5TH GRADE 4-H

PAPER AIRPLANE ENGINEERING

Three Days of Tests, Variables, and Fun

Materials Needed: 11 sheets of blank copy paper **per student group**, 1 extra piece of paper for each member of the class, Invention Convention Handouts for each group, paper clips, masking tape, measuring tape

Procedure:

Day #1: In a nearby hallway or gym (where you can leave the tape for three days), measure out a 30 ft flying area with one-foot of masking tape every 5 feet. (If the instructor prefers the use of meters, measure a 10-meter course, with tape every two meters.) Leave at least 10 feet extra (3-4 meters) at the end of the hall, in case you need to add more flying space.

Ask the class, "If we wanted to have a contest to design the best paper airplane, what attribute should we measure (coolest decorations, distance it can fly, originality, biggest wings, smallest wings, longest body/fuselage, etc.)?" Give them a few minutes to discuss the options. If necessary, explain how difficult it would be to measure coolest or originality. Explain how an airplane with biggest, smallest, or longest might not actually fly...and flying is the point of an airplane after all. They should decide that their contest will be judged on distance. If not, let them know how much you value their insight; but, because you already went to the trouble of measuring out a flying area, a "good" airplane will be based on distance flown.

Have the instructor break the class into groups of 3 (preferred) to 5.

Hand out an Invention Convention packet (pages 6-14) and one piece of paper to each group. Show them this video, stopping it at each fold, as they fold their paper the same way: www.youtube.com/watch?v=u-HKNkao6i0

Ask the students, how they could modify their folds to make the plane's wings bigger or smaller? Ask them how they could make the plane shorter (without cutting)? (Hint, after doing the two side folds for the nose, fold part of the nose back before folding the plane in half.) Could you easily add weight to the back or front of the airplane? (Hint, paper clips)

PURDUE UNIVERSITY
Extension

For More Information Contact:
Bill Decker
4-H Regional Educator--Discovery Projects
wdecker@purdue.edu

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After discussion, give each team three pieces of paper. Tell them their first task is build three of the same type of paper airplane with one difference, the size of the wing. They can start with the design they saw on the video; or, they can start with their own design. The end product needs to be three airplanes, same basic design, with three different wing sizes.

Have students look at page 6 from the packet. Explain the data collection example. Tell the students that they are about to do their own testing, and to use the example layout with their data to fill out Trial #1. They will fly each airplane 3 times and average the results.

Collect Invention Convention packets from each team, make sure they have their names on the packet.

End Day #1

If you have extra time, this is a good chance to talk about the 4-H Aerospace project, current events in aerospace (satellites, spacecraft, aircraft, etc.), where students can go to get free airplane flights (EAA Young Eagles Programs), etc.

Day #2

Break back into previous day's groups. Have the instructor hand back packets.

Ask each group, "What worked best for your group (short, medium, or long wings)?"

Show the group how to graph their data. "Wing Test Data" written at the top, "Distance" on the Y-Axis (up and down), "Trial Number" on the X-Axis (across), label each data set (line) "Short", "Medium," or "Long."

Allow students to make their graph, check on each group to make sure they are making a graph that accurately represents their data. As a class, discuss variability in data. "Why could one flight have a different result with the same wing?" Hopefully, they will start to get the idea that if they throw the plane in an identical way every time, they would get a nearly identical result. Variation is largely based on how they threw the aircraft.

Ask students to answer questions 1, 2, and 3 on page 8.

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Give each team more paper and allow them to test another characteristic of their choice. Suggestions could be weight distribution (paper clip forward, middle, back or number of paper clips in one position), length of airplane body (short, medium, long), ailerons/flaps folded at the trailing edge of the wing (flaps/ailerons flat, bent down, bent up), or any option they would like to try. They are only testing one variation/variable on these three aircraft. If they are testing something like aircraft length, they will need to build three new aircraft. If they are testing something like ailerons or weight, they can build a single aircraft and test each modification on the same plane. Remember, they should start with the same basic airplane type they used in test #1 with the "normal" wing.

Have teams test their modifications, write down the data, draw a graph and answer questions 1, 2, and 3 on page 11.

Tell the students to do a last characteristic test of choice, using the same guidelines as in Trial #2. Write down data on page 12, do the graph on page 13, answer questions 1, 2, and 3 on page 14. If time allows, have them draw an outline of the airplane they think will work the best, using what they learned in the three tests.

