MODELING OF PENDULUM MDOF STRUCTURE USING OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

K1, C1

0.25L

0.5L

K2, C2

0.75L

m

$$P(t) = -m\ddot{u}_g(t)$$
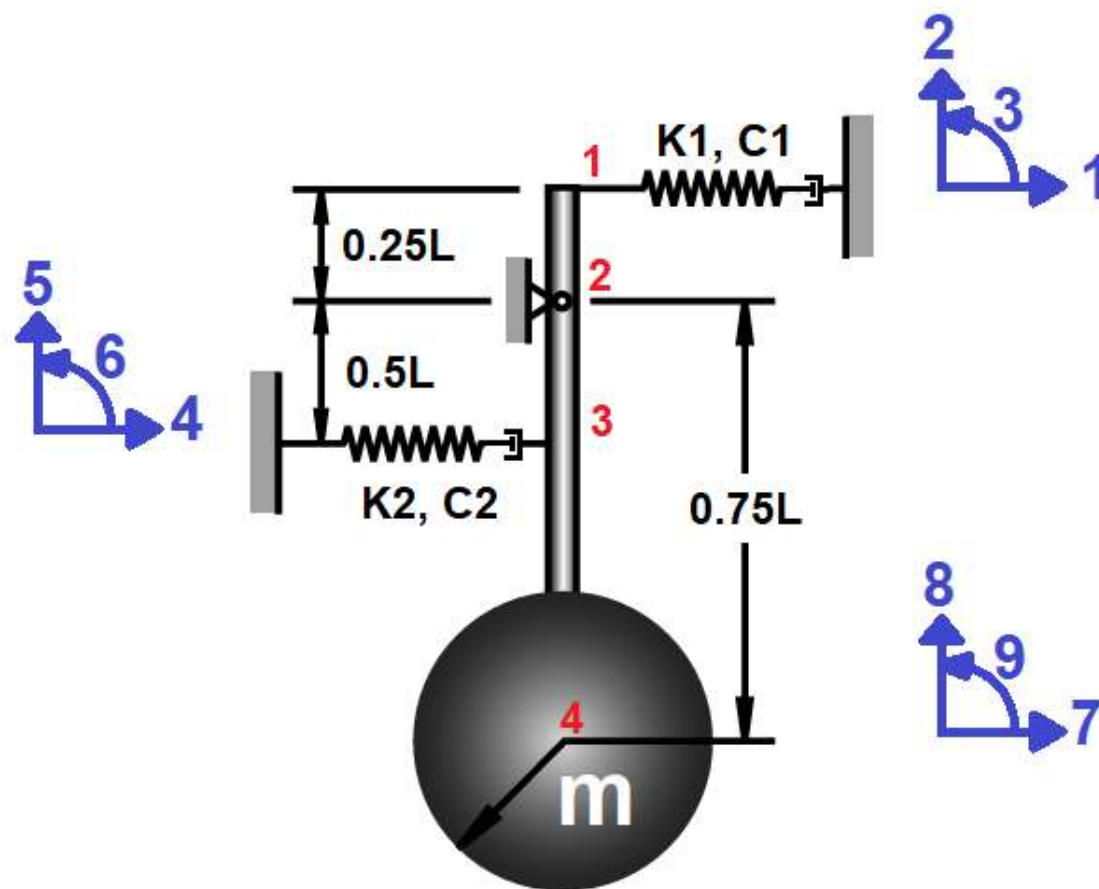
External Time-dependent Loading Over Time [P(t) = -m * ug**(t)]
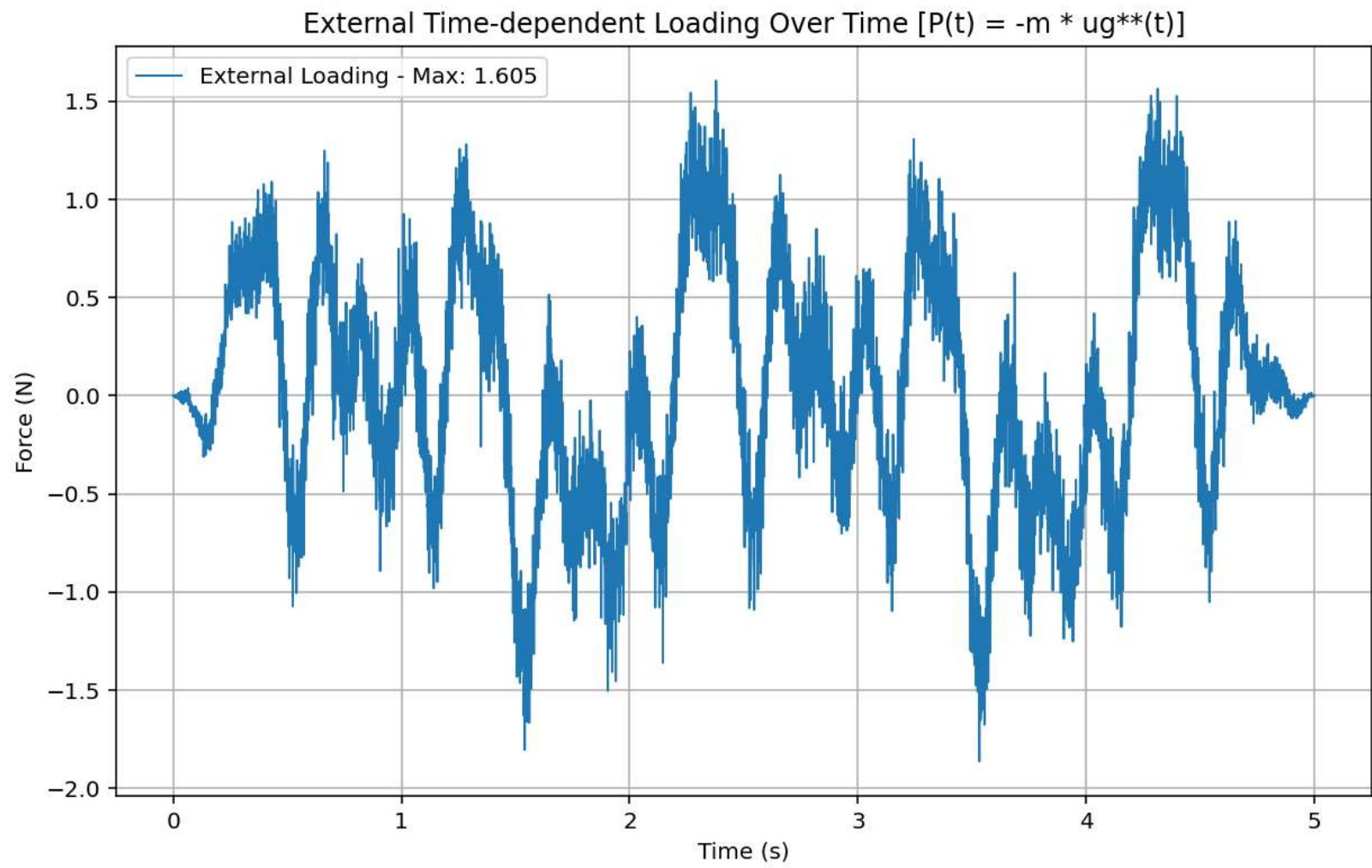
Spyder (Python 3.12)

