E80 Intro & Flight Basics

Engineering 80 S 2012
Erik Spjut
Important Dates

• 19 JAN 2012 – Labs Begin (Section 4)
• 27 JAN 2012 – 1st LabVIEW Assignment Due
• 8 MAR 2012 – Final Project Begins
• 14 APR 2012 – Final Project Launch 1
• 21 APR 2012 – Final Project Launch 2
• 30 APR 2012 – 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 21 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, but almost nothing else

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

• Modeling and Measurement of Rocket Performance
• FAA
• Rocketry Certification
Forces on a Rocket

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

• Full Model

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

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

• Rocksim

\[ \ddot{x}(t) = \ddot{x}_0 + \ddot{v}_0 t + \int_0^t \int_0^t \ddot{a} \, dt \, dt \]
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

Inclometer

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How to Perform Single-Station Altitude Tracking

A P O G E E R O C K E T S

By Norman Dziedzic Jr.

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Introduction

In model rocketry sooner or later, although usually sooner, you will come across the question, “How high did it go?” There are several ways to deal with this question such as:

1. Use the mfg.’s listed altitude.
2. Perform a computer simulation.
3. Include an altimeter within the model.
4. Track the model with a radar type system.
5. Visually track the model and use the observations to calculate the altitude.

Methods 1 and 2 give an approximate idea of altitude but cannot account for the actual conditions at the launch. Methods 3 and 4 can give accurate altitudes but are costly and the electronics required will not fit into smaller rocket bodies and add weight to the model. Also, using advanced radio methods may require special licenses.

Method 5 gives accurate results without adding any weight to the model and without requiring expensive components or radio operator licenses. In this article, we will investigate the visual tracking methods.

Get on the Right Track

Visual tracking methods consist of measuring the line of sight from a fixed point or points on the ground to the model’s apogee. The actual measurements taken are the angles from the horizontal (elevation) and in two point tracking, the angle in the plane of the ground (azimuth).

The angles are manipulated along with the known distances on the ground to determine the altitude the model reached. This process is sometimes called data reduction.

Of course, to derive these procedures requires the use of some trigonometry—but fear not! You won’t have to go through 11th grade math again. We’ll just cover what’s required for the altitude tracking and try to make it plain as pi.

One is the Loneliest Number

The simpler but less accurate method of determining altitude is called Single Station Tracking (SST). As the name suggests, only one tracker is required. He or she stands a known distance from the launch pad and sights the flight of the model through a tracking device (we’ll cover these instruments later).

At apogee, the tracker fixes the position of the instrument and can then read off the angle of elevation (above horizontal) at which the apogee was observed as depicted in Figure 1.

For SST to work, we have to assume that the model rocket will travel straight up. Since this is rarely the case, there can be quite a margin of error but SST is still better than “eye-ball ing” an altitude. Also, analyzing SST will give us a good footing to move on to Two Station Tracking (TST).

Right as Rain - Or - History Repeats Itself

This straight up motion assumption leads to the generation of a 90° angle at the launch pad (see Fig. 1) between the rocket’s flight path and the baseline. The triangle formed by those two lines and the tracker’s line of sight is then called a right triangle and lets us make use of some powerful trigonometry to quickly and easily determine the altitude attained.

We will call the measured angle of elevation epsilon (ε).

Angles are often labeled with Greek symbols to differentiate them from lengths which are usually labeled with regular letters but don’t let that ε scare you. It’s just a name we give the

(Continued on Page 3)
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
14 APR 2012 Launch

• Joint with [ROC](#)

• Can certify [Level 1](#) (one per team)
  – 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