University of Akron LDRD Modeling Update

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**College of Engineering**

Partial Dissertation Overview

- Developed modeling capability in Abaqus.
  - Enhanced friction.

- Studied jointed structure under blast loading.
  - Characterized nonlinear properties of system.
  - Identified advancements and limitations.

- Modeling support to fluid experimentalists.

Acknowledgment
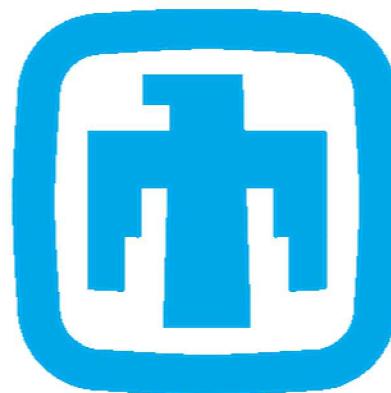
Modeling Capability Advancements

Macro-Scale Part Mechanics

Micro-Scale Asperity Contact
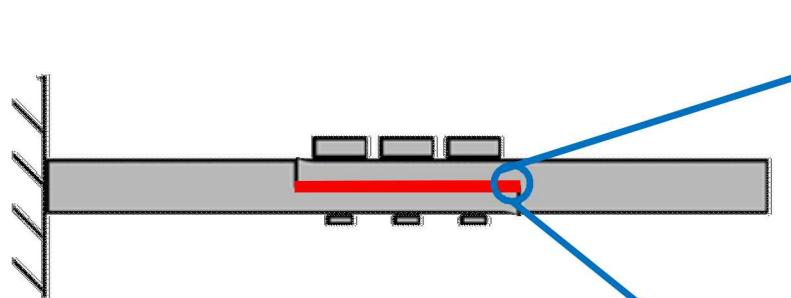
Disparate Length Scales

Body 1

Body 2
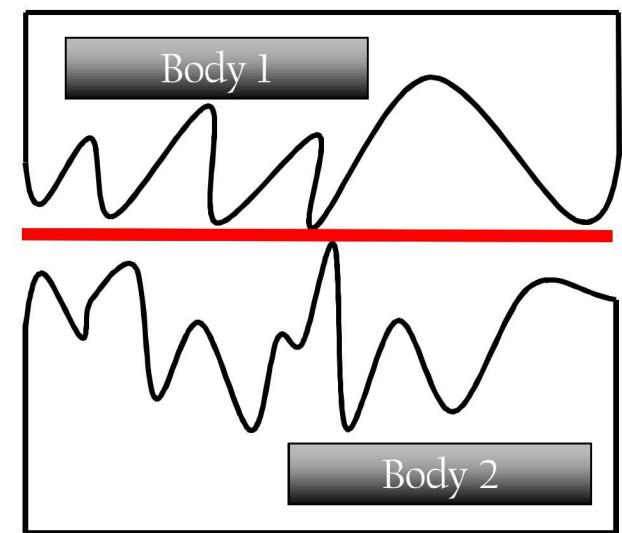
Modeling Capability Advancements

Micro-Scale Asperity Contact

Body 1

Body 2

Masing/Iwan Model

k_1

ϕ_1

k_i

ϕ_i

k_N

$F(t)$

ϕ_N

$u(t)$
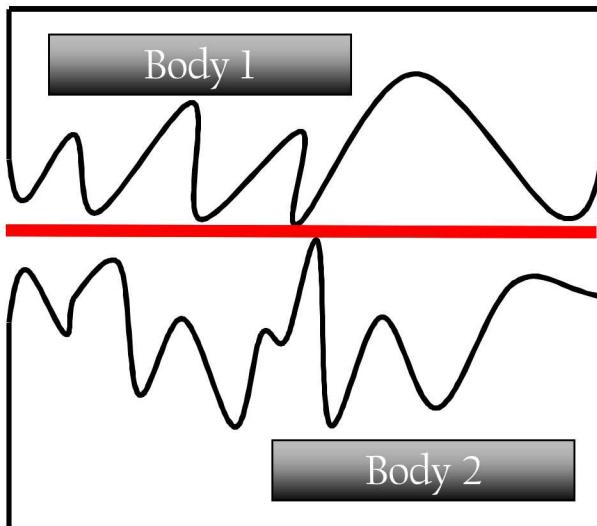
Abaqus VFRIC Subroutines
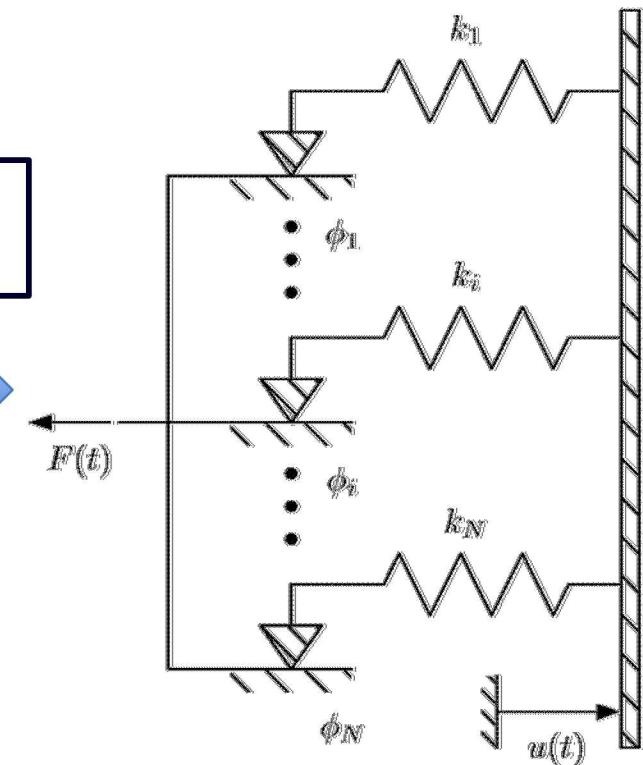
Modeling Capability Advancements

