

Engineering Design Notebook

Sail Car Challenge 2020



This notebook belongs to:

Mrs. Flaherty, Josh, Henry, Liam, Caitlyn, Emily,
Amiya, Abby, Beth, Sandrine, Madhavi, Mila,
Oliver, Tommaso, Ava, Sofia, Raghav, & Sidarth

Timeline & Due Dates:

Monday, 6/22	Introduction to problem & background knowledge in Zoom Session HERE	Done?
Tuesday, 6/23	Complete the ASK portion of your Engineering Notebook	
Wednesday, 6/24	Complete IMAGINE portion of your Engineering Notebook	
Thursday, 6/25	Complete the PLAN portion of your Engineering Notebook	
Friday, 6/26	Plans are approved and reviewed by teacher in Zoom session HERE	
Monday, 6/29	CREATE your model/prototype and share a photo in your Engineering Notebook	
Tuesday, 6/30	Watch the video lesson on how to TEST your design Conduct your TEST & collect data in your Engineering Notebook	
Wednesday, 7/1	Review the data from your test and make a plan for improvements in your Notebook Implement your IMPROVEMENTS	
Thursday, 7/2	Test your design again while sharing the final results of your design in their Engineering Notebooks Complete the REFLECTION page of your Engineering Notebook	
Friday, 7/3	Share your results with your classmates in a Zoom session HERE	

Job Description:

Congratulations Mechanical Engineers! You've been hired by General Electric to research, design, and test a prototype for a wind powered car.



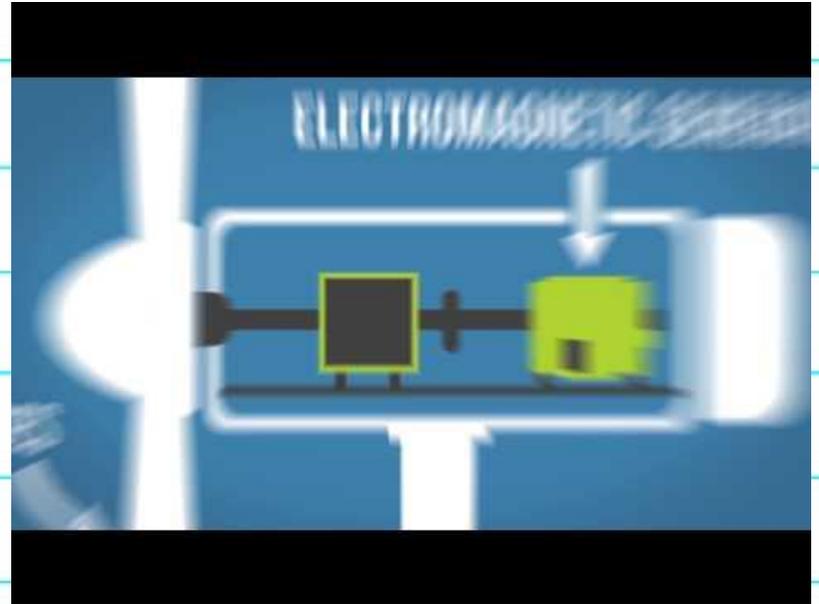
Your Goals & Objectives for this Challenge:

- Describe different sources of energy.
- Explain that wind energy is a renewable and sustainable form of power production.
- Relate how different shapes and angles affect sail (and wind turbine) design and performance through the testing and improvement stages of the engineering design process.

Background Knowledge (Schema):

Review renewable energy sources by clicking on and reading through the presentation found [HERE](#).

Watch the video posted [HERE](#)  to learn more about wind power.



Background Knowledge (Schema): Review the Engineering Design Process

NASA's BEST
Engineering Design
Process



Challenge: Design a sail for a wind powered car

Constraints:

- Your base MAY be made up of the following materials
- Choose ONE material from each column

