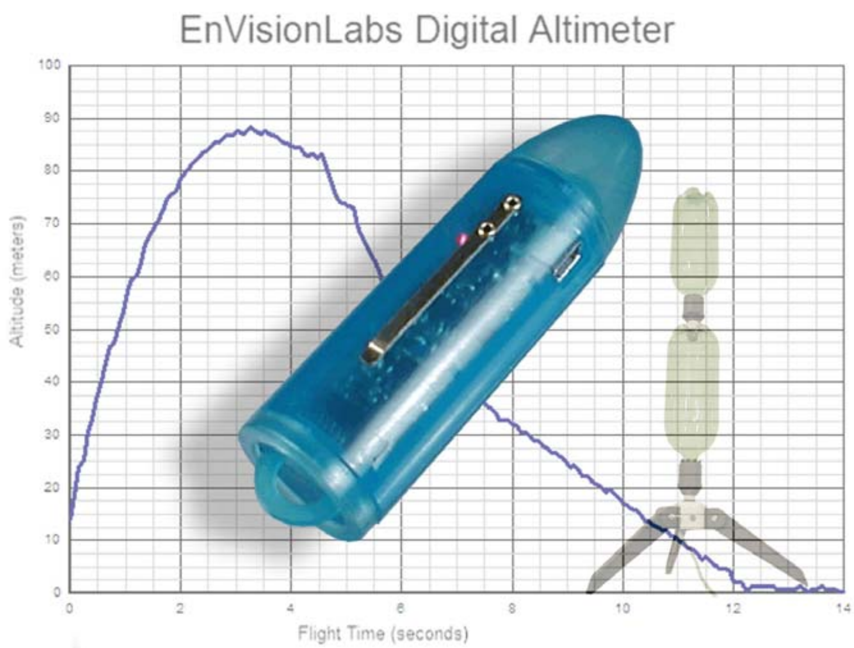
SCIENCE STUFF FOR KIDS

EnVision LABS

1550 FINNTOWN ROAD
WALDOBORO, ME 04572
TEL/FAX: 207.832.0336
SALES@ENVISIONLABS.COM

# Digital Altimeter Instruction Manual
# #20700



## Introduction:

An altimeter is a device that measures small changes in atmospheric pressure to determine a relative change in height. Therefore, changes in atmospheric pressure (such as weather systems) changes in elevation, or buffeting by turbulence or wind will affect the altimeter's response.

## Specifications:

### Physical dimensions:

| | |
|---|---|
| Length: | 3.6 inch long |
| Diameter: | 1.0 inch diameter |
| Weight: | 1 ounce |

### Digital:

| | |
|---|---|
| Altitude resolution: | 0.9 meter |
| Data points/Acqusition: | 200 |

### Programable Settings:

| | |
|---|---|
| Altitude Range: | 100m, 200m, 400m, 800m |
| Acqusition Times: | 2s, 4s, 8s, 16s, 0.5min, 1min, 2min, 4min |
| Dwell Times: | 10ms, 20ms, 40ms, 80ms, 160ms, 320ms, 640ms, 1280ms |

### Requirements:

Windows Operating System 2000 or later
Available serial port -or- USB to Serial adaptor cable
#A544 Photo Battery (6 volt)