Meta CoE Framework

$$F_{fric} = \min \left(\mu_{meta} \, N \, F_{model}, F_{stick} \right)$$

Model Calibration

Flow
Direction

Calibration
Point

v   u

w
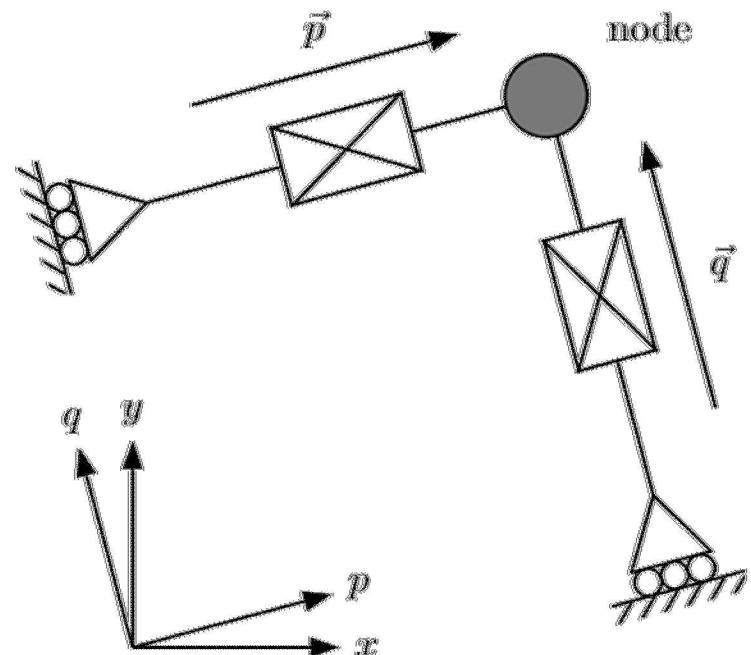