Design Project 1 – Renewable Technology Challenge

ENGINEER 1P13 – Integrated Cornerstone Design Projects in Engineering

Tutorial T01

Team Mon-11

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Submitted: November 1, 2022

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Academic Integrity Statement

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Mohammad Bilal 400445889

(Student Signature)

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Iris Lin 400464695

(Student Signature)

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Shreya Gopalakrishnan 400462096

(Student Signature)

Main Body

Finalized Problem statement

Our group was assigned the “Roof Generator” scenario, in which we had to design a wind turbine blade that would be suitable for a residential roof and generate electricity for the building. Specifically, we were contracted for Calgary homeowners who wanted to take advantage of their city’s strong winds and lower their electricity bills [1]. As the turbine blade had to be designed for the average roof and behind that, the average homeowner, we had three top objectives: aerodynamic, a compact-size, and low-cost. The constraints were that it could not collide into nearby things by its size nor collapse the roof by its weight. In addition, the stiffness design constraint required our maximum deflection to be less than 10 mm [1]. With these objectives, constraints, and the function in mind, we proceeded to design the ideal blade for a roof turbine and its owner.

Justification of Technical Objectives and Material Performance Indices

Our objective tree for “The Roof Generator” design scenario had three main objectives: aerodynamic, non-intrusive, and cost-efficient (see Figure 1). Under aerodynamic, we said the turbine should be able to reduce drag through its bent/curved shape and its low-density material. Under non-intrusive, we said the turbine should be small so it does not interfere with neighboring objects, quiet to not disturb the residents, and lightweight so an average residential roof can support it. Under cost-efficient, we said the turbine should be low maintenance, so it is less long-term cost for homeowners, and made of an inexpensive and durable material. During the MPI selection process, our MPIs were chosen with the primary objective being to minimize volume, and our secondary being to minimize cost [1]. The criteria in our decision matrix were volume, cost, density, strength, sustainability, and weather resistance. These criteria were best suited for the given roof generator scenario and the average homeowner client.

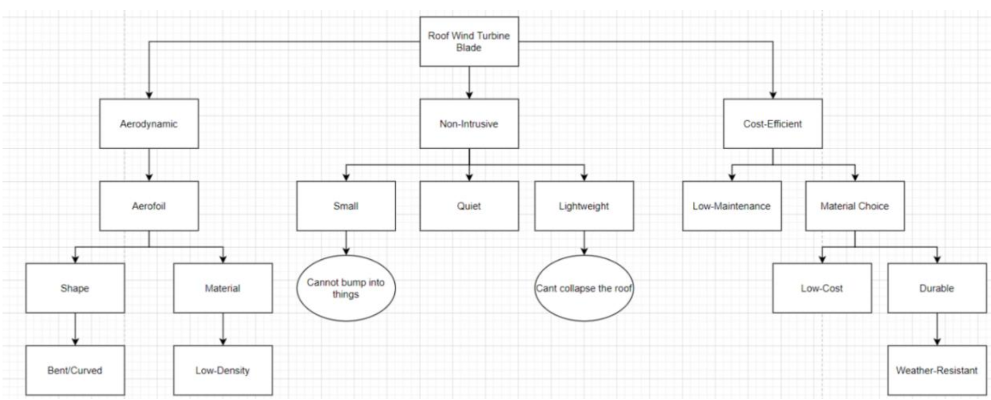


Figure 1 – Objective tree for our given scenario

Material Name	Average value
Young's modulus E (GPa):	205
Yield strength σ_y (MPa):	1034.5
Tensile strength σ_{UTS} (MPa):	1249.5
Density ρ (kg/m^3):	7.8x10^3
Embodiment energy H_m (MJ/kg)	31.05
Specific carbon footprint CO_2 (kg/kg)	2.49

Figure 2 – Chosen Material's Properties

Conceptual Design - Justification of Selected Material

We started with listing our primary and secondary objectives and listed the MPIs for each. Using Granta, we created a materials selection graph for each MPI (see Figure 3) and ranked our top 5 materials [2]. After narrowing it down to 3 materials, we used a simple decision matrix to help compare the materials with our criteria. For our project objectives, we focused on minimal volume and costs since the turbines will be used by homeowners. Finally, we chose low alloy steel since it was the highest scoring material in our decision matrix.

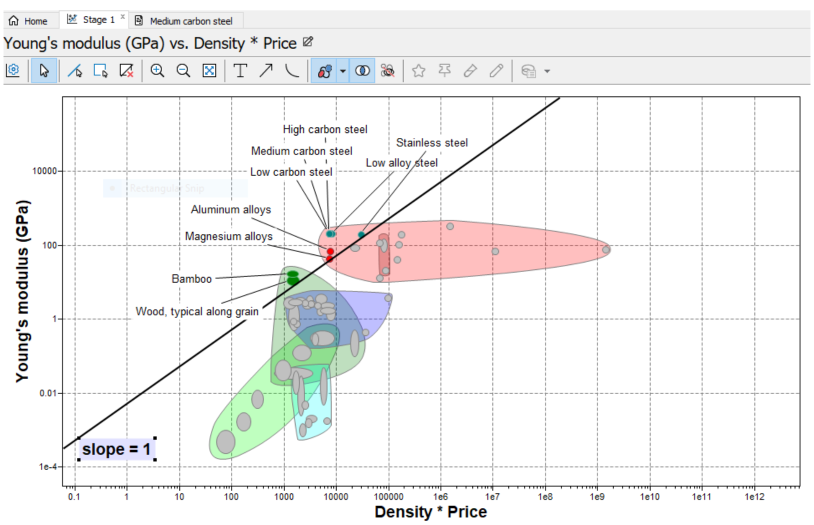


Figure 3 – Granta Edupack Plot

Design Embodiment – Justification of Solid (CAD) Modelling

After determining the material of our turbine, we created our new material property and tested the deflection of the blade using different thicknesses (15mm, 30mm, 150mm) [3]. Our constraint was to refine the thickness until the maximum deflection is in the range of 8-10mm. Our refined and optimal thickness was 27 mm since the corresponding deflection value was 8.892 mm in the simulation [3]. We had adjusted the thickness of the blade until it satisfied our constraint.

