Initial Investigation of Damping using ANSYS

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G-1800233-v3

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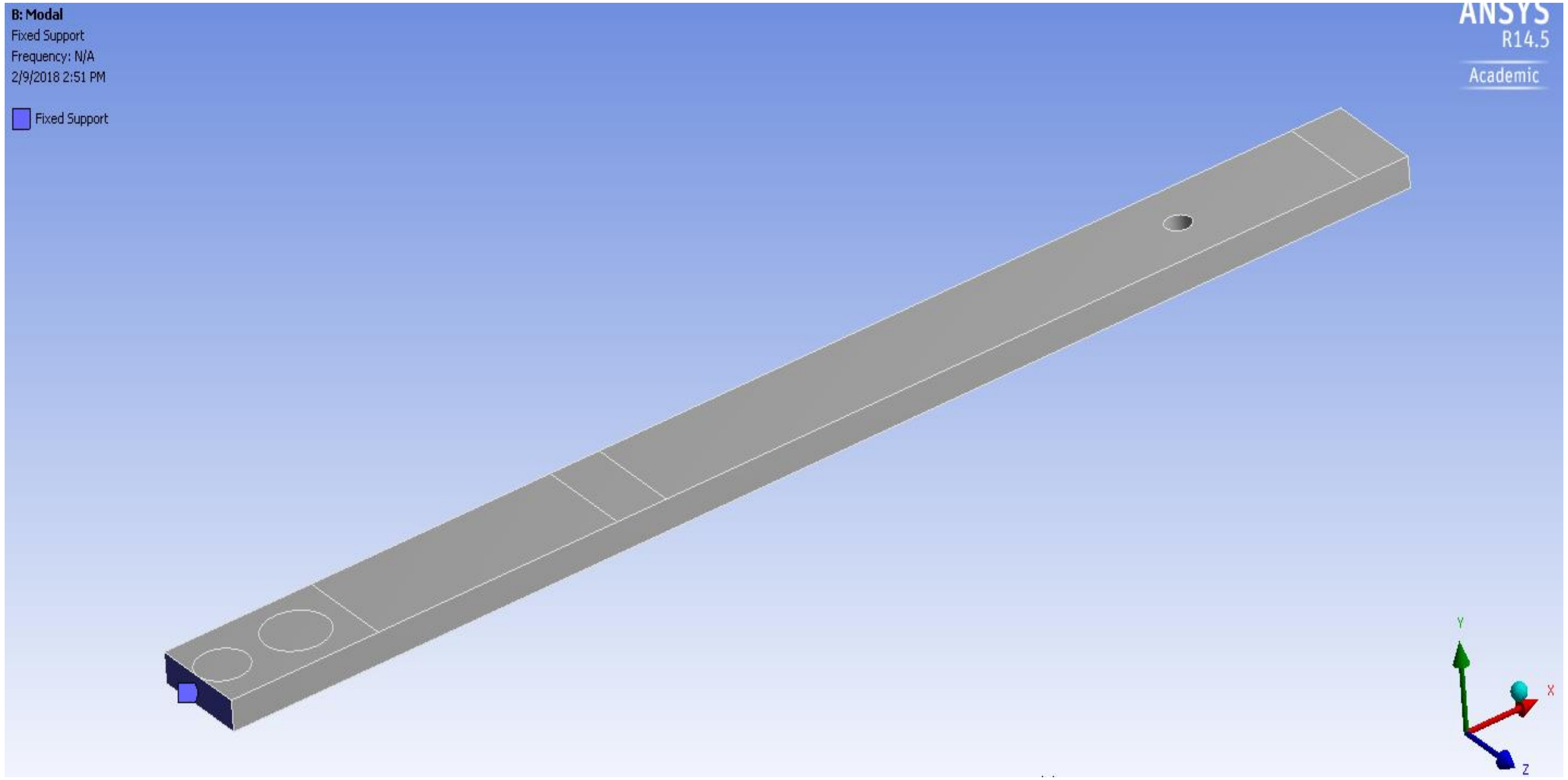
Can be accessed on computer m49

Outline

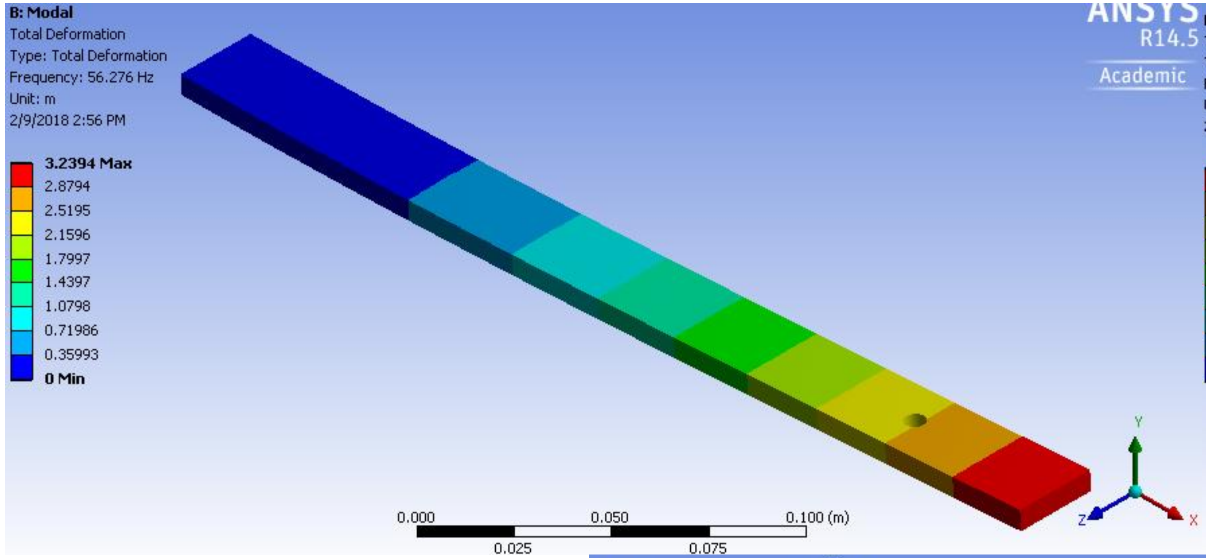
- Undamped Cantilever with hole, modal analysis
- Damped Cantilever with hole, modal analysis
- Harmonic Analysis of damped cantilever
  - $b = \{0, 0.546, 2.73\}\frac{N*s}{m}$
- Damping as a function of cantilever mass
- Future steps (vibration absorber parameters)