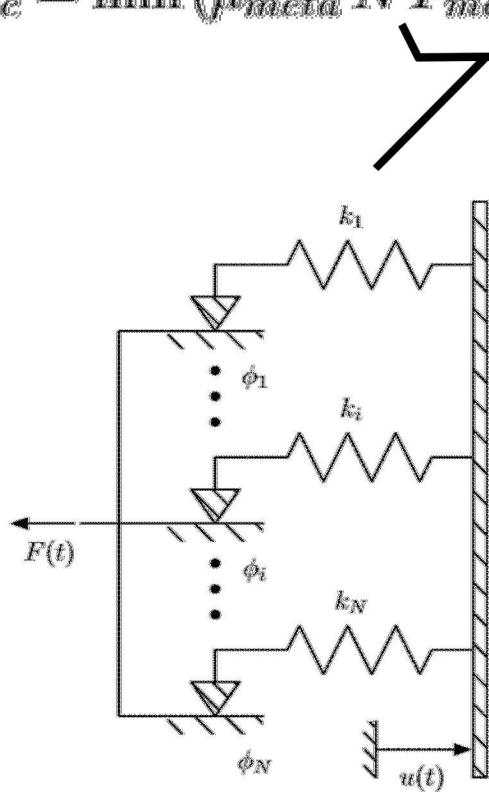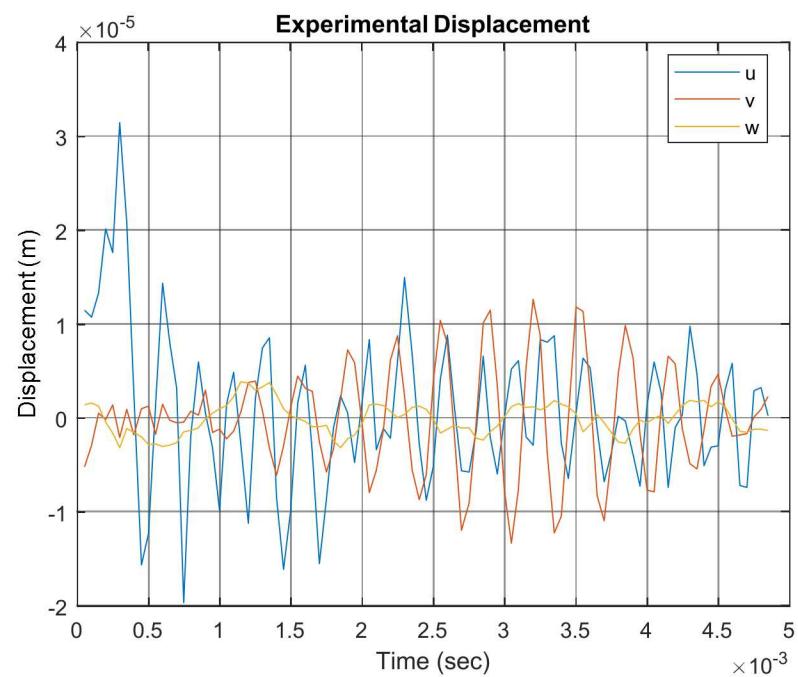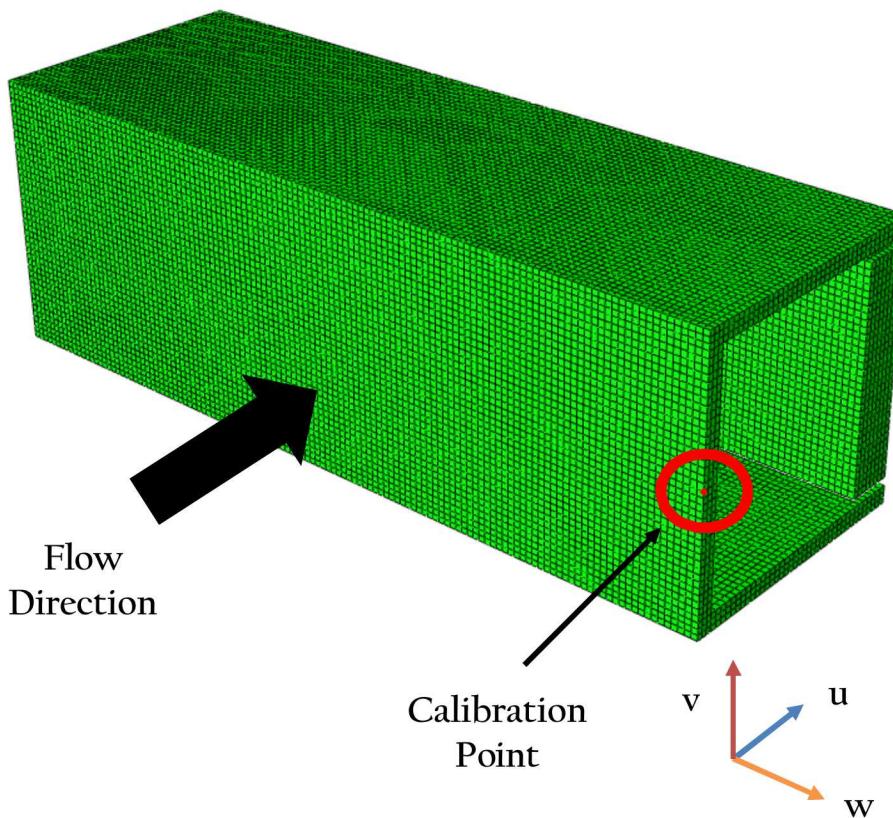
Modal Analysis: Rocking Mode
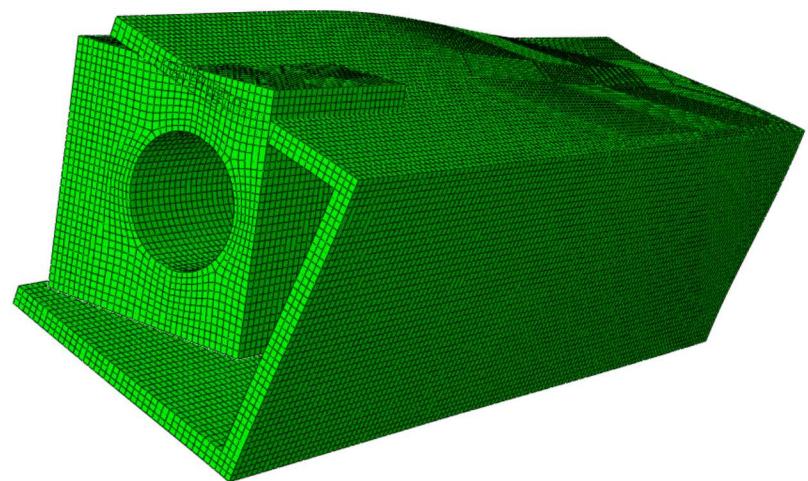