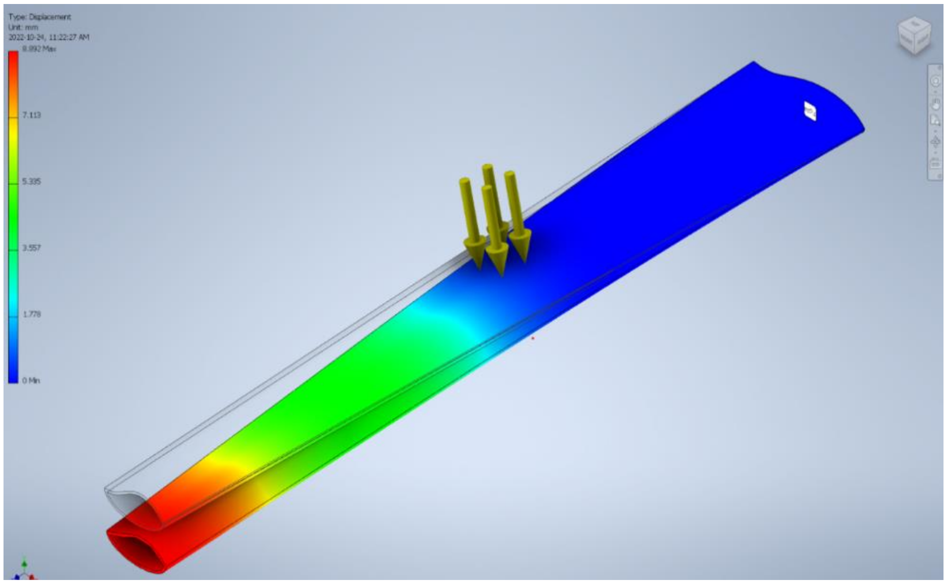


Figure 4 – Deflection Simulation

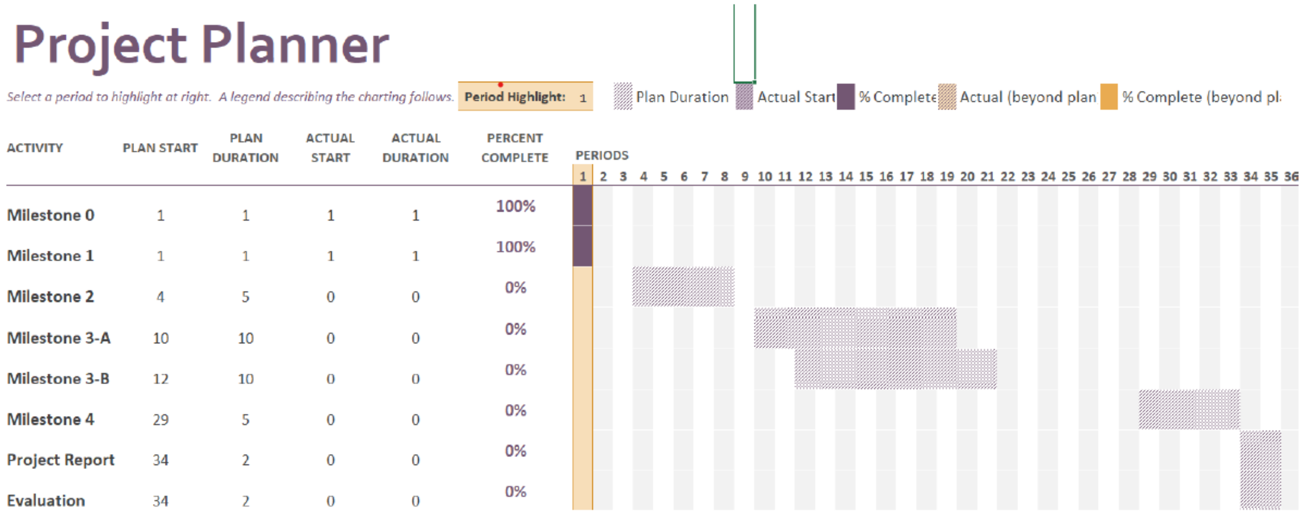
Concluding Remarks – Reality Check

Throughout this project, we were able to learn new engineering concepts and explore different methods to decide the material of our turbine blade. We learned about the material selection process, specifically how to use MPIs to find the ideal materials and how to use decision matrices to narrow down to one material. We also learned how to run simulations on Autodesk to test the stiffness and deflection of our turbine blade. Careful and conscientious planning was involved with each step of the project to ensure that our design met the requirements of our initial problem statement, achieved our objectives, and adhered to given constraints. The objectives that we decided on at the start influenced our decisions throughout the process (such as our material selection) which demonstrates the importance of effectively defining the problem. In the future, other considerations include planning out the rest of the turbine tower accordingly, the furling [13] which prevents the turbine blade from spinning too fast and maximizing energy conversion. Project 1 allowed us to learn about the fundamentals of material selection, design, and teamwork.

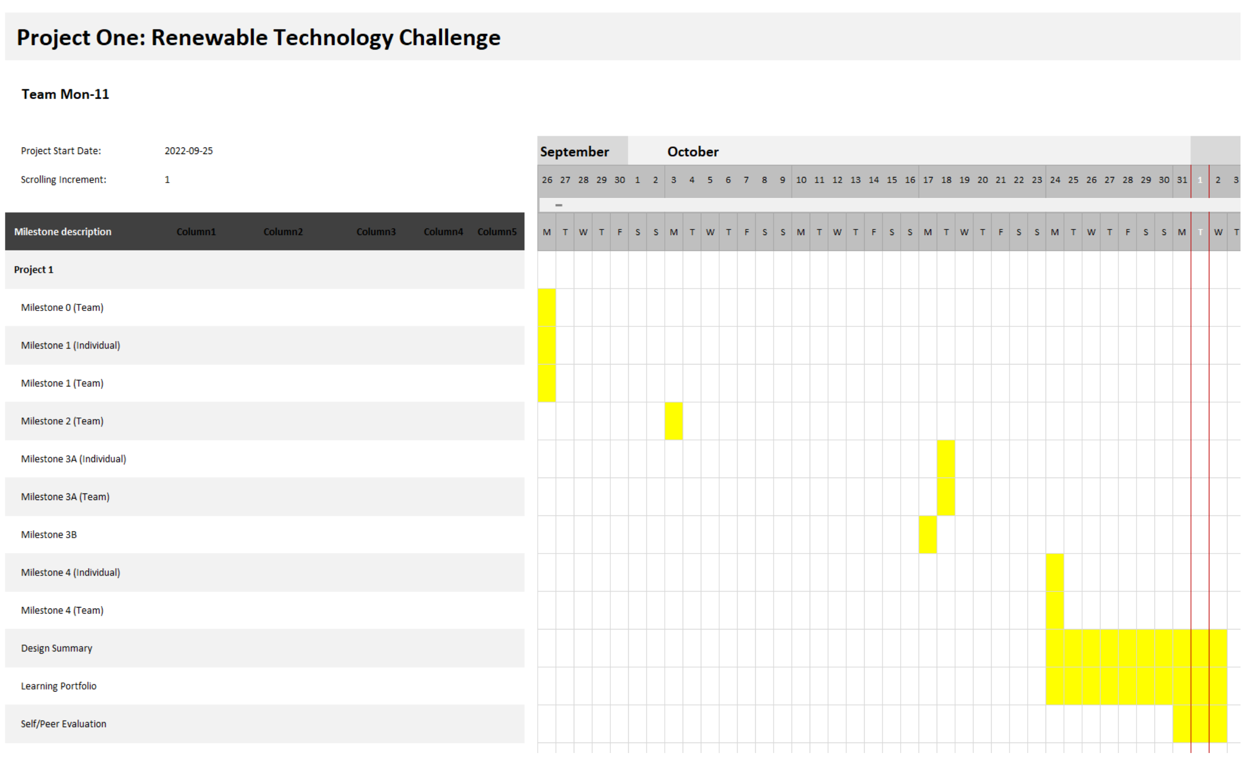
Appendices

Appendix A: Project Schedule

Preliminary Gant Chart:



Final Gant Chart:



Logbook of Additional Meetings:

Oct 26	Project 1 Report	• Started working on the final report (3h)
		  ○ Rough drafts of all section paragraphs
		  ○ Completed most appendices

Nov 1	Project 1 Report	• Finished report (2h)
		  ○ Revised paragraphs.
		  ○ Finalized problem statement
		  ○ Wrote concluding remarks
		  ○ Inserted PDF of Design Studio worksheets

Appendix B: Scheduled Weekly Meetings

Design Studio Agenda and Meeting Notes

Date	Milestone	Tasks
Sep 26	Milestone 0	• Complete Team Charter ○ Assign and review responsibilities ○ Preliminary Gantt chart
Sep 26	Milestone 1	• Determine an objective tree for each scenario ○ Discuss your given scenario ○ Refine the objective trees
Oct 3	Milestone 2	• Refine the problem statement of the assigned scenario ○ Refine the objective tree of the assigned scenario • Determine 3 objectives for our turbine ○ Determine metrics for each objective
Oct 17	Milestone 3B	• Model the turbine blade in Autodesk Inventor ○ Run a deflection simulation and record the displacement
Oct 18	Milestone 3A	• List MPI for primary and secondary objectives ○ Justify the objective • Create a materials selection graph for each MPI ○ Rank the materials (top 5) ○ Narrow the materials (top 3) • Select the final material by using a decision matrix ○ Consider 6 criteria depending on the objectives ○ Create a summary of the chosen material
Oct 25	Milestone 4	• Interview and discuss our scenario with another group

Appendix C: Comprehensive List of Sources

[1] "P1 Project Module," class notes for ENG 1P13, Department of engineering, McMaster University, Fall, 2020

[2] Ansys Granta EduPack software, Granta Design Limited, Cambridge, UK, 2020 (www.grantadesign.com).

