A DYNAMICAL ANALYSIS OF KITE FLIGHT

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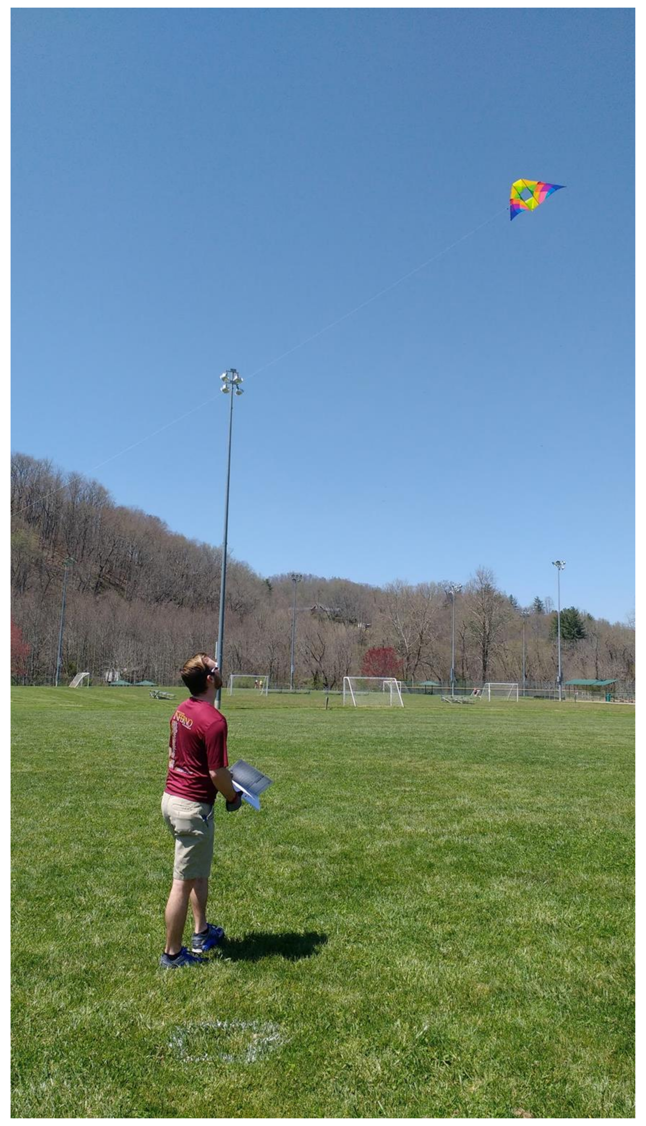
Abstract

The mechanics of kite flying is a highly dynamic field of study due to the variability of one aspect, namely the wind. However, it is anticipated that a model of vertical kinematics may be achieved by taking data during a flight. Two teams were formed consisting of three people in order to fly a kite and gather data. Two identical kites were flown. A Kestrel Drop data logger was suspended from the line on each kite in order to collect data on temperature, relative humidity, heat stress index, dew point, station pressure, and density altitude; all with respect to time. From this data actual altitude was derived as were graphs showing the relationships between altitude and temperature. Both groups were successful in deriving a kinematic relationship for flight as a third order polynomial.

Equipment

Size: 10-'0'' x 4'-3''
Wind range: 3 to 20 mph
Made of ripstop nylon with carbon spars

Black carabiner to bring down kite via the string
Yellow Safety Gloves (+1 Defense against kite string)
Blue Kestrel Drop Data Logger
Red plastic spool containing 500ft., 100lb. test line