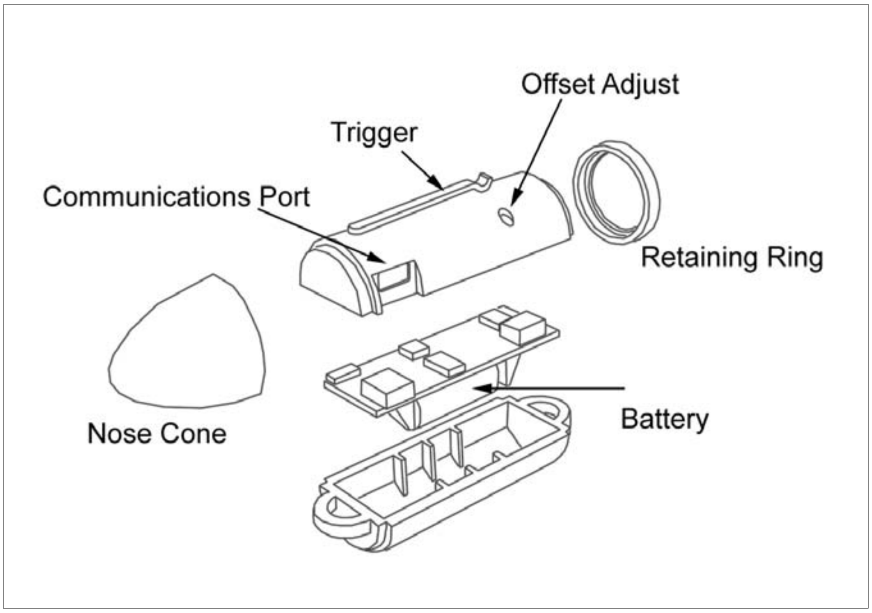



**Figure 3** Altimeter components

## Quick Start:

### Install the Battery:

Remove the nose cone and the clip ring that hold the two halves of the altimeter case together. Separate the two halves and carefully remove the circuit board. Insert the battery into the battery clip on the circuit board paying attention to the polarity markings located on the circuit board (the negative terminal is the one with the attached spring).

### Load Software:

Load the CD into your computer's CD-ROM player. Double click on the file named "Set Up". Follow the onscreen directions to complete the installation.

### Connect serial cable:

Each end of the supplied serial cable is keyed to fit only one way. Simply plug one end of the serial cable into your available serial port or the USB to Serial adaptor.

### Start the Altimeter Control Panel Software:

After the USB to Serial adaptor cable has been plugged into your computer, double click on the Altimeter Control icon to start the Altimeter Control Panel. This interface allows you to program the altimeter with various acqusition parameters, retrieve data from the altimeter, view the retrieved data in graphical form, and save the data to a text file.

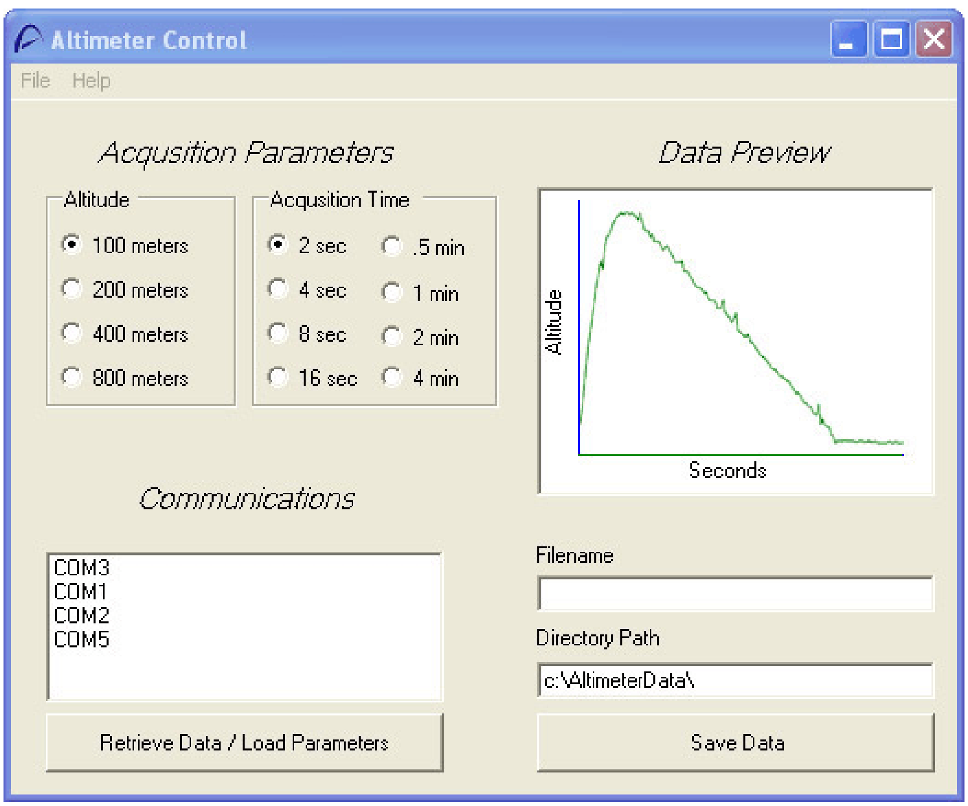



**Figure 4** The altimeter control panel.

**Offset Adjustment:**

Because the altimeter is measuring pressure changes in the atmosphere as it changes altitude, it is also affected by pressure changes due to changing weather conditions. High pressure systems associated with good weather will push the baseline lower while low pressure systems associated with overcast and rain will raise the baseline readings. As you'll read below, these offsets can be accommodated by using the fine and coarse offset adjustments provided. The device has been set during manufacture to provide approximately 400m reading while at sea level with 29.92 inches Hg barometric pressure, when both offsets are fully clockwise (15 turns).