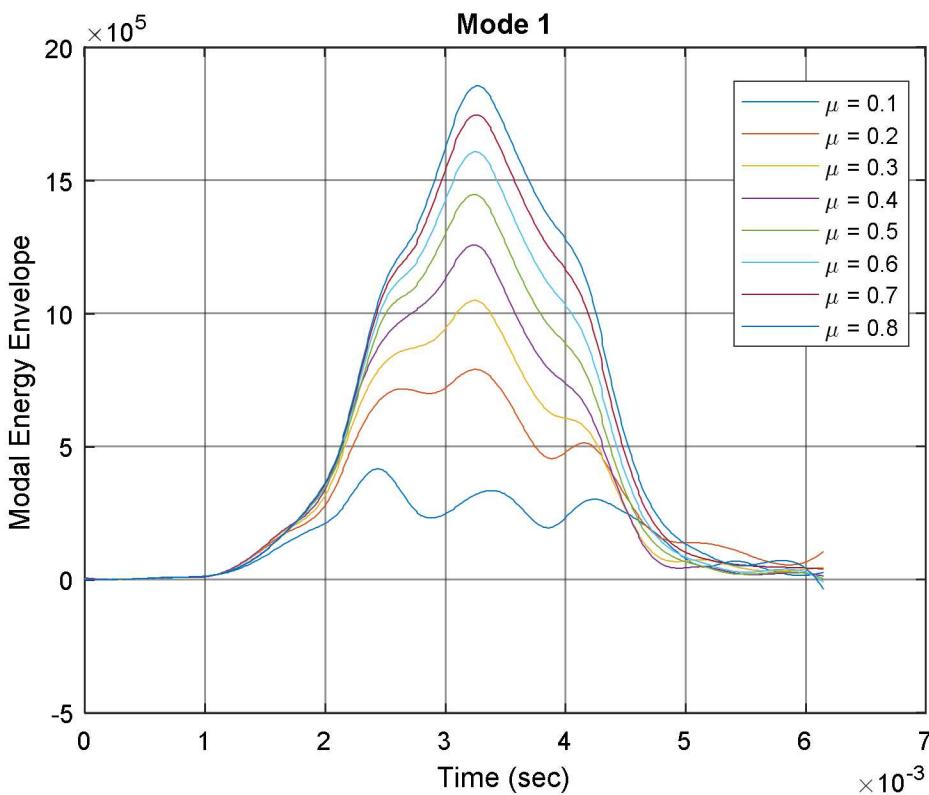
# Modal Analysis: 1ˢᵗ Bending Mode
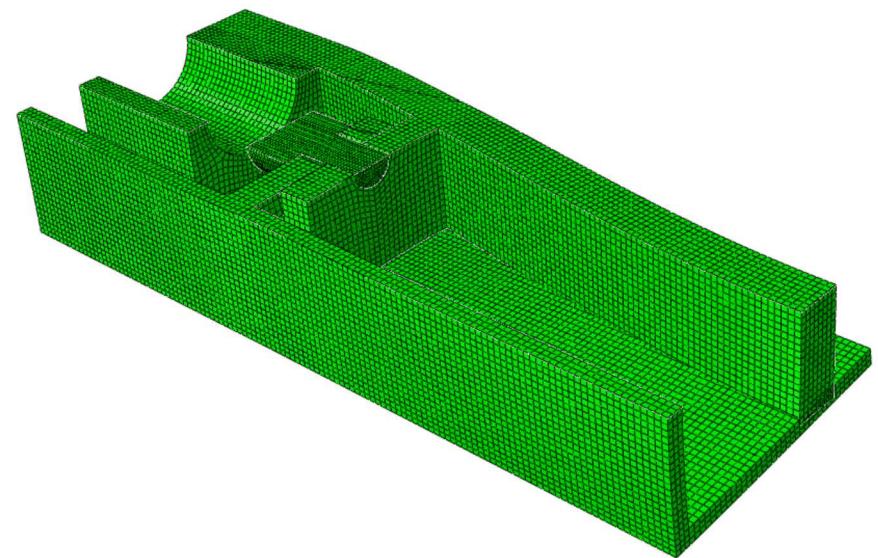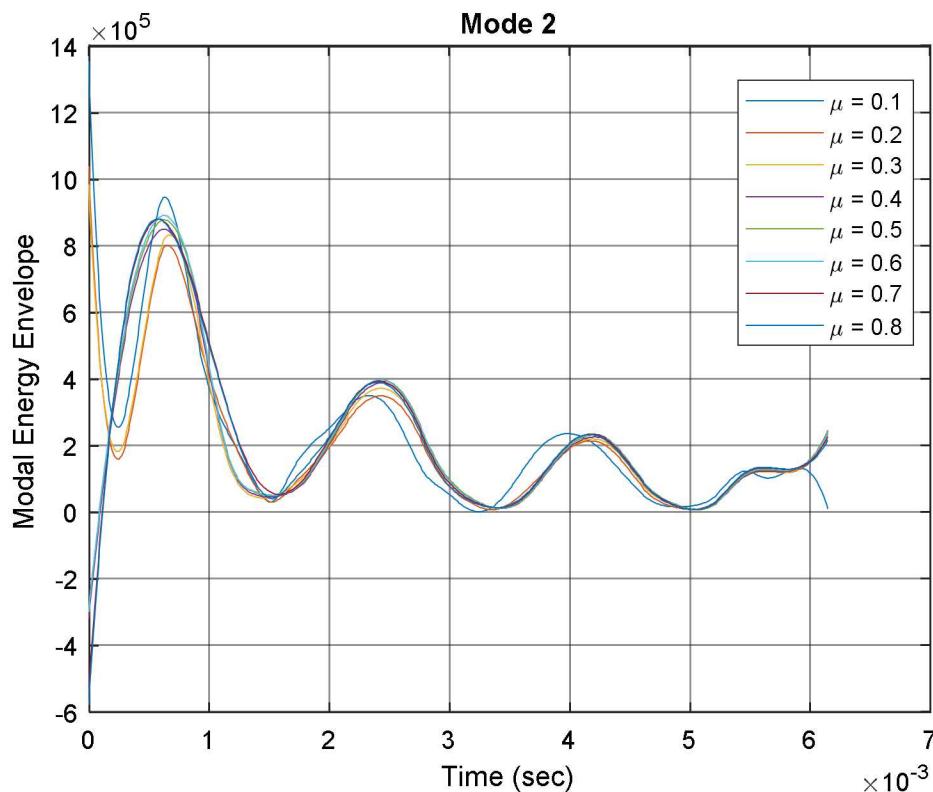
Modal Analysis: 1st Shell Mode