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C:\Users\Dell\Desktop\OPENSEES_FILES\SEISMOMETER

C:\Users\Dell\Desktop\OPENSEES_FILES\SEISMOMETER\MDF_PENDULUM\MDF_PENDULUM.py

MDF_PENDULUM.py

```
1   ##############################################################################
2   #                >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
3   #                       MODELING OF PENDULUM 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 (MDOF)
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, reactions,
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  This code performs nonlinear time-history analysis of a 2D moment-resisting frame
```
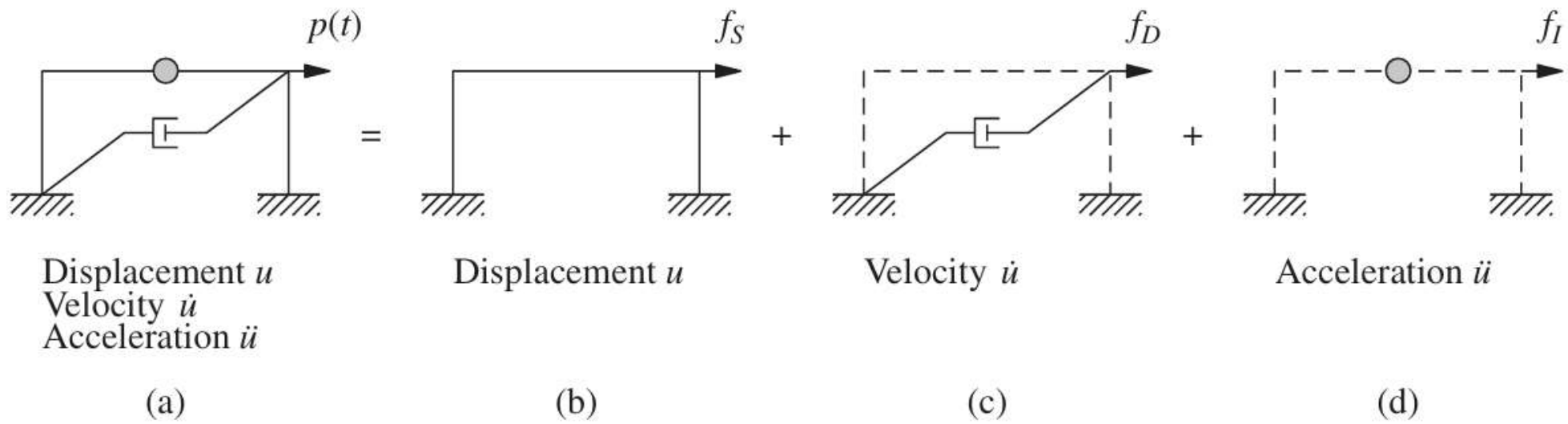
Damping Force (fD) vs Displacement Curve

Legend:
— ELASTIC IN X DIR.
— INELASTIC IN X DIR.
— ELASTIC IN Y DIR.
— INELASTIC IN Y DIR.