Collect Invention Convention Packets! If any new students were added to groups, make sure their names are on the packet.

End Day #2:

If extra time exists, ask students to share some of their experiences with the tests. Do they think that they have a good idea of what their new and improved aircraft will look like for the flight contest? Is there any disagreement on teams as to what they want to build for the contest?

Day #3:

Give each student a piece of paper (everyone--not by team). Tell them, not to start building until you are done talking. They will have 10 minutes to build, test, and modify their aircraft, after you are done speaking. They each will build an airplane using the knowledge they have gained doing testing. They can change the aircraft type, if they believe that the prior testing supports that major design change. The only rules are: only one piece of paper (the one the instructor gave you), no glue, no tape, no staples, no cutting (but ripping is fine). The only metal that can be on the aircraft is paper-clips. PUT YOUR NAME ON THE AIRPLANE! (Start!)

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After 10 minutes, break the class into groups of 8 (less if your space is limited). Have all 8 launch their planes in the test area. Remove any airplane that did not fly at least 15 feet (5 meters). Go through the groups until everyone has thrown, removing those aircraft that flew under 15 feet. Now, have the students that went over 15 feet throw in groups of 5. Remove aircraft that did not fly over 20 feet (or 7 meters). Repeat with a groups of 4, flying 25 feet (or 8 meters), groups of 3 for 30 feet (or 10 meters). By this time, if anyone is left, declare their aircraft to be a "winning design." You are welcome to have a sudden-death flight, using all the space you can find, for the "grand champion," if more than one student made 30 feet. However, be flexible in the contest. If during the build and test phase (10 minutes) you see that the aircraft are not flying very far, reduce your first cut to 6 feet (or two meters) and then lower the other cuts accordingly. You don't want all but one design to be eliminated on the first throw.

If time allows, bring the class back together at their seats.

Ask, "Does every modification make a paper airplane fly better?" "Would you say it is better to test an idea on something like a paper airplane, or just build a real airplane with the modification, and why?" "What else did you learn building and testing paper airplanes?" Last, and most important, "Did you have fun?"

End Day #3

Note: "Invention Convention" is an outreach program of the Henry Ford Museum. If you know of an instructor or volunteer interested in hosting an Invention Convention team, please contact Dani Lay, Indiana 4-H Science Specialist, at: winter35@purdue.edu.)

Indiana Standards:

3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5—ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

4-H Project: Aerospace

PURDUE UNIVERSITY
Extension

For More Information Contact:
Bill Decker
4-H Regional Educator--Discovery Projects
wdecker@purdue.edu

EA/EOU

Paper Airplane Fun

Invention Step: Testing
Grade Level: 3-5
Base Lesson Time: 55 minutes

Driving Question

How does testing an invention help improve your prototype?

Learning Objectives

Students Will Be Able To:

- Design a testing system for their invention.
- Evaluate how to modify their invention design and materials based on testing.

Why This Matters

Inventors need to test their inventions to understand redesign needs and to improve upon inventions. Students must test their inventions with an understanding of the importance of testing on invention design and function.

Standards

Next Generation Science Standards:

- 3-5-ETS1-1
- 3-5-ETS1-2
- 3-5-ETS1-3

Common Core ELA Standards:

- CCSS.ELA-LITERACY.W.3.7; 4.7; 5.7
- CCSS.ELA-LITERACY.SL.3.1; 4.1; 5.1

Materials

An assortment of paper, such as lined paper, copy paper, construction paper, magazines, newspaper, cardstock

Prep Activity

Students will discuss and identify the important components of a testing plan.

Core Activity

Students will research and build a prototype paper airplane. They will test it and collect data, then redesign and build.

Post Activity

Students will analyze the testing process and apply their knowledge to their invention logbooks.

Homeschoolers or Virtual Learners

All activities can be completed, though collaboration through learning pods and virtual breakout rooms is encouraged.

Model i Connectors

If using The Henry Ford's Model i Innovation Learning Framework, the activities in this lesson connect to the following Habits and Actions: Collaborate, Challenge the Rules, Learn from Failure, Design, Optimize, Implement

Model i Connectors

Throughout this lesson, there will be opportunities to practice and develop Model i's Habits of an Innovator and Actions of Innovation. Listed below are the Habits and Actions that students will develop and practice for this lesson.

