Theme for Lab Reports

The formal lab reports (“long forms”) are to be written with reference to a theme system, particularly in the introduction and discussion sections. See the guidelines for the formal reports. In this case, the theme is the vibration of large flexible space structures. A space structure may be so enormous that, except for the moon, it could be the brightest object in the night sky. Such size is needed so that multiple shuttles can be docked and serviced at one time, and also to support many other functions, such as solar energy conversion, scientific monitoring of space, and international communications. A large structure is also expected to be flexible. Successful design of the structure will require many disciplines, including vibrations and controls. Background on vibration issues in large flexible space structures is given below.

Background on Large Flexible Space Structures

It is expensive to send materials against the earth’s gravitational field up into space. As such, materials will be as light as possible, and will therefore be quite flexible. A large structure with mass and flexibility will be expected to have vibration and control problems.

Vibrations

Sources of vibrations will include the impact of docking shuttles, the eccentric rotation of communication disks, the rotation and orientation of solar panels and telescope fixtures, the transport of items from one part of the structure to another, and even disturbances such as impacts from space debris. It is essential that such vibrations not disrupt ongoing functions and activities on the structure. Vibration properties must be well understood so that designs and control strategies can be effectively implemented.

Types of questions that may be relevant to the design of a space structure are

How do parameters such as the stiffness and mass of the structural members effect the vibrations?
How would you model the effect of an impulse from a docking shuttle or from impacting space debris?
How might imbalances in a rotating component cause vibrations in the structure? How will the spin rate Ω effect these vibrations? How will we measure the vibrations?
What modes of vibrations might the structure have, and how would you model them?
Will vibrations of one component of the structure be transmitted to the rest of the structure? How can we reduce these transmitted vibrations, for example in image stabilization?
Suppose a small meteor slams into the structure. How can we isolate a telescope system from the resulting vibrations?
What kinds of vibration sensors should be used, and how do they work?
These kinds of questions can be considered when writing your formal report on vibration experiments.

**Controls**

Rotating devices, such as communication transmitters and receivers, GPS antennas, and motion actuators, for example in positioning solar panels, make use of motors for which control is a major consideration. Motors are required to focus cameras and telescopes, such as the Hubble. DC motors may require speed control, while stepper motors may require control of angular positions. Vibration control is also a major issue for the reduction of motion in these flexible structures. Tracking control is another important aspect, be it of docking shuttles, tracking of celestial bodies by telescopes, or the path control of launched probes. Climate control is needed for space station occupants, as there can be an enormous difference in heat transfer on the bright side and the dark side of the earth. The Hubble telescope requires control of the internal mirrors.

Types of questions that may be relevant to the operation of a space structure are

- How are DC motors modeled and controlled?
- How would you reduce the transient vibration due to an impulse from a docking shuttle or from impacting space debris?
- How might ambient vibrations affect the control performance of a motor or actuator? Can disturbances be rejected?
- How are dynamic elements modeled, and what control strategies can be applied?
- How will the control strategy affect the steady state error? In this regard, what kind of control strategy might be needed for various types of situations?
- What is the “system order” for applications such as thermal control, vibration control, motor control, and tracking control? How does it affect the control strategy?

These kinds of questions can be considered when writing your formal report on control system modeling and design.

“Make it so . . .” –Jean Luc Picard