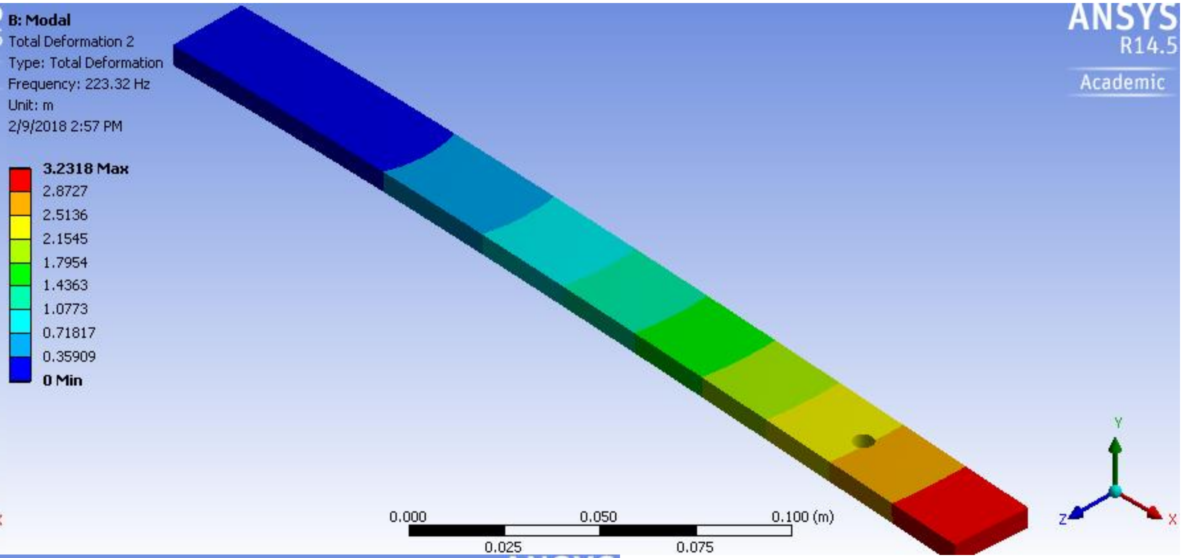
Individual Analysis of the Cantilever

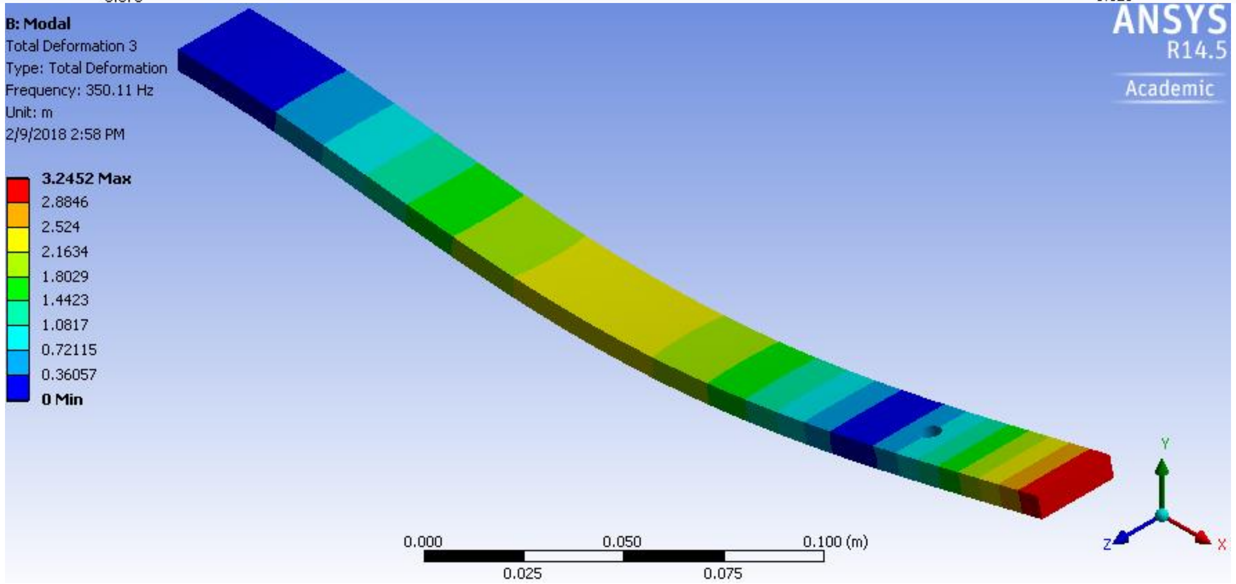
- Modal Analysis setup
- Note the fixed supports, these were used on all implementations of the cantilever.
- Cantilever mass = 0.384 kg
- Credit to Cormac for slide.



