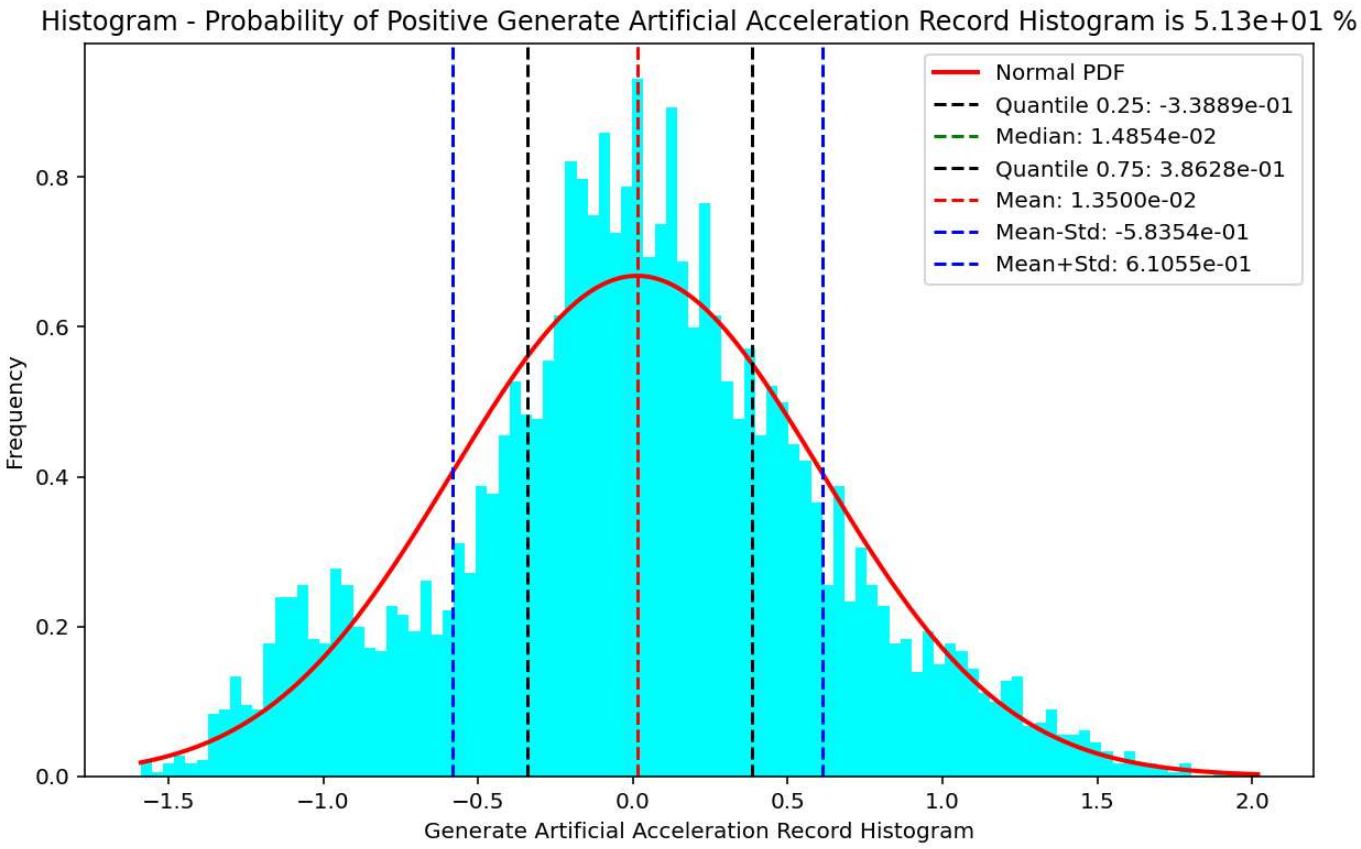


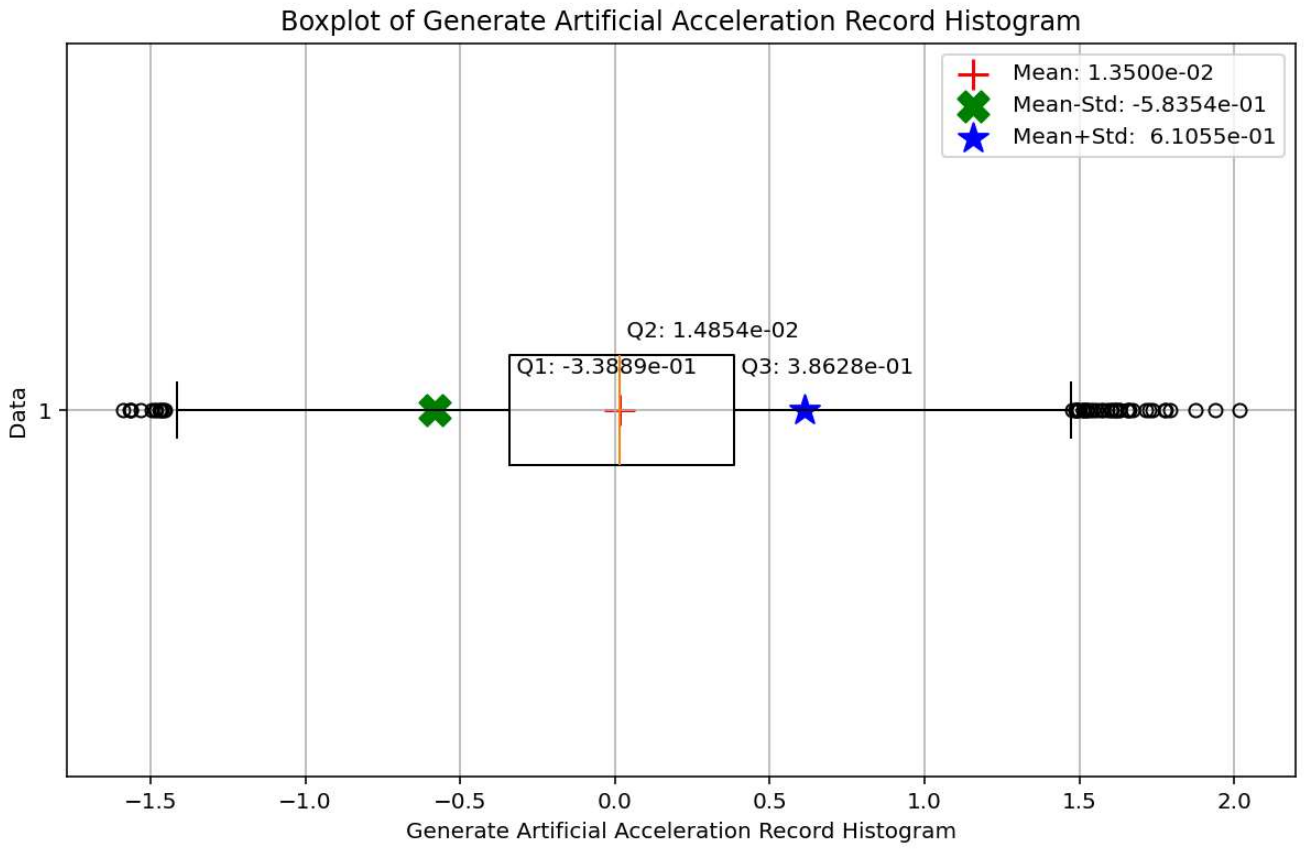
(a) System; (b) stiffness component; (c) damping component; (d) mass component.