Developing Habits of an Innovator

Collaborate

Share what we know. Respect what others bring.

Challenge the Rules

Turn can't into can do. Dare to be different.

Learn from Failure

Be resilient. Use feedback to make improvements.

Practicing Actions of Innovation

Design

Brainstorm solutions and create a prototype for testing that solution.

Optimize

Use feedback to improve the design through iteration.

Implement

Take prototype to market, seek new insight and re-enter the cycle.

Prep Activity

Invention Step: Testing
Grade Level: 3-5
Prep Activity Time: 10 minutes

Testing Plan Discussion

Tell students that they will explore the testing step of the invention process. Ask students why testing is important.

Explain that students could simply try out their invention and see if it worked. That is a form of testing. But if it doesn't work, what have they learned?

Instead, students should make a plan for testing. Ask students to brainstorm a list of testing components; write them where everyone can see them.

Possible answers include:

- Observations (also known as qualitative data): What specific actions do they see happening or not happening? Did something work or did something break? Where did this happen?
- Data measurements: What measurements should they collect? Depending on the invention, this could be answers to questions like: How far did …? How fast did …?
- Organizing the data: How can data be organized to be understood and/or visualized?

Core Activity

Invention Step: Testing Grade Level: 3-5
Core Activity Time: 40-60 minutes, depending on number of trials completed

Testing

Tell students to research different paper airplane designs. Give them copies of designs to choose from, or students can do their own research on the internet.

Using no more than 10 minutes and working in small groups, students should choose a single design to develop. Remind them that they will be able to make changes to their designs.

Distribute a copy of the Paper Airplane Fun worksheet to each student. Walk through the wing length example with them. Once students have selected their designs, they should create a testing plan by identifying the characteristics being tested.

Using the assortment of paper provided, students should then build prototypes.

With their worksheet as a guide, students should conduct their testing and record their observations and data. Tell them to record their data under “Trial 1.” Additional rounds will be recorded under “Trial 2” and “Trial 3.”

Following Trial 1 and data collection, students can turn their data into a visual graph.

Then students should analyze their results, make modifications to the design and build a new prototype.

Depending on available class time, students can complete up to three trials.

Adjustments for Virtual Learning

- Students can discuss plane features through online platforms or a shared document. Although students will have to build the plane on their own, they can work in groups to discuss how to build it.
- Discuss data through online class meetings or shared documents.
- Students can film their flights and show them to their peers. The teacher can show a successful and unsuccessful flight from the class.

Post Activity

Invention Step: Testing Grade Level: 3-5
Post Activity Time: 5 minutes

Class Discussion

Hold a class discussion. Ask students these questions:

- How did your group know which plane was most successful?
- Did you change materials or folding techniques after testing? How did you know to try something different?
- Why is testing important to the invention process?

Upon completion, students should begin working on Invention Step: Testing in their logbook.

Name_____

Paper Airplane Fun

Directions: In your groups, you will determine the best method to test and collect data for your prototypes. Below are blank tables you can use for your tests, or you can design your own on the back. Create graphs of your data using graph paper, a computer program or the back of the paper.

Data Collection Example

Example Data Setup
Characteristic Being Tested: Wing Length

Characteristic Tested: Wing Length	**Trial 1 (M)**	**Trial 2 (M)**	**Trial 3 (M)**	**Average (M)**
Short Wings	1.40	1.60	1.50	1.50 meters
Medium Wings	1.70	1.60	1.80	1.70 meters
Long Wings	1.60	1.65	1.62	1.62 meters

Trial 1

Characteristic Tested:	**Trial 1 (M)**	**Trial 2 (M)**	**Trial 3 (M)**	**Average (M)**

Qualitative Data Collection Space (observations/data without numbers)