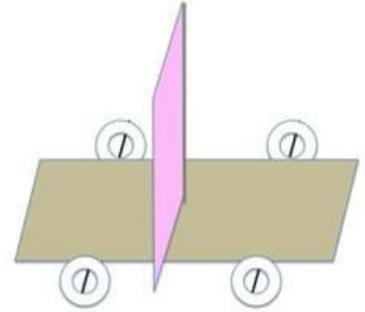


2 Axles	4 Wheels	8 Wheel mounts	Body
<ul style="list-style-type: none">• Coffee stirrers• Pipe cleaners• BBQ Skewers• Sticks• Straws• Any other long, cylindrical material	<ul style="list-style-type: none">• Life saver candies (ring shaped hard candies)• Lego wheels• Metal washers• Any other material that can function as a wheel	<ul style="list-style-type: none">• Plastic beads• Hot glue• Elmer's glue• Tape• Anything that can hold the wheel onto the axle so it won't fall off, but will still let the wheel rotate	<ul style="list-style-type: none">• A cardboard rectangle (3 x 5 inches)• Legos• Cardstock paper• Any other flat, rectangular material that you can attach the axles to

Challenge: Design a sail for a wind powered car

Constraints:

- Your choice of materials for sail design are (but not limited to) the following
- Choose ONE material from each column



Mast	Sail (12 x 12 inches)
<ul style="list-style-type: none">● Coffee stirrers● Pipe cleaners● BBQ Skewers● Sticks● Straws● Popsicle sticks● Any other long, thin, sturdy material	<ul style="list-style-type: none">● Aluminum foil● Tissue paper● Index cards● Copy paper● Wax paper● Any other flexible and light material

Challenge: Design a sail for a wind powered car

Suggestions for base construction



Background Knowledge (Schema): Review the Engineering Design Process



Ask: Identify & Define the Problem

DUE: 6/23

- Answer the following questions in the boxes below:

What is the goal of the activity?	Can you imagine how someone could use what you're going to design? How would it help them?	Are there any special requirements for the activity? For example, are you only allowed to use certain types of materials?	How will you know if you've been successful?
<p>The goal of this activity is to create and test a small prototype of a wind-powered sail car.</p> <p>-Amiya</p>	<p>The design can help people because instead of making old people walk a long distance to give something to someone they can just use the car which doesn't even require electricity!</p> <p>-Madhavi</p> <p>A person that could use a wind powered vehicle is a mail carrier or someone with limited mobility can use to to get their mail - Ava</p>	<p>In this activity, one of the constraints is the base of the car. The car must have a rectangular-shaped piece of cardboard (or something sturdy), with the axles glued to the bottom of it. Since we are not in school right now, we are not too constrained on the materials that we are allowed to use.</p> <p>-Amiya</p>	<p>I will know that I have been successful with this activity, if my wind-powered car is able to go 36 inches faster than 2 MPH. I also know that I can always keep improving upon my design to make the time that it takes to go from one end of the 36" "race track" to the other end of it, shorter.</p> <p>-Amiya</p>

Imagine: Brainstorm Solutions & Research Ideas DUE: 6/24

- Write down all ideas, no matter how wild. The more ideas, the better!
- Be creative and spontaneous. There are no wrong answers and lots of possible solutions.
- Research sail types by clicking [HERE](#)
- Answer the following questions in the boxes below:

What are some ways you can start tackling today's challenge?	How many different ideas can you come up with?	What materials will you be using? Do they give you any ideas?
<p>We can research ways to make our car in the best possible way we can. We will also design our car on paper. We want to sketch out our ideas first to understand what we want our car to look like</p> <p>-Sandrine & Mila</p>	<p>We have decided to come up with two different prototypes that will be slightly different since it is hard to make two of the same prototypes because we are socially distanced and might not have the same materials or measurements at home</p> <p>-Sandrine & Mila</p>	<p>We will use the following materials:</p> <ul style="list-style-type: none">● Straws● Cardboard● Canvas/paper● Fabric● Coffee Stirrers● Lego Wheels● Plastic beads <p>-Sandrine & Mila</p>

