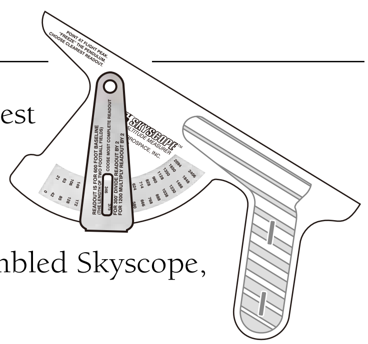
Altitude Tracking 102

An Inquiry Based Method challenges students to answer the natural question: "How high did my rocket fly?"

If you have ever seen a model rocket lift off into a clear blue sky, then you know that most observers will have two reactions. The first will usually either be “wow!”, “cool!” or “awesome!”. The second reaction will undoubtedly be “I wonder how high that rocket went?”

Developing an inquiry-based project that explores key concepts in measurement, geometry, and probability is a logical extension of the model rocketry experience. The key is to use the natural curiosity that drives us to ask “how high?” as the catalyst for the inquiry process.

Materials Required:



We will be utilizing the Quest Skyscope as the primary measurement tool for this project. Each team of two students will need an assembled Skyscope, paper and pencil.

Three other helpful (and free) Quest publications are The Typical Model Rocket Flight Profile, the Altitude Tracking Worksheet and the Altitude Tracking Crossword. All are available for free download from the Quest website at www.questaerospace.com.

Altitude Tracking: The Basics.

To better understand the basic concepts that underlie altitude tracking, lets first take a look at an example that involves a static object - a tall building.

To determine the height of the building, we need to know two things; first the baseline (which is the distance from the observer to the base of the building) and the angular distance (which is the angle observed between the base and the very top of the building.

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The Inquiry Process:

Step 1: Examine Natural Questions:
Although the catalyst for this project is the natural curiosity that drives us to ask “how high?”, there are many other natural questions that are also pertinent:

“Why is it important to know estimated height?
“What is the relationship between height (altitude achieved) and aerodynamic performance?”
"What other objects can we use to compare height? (trees, buildings etc.)”
“What is your guess as to ‘how high’ ?”

Step 2: Establish “fundamental knowledge”
This project will challenge students to examine topics related to the following areas of focus:

Measurement: feet/yards/meters
Numbers: decimal multiplication and table-based information
Geometry: triangles, angles and the basic grid coordinate system.
Probability: data collection, interpretation and dissemination

Step 3: Collect “real world” data (measurement)
Using the Quest Skyscope, students will collect data from actual model rocket flights. This data will be in two forms: “direct read” (providing immediate estimation of altitude) and “angular read” (requiring interpretation using a table of tangents.).

Step 4: Analyze Data (numbers and geometry)
Once the “real world” data has been collected, students will need to calculate approximate altitudes using baseline distances and a table of tangents.

Step 5: Interpret and report findings (probability)
When the data has been analyzed, students will average their findings and present the final data in graph form. Students will then have to compare and contrast their data against a “class average” graph.

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Looking at the diagram below, we can see that the angle between the baseline and the top of the building is typically 90 degrees. This creates a right triangle between the observer, the base, and top of the building.

Using the Quest Skyscope, we can determine the height of the building either by direct read or tangent calculation.

Direct Read:
The easiest (but less accurate) method to approximate the height of the building is by using the direct read feature of the Quest Skyscope. To do this we must station ourselves a given distance from the building (normally 200 yards). Then we simply align (or "sight") the Skyscope with the top of the building and "freeze" the pendulum. The "direct read" side of the Skyscope will indicate an approximate height based on the known baseline distance.

Tangent Calculation:
A more accurate method is to use the Skyscope to measure the angular distance to the top of the building and then find the tangent of that angle by using a standard trigonomic table of tangents. Once the tangent value has been determined, we can multiply the tangent value by the length of the baseline with the result yielding the height of the building.

