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| **Course:** Middle School |
| **Unit:** Flight Level 2 | **exercise:** Paper Rocket | **Time Frame:** 8 - 10 Hours |
|  | Preparation: *Summary of “to do’s” that the teacher should understand and prepare before bringing this lesson to the classroom.* |
| Teachers will need to ensure that the proper supplies are available for students to build their solutions. From the kit you will need these items:**Materials:*** Copy paper
* Clear tape
* Graph paper
* Index cards

**Tools:*** Completed straw rocket launcher assembly (see teacher resources section for instructions)
* Pump, bike w/gauge
* Rulers
* Scissors
* Finder altitrak altitude

\*\*Material distribution can affect how the problem is designed and solved. For example, a box of materials can be put out for all to use; a paper bag process where you only get to use what’s in the bag; a shopping trip theory where the designer has a set amount of “money” and they are forced to buy materials and when you run out of money there is no more; do you give more materials for failure solutions or ideas? Etc.\*\***Teacher Methodologies:**1. Define the four major components of a rocket: body-holds everything together, nose-cone – cuts through drag, fins – steer, propellant – provides thrust. A fifth component could be mentioned: a recovery system of some kind (difficult to design in this problem). How does this relate to real rockets?
2. What is compressed air and how does it provide thrust?
3. Decide how the distance will be measured and how many times will the rocket be launched. 3-5 launches provide an averaging aspect to the final calculations. Linear distance versus altitude provides a different problem set.
4. What are the factors that affect the problem? Help students understand how to identify the factors.
5. There is a value to comparing design versus successful flights.
6. Require proper geometric construction of cylinders and cones
7. Air leaking between the nose cone and the body is a big factor in harnessing the compression for thrust.
8. How much time to solve the problem
9. Have student develop the rules and laws
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|  | Safety: *Summary of safety strategies in the lesson.* |
| Projectiles are used in this activity. Clear the launch area before loading pressure into the reservoir and pulling the launch cord. 35-40 PSI is the maximum load for the reservoir. Risk of seal rupture on the pump if any more is applied. Do NOT use a compressor plugged into the wall or shop air. |
|  | Desired Results:  |
| Established Goals: |  | Transfer: |
| *Problem Solving Techniques and Applications Standards:*Teachers should use the STEM Academy Standards Correlation System available in the STEM Connections area of a unit to extract specific standards and insert these standards here.  | *Students will be able to independently use their learning to…** Problem solve and construct a rocket.
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| Meaning: |
| Understandings*Students will understand that...** Much of engineering design depends on good documentation of the design process
* For an experiment to be valid, it must be designed so that only the independent variable can cause the change in the dependent variable.
* To find the optimum straw rocket, all variables except one independent variable must be controlled, or kept the same during each test.
* In any experiment, students should perform multiple tests on each variable.
* Variables do not have to be numbers
 | Essential Questions*Students will keep considering...** When do we have independent variables? Dependent variables? Controlled variables?
* What engineering careers may involve working with independent and dependent variables?
* How can a rocket be built to exceed in length of flight?
* Which principles of rocket construction contribute most to the flight?
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| Acquisition OF KNOWLEDGE AND SKILL: |
| *Students will know...** Aerodynamics and rocketry
* Principles of rocket construction
* Isolating variables
* Methodical approaches to problem solving
* Recording Data
* Engineering design process
* Principles of a variable
 | *Students will be skilled at...** Defining the origin of a problem
* Breaking down a problem, analyzing it, and determining the elements, specific issues within it
* Determining where problems come from
* Analyzing what is needed to solve a problem
* Investigating resources needed to solve a problem
* Working on a team
* Balancing testing with planning and research
* Repurposing old technology
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|  | Evidence:  |
| Evaluative Criteria: |  | Assessment Evidence: |
|  | *Performance Task(s):* Student will develop and design a rocket (4 major parts of a rocket: nose cone-cut through drag, body-holds everything together, fins-steering, and propellant provides thrust. Some include a fifth component in a recovery system and a sixth might be considered as human and material payload locations) using the assembled launcher (3-5 times) the paper rocket further in distance or height (average) than any other student in class. It is suggested to have the class develop the rules and laws that govern the activity. Student ownership in developing the criteria is a powerful component in the problem solving activity. Some suggestions might include: assembly time less than one hour, accurate geometric solutions for the nose cone, no human intervention, no modifications in between launches, etc. Some of these rockets will launch in excess of 50ft +. Do all six steps of this problem including sketching, drawing, testing, charting data collection, measuring, (altitude calculation or distance), averaging, evidence of learning, presentation, etc. Make this a common theme for the problem solving activities if possible.\*\*It is necessary for the designers and the teacher to discover the solutions. The author can provide lots of secrets or answers, but there is a huge value in identifying and discovering solutions.1. Record distances
2. Average distances and longest distance
3. Have student’s rank individual success
* How did the class rank relate to the design?
* Match the assessment to the communicated goals
* What value is assigned to a no fly or a rocket that blows up on the pad?
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| * Thoughtful, clear, thorough
* Graded on accuracy, multiple choice questions
* Completed on time
 | *Other Evidence:* * Online end of unit test
* Self-reflection
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|  | Learning Plan: *Summary of Key Learning Events and Instruction* |
| **Outline:**1. **Introduce**
2. Have students read through the activity.
3. Have students listen as you review the activity, materials, and testing procedures.
4. Start a conversation about the constraints. Have students talk about what they think the constraints should be and listen to their peers’ ideas.
5. Have students write down the constraints decided upon by the class.
6. Break students into groups of 2-3.
7. **Brainstorm**
8. Students discuss ideas with their group then write down and sketch five designs into the space provided.
9. Students determine which design they will use and sketch their final solution with parts and measurements labeled.
10. **Construct**
11. Students construct their rocket
12. **Test**
13. Students test their rockets in rounds.
14. Students write down their data next to their sketches and input it into an Excel sheet.
15. Students choose a variable to modify and take notes on the modification.
16. Students retest their rocket and continue to collect data and make modifications.
17. Once testing is over, they should calculate averages, write them down, and input them into the Excel sheet.
18. **Communicate Results**
19. Students discuss their results with their groups and write a brief presentation for the class. Students talk about the variables they tested and their results, then listen as other groups present their results.
20. Have students read the reflection questions and write down their answers.

