**Kite Engineering with Calculations Guide Sheet**

**Pre-Launch**

1. Create a scaled sketch of your delta kite. Label the sketch with spar and span lengths, and angles.

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1. Mass (m) and measure the span of your kite. Note these measurements on the data table below. Use them, to calculate weight, surface area, and aspect ratio using the formulas below.
   * Weight (Fw) Fw = m \* 9.8 N/kg;
   * Surface area (A) - divide kite into triangles, calculate areas in square meters and obtain sum;
   * Aspect Ratio (AR) AR = s2 / A
2. Find the approximate center of pressure and center of gravity.
   * Locate your kite’s aerodynamic center. This point is located below the front tip of the kite, one quarter of the way down the vertical spar. Create a pressure point mark on the kite.
   * Locate the center of gravity by balancing the kite on your finger such that it remains horizontal. The point where the kite is balanced is the center of gravity. Create a center of gravity mark on your kite at that location.

Based on your markings for center of pressure and center of gravity, predict the stability of your kite—i.e. will your kite fly?

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**Kite Engineering Data Table**

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| --- | --- | --- | --- | --- | --- | --- |
| **Measurements** | | | | | | |
|  | **mass of kite** | **span of kite** | **wind speed** | **air density** | **tension force** | **angle of attack** |
| **variables** | *m* | *s* | *v* | *ρ* | *FT* | *a* |
| **units** | *(kg)* | *(m)* | *(mi/hr)* | *(kg/m3)* | *(N)* | *(radians)* |
| **How to** | Use balance, measure in grams, convert to kilograms | Measure with a meterstick across from widest point on leading edge spar tips | Use phone app, anemometer, or consult [NOAA’s guide for estimating wind speeds](http://www.wrh.noaa.gov/pqr/info/wind.php) for qualitative estimation | Obtain values for temperature, pressure, and dewpoint from [Gribble.org](http://www.gribble.org/cycling/air_density.html) | Make loop in kite string and measure with spring scale | Film (from the side), use protractor or video analysis to get degrees from horizontal, convert to radians |
| **Data** |  |  |  |  |  |  |
| **Calculations** | | | | | | |
|  | **weight** | **surface area** | **aspect ratio** | **aerodynamic center** | **lift coefficient** | **lift** |
| **variables** | *Fw* | *A* | *AR* | *ac* | *Clo* | *L* |
| **units** | *(N)* | *(m2)* |  | *(cm)* |  | *(N)* |
| **How to** | FW=m \* 9.8 | Divide kite into triangles, calculate areas and obtain sum | AR=s2/ A | Found ¼ of the way down the vertical spar.  e.g. ac=62/4 | *Clo= 2\*π\*a* | L = Clo\*A\*ρ\*(v2/2) |
| **Data** |  |  |  |  |  |  |

**Kite Launch & Data Collection**

Measure the wind speed (v) and air density (ρ), and note them on the data table above.

**Analyze and Conclude**

1. **Measure the angle of attack (a**) using your photos/video with either a protractor or video analysis software, like Vernier’s Logger Pro. Be sure to convert degrees to radians using your calculator.
2. **Calculate the lift coefficient** (Clo) – a number that describes lift characteristics) and then lift (L) using the formulas below.

* Clo = 2\*π\*a
* L = Clo\*A\*ρ\*(v2/2)
* Describe the kite’s flight as accurately as possible using the terms outlined on the Kite Image. The success of the flight doesn’t matter—what matters is that your observations provide detailed data. Reflect on your pre-flight prediction. Did you observe instability in your kite?

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What four forces did the kite experience? Are these forces that a ski jumper would encounter? Explain.

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Select a problem or issue you encountered during flight that you think could be addressed by redesigning the kite. What is the problem or issue you wish to address?

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**Plan your redesign**

Part of the fun of engineering is the freedom to improve on what has already been built, but redesigning a kite needs to be done thoughtfully. Kites fly upward when the lift is greater than or equal to the weight, and drag and tension are in balance. Since the dynamics that affect kite flight are complex, it’s a good idea to learn which variables (e.g. location of center of pressure and center of gravity, wingspan, point where control line attaches) influence the main forces of flight and make alterations from there.

1. How would you like to redesign your kite? Use the space below to brainstorm.
2. Explain your final idea, and explain why you think each change to the design will improve the kite’s flight.
3. Create a labelled sketch of your redesign.

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| Brainstorming Area | Sketch your redesign  /Users/xochitl/Desktop/Screen Shot 2017-02-09 at 10.46.46 PM.png |
| Explain your redesign |

**Build and launch your new kite**.

Be sure to take new measurements for your new design so that you can calculate and compare the lift between the two kites. Feel free to continue redesigning your delta kite. Make sure that you calculate lift for each of your designs.

**Kite Engineering Redesign Data Table**

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| **variables** | *m* | *s* | *v* | *ρ* | *FT* | *a* |
| **units** | *(kg)* | *(m)* | *(mi/hr)* | *(kg/m3)* | *(N)* | *(radians)* |
| **How to** | Use balance, measure in grams, convert to kilograms | Measure with a meterstick across from widest point on leading edge spar tips | Use phone app, anemometer, or consult [NOAA’s guide for estimating wind speeds](http://www.wrh.noaa.gov/pqr/info/wind.php) for qualitative estimation | Obtain values for temperature, pressure, and dewpoint from [Gribble.org](http://www.gribble.org/cycling/air_density.html) | Make loop in kite string and measure with spring scale | Film (from the side), use protractor or video analysis to get degrees from horizontal, convert to radians |
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| **Calculations** | | | | | | |
|  | **weight** | **surface area** | **aspect ratio** | **aerodynamic center** | **lift coefficient** | **lift** |
| **variables** | *Fw* | *A* | *AR* | *ac* | *Clo* | *L* |
| **units** | *(N)* | *(m2)* |  | *(cm)* |  | *(N)* |
| **How to** | FW=m \* 9.8 | Divide kite into triangles, calculate areas and obtain sum | AR=s2/ A | Found ¼ of the way down the vertical spar.  e.g. ac=62/4 | *Clo= 2\*π\*a* | L = Clo\*A\*ρ\*(v2/2) |
| **Data** |  |  |  |  |  |  |