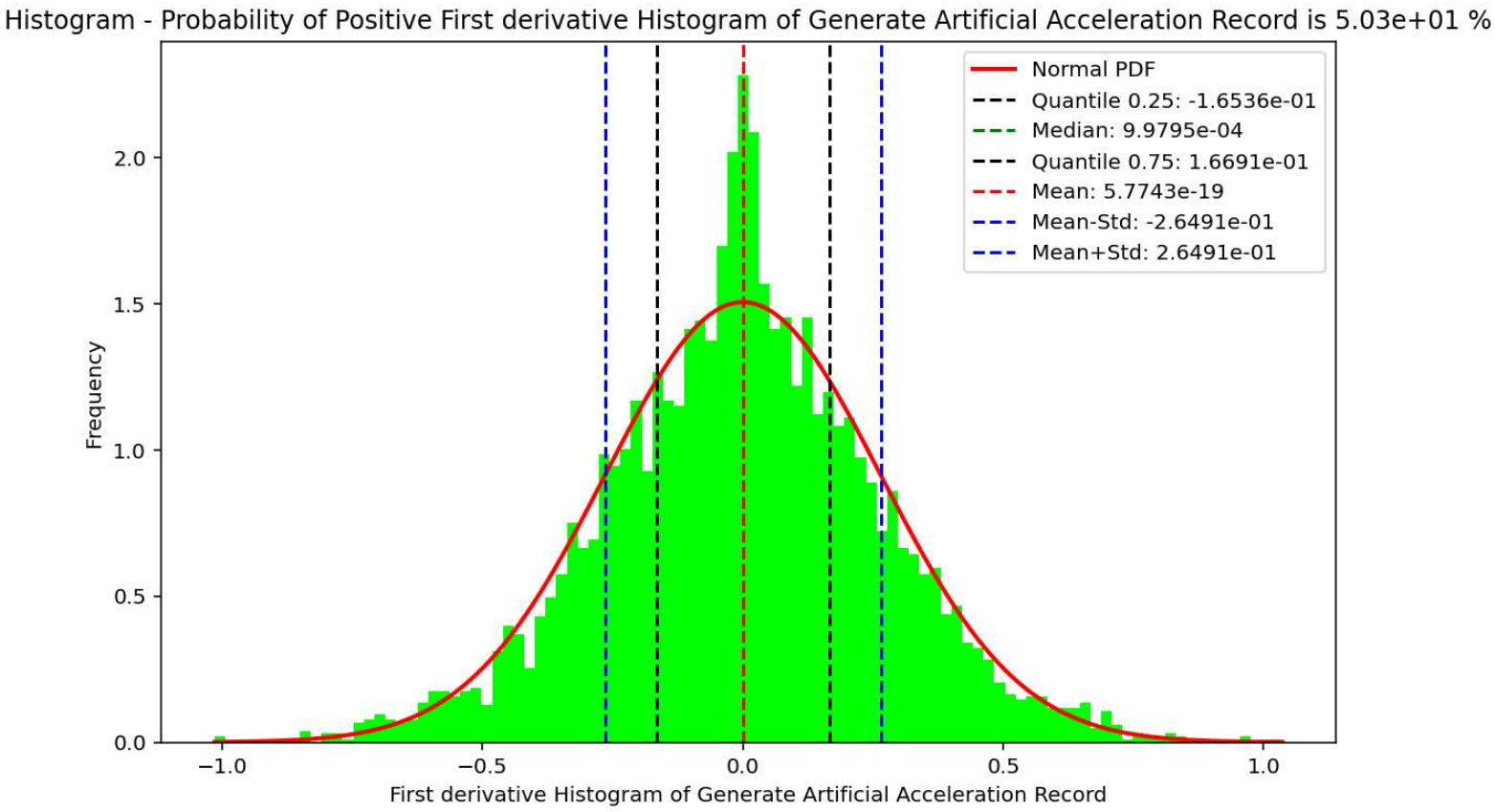


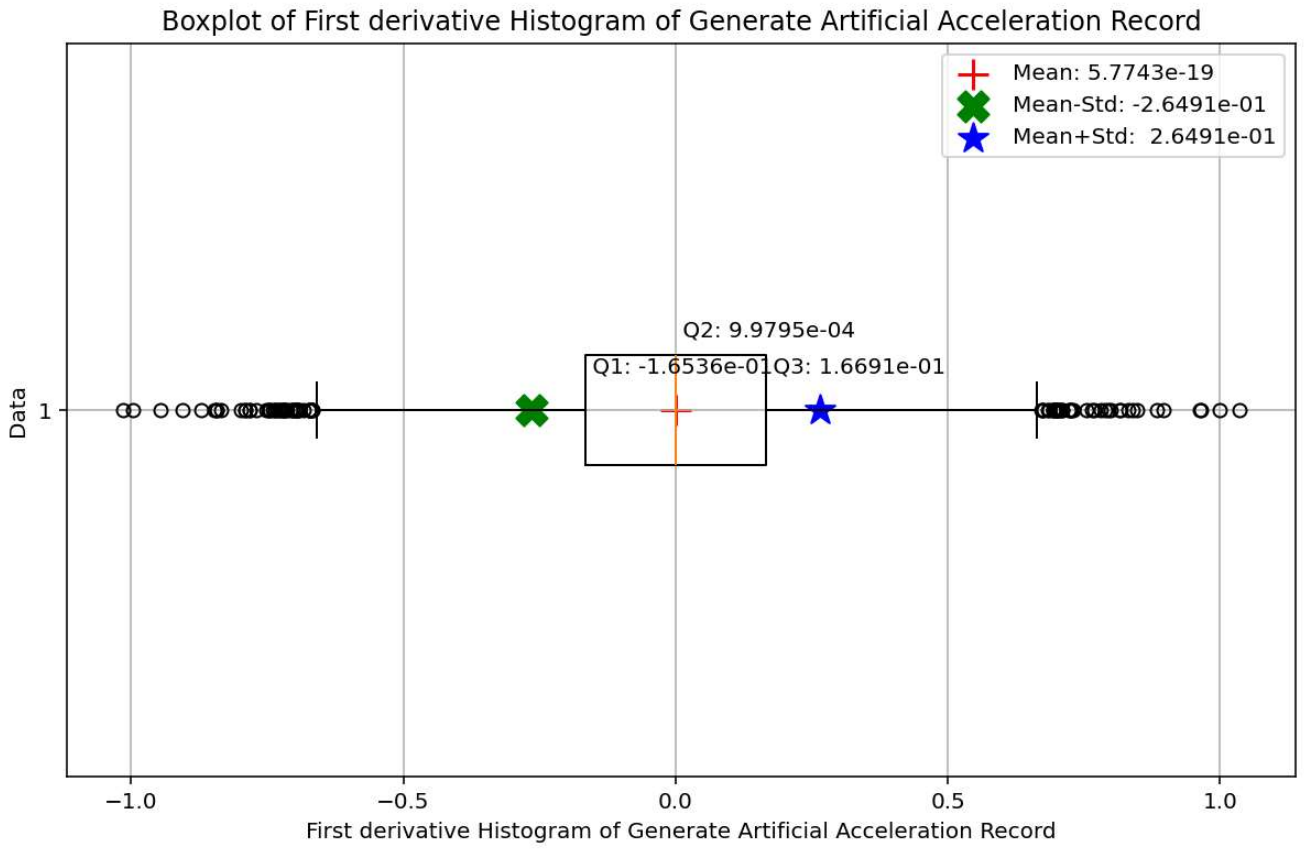

Force–Displacement Curve
1000
750
500
250
0
−250
−500
−750
−1000
Force [N]
−0.4
−0.2
0.0
0.2
0.4
Displacement [m]

