Cougs in Space Attitude Determination & Control System Mechanical Engineering Introduction

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Basics

- Read through this NASA guide on a basic CubeSat:
  - https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20180007966.pdf
  - Covers:
    - Damp tip-off rates
    - Earth as a magnet
    - Magnetorquer (they call it magnetic torque rod) control & limitations
      - Ignore reaction wheels – we won't be using them
    - Attitude estimation
      - Attitude quaternation from DCM (Direction Cosine Matrix)
    - Maneuvers
    - Types of attitude
      - Inertial
      - Nadir pointing
    - Attitude Control
      - Uses the PD from a PID control system
    - Gravity gradient torque and stabilization
    - 3 Axis control
    - Environmental disturbance
- Magnetorquers
  - https://www.youtube.com/watch?v=r2Ep3aZ630U
    - Short intro on how they work
  - https://en.wikipedia.org/wiki/Magnetorquer
    - How/why they work and dis/advantages
  - "Design optimization of the CADRE Magnetorquers"
    - http://www.aerospades.com/uploads/3/7/3/2/37325123/cadre_torquers.pdf
    - Contains basics on magnetorquers and how to implement in CubeSat design
  - Documentation of our magnetorquer coils modeled in Simulink:
    - Search "Simulink modeling of the Magnetorquer Coils.docx" in Slack
    - This is our developed model for magnetorquer coils
- Orbital Mechanics
  - http://www.nssc.ac.cn/wxzygx/weixin/201607/P020160718380095698873.pdf
  - This textbook is an extremely in-depth resource for the following topics:
    - Point masses
    - Two-body orbit
    - Time based orbital position

        - 3d orbits
        - Orbit determination
        - Relative motion
        - Attitude dynamics
- Gravity Gradient Attitude Control
    - http://www.diva-portal.org/smash/get/diva2:480456/FULLTEXT01.pdf
        - Masters thesis on theoretical control of an actual CubeSat
        - Example of how a gravity gradient might work in a model
- Attitude Determination
    - http://www.dept.aoe.vt.edu/~cdhall/courses/aoe4140/attde.pdf
    - Goes through how we can determine what our attitude is through a variety of methods

Math Topics

- Eigenvectors and Eigenvalues
    - https://www.youtube.com/watch?v=PFDu9oVAE-g
    - Brush up on matrices from linear algebra
- Quaternions
    - https://www.youtube.com/watch?v=zjMuIxRvygQ&t=2s
    - https://www.youtube.com/watch?v=d4EgbgTm0Bg&t=89s
    - These will help to visualize 4d numbers in a 3d space
    - 3Blue1Brown has all kinds of great videos on advanced math topics
- Laplace Transforms
    - https://www.khanacademy.org/math/differential-equations/laplace-transform
    - We will be using Laplace to take complex variables input to our system and output a function of a real variable
    - Brush up on differential equations
- System Dynamics and Control
    - https://en.wikipedia.org/wiki/System_dynamics
    - Since our satellite is a complex system, we can model it accurately as a dynamic system (take a complex input and translate it to a real output)
    - https://www.youtube.com/watch?v=MN3RJWcJKnk
        - Examples of modelling systems

Software

- Install MATLAB R2019a/Simulink 9.3
    - R2019a is the newest and most comprehensive version – thus it will be the version we use for club work
    - https://www.mathworks.com/academia/tah-portal/washington-state-university-40714885.html
        - Follow the link and sign in with WSU portal
        - Select Simulink 9.3 during installation
- Watch videos to get started with Simulink
    - https://www.youtube.com/watch?v=iOmqgewj5XI&t=114s
    - Follow MATLAB series and other tutorials

- If you have not used MATLAB before, also follow tutorials for getting started with MATLAB
    - This will be very useful in future classes as well

Example ADCS work on CubeSats

- “Attitude Control Model for CubeSats”
    - https://www.researchgate.net/publication/317834979_Attitude_Control_Model_for_CubeSats/link/5a7c9a93a6fdccc013f3067c/download
- “Attitude Determination and Control System for CubeSat”
    - https://web.wpi.edu/Pubs/E-project/Available/E-project-030113-141835/unrestricted/2013_ADC_Report_Final.pdf
- “CubeSat ADCS Validation and Testing Apparatus”
    - https://scholarworks.wmich.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=3786&context=honors_theses
- “Micro-satellite detumbling mode attitude determination and control: UKF approach”
    - https://ieeexplore.ieee.org/document/5524162/metrics#metrics
- “Design Standard Attitude Control System”
    - http://sma.jaxa.jp/en/TechDoc/Docs/E_JAXA-JERG-2-510A.pdf