E80 – The Ultimate Adventure
Intro & Flight Basics

Engineering 80 S 2016
Erik Spjut

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

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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

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Course Structure

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

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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

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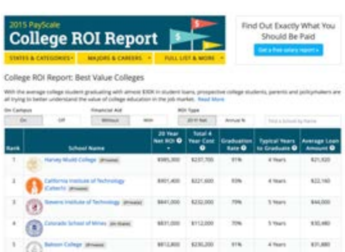
What is the HMC Value Added?



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What is the HMC Value Added?


SILICON VALLEY BUSINESS JOURNAL

The top 10 colleges that fuel the Silicon Valley

Here's the full list:

1. Stanford University: 0.193
2. Harvey Mudd College: 0.191
3. Massachusetts Institute of Technology (MIT): 0.133
4. Yale University: 0.112
5. Duke University: 0.083

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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

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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

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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.

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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.

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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.

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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

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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.

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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.

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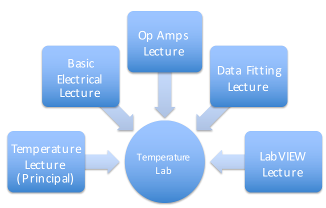
Example Connections



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Pre- & Intra-Lab Don'ts

- You may NOT collect data (for you 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

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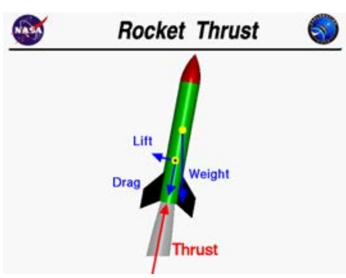

http://exploration.grc.nasa.gov/education/rocket/bgmr.html

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Modeling and Measurement of Rocket Performance

- Full Full Model

$$\frac{d}{dt}\left(m\vec{v}\right) = \sum \vec{F} = Thrust + Lift - Drag - Weight$$

$$\frac{d}{dt}\left(J\vec{\omega}\right) = \sum \vec{T}$$

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Modeling and Measurement of Rocket Performance

- Full Model

$$m\ddot{\vec{x}} = \sum \vec{F} = Thrust - Drag - Weight$$

$$J\ddot{\vec{\theta}} = \sum \vec{T}$$

- Rocksim

$$\vec{x}\left(t\right) = \vec{x}_0 + \vec{v}_0 t + \int_0^t \int_0^t \vec{a}\,dt\,dt$$

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Altimeter Data Analysis

$$v\left(t\right) = \frac{d}{dt}x\left(t\right)$$

$$a\left(t\right) = \frac{d}{dt}v\left(t\right) = \frac{d^2}{dt^2}x\left(t\right)$$

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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

$$v_n = \frac{x_n - x_{n-1}}{t_n - t_{n-1}}$$

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Noise Reduction

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

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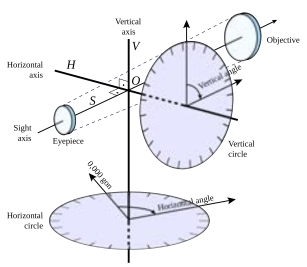
Inclinometer or Theodolite



http://en.wikipedia.org/wiki/File:Theodolite_vermeer.png

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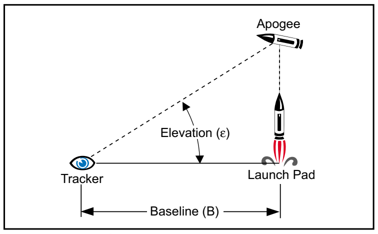
Inclinometer



http://www.apogeerockets.com/education/downloads/newsletter92.pdf

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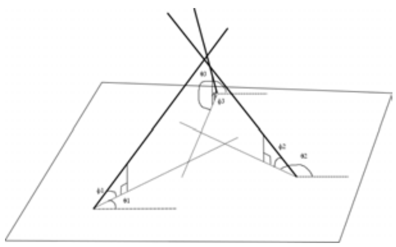
Three Theodolites



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Lines in 3 Space

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

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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.

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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

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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.

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