ASTE 556: Spacecraft Structural Dynamics

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Syllabus

Required Textbook: Sarafin, T. P., "Spacecraft Structures & Mechanics: From Concept to Launch," third printing, Torrance, California, 1998.
References: class materials on web page
Exams: One midterm on week 8 (30%), Final on Week of Finals (30%)
Homework: Assigned every week/collected at end of semester (20 % grade)
Term Project: final report due on week 15 (20%)

0 – Introduction: Structural Dynamics, Spacecraft Design, & Analytical Tools (week 1)

- Role of the structural dynamicist in the spacecraft design cycle
- Spacecraft design and requirements
- Class overview
- Discussion

I – Vibration of Single and Multiple Degree of Freedom Systems (weeks 2, 3, 4)

- Introduction
- Review of basic concepts in mechanical vibrations
- Concept of stiffness, inertia, damping
- Concept of "degree of freedom"
- Introduction to Finite Element Modeling (FEM)
- Examples
- Synthesis of equations of motion
- Solution of the equations of motion – time and frequency methods
- Some mathematical tools – linear algebra
- Applications – oscillators/magnetic damping/voice coils

II – Infinite Degree of Freedom Systems (week 5)

- Introduction
- Continuous structural systems vs. single degree of freedom or multi degree of freedom systems: advantages and disadvantages
- Flexible vs. rigid body systems
- Canonical examples
- Synthesis of the equations of motion of continuous systems
- Solution of the equations of motions
  - Natural frequencies of vibration
  - Concept of the mode shape – a relative issue
  - Dynamic response to excitations

- Some mathematical tools
- Applications – Active/Smart structures

Week 8: Midterm

III – Structural Dynamic Modeling of Spacecraft (weeks 6, 7, 8, 9, 10 & 11)

- Introduction
- Dynamics models
  - Structural dynamics Finite Element Model (FEM),
  - Acoustics dynamics model,
  - Shock dynamics model,
  - Deployment dynamics model,
  - Modal model for frequency analysis of spacecraft dynamics
- Analysis of spacecraft dynamics
  - Dynamic displacements
  - Dynamic loads,
  - Frequency analysis
  - Time domain analysis
  - Spacecraft response to on-orbit loads
  - Pointing
  - Modal analysis
- Introduction to FEM & rigid body dynamics tools (NASTRAN, PATRAN, Pro-Mechanica)
- Structural Dynamics Tailoring
- Examples

IV – Computation of Spacecraft Dynamic Loads (weeks 12 & 13)

- Ground loads,
- Launch loads, and coupled loads analysis
- On orbit loads
- Generation of dynamics requirements for structural design
- Iteration and convergence of loads analysis
- Examples

V – Dynamics Testing of Spacecraft (week 14)

- Week 15: project report due
- Introduction
- Model validation testing
- Modal surveys
- Deployment/repeatability tests
- Pointing accuracy tests
- Examples

Week 15: Final Project Report