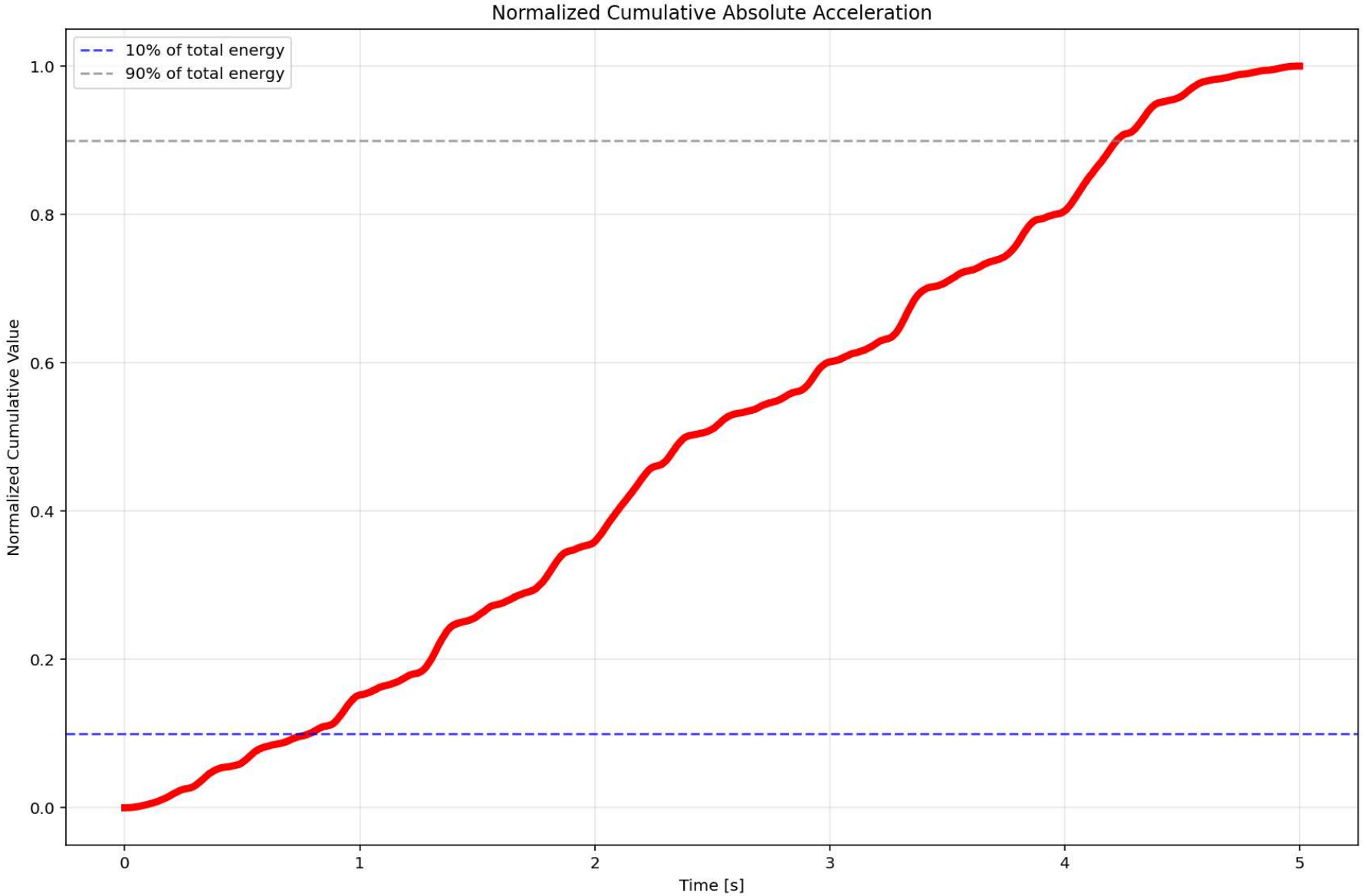

Artificial Acceleration Record for Response Spectrum Analysis
Earthquake Ground Acceleration [m/s²]
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
0
1
2
3
4
5
Time [s]

