Maryland Engineering Challenges
2023 Paper Airplane Challenge

Elementary Level – Grades 1 to 5

Each grade will be judged separately.

Supported By:
Directors Team, Maryland Wing Aerospace Education,
American Institute of Aeronautics and Astronautics, Mid-Atlantic Section

Engineer Contacts:
Dr. Robert E. Terry rterry@cap.gov

Important Dates

Registration Due

- ⇒ **April 7, 2023** **Prior to 4:00 PM**
- ⇒ In order to be a participating team, each team must have their adult Coach register online at https://bit.ly/2023MECRegistration in advance of the due date

Written Report Due

- ⇒ **April 14, 2023** **Prior to 4:00 PM**
- ⇒ Submit the team's **Written Report** (Email in PDF format) to challenges@thebmi.org

Paper Airplane Competition

- ⇒ **Saturday, April 22, 2023** **Doors open at 9:00 AM**
- Competition will be at the Baltimore Museum of Industry, 1415 Key Highway, Baltimore
- Teams should bring their completed airplane to the competition ready to be tested
- Full details about the Challenge event will be emailed to Coaches after the registration deadline.

Questions about Challenge specifications or judging should be sent to the Engineer Contact:
Dr. Robert E. Terry rterry@cap.gov
Other questions? Contact Jessica Celmer challenges@thebmi.org

THE CHALLENGE

Design a paper airplane to fly a paperclip “passenger” as safely, as far, and accurately as possible.

ENGINEERING TEAM REQUIREMENT

Each team should consist of at least four students. Teams may share students at the same grade level or use younger grade students if needed to have at least 4 students on a team. There is no limit to the number of teams a school/organization may have. The student teams need to launch and test their designs to determine the best set of planes to bring to the BMI for the final competition.

DESIGN AND CONSTRUCTION STANDARDS

1. To build the paper airplane, teams may use any amount of standard 8.5" x 11" paper (20- pound or 75 grams/meter2) or similar cut sheet card stock, up to an equal mass of 3 sheets of 8.5" x 11" card stock.
    - At the competition, each plane will be weighed on a scale to make sure it falls at or under the weight of **1.32 oz** equal to 3 sheets of cardstock.
    - Internal and external use of glue, paper, or masking tape to affix or secure a launch hook assembly is also permitted.
    - Framing to be covered by paper is not permitted, the airplane must be formed by folded paper, starting from flat sheets.
    - Sheets may be affixed in layers, to form airfoils for example; and sheets may be rolled to form internal assemblies.
    - For extra credit, Heavy Class paper airplanes, up to 5 sheets of cardstock (measuring a max of 2.20 oz) mass equivalent, may also be entered and judged separately.
2. All airplanes must provide a launch hook assembly capable of accepting a standard width rubber band and strong enough to not bend when the hook is used to extend a typical rubber band.
    - Hooks that warp over repeated use will disqualify the airplane that bears them from further testing.
3. At least two paper clip “passengers” must remain attached to or inside the airplane for a flight to count. One relaunch is allowed for any lost passenger

DESIGN OF LAUNCH HOOKS

The simplest launch hooks can be constructed from a popsicle stick or a toothpick to be mounted along the “keel fold” or base of the paper airplane.

1. Opening the paper clip to an approximately right angle, slide the unperturbed wire over the toothpick or popsicle stick as shown in Figure 1a.
2. Then apply paper or masking tape to secure the clip to the wood piece, wrapping it tightly and burnishing it down around the wire to bind onto the wood, Figure 1b.

3. For extended use these single wire launch hooks will tend to bend out further and lose the ability to capture the driving rubber band. This problem can be solved by curving the hook further by using a pair of pliers or a dowel, so that the rubber band stays on.
4. Creating your own design of a launch hook is permitted and encouraged, so long as they do not add so much weight to the airplane that it exceeds the three (or five) card stock sheet mass constraint above. Other everyday materials can be used or you can even create a launch hook using a 3D printer, if you have access.

