Astro 331 Prelab 5: Testing

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Documentation:

- DFAS writing guide (I used to write these instructions—you should read it but don't need to list it in your documentation statement)
- Cite references as necessary, but don't include course notes, course text (SMAD), or these instructions as documentation
- Don't forget to update your own documentation statement when you write your prelab report!

Overview

To validate your modeling of the spacecraft structure, you will predict the fundamental frequency of a cantilever beam in two axes. During the lab, you will witness both a sinusoidal sweep and a random vibration test of the beam. The sinusoidal sweep test should identify the fundamental frequency, and the random vibe test should give information about the beam's response to high loading conditions.

Additionally, you will predict the performance of a component-level thermal test. You will present the predicted thermal profile and comment on your expectations for response of the component (a resistor) throughout the profile. After the lab, you will then be given the data from the vibe tests and the thermal cycle test to plot, analyze and discuss in your final lab report.

Format

Include the sections required in a Short Summary Report from the USAFA/DFAS writing guide, with the addition of a Nomenclature section. Do not include a cover sheet for prelabs.

- Objectives
- Nomenclature
- Approach
- Assumptions
- Math Technique
- Theoretical Predictions
- Experimental Setup
- Discussion
- Conclusion and Recommendations
- Appendices

This assignment will be no more than three typed pages. This assignment is individual effort, but you may use websites and textbooks provided that you cite all sources used (see the References section in the DFAS Writing Guide).

Nomenclature

I	=	moment of inertia ($kg\,m^2$)	**Subscripts**		
T	=	torque ($N\,m$)	g	=	gravity gradient
ω	=	angular speed (rad/s)	SRP	=	solar radiation pressure

Content

You will discuss predictions for a vibration test and a thermal test. Be sure to explain each equation, define all variables and include units, and state any assumptions you made in order to use those equations. You must show all work to arrive at your answers, though this work may be either in the main body of the prelab or attached as an appendix. Work may be hand-written or typed, as long as it is clear to the reader how you arrived at your answers. This prelab should be a stand-alone document that any engineer without prior exposure to this course could read and understand.

Using supplementary course material as a reference (AI&T), you will discuss why spacecraft test campaigns perform vibration and thermal cycling tests at the unit level and at the integrated spacecraft level.

Vibration test
Calculate the fundamental frequency of the cantilever beam along the x- and y-axes. Present the results in a table. At a minimum, you will need the following equations:

Natural frequency of a lateral beam:

$$f_{nat} = 0.560\sqrt{\frac{EI}{m_B L^3}} \tag{1}$$

Second moment of area for a beam:

$$I = \frac{bh^3}{12} \tag{2}$$

In your theoretical predictions section, present your results as in Table 1.

Table 1 Predicted natural frequencies

	x-axis	y-axis
frequency (Hz)		

Vibration test information
Beam dimensions are given in Table 2 and correspond to the labels shown in Figure 1.

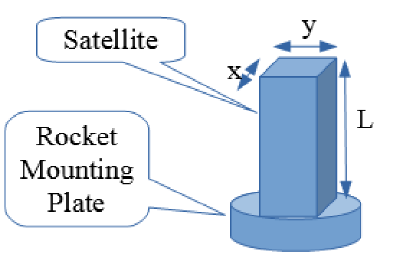
Table 2 Beam properties

x	4”
y	1”
z	7”

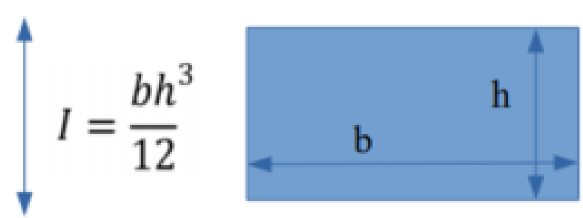
(a) Beam Dimensions

density	$2710\,\mathrm{kg/m^3}$
Young’s modulus	68 GPa
tensile strength	290 MPa
Poisson’s ratio	0.33

(b) Material properties of 6061 Aluminum



(a) Spacecraft Mounted to Vibration Table*
*Neglect the mounting plate in your calculations.



(b) Top-Down View of Beam Mounted to Vibration Table*
*arrow indicates vibration direction. Note that “h” aligns with the direction of vibration.

Fig. 1 Beam diagrams

Thermal test

FlatSAT will measure the current through a $220\,\Omega$ carbon film resistor during a thermal cycle test.

FlatSAT's +5V $\rightarrow$ $220\,\Omega$ resistor $\rightarrow$ INA219 current sensor $\rightarrow$ ground

The thermal chamber will complete four cycles from $-30\,^{\circ}\mathrm{C}$ to $70\,^{\circ}\mathrm{C}$ at a ramp rate of $3.33\,^{\circ}\mathrm{C/min}$ with no dwell time. Using the example thermal profile from your Lesson 27 (AI&T) notes, plot the expected temperature profile.

Discuss what changes you expect in measured current during the thermal test. What implications does your prediction have for telemetry readings?