Name _____

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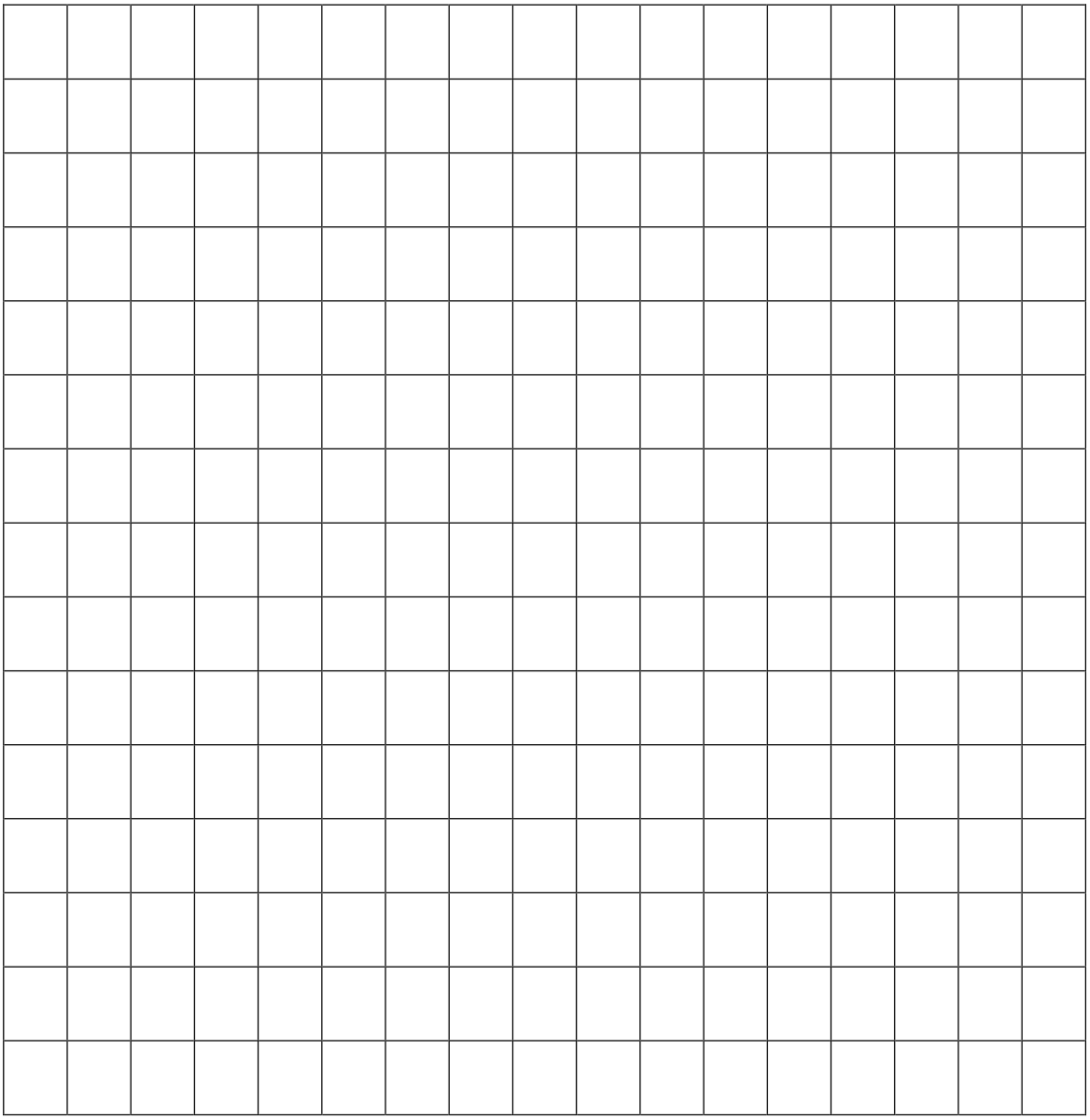
the Henry Ford

Paper Airplane Fun

Graph Title:



Note: You may also use the back of this paper and extra blank sheets to create your own graphs.

Name _____

Paper Airplane Fun

Analyzing Your Results

1. What trial did the best? Why?

2. What trial did the worst? Why?

3. Which design of the characteristic you tested will you add to your prototype? Why?

4. Draw a design of your prototype below, gather materials and build it for the next round of testing.

Name _____

Paper Airplane Fun

Trial 2

Characteristic Tested:	Trial 1 (M)	Trial 2 (M)	Trial 3 (M)	Average (M)

Qualitative Data Collection Space (observations/data without numbers)