[3] Autodesk® Inventor LT™ software, Autodesk, Inc, 2020 (www.autodesk.com)

[4] L. Dong, M. Liao, Y. Li, X. Song and K. Xu, "Study on Aerodynamic Design of Horizontal Axis Wind Turbine Generator System," *2009 International Conference on Energy and Environment Technology*, 2009, pp. 841-844, doi: 10.1109/ICEET.2009.208.

[5] W. Tjiu, T. Marnoto, S. Mat, M. H. Ruslan, and K. Sopian, "Darrieus Vertical Axis wind turbine for Power Generation II: Challenges in hawt and the opportunity of multi-megawatt Darrieus Vawt Development," *Renewable Energy*, 01-Nov-2014. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0960148114006661. [Accessed: 26-Sep-2022].

[6] P. J. Schubel and R. J. Crossley, "Wind Turbine Blade Design," *MDPI*, 06-Sep-2012. [Online]. Available: https://www.mdpi.com/1996-1073/5/9/3425/htm. [Accessed: 26-Sep-2022].

[7] "Introduction, history, and theory of wind power," *IEEE Xplore*, 14-Jun-2010. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/5484084. [Accessed: 26-Sep-2022].

[8] Alternative Energy Tutorials. (2022, January 7). *Wind turbine design for a wind turbine system*. Alternative Energy Tutorials. Retrieved September 22, 2022, from https://www.alternative-energy-tutorials.com/wind-energy/wind-turbine-design.html

[9] Corporativa, I. (n.d.). *What is a wind turbine and how does it work?* Iberdrola. Retrieved September 22, 2022, from https://www.iberdrola.com/sustainability/wind-turbines-blades#:~:text=What%20materials%20are%20used%3F,%2Depoxy%2C%20is%20being%20investigated.

[10] "Wind energy basics," *NREL.gov*. [Online]. Available: https://www.nrel.gov/research/re-wind.html. [Accessed: 01-Nov-2022].

[11] "Anatomy of an eco-friendly wind turbine," *IEEE Transmitter*, 23-Jun-2021. [Online]. Available: https://transmitter.ieee.org/anatomy-of-a-wind-turbine-the-eco-friendly-power-solution/. [Accessed: 01-Nov-2022].

[12] "Turbine Technology: The science behind generating electricity from Thin Air: News and insights: Home," *bp global*. [Online]. Available: https://www.bp.com/en/global/corporate/news-and-insights/reimagining-energy/how-wind-turbine-technology-works.html. [Accessed: 01-Nov-2022].

[13] "Reuk.co.uk," *REUKcouk*. [Online]. Available: http://www.reuk.co.uk/wordpress/wind/what-is-wind-turbine-furling/. [Accessed: 01-Nov-2022].

Appendix D: Peer-Learning Interview

Group 12 was commissioned to build a clean wind turbine for the government of Sweden. A that country wishes to gravitate towards clean energy to fight climate change. The main difference between our groups was the scale of our turbines. Our turbines were only used by homeowners while their turbines were used to power a whole population. This meant we had different objectives as we had to keep our blade small and inexpensive, whereas for them, those were not top priorities. Some similarities we shared were the sustainability and maintenance of the turbines. Maintaining turbines can be quite costly which was going against our objective of making it cost effective, while for group 12, maintaining turbines can increase their energy usage and production of turbines. This led to our materials being similar as we both decided on a type of steel in the same metal family.

Appendix E: Design Studio Worksheets

Project One Milestone (Team) Worksheets

Milestone 0 (Team): Cover Page ... 2
Milestone 0 – Team Charter ... 3
Milestone 0 – Preliminary Gantt Chart (team Manager ONLY) ... 4
Milestone 1 (Team) – Cover Page ... 5
Milestone 1 (Stage 1) – initial Problem statement ... 6
Milestone 1 (Stage 3) – refined objective trees ... 7
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Milestone 2 (Stage 1) – Refined Problem Statement for a Wind Turbine ... 12
Milestone 2 (Stage 2) – Design requirements for A turbine blade ... 13
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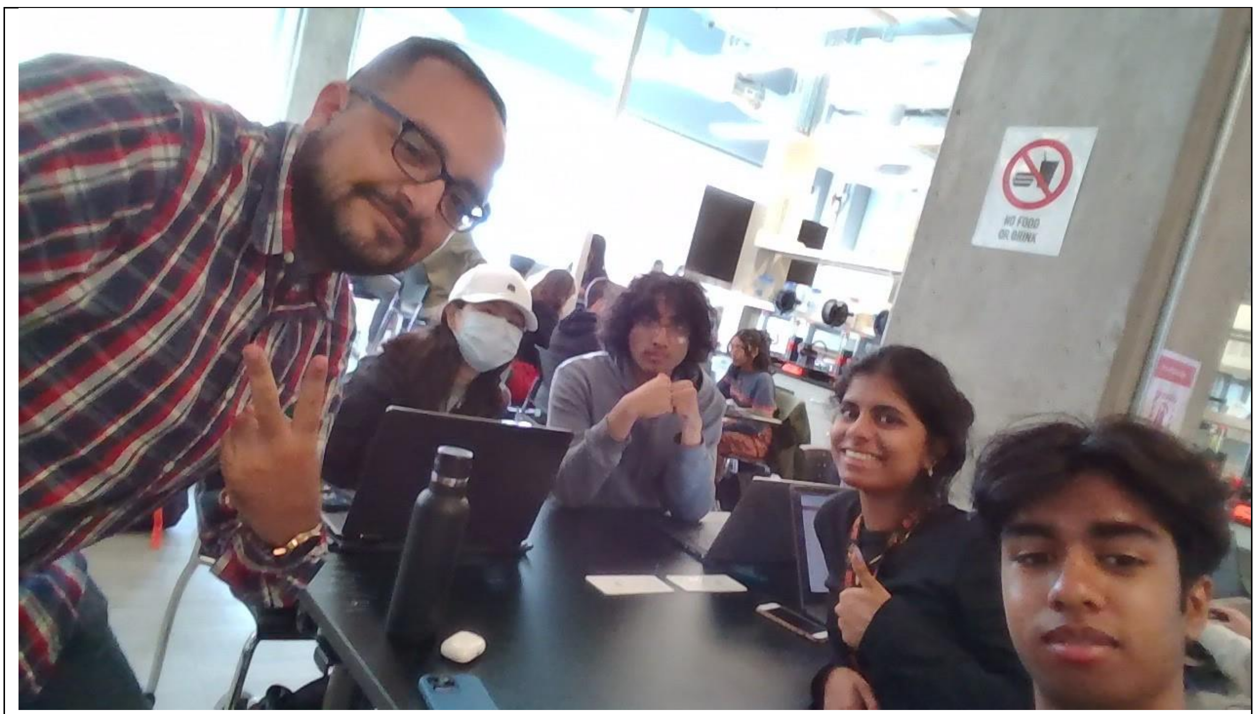
MILESTONE 0 (TEAM): COVER PAGE

Team ID: Mon-11

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Mohammad Bilal	Bilalm14
Shreya Gopalakrishnan	gopals4
Iris Lin	lini8
Ayaz Aziz	Aziza30

Insert your Team Portrait in the dialog box below



MILESTONE 0 – TEAM CHARTER

Team ID: Mon-11

Project Leads:

Identify team member details (Name and MacID) in the space below.