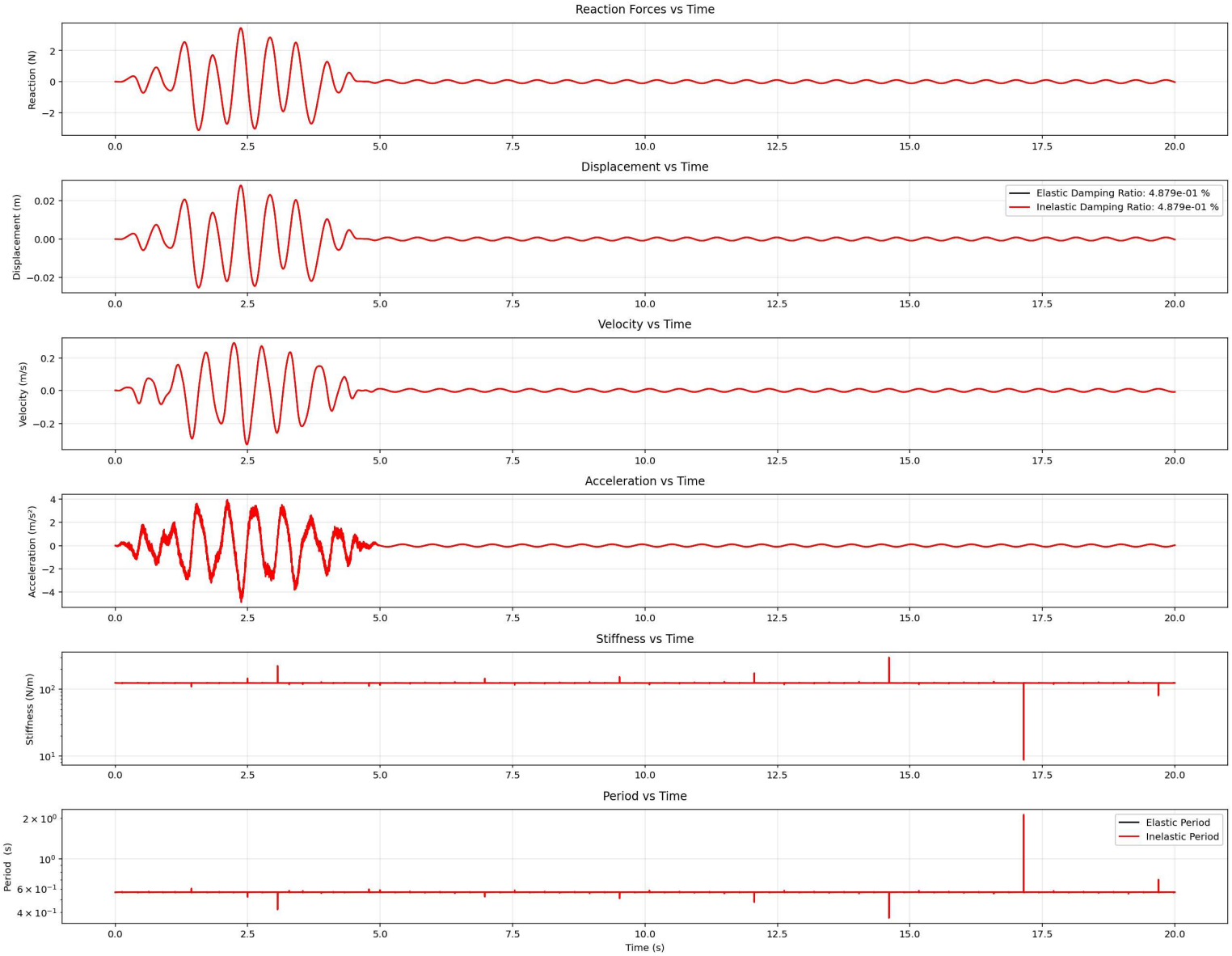

Histogram - Probability of Positive Generate Artificial Acceleration Record Histogram is 5.13e+01 %
Normal PDF
Quantile 0.25: -3.3889e-01
Median: 1.4854e-02
Quantile 0.75: 3.8628e-01
Mean: 1.3500e-02
Mean-Std: -5.8354e-01
Mean+Std: 6.1055e-01
Frequency
0.0
0.2
0.4
0.6
0.8
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