Modes: Undamped Cantilever with Hole





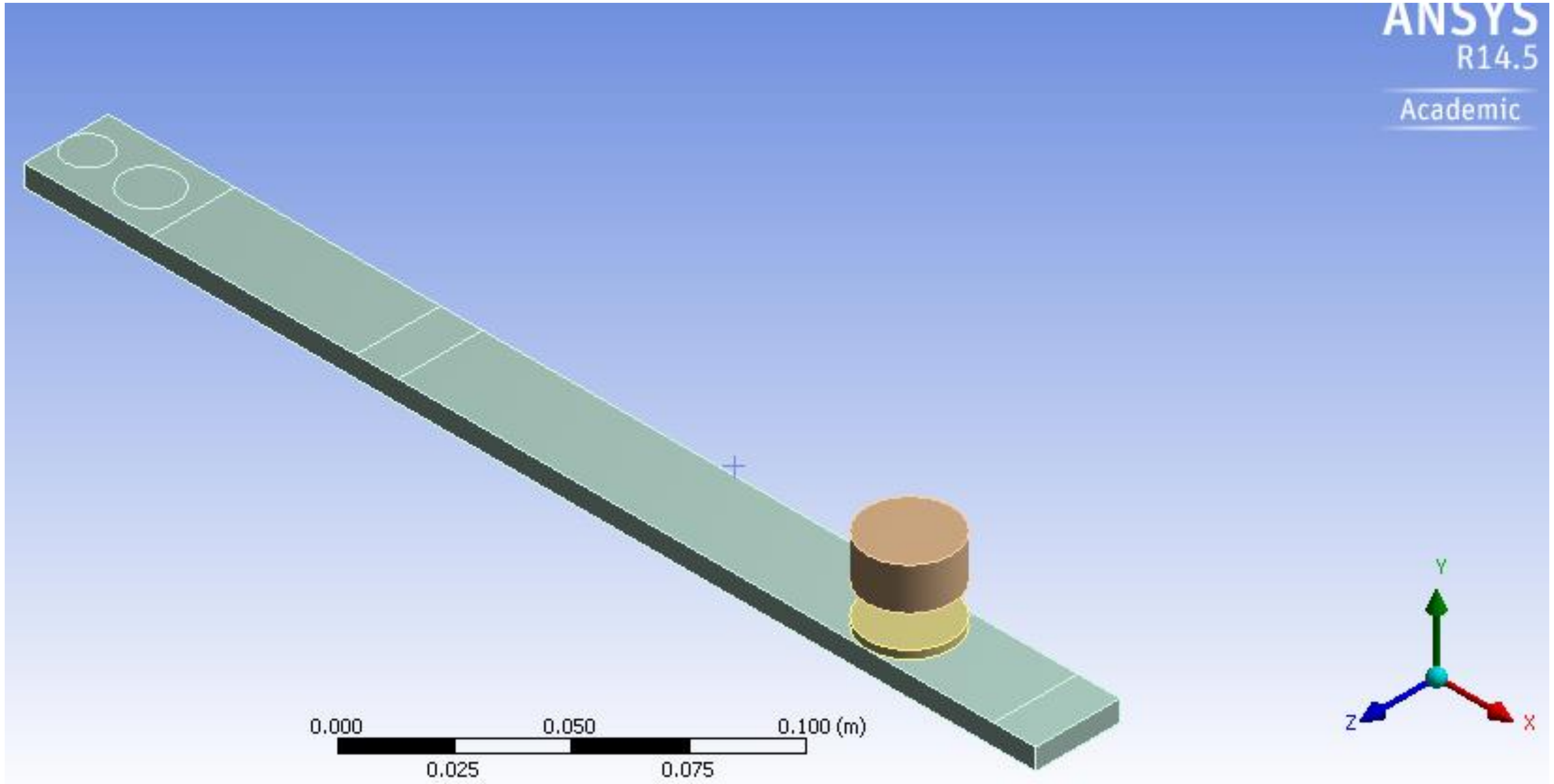


Modes: Undamped Cantilever with Hole

Mode #	Frequency [Hz]	Motion
1	56.27	Y-direction
2	223.32	Z-direction
3	350.11	Y-direction

Individual Analysis of the Cantilever w/ Damper

- Second Modal Analysis setup
- Fixed Support the same as before
- Damper mass = 0.060 kg
  - Total mass = 0.444 kg