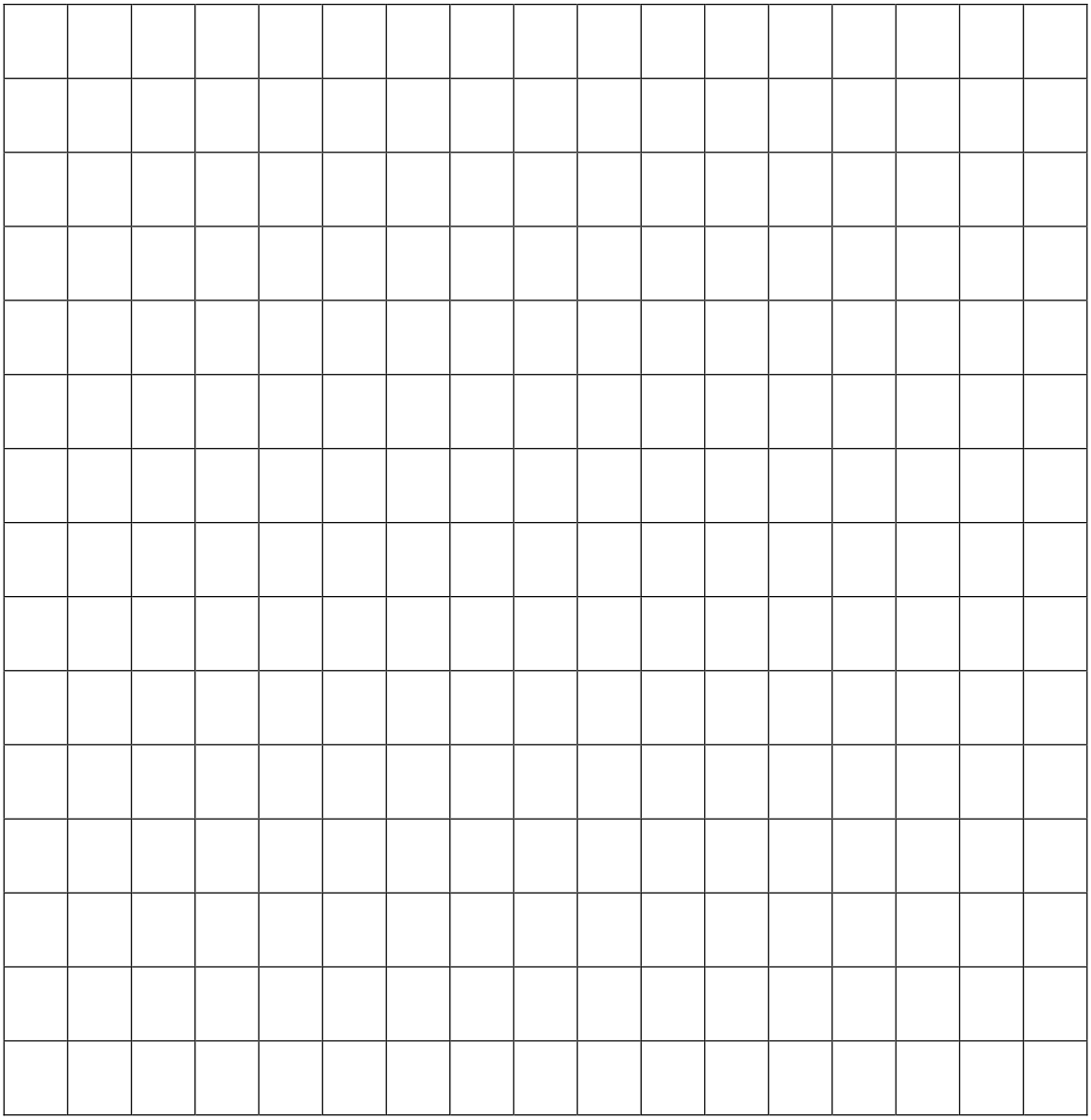
Name _____

iNVENTIoN CoNVENTIoN CURRICULUM

the Henry Ford

Paper Airplane Fun

Graph Title:



Note: You may also use the back of this paper and extra blank sheets to create your own graphs.

