Familiarization of Dynamics of Numerical Benchmarks

TRC 2019 Project 2 WP 2 Homework Assignment 1

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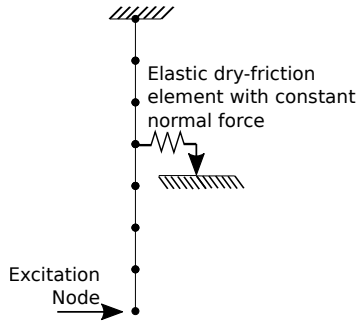
Outline

System 1 - Cantilevered Beam with Elastic dry friction

System 2 - Systems with Polynomial Nonlinearities
- Flat Clamped-Clamped Beam
- Curved Clamped-Clamped Beam

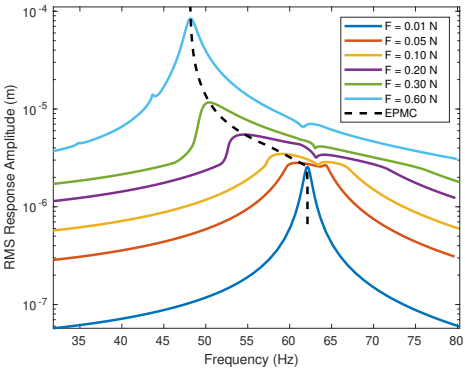
Section 1

System 1 - Cantilevered Beam with Elastic dry friction

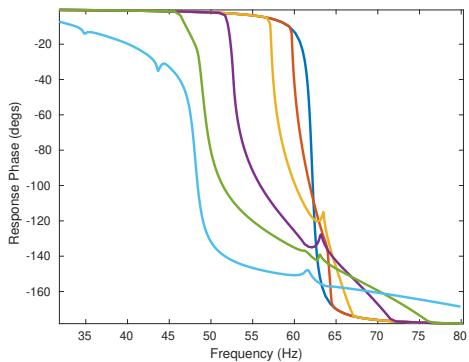


Cantilevered Beam with Elastic dry friction

- Forced response and nonlinear modal backbone characterized for system using the given parameters



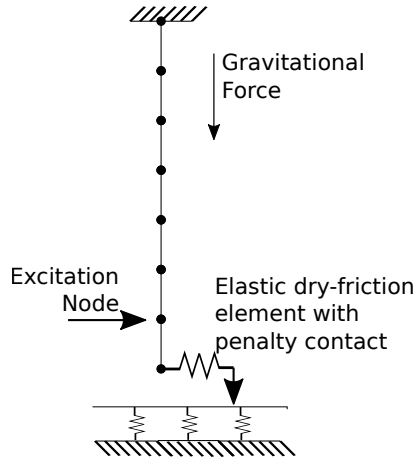
(a) Amplitude



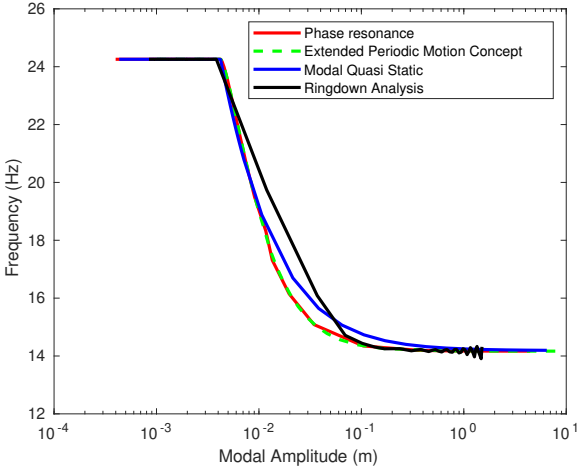
(b) Phase

Cantilevered beam with elastic dry friction I

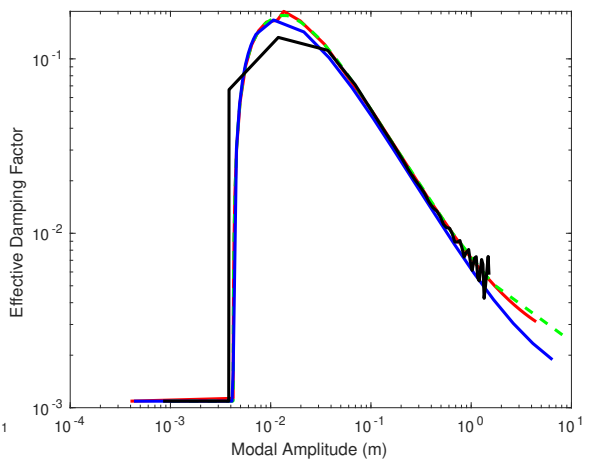
- I'm now presenting some work I've done on a similar system
- This compares backbone estimation from 4 different methods:
  1. Phase resonance
  2. EPMC
  3. QSMA
  4. Ringdown analysis