Generate Artificial Acceleration Record Histogram

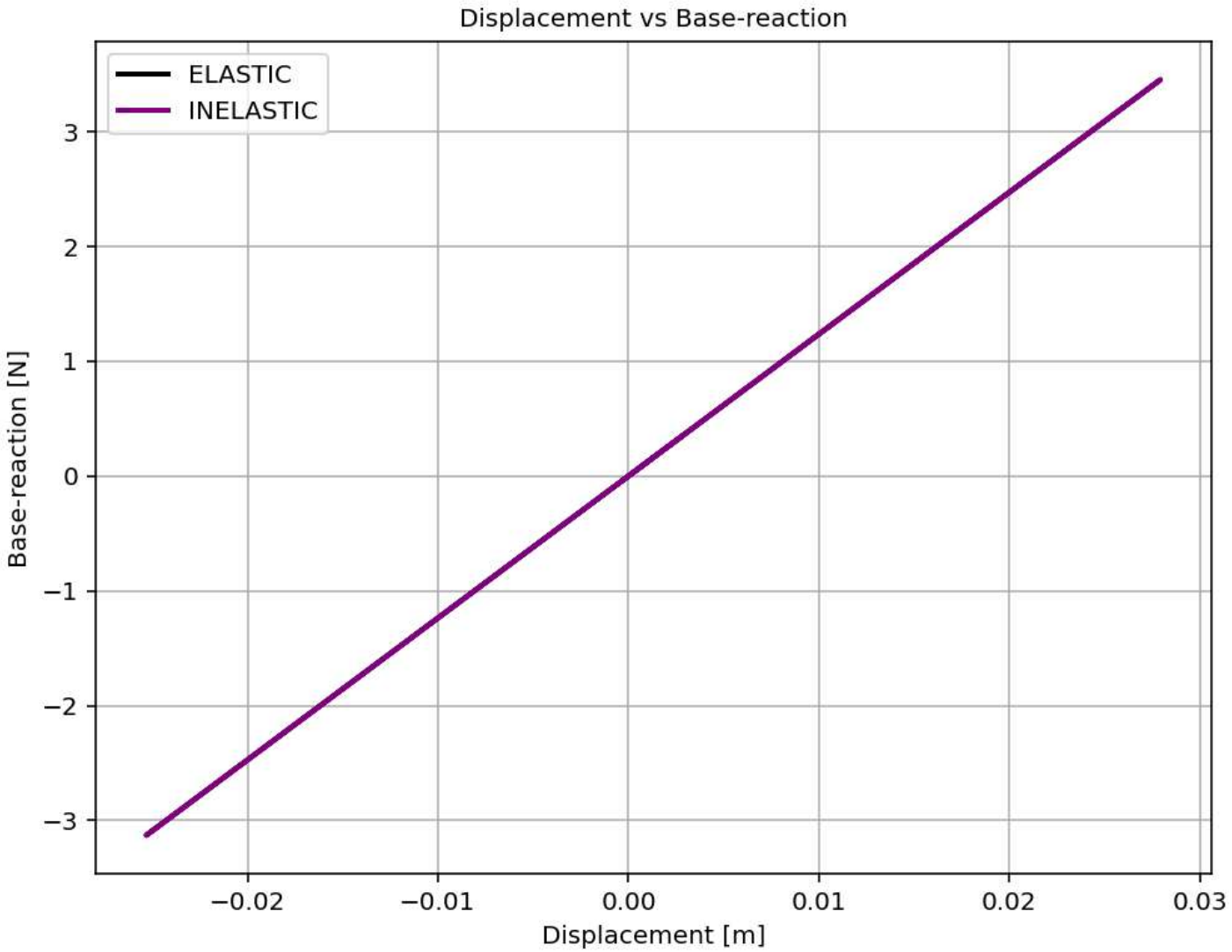

Boxplot of Generate Artificial Acceleration Record Histogram
Mean: 1.3500e-02
Mean-Std: -5.8354e-01
Mean+Std: 6.1055e-01
Q2: 1.4854e-02
Q1: -3.3889e-01
Q3: 3.8628e-01
Data
1
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
Generate Artificial Acceleration Record Histogram