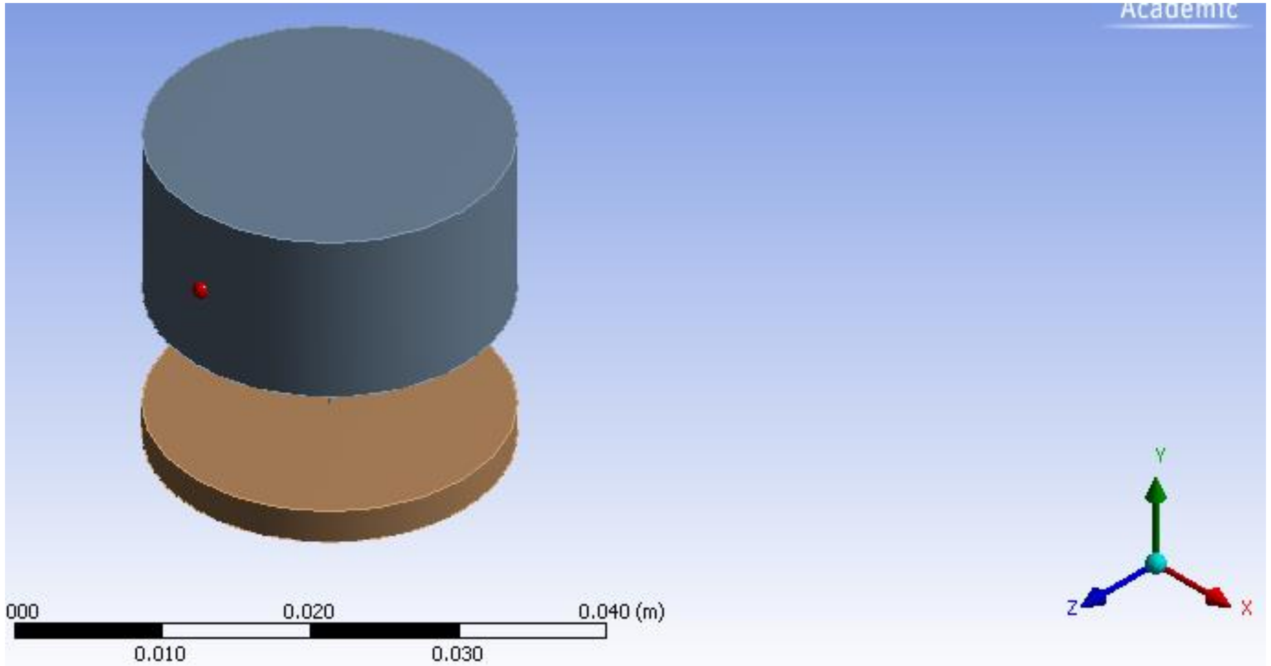
Modes: Cantilever w/Hole and Damper

Mode #	Frequency [Hz]	Motion
1	29.3	Y-direction (symmetric)
2	58.2	Y-direction (anti)
3	216.6	Z-direction

Note: “symmetric” and “anti-symmetric” occur with respect to the cantilever beam and damper unit motion.

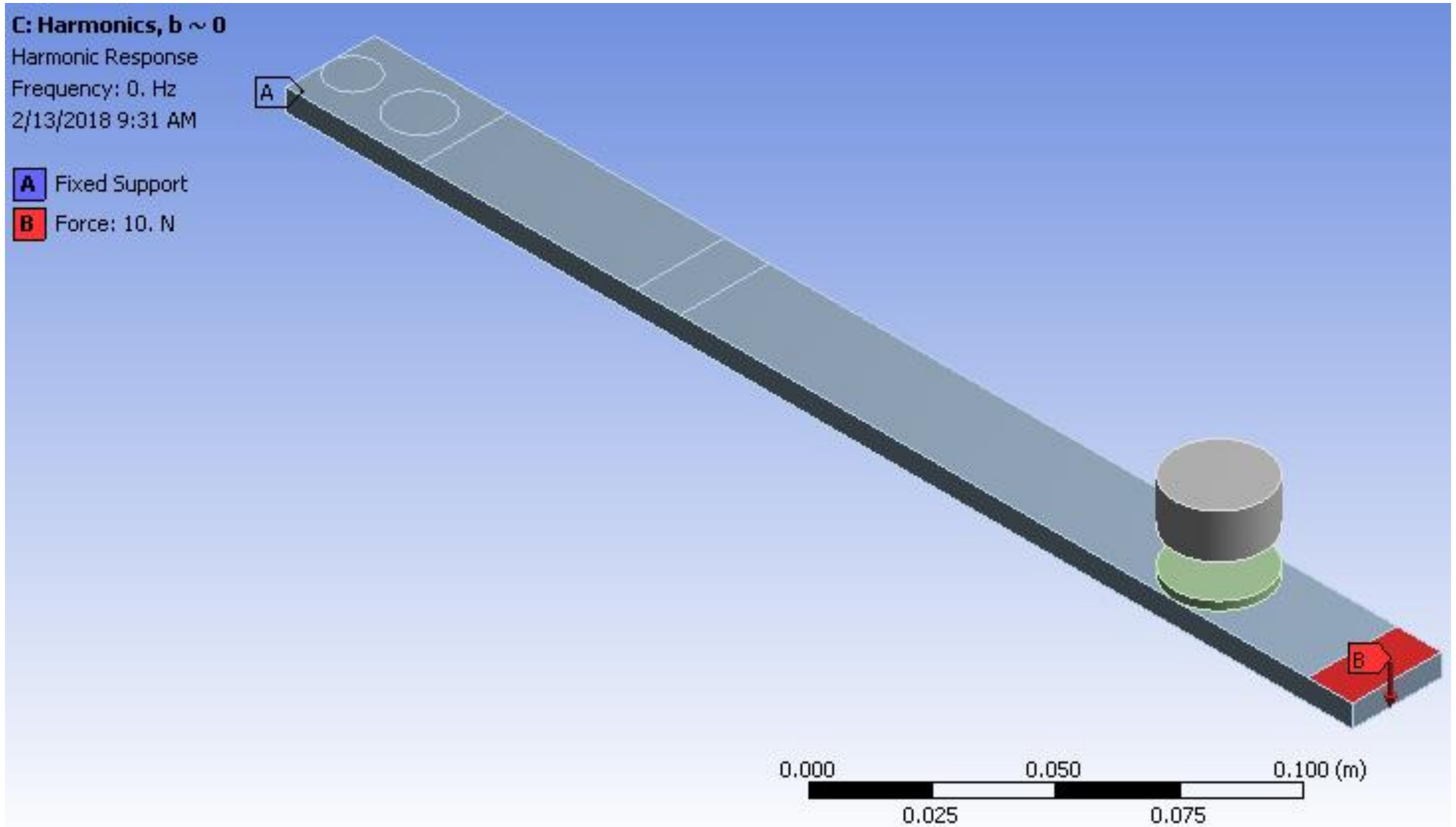
Modal Analysis: Damper Only

- Damper unit only, mass = 0.0606 kg
- Resonance at $f_0 = 31.19\ Hz$
  - In y-direction



