JROTC STEM LEADERSHIP ACADEMY

June 21-26, 2017

Spring Hill College

Engineering Mobile's Future STEM Workforce

Instructors and Staff Notebook

Mobile County PUBLIC SCHOOLS

SPRING HILL 1830 COLLEGE

U.S. ARMY

STEMWorks, LLC

The JROTC STEM Leadership Academy is a program of the Mobile County Public Schools and its Career and Technical Education Division's JROTC program in collaboration with area industry, post-secondary education institutions, civic and community organizations and with significant financial support from Alabama Power, Book-A-Million, the J.L. Bedsole Foundation, Military Order of the Purple Heart, Mobile County Commission, MCPSS Federal Programs, the Society of American Military Engineers and the US Army.

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JROTC STEM LEADERSHIP ACADEMY

The purpose of the JROTC STEM (science, technology, engineering, mathematics) Leadership Academy is to engage a unique population of high school students, 9th and 10th grade JROTC Cadets, in STEM content, skills, and fields of study needed by business and industry today. The Academy is a program of the Mobile County Public Schools in collaboration with the Mobile Area Chamber of Commerce, a multitude of area business and industries, post-secondary institutions, as well as area community organizations and foundations.

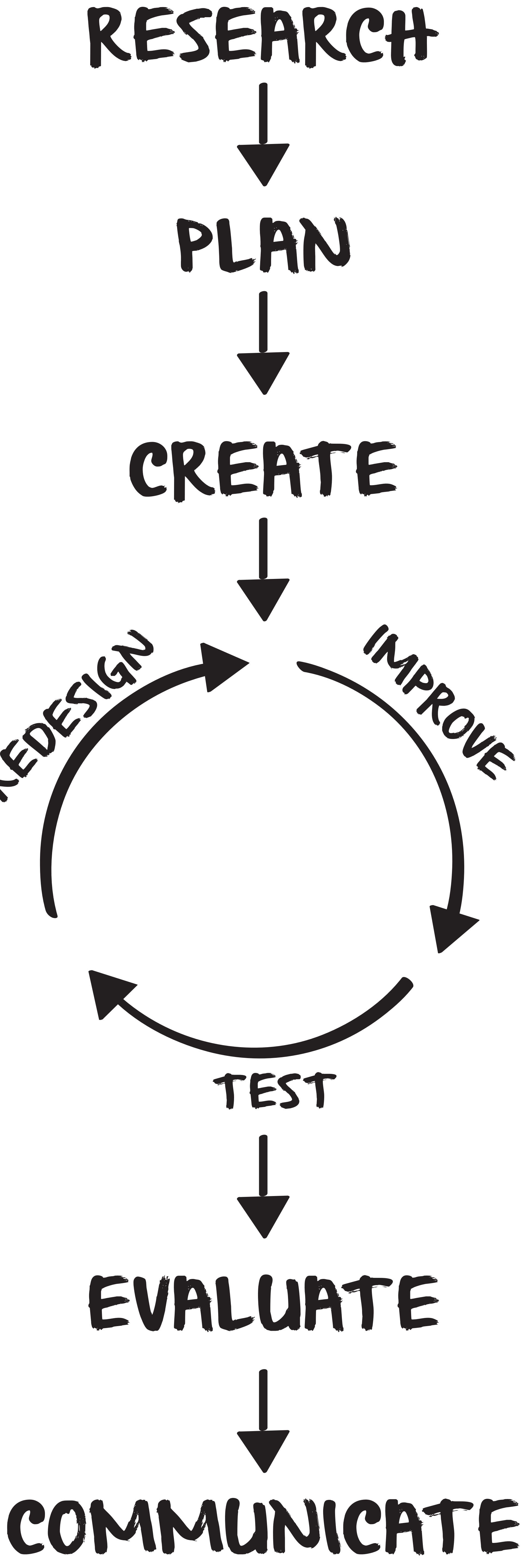
The JROTC STEM Academy is designed to increase awareness of good-paying STEM career opportunities in our area for Mobile's youth and what it takes to secure these jobs. Cadets participate in area industry and university field trips, interacting with scientists, engineers and technicians who are designing innovative solutions to their and our community's problems. The STEM Academy includes leadership development, critical thinking, and STEM skills as cadets solve team engineering-focused design challenges and complete rappelling, drown-proofing, and land navigation exercises. Industry and education leaders provide motivational talks each evening, inspiring cadets to persist in STEM and life. Due to the success of the past two summer's Academies, we anticipate the number of cadets participating in the 2017 Academy to increase from 140 in 2016 to 160 cadets (approximately 13 cadets per Mobile area high school).

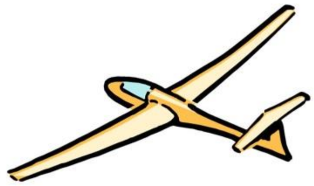
The STEM Leadership Academy addresses the important issue of preparing Mobile's youth for the workforce as a step toward ensuring their economic prosperity. Over 70% of the MCPSS JROTC Cadets live in poverty and over 50% are from populations under-represented in STEM fields. Fewer than 20% actually enter the military; 80% pursue other careers. Many of these 9th and10th grade students are potential 1st generation college enrollees. As recommended by the Academy's Advisory Team (comprised of key leaders in business/industry and education), the Academy Cadets live on a college campus for the 6 days and nights. They get a taste of college campus life while being able to enjoy this quality STEM Academy without distractions often found at home.

Thus, the Academy addresses the growing need of our area industries for graduates eager and able to fill industries' STEM-dependent job openings by ensuring that these youth, typically underserved by existing STEM opportunities, are aware of the good career opportunities here in Mobile and the knowledge and skills needed to secure those jobs. Through pre- and post-assessments, focused group interviews, site-based observations and post-camp surveys the following measurable outcomes will be assessed and used to improve future STEM Academies:

- Increased awareness of and interest in pursuing STEM-dependent jobs available in the Mobile and Gulf-coast region with an understanding of the academic and skill requirements for those jobs.
- Increased understanding of, and value for, STEM content and skills, e.g., team and leadership skills, as applied in the Academy experiments and investigations.
- Increased awareness of and interest in attending post-secondary two or four year academic or technical institutions

Engineering Design Process





STEM IN THE AIR

Challenge 1:Falling with Style!

Perhaps the earliest form of human flight was more like falling with style. Gliders utilize the properties of the air that surrounds them to cover large horizontal distances with minimal loss of vertical height. Once launched, gliders have no means of self-propulsion. They are designed to take advantage of physical concepts like lift and drag to keep them in the air.

Your mission will be to design and build a paper airplane glider to meet certain criteria. Be warned! Maximizing results for one criteria may be detrimental to others. It will be important to find a delicate balance that allows your team's score to soar to the highest heights!

RESEARCH AND PLAN:

Think of some paper airplane designs you have seen or built in the past. What do they have in common? What may make one design better than another?

It will be important that all members of your team understand the constraints given by your instructors. Take a short time to discuss these and check each other's designs for compliance.