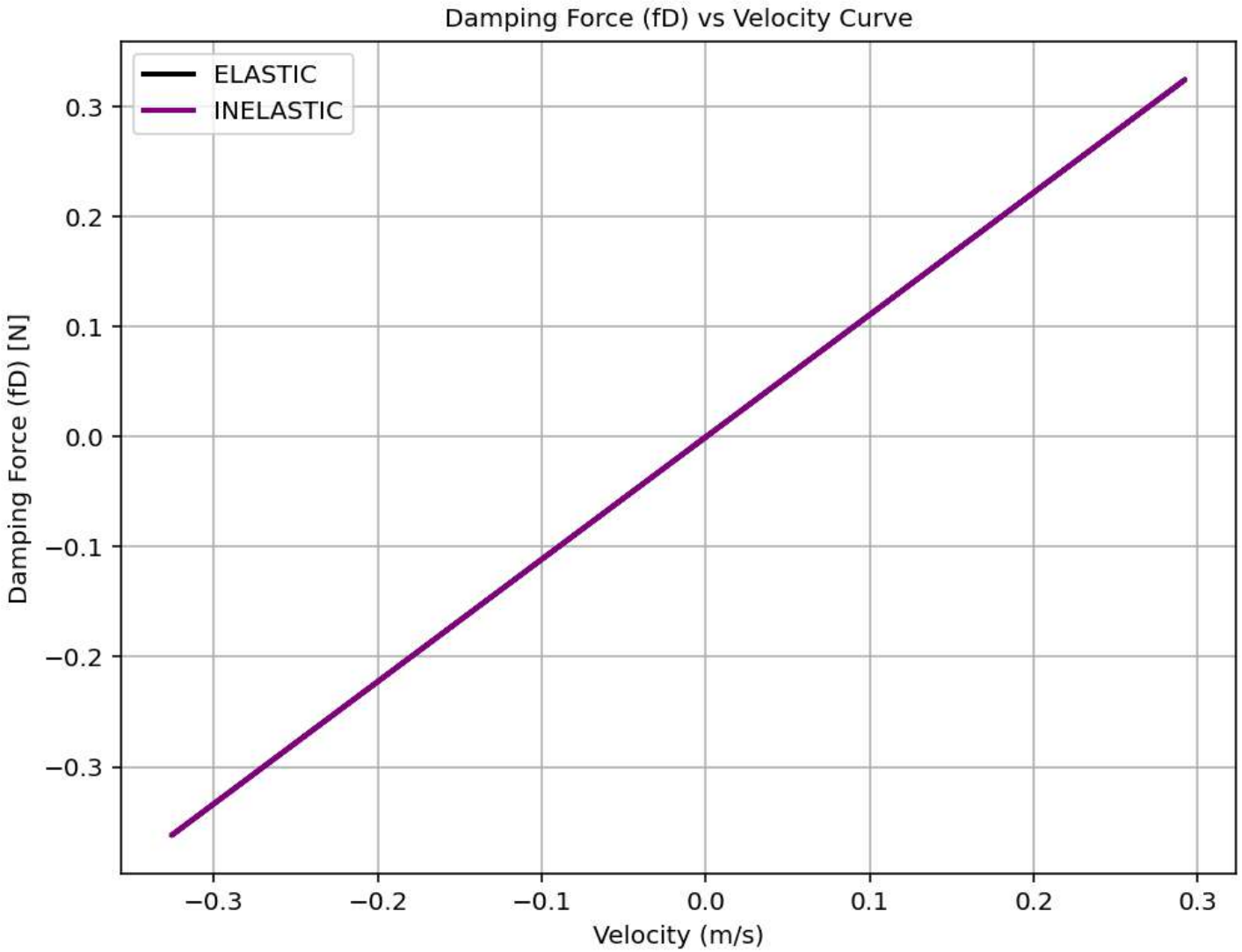

Histogram - Probability of Positive First derivative Histogram of Generate Artificial Acceleration Record is 5.03e+01 %
Normal PDF
Quantile 0.25: -1.6536e-01
Median: 9.9795e-04
Quantile 0.75: 1.6691e-01
Mean: 5.7743e-19
Mean-Std: -2.6491e-01
Mean+Std: 2.6491e-01
Frequency
0.0
0.5
1.0
1.5
2.0
−1.0
−0.5
0.0
0.5
1.0
First derivative Histogram of Generate Artificial Acceleration Record