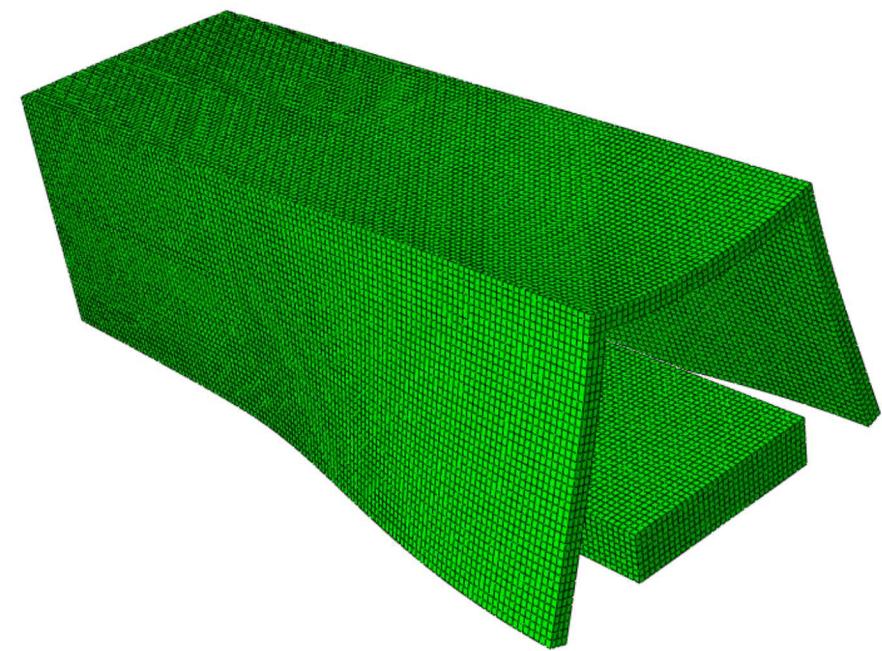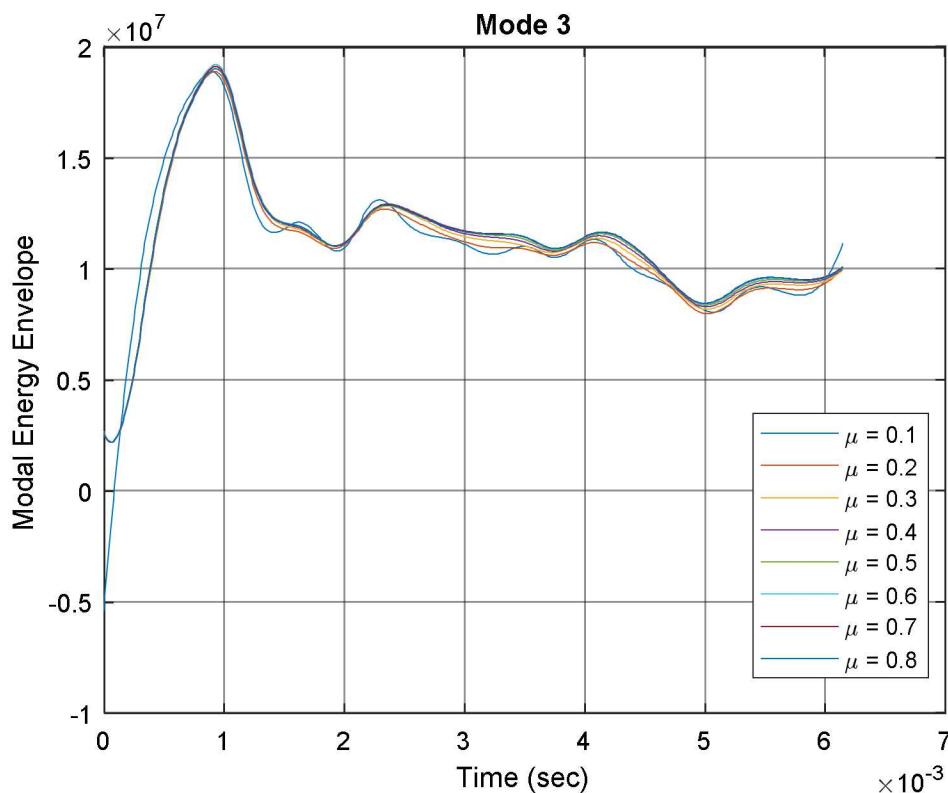
Proper Orthogonal Decomposition
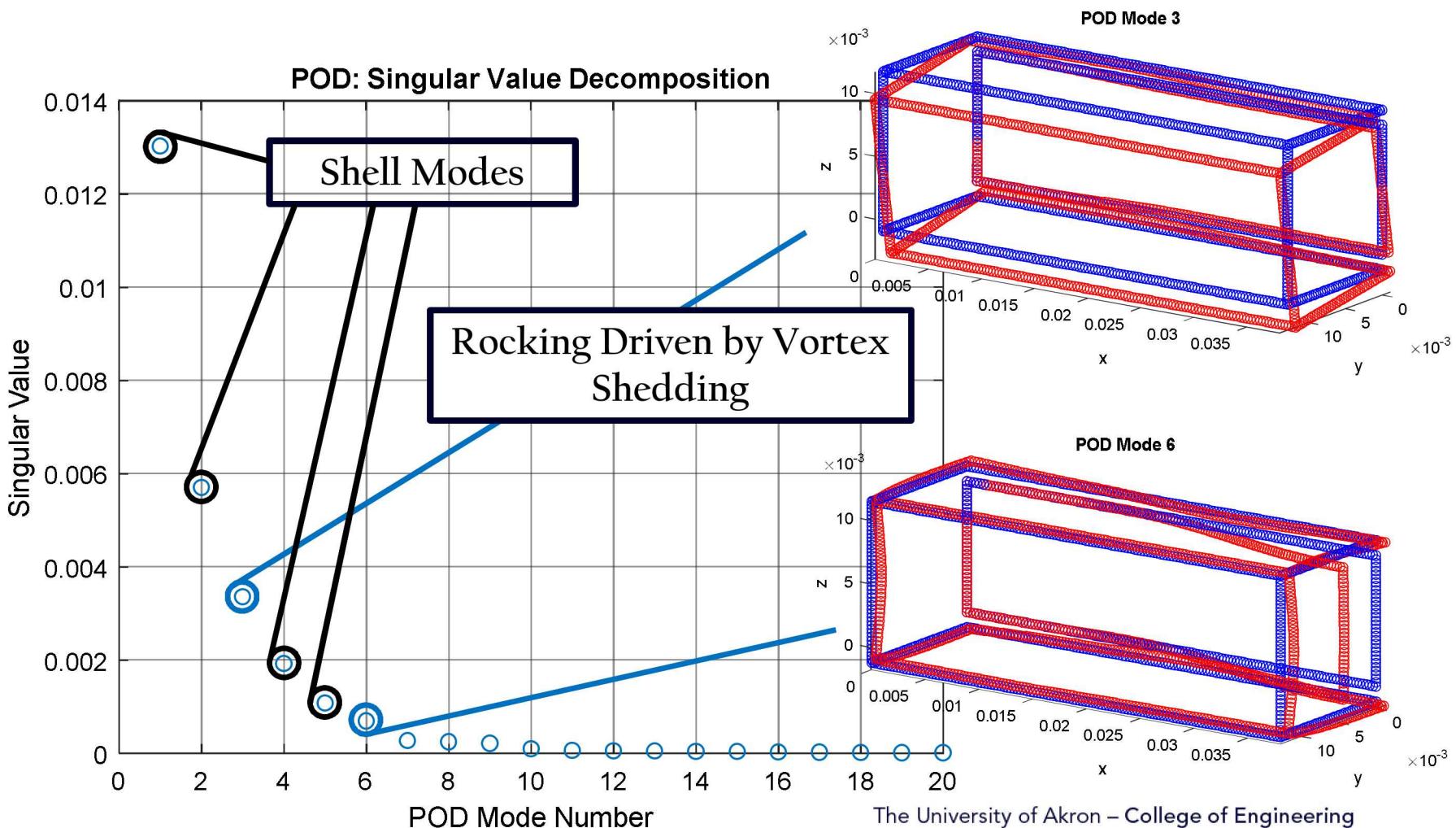
POD: Singular Value Decomposition