Y-axis: Damping Force (fD) [N]
X-axis: Displacement [m]
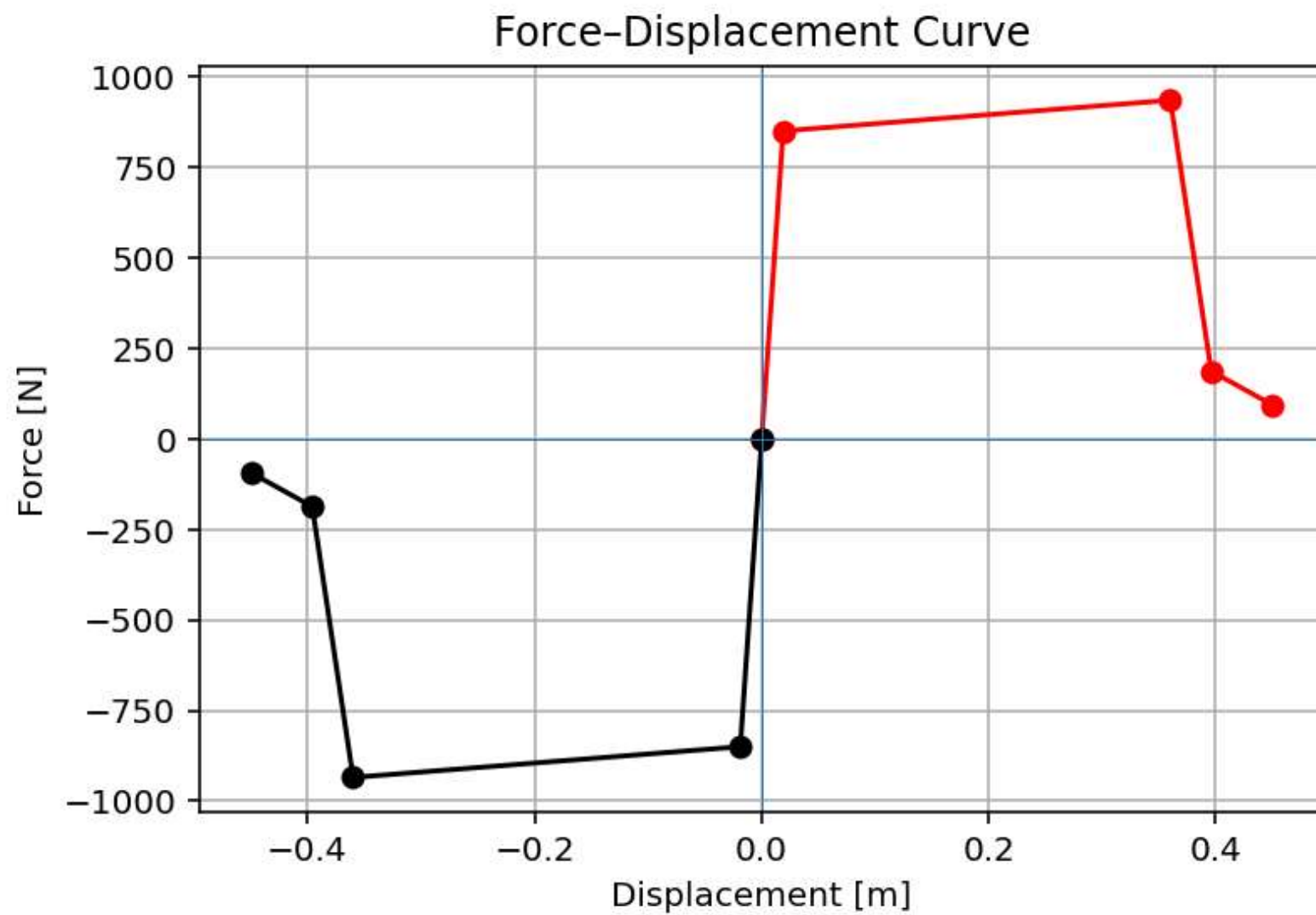
IPython Console | Files | Help | Variable Explorer | Debugger | Plots | History

Inline   Conda: anaconda3 (Python 3.12.7)   ✓ LSP: Python   Line 17, Col 21   UTF-8   CRLF   RW   Mem 42%

$p(t)$ f_S f_D f_I

Displacement u
Velocity $\dot{u}$
Acceleration $\ddot{u}$

Displacement u Velocity $\dot{u}$ Acceleration $\ddot{u}$

(a)   (b)   (c)   (d)

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

Force–Displacement Curve
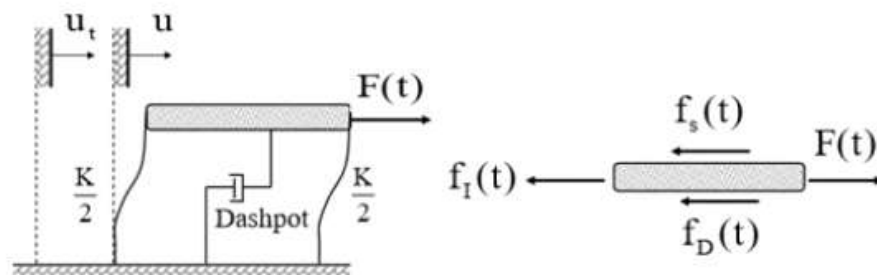
Artificial Acceleration Record for Response Spectrum Analysis