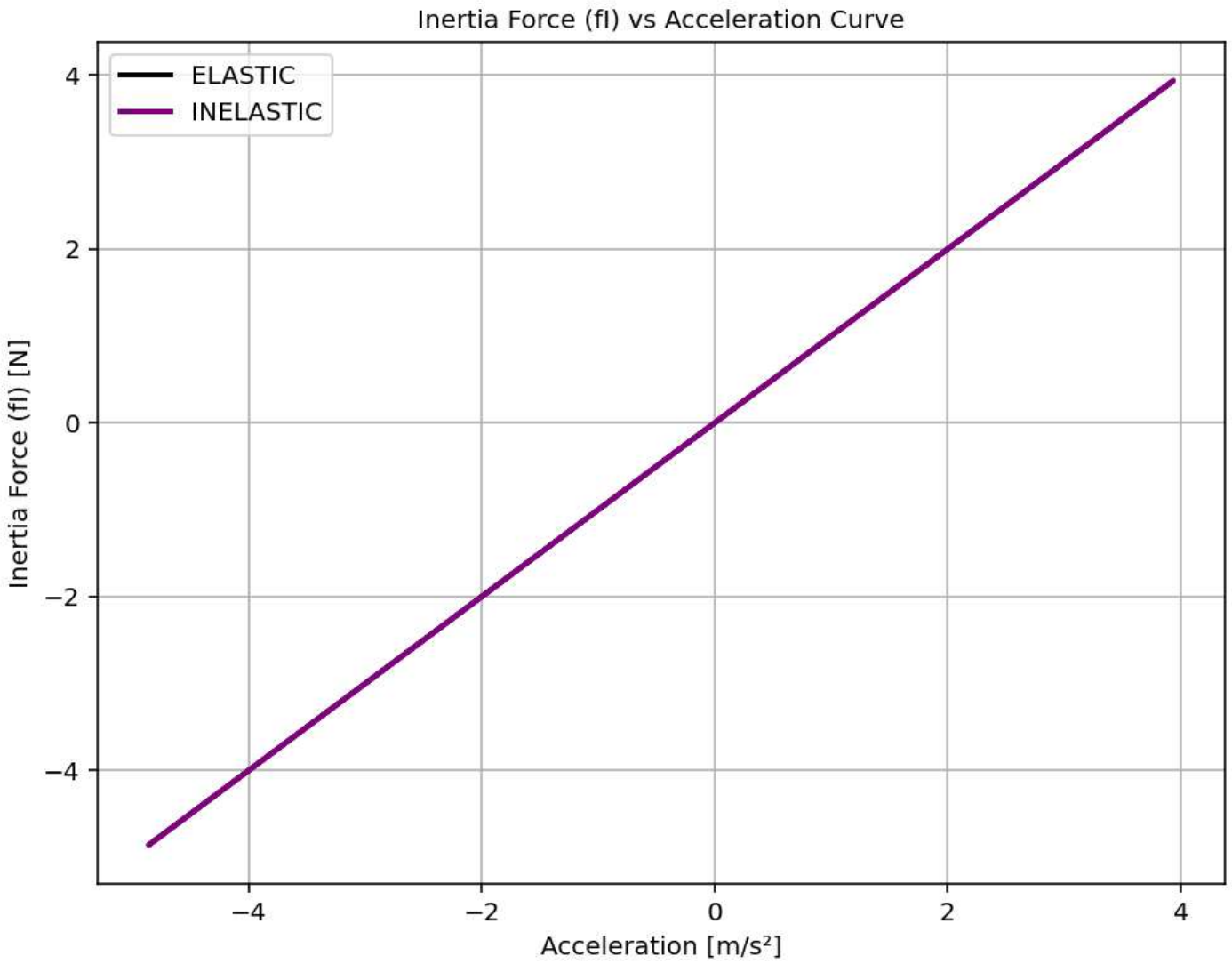

Boxplot of First derivative Histogram of Generate Artificial Acceleration Record
Mean: 5.7743e-19
Mean-Std: -2.6491e-01
Mean+Std: 2.6491e-01
Q2: 9.9795e-04
Q1: -1.6536e-01
Q3: 1.6691e-01
Data
1
−1.0
−0.5
0.0
0.5
1.0
First derivative Histogram of Generate Artificial Acceleration Record

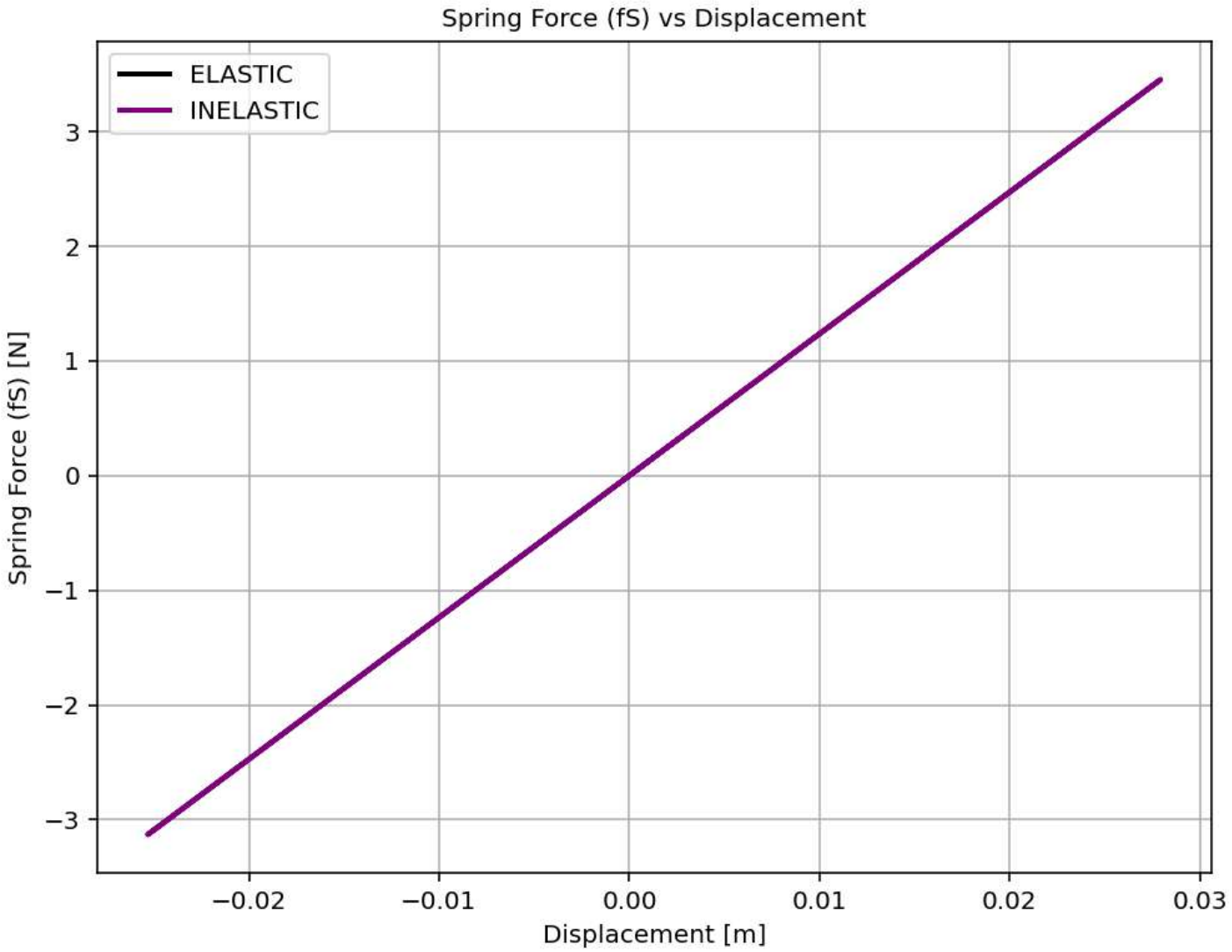

Normalized Cumulative Absolute Acceleration
10% of total energy
90% of total energy
Normalized Cumulative Value
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
Time [s]

