E80 Intro & Flight Basics

Engineering 80 S 2014

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Important Dates

- 23 JAN 2014– Labs Begin (Section 4)
- 31 JAN 2014 – 1st LabVIEW Assignment Due
- 13 MAR 2014 – Final Project Begins
- 19 APR 2014 – Final Project Launch 1
- 26 APR 2014 – Final Project Launch 2
- 5 MAY 2014 – 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

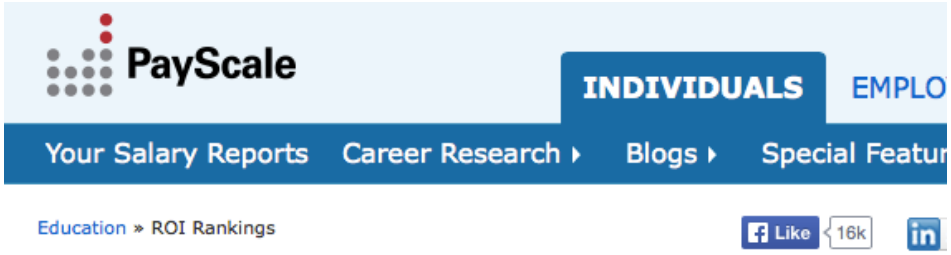
- Informational Lectures
  - T Th from today through 27 FEB + 2
- Pre-lab
  - Modeling and Data Manipulation Prep
  - VIs & Code, Equipment Manuals, Ask Professors
- 6-hour Lab Sessions
- LabVIEW assignments
- Tech Memo
- Final Project
  - Launches
  - Final Report
  - Final Presentation

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, but almost nothing else

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

What is the HMC Value Added?



2013 College Education ROI Rankings:

RANK	SCHOOL NAME	TYPE	CATEGORY	2012 COST	30 YEAR NET ROI (?)	ANNUAL ROI (?)
1	Harvey Mudd College	Private not-for-profit	Private Schools, Liberal Arts, Engineering	$221,700	$2,113,000	8.3%
2	California Institute of Technology (Caltech)	Private not-for-profit	Private Schools, Research Universities, Engineering	$213,000	$1,991,000	8.2%
3	Polytechnic Institute of New York University (NYU-Poly)	Private not-for-profit	Private Schools, Research Universities, Engineering	$214,300	$1,622,000	7.6%
4	Massachusetts Institute of Technology (MIT)	Private not-for-profit	Private Schools, Research Universities, Engineering	$215,700	$1,606,000	7.5%
5	SUNY - Maritime College	Public (In-State)	State Schools, Engineering	$90,530	$1,586,000	10.4%

What is the HMC Value Added?

SILICON VALLEY BUSINESS JOURNAL

Dec 17, 2013, 6:26am PST | **UPDATED:** Dec 18, 2013, 1:24pm PST

The top 10 colleges that fuel the Silicon Valley

Jon Xavier
Technology Reporter-
Silicon Valley Business Journal
Email | Twitter | Google+