Role:	Team Member Name:	MacID
Manager	Ayaz Aziz	Aziza30
Administrator	Mohammad Bilal	Bilalm14
Coordinator	Shreya	gopals4
Subject Matter Expert	Iris Lin	lini8

MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team ID: Mon-11

Only the **Project Manager** is completing this section!

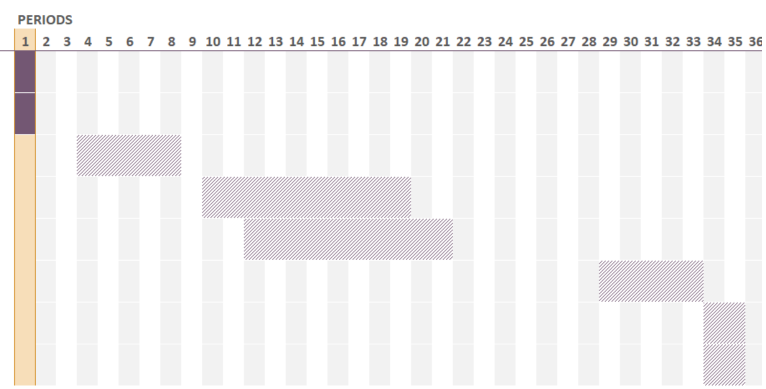
Full Name of Team Manager:	MacID:
Ayaz Aziz	aziza30

Preliminary Gantt chart

Project Planner

Select a period to highlight at right. A legend describing the charting follows. **Period Highlight:** 1 — Plan Duration, Actual Start, % Complete, Actual (beyond plan, % Complete (beyond pl

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0	1	1	1	1	100%
Milestone 1	1	1	1	1	100%
Milestone 2	4	5	0	0	0%
Milestone 3-A	10	10	0	0	0%
Milestone 3-B	12	10	0	0	0%
Milestone 4	29	5	0	0	0%
Project Report	34	2	0	0	0%
Evaluation	34	2	0	0	0%



MILESTONE 1 (TEAM) – COVER PAGE

Team Number: Mon-11

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Shreya Gopalakrishnan	gopals4
Mohammad Bilal	Bilalm14
Iris Lin	lini8
Ayaz Aziz	aziza30

Any student that is ***not*** present for Design Studio will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their P-1 grade.

MILESTONE 1 (STAGE 1) – INITIAL PROBLEM STATEMENT

Team ID: Mon-11

Stage 1: Initial Problem Statement:

What is your first draft of the problem statement? Keep it brief and to the point. One or two sentences should be enough. **For this initial problem statement, you should be focusing on the main function(s) of the wind turbine.**

Design a turbine that generates electricity through wind.

MILESTONE 1 (STAGE 3) – REFINED OBJECTIVE TREES

Team ID: Mon-11

For each engineering scenario, you will be submitting a modified/revised objective tree agreed upon by the group. Each branch of objective trees should have a minimum of 3 layers. This can be hand-drawn or done on a computer.

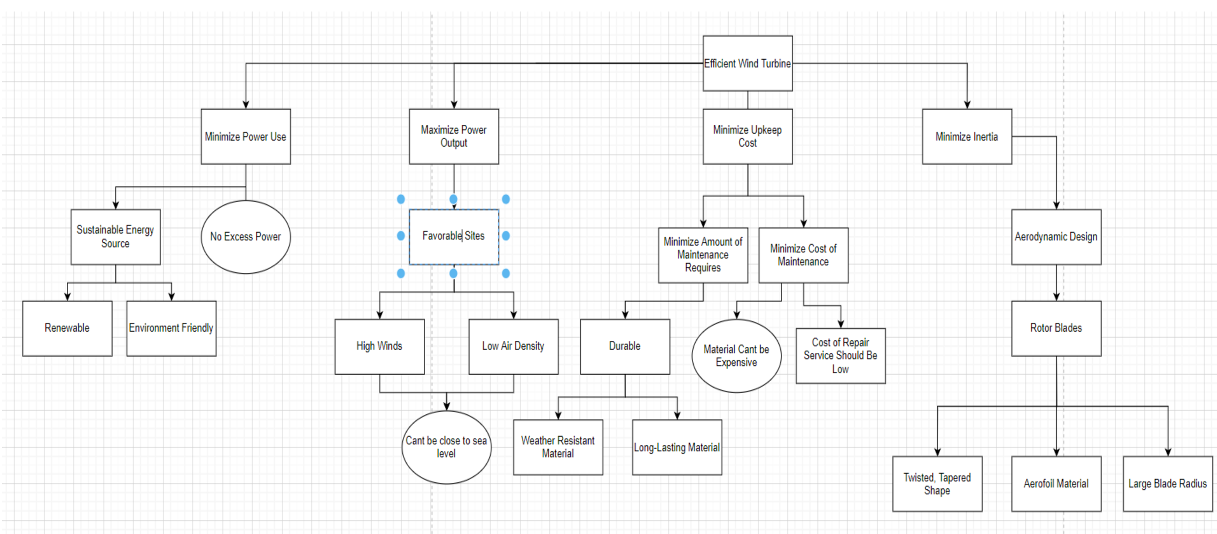
Engineering Scenario #1

The title of the scenario

Renewable Energy for a Large Population

Team objective tree diagram for scenario #1

Please insert a copy of the refined and finalized team objective tree for scenario #1.



