Name: ______________________ Period: _________ Date: ____________________

Linear Motion Challenge: Maximizing speed through use of wind

I. Overview:

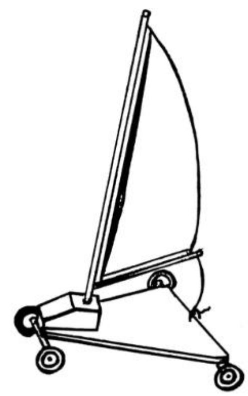
In some way or another, engineers are involved in the production of almost everything around you. They can design buildings and planes, develop parts of our i-Pods and cell phones, and manufacture medicines. They even design high efficiency sail "car"s as you see to the right!!

In our second challenge of the year, we will be working as engineers similar to those at Mercedes Benz that designed the sail "car" to the right. These engineers work tirelessly to optimize the speed and acceleration of each sail "car" to produce the fastest possible speed by maximizing all the available wind. Your objective is to create the fastest design of sail that can be quickly installed and removed on a stock low-friction track "car". The fastest, most creative, and best-engineered sail "car" that can school all other competitors in the 3rd Annual Fairchild Wheeler Sail "car" Stand-off will take top honors!!!

II. Objective:

You will work in maximum groups of two partners to research, design, and build a "car" and submit **one sail "car" prototype per group for competition**. Groups will research the most effective sail designs so that their prototypes can take advantage of any and all available wind. This challenge will assess your understanding of the following topics: *Speed*, *Velocity*, *Acceleration* and *Graphing Linear Motion*; and your focus and effort will also be graded. Remember, teams with dedicated members are the ones who win these challenges! How can you maximize the wind for speed???

III. Rules:



- Your "car" must travel at least 4m meters on the test date in class.
- Your sail must withstand the force of the wind that propels the "car".
- Your "car" must be powered solely by the wind generated from the fan.
- You are not allowed to push your "car" to start it in any way.
- Sail mast must be no taller than 30cm before fixed to the zero-friction "car".
- Boom can be no longer than 20cm.
- There is no limit on jib and/or forestay size.
- Jib and mainsail must be adjustable to catch wind from both port and starboard directions.
- You may not create a galleon-style sail, they must be triangular and exhibit Bernoulli's Principle in its function
- Your instructor will provide you with the materials for the basic design on day 2 of the project. You should bring your own materials for any specific design modifications your group "car"es to make. HOWEVER, you must put together the parts yourself (using any toy "car"/sail components that is ready-bought or pre-constructed is not allowed and will result in serious point deductions).
- Design must be able to accommodate a wind shift from directly behind the sail "car" to a 45 degree angle from a 0 degree tailwind. Bonus points for sail "car"s that can complete a 4 meter run in both scenarios of wind direction.

IV. Prizes:

Extra credit points (3) will be given to one group in each of the following categories:

- Greatest speed achieved.
- Best Engineering Innovation (for the best design modifications)
- Most Artistic Design

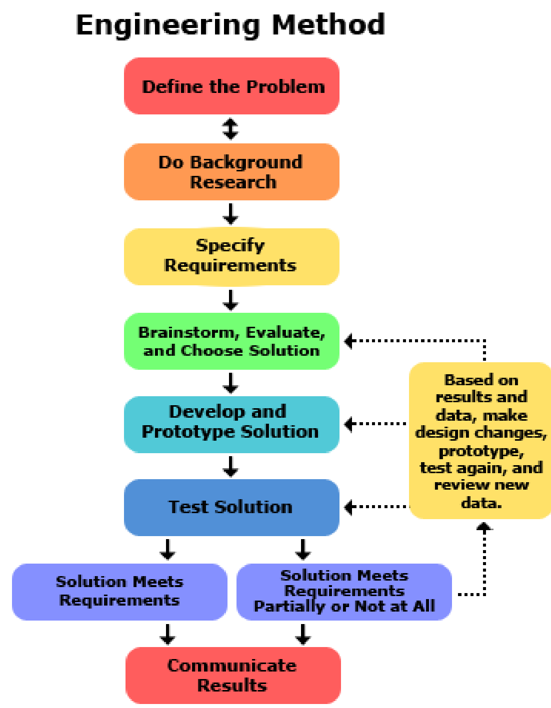
V. Final product requirements:

You will turn in a packet that includes the following:

a. **Product 1:** Research log showing a listing of any videos watched, sites researched and a list of topics that your group learned along the way. There should be a short 2-3 sentence summary of what was learned in the video, or read on the website. It is also valuable to insert diagrams/photos and the website they came from to help enhance your concept drawings for this project. This log **SHOULD BE EXTREMELY DETAILED! Students will use a different color to mark their contributions in the log. The document should be saved to the lead engineer's folder** (15 points).

b. **Product 2:** Draw a detailed diagram of your "car". Dimensions of wheels and "car" body, , length x width of the platform you intend to build, etc. TOP AND SIDE VIEWS ARE REQUIRED. All measurements are mandatory. Sketch of your "car", including at least one design improvement for a group of 2 students and at last 2 improvements to the basic design for a group of 3 students. (15 points)

c. **Product 3**: Draw a sketch of the engineering process' steps (see diagram to the right) beside each step there would be detail included about what the group did specifically each step of the build, re-design, etc. (10 points)



d. **Product 4:** PHYSICS "CAR" MOTION REPORT. Create an MS Excel spreadsheet that includes **appropriate time-distance intervals** of their sail "car" in the race, **data table has correct units**, has the **work and solution to the average-speed** of the "car" during the race. **Correct graph displayed for Distance vs. Time and Velocity vs. Time**. This should be done individually, and saved to each student's Applied Fluid Mechanics Google drive folder (15 points). In this motion report on your sail "car", you will use the reflection questions in section VIII.

e. **Product 5:** Group Work Survey & Project Reflection – Done on/after test day. Each group member must answer questions regarding how your group shared the work. (10 points)

f. **OPTIONAL - EXTRA CREDIT:** A one-page minimum (double spaced, Times New Roman 12 point font, 1" margins) report attached to the packet detailing the science behind why a sail "car" is able to move. What physics principles are at work in your sail "car"? How do variables in the design of sail size and shape change the speed achieved? Additional information up to student. Paper must be properly referenced to receive credit. 5 bonus point potential.

VI. Schedule:

You will have time to work on this project in class but work at home is also required:

- Monday, 25 September – Introduction to linear motion and problem solving
- Tuesday, 26 - 27 September – Design a speed test
- Wednesday, 27 September –
- Thursday, 28 September - Introduction to acceleration. Sail "car" Challenge Intro – RESEARCH, PLANNING, & DESIGN. Answering research log questions to build mini-expertise! HW – finish research log answers.
- Friday, 29 September – Accelerometer lab activity. Completion of research logs and oral exams. Students introduced to materials and test track. Students apply research elements to start creation of sail platform. HW – Acceleration problem set.
- Monday, 2 October – Introduction to graphing motion. Building day 1 of 3. HW – graphing motion podcast and practice.
- Tuesday, 3 October – Building day 2 of 3
- Wednesday, 4 October – Building day 3 of 2. Sail platforms must be completed by end of class. Students can test sail "car"s and conduct modifications/re-designs.
- Thursday, 5 October – TEST DAY! Finish re-designs and prepare to test.

The completed project is due on **Tuesday, 10 OCTOBER, no exceptions!**

VII. Pre-build Research Log Questions:

1. When was the first sail created? Who was responsible for this amazing use of wind/physics?

2. How does a sail function? Find diagrams as well as provide verbal explanations. Discuss Bernoulli's Principle as it applies to making an object move.

3. How is a sail on a sailboat similar to an airplane wing as far as how it creates motion? How is it different? Use diagrams and discussion to answer this.

4. What shape is a modern sail designed around? Why is this important? Use at least 4 types in your research.

5. What is the difference between port and starboard as it pertains to a sail craft? What about fore and aft?

6. Go to the following website: http://www.psychosnail.com/sailing/howtosail/partsofasailboatrig

   a. Look at the Lesson 1.2 animation and get to know the "parts of a sailboat rig". You should be able to pick out the 5 most important aspects from this animation and summarize them in your log.

   b. Click on "Next Lesson" above the animation and click through Lesson 1.3 and get to know the "parts of and types of sailboat sails". Discuss the difference between the mainsail and the jib.

   c. Click on "Next Lesson" above the animation and click through Lesson 1.4 and get to know the "points of sail and sailing directions" animation. Look up "points of sail" and how does the angles of the sail change with the direction of the wind? Include BOTH a diagram and a verbal explanation.