Histogram - Probability of Positive Generate Artificial Acceleration Record Histogram is 4.86e+01 %
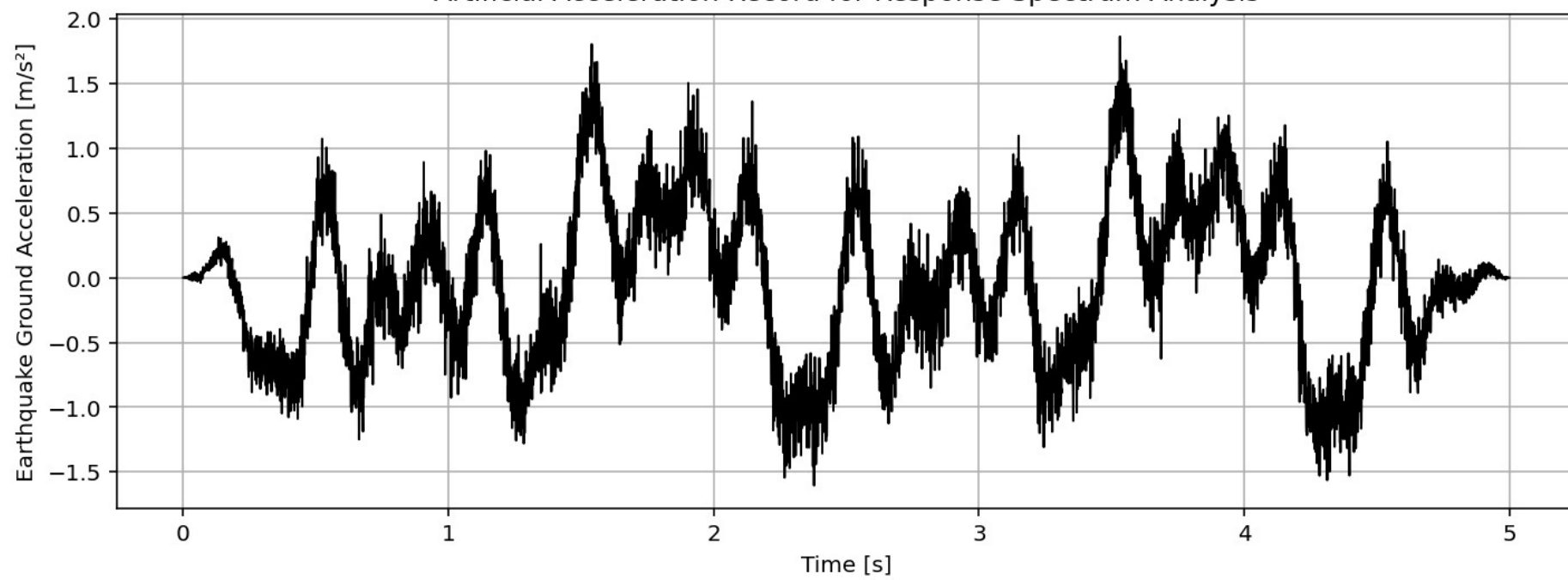