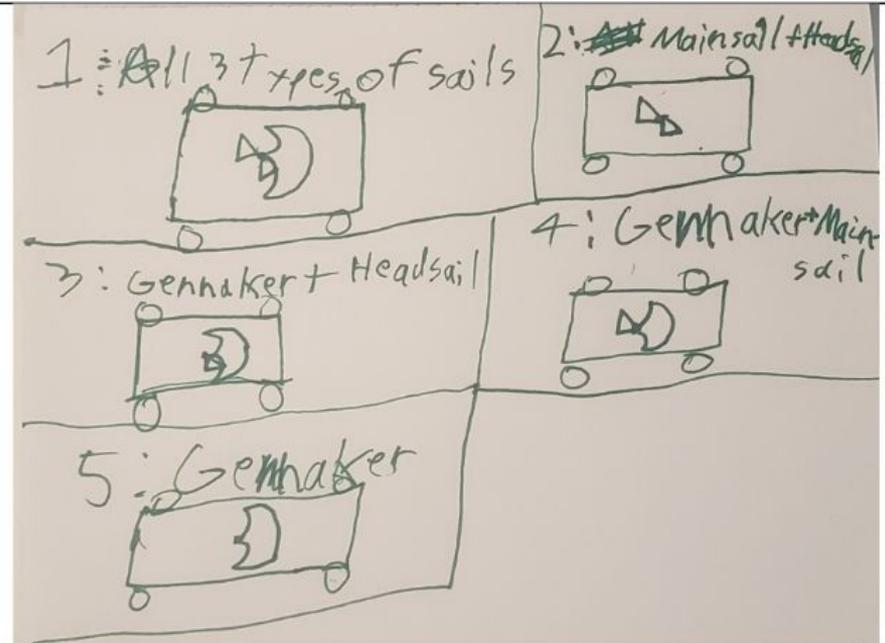
Imagine: Brainstorm solutions & Research Ideas DUE: 6/24

- Write down your ideas in list format on the left or sketch form on the right

List Ideas Below:

- All 3 types of sails
- The mainsail with the gennaker
- The headsail with the gennaker
- The mainsail with the headsail
- The gennaker by itself

Insert Images of your Sketches below:



-Josh & Henry

Plan: Select & Sketch a Design

DUE: 6/25

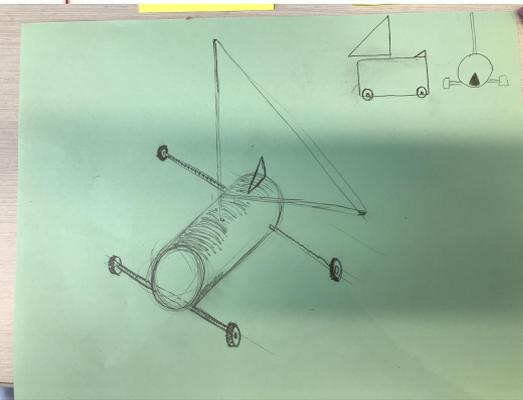
- **Review all of your ideas from yesterday and answer the following questions before selecting a design**

What goals are you trying to achieve?	How might this idea look on paper?	Do you have enough time to build this design?	Do you have materials that can work with this design?
<p>To finish the boat in the time that is given and test different materials and designs based on what works and what does not. -Emily</p>	<p>It will look similar to the sketch on the previous slide. (I might change some of the materials based on how the prototype works.) -Emily</p>	<p>Yes I have the design planed out and I will have enough time to build it in a few days. -Emily</p>	<p>Yes. All of the materials listed on the previous slide, I have at my house. -Emily</p>