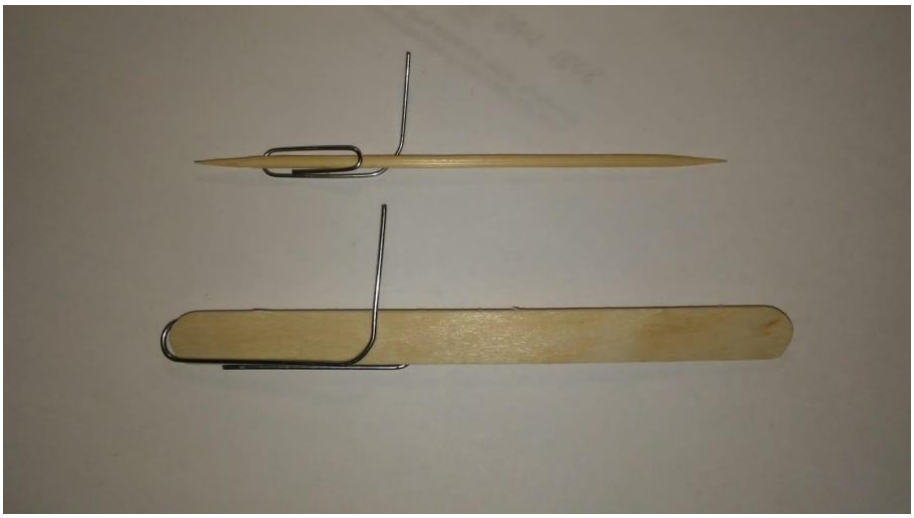

Figure 1a. Basic launch hook assemblies.

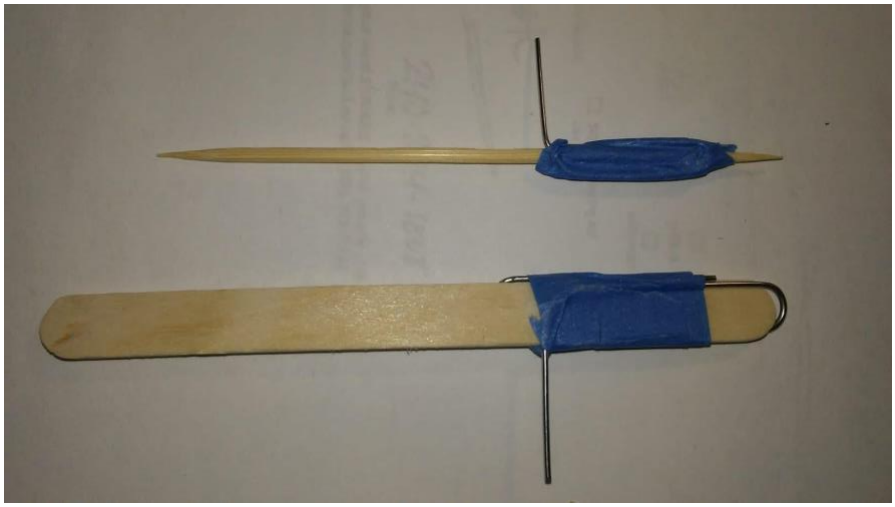

Figure 1b. Securing the wire to the core.

DESIGN AND TESTING OF AIRPLANES

Contestants are encouraged to test their designs extensively to determine what performance can be expected as normal when launched at the competition in April.

While testing, if an airplane develops any distortion of the launch hook (or hook assembly) that

keeps it from being launched again, then testing of that airplane will stop. Similarly, if any airplane develops an unstable shape distortion, or loses paper clip “passengers” irreversibly, then testing will cease.

PAPER AIRPLANE EXAMPLE

A basic airplane design is demonstrated in Figure 2 showing some typical nose and tail reinforcements that provide ease of handling the plane when launching, and also used to secure the launch hook.

The placement of the launch hook, along the “keel” (base) of the airplane, can be placed as desired so long as it is forward of the wing’s “center of pressure”. The example shown also clearly conforms to the construction and mass constraints covered above.