Team ID: Mon-11

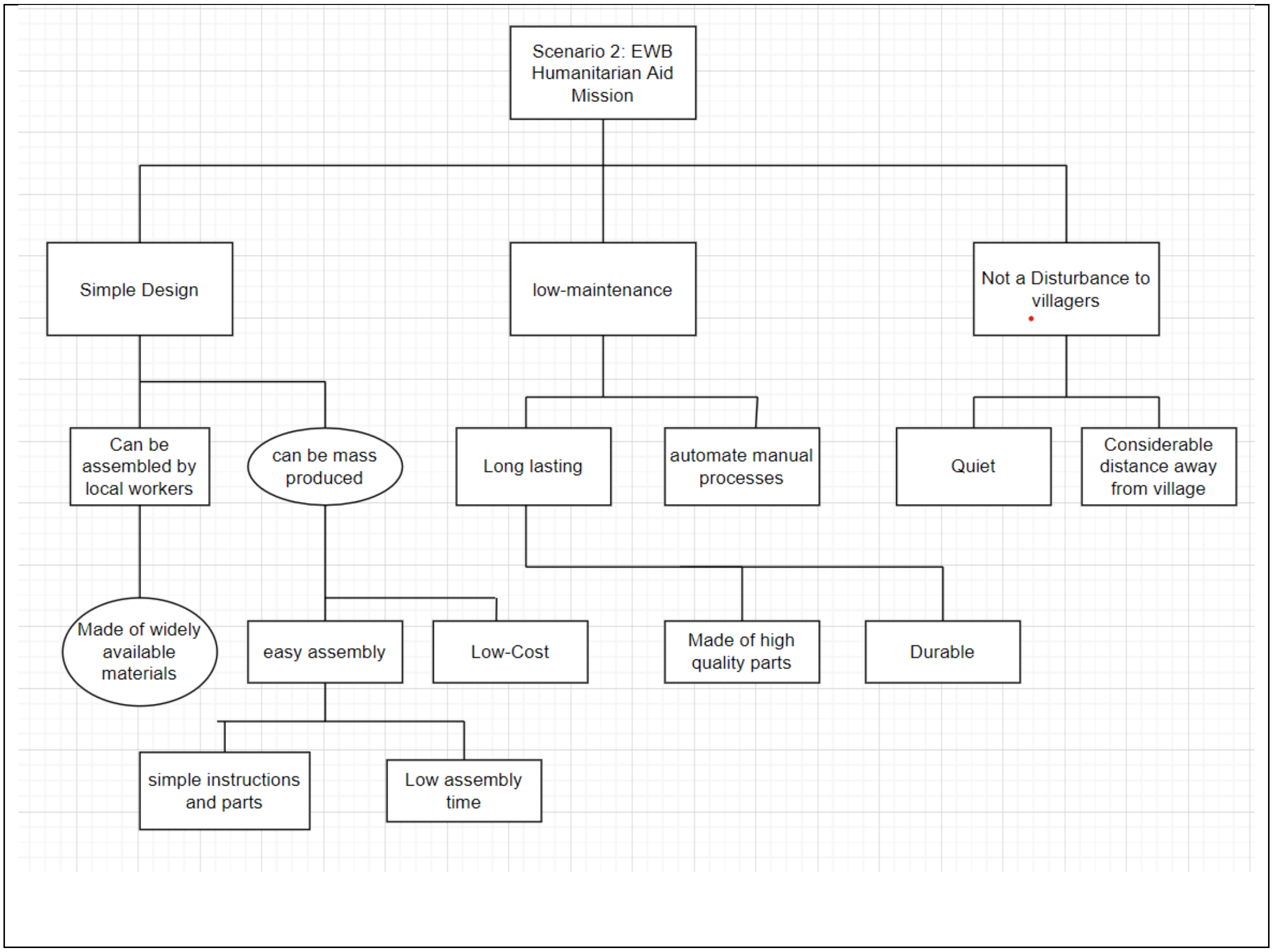
Engineering Scenario #2

The title of the scenario

EWB Humanitarian Aid Mission

Team objective tree diagram for scenario #2

Please insert a copy of the refined and finalized team objective tree for scenario #2.



Team ID: Mon-11

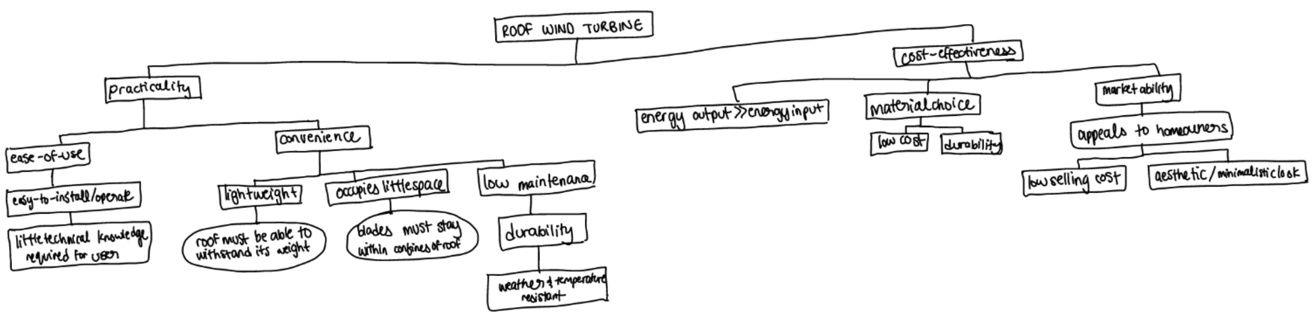
Engineering Scenario #3

The title of the scenario

The Roof Generator

Team objective tree diagram for scenario #3

Please insert a copy of the refined and finalized team objective tree for scenario #3.



Team ID: Mon-11

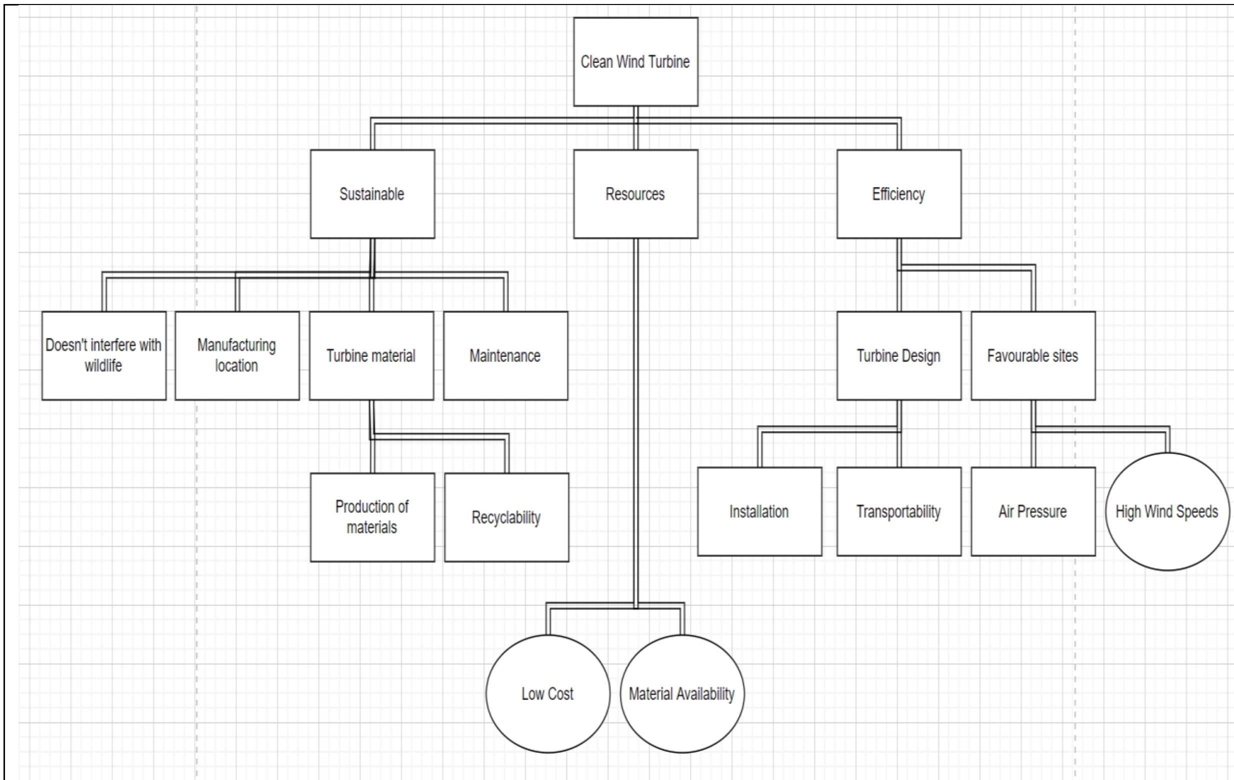
Engineering Scenario #4

The title of the scenario

A Pioneer in Clean Energy

Team objective tree diagram for scenario #4

Please insert a copy of the refined and finalized team objective tree for scenario #4.



MILESTONE 2 (TEAM) – COVER PAGE

Team Number: Mon-11

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Mohammad Bilal	Bilalm14
Ayaz Aziz	aziza30
Shreya Gopalakrishnan	gopals4
Iris Lin	lini8

Any student that is ***not*** present for Design Studio will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their P-1 grade.