CREATE A PROTOTYPE:

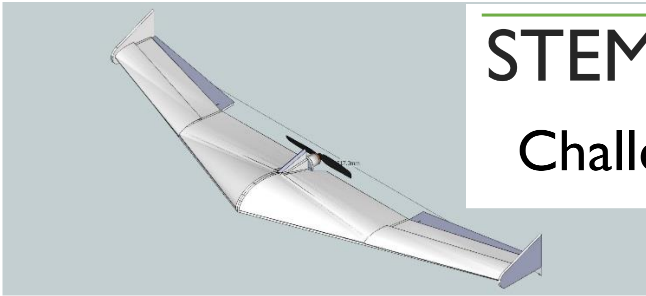
Each team member should now begin building a paper plane design. Remember that your piece of paper can only be replaced one time (so be careful with those folds).

TEST AND IMPROVE:

Short tosses (less than ~3ft) from one teammate to anotherare allowed for testing, but no full launches are allowed outside the testing area before the final evaluation begins.

EVALUATE:

Each team member will launch his or her glider at the same time with the team's score being the total of all team members. Team members will launch their gliders from behind the start line with distance measured using the scale marked on the floor. Each team will work with an instructor to measure the "flight" time of each launch using a stopwatch. Time will be measured from when each glider loses contact with its launching apparatus (or thrower's hand) until when the glider has come to rest. The team with the highest total score will be considered the most successful team.



STEM IN THE AIR

Challenge 2: Controlled Flight

Not all flying machines are created the same, but all flying machines are designed to utilize the forces of flight to maximize their performance. Look at the pictures on this handout. What looks familiar and different about these planes compared to what you picture in your head when someone mentions a plane?

In this challenge, you will be adjusting various aspects of a “flying wing” to establish continuous, stable flight. After some practice, your team will be required to fly this glider through an obstacle course made to push your flying skills to the limit. Keeping the plane in the air will be paramount, but navigating through the obstacles will separate the average fliers from the Top Guns.

RESEARCH AND PLAN:

To get started, read over the instructions that come with your foam glider. Circle the words that are new to you or that you don’t understand. Your team can discuss the instructions to make sure you all have a good idea of how to get started preparing your glider for flight. **Be very gentle with the glider.** These gliders are very delicate and need to be handled carefully so that you have something to fly when that time comes.

Create a Prototype:

Once your team feels confident in their understanding of the instructions begin making the necessary adjustments. You may release your glider to test for stability in flight, but should not attempt extended flights until given procedures by your instructor.

Test and Improve:

Once your instructor gives you the flight testing protocol, you may begin controlled flights of your glider. Refer back to the instruction sheet often for advice on how to correct various flight problems. Share your experiences with teammates so that you can all improve your ability to sustain stable flight.

Evaluate:

At some point, your instructor will end the practice session and orient you to the obstacle course challenge. They will also share the constraints and criteria for success for this challenge, so pay close attention. Make sure to discuss in your team potential problem areas and devise a plan to overcome those challenges. Remember that sustained flight is the most important objective, but navigating the obstacles will allow your score to soar high.

UP, UP, BUT NOT AWAY

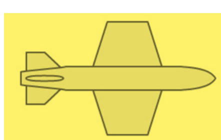
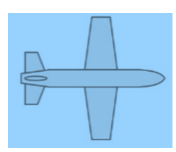
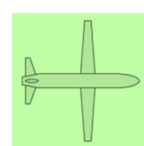
Final Challenge: Around-the-Pole Flight

Your team has been selected to participate in an "Around the Pole" flight competition against other JROTC cadets. In this competition, your team will attempt to get your rubber band-powered plane to complete as many loops around a "pole" as possible while sustaining flight for as long as possible. Unfortunately, during testing the wing of your plane was destroyed by a dramatic interaction between the plane and the pole. The rules of the competition specifically state that you cannot use the wing from another plane, but don't seem to prevent you from making your own wing. You have access to a limited set of resources, but you are confident that using the knowledge you gained this week about designing wings and the dynamics of flight your team can design and build a replacement wing that will make your plane (and score) soar.

RESEARCH AND PLAN:

Think about everything you've learned about flight and how differences in design features can impact the performance of a plane. When designing your wing, remember that the ratio between the wingspan and wing surface area can impact the performance of your plane. Use the information below to help you decide on the best aspect ratio, materials, and overall design.

Common Aspect Ratios:

Low	Medium	High
2:1 to 6:1	7:1 to 10:1	12:1 to 22:1
Could look like…	Could look like…	Could look like…
		

LOW Aspect Ratio	HIGH Aspect Ratio
 Pros: • Tolerance to construction irregularities • Higher weight tolerance • More maneuverability  Cons: • Requires high powered engine • Poor no-powered gliding	 Pros: • Requires less engine power • Excellent no-power gliding  Cons: • Less tolerance to construction irregularities • Lower weight tolerance • Less maneuverability

CREATE A PROTOTYPE:

Once your team has a complete sketch and decided on initial materials, use your selected materials to create your first wing design. After you've created and tested your first design, you will have access to additional materials for redesign.

TEST AND IMPROVE:

Your team will be able to test your wing design at one of two testing stations in the room. You need to complete each test within 3-5 minutes. Use the trimming chart in your team engineering notebook to identify problems and design solutions. You can test and make improvements to your design as many times as time allows. Be sure to sketch and diagram your final design in your Team Engineering Notebook.

EVALUATE:

At some point, your instructor will end the Test and Improve session and orient you to the final evaluation of your design. Your team score will depend on two measurements: the number of loops around the pole and the time spent in the air. You want to maximize each.

Criteria for Success

1. Plane completes at least 1 complete loop around the pole.
2. Plane remains in the air for at least 10 seconds.

Constraints

1. Only materials identified in the sketch of Wing Design #1 in TEN can be used for the initial design. Subsequent designs can only be constructed with materials within the flight materials bag.
2. The parts of the plane provided to you may not be modified in any way.
3. Damaged materials can only be replaced one time.
4. You must be able to attach your wing to the Around-the-Pole device using the paperclip at the end of the string.

STEM in the Air Final Challenge: Up, Up, but not Away

SUNDAY AFTERNOON (2:15PM -6:00 PM)

SESSION 1: DESIGNING WINGS FOR RUBBER POWERED PLANES (225 MIN)

Overview

This final challenge will require cadets to apply what they have learned about aeronautical design throughout the week to design the wing structure for a rubber band powered plane made out of balsa wood. All parts of the plane will be provided to the teams except for a wing. Teams will be given a variety of materials to use in their design of a functional wing. Success in the challenge will be determined by the amount of time the plane stays in the air while rotating around a center point along with the number of revolutions made during that time. As this challenge is introduced, cadets will share what they learned during their session earlier today at the Exploreum about the four primary forces impacting flight (lift, drag, thrust, and gravity) and how the relative strength of these forces can be represented by vectors.

Note: The final challenge will be completed over two days and three sessions. The first two sessions focus on planning, creating, and evaluating wing designs. The third session focuses on communicating results and preparing presentations for the Academy celebration.