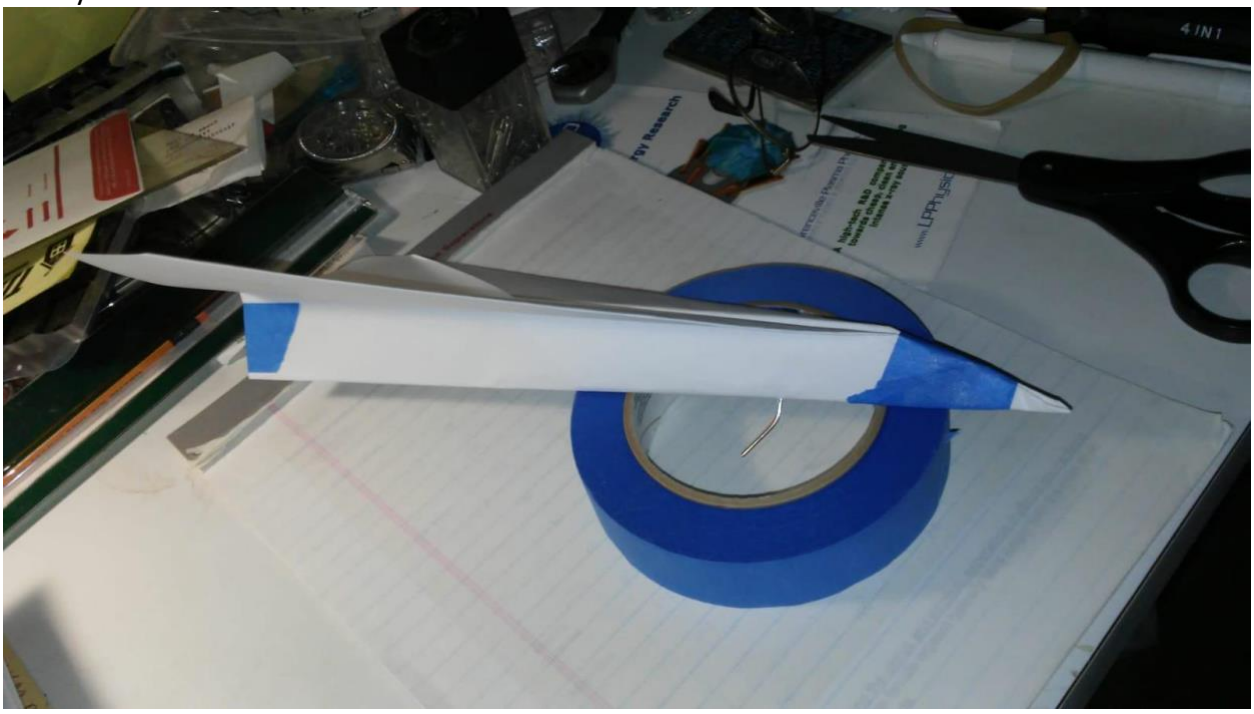

Figure 2. Basic Airplane Design.

PERFORMANCE DEMONSTRATION GUIDELINES

Individual score is Length x Speed x Accuracy. Team score is the sum of individual scores.

- L = Length = Length of Flight (along Reference Line to tip of plane)
- S = Speed = Length of Flight / Time of Flight = L/T
- A = Accuracy = 1 - Distance from Reference Line / Length of Flight = 1 – D/L
- At least 3 test launches will be evaluated for performance.
- See Figure 3 for an illustration of scoring terms in practice.