The first time you use your altimeter, you will need to adjust the coarse zero offset for your particular elevation. To do this, remove the altimeter circuit board from it's case then connect the serial cable to the altimeter.

There are two adjustments available for offset. The coarse adjustment corresponds to approximately 400 meters per turn and the fine adjustment corresponds to approximately 200 meters per turn. Begin by turning the fine and coarse adjustments fully clockwise (15 turns). This will place the altimeter reading at it's highest possible value and is appropriate for elevations near sea level.

Select the 2 second acqusition time and the 800 meter altitude range. Click on the name of the COM port that connects to your altimeter. This can be found in the window above the "Retrieve Data / Load Parameters".

To program the altimeter with these parameters and ready it for collecting data, perform the following steps:

1) Click on the Retrieve Data / Load Parameters button. At this point the light on the altimeter will begin blinking to indicate that the altimeter is armed and ready to begin acquiring data. Trigger the acqusition by interrupting the electrical connection between the trigger clip and the contact on the altimeter case. The indicator light will go out while the altimeter is collecting data. Once the indicator light turns ON again, you can retrieve the new data set by clicking on the Retrieve Data / Load Parameters button. The newly acquired data will be received and displayed in the graphical region of the control panel. Based upon the position of the data, proceed with one of the following actions:

    A) Data is off the top of the chart - here you will see a straight flat line at the top of the graphical region. This means the offset is off scale in the positive direction. Turn the **COARSE** offset adjustment screw 1 turn counter clockwise (CCW) and collect a new set of data as you did in step 1.

    B) Data is off the bottom of the chart **-** here you will see a straight flat line at the bottom of the graphical region. This means the offset is off scale in the negative direction. Turn the **COARSE** offset adjustment screw 1 turn clockwise (CW) and collect a new set of data as you did in step 1.

    C) Data is visible in the graphic window **-** here you will see a generally horizontal line with some minor variations in the graphic region of the control panel. Turn the **FINE** offset adjustment screw 1 turn (or less if necessary) counter clockwise (CCW) and collect a new set of data as you did in step 1.

Repeat these steps as necessary until you have the baseline offset near the bottom 10% or 20% of the graphical region.

When the offset data is within the bottom 10% or 20% of the graphic window, move to the next lower altitude range (400 meters) and repeat the process. Continue in this fashion until the offset data is within the bottom 10% or 20% of the graphics region when the max altitude range is at it's lowest value (100 meters). Remember, as you get closer and closer to the desired offset level, turn the FINE offset adjustment screw by smaller and smaller amounts.

Keep in mind that it is ***not necessary*** to have the offset level at exactly zero. Any value above zero that still gives you enough room to capture the maximum height of your rocket's flight will do nicely. Any offset that does exist can be easily subtracted from the entire data set after it's been collected.

Place the circuit board back into it's case and secure the two halves of the case with the nose cone and retaining ring.

Once the coarse offset adjustment is set for your particular elevation, any remaining offset adjustment for varying weather conditions or small changes in elevation when launching from different sites, can usually be done using the fine adjustment screw.

### Preflight Offset Adjustment:

Before each flight, be sure to check the zero offset by simply setting the maximum altitude to the range you intend to use for your flight and the acqusition time to 2 seconds. Acquire a new data set, view the resulting graph, and make the necessary adjustments using the FINE adjustment screw. This can be done through the hole in the case directly above the fine adjustment screw and it is not necessary to remove the altimeter from it's case as was previously described for coarse adjustments. When you are satisfied with the base line offset, select an Acqusition Time that corresponds to the data you wish to collect.