Cantilevered beam with elastic dry friction II



(a) Frequency Backbone



(b) Damping factor Backbone

Rate form of Elastic Dry Friction (SDOF Case)

$$m\ddot{x} + c\dot{x} + kx + z = f_{ex}(t) \tag{1}$$

$$\dot{z} = \begin{cases} k_t & |z| < f_{slip} \\ 0 & |z| \geq f_{slip} \end{cases} \tag{2}$$

- The above model is valid only when the frictional element never separates, i.e., $f_{slip} > 0$ always
- This is the case for the considered cantilevered system with friction

Section 2

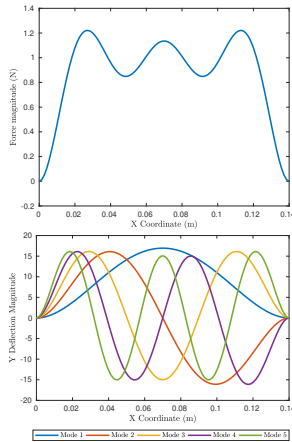
System 2 - Systems with Polynomial Nonlinearities

Subsection 1

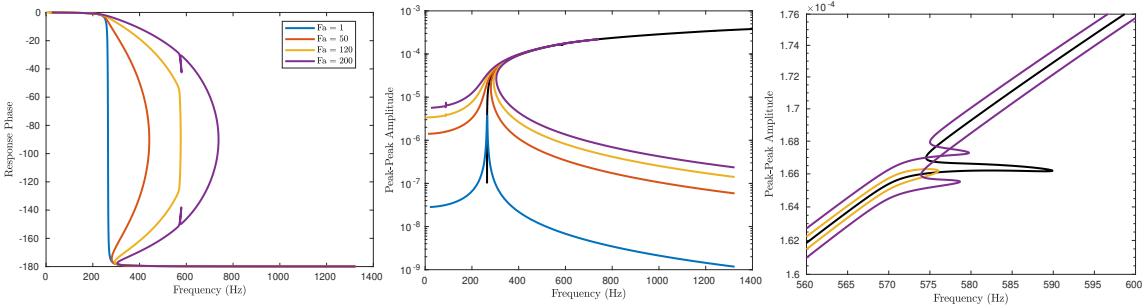
Flat Clamped-Clamped Beam

Geometrically Nonlinear Flat Beam I

- Forced response and NMA are conducted for the given system
- Emphasis is placed on amplitude as well as phase of response
- Depicted in the right is the modal forcing for 5 modes considered
- The forcing seems to be non-zero for the odd modes and zero for the even modes