Shell Modes

Rocking Driven by Vortex Shedding

Singular Value

POD Mode Number

POD Mode 3

POD Mode 6

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Meta CoF Calibration

- Calibrated to $\mu_{Meta} = 0.5$
  - Good agreement between experiment and FEA

Calibration Point
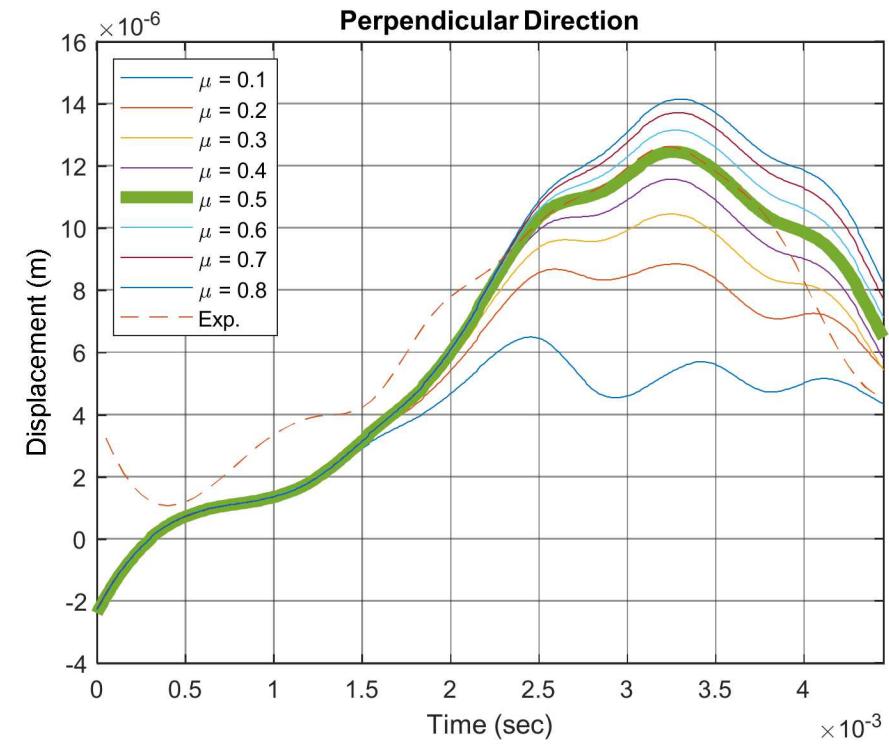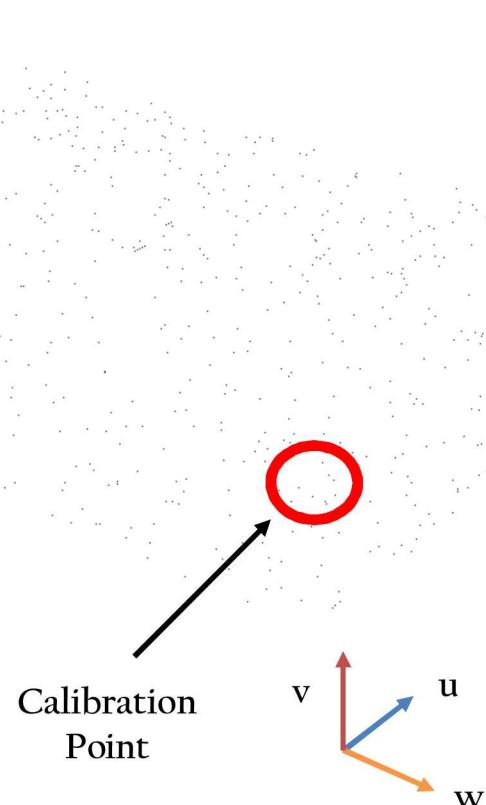
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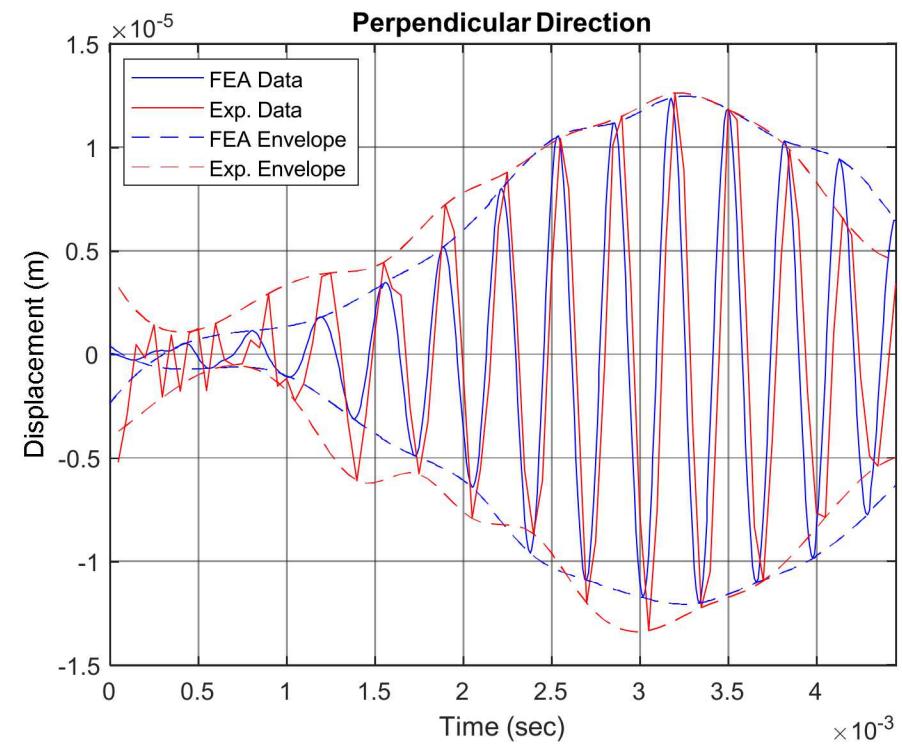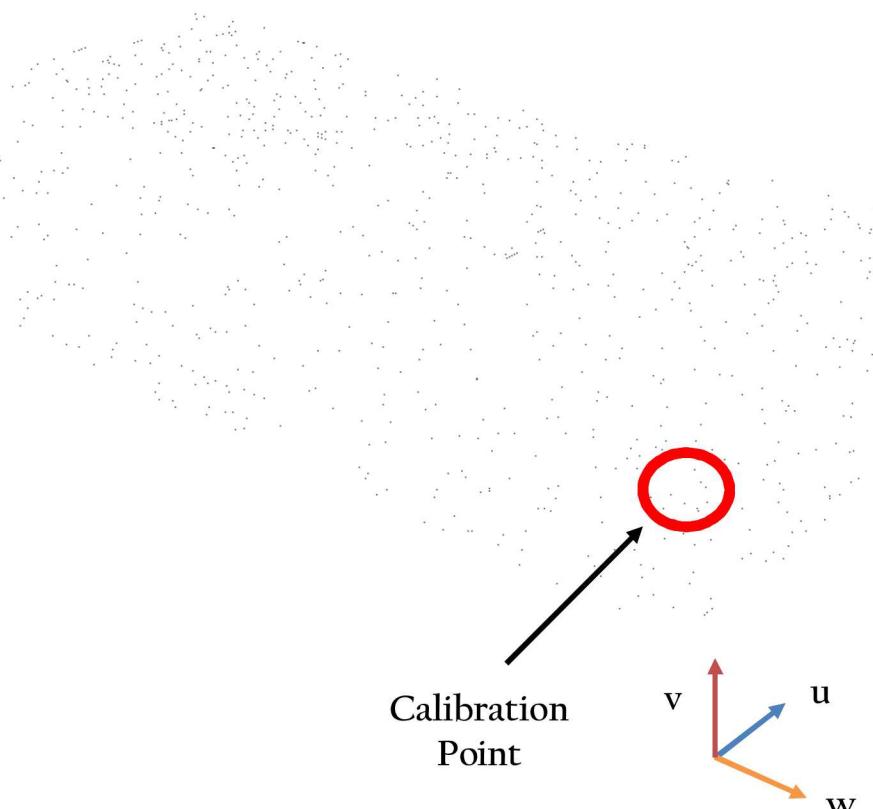