### Recording a New Data Set:

Data that is recorded during a flight will be retained in the altimeter's memory even if the power to the altimeter fails. In other words, the altimeter behaves much like the black box recorder in airplanes. Even if the battery fails, or the power switch is accidentally turned off, the data remains intact. With this in mind it will help to conserve battery power by turning the altimeter power off once it's retrieved from the landing site. Then, when you finally return it to the location of your laptop, turn it back on again to transfer the data.

### Saving Data to a Text File:

After viewing the new data in the graphics region of the control panel, you can save it to disk by typing the desired path and filename into the text box above the "Save Data" button on the control panel. The default location for your saved data is c:\Documents and Settings\All Users\Desktop, however, any valid path and filename can be entered when saving your data. For example c:\mydata\myfilename.txt

The data is stored to disk as a comma separated file which includes the data's filename for reference. The time and altitude information are recorded and zero-padded to 256 points.

# Using Spreadsheets for Data Analysis:

## Signal Noise and Curve Fitting:

All data that is collected from real world applications will have varying amounts of noise associated with the actual measurements. There are two primary sources for noise in your dataset: noise related to pressure measurements, and noise related to electrical interference.

The most common source of noise is due to pressure variations. Because such small changes in air pressure are used to determine altitude, noise can come from a variety of sources such as buffeting by wind, or excessive vibration. It's important to try to minimize sources of noise to improve the quality of your data. This can be improved by streamlining the nose cone of your rocket, or protecting the vents through the altimeter case by covering them with fabric or other material that will allow the altimeter to record static pressure changes but reduce those changes caused by air blowing directly into the vent holes. A little bit of experimentation may be required to determine the method that works best for your situation.

Electrical interference can also produce noise in your data set. It is possible to experiment with this by shielding the electronics within the altimeter case by coating the inside walls of the case with a conductor (such as tinfoil) and then connecting the conductor to the ground terminal of the battery. Be careful that this conductor does not contact any of the components on the circuit board. If it does, the altimeter may not function properly.

It is a simple fact of collecting experimental data that some level of noise will always persist. Fitting curves (mathematical formulas) to your data will offer the best options for analysis and the elimination of noise.
Before attempting to fit a curve to your data, it is useful to understand a few characteristic types of motion:

**Constant velocity:** graphically, your position data for constant velocity is represented by a straight line and is mathematically described by the formula $\mathbf{y = y_0 + v_{0y}t}$. This equation describes **y** as a linear function of **t**. Where we will call **y** the measured altitude and **t** the elapsed time. Note that the velocity, $\mathbf{v_{0y}}$, is a constant in this equation. If your rocket uses a parachute or streamer as a recovery method, it's return to Earth will have a constant velocity and that portion of the trajectory can be fitted to a ***first order (linear) polynomial***. This curve can be fit to the data on a spreadsheet chart by selecting a trendline option for that portion of your curve. When using a spreadsheet to fit a trendline to your data, it is useful to select the option to display the equation on the chart. This equation can then be used as the best fit curve for that portion of the data and calculations for velocity and acceleration can be made using this "best fit curve".

**Constant acceleration:** graphically, the position data for constant acceleration is represented by a parabolic curve and mathematically described as $\mathbf{y=y_0+v_{0y}t + \frac{1}{2} a_y t^2}$. Curves of this shape are found when an object is under the influence of a constant force, which directly results in a constant acceleration. Gravitational attraction is such a force, and objects that are in free fall describe trajectories of this shape. This portion of the rocket's trajectory can be fitted to a ***second order polynomial***. This curve can be fit to the data on a spreadsheet chart by selecting a trendline option for that portion of your curve. When using a spreadsheet to fit a trendline to your data, it is useful to select the option to display the equation on the chart.

This equation can then be used as the best fit curve for that portion of the data and calculations for velocity and acceleration can be made using this “best fit curve”.

If your data set includes multiple curve shapes (and it is very likely that it does), separate the data set into segments that correspond to each curve shape and then fit the appropriate polynomial to each of the smaller data sets.

**Calculating Velocity**:

Once you’ve fit an appropriate curve to your data set, this curve can be used to determine the velocity of the object at any point along it’s trajectory. The velocity is merely the slope of this (the position curve). The slope can be determined point by point by dividing the change in altitude by the change in time for any two neighboring data points. Similarly, if you have determined the equation for the best fit curve, this curve that describes the object’s position can be differentiated using the techniques of introductory calculus to find the velocity at any point along the trajectory.