MILESTONE 2 (STAGE 1) – REFINED PROBLEM STATEMENT FOR A WIND TURBINE

Team ID: Mon-11

The Title of The Assigned Engineering Scenario

The Roof Generator

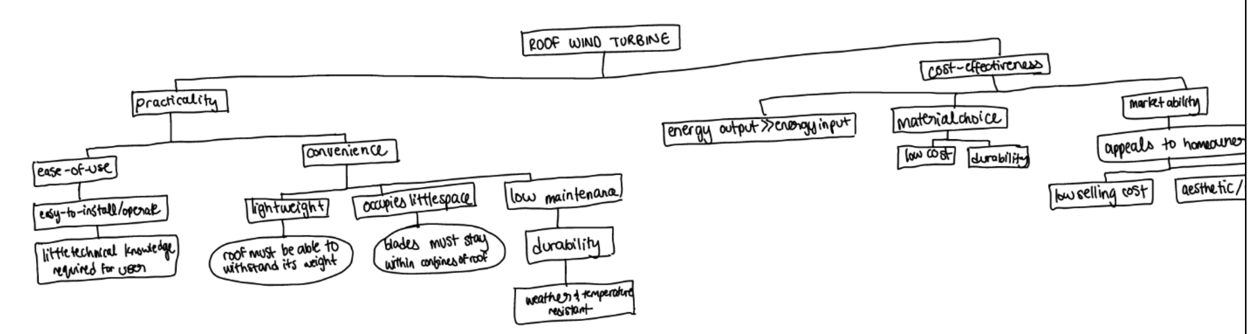
Write the Initial Problem Statement Below

→ This is a *copy-and-paste* submission of what you submitted for Milestone 1

Design a turbine that generates electricity through wind.

Finalized Objective Tree of Wind Turbine for Your Assigned Engineering Scenario

→ Please insert a copy of your finalized team objective tree of a wind turbine for your assigned engineering scenario.



Refined Problem Statement:

→ Write the refined problem statement for the design of a wind turbine based on your assigned scenario.

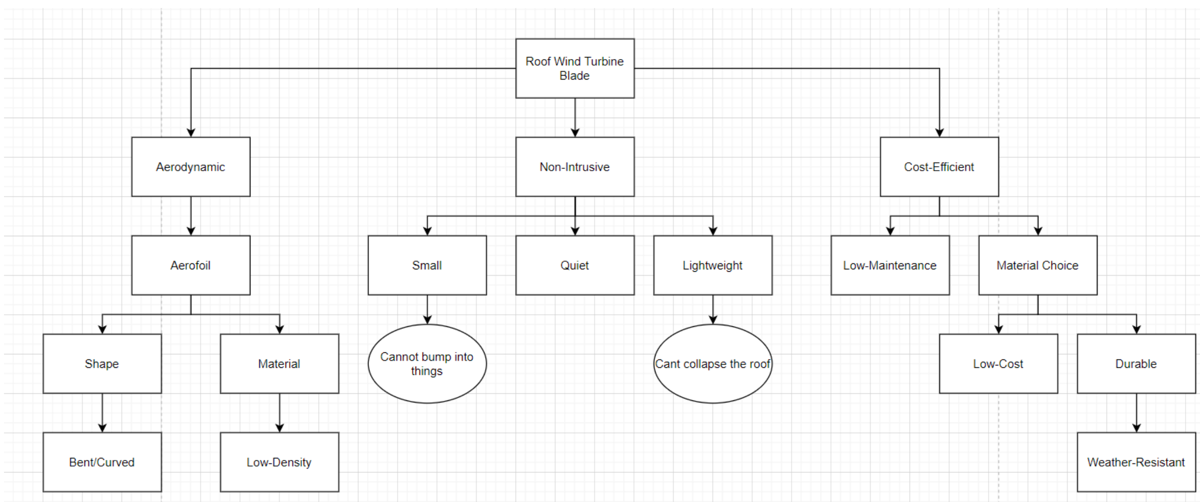
Design a wind turbine that rests on a residential roof and generates electricity for residential homeowners.

MILESTONE 2 (STAGE 2) – DESIGN REQUIREMENTS FOR A TURBINE BLADE

Team ID:	Mon-11

Objective Tree of turbine blade for assigned engineering Scenario

→ Please insert a copy of your team objective tree for the design of a turbine blade based on your assigned engineering scenario.



Turbine Blade Problem Statement:

→ Write a complete problem statement for the design of a turbine *blade* based on your assigned engineering scenario.

Design a wind turbine blade for a wind turbine that rests on a residential roof.

MILESTONE 2 (STAGE 3) – SELECTION OF TOP OBJECTIVES FOR A TURBINE BLADE

Team ID: Mon-11

List the top three objectives of a turbine blade for your assigned engineering scenario

1: Aerodynamic

2: Compact Size

3: Low-Cost

Include a rationale for selecting each of these objectives

→ Write *maximum* 100 words for each objective

Objective 1: Aerodynamic

Rationale: The wind turbine blade should be able to reduce the drag from air moving past, this is because our blades being aerodynamically structured allows for less friction (not turbulent) between consecutive swings which enables our turbine to produce electricity efficiently.

Objective 2: Compact Size

Rationale: The wind turbine blade should be compact and not interfere with neighbouring housing and/or wind turbines. Since the turbine is in a residential area, it should not cause disturbance to residents.

Objective 3: Low-Cost

Rationale: The wind turbine blade should be affordable considering there will be multiple blades on the turbine and it is meant for the average homeowner. Also, a blade that is low-cost probably cannot simultaneously have the most durable material (as that would be expensive). So should a blade need replacement, the cost will be affordable for the homeowner.

MILESTONE 2 (STAGE 4) – METRICS

Team ID: Mon-11

For your selected top three objectives fill out the table below with associated metrics (including units) for each objective.

Objective 1:	Aerodynamic
Unit/Metric:	Lift-to-drag ratio

Objective 2:	Compact Size
Unit/Metric:	Length (meters)

Objective 3:	Low-cost
Unit/Metric:	Cost ($)

MILESTONE 3A (TEAM) – COVER PAGE

Team Number: Mon-11

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Mohammad Bilal	Bilalm14
Iris Lin	lini8
Shreya Gopalakrishnan	gopals4

Any student that is ***not*** present for their scheduled Lab-B session will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their P-1 grade.

MILESTONE 3A (STAGE 1) – MATERIAL SELECTION: PROBLEM DEFINITION

Team ID: Mon-11

1. Copy-and-paste the title of your *assigned* scenario in the space below.

The Roof Generator

2. MPI selection
   - → List one primary objective and one secondary objective in the table below
   - → For each objective, list the MPI
   - → Write a short justification for your selected objectives

	Objective	MPI-stiffness	MPI-strength	Justification for this objective
Primary	Minimize Volume	MPI = E	MPI = σ_y	Since houses are closely packed, the turbine should not collide with neighbouring objects. Thus, minimizing volume would minimize the overall size of the turbine. Also, volume is proportional to mass (v=m/p) -- so minimizing the volume would also ensure a low mass (so the average roof can withstand its weight).
Secondary	Minimize Cost	MPI = $\frac{E}{\rho C_m}$	MPI = $\frac{\sigma_y}{\rho Cm}$	Residential homeowners are looking to reduce their electricity bills. Therefore, minimizing the cost makes it easier and more affordable for the homeowners buying the turbines.

MILESTONE 3A (STAGE 3) – MATERIAL SELECTION: MATERIAL ALTERNATIVES AND FINAL SELECTION

Team ID: Mon-11

Document results of each team member's materials selection and ranking on the table below.

- All different types of steel (carbon steels, alloy steels, stainless steels) have very similar Young's moduli. **For this stage in Project 1, please group all variations of steels into one family as "steel"**. Please put **steel** in your material ranking list only once and indicate in a bracket which steels made the top ranks.