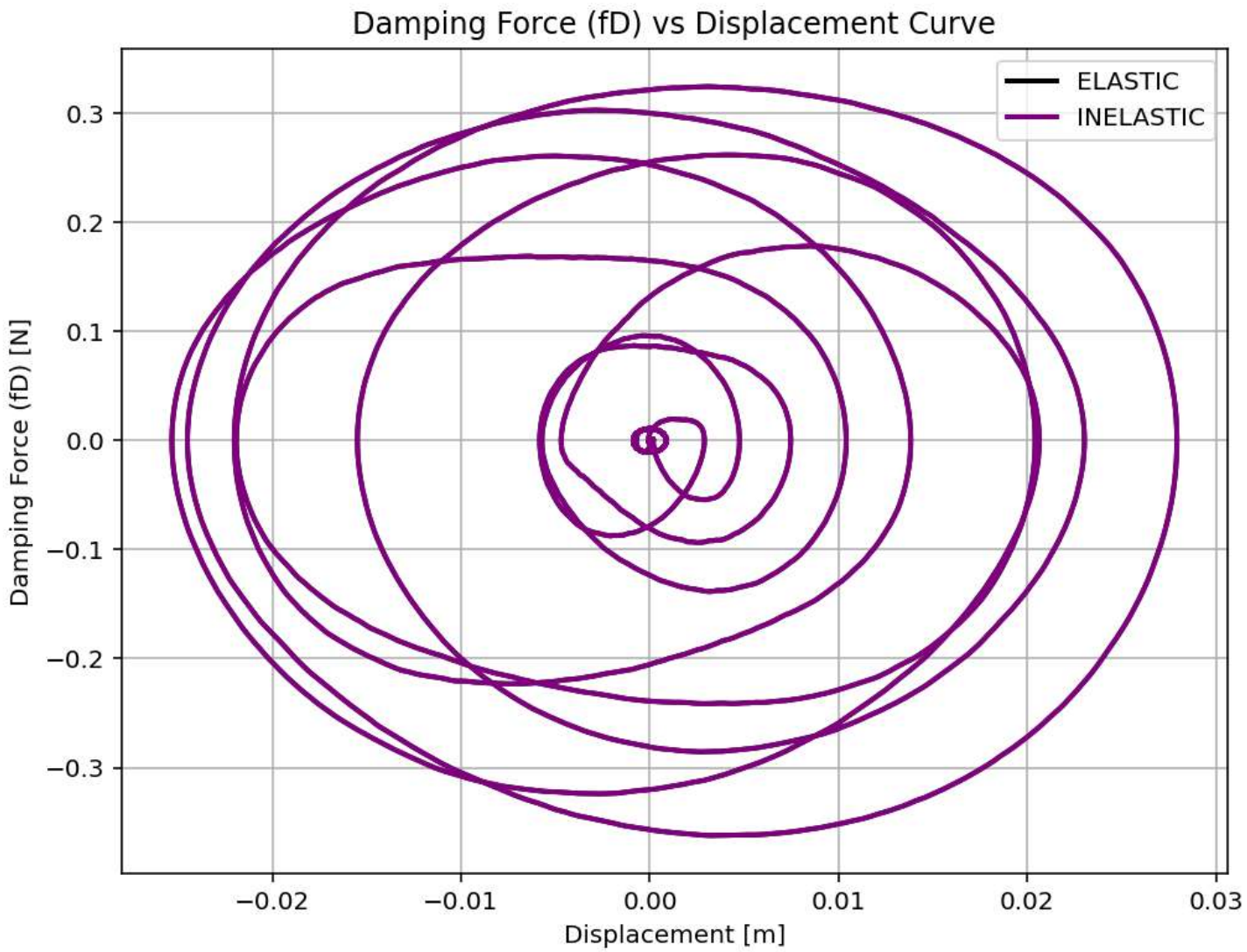

Reaction Forces vs Time
Reaction (N)
Displacement vs Time
Displacement (m)
Elastic Damping Ratio: 4.879e-01 %
Inelastic Damping Ratio: 4.879e-01 %
Velocity vs Time
Velocity (m/s)
Acceleration vs Time
Acceleration (m/s²)
Stiffness vs Time
Stiffness (N/m)
Period vs Time
Period (s)
Elastic Period
Inelastic Period
Time (s)


Displacement vs Base-reaction
ELASTIC
INELASTIC
Base-reaction [N]
3
2
1
0
−1
−2
−3
−0.02
−0.01
0.00
0.01
0.02
0.03
Displacement [m]


Damping Force (fD) vs Velocity Curve
ELASTIC
INELASTIC
Damping Force (fD) [N]
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.3
−0.2
−0.1
0.0
0.1
0.2
0.3
Velocity (m/s)


Inertia Force (fI) vs Acceleration Curve
ELASTIC
INELASTIC
Inertia Force (fI) [N]
Acceleration [m/s²]
4
2
0
−2
−4
−4
−2
0
2
4


Spring Force (fS) vs Displacement
ELASTIC
INELASTIC
Spring Force (fS) [N]
3
2
1
0
−1
−2
−3
−0.02
−0.01
0.00
0.01
0.02
0.03
Displacement [m]


Damping Force (fD) vs Displacement Curve
ELASTIC
INELASTIC
Damping Force (fD) [N]
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.02
−0.01
0.00
0.01
0.02
0.03
Displacement [m]