**Calculating Acceleration:**

This procedure is virtually identical to that used to calculate the velocity from the position data. In this case, start with the velocity curve which you have just determined and either divide the change in velocity by the change in time for each of the consecutive data points, or differentiate the equation for the velocity curve to obtain a new curve that describes the object’s acceleration.

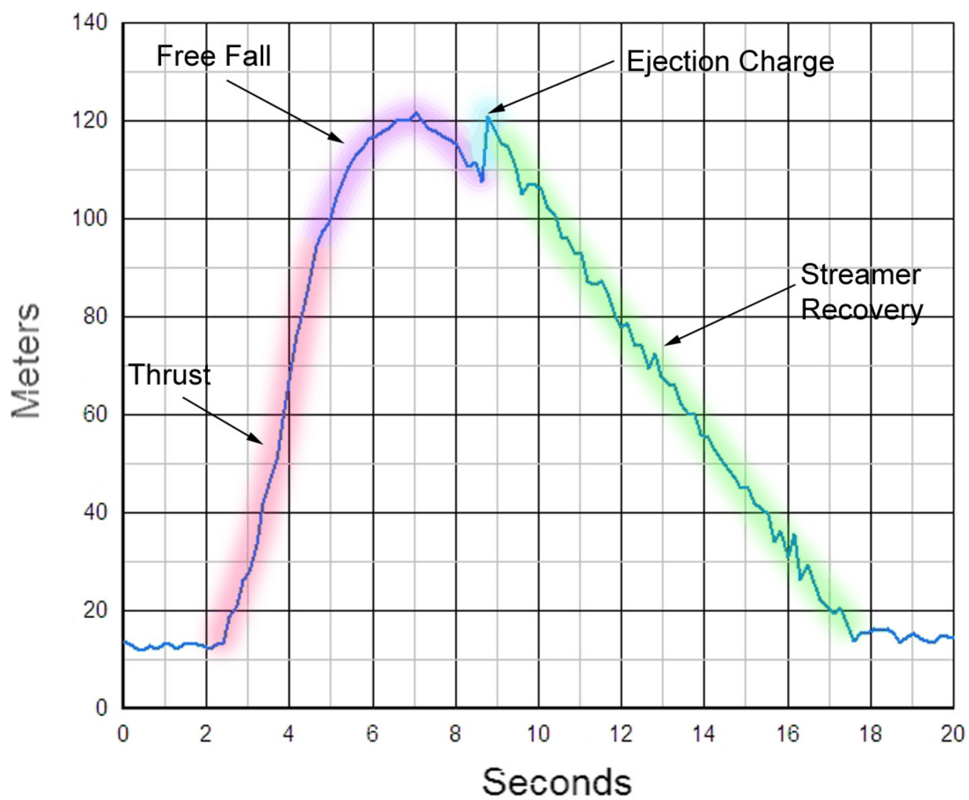



**Figure 5** The different phases of a solid fuel rocket trajectory.

## Safety:

Launching rockets and projectiles can be potentially dangerous. Always use caution and common sense when working with rocketry and payloads.

Choose an adequately large space for the size rocket you're using. Keep in mind the effects of wind for recovering your rocket.

Stay away from power lines! If your rocket becomes entangled in a power line, Do Not attempt to retrieve it! Notify your power company and they will take care of it.

Never aim a rocket or projectile at another person or towards objects that could be damaged by a collision with your rocket or payload.

Use multiple spotters to track the flight of the rocket.

Be considerate and courteous of others and their property when retrieving a rocket that's drifted beyond your launch area.

## Experiments:

### Solid Fuel Rockets:

Always, always, always use a dummy payload in place of the altimeter when testing your solid fueled rocket to make sure the rocket engine has enough thrust to gain sufficient altitude so that does not impact the ground prior to the deployment of the recovery system. Parachutes or streamers work well with payloads such as the altimeter. If you are performing launches in a more confined space or using very large engines, streamers are recommended above parachutes for more rapid descents and quicker recovery times that are less influenced by wind drift. Since solid fuel rockets are capable of greater altitudes, it is important to have several spotters for the recovery of your rocket and altimeter.