Cory Gates

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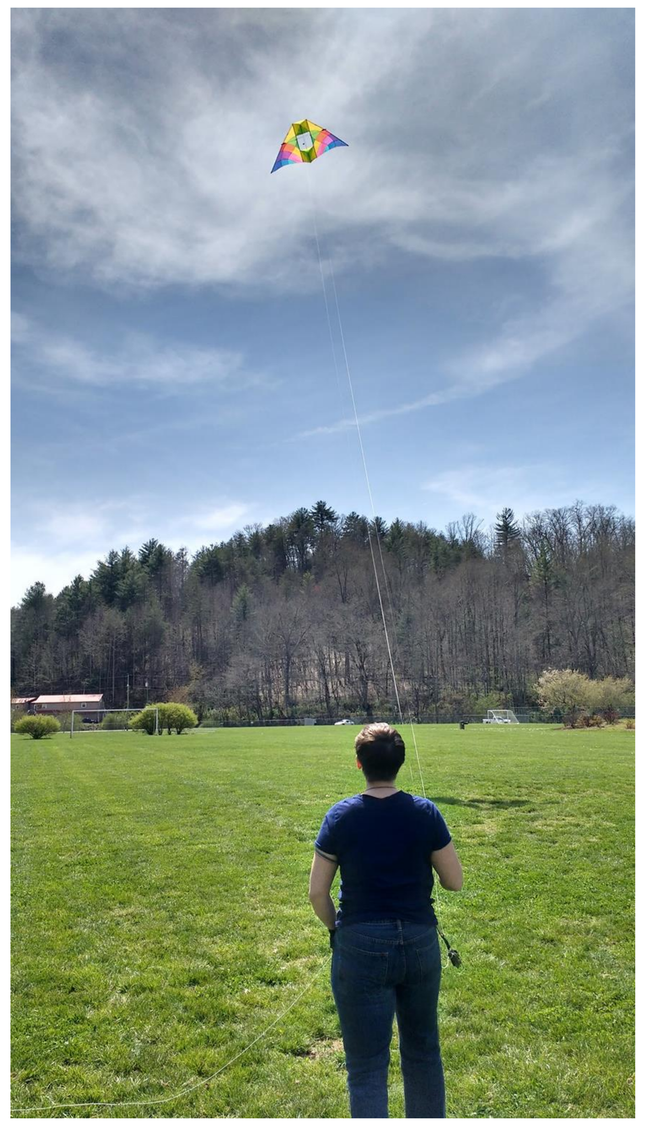


Shannon Pope

Kinematics

The following equations were derived from the best fit line on the data to describe the position, velocity, acceleration, and jerk functions of each "best flight" for each kite team.

Kite 1

Position: $\vec{r}(t) = 9x10^{-5}t^3 - 0.2542t^2 + 237.04t - 73860\ (ft)$

Velocity: $\vec{v}(t) = \dot{r}(t) = 2.7x10^{-4}t^2 - 0.5084t + 237.04\ (ft/s)$

Acceleration: $\vec{a}(t) = \dot{v}(t) = \ddot{r}(t) = 5.4x10^{-4}t - 0.5084\ (ft/s^2)$

Jerk: $\vec{j}(t) = \dot{a}(t) = \ddot{v}(t) = \dddot{r} = 5.4x10^{-4}\ (ft/s^3)$

Kite 2

Position: $\vec{r}(t) = 1x10^{-5}t^3 - 0.0213t^2 + 12.991t - 2663.5\ (ft)$

Velocity: $\vec{v}(t) = \dot{r}(t) = 3x10^{-5}t^2 - 0.0426t + 12.991\ (ft/s)$

Acceleration: $\vec{a}(t) = \dot{v}(t) = \ddot{r}(t) = 6x10^{-5}t - 0.0426\ (ft/s^2)$

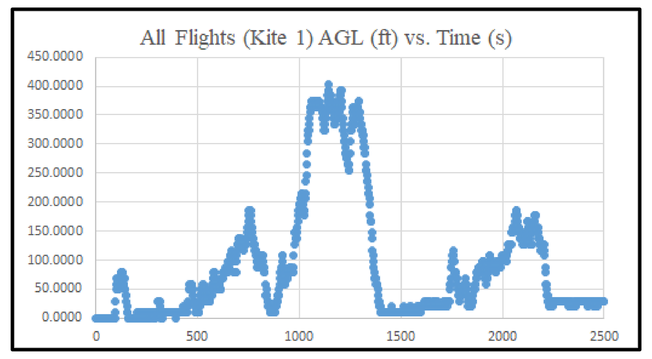
Jerk: $\vec{j}(t) = \dot{a}(t) = \ddot{v}(t) = \dddot{r} = 6x10^{-5}\ (ft/s^3)$