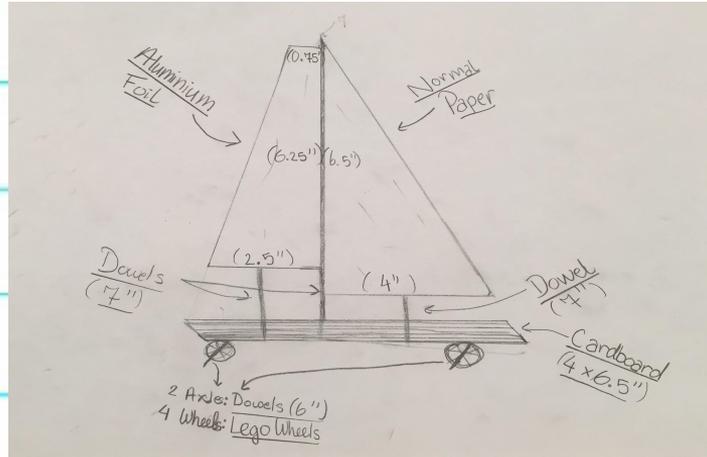
Plan: Select & Sketch a Design

DUE: 6/25

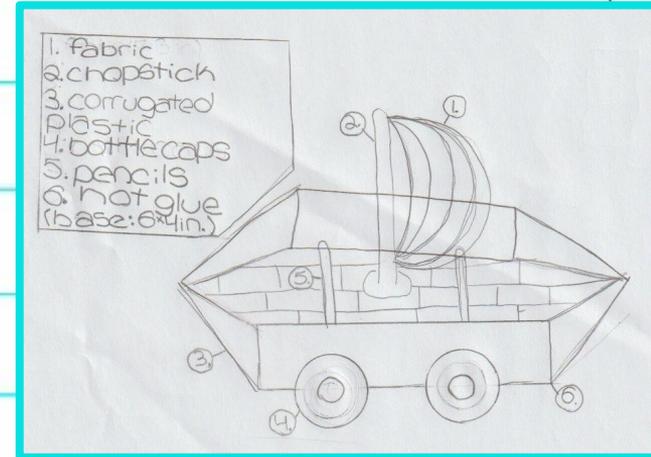
- Sketch your design in google draw [HERE](#) or on a piece of paper
- Remember to label your design with what materials you'll be using and the measurements/proportions of your sail
- Insert the image of your design below:



Tommaso



Amiya



Emily

Test: Collect Data

DUE: 6/30

- Look at t



Sail Car Test Table

Introducing the kinematic equations!

$$d = V_i \cdot t + 0.5 \cdot a \cdot t^2$$

AND

$$V_f = V_i + at$$

Test Number	d (inches)	V_i (inches/second)	t (seconds)	t^2 (seconds ²)	a (inches/second ²) $= 72/t^2$	V_f (inches/second) $= a \cdot t$	V_f (miles per hour) = $V_f \cdot 0.06$
1	36	0	3	9	8	24	1.44

1. Insert the number of seconds it took your car to go 36 inches
2. Multiply that number by itself
3. Divide the number you got in orange by 72 (This is your car's ACCELERATION)
4. Multiply the number you got in green by the number you got in red (This is your car's VELOCITY)
5. Take the number you got in blue and multiply it by 0.06 (to convert your inches/second into MPH)

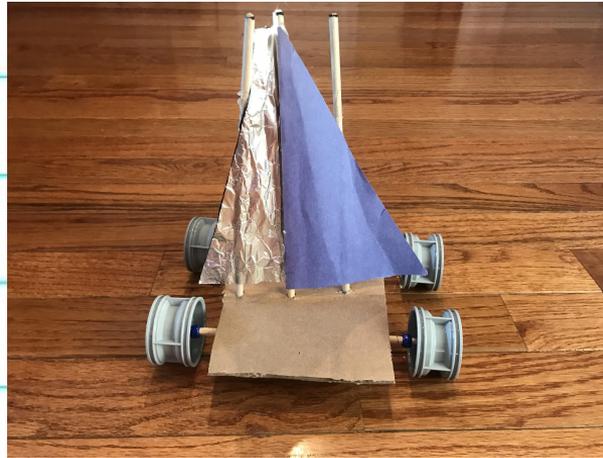
Create: Build a Model or Prototype

DUE: 6/29

- Review the constraints listed for materials on slides 7 and 8
- Create your model today & upload an image of your finished product below:



Tommaso



Amiya



Emily

- **Set up your sail car for testing by doing the following:**
 1. Find a flat surface in your house or outside to test your car
 2. Measure the “race track” to be 36 inches long (mark a starting point and ending point with tape or chalk)
 3. Get a timer ready to see how many seconds it will take your car to go from the start point to the end point
 4. Use a fan, the wind, or your breath to move your sail car from the starting point to the ending point
 5. Take note of how many seconds it took your car to travel 36 inches.

Test: Collect Data

DUE: 6/30

- Watch the video lesson on how to collect data on the tests you conducted today
- Take note of the definitions of velocity & acceleration

Test: Collect Data

DUE: 6/30

- Look at the sample chart below & follow the steps

Sail Car Test Table

Introducing the kinematic equations!

$$d = V_i \cdot t + 0.5 \cdot a \cdot t^2$$

AND

$$V_f = V_i + at$$

Test Number	d (inches)	V _i (inches/second)	t (seconds)	t ² (seconds ²)	a (inches/second ²) = 72/t ²	V _f (inches/second) = a*t	V _f (miles per hour) = V _f *0.06
1	36	0	3	9	8	24	1.44