### Water Rockets:

The major difference between solid fuel rockets and water rockets is their method of recovery. Water rockets are essentially a free fall recovery device. This means that it doesn't have a parachute. One can design the body of a water rocket so that it will flutter slowly back to Earth, however, if the rocket does not do this, it is likely to nose over at the peak of it's trajectory and begin accelerating downward ending it's flight by crashing into the ground.

Because of this possibility, always, always, always use a dummy payload in place of the altimeter when testing your water rocket to make sure the rocket does not impact the ground with such force that it will destroy the altimeter. Secondly, always use a sufficiently large soft foam nose cone for your water rocket in which the altimeter can be placed. Some "home made" possibilities include using a length of the polyethylene foam swim toys known as "swim noodles" These can be cut to an appropriate length and a hole can be formed in the middle of it to hold the altimeter. This arrangement can then be taped onto the front of the soda bottle that will be used as the rocket. Another possibility is to "drill" a hole through the middle of a Nurf football large enough to hold the altimeter case, then cut one end from the ball so that it will sit flat on the end of a 2 liter soda bottle. A healthy dose of packing tape or duct tape will hold it in place to form the rocket's nose cone.

### Elevators:

If you live in an area where there are tall buildings, the altimeter can be used to measure the heights of these buildings by recording the altitude as you ride up and down in the elevator. With a little bit of math, you can also determine the speed with which the elevator moves!

### Free Fall:

An object in free fall is acting solely under the influence of gravitational acceleration. The equation of motion for this situation is:

$$y=y_0+v_{0y}t + \frac{1}{2} a_y t^2$$

This equation is a second order polynomial and represents a parabolic trajectory. When curve fitting your data, fit free fall portions of the trajectory to a second degree polynomial.

### Terminal Velocity:

If you are launching rockets that use parachutes or streamers for recovery systems. You'll notice something interesting when you view your data - the downward portion of the graph is a straight line. This is typical of objects that have reached their terminal velocity. As an object falls, it initially gains speed, but the faster it goes, the greater the air resistance (drag) it experiences. Eventually it reaches a speed where the air resistance prevents it from gaining any more speed and the result is a constant velocity decent. This is known as an objects terminal velocity. The equation for linear motion such as this is:

$$y = y_0 + v_{0y}t$$

### Vacuum/Pressure Measurements:

Your altimeter is also useful for vacuum and pressure measurements. To convert altitude measurements to pressure measurements, use the following conversion factor:

**1 meter = 10.6 Pa = 0.08 mm Hg**

## Data Analysis Techniques:

### Offset Elimination:

To eliminate a vertical offset after the data has been collected, plot your data and look at the shape of the curve. At the beginning of your data, you may find a short horizontal region. This is data that was collected before the rocket began it's flight. Average these values together to obtain your baseline altitude and then subtract this value from all altitude points in your data set. This shifts your data vertically so that your altitudes are all referenced to zero. This is useful when comparing, or plotting, two or more data sets on the same chart.

To eliminate a horizontal offset note the time (and hence data point number) where the data begins to change from the baseline value. That is to say, when the rocket begins moving upward. Shift the time data relative to the altitude data so that zero seconds is now adjacent to this point in the altitude data column. When this new data set is plotted the trajectory will begin at T=0 seconds. Again, this is a useful technique when plotting two or more data sets for comparison.

## Use and Maintenance:

The altimeter is durably constructed, but always remember it is a precision piece of measuring equipment and should be handled accordingly. Do not drop it, or subject it to sudden impacts. Do not expose it to rain, water, or any other liquids. Clean with a damp cloth only. Do not use solvents of any kind.

When using it for free fall experiments - always place the altimeter deeply within a large foam ball to cushion any impact it may experience.

When trying a new experiment, always start by using a “dummy” payload in place of the altimeter itself until you have gained some experience and understand how everything involved will perform. In this way, if there is an unexpected failure, you will not have damaged the altimeter - you will only have lost the “dummy” payload.. This is especially important when trying new recovery systems!

When launching the altimeter on a rocket, always have two or more spotters to track the path of the rocket.

Always keep an extra battery on hand. Although the batteries will last many hours, always keep a new battery in your “fix-it” bag  to avoid the inconvenience of having the battery run down in the middle of your experiments.