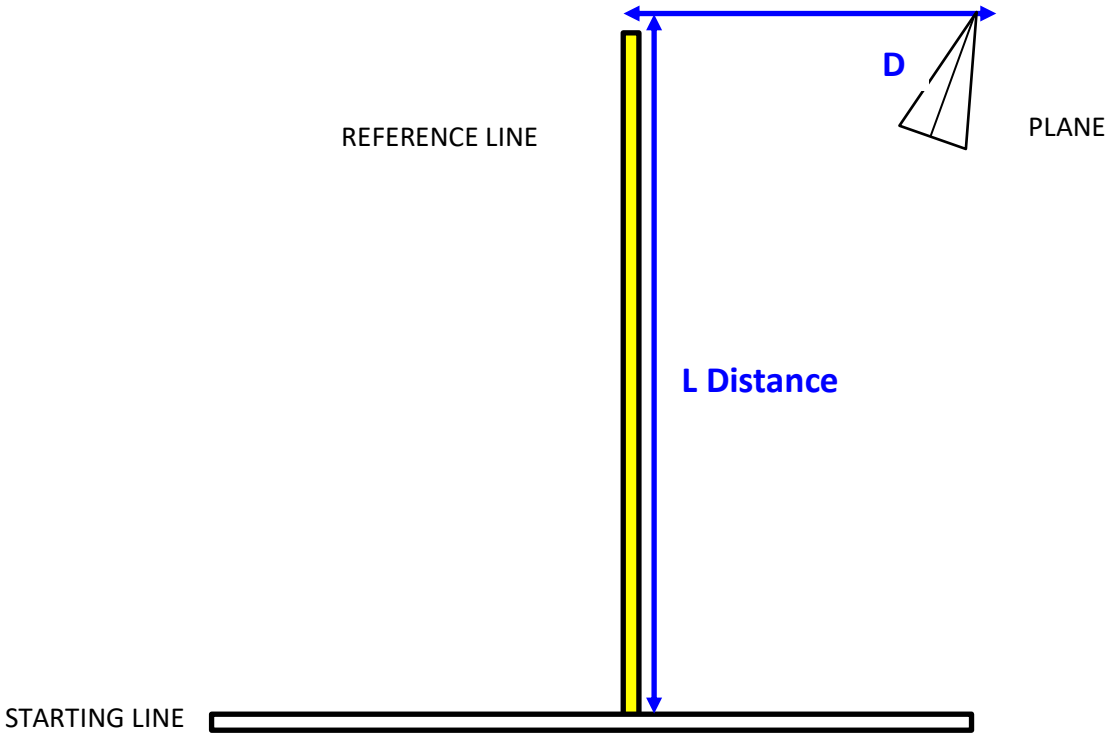

Figure 3. Scoring Variables

Paper clip(s) must remain attached to or inside the airplane for flight to count. One relaunch allowed for lost passengers.

EVALUATION STANDARDS

This elementary school-level competition involves four main components: the design and construction of the project, a written report, an oral report, and the performance demonstration.

1. Design & Construction — Competition value: 20 points
2. Written Report — Competition value: 30 points
   Each TEAM should complete the "Student Design Report" at the end of this document.
3. Oral Interview — Competition value: 20 points
4. Performance Demonstration — Competition value: 30 points

General guidance on how to participate in the Maryland Engineering Challenges can be found here: https://www.thebmi.org/wp-content/uploads/2020/09/MEC-Information-Sheet1.pdf

CURRICULUM TIES-- Maryland Engineering Challenges and the Next Generation Science Standards

PK-2nd Grade - S1.0 Skills and Processes - Topic A. Constructing Knowledge Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out. ***3rd-5th Grade - S1.0 Skills and Processes - Topic A. Constructing Knowledge*** Gather and question data from many different forms of scientific investigations which include reviewing appropriate print resources, observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments.	**In preparing for the challenge, students will:** ● Seek information through reading, observation, exploration, and investigations. Objective b ● Use tools such as thermometers, magnifiers, rulers, or balances to extend their senses and gather data. Objective c ● Participate in multiple experiences to verify that science investigations generally work the same way in different places. Objective e ● Support investigative findings with data found in books, articles, and databases, and identify the sources used and expect others to do the same. Objective a ● Recognize that the results of scientific investigations are seldom exactly the same, and when the differences are