7. How do you need to position your jib and mainsails if the wind blows: (1) from 0 degrees directly from the rear of the "car" (called a "run"), (2) from a 45 degree angle off either rear corner of the boat (called a "broad reach"), and (3) from a 90 degree angle from either side of the boat (called a "beam reach"). Know how you should position the sails in each situation to be able to earn bonus points during the competition!

VIII. Reflection Questions: *answer as part of product 4 (Motion Report). Add the distance vs. time and velocity vs. time graphs to the document before you answer the questions below. Save to your Applied Fluids folder on your Google drive on or before 11:59 p.m. Friday, 7 October 2016.*

1. What was your sail "car"'s average speed and highest instantaneous speed? Between what distance markers did your "car"'s highest instantaneous speed occur?

2. Choose any 2 distances and calculate the acceleration between those two points of your test.

3. How did your "car" make best use of the wind present to maximize the speed your "car" reached?

4. When you look at your "car"'s performance versus competitors, why do you think your "car" performed better, or not as well as other's when you look at the designs. Be detailed here and use the proper terminology from the pre-build research.

5. What did you discover about the science and effectiveness of sails that you did not know about after building one?

6. In detail, describe how Bernoulli's Principle plays into the function of a sail and explain why the points of sail are important when applying Bernoulli's Principle to sail position.

7. In your own words, what was the reason for conducting this challenge? What concepts did you become very comfortable with, and which one(s) do you need more help on. Explain.

8. In order to describe the motion of an object (speed, velocity, or acceleration), what MUST we have present in order to do so? What does having this point allow us to gather so we can ultimately describe the motion of our object?

Your Name: ________________________ Period: ___________ Date: ____________________

Name2: ___________________________ Name3: _________________________________

IX. The Sail "car" Challenge: Grading Criteria and Rubric

Description	Points Earned	Points Possible
"car" Design & Performance (25 points total)		
"car" design has incorporated all project specifications and is original		**10**
"car" remains intact during test and travels at least 4 meters		**15**
Product 1: Comprehensive Research Log (25 points total)		
Research log comprehensively answered all pre-build questions to become mini-experts		**15**
Product 2: Sketch (15 points total)		
Sketch shows ALL improvements to the basic design (1 for groups of 2, 2 for groups of 3)		**7.5**
Labeled to show all materials used, scale measurements of each part, front and side views shown		**7.5**
Product 3: Engineering Method Sketch (10 points)		
Sketch correctly shows steps of engineering method		**5**
Sketch includes exact steps that each group took for each step of the process		**5**
Bonus(es) Earned		**6**
Group Subtotal		**65**

Individual Contributions (50 points) **Names:**				**Points Possible**
Product 4: Physics "car" Motion Report (35 points)				
Excel Spreadsheet shows Distance vs. Time AND Velocity vs. Time data tables				**10**
One-paragraph explanation of each graph				**10**
Work & Solution: Average Speed of "car"				**5**
Product 5: Other Requirements (15 points)				
Group Work Survey completed by each individual				**5**
Each person made a fair contribution to the work				**10**
Extra Credit Sail Physics Paper				**5 pts. possible**
Individual Subtotal				**40**
TOTAL PROJECT GRADE				**105**

IX. Product 2: <u>INITIAL DESIGN</u> - DETAILED DIAGRAM OF "CAR" FROM THE TOP AND SIDE WITH ALL DIMENSIONS AND PROPORTIONALLY SIZED COMPONENTS. THIS MUST BE EXPLAINED TO AND DEFENDED TO YOUR INSTRUCTOR BEFORE PROJECT GETS SIGNED OFF ON!!!

Instructor Signature: ___________________________ Date: ________________

X. Product 2 (Cont'd): <u>REDESIGN # ONE</u> - DETAILED DIAGRAM OF "CAR" FROM THE TOP AND SIDE WITH ALL DIMENSIONS AND PROPORTIONALLY SIZED COMPONENTS.

XI. Product 2 (Cont’d): FINAL DESIGN - DETAILED DIAGRAM OF “CAR” FROM THE TOP AND SIDE WITH ALL DIMENSIONS AND PROPORTIONALLY SIZED COMPONENTS.

XII. Product 3: ENGINEERING PROCESS DIAGRAM & ALL GROUP ACTIONS TAKEN DURING EACH STEP (including prototype tests & re-design efforts taken):