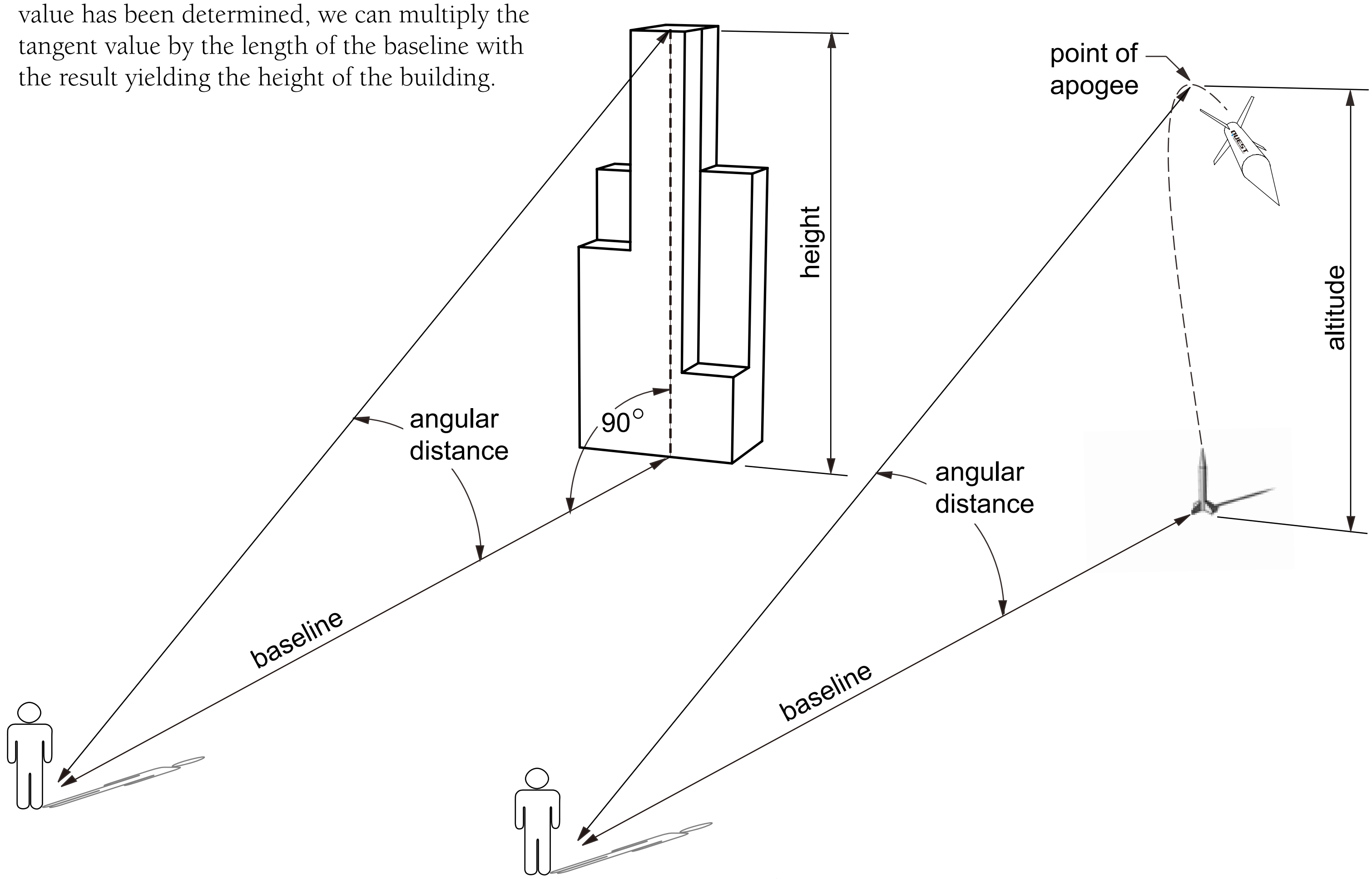
Example:
Jake is unconvinced that this whole "tangent thing" works, so while on vacation in Chicago he decides to try to determine the height of the Sears Tower. He walks 1000' down Jackson Blvd. Using his Skyscope he sights to the top of the roof, "freezes" his pendulum and reads the angle of 55 degrees. The table of tangents tells Jake that 55 degrees equals a tangent of 1.43. He then multiplies this tangent by the known baseline. The result is the height of the building.