1. Insert the number of seconds it took your car to go 36 inches

2. Multiply that number by itself

3. Divide the number you got in orange by 72 (This is your car's ACCELERATION)

you got in red (This is your car's VELOCITY)

0.06 (to convert your inches/second into MPH)

Velocity

the speed of an object in a particular direction

same formula as speed

+ direction!



$$v = \frac{d}{t}$$

Acceleration

the rate at which velocity changes over time



$$a = \frac{\Delta v}{\Delta t}$$

Test: Collect Data

DUE: 6/30

- Look at the sample chart below & follow the steps

Sail Car Test Table

Introducing the kinematic equations!

$$d = V_i * t + 0.5*a*t^2$$

AND

$$V_f = V_i + at$$

Test Number	d (inches)	V_i (inches/second)	t (seconds)	t^2 (seconds ²)	a (inches/second ²) = $72/t^2$	V_f (inches/second) = $a*t$	V_f (miles per hour) = $V_f*0.06$
1	36	0	3	9	8	24	1.44

1. Insert the number of seconds it took your car to go 36 inches
2. Multiply that number by itself
3. Divide the number you got in orange by 72 (This is your car's ACCELERATION)
4. Multiply the number you got in green by the number you got in red (This is your car's VELOCITY)
5. Take the number you got in blue and multiply it by 0.06 (to convert your inches/second into MPH)

Test: Collect Data

DUE: 6/30

- Test your design between 1-3 times & complete the chart below

Sail Car Test Table

Test Video With Balloon



Introducing the kinematic equations!

$$d = V_i * t + 0.5 * a * t^2$$

AND

$$V_f = V_i + at$$

Test Number	d (inches)	V _i (inches/second)	t (seconds)	t ² (seconds ²)	a (inches/second ²) = 72/t ²	V _f (inches/second) = a*t	V _f (miles per hour) = V _f *0.06
1	36	0	0.8	0.64	112.5	140.6	8.44
2	36	0	1	1	72	72	4.32
3	36	0	0.8	0.64	112.5	140.6	8.44

Emily

Test: Evaluate the Solution

DUE: 7/1

- **Review the data you collected from the test you conducted yesterday**
- **Review your sail car's acceleration, velocity, and miles per hour**
- **Answer the following questions:**

Does your design meet the goal of the challenge? How?	What can you learn from the data you collected yesterday?	What aspect of your design do you feel needs improvement?
<p>My design met the goal of the challenge because I was able to have my wind-powered sail car go the 36 inches on the "racetrack" in a good amount of time, though now, that I have accomplished this, I will always be looking for ways to make the car even quicker.</p> <p>-Amiya</p>	<p>My car can move for 36 inches in two or three seconds. Depending on the area of the sail hit by the wind, the car can change direction.</p> <p>-Tommaso</p>	<p>I feel that my design could improve by making the car able to go straight and not curve to the left or right after a couple seconds.</p> <p>-Amiya</p>

Improve: Optimize & Redesign the Solution

DUE: 7/1

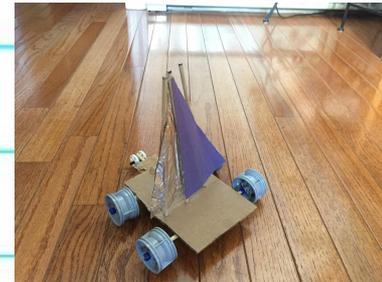
- **Make a plan for improvement & make adjustments to your design**
- **Upload a picture of your improved design below:**

**What is your plan for making improvements?
Why do you think these improvements will optimize your design?**

I think that the improvement that I will do is to block the sail in one place so it does not move. I think this improvement will optimize my design because the car will not go in different directions. It will only go forward. -Tommaso

My plan for improvements for my wind-powered sail car is adding a 5th wheel in the back of the car. I think that this will optimize my design because with this 5th wheel, I think that my car will be able to go straight for a long time without curving to the left or right after 6 feet or a couple seconds have passed.