Learning Outcomes

- Utilize the Engineering Design Process to complete the design of a wing to meet given criteria under given constraints.
- Compute the aspect ratio of wings.
- Apply the concept of aspect ratio into creating a reasonable wing design.
- Use concepts of balance, lift, and drag to discuss a wing design.

Materials

- 1 Large balsa wood plane (assembled)
- 2 Around-the-Pole apparatus
    - center structure
    - tether line (plus extra line if replacements are needed)
    - paper clip (plus extras if replacements are needed)
    - tape (to mark quadrants on the floor)
- 2 stopwatches (or phones with timer app)
- Chart paper and markers
- 2 Clipboards
- Scratch paper
- Graph paper

- Rubber bands (to replace bands used to power planes)
- Wing design materials (extra for teams)
- LCD projector with speakers (to show Dr. Finn's Aspect Ratio You Tube video)

Per Team

- 1 *Final Challenge* Team Engineering Notebook (TEN)
- 3-4 *Final Challenge Brief* (1 per cadet)
- 1 medium balsa wood plane kit (excluding premade wing) per team
- 1 Table Kit
- 1 set of wing design materials (in plastic bag)
  - 2 foam plates
  - 2 wooden skewers
  - 1 sheet of foam paper (11" x 17")
  - 2 sheets tissue paper (10" x 15")
  - 1 manila folder
  - 1 sheet of cardstock
  - 4 craft sticks (2 large and 2 small)
  - 2 drinking straws (not bendable)
  - 2 small rubber bands (for wing design only, not powering plane)
  - 2 large rubber bands (for wing design only, not powering plane)

Preparation

This challenge involves a lot of "Around-the-Pole" flying so be prepared! Talk with your teaching assistants and Cadre about how you will work together to manage this on-going activity.

Construct 2 Around-the-Pole Apparatus (2 per platoon; 4 per ballroom)-Decide where you want to place each apparatus in the room. It is recommended that each be placed along the free space (or runway) in the room. Use the tape to make the four evenly spaced quadrants and place the apparatus where the quadrants intersect. The tape will be used to help everyone determine if the plane flies in a complete loop around the pole and to measure how many loops a plane completes (measured in half-loop units). Attach the tether line to the nail on top of the center structure. Cut the tether line so that it is about 36 inches long. Attach a paper clip to the other end of the tether line so that it is secure enough to hold one wing of a plane and not detach during flight.

Assign 2 Testing Supervisors- Cadets will be able to test their wing designs using the 2 testing apparatus. This will be an ongoing activity, based on how quickly teams complete the plan and design phases of the Engineering Design Process. One Testing Supervisor is assigned to each station.
Testing Supervisors will be responsible for:

- Assisting teams with attaching their plane wing to the apparatus.
- Counting the number of loops a plane travels (measured in half-loop units)
- Timing the flight of a plane and giving that information to teams

The clipboards and scratch paper can be used by the Testing Supervisors, if they need to take notes.

Plan Logistics of Testing Stations: A rotating, timed schedule will need to be developed to keep testing areas safe and organized. Each ballroom will have 4 testing stations (two per platoon). Each station should have no more than 1 plane flying at a time. At least one adult should be assigned as the Testing Supervisor. A stopwatch should be available for teams to record flight times for their tests.

Once several teams move into this phase of testing, the Testing Supervisor should limit each team to 3-5 minutes per test. After the allotted time, the team should return to their work area for redesign or move to the back of the line. A record should be kept ensuring that each team has at least one opportunity on the around-the-pole device.

Assign a Staff Materials Manager- The person managing this area will need to be sure teams have completed parts 1, 2, and 3 of the *Team Initial Wing Design* on **page 3** in the **TEN** before giving out any materials. Have the extra wing design materials arranged so that teams can come to a designated location to present their completed *Team Initial Wing Design* page and collect the listed materials. These materials are separate from the set of materials teams will receive to improve their designs.

When teams are ready to improve their designs and have completed the appropriate page in their TEN, this person can give them a plastic bag with the standard set of materials for wing design. As needed, teams can return to this person to replace damaged materials.

Assemble the Large Balsa Wood Plane- Follow the instructions on the outside of the model packaging to construct the plane. Be prepared to demonstrate how to conduct a flight test using one of the apparatus. It is recommended that you twist the rubber band (using the propeller) 150 turns. The rubber band will break at about 200 turns.

Prepare to Show Aspect Ratio You-Tube Video - There are two places during the Final Challenge when you need to show cadets segments of a You-Tube video made by Dr. Joshua Finn, an aeronautical engineer: https://www.youtube.com/watch?v=OkHsfmAs8vA. You will need to work with your fellow STEM Instructor and be sure you can access this video. Check that your computer, speakers, and LCD projector can show this video where both platoons in your ballroom can see and hear.

Session 1 Instructional Plan: (225 mins)

RESEARCH (25 mins):

Introduce the Final Challenge by giving each cadet a copy of the **Final Challenge Brief**, allowing time for them to read it. Start a discussion of the challenge by clarifying any questions about the criteria and constraints of the challenge (as listed in the Brief).

Criteria
1. Plane completes at least 1 complete loop around the pole.
2. Plane remains in the air for at least 10 seconds.

Constraints
1. Only materials requested can be used for the initial design. Subsequent designs can only be constructed with materials within the flight materials bag.
2. The parts of the plane provided to you may not be modified in any way.
3. Damaged materials can only be replaced one time.
4. You must be able to attach your wing to the Around-the-Pole device using the paperclip at the end of the string.

Show cadets the sample balsa wood plane, the around-the-pole testing structure, and how the plane will be attached to the testing apparatus. Wind up the rubber band on the balsa wood plane and demonstrate how the plane flies around the pole.

Explain that teams will receive all parts of the model plane except for the wing. Also display the materials available for their wing designs, using a pre-assembled wind design materials kit. Tell teams they will be able to decide which materials they want to use for their first design and then will receive a full set of materials for subsequent improvements.

Use this time also to help cadets identify and connect what they learned this week, especially about force vectors in their sessions at the Exploreum and USA, to solving this challenge. Chart these concepts using appropriate vocabulary and post so cadets can refer to it throughout the challenge. Have cadets think about the similarities and differences between the foam glider and the balsa wood plane, especially differences in lift, drag, thrust and weight forces on each Have the cadets sketch a picture of the balsa wood plane on the back of their Final Challenge Brief and diagram their predictions of the impact of the force vectors on their balsa wood gliders.

Key Points to be charted:

- Balance is important for stable flight
- Both lift and weight should be considered in the design
- Drag can both hinder and help flight (slow down plane vs. used to make plane turn)
- Aspect ratio (wing shape and size) affects stability and efficiency of the wing

Aspect Ratio = $\frac{(wingspan)^2}{actual\ surface\ area}$

Inform cadets that an aeronautical engineer, Dr. Josh Finn, made a special You-Tube video for them to provide them additional information about the relationship between a wing's aspect ratio and performance. Let them know that Dr. Finn used a different way to compute Aspect Ratio but that it gives the same result. His process and ours are mathematically equivalent. Tell them to listen for big design take-a-ways that might help their team with their design. Show the first half of Dr. Finn's video, stopping at the 8 min 10 sec mark when the section titled Design and Purpose of the Experiment appears. Chart additional take-a-ways they gleaned from the video.