**Learning Experiences:**1. The student will develop and design a paper rocket that launches from an air-compressed system farther than any other rocket in the class. The rocket must be technically designed utilizing the materials provided for the problem. It is necessary for the designer to pull the problem apart and identify the major factors. Some of these include PSI, compression factors between the straw and the copper pipe, the function of each of the parts, the four forces of flight, how will the distance be measured, etc.
2. Defining the rules and laws for this activity can be fun! Negotiating with the class to set the criteria can stimulate a great amount of ownership in the design of the problem. Suggestions for several constraints are no human intervention, only the material handed out can be used (no replacements), glue and tape for adhesion purposes only, technically correct geometric constructions, the rocket should fly technically correct (nose cone first), assembly time, no fixing or adjusting the rocket in between flights, how many flights?, etc.
3. Sketching is more informational for some and not others. Most students will formulate the solutions in their head and resist the planning process. In this activity, require 5 design sketches. Encourage the students to communicate how they are addressing the factors of the problem. They can draw the fin configuration, what the cone might look like, how to attach the nose cone, etc. Sketching is hand and paper thinking. This is an important exercise to emphasize, but not in volume in this instance.
4. The final solutions should feature a technical sketch. A technical sketch communicates clearly, includes notes and dimensions, and is accurately crisp in presentation. The final product should resemble this drawing very closely! It is a good challenge for all designers to follow. It is the control factor to insure planning ahead of time versus just getting stuff and throwing it together. The instructor is encouraged to introduce the learners to technical drafting products and techniques. Representing different views and method can introduce the students to a big world of technical communicating!
5. The Test and Evaluate phase is perhaps one of the student’s favorite parts. Most students would prefer to go from problem announcement, to get materials, to put it together, and see if it works. The goal of this step is to collect data (technically) and determine how modifying the factors changes the outcome of the solution. Does the solution work? Does a problem create another solution? One of the issues with the paper rocket will be wearing down the material. The more they test them, the more they wear down and lose compression. There is a fine line between testing and evaluating solutions or testing models. This problem utilizes more of the actual product than a model. Make sure the student measures and collects data every time they test the product. This is the significant difference between playing and testing. Remind them that this product has a “shelf life”. At what point should they stop testing and save the product for the final test. Require listing data on paper as well as an excel document. Excel does a great job with charting and it is a quick gratification to see results.
6. The presentation step has a number of processes in this problem. The first process is to launch the rockets in a controlled and measureable environment. Students and instructors can be involved with the measuring and recording. Three launches works well for larger classes and 5 launches for a smaller class. Rain, wind, and snow are the enemies, but you don’t always get to pick out a sunny day. This activity can be done in a gym if necessary but the outside element makes it feel more like a real rocket. Launching should happen in a round so that the launching pace can be maintained. Once the data is collected, then the students should average their distances, rank the class, determine the longest launch, and the longest average. Debrief the activity by tying the design of the rockets to the successful flights. Were the results predicted? How might this be different with different materials?

**Progress Monitoring:**The teacher will need to monitor student progress. Teachers should move throughout the classroom checking to see that students are keeping up with the lesson. After lecturing, the teacher should use students to help move students forward during the activity by sharing their expertise. Teacher may choose to post exemplars of student work for students to use who may have missed the lesson, missed some steps in the process, or may be struggling to keep pace with the class. |
|  | Differentiation: *Summary of Key Differentiation Techniques* |
| Please use this space to insert your differentiation techniques. Depending on the needs of students, various techniques might be needed in a classroom, therefore use the information below and experts in the area needed to design your plan for differentiation.The ASCD Study Guide for Integrating Differentiated Instruction and Understating by Design: Connecting Content and Kids.by Carol Ann Tomlinson, Jay McTigheIntegrating Differentiated Instruction and Understating by Design: Connecting Content and Kids.by Carol Ann Tomlinson, Jay McTigheISBN-13: 978-1416602842 ISBN-10: 1416602844Differentiating Reading Instruction*by Laura Robb.*ISBN13: 9780545022989A Teacher's Guide to Differentiating InstructionThe Center for Comprehensive School Reform and Improvement |

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|  | career Connections: *Summary of Career Opportunities Associated with this Lesson* |
| Please use this space to insert careers that might be connected to this lesson. This section will need continuous updating as new careers and emerging technologies change the opportunities available in the workforce.Good sources for career connections:Occupational Outlook Handbook<http://www.bls.gov/ooh>The National Career Clusters® Framework<http://www.careertech.org/career-clusters> |
|  | Keywords: *Please Insert Keywords from this Lesson with their Definitions* |
| Please use this space to insert keywords and their definitionsUse resources like [dictionary.com](http://dictionary.reference.com/) to find definitions to your keywords |