55 degrees = tangent of 1.43

tangent x baseline = height

1.43 x 1000 (baseline in feet) = 1430 feet.

Given that the height of the Sears Tower roof is known to be 1450' Jake's calculations are within +/- 2%.



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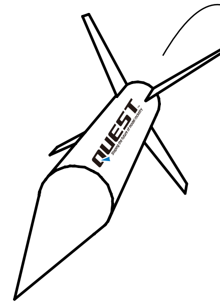
Lets take a look at a five step project methodology that uses an inquiry-based structure designed to challenge students to answer the question: "how high did my rocket go?"



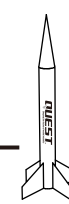
Step 1: Examine Natural Questions.
As we mentioned in the beginning, the catalyst for this project is the natural curiosity that drives us to ask "how high did that rocket go?". Encourage your students to hypothesize on the relationship between altitude achieved and aerodynamic efficiency. We often notice that students have difficulty conceptualizing vertical distances - have your students try to estimate the heights of static objects (buildings, trees etc.) to gain a point of reference for this project. Another comparative strategy is to have students research the heights of famous known landmarks (e.g. the Eiffel tower is a little over 1000').

Step 2. Establish Fundamental Knowledge
Ensure that all of your participating students are familiar with the core concepts and capabilities needed to use the Quest Skyscope effectively and to calculate altitude using both the direct read and tangent calculation methods. Two great resources for introducing and reinforcing core concepts are the Quest Altitude Tracking Worksheet and the Quest Altitude Tracking Crossword. In addition, having your students break into pairs to calculate the height of a known object (such as the corner of the school building) is a great way to build skills and confidence.

Step 3. Collect "Real World" Data.
Now it's time to "hit the field" Be sure to read the "Taking Advantage of the Wind" column at the end of this report. Pair up your students ensuring each team has an assembled Skyscope, paper, and pencil. Have one team member responsible for tracking the upward flight of the model rocket with the Quest Skyscope while the second student assists with determining when apogee occurs. Once the Quest Skyscope pendulum has been "frozen", the second student reads and records both the "direct read" and "angular distance" readings.

Step 4. Analyze and translate.
Once the student teams return from the field, they should compare and contrast the direct read and tangent calculated data. Are the two sets of data close to each other or do they differ greatly? How do the altitudes reported contrast with what your students estimated in the beginning? What static objects have a height similar to the final altitudes achieved?

Step 5. Interpret and Report
Using the Quest Altitude Tracking Worksheet as a reference, encourage your students to average their team results and compile these into a class data graph. Now that each team can compare their result against the classes' data graph, what interpretations can be made? Were all of the class teams close? If not, what factors could explain the diversity of the results? How can this data be combined to represent an average of all team data?



