University of Southern California (USC)
Astronautical Engineering Department

Viterbi School of Engineering

ASTE 552: Spacecraft Thermal Control Syllabus (Spring 2016)

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Course Objectives

- **Understand heat transfer fundamentals**
  1. **Radiation**
  2. **Conduction**
  3. **Convection**
  4. **Phase change**

- **Apply these fundamentals to design and analysis of Spacecraft Thermal Control Subsystem (TCS)**
  1. **Passive thermal control (PTC)**
  2. **Active thermal control (ATC)**

Emphasis on TCS for GEO spacecraft

- **Upon completion of this course, students will have good understanding of basic heat transfer fundamentals and how these fundamentals apply to Satellite TCS Analysis, Design, Testing, Ground Operations, and Flight Operations**

Grading Criteria

- **Homework: (Problem Solving)**
  - **Homework will be assigned but not graded and not to be turned in**
  - **Homework will be solved in the class in the following lecture**

1. **Project: (Qualitative) 15%**

2. **Mid Term: (Mostly Problem Solving) 35%**
   - **In-class, Open book/notes**
   - **Calculator will be needed**
   - **Graded mid-term will be given back to students**

3. **Final: (Mostly Problem Solving) 50%**
   - **In-class, Open book/notes**
   - **Calculator will be needed**
   - **Graded final will *not* be given back to students**

Homework

- **Purpose of Homework is to help students' understanding of Heat Transfer Fundamentals and how these fundamentals are applied to**
  - **Spacecraft overall Thermal Design and Analysis**
    - **Ground (Launch processing)**
    - **Flight operations**
  - **Spacecraft Component Thermal Design and Analysis**
    1. **Electronic Boxes**
    2. **Propellant and Helium Tanks**
    3. **Thrusters**
    4. **Solar arrays**
    5. **Batteries**
- **Homework will be assigned but *not* graded and *not* to be turned in**
- **Homework Format (as a good practice in general)**
  - **Neat work**
  - **Sketch of thermal model**
  - **Sketch of thermal network**
  - **Assumptions**
  - **Analysis**
  - **Your observations and comments as a result of analysis**
- **Homework will be solved in the class in the following lecture**
  - **Students are encouraged to redo all the class examples and the home work problems solved in the class**

Project

- **Project (Same Project for every student)**
  - **Purpose of the Project is to help students' *qualitative* understanding of Spacecraft Thermal Control**
- **Summarize your understanding of Chapters 1 through 8 of Textbook in *Word***
  - **Approximately 50 pages (single space)**
  - **Feel free to include Figures (Graphs, Pictures) and Equations as you feel appropriate**
- **e-mail the Project to me latest *by 15 April – no excuses!***
- ***Not submitting the Final Project will be considered not meeting the course requirement and will result in an Incomplete grade in the class***
- **Good work will help especially if your final grade in the course is marginal**

Textbook

- **Satellite Thermal Control Handbook, 2002**
  - **Author: David G. Gilmore**
  - **836 pages, Hard Cover**
  - **Publisher: AIAA**
  - **ISBN: 1-884989-11-X**
  - **Microcosm website**

Course Topics

- Spacecraft Subsystems & Interfaces
- Spacecraft Thermal Environments
  1. External
     - Orbit and Eclipse dependence
  2. Internal
- Thermal Design Techniques
  1. Thermal Coupling (Heat Sinks)
     a) Mountings and Interfaces
     b) Thermal Contact Resistance
  2. Thermal isolation
     - Thermal standoff
  3. Thermal Surface Finishes
  4. Thermal Insulation
  5. Phase-Change Materials
  6. Radiators
  7. Heaters
  8. Louvers
  9. Heat Pipes

- Thermal Analysis
  1. Radiation
  2. Conduction
  3. Convection
  4. Phase Change
- Thermal Design Examples
  1. Overall Spacecraft TCS
  2. Electronic Boxes
  3. Solar Arrays
  4. Batteries
  5. Chemical Thrusters
  6. Propellant Tanks
- Thermal Testing
  1. Component thermal cycling
  2. Component thermal vacuum
  3. Spacecraft thermal vacuum

Thermal Design Examples

1. Spacecraft Overall Thermal Design Examples
2. Heat Pipe Example
3. Heat Transfer in Electronic Components
4. Thermal Vacuum Chamber Example
5. Launch-pad Cooling of Satellite
6. Transient Analysis of Solar Array Entering and Exiting Eclipse
7. Battery Thermal Management
8. Heat Transfer in Bipropellant Thrusters
9. Heat Transfer within a Spinning Satellite Propellant Tank
10. Thermal Analysis of Launch Vehicle Cryogenic Propellant Tank
11. Cryogenic Sensor Example
12. Heat Transfer During Zero-g Drop Tower Tests
13. Space Shuttle Heating During Atmospheric Reentry
14. G. P. Purohit