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

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

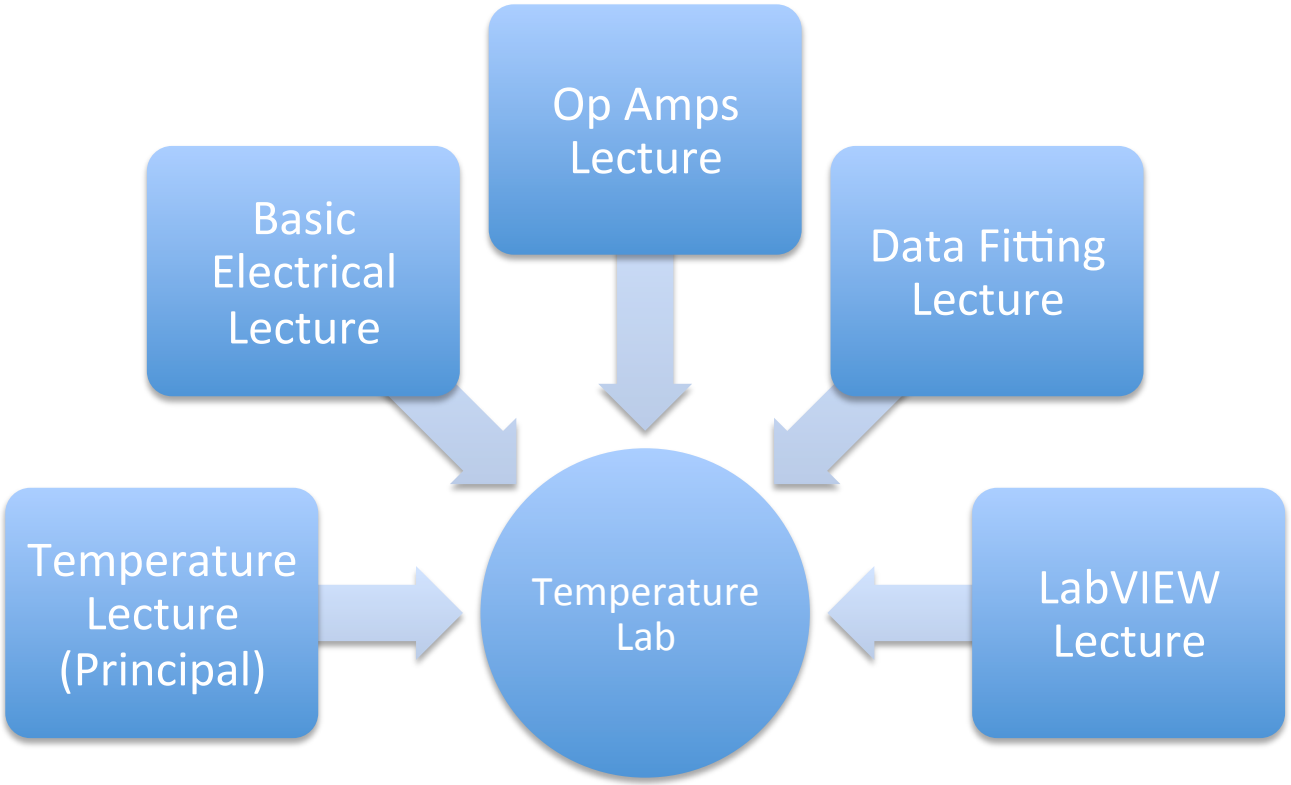
Pre-Lab (cont.)

- 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.
- Develop process router, task assignment for lab.

Example Connections



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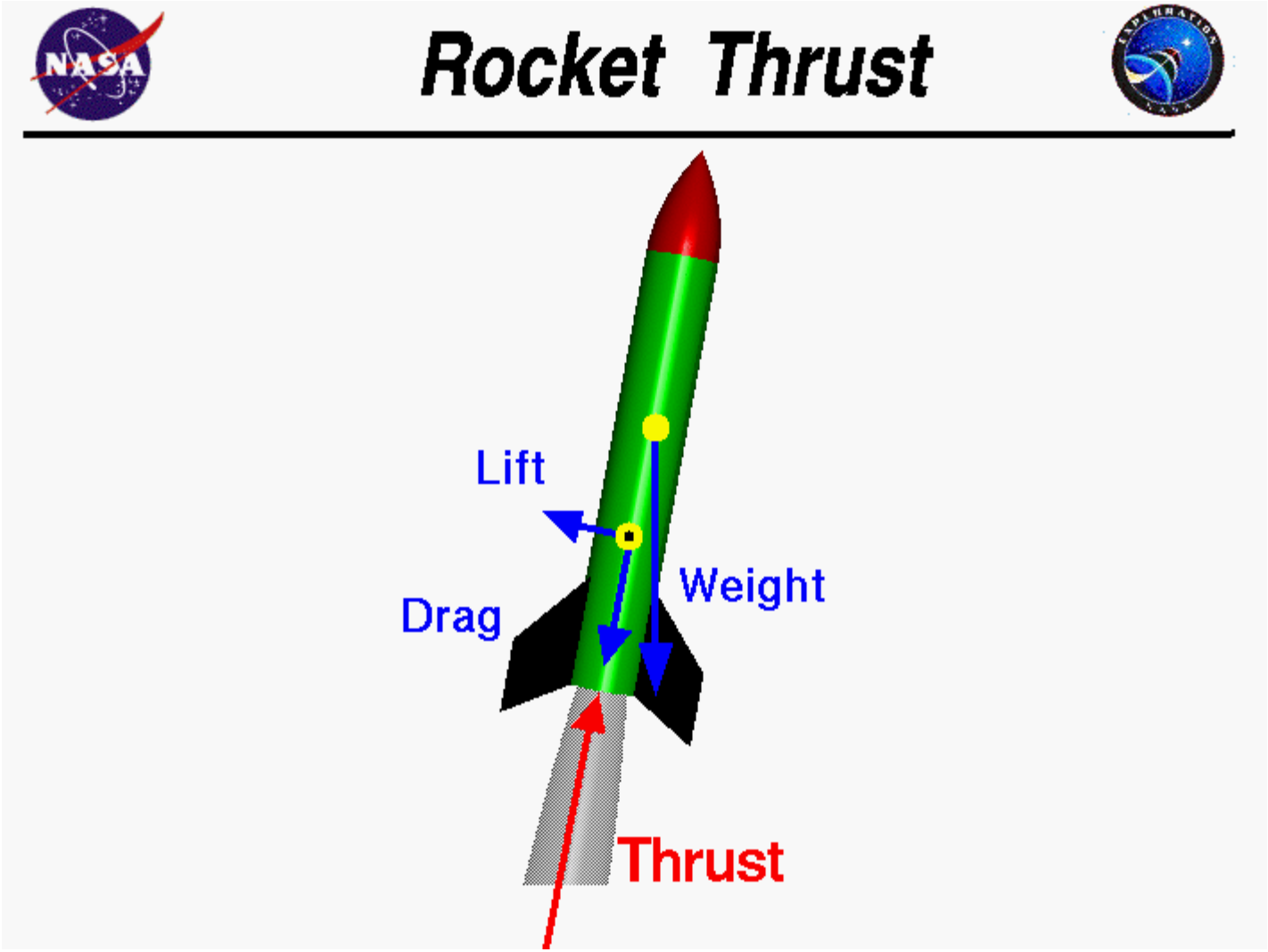
Rocketry Basics