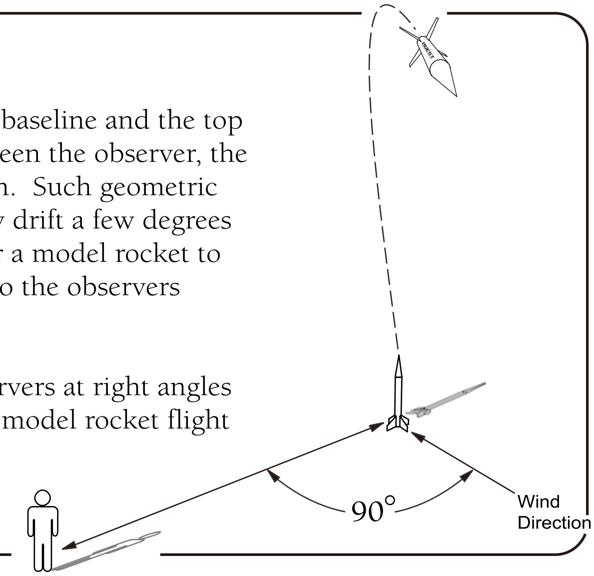
Apogee vs. Ejection

In the "building" example on the previous page, our goal was to estimate the highest point of a static object. When working with model rockets, we are attempting to measure the highest altitude attained. The highest point of the flight path of the model rocket is called the point of apogee. If you have downloaded the Quest Typical Model Rocket Flight Profile, then you will notice that at the point of apogee the model rocket should be in a relative horizontal position. It is important for students to understand that they are attempting to estimate the point of apogee rather than ejection. Ejection of the recovery system (either a streamer or parachute) often occurs slightly after the model rocket has reached the point of apogee.

Taking Advantage of the Wind...

In the “building” example (page 2) we noted that the angle between the baseline and the top of the building is typically 90 degrees. This creates a right triangle between the observer, the base, and top of the building and allows for easy and accurate estimation. Such geometric accuracy is not easily replicated “on the field” where a model rocket may drift a few degrees from vertical, depending on the direction of the wind. The tendency for a model rocket to arc slightly into wind is called “weathercocking” and can often be used to the observers advantage in gaining a more accurate estimate of angular distance.

To gain the most accurate measurement, it is important to position observers at right angles to the direction of the wind. This will allow observers to clearly see the model rocket flight path and will help in accurately determining the point of apogee.



eLibrary

www.questaerospace.com

Did you know that Quest Aerospace offers a wide range of download-ready (and free) educational resources?

Altitude Tracking 101: Fundementals and Flics
Using Flics Precision Paper Models’we ll examine fundemental concepts in altitude tracking and rocket flight.

Altitude Tracking 102:
An inquiry based method challenges students to answer the natural question: How high did my rocket fly?

The Need for Speed 101:
Combine basic and intermediate concepts in numbers, mathematics and algebra to examine the quesion: How fast is fast?

These resources (and more) are available online at **www.questaerospace.com**

QUEST™ Shaping the future of model rocketry

Standard Table of Tangents

Angle	Tangent	Angle	Tangent	Angle	Tangent
0	0.0000	30	0.5773	60	1.7317
1	0.0175	31	0.6008	61	1.8037
2	0.0349	32	0.6248	62	1.8804
3	0.0524	33	0.6493	63	1.9622
4	0.0699	34	0.6744	64	2.0499
5	0.0875	35	0.7001	65	2.1440
6	0.1051	36	0.7265	66	2.2455
7	0.1228	37	0.7535	67	2.3553
8	0.1405	38	0.7812	68	2.4745
9	0.1584	39	0.8097	69	2.6044
10	0.1763	40	0.8390	70	2.7467
11	0.1944	41	0.8692	71	2.9033
12	0.2125	42	0.9003	72	3.0767
13	0.2309	43	0.9324	73	3.2698
14	0.2493	44	0.9656	74	3.4862
15	0.2679	45	0.9999	75	3.7306
16	0.2867	46	1.0354	76	4.0091
17	0.3057	47	1.0722	77	4.3295
18	0.3249	48	1.1105	78	4.7023
19	0.3443	49	1.1502	79	5.1418
20	0.3639	50	1.1916	80	5.6679
21	0.3838	51	1.2347	81	6.3095
22	0.4040	52	1.2798	82	7.1099
23	0.4244	53	1.3269	83	8.1372
24	0.4452	54	1.3762	84	9.5045
25	0.4663	55	1.4279	85	11.4157
26	0.4877	56	1.4823	86	14.2780
27	0.5095	57	1.5396	87	19.0404
28	0.5317	58	1.6001	88	28.5437
29	0.5543	59	1.6640	89	56.9168