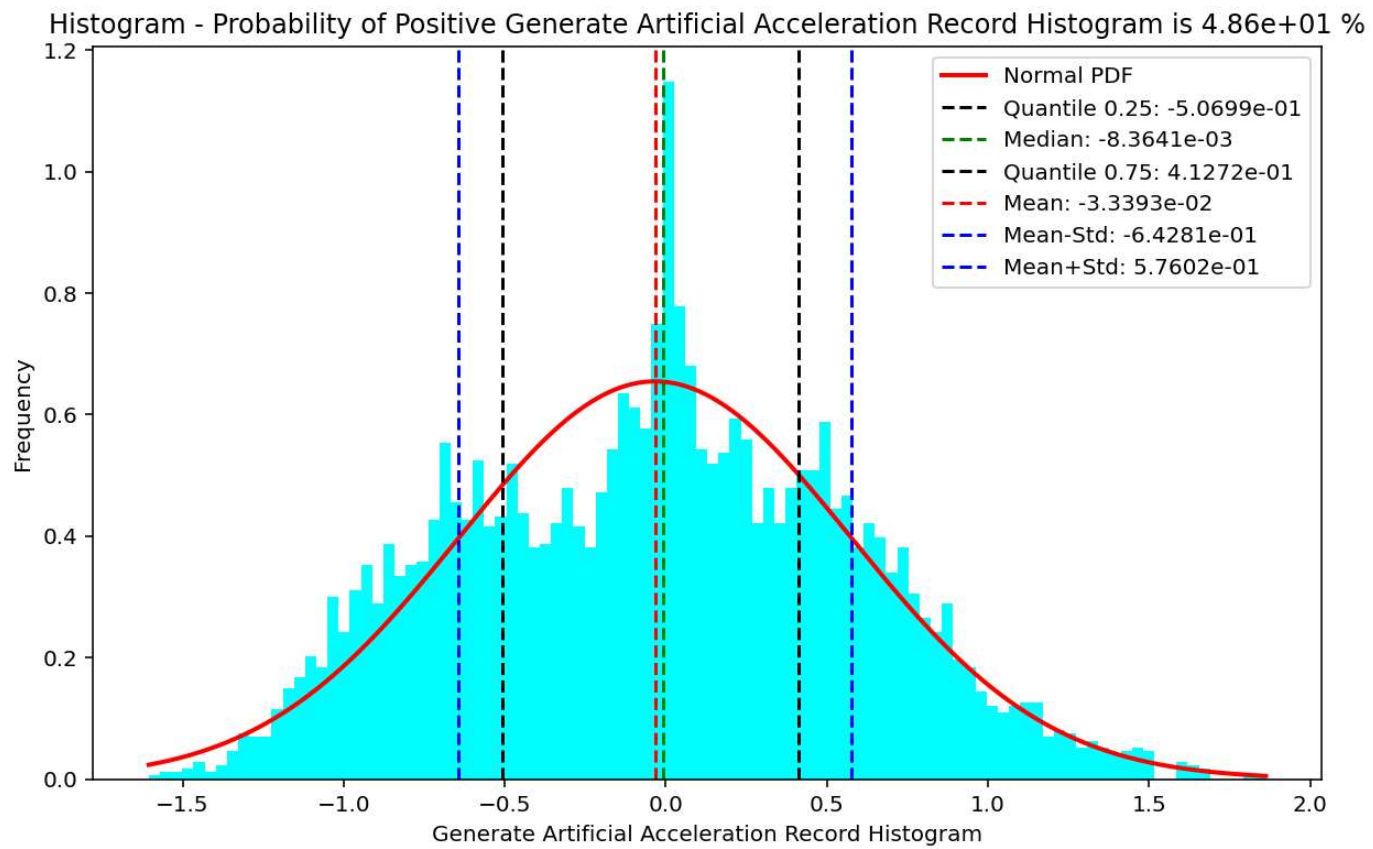
Boxplot of Generate Artificial Acceleration Record Histogram