	large, it is important to try to figure out why. Objective d ● Follow directions carefully and keep accurate records of one's work in order to compare data gathered. Objective e
PK-2nd Grade - S1.0 Skills and Processes - Topic B. Applying Evidence and Reasoning People are more likely to believe your ideas if you can give good reasons for them. ***3rd-5th Grade - S1.0 Skills and Processes - Topic B. Applying Evidence and Reasoning*** Seek better reasons for believing something than "Everybody knows that..." or "I just know" and discount such reasons when given by others.	**In designing their projects, students will:** ● Provide reasons for accepting or rejecting ideas examined. Objective a ● Develop reasonable explanations for observations made, investigations completed, and information gained by sharing ideas and listening to others' ideas. Objective b ● Offer reasons for their findings and consider reasons suggested by others. Objective b ● Keep a notebook that describes observations made, carefully distinguishes actual observations from ideas and speculations about what was observed, and is understandable weeks or months later. Objective d
PK-2nd Grade - S1.0 Skills and Processes - Topic C. Communicating Scientific Information Ask, "How do you know?" in appropriate situations and attempt reasonable answers when others ask them the same question.	**In composing the written and oral reports, students will:** ● Describe things as accurately as possible and compare observations with those of others. Objective a ● Describe and compare things in terms of number, shape, texture, size, weight, color, and motion. Objective b ● Have opportunities to work with a team, share findings with others, and recognize that all team members should reach their own conclusions

3rd-5th Grade - S1.0 Skills and Processes - Topic C. Communicating Scientific Information Recognize that clear communication is an essential part of doing science.	about what the findings mean. Objective d ● Make use of and analyze models, such as tables and graphs to summarize and interpret data. Objective a ● Avoid choosing and reporting only the data that show what is expected by the person doing the choosing. Objective b ● Construct and share reasonable explanations for questions asked. Objective d
PK-2nd Grade - S1.0 Skills and Processes - Topic D. Technology Design and make things with simple tools and a variety of materials. ***3rd-5th Grade - S1.0 Skills and Processes - Topic D. Technology*** DESIGN CONSTRAINTS: Develop designs and analyze the products: "Does it work?" "Could I make it work better?" "Could I have used better materials?" DESIGNED SYSTEMS: Investigate a variety of mechanical systems and analyze the relationship among the parts.	**In building their projects, students will:** ● Make something out of paper, cardboard, wood, plastic, metal, or existing objects that can actually be used to perform a task. Objective a ● Recognize that some kinds of materials are better than others for making any particular thing. Objective d ● Realize that there is no perfect design and that usually some features have to be sacrificed to get others. Objective b ● Identify factors that must be considered in any technological design-cost, safety, environmental impact, and what will happen if the solution fails. Objective c ● Explain that something may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched, or misconnected. Objective b

GOOD LUCK TO YOUR TEAM!

STUDENT DESIGN REPORT

Team Name

We are (please check one):

Grade One: ___ Grade Two: ___ Grade Three: ___ Grade Four: ___
Grade Five: ___

Team Members

Team's School Name (if applicable) and County

Adult Coach

Coach's Email

DESIGN REPORT DIRECTIONS

Make a copy of the "Student Design Report" pages for each TEAM. Team members should complete each part by clearly printing the requested information. Additional pages may be inserted as needed. The information in this booklet must be the work of student team members, as certified on the final page.

Written reports must be submitted by EMAIL in Word or PDF format to challenges@thebmi.org prior to 4:00 p.m. on April 15, 2022.

Explain why you chose your first design for an airplane. *Include a picture of this design.*

What problems did you encounter with your first design?

Explain the improvements or changes made to your design after testing. *Include pictures of improved designs*, and explain how they were better

Explain which design is the best.

How successful is your best plane?

What math skills were needed in this challenge?

What science skills were needed in this challenge?

List the safety rules you followed to make sure no one got hurt:

What did you learn by taking part in this project?

What did you enjoy most about taking part in this project?

List dates of important milestones in your project and describe those milestones:

Resources: List all the information resources used to solve the challenge problem. Include books, pictures, and websites.

List the materials used in constructing your project:

Materials	Cost	Tools Used

Explain what help adults gave your team:

Name	Type of Assistance

Team Members: List the team members, with a short description of how each person helped to make the project a success. What special skills were learned or demonstrated by each person?

TO BE SIGNED BY ALL STUDENTS, ADULT HELPERS, AND TEAM COACH.

We hereby certify that the majority of the ideas, design, and work was originated and performed by the students, with limited assistance by adults, as described above.

Printed Name Signature Date