PLAN AND CREATE (40 mins):

To begin the Plan and Create phase instruct teams to complete all three sections of **page 3** in their **TEN**. These must be completed before teams receive the materials they identify in their sketch. Show teams where they can locate graph paper if they need it to determine the dimensions of their initial wing design. Help teams to recall the appropriate measurements, their importance, and how to calculate aspect ratio.

When teams complete this page, they should bring it to the Staff Materials Manager who will look for measurements including the length and width of the wing's design as well as calculations of surface area and aspect ratio. Initially only the materials listed in their design should be supplied. Remind teams that materials are limited so that damaged materials may not be replaced for the initial design. Once teams receive their materials they should begin building their design.

You may find some teams stuck in the plan phase. After about 10 minutes spend time with these teams and encourage them to get something down on paper so that they can move into the create phase of the Engineering Design Process. Reassure them that they will have ample time to redesign if their first plan is unsuccessful. Use this as an opportunity to reinforce the importance of trying and failing in the learning process. All teams should have their materials and be building their design within 20 minutes of starting the challenge.

As teams complete their initial design, allow them to move to the Test and Improve phase. Be sure cadets know the purpose of this test is for them to check for stability and lift of their design. Teams should use the provided rubber band and testing apparatus to complete this test (no "throwing" tests). The number of turns of rubber band is an additional variable for them to consider, but a suggested starting point would be 100 turns.

TEST AND IMPROVE (135 mins – includes 10 min break, if needed):

Facilitate Testing at Stations (55 min): The two Testing Supervisors should monitor teams and help them attach their planes for testing. Each station should have no more than 1 plane flying at a time. The Testing Supervisor will oversee the team's use of a stopwatch (or phone app) to record flight times for their tests and help cadets count the number of loops their plane makes (in half-loop units).

Once several teams move into this phase of testing the Testing Supervisor should limit each team to 3-5 minutes per test. After the allotted time, the team should return to their work area for redesign or move to the back of the line or "holding pattern" for retesting. A record should be kept ensuring that each team has at least one opportunity to test their design on the around-the-pole device. Teams should wait in a "holding pattern" line for clearance to run their test flight. Make sure the holding pattern will not interfere with the testing of planes.

As teams finish their first test flight have them return to their work area to record notes about the flight and any possible changes to their design, including the number of turns of the rubber band, on **page 4** of their **TEN** under Test 1. These notes should be presented to the Materials Manager at the materials table so they can now get a full set of wing design materials. They may still use the materials they received initially in addition to the full set of materials.

As teams continue through the improvement and testing process, they should record notes and decisions after each test on **pages 4 - 7** of their **TEN**. If a team begins to struggle with their design, encourage them to learn by observing other teams and the notes they took about their previous designs. Cadets may be tempted to scrap their design after one or two failing attempts. This is another opportunity to reinforce the importance of failure to the design process. Emphasize that persistence through setbacks leads to learning opportunities that can generate improved designs. Remind cadets that learning from any failures is the key.

If a team is satisfied with how their plane is performing remind them that one team will be named the Wing Design Top Gun for each ballroom. They should be working towards achieving that lofty goal. Suggest they try different numbers of turns of the rubber band up to 200 turns. Caution them, however, that broken rubber bands will only be replaced once (additional rubber bands should be available, but cadets should be cautioned against careless use of the materials).

Check-in and Discuss Progress (15 min): Have all teams stop testing for a brief discussion about their progress and to show them the remainder of Dr. Finn's video. Show the last half of Dr. Finn's video, starting at the 8:10 mark where he conducts and compares two flight tests of his two hand-made gliders that have rectangular wings with the same surface area but different dimensions and aspect ratios: one is 12" by 2" and one is 8" by 3", before concluding with a flight test of one of his highly refined gliders. Remind cadets there is a lot to think about when designing a wing.

Encourage teams to use the Trim Charts in their TEN following each test to help them troubleshoot design issues and solutions. Also use this time to highlight teams who have persisted through failure to improve their design. Have these teams share about how they dealt with frustration, learned from mistakes, and incorporated this knowledge into their design. Allow teams to share any information they feel may help struggling teams. Also take this time to address any consistent problems you see across many teams (e.g., no lift, nose dives, bounces).

Continue the Test & Improve Cycle (55 min): Allow teams to return to their work, walking around the room to support struggling teams and encourage successful teams to find ways to improve their design's performance. Remind teams they should document all decisions on **pages 4 -7** of their **TEN.**

If needed, cadets may have a 10 minute break during this segment.

With about 30 minutes left in this phase, double check with the Testing Supervisor that all teams have had at least one test on the around-the-pole apparatus. Have any teams that have not tested at least once move to the testing area and test their current design.

Wrap-up and Prepare for Evaluation (25 mins):

Have all teams stop testing and come to agreement on a final wing design. They should make final adjustments to their prototype at this time, and then draw a new sketch (with labels) of their final design on **page 8** of their **TEN**. Inform teams that this page will be required to enter the final evaluation and no adjustments to the design will be allowed from this point forward. Their plane should be completely ready for evaluation before they leave this session. As teams complete this task, have them place all remaining materials back in the materials bag. During the final evaluation they will be able to use these materials to make small adjustments or repairs (no major design changes) to their prototype.

Use the remaining time to review the evaluation procedures with cadets. Direct teams to **page 9** of their **TEN** so they can follow along with you during the discussion. During the evaluation each team will have the chance to try to fly their plane two times. Each time, or trial, should be recorded in their TEN. For each trial, teams will calculate a flight score [(number of loops) + (time in sec/60)]. Teams will then choose the higher of the two scores as their final score. The evaluation will begin with two teams (1 per testing station) while all other teams are waiting in a "holding pattern" and observing fellow teams' results. During testing, one team member will launch the plane, another will count the number of loops (to the nearest half-loop) and another team member will time the flight. The testing teams will each complete one trial, record the number of loops (in half-loop units), and time in their TEN. If there is a problem caused by a malfunction of the apparatus, teams will be allowed to retest as part of this trial. These teams will then move into the "holding pattern" line to allow all teams to complete their first trial. Teams can calculate their flight scores and should rewind the plane's rubber band while in the holding pattern. Once all teams have completed their first trial and recorded the pertinent information, the cycle will start again for the second trial. In between trials, teams can make small adjustments to their prototype and repair any damage. After all trials are complete, teams will report out their top score so it can be charted for the whole ballroom to see. The team with the overall highest score (in the ballroom) wins the challenge and is declared the Wing Design Top Gun Team. The best performing team of each ballroom will get to fly their planes during the final celebration for honored guests.

Have each team place their **plane**, **materials bag**, and **TEN** in the center of their space on the table. All other materials should be put away.