Name _____

Paper Airplane Fun

Analyzing Your Results

1. What trial did the best? Why?

2. What trial did the worst? Why?

3. Which design of the characteristic you tested will you add to your prototype? Why?

4. Draw a design of your prototype below, gather materials and build it for the next round of testing.

Name _____

Paper Airplane Fun

Trial 3

Characteristic Tested:	Trial 1 (M)	Trial 2 (M)	Trial 3 (M)	Average (M)

Qualitative Data Collection Space (observations/data without numbers)

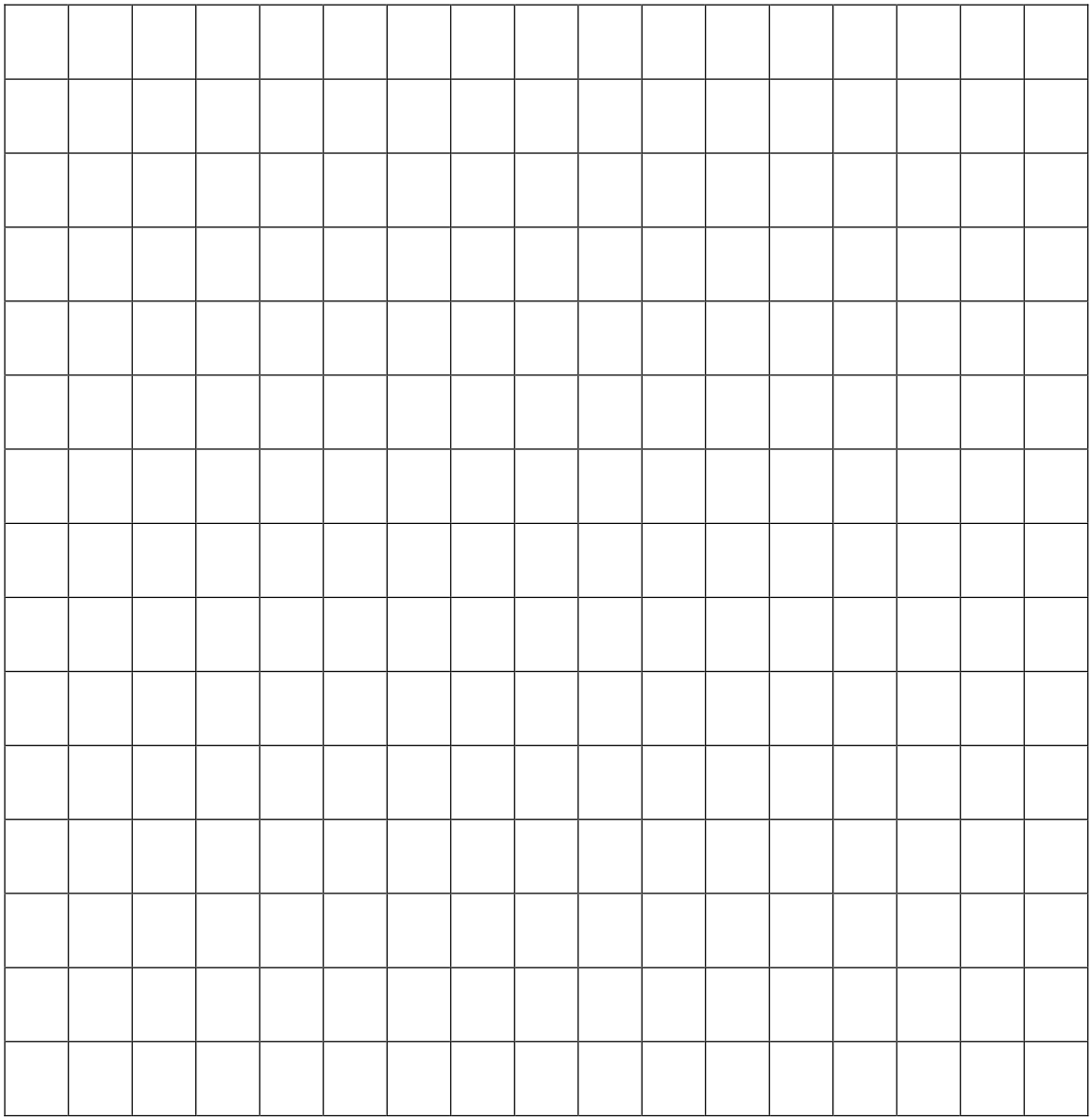
Name _____

iNVENTIoN CoNVENTIoN CURRICULUM

the Henry Ford

Paper Airplane Fun

Graph Title:



Note: You may also use the back of this paper and extra blank sheets to create your own graphs.

Name _____

Paper Airplane Fun

Analyzing Your Results

1. What trial did the best? Why?

2. What trial did the worst? Why?

3. Which design of the characteristic you tested will you add to your prototype? Why?

4. Draw a design of your prototype below, gather materials and build it for the next round of testing.