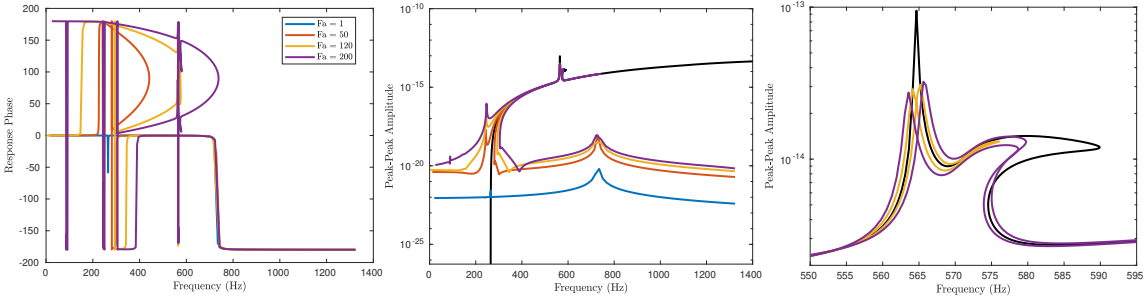


Geometrically Nonlinear Flat Beam II



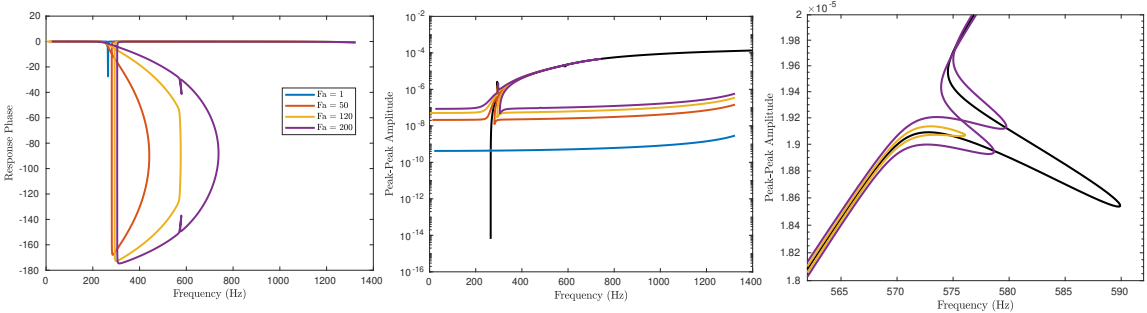
(a) Mode 1

Geometrically Nonlinear Flat Beam III



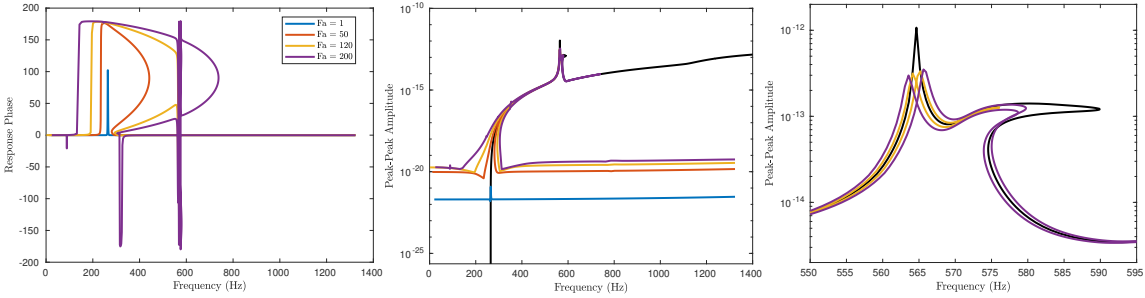
(b) Mode 2

Geometrically Nonlinear Flat Beam IV



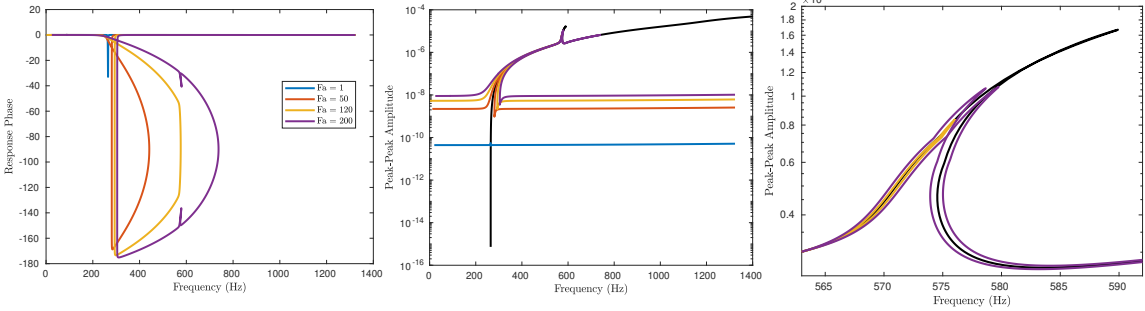
(c) Mode 3

Geometrically Nonlinear Flat Beam V



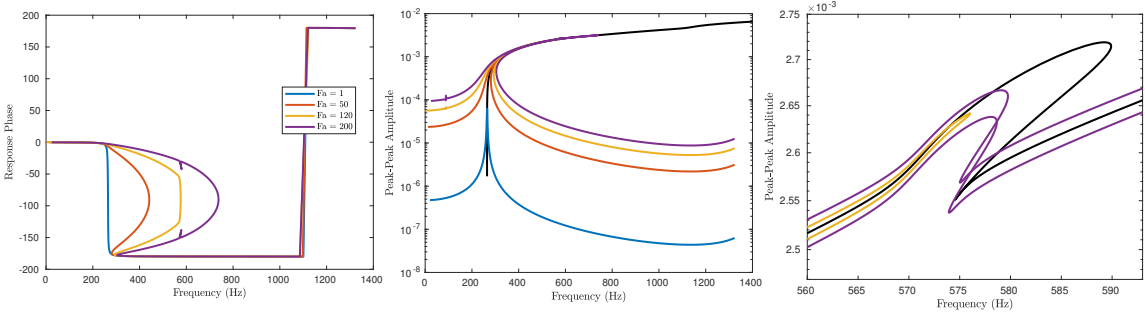
(d) Mode 4

Geometrically Nonlinear Flat Beam VI



(e) Mode 5

Geometrically Nonlinear Flat Beam VII



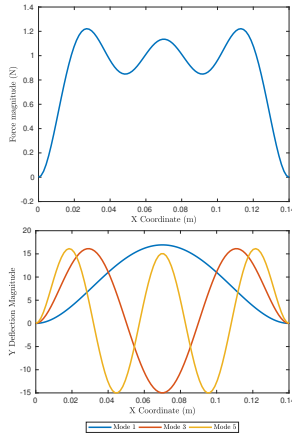
(f) Mode 6

Subsection 2