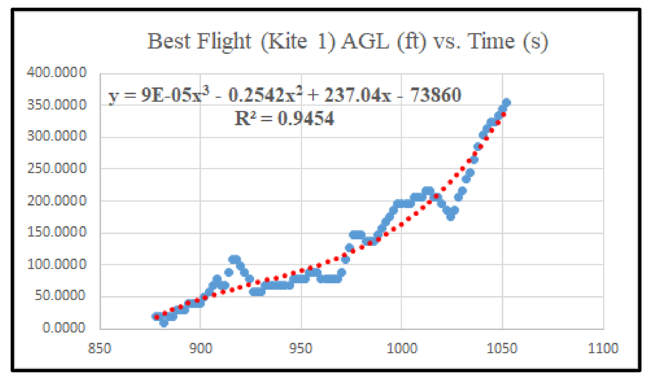
Future Plans

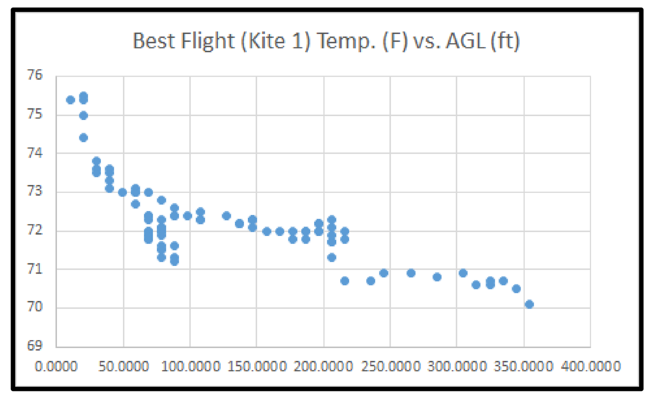
The Kestrel Drop proved to be a useful tool for collecting real-time data about a kite's flight. Future flights will explore the other data available and look for relationships between altitude and relative humidity and altitude and dew point.

The only drawback noted with the Kestrel Drop was the 2 second resolution on data collection. It is predicted a more rapid approach to data collection would result in a better kinematic model. The team plans to utilize Arduinos to design specific instrumentation that may yield results with higher resolution.

Kite 1 Data

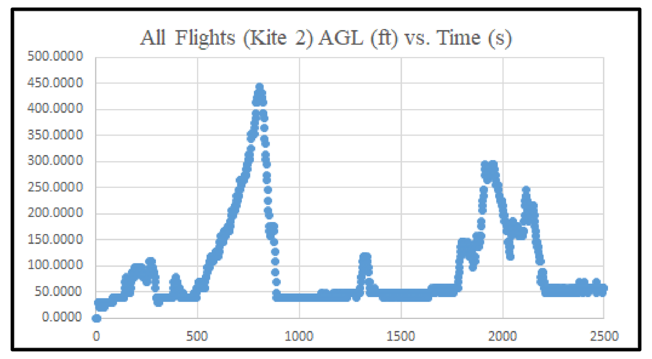


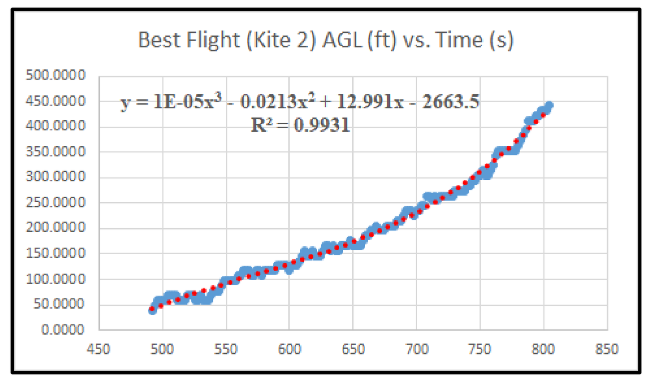


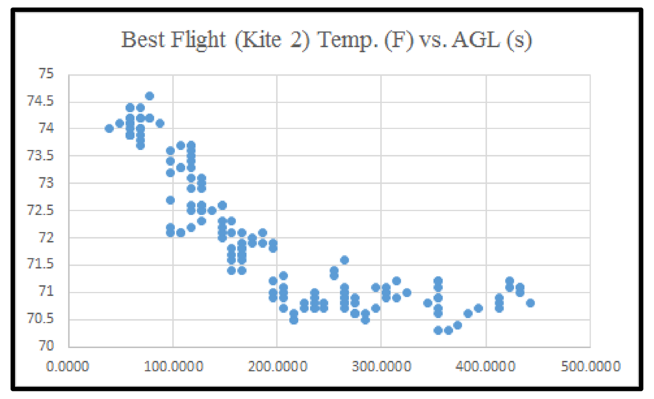


(AGL - Above Ground Level)

Kite 2 Data







(AGL - Above Ground Level)

Analysis

The data was retrieved from the Kestrel drop data loggers attached to each kite, respectively. Altitude (vertical position) was calculated using the barometric pressure (in inHg) formula:

$$Altitude = 145366.45 * \left(1 - \frac{P_{station}}{P_{sea\ level}}\right)^{\frac{1}{5.255}}$$

Subtracting the altitude of the kite flying location from the altitude calculated above yielded the above ground level elevation (in ft). Plotting AGL vs. Time and including a line of best fit provided a function for position vs. time. In both cases, a cubic function was most accurate.

In the bottom two graphs, it was observed that as AGL elevation increased, temperature decreased.

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