Mean: -3.3393e-02
Mean-Std: -6.4281e-01
Mean+Std: 5.7602e-01

Q2: -8.3641e-03
Q1: -5.0699e-01
Q3: 4.1272e-01

Data

Generate Artificial Acceleration Record Histogram
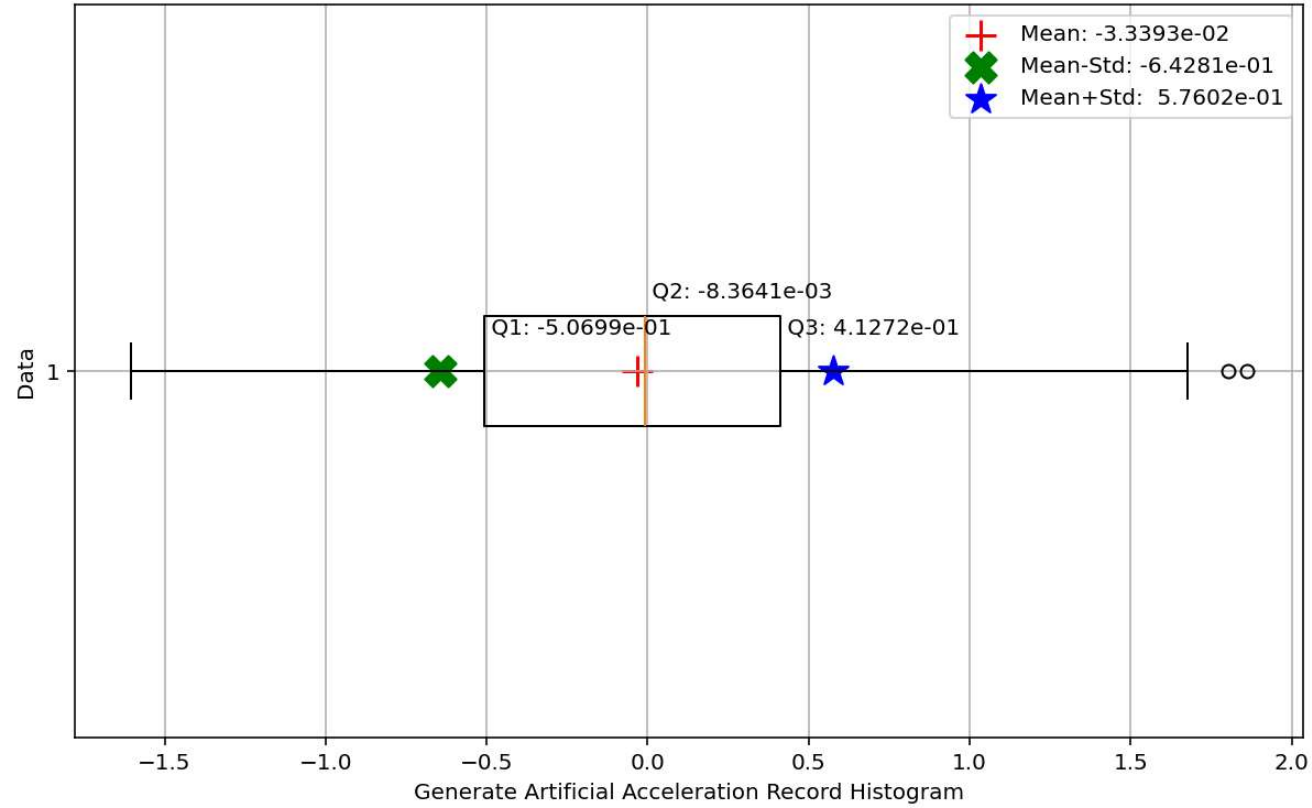
Histogram - Probability of Positive First derivative Histogram of Generate Artificial Acceleration Record is 5.07e+01 %

Boxplot of First derivative Histogram of Generate Artificial Acceleration Record

Mean: 2.2209e-19
Mean-Std: -2.5715e-01
Mean+Std: 2.5715e-01

Q2: 2.0546e-03
Q1: -1.5802e-01 Q3: 1.6207e-01

Data
1

First derivative Histogram of Generate Artificial Acceleration Record

Reaction Forces vs Time in X Dir.

Displacement vs Time in X Dir.

Elastic Damping Ratio: 6.924e-01 %
Inelastic Damping Ratio: 6.804e+00 %

Velocity vs Time in X Dir.

Acceleration vs Time in X Dir.

Stiffness vs Time in X Dir.

Period vs Time in X Dir.

Elastic Period
Inelastic Period

Time (s)

Reaction Forces vs Time in Y Dir.

Displacement vs Time in Y Dir.

Velocity vs Time in Y Dir.

Acceleration vs Time in Y Dir.

Stiffness vs Time in Y Dir.

Period vs Time in Y Dir.

Damping Force (fD) vs Velocity Curve

Inertia Force (fI) vs Acceleration Curve

Spring Force (fS) vs Displacement

Damping Force (fD) vs Displacement Curve