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



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

Modeling and Measurement of Rocket Performance

- Full Full Model

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

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

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

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

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

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

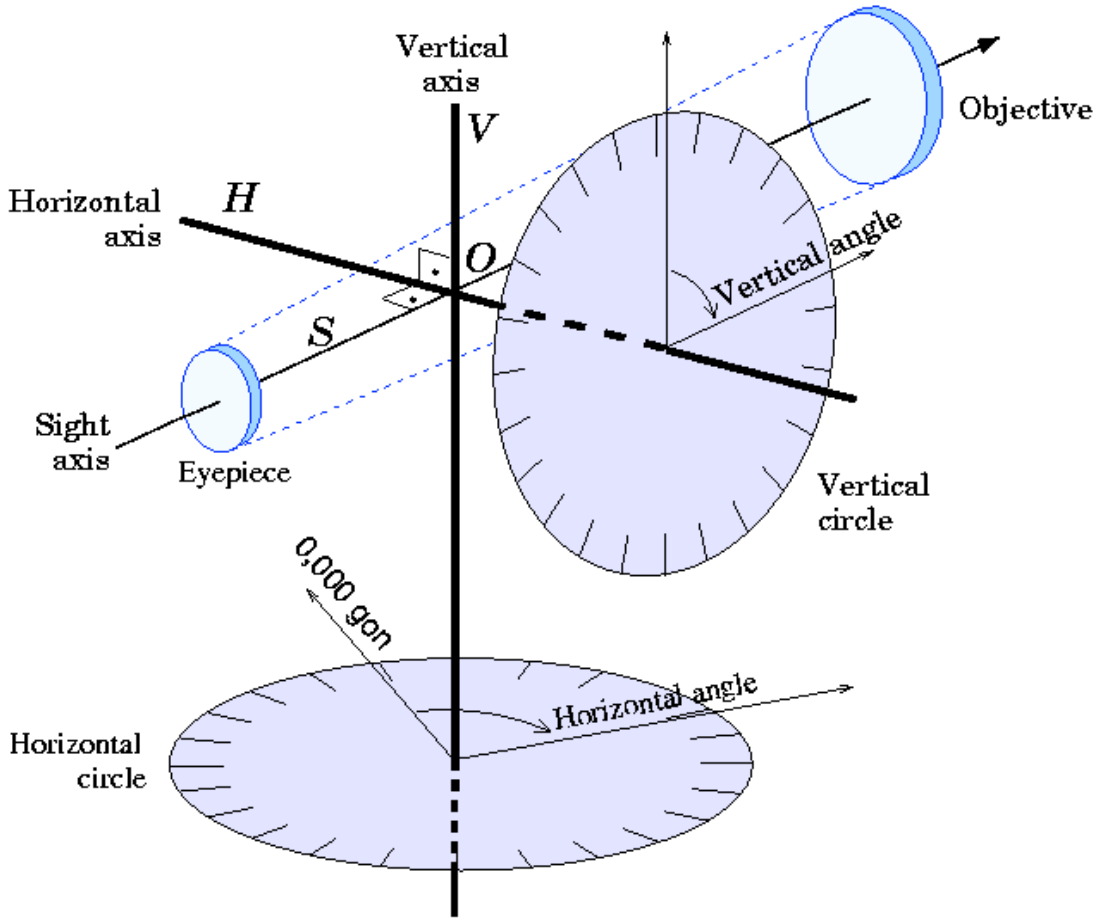
- Backward Difference

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

Noise Reduction

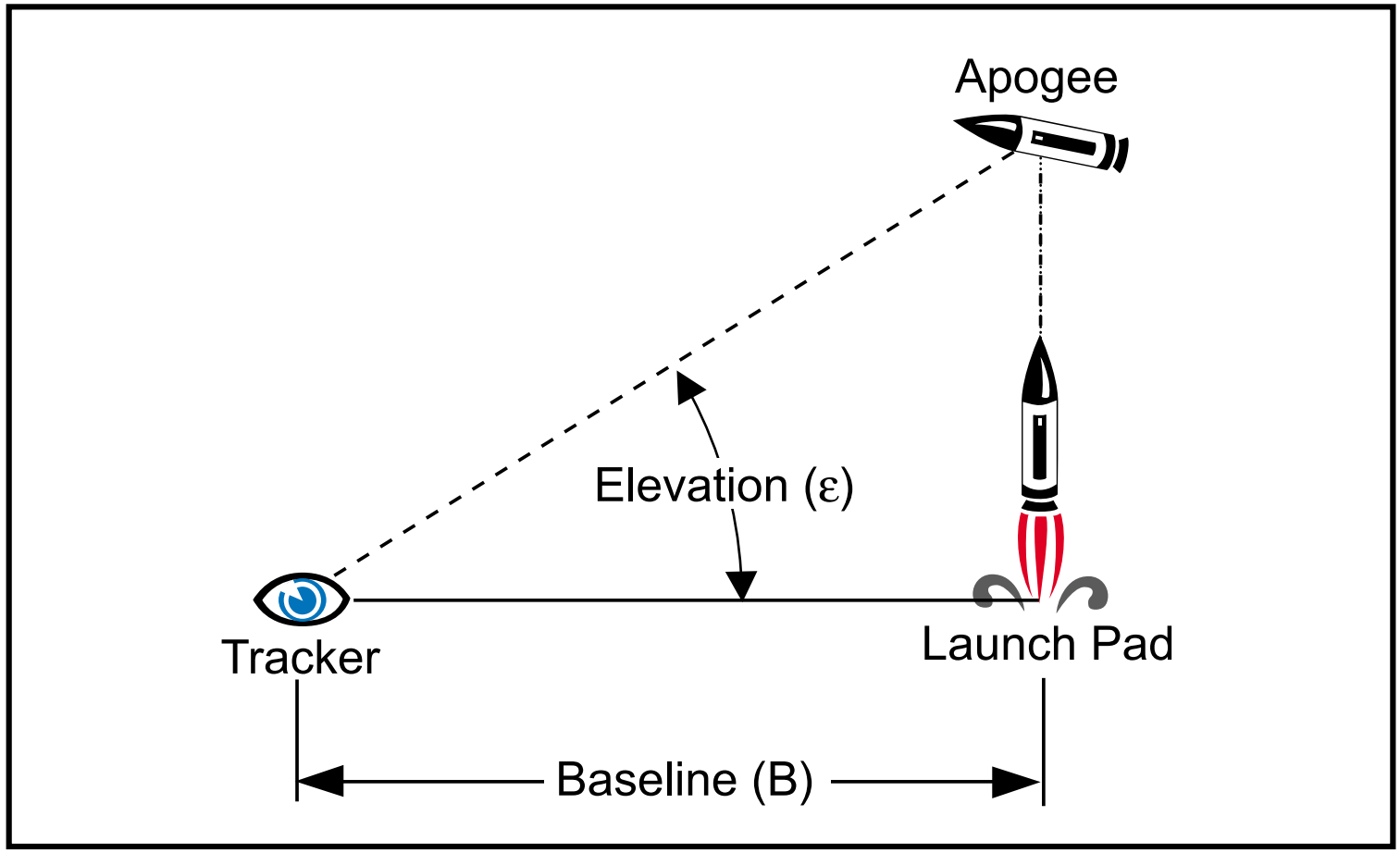
- Lowpass filter signal, derivative, or both
- Fit a smooth analytical function, e.g., cubic spline
  - Take analytical derivative