STEM in the Air Final Challenge: Up, Up, but not Away

SUNDAY EVENING (7:00PM -8:30 PM)

SESSION 2: AROUND-THE-POLE EVALUATION (90 MIN)

Overview

This session continues the STEM in the Air Final Challenge and shifts the focus from the Test and Improve phase to the Evaluation and Communication phases of the Engineering Design Process. After each team evaluates their final wing design using an around-the-pole testing apparatus, cadets prepare for formal communication of their design process, solution and results. Success in the challenge will be determined by the amount of time the plane stays in the air while rotating around a center point, along with the number of revolutions made during that time.

Learning Outcomes

- Utilize the Engineering Design Process to complete the design of a wing to meet given criteria under given constraints.
- Compute the aspect ratio of their wing design.
- Incorporate the concept of aspect ratio into formulating a reasonable wing design.
- Use concepts of balance, lift, and drag to discuss a wing design.

Materials

- 2 Around-the-Pole apparatus
- 2 stopwatches (or phones with timer app)
- Chart paper and markers
- Rubber bands (to replace bands used to power planes)
- Assorted Colored Paper
- Extra fishing line (to repair testing apparatus, if needed)
- Teamwork Check-In (1 per cadet)

Per Team

- *Final Challenge* Team Engineering Notebook (TEN)
- Team balsa wood plane with final wing design and materials kit
- 1 Table Kit
- Trifold Poster Board
- Index Cards (as needed)
- Scratch Paper (as needed)

Preparation

Check Testing Apparatus: Test the Around-the-Pole testing apparatus to make sure it is functioning properly.

Confirm Logistics of Final Evaluation at Testing Stations: The evaluation process will be similar to the process used during the Test and Improve phase of the challenge. However, teams are competing against all other teams in the ballroom. You will need to work with your fellow instructor to decide how you debrief the final results and name the Wing Design Top Gun Team for that ballroom.

Be sure the teaching assistants and Cadre are familiar with the evaluation process so they can help complete this activity efficiently. You will need two Testing Supervisors, one per station (like before). A summary of the evaluation process is below:

> Each team will have the chance to try to fly their plane two times. During testing, one team member will launch the plane, another will count the number of loops (to the nearest half-loop) and another team member will time the flight. Each time, or trial, should be recorded in their TEN. For each trial, teams will calculate a flight score [(number of loops) + (time in sec/60)]. Teams will then choose the higher of the two scores as their final score. The evaluation will begin with two teams (1 per testing station) while all other teams are waiting in a “holding pattern”. The testing teams will each complete one trial, record the number of loops (in half-loop units), and time in their TEN. If there is a problem caused by a malfunction of the apparatus, teams will be allowed to retest as part of this trial. These teams will then move into the “holding pattern” line to allow all teams to complete their first trial. Teams calculate their flight scores and rewind the plane’s rubber band while in the holding pattern. Once all teams have completed their first trial and recorded the pertinent information, the cycle will start again for the second trial. In between trials, teams can make small adjustments to their prototype and repair any damage. After all trials are complete, teams will report out their top score so it can be charted for the whole ballroom to see. The team with the overall highest score between both platoons in the ballroom wins the challenge. The best performing team of each ballroom will be the Wing Design Top Gun team and get to fly their planes during the final celebration for honored guests.

Additionally, use the following guidelines to help clarify important details of the evaluation activity:

- The NUMBER OF LOOPS around the pole will be measured from when the plane first leaves the ground to when it first touches down. This will be measured in units of 0.5 loops.
- The TIME in flight will be measured in seconds to the nearest hundredth from when the plane first leaves the ground to when it first touches down.
- The score for each trial will be calculated as follows: (number of loops) + (time in sec/60)
- Any “flight” that results in fewer than 0.5 loops or lasts fewer than 5 seconds will be deemed a bounce and teams should record a score of zero.
    - If a team has two scores of zero (their plane bounced but did not fly), and if time permits, they may be allowed to change their design and complete a third trial.

Prepare Team Scoring Chart: Make a grid on chart paper that lists the names of all teams and provides space to record their final top score. After all trials are complete, teams will report out their top score so it can be charted for the whole ballroom to see.

Session 2 Instructional Plan: (90mins)

Final Evaluation (60 mins):

Quickly remind teams of the testing procedures and criteria for success. Organize them in a rotating schedule for the final evaluation. Before a team is ready for a trial, they should wind up the rubber band. During testing, one team member will launch the plane, another will count the number of loops (to the nearest half-loop) and another team member will time the flight.

Teams should rotate through testing as quickly as possible. Teams can make small adjustments and repairs to their planes between trials as long as it does not alter their design in a major way. You may find that one or two teams have designs that are not successful after two trials. Allow them to make changes using extra wing design materials and to conduct a third trial, if time allows.

Once all teams have tested and have determined their best score, record their top scores on chart paper and identify the Wing Design Top Gun Team for your ballroom. The winning team will be asked to fly their plane in a demonstration to guests at the next day's Academy celebration.

Nomination of Squad Leaders to serve on Interview Panel (8 min)

Congratulate all teams on their persistence in tackling this Final STEM Challenge. Point out that throughout the challenge teams exhibited significant teamwork and leadership skills. At this time, each **Squad** needs to ***nominate*** two cadets who the Squad believes have best exhibited strong leadership and teamwork traits throughout the Academy – not only while solving the STEM Challenges, but during all of the Academy's activities, e.g., industry and educational field trips, physical fitness exercises. Let Squads know that ***some*** of these nominees will be selected to serve on a panel during the Awards Luncheon. Through a question & answer process, the selected cadets will get to share his/her perspective on this summer's STEM Academy and what experiences have meant the most to them. Before lights are out tonight, Cadre will inform cadets if they have been selected to be on the panel and will give instructions on where to meet during breakfast to prepare for the panel. Be sure cadets understand that this is a low pressure panel and that they will help decide what questions will be asked and will have time to think about responses.

> Note: As soon as the nominations have been completed, STEM Instructors need to give the Academy Coordinator an index card with their ranking of the 2 nominees for each Squad including the following information on each: Cadet's name, High School, Platoon and Squad Number, Gender and Ethnicity. Academy Staff Leaders will make the final selections in an effort to provide a diverse panel representing as many schools as possible. The Academy Leaders will convey the final selections to the Cadre who will inform cadets of their selection and instructions before cadets leave the session tonight.

Prepare for Formal Communication (20 min):

Have teams turn to **page 10** in their **TEN** and give cadets a few minutes to reflect on what features of their design worked well and what they would do to make improvements if they had more time.

Explain that one of the most important steps of the engineering design process is communication where engineers describe results and make recommendations, usually to the person who hired them to design the prototype. Tell teams they will plan, develop, and present an "Around-the-Pole Flyer Challenge Brief." This Brief will be used during the Academy celebration to inform guests about what they have learned over the week and how they applied their knowledge to solve this challenge.

Tell cadets to turn to **pages 11-12** in their **TEN** to learn more about what is expected in the Brief. Use chart paper to record and display the criteria for the Brief. The Brief must contain:

1. An explanation of how you used the Engineering Design Process to solve this challenge.
2. A sketch of your wing design (with labels).
3. A brief explanation of the science and mathematics content you applied to solve this challenge.
4. The final wing design prototype and TEN.
5. The evaluation results and recommendations for how you might continue to improve your design.