Calibration
Point

Hysteresis Model Calibration

- Calibrated Bouc-Wen Model
 - Adjusted parameter A

$$\dot{z} = \{A - [\alpha \operatorname{sgn}(z\dot{u}) - \beta] |z|^{m}\} \dot{u}$$

- Developed approximate hand-calculations
  - Series-series Iwan model
 - Characteristic displacement

- Fine-tuned using FEA

Bouc-Wen Model

Hysteretic Variable: $z(t)$

Displacement Input: $u(t)$
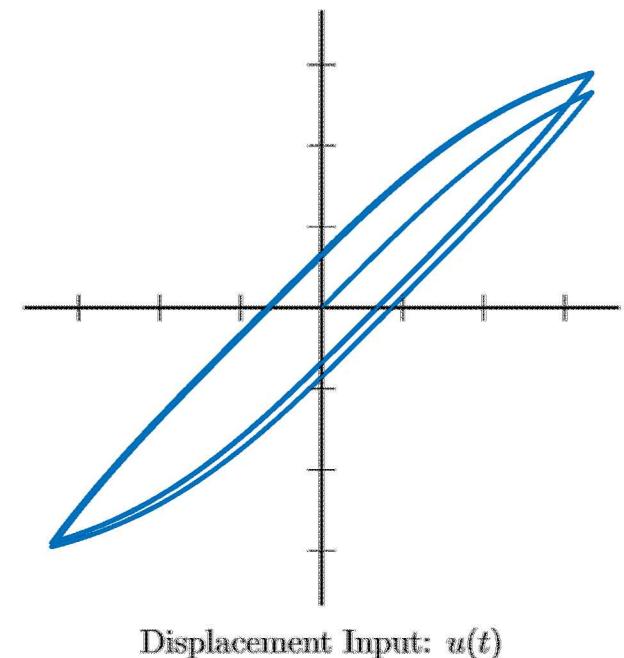
Hysteresis Model Calibration