Inclinometer or Theodolite



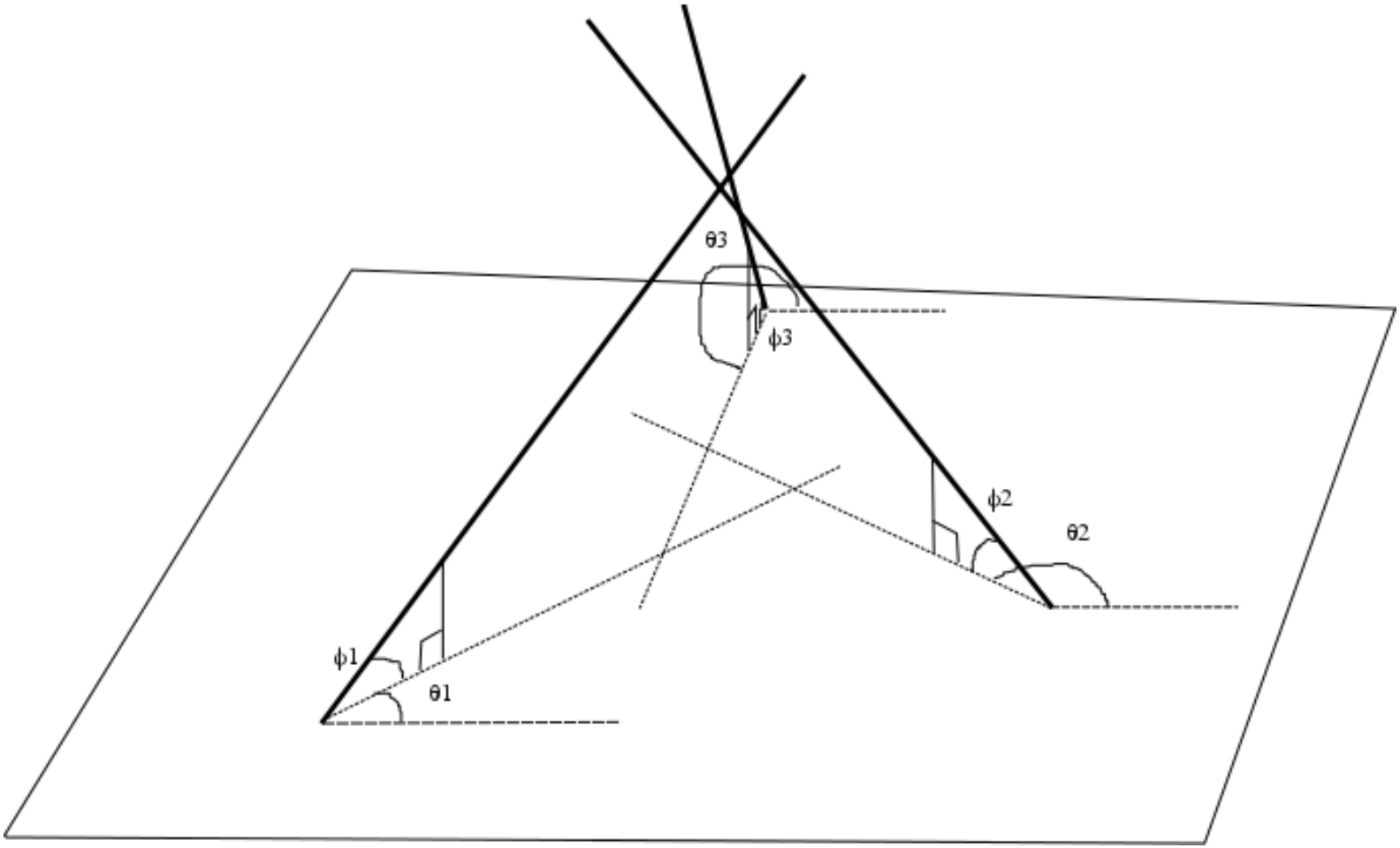
http://en.wikipedia.org/wiki/File:Theodolite_vermeer.png

Inclinometer



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

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

12 APR 2014 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.