Harmonic Analysis Setup: Cantilever w/ Damper

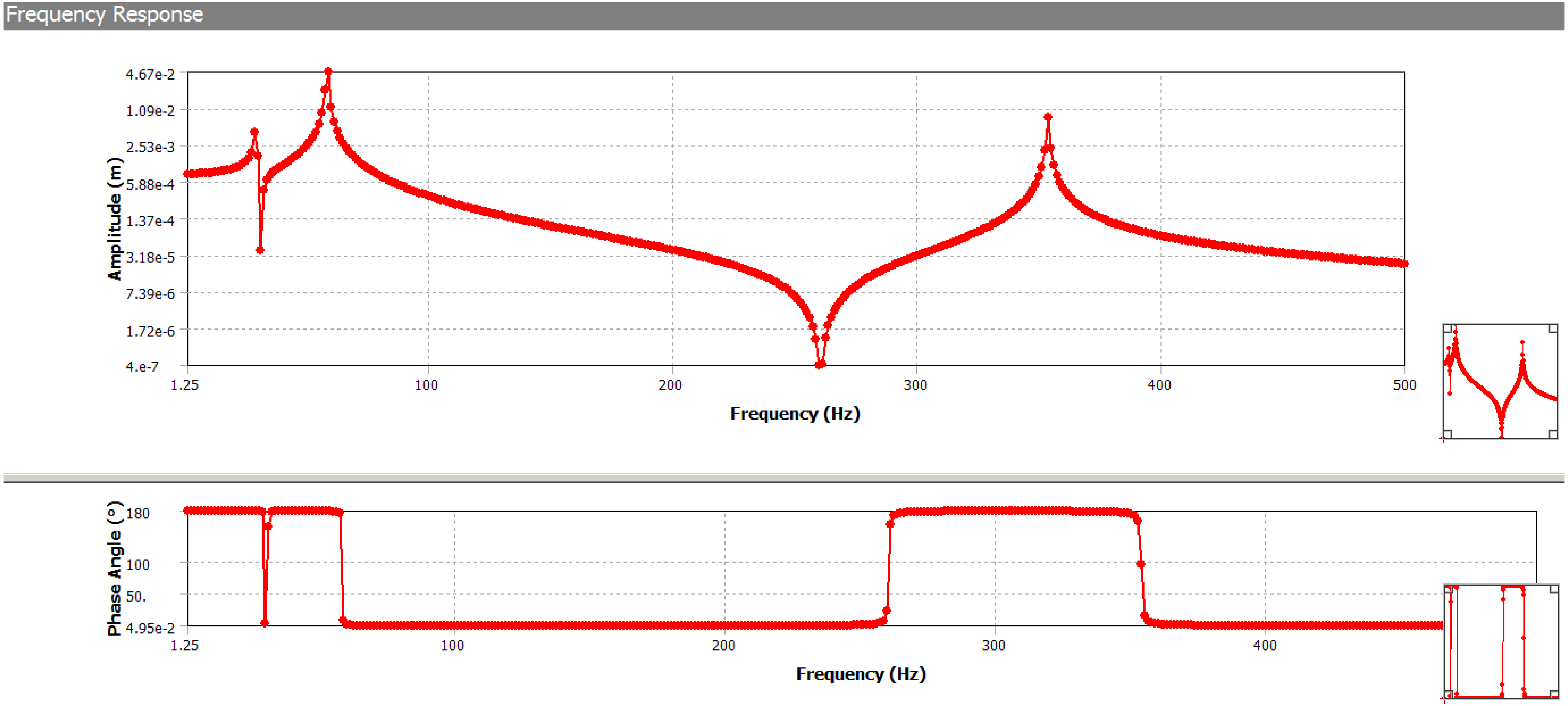
- Cantilever with damper subject to harmonic analysis
- Note fixed support at back (same as before) and applied force