In addition, teams should plan to give a 2 to 3-minute oral presentation to any guests who come to their posters. Each team member should have a speaking part. Refer to the Communication Scoring Rubric on **page 12** in the **TEN** and review with cadets once again the important vocabulary and learning outcomes charted at the beginning of the final challenge. Encourage them to incorporate this information into their presentation. Explain the Communication Scoring Rubric should be used as a guide to self-evaluate the quality of their poster and planned presentation.

Let teams know that they will have limited time in the morning to make their presentation boards and to practice their oral presentations with other teams, but now teams need to discuss ideas for their presentation. Give cadets the remaining time to start brainstorming and planning their poster and what they want to say in their presentation. Scratch paper can be used by teams to record their ideas.

Wrap-up and Transition to Teamwork Check In and Reflections (2 mins):

With the few minutes remaining for the lesson, have teams clean up their work areas and organize their TEN, plane prototype, and poster materials. Teams can leave these materials at their workstation for the next session.

Turn the session over to the SHC Platoon Leader to conduct the Teamwork Check in and Journal Reflections, based on the reflection prompts for this day. **(Display slide with Sunday's Reflection Prompts.)**

STEM in the Air Final Challenge: Up, Up, but not Away

MONDAY MORNING (9:00AM -11:30 AM)

SESSION 3: COMMUNICATING RESULTS (120 MIN + 30 MIN FOR ACADEMY SURVEY)

Overview

This final session of the challenge will emphasize the importance of communication. Teams will work together to create an Around-the-Pole Flyer Brief and plan a two-minute oral presentation. As this session is also the last session of the Academy, teams will prepare to give their presentations to visiting guests. The Wing Design Top Gun Teams with the highest performing planes (one per ballroom) will also prepare to demonstrate their plane's around-the pole performance for visitors. During this session, one squad at a time will leave for 30 minutes to take the Academy post-test.

Learning Outcomes

- Utilize the Engineering Design Process to complete the design of a wing to meet given criteria under given constraints.
- Compute the aspect ratio of their wing design.
- Incorporate the concept of aspect ratio into formulating a reasonable wing design.
- Use concepts of balance, lift, and drag to discuss a wing design.

Materials

- 1 Around-the-Pole apparatus
- Chart paper and markers
- Rubber bands (to replace bands used to power planes)
- Assorted colored paper
- Extra fishing line (to repair testing apparatus, if needed)

Per Team

- *Final Challenge* Team Engineering Notebook (TEN)
- Team balsa wood plane with final wing design
- 1 Table Kit
- Trifold Poster Board
- Index Cards (as needed)
- Scratch Paper (as needed)

Preparation

Plan for the Poster Session-work with the other Instructor in your ballroom to consider and plan for the poster session. Teams from both platoons will participate in a practice poster session with another team using the Communication Brief Rubric to receive feedback and improve their posters and team presentation.

Posters should be arranged on the tables so that teams can stand in front of their posters and talk with visitors (and other teams) as they walk around the room. If table space is not available for all posters, identify additional locations in the ballroom to arrange posters and teams. Each team will need to have their poster, porotype, and TEN.

Plan for Around-the-Pole Demonstration- The Wing Design Top Gun Team for each ballroom will be asked to demonstrate their plane's around-the pole performance for visitors. Work with your fellow instructor to identify the best location in the ballroom (or directly outside of the ballroom) for the around the pole apparatus. Also consider allowing the team to access additional prototype materials in case the plane gets damaged and they need to make quick repairs.

Plan for Foam Glider Demonstration- One cadet of the Foam Glider Top Gun Team that had the best foam glider obstacle course performance per ballroom should be asked to fly a foam glider while visitors come up to the presentations. Gliders will be flown in the hallway leading up to the ballrooms. Again, work with your fellow instructor to decide which cadet will give this demonstration. The team may choose the person or you can choose the person.

Session 3 Instructional Plan (120 mins)

Prepare for Communication and Complete Post-Assessment (100 min):

Allow cadets to spread out in the room to begin designing their posters and writing up notes to help them with their presentation. Remind teams to use **pages 11** and **12** of their **TEN** as a guide for designing a high-quality communication poster and presentation. Refer to the sample poster diagrams in their TEN if teams need some guidance on how to organize the information. Tell teams they will have about an hour to complete their posters and practice their presentations. Encourage cadets to record their talking points on index cards.

> Note: Teams will be interrupted during the preparation time to complete the JROTC STEM Leadership Academy post-test and questionnaire. Cadets may need their cell phones to access the survey. Cadets will complete the assessment by squad, rotating out of the ballroom in turns. This activity may take up to 30 minutes for each squad. So, team will really have about 70 minutes to develop their posters and presentations.

Practice Communicating Results: (35 min)

Direct teams to put away all unused presentation materials and display their posters in the designated areas of the room. Either gather these materials or have cadets return them to a central location in the room. Teams should keep their TEN and prototype with them. Be sure to space the Briefs so that one team can cluster around their poster while another team listens to the presentation. Teams should turn to **page 12** of their **TEN**.

Explain that now teams will have a chance to practice their presentation and evaluate their communication brief (poster) with the other teams in the ballroom through a practice poster session. Emphasize that poster sessions are a little different from other types of presentations in that people are usually walking around and discussing the information on the visual aid and the general project in a more informal way. However, it is the responsibility of each team to make sure visitors coming up to them walk away with a clear picture of their challenge, how their team addressed the challenge, and how they used the mathematics and science content in this challenge.

In coordination with the other instructor in the ballroom, briefly explain how teams will pair up to evaluate each other's posters. Teams will take turns being the listeners and the presenters. Be sure to cadets understand:

- One team will start off as the Presenters. These teams will station themselves around their posters and have their wing prototype in their hands.
- The other team will start off as the Listeners. Each Listening Team will start the activity at one of the Presenting Team's posters (1 Listening Team per 1 Presenting Team).
- The Presenting team should give their **TEN** to the Listening team. The Listening team will complete the Communication and Design Scoring Rubric on **page 12**.
- When an instructor says begin presentations, the two teams can interact more casually, understanding that the goal is to give the Presenting Team a chance to practice talking about how they addressed the engineering design challenge (about 2 minutes) and allowing time (about 2 minutes) to respond to questions posed by the "Listening Team."

- After about 4 minutes, an instructor will signal all to stop and direct the listening teams to complete a *Communication Scoring Rubric* for the Presenting Team. While the Listening Team completes the rubric, the Presenting Team should discuss ways to improve their presentation. After 2 minutes the Listening Team will give the completed rubric back to the Presenting Team.
- Instructors will direct Teams to switch roles and repeat the process.

Encourage teams to use the scores on their rubrics as feedback to help them make their presentations better before the Academy special guests arrive.

Prepare for Formal Presentations and Demonstrations (15 min)

Once teams have had a chance to practice, tell them they are now going to make final plans to present for guests who will attend the Academy celebration. This is their opportunity to show people what they have learned over the week and how they used their knowledge to solve this engineering design challenge.