Consolidation of Individual Material Rankings					
	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
1: MPI = E	Tungsten alloys	Steels (medium carbon, low carbon, high carbon, low alloy, stainless)	Nickel alloys	CFRP	Copper alloys
2: MPI = σ_y	Low alloy steel	Tungsten alloys	Stainless steel	Titanium alloys	CFRP
3: MPI = $\frac{E}{\rho C_m}$	Steels (medium carbon>low carbon>high carbon> low alloy)	Bamboo	Aluminum alloys	Wood, typically along grain	Magnesium alloys
4: MPI = $\frac{\sigma_y}{\rho C_m}$	Steels (Medium Carbon, Low Carbon, High Carbon, Low Alloy, Stainless Steel)	Bamboo	Aluminum Alloy	Wood	Magnesium Alloy

As a team, fill out the table below and narrow down the possible materials for your assigned scenario by choosing the 3 materials which showed up the most across all MPI rankings in the table above.

- For this stage in Project 1, if **"steel"** is one of your three material finalists, please specify which steel your team chose to continue with, based on which showed up the most in your team's consolidated table.
- Remember to save the datasheets of all 3 material finalists

Narrowing Material Candidate List to 3 Finalists	
Material Finalist 1:	Low Alloy Steel
Material Finalist 2:	Tungsten Alloys
Material Finalist 3:	Bamboo

Team ID: Mon-11

As a team, compare material alternatives and make a final selection based on either a simple decision matrix or a weighted decision matrix (up to your team to decide)

→ As a team, consider *at least* 3 additional criteria that are relevant to your assigned scenario and discuss your 3 materials finalists for each criterion

- Feel free to pause at this stage and do some quick research on the materials finalists
- You may refer to the material finalists' datasheets for any relevant information that will enable your discussion.
- To help you come up with your additional criteria, below are some question prompts that you may consider. Please note that you are not limited to these suggestions, and they may or may not be relevant to your assigned scenario

Additional Criteria	Possible question prompt
Ease of access to material	Is the material easy to source in the country, are there tariffs due to international trade policy?
Chemical, weather and/or corrosion resistance	Will the material degrade over time (e.g. due to chemical resistance, corrosion resistance, fatigue resistance)?
Ease of maintenance	Consider maintenance if the part got damaged. Based on the material, is it easy to fix or will the entire part need replacement?

→ Remember that:

- Your MPI ranking takes into consideration both material and mechanical properties relevant to the objectives of your assigned scenario.
- Your additional considerations should not include previously evaluated objectives e.g. If minimizing the carbon footprint was either your primary or secondary objective, then it not be an additional criterion

→ Compare the material alternatives and make a final selection based on either a simple decision matrix or a weighted decision matrix (up to your team to decide)
- *Applies to a weighted decision matrix only:* choose a range for the weighting (e.g., 1 to 5) for each criterion. The higher the number on the weighting, the more important that criterion is.
- Choose a range for the score (e.g., 1 to 5) for each material on each criterion. Give each material a score based on how successfully it meets each criterion. The higher the score, the better the material is for that criterion.
- Add additional rows as needed.
- Add up the total score for each material alternative.

Fill one of the following templates only:

Simple Decision Matrix - Template			
	Material 1: *Low Alloy Steel*	*Material 2:* *Tungsten Alloy*	*Material 3:* *Bamboo*
Volume	4	5	1
Cost	5	1	4
Density	3	2	5
Strength	3	5	3
Sustainability	2	2	3
Weather Res.	3	4	2
TOTAL	20	19	18

Weighted Decision Matrix - Template							
	Weighting	*Material 1:*		*Material 2:*		*Material 3:*	
		Score	Total	Score	Total	Score	Total
Criterion 1	3	5	15				
Criterion 2	2						
Criterion 3	4						
…							

	TOTAL						

→ State your chosen material and justify your final selection

Justification	
Chosen Material:	Low Alloy Steel
Discuss and justify your final selection in the space below (based on the decision matrix results and any other relevant considerations). We chose low alloy steel because it was the highest scoring material in our decision matrix and was a high-ranking material in all 4 of our MPIs. Our 2 main objectives were minimal volume and cost, which low alloy steel highly ranks in both. It is very cost effective for the average homeowner and will not collide with neighboring objects. Our additional criteria included minimal density to prevent roof collapse, which low alloy steel ranked fairly well in. Low alloy steel also ranked fairly well for strength and weather resistance, so the wind turbine will require minimal maintenance and will be long lasting.	

Summary of Chosen Material's Properties

Material Name	Average value
Young's modulus E (GPa):	205
Yield strength σ_y (MPa):	1034.5
Tensile strength σ_{UTS} (MPa):	1249.5
Density ρ (kg/m^3):	7.8x10^3
Embodiment energy H_m (MJ/kg)	31.05
Specific carbon footprint CO_2 (kg/kg)	2.49

MILESTONE 3B (TEAM) – COVER PAGE

Team Number: Mon-11

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Mohammad Bilal	Bilalm14
Shreya Gopalakrishnan	Gopals4
Iris Lin	Lini8

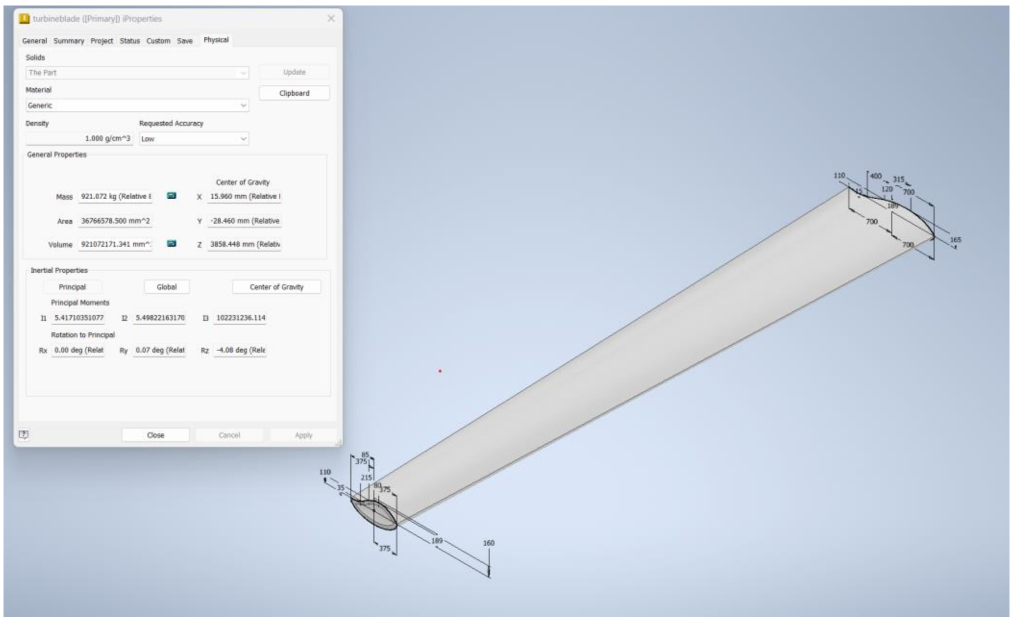
Any student that is ***not*** present for Design Studio will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their P-1 grade.