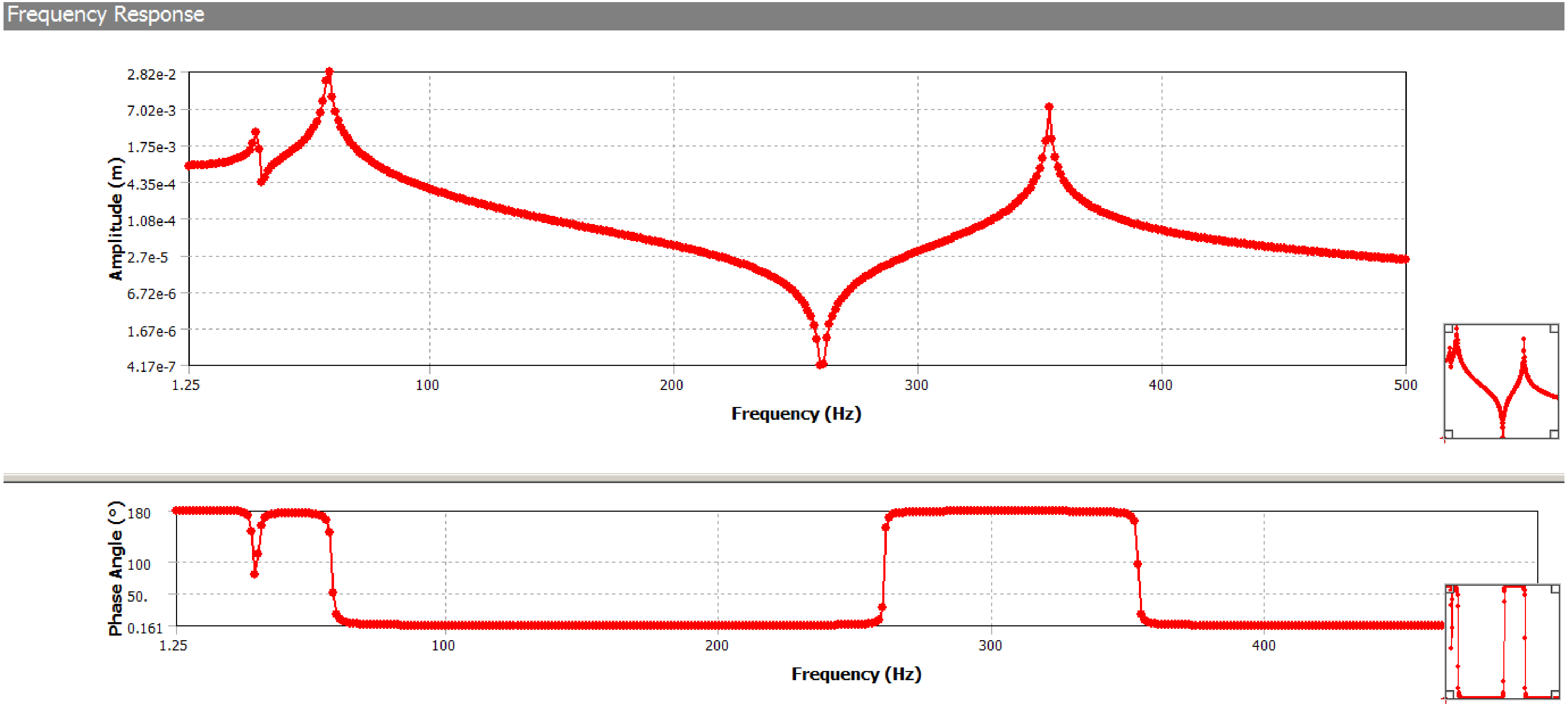
Harmonic Analysis Setup: Cantilever w/ Damper

- Three test cases:
  - $b \sim 0 \frac{N*s}{m} \rightarrow Q \rightarrow Infinity$
  - $b = 0.546 \frac{N*s}{m} \rightarrow Q = 50$
  - $b = 2.73 \frac{N*s}{m} \rightarrow Q = 10$
  - $b = \frac{\sqrt{m*k}}{Q}$; altered Q w.r.t. bar mass to arrive at initial b values
- All other variables constant; $k = 1942 \frac{N}{m}$ (taken from prior analysis by Cormac O’Neill, G-1701054)
- Full solution model used to perform analysis