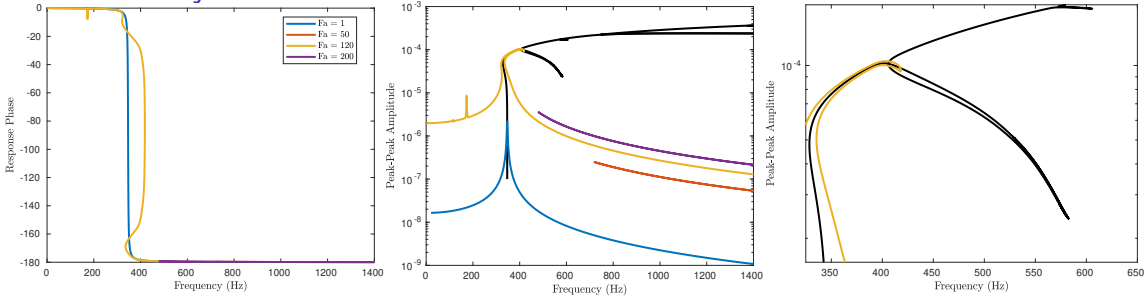
Curved Clamped-Clamped Beam

Geometrically Nonlinear Curved Beam I

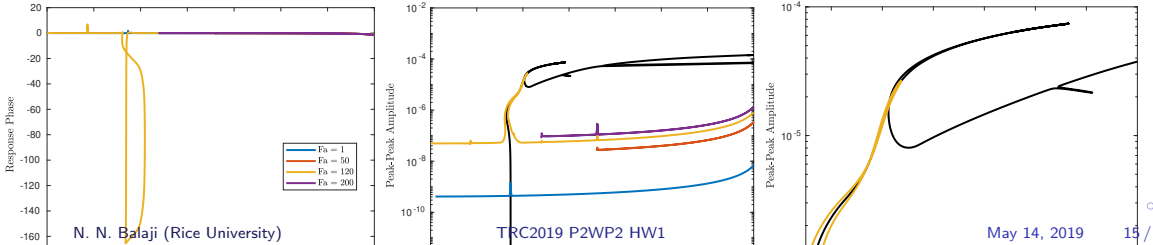
- Forced response and NMA are conducted for the given system
- Emphasis is placed on amplitude as well as phase of response
- Depicted in the right is the modal forcing for 5 modes considered
- The forcing seems to be non-zero for the odd modes and zero for the even modes



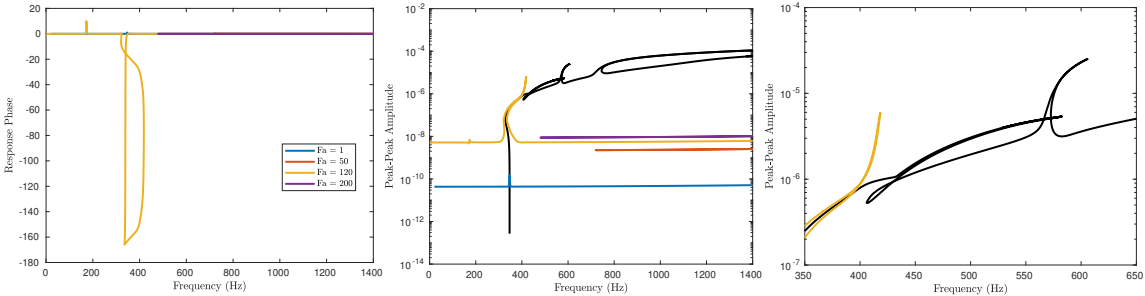
Geometrically Nonlinear Curved Beam II



(a) Mode 1



Geometrically Nonlinear Curved Beam III



(c) Mode 3