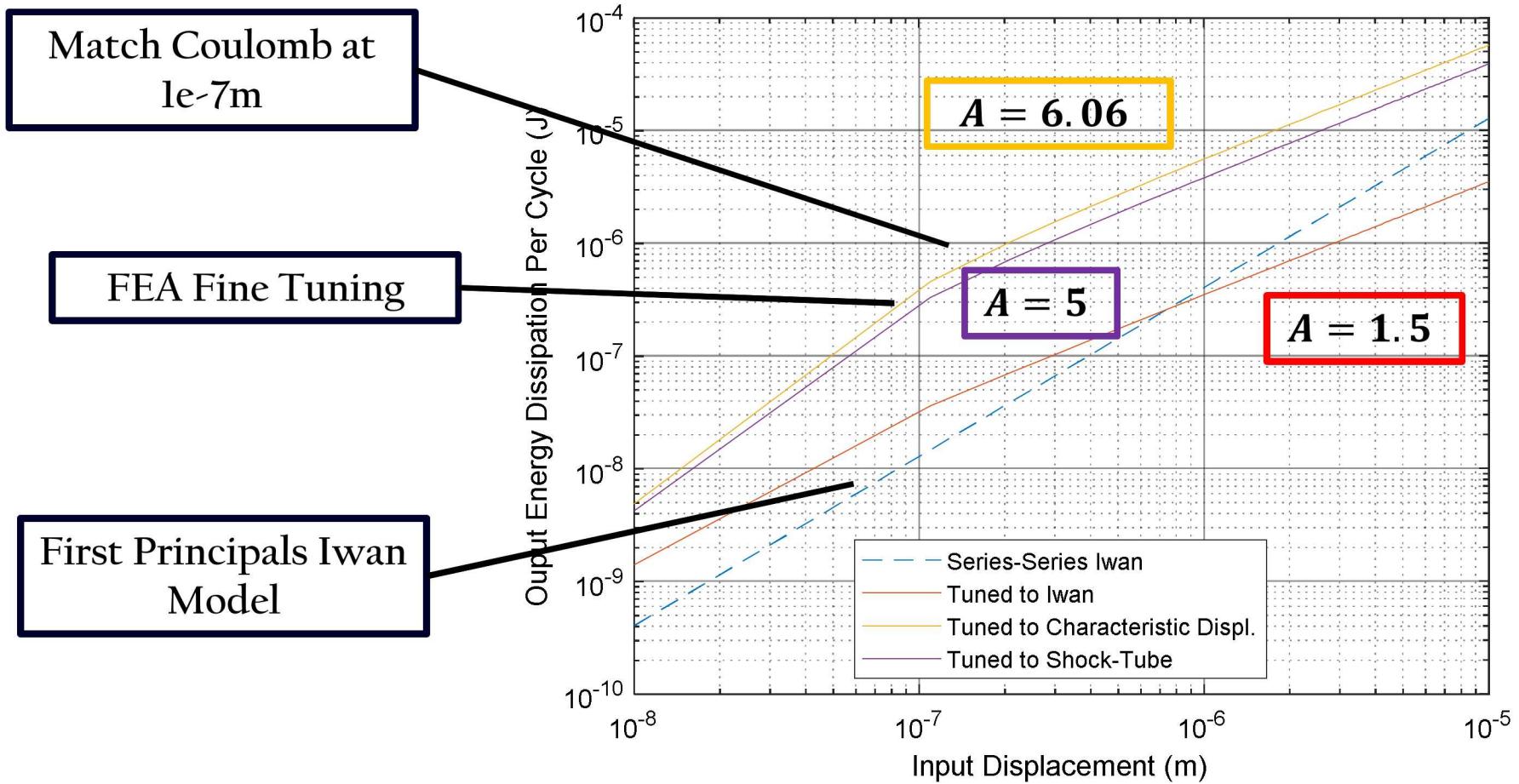
Hysteresis Model Calibration
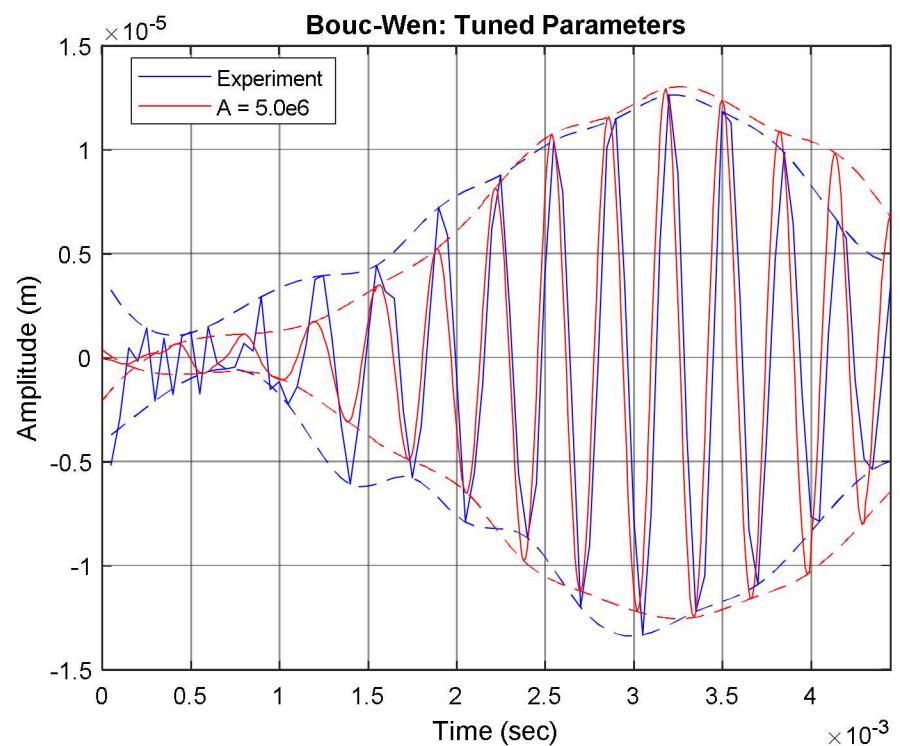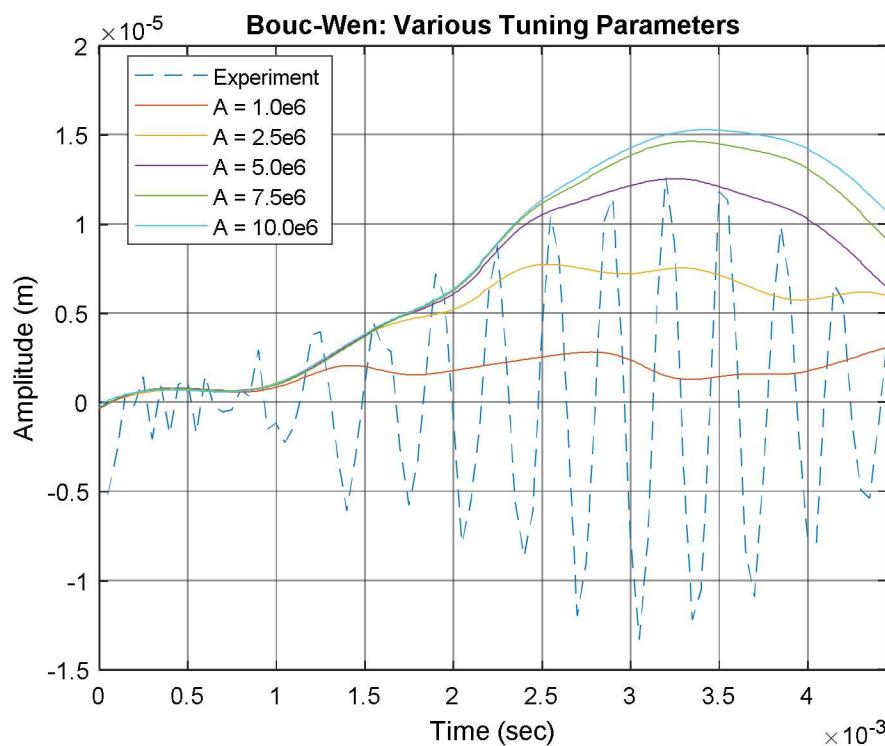
Modeling Conclusions

- Identified dynamics of the structure.
  - Modes of interest to the joint.

- Determined friction parameters.
  - Computational expensive process.
  - Scale up methodology determined.

- Future work identified.

- Final deliverables?

Bouc-Wen: Tuned Parameters