The Wing Design Top Gun Team that had the best performing prototype in the ballroom should also prepare to fly their plane for visitors as part of their presentation.

Also, the Foam Glider Top Gun Team that had the best foam glider obstacle course performance per ballroom should identify one team member to demonstrate using the guiding material to fly their glider. Set aside space in the hallway for the foam glider demonstration for visitors.

All teams must be ready for guests in the 2nd Floor Ballrooms no later than 11:25 am on Monday morning.

STEM in the Air Final Challenge

Up, Up, but not Away

Team Engineering Notebook

Team Name:______________________________

Platoon Color: __________ **Squad #**______

Team Cadets:______________________________

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Up, Up, but not Away
Final Challenge: Around-the-Pole Flight

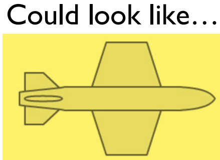
Your team has been selected to participate in an “Around the Pole” flight competition against other JROTC cadets. In this competition, your team will attempt to get your rubber band-powered plane to complete as many loops around a “pole” as possible while sustaining flight for as long as possible. Unfortunately, during testing the wing of your plane was destroyed by a dramatic interaction between the plane and the pole. The rules of the competition specifically state that you cannot use the wing from another plane, but don’t seem to prevent you from making your own wing. You have access to a limited set of resources, but you are confident that using the knowledge you gained this week about designing wings and the dynamics of flight your team can design and build a replacement wing that will make your plane (and score) soar.

RESEARCH AND PLAN:

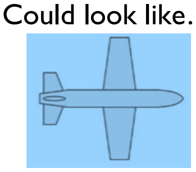
Think about everything you’ve learned about flight and how differences in design features can impact the performance of a plane. When designing your wing, remember that the ratio between the wingspan and wing surface area can impact the performance of your plane. Use the information below to help you decide on the best aspect ratio, materials, and overall design.

<u>Common Aspect Ratios</u>:

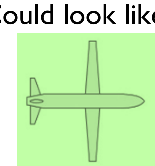
Low
2:1 to 6:1
Could look like…



Medium
7:1 to 10:1
Could look like…



High
12:1 to 22:1
Could look like…



LOW Aspect Ratio	HIGH Aspect Ratio
Pros: • Tolerance to construction irregularities • Higher weight tolerance • More maneuverability Cons: • Requires high powered engine • Poor no-powered gliding	Pros: • Requires less engine power • Excellent no-power gliding Cons: • Less tolerance to construction irregularities • Lower weight tolerance • Less maneuverability

Create a Prototype:

Once your team has a complete sketch and decided on initial materials, use your selected materials to create your first wing design. After you've created and tested your first design, you will have access to additional materials for redesign.

Test and Improve:

Your team will be able to test your wing design at one of two testing stations in the room. You need to complete each test within 3-5 minutes. Use the trimming chart in your team engineering notebook to identify problems and design solutions. You can test and make improvements to your design as many times as time allows. Be sure to sketch and diagram your final design in your Team Engineering Notebook.

Evaluate:

At some point, your instructor will end the Test and Improve session and orient you to the final evaluation of your design. Your team score will depend on two measurements: the number of loops around the pole and the time spent in the air. You want to maximize each.

Criteria for Success

1. Plane completes at least 1 complete loop around the pole.
2. Plane remains in the air for at least 10 seconds.

Constraints

1. Only materials identified in the sketch of Wing Design #1 in TEN can be used for the initial design. Subsequent designs can only be constructed with materials within the flight materials bag.
2. The parts of the plane provided to you may not be modified in any way.
3. Damaged materials can only be replaced one time.
4. You must be able to attach your wing to the Around-the-Pole device using the paperclip at the end of the string.

Up, Up, but Not Away!

Team Initial Wing Design

Directions: Complete parts 1, 2, and 3. Then bring the completed sheet to the instructor to receive the materials you need to create your wing design.

1. Sketch of Team Wing Design #1

2. On the sketch above, record the relative measurements (width, wingspan, and approximate surface area) and aspect ratio. You may use graph paper to measure wingspan and surface area. Show how you computed aspect ratio.

3. List the materials you will need to construct Wing Design #1.

Up, Up, but Not Away!

Test & Improve

Directions: Use the next two pages to take notes and make decisions as you cycle through the iterative process of testing and improving your designs. The trimming charts are provided to offer suggestions about possible adjustments to your design given specific flight problems. You should understand that making an adjustment to one variable could affect others in the overall design.

Test 1:

Notes:____
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Trimming Chart: Use the chart below to "trim" or adjust your wing design.

Potential Problem	Potential Reason	Design Adjustment
Plane pitches nose down before or shortly after take-off	Balance	
Plane drastically pitches nose up before or shortly after take-off	Balance	
Plane tilts with one wing up and the other down before take-off or during runway test	Balance	
Plane performs smoothly but is unable to achieve lift-off	Weight and/or Thrust and/or Aspect Ratio	
Plane seems to move too slowly for flight.	Drag and/or Thrust	
Plane lifts off but does not stay in the air long enough.	Aspect Ratio and/or Thrust	

Up, Up, but Not Away!

Test & Improve

Test 2:

Notes:____
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Trimming Chart: Use the chart below to "trim" or adjust your wing design.

Potential Problem	**Potential Reason**	**Design Adjustment**
Plane pitches nose down before or shortly after take-off	Balance	
Plane drastically pitches nose up before or shortly after take-off	Balance	
Plane tilts with one wing up and the other down before take-off or during runway test	Balance	
Plane performs smoothly but is unable to achieve lift-off	Weight and/or Thrust and/or Aspect Ratio	
Plane seems to move too slowly for flight.	Drag and/or Thrust	
Plane lifts off but does not stay in the air long enough.	Aspect Ratio and/or Thrust	

Up, Up, but Not Away!

Test & Improve

Test 3:

Notes:____
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Trimming Chart: Use the chart below to "trim" or adjust your wing design.

Potential Problem	Potential Reason	Design Adjustment
Plane pitches nose down before or shortly after take-off	Balance	
Plane drastically pitches nose up before or shortly after take-off	Balance	
Plane tilts with one wing up and the other down before take-off or during runway test	Balance	
Plane performs smoothly but is unable to achieve lift-off	Weight and/or Thrust and/or Aspect Ratio	
Plane seems to move too slowly for flight.	Drag and/or Thrust	
Plane lifts off but does not stay in the air long enough.	Aspect Ratio and/or Thrust	

Up, Up, but Not Away!

Test & Improve

Test 4:

Notes:____

Trimming Chart: Use the chart below to "trim" or adjust your wing design.

Potential Problem	**Potential Reason**	**Design Adjustment**
Plane pitches nose down before or shortly after take-off	Balance	
Plane drastically pitches nose up before or shortly after take-off	Balance	
Plane tilts with one wing up and the other down before take-off or during runway test	Balance	
Plane performs smoothly but is unable to achieve lift-off	Weight and/or Thrust and/or Aspect Ratio	
Plane seems to move too slowly for flight.	Drag and/or Thrust	
Plane lifts off but does not stay in the air long enough.	Aspect Ratio and/or Thrust	

Up, Up, but Not Away!