Results, $b \sim 0 \frac{N*s}{m}$

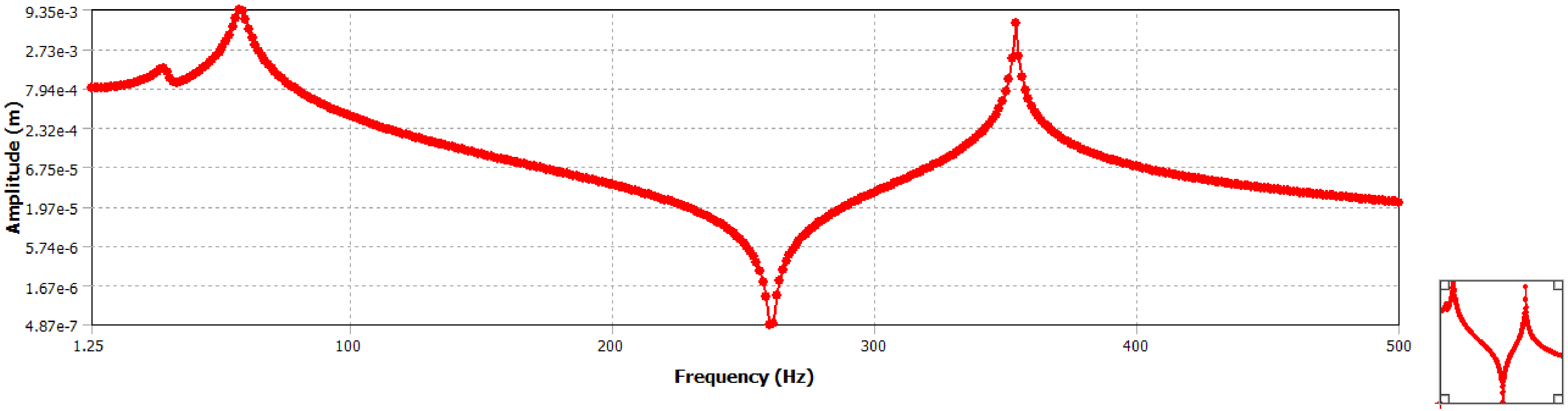


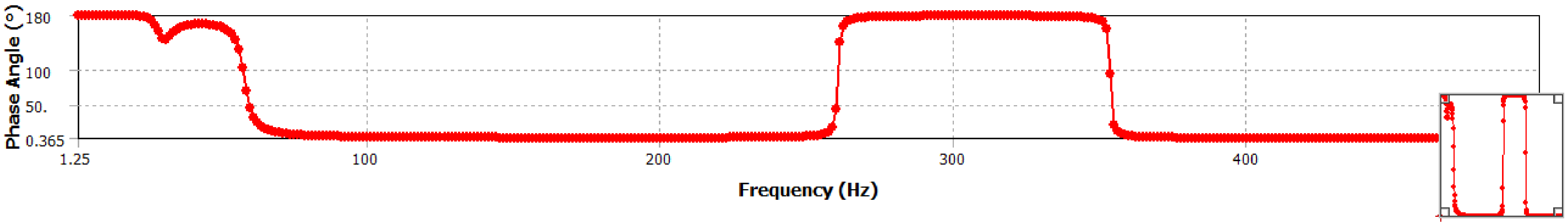
Results, $b = 0.546 \frac{N*s}{m}$



Results, $b = 2.73\frac{N*s}{m}$

Frequency Response





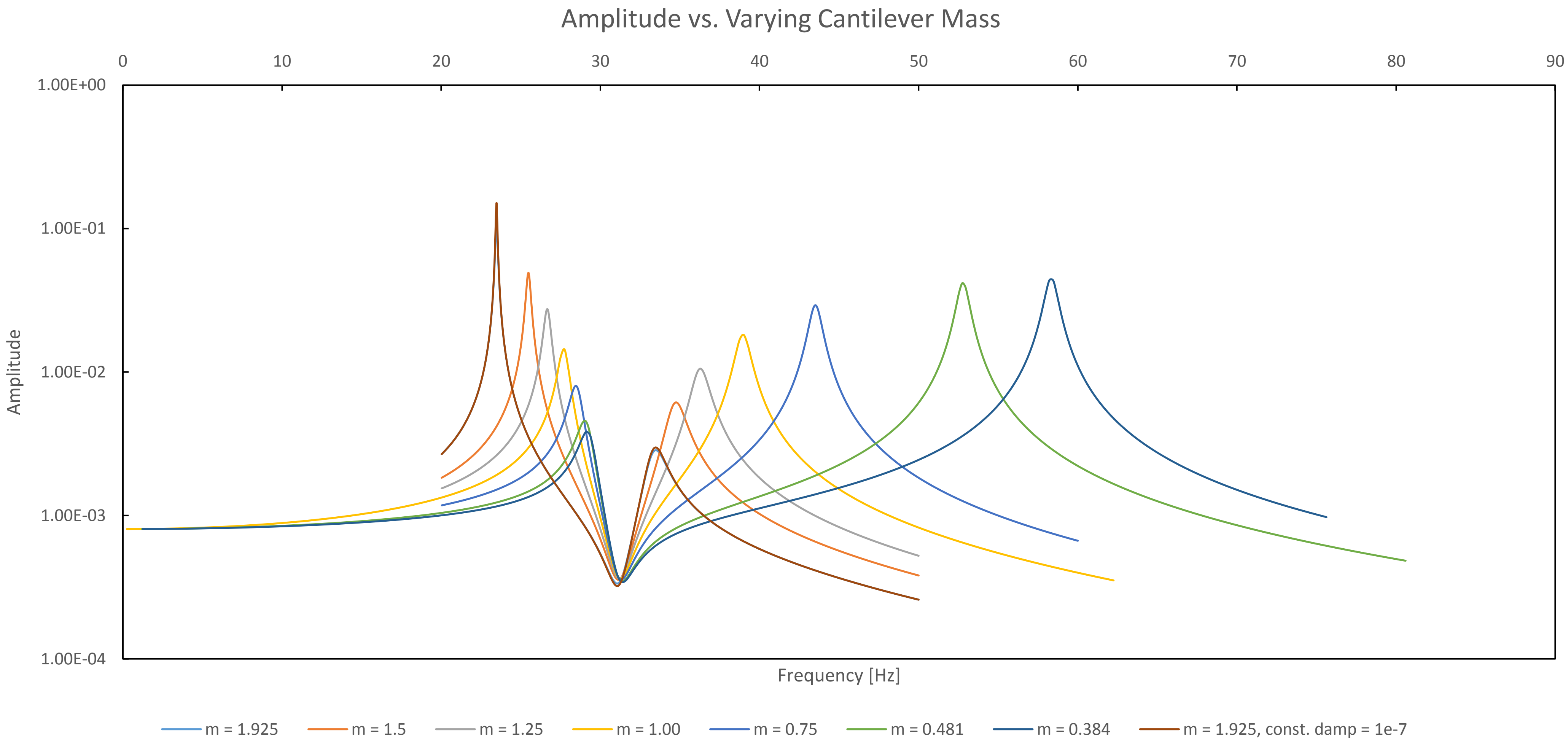
Conclusions: Harmonic Analysis

- From initial inspection, amplitude of frequency curve decreases overall
- Sharpness in phase transition decreases as damping coefficient increases
  - Indication that damping correlates with b, as desired
- Conclusions match those seen in prior investigations

