E80 – The Ultimate Adventure
Intro & Flight Basics

Engineering 80 S 2016
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Important Dates
• 21 JAN 2016 – Labs Begin (Section 4)
• 29 JAN 2016 – 1st LabVIEW Assignment Due
• 10 MAR 2016 – Final Project Begins
• 16 APR 2016 – Final Project Launch 1
• 23 APR 2016 – Final Project Launch 2
• 2 MAY 2016 – Final Presentation, Final Project Due

Course Objectives
By the end of the course students will:
1. Demonstrate hardware and equipment skills
2. Demonstrate experimental and analytical skills
3. Demonstrate the beginnings of professional practice
Course Structure

- Informational Lectures
  - Th from today through 25 Feb + 2
- Pre-lab
  - Modeling and Data Manipulation Prep
  - Vb & Code, Equipment Manuals, Ask Professors
- 6-hour Lab Sessions
- LabVIEW assignments
- Tech Memo
- Final Project
  - Launches
  - Final Report
  - Final Presentation

The E80 Website

- Fount of almost all knowledge (sort of like Wikipedia but harder to search)
- Sakai used for submission of LabVIEW assignments and labs, and finding the latest lecture video streams, but almost nothing else

http://www.eng.hmc.edu/NewE80/index.html

What is the HMC Value Added?
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HMC Engineering Value Added

- Technical Excellence
- Grasps essence of problem quickly
- Self educates quickly to needed expertise
- Not stuck in narrow expertise
- Delivers top-notch results quickly
- Communicates needs and solutions professionally
When could you be stuck on the escalator?
• Unfamiliar equation in lecture
• Unfamiliar term in data sheet
• Not enough detail in lab instructions
• Didn’t quite get E59 and you’re expected to use it, e.g., impedance
• Staring at a LabVIEW VI
• Expected to do an error analysis

E80 Expectations
• Professional Practice
  – Be prepared (do pre-lab).
  – Don’t expect to be hand fed.
  – Ask for help when you’re not making progress.
  – Budget your time, e.g., Section 3 completed by 8:30 PM.
  – Make efficient use of your team.

Experimental Engineering
• Determine Experimental Objectives.
• Model experiment to determine expected ranges of measured variables, and useful range of specified parameters.
• Use model to develop error models.
• Perform initial experiments and compare results with expectations and error estimates.
• Adjust input parameters to account for lessons learned.
Experimental Engineering (cont.)

• Perform remaining experiments.
• Plot experimental results with error bars on same graph with modeled results.
• Quantitatively explain similarities and differences.
• Quantitatively determine degree of attainment of Experimental Objectives.
• Make quantitative recommendations for future work.

Pre-Lab

• Read through the entire lab
• Create outline of lab report
  – Determine relative importance of different sections
  – Allocate time to different sections, e.g., if Section 1 is worth 10%, allocate 10% of 6 hours = 36 minutes. Plan to have it done by 7:06 PM.
• Allocate prep for different sections to team members

Pre-Lab (cont.)

• Determine which lecture(s) apply to this specific lab.
• Use lecture material to start writing report.
• Open and learn software and/or VIs that are specific to this lab.
• Set up models or spreadsheets for processing data.
• Test process example or synthetic data.
Pre-Lab (cont.)
• Use model and/or other info to determine input parameter ranges and output variable ranges.
• Read manuals for any unfamiliar equipment.
• Prepare list of questions for proctors and/or professors. Visit prof’s as needed.
• Develop process router, task assignment for lab.

Example Connections

Pre- & Intra-Lab Don’ts
• You may NOT collect data (for your experiment).
• You may NOT manipulate or test hardware (except for your personally-owned myDAQ).
• You may NOT populate a protoboard.
• You may NOT use the laboratory equipment outside of lab.
• You may NOT process data collected during the lab.
• When in doubt, ask.
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Rocketry Basics

- Modeling and Measurement of Rocket Performance
- FAA
- Rocketry Certification

http://exploration.nasa.gov/education/rocket/basics.html
Modeling and Measurement of Rocket Performance

- Full Model

\[ \frac{d}{dt}(mv) = \sum F = \text{Thrust} + \text{Lift} - \text{Drag} - \text{Weight} \]

\[ \frac{d}{dt}(J\ddot{\theta}) = \sum \ddot{F} \]

Modeling and Measurement of Rocket Performance

- Full Model

\[ m\ddot{x} = \sum F = \text{Thrust} - \text{Drag} - \text{Weight} \]

\[ J\ddot{\theta} = \sum \ddot{F} \]

- Rocksim

\[ x(t) = \dot{x}_0 + v_0 t + \int_0^t \ddot{x} dt \]

Altimeter Data Analysis

\[ v(t) = \frac{d}{dt} x(t) \]

\[ a(t) = \frac{d}{dt} v(t) = \frac{d^2}{dt^2} x(t) \]
Numerical Derivatives

- For a set of points \( x_0, x_1, x_2, \ldots \)
  taken at times \( t_0, t_1, t_2, \ldots \)
- Forward Difference
  \[ v_n = \frac{x_{n+1} - x_n}{t_{n+1} - t_n} \]
- Backward Difference
  \[ v_n = \frac{x_n - x_{n-1}}{t_n - t_{n-1}} \]

Noise Reduction

- Lowpass filter signal, derivative, or both
- Fit a smooth analytical function, e.g., cubic spline
  - Take analytical derivative

Inclinometer or Theodolite
Inclinometer

Three Theodolites

Lines in 3 Space

- Rarely intersect
- Use points of closest approach
- Details of calculation and VI to do calculation are on website
FAA Regulations

- **Class 1** - a model rocket that uses no more than 125 grams (4.4 ounces) of propellant; uses a slow-burning propellant; is made of paper, wood, or breakable plastic; contains no substantial metal parts; and weighs no more than 1,500 grams (53 ounces) including the propellant – Requires permission of the Fire Department and the property owner.

- **Class 2** - a high power rocket, other than a model rocket, that is propelled by a motor or motors having a combined total impulse of 40,960 Newton-seconds (9,208 pound-seconds) or less – Requires permission of FAA, Fire Department, and property owner. Operator must also be TRA or NAR certified.

- **Class 3** - an advanced high power rocket, other than a model rocket or high-power rocket – Has lots of regulatory restrictions.

Rockets flown in California require either State Fire Marshall certified motors or a bunch of permits.

NAR or Tripoli Certification

- **Level 1**
  - Can fly H and I impulse motors

- **Level 2**
  - Can fly J, K, and L impulse motors

- **Level 3**
  - Can fly M and above

9 APR 2016 ROC Launch

- 1 week before our first launch
- One team member can certify Level 1.
  - Have to construct the Final Project rocket yourself.
  - Have to prep and load the motor yourself.
  - NAR best for general rocketeers
  - Tripoli best for BIG rockets
- Can test out rocket if desired.