Final Wing Design

Directions: Complete parts 1, 2, and 3. Your team will need to show this page to the instructor before you can participate in the final evaluation of your design.

1. Sketch of Team's Final Wing Design

2. On the sketch above, record the relative measurements (width, wingspan, and approximate surface area) and aspect ratio. You may use graph paper to measure wingspan and surface area. Show how you computed aspect ratio.

3. List the materials you used to construct your final design.

Up, Up, but Not Away!

Team Evaluation

Directions: Use the table below to record the flight time and number of loops your plane prototype completed. Calculate the total score and then select the highest score.

Score Results for Final Evaluation

	Trial 1	**Trial 2**
Time (seconds in hundredths)		
Number of Loops (units of 0.5 loops)		
Total Score (number of loops) + (time in seconds/60)		
Top Score:		

NOTE: Any "flight" that results in fewer than 0.5 loops or lasts fewer than 5 seconds will be deemed a bounce and teams should record a score of zero.

Up, Up, but Not Away!

Thinking About Redesign

Observations

a. What worked well?

b. Given additional time, what are three things your team could try to continue to improve your flight score? Explain your thinking.

1.

2.

3.

Up, Up, but Not Away!

Communicating Team's Design Process, Wing Design, and Results

Your team will need to plan, develop, and present an Around-the-Pole Flyer Challenge Brief. Your brief will be presented orally, along with a large visual aid, which you will need to develop. Your team should prepare for a 2-minute presentation. Each team member should have a speaking part. Your presentation will be evaluated using the "Communication Scoring Rubric" located on the next page in your Team Notebook. This rubric provides additional important information about how your team's presentation of your brief will be evaluated.

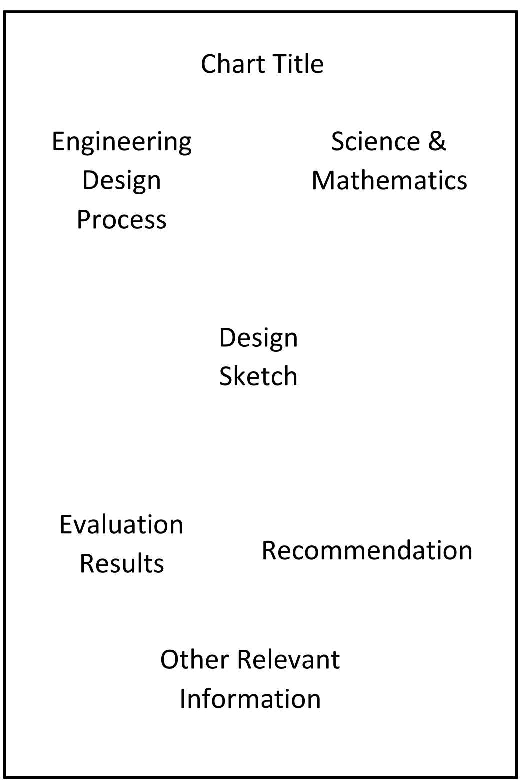
Criteria for Presentation Brief. You need to include the following components in your brief:

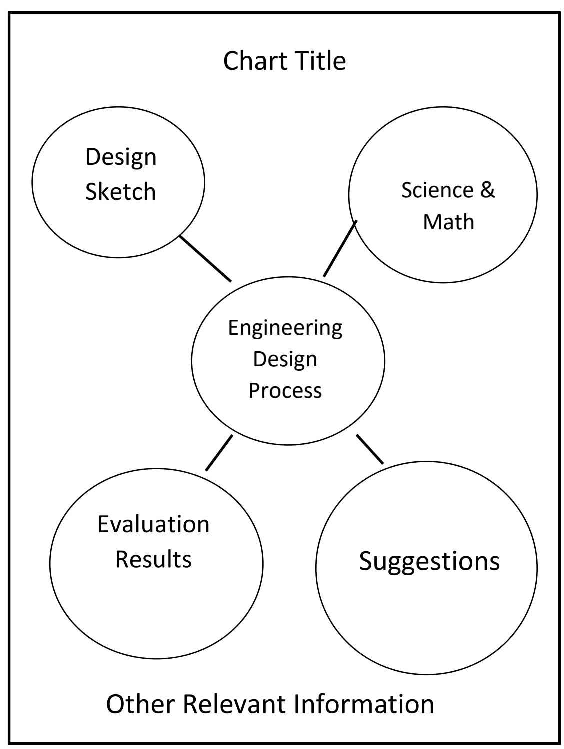
1. An explanation of how you used the Engineering Design Process to solve this challenge.
2. A sketch of your wing design (with labels).
3. A brief explanation of the science and mathematics content you applied to solve this challenge.
4. The final wing design prototype and TEN.
5. The evaluation results and recommendations for how you might continue to improve your design.

Materials. To help you create your visual aid, your team will use the following materials:

- 1 tri-fold poster
- 1 set of colored construction paper
- Index Cards
- Scratch paper
- Table kit materials

Use the materials, rubric, and time wisely to prepare your Brief and presentation. Consider the following layouts as possible ways to organize your information on the chart paper. These are suggestions only and may not include all the required components. Be creative and be sure to include all required information.





Up, Up, but Not Away!

Communication Scoring Rubric

	Criteria	*Needs Improving 1pts*	*Satisfactory 2pts*	*Outstanding 3pts*	*Points*
Overall Presentation	**Presentation Organization**	Either not very organized or not very clear	Mostly logical and clearly presented	Very logical and clearly presented	
	Oral Presentation Quality	Very little eye contact, mostly reading poster; low voice volume and often hard to understand words	Some eye contact; reads poster about ½ of the time, adequate voice volume & fairly easy to understand words	Substantial eye contact (over ½ of time), rarely reads poster; speaks clearly, good voice volume	
	Involvement of Team Members	Only 1 team member involved	2 team members involved	All team members involved	
Content In Presentation	**Describes Design Process (that led to final design)**	Does not include a description of the steps of the Team's design process.	Includes a description of most of the steps of the Team's design process.	Includes a description for each step of the Team's design process.	
	Includes STEM Content (applied in designing the wing)	Does not correctly convey using or applying at least 1 content fact, with targeted vocabulary, related to aeronautics.	Correctly conveys using or applying 2 to3 content facts, with targeted vocabulary, related to aeronautics.	Correctly using or applying 4 or more content facts, with targeted vocabulary, related to aeronautics.	
	Includes Skills Learned about Effective Teams	Does not convey at least 1 skill learned about effective teams.	Conveys 2 to 3 skills learned about effective teams.	Conveys 4 or more skills learned about effective teams.	
	Includes Evaluation Results and Recommendations	Does not include both results and recommendations	Includes evaluation score and at least 1 recommendation	Includes evaluation score, how score was derived and multiple recommendations	
				TOTAL SCORE	***/21 pts***