Damping as a Function of Cantilever Mass

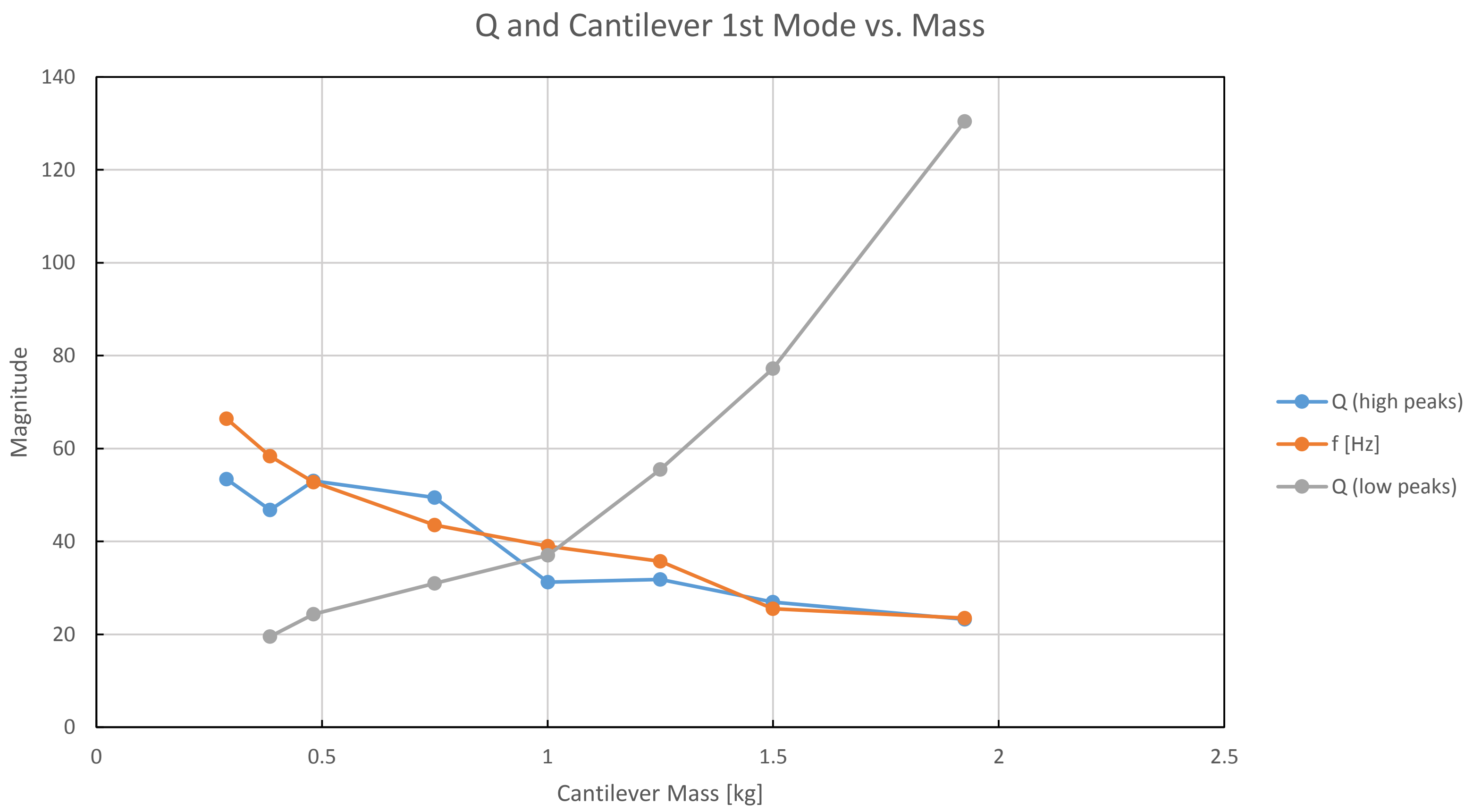
- Mass of cantilever changed by varying its density
- Predefined b = $0.421\,\frac{N*s}{m}$, k = $1942\,\frac{N}{m}$
  - Legacy numbers used for consistency, but strong evidence that these may not be accurate
- Parameters specified such that Q = 25 at damper resonance

Damping w.r.t. Cantilever Mass: Amplitudes



Damper frequency $f_d = 31.19$ Hz. Low peaks (20-30 Hz) correspond to cantilever frequency; high peaks to damper frequency. Lines correspond to varying mass of cantilever (in kg).

Damping as a Function of Mass



- Original cantilever mass $m_0 = 0.384$ kg and mass of damper $m_d = 0.06\ kg$; simulation ranged from $0.75 * m_0$ to $30 * m_0$. Resonant frequency of damper $f_d = 31.19$ Hz.

Conclusions: Damping as a Function of Cantilever Mass

- Varying cantilever mass with constant damper mass led to inconclusive results
  - Damper mass in close proximity to cantilever mass introduced coupling effects, seen in amplitude graph – damper peaks were much higher than expected when the ratio of cantilever:damper mass was small (~3-10).
- Damper performance decreased as ratio of cantilever:damper mass increased
  - Damper and cantilever mode frequencies were adjacent at small cantilever mass (due to geometry of cantilever), so Q was smaller than designed-for (Q_{damper} = 25).

Current: Adding Vibration Absorber Parameters to Toy Damper

- Currently attempting to “scale up” (increase dimensions) of toy cantilever-damper model
  - Increasing (and altering) dimensions of cantilever done to change resonant frequency with goal of targeting ~60 Hz first mode for cantilever model
  - Damper model designed to mimic vibration absorber properties as determined through testing and documentation
    - Start initial simulations with damper model designed for primary frequency $f_0 = 100\ \mathrm{Hz}$ and $\mathrm{Q} = 1.5$

Future Steps

- Vibration absorber parameters can be applied to the damper in the current cantilever-damper system to provide a reasonable analogue to the system of interest
  - Cantilever design has been scaled up to create appropriate first frequency of ~ 57 Hz
  - Damper should be scaled up to match vibration absorber parameters more closely
    - Even using parameters mimicking vibration absorber performance (per previous slide), ANSYS mass-spring toy damper model as currently designed (taken from previous work) did not appreciably damp up-scaled cantilever
      - May potentially be solved by scaling up damper model to match mass of vibration absorber
      - Current work under "Cantilever_VaryingDamperMass.wbpj" ANSYS Workbench file on computer m49