- Amiya



Re-Test: Collect Data

DUE: 7/2

- Test your improved design
- Fill out the test table below

Test Video
Without Balloon



Sail Car Test Table

Introducing the kinematic equations!

$$d = V_i * t + 0.5 * a * t^2$$

AND

$$V_f = V_i + at$$

Test Number	d (inches)	V _i (inches/second)	t (seconds)	t ² (seconds ²)	a (inches/second ²) = 72/t ²	V _f (inches/second) = a*t	V _f (miles per hour) = V _f *0.06
4	36	0	0.7	0.49	146.9	102.8	6.17
5	36	0	0.8	0.64	112.5	140.6	8.44
6	36	0	0.3	0.09	800	240	14.4

Emily

Re-Test: Evaluate the Solution

DUE: 7/2

- **Review the data you collected from both of the tests you conducted**
- **Answer the following questions:**

In which test did your sail car perform the best?	Do you think the improvements you made helped or hurt your design?	What further improvements would have liked to make given additional time?
<p>My sail car performed the best in the 3rd trial of the tests before I made my improvements to my car. -Amiya</p>	<p>I think that the improvement that I made to my car neither helped nor hurt my design. With the 5th wheel that I added as an improvement, my car just curves to the right after a couple seconds instead of the left, which it had been doing before I made my improvement. Also, with the extra wheel the times are slightly slower, which was expected since the 5th wheel adds more weight to the car. -Amiya</p>	<p>Given additional time, I would have liked to keep working on the improvement that I was trying, and I would like to try to figure out a way for the wind-powered sail car to go straight. -Amiya</p>

Reflection

DUE: 7/2

- **Reflect on your experiences completing this design challenge**
- **Answer the questions in the boxes below:**

What do you think is the best feature of your design? Why?	What steps of the design process helped you the most?	Who might use what you've designed, and how would it help them?
<p>I think that the best feature of my design is its sail because when I tried putting the base of my car (just the cardboard and wheels) in front of a fan for fun, the base was barely able to move, and moved extremely slowly. Once I added the sail to my car, although it added a little weight to the car, it was able to make the car move many times faster.</p>	<p>I think that the two steps in the design process that helped me most were imagine and plan. The imagine step helped me, because I had no previous knowledge about sails before this project, but on the day that was designated to the imagine step, I was able to do a lot of research and understand more about sails. The planning step helped me because I was able to envision what I wanted to create, and write down measurements and materials for each part of my car, so that the create step was quite easy for me.</p>	<p>Many people who want to help save the environment might use what I have designed, if General Electric takes my main idea and adds a steering wheel on it, like a normal car so that people can use it.</p>

Amiya

Communicate Results

Prototype A

Prototype B

Our Group's AVG MPH: 1.97	Our Group's AVG MPH: 2.65
What else travels at a speed of 2 MPH?	What else travels at a speed of 3 MPH?
Tortoises	Humans

Highest Performing Designs



Group Reflection

What do the three fastest designs have in common?	What makes them different?	Could these designs be used on a practical basis? What would need to be changed for commercial use?
<ul style="list-style-type: none"> - Triangular sail shape - Skewers for the masts and axles - Secure wheels with the wheel mounts 	<ul style="list-style-type: none"> - Helium balloon - Bodies of the cars are all different - Wheels are different, but all plastic 	<ul style="list-style-type: none"> - We'd need to swap out some of these materials in order for them to be used in a real world context and figure out what we'd want to market our car to be used for

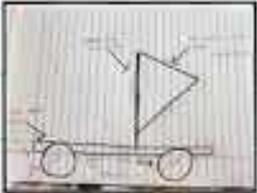
Closure: Did you have fun? Would you want to engage in more engineering challenges that connect to the real world?

They all had fun, citing building/creating as their favorite step. They prefer real world problems to solve as they can use their designs to truly make a difference and help people.

Zoom Meeting 3: Communicate results

7/3

Plan



Oliver

Reflection

What steps of the design process helped you the most?	Who might use what you've designed, and how would it help them?
TEST and PROVE helped most.	My brother can use this to learn about wind energy

Prototype A



AVG MPH: 1.24

Prototype B



AVG MPH: 1.64

Most: Using tape added weight and drag

Work Cited

Emily Gill, Kristi Ekern, Wyatt Champion, Denise W. Carlson. "Gone with the Wind Energy: Design-Build-Test Mini Sail Cars! - Activity."

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Student Energy. "Wind Power 101." *Youtube*, 1 Dec. 2014, https://youtu.be/Z5c50-_hcD0