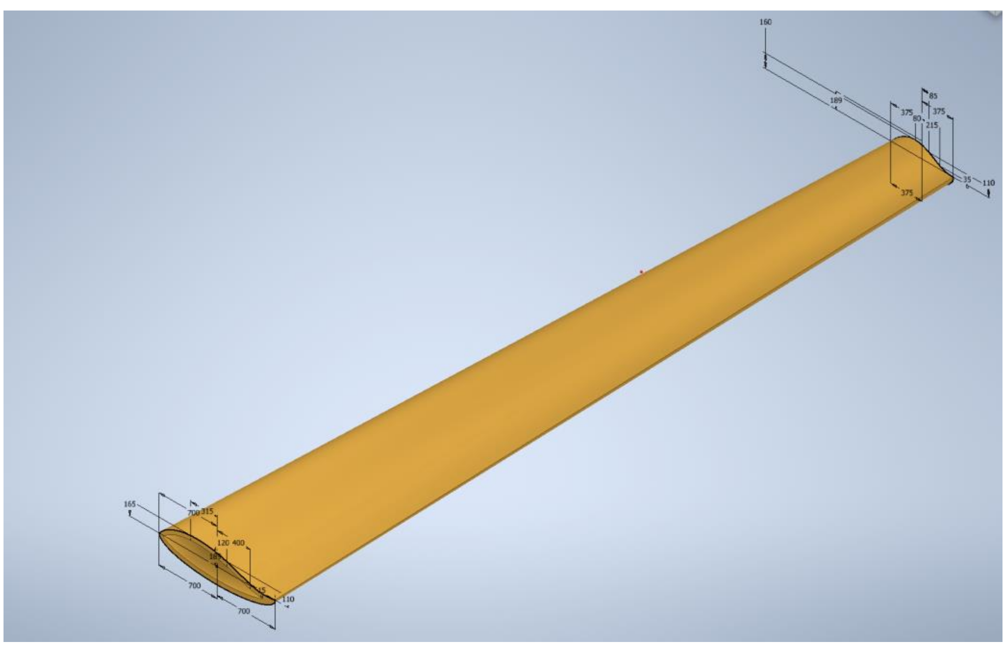
MILESTONE 3B – DESIGN EMBODIMENT

Team ID:	Mon-11

1. Solid Model of Turbine Blade

Insert screenshots of your team's solid models in multiple views (please show evidence of accurate CAD modeling by showing measurements).



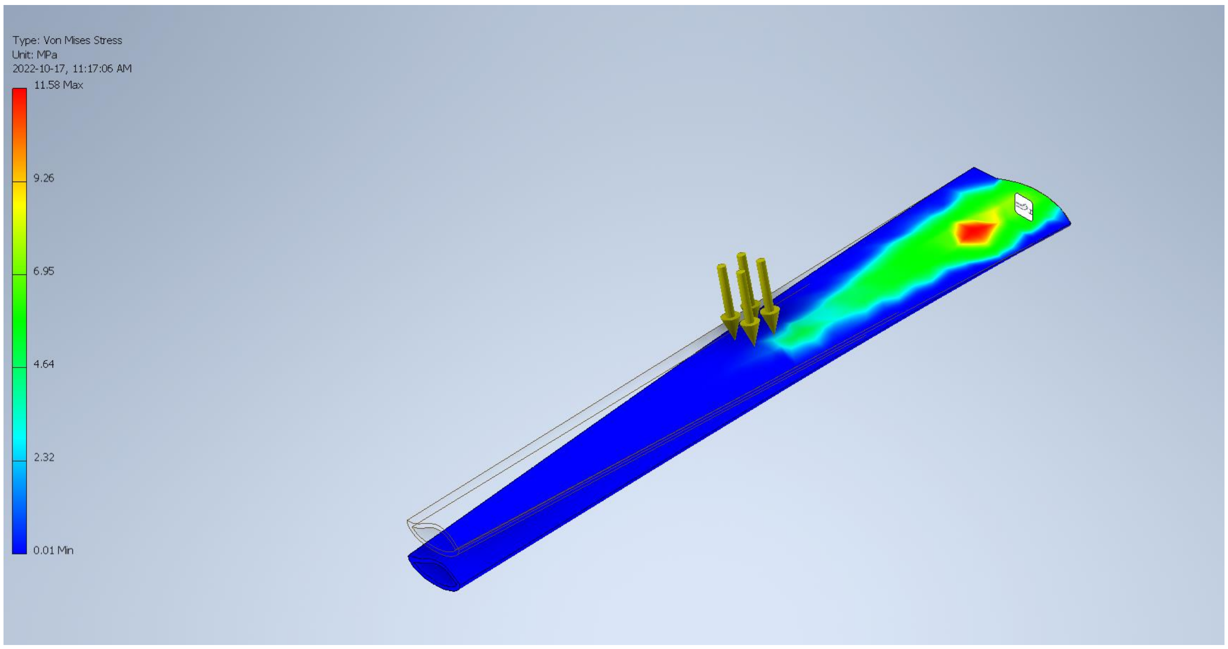


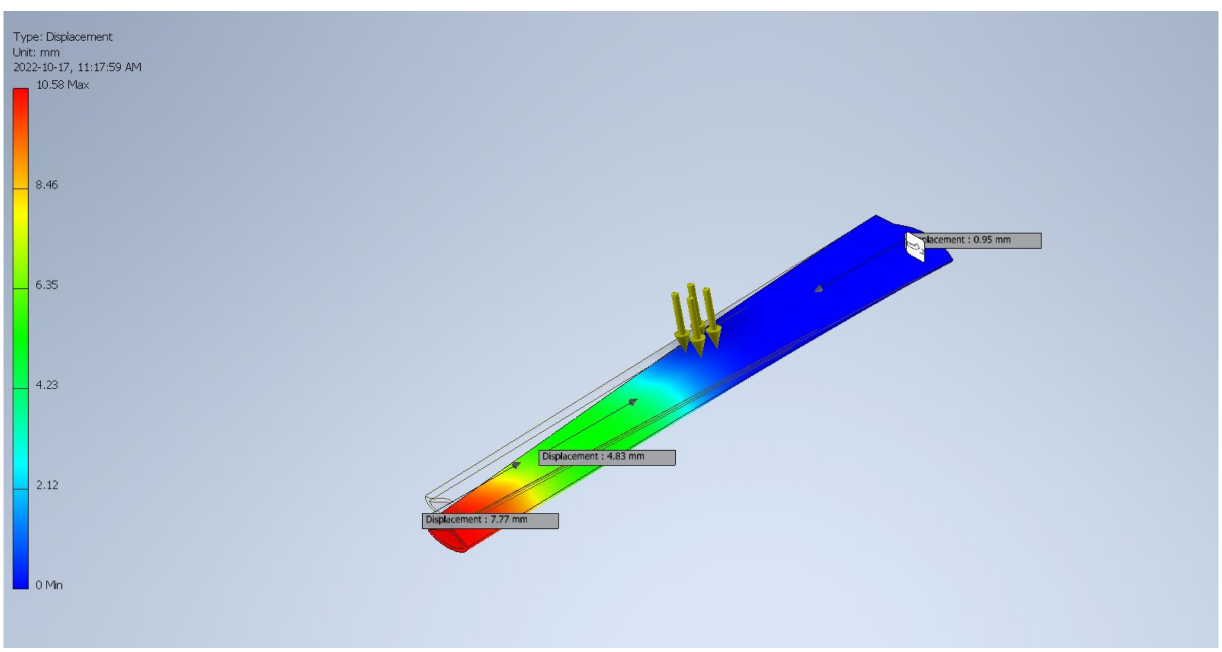
Team ID: Mon-11

2. Deflection Simulation

Simulated deflection δ (mm):	10.58

Insert screenshots of your team's deflection simulation and provide evidence of the simulated deflection.





BONUS: BLOW US AWAY (TEAM) – COVER PAGE

Team Number: Day-##

Please list full names and MacID's of all *present* Team Members

Full Name:	**MacID:**

BLOW US AWAY! CHALLENGE WORKSHEET

Team ID:	Day-##

1. Solid Model of Turbine Blade

Insert an isometric pictorial of your team's solid models in multiple views (please show evidence of accurate CAD modeling by showing measurements).

Team ID: Day-##

2. Justification

Include your one-page design justification explaining how the turbine design fits with the overall project, reasoning behind the design, creative components within the design, and sources of inspiration.

MILESTONE 4 (TEAM) – COVER PAGE

Team Number: Mon-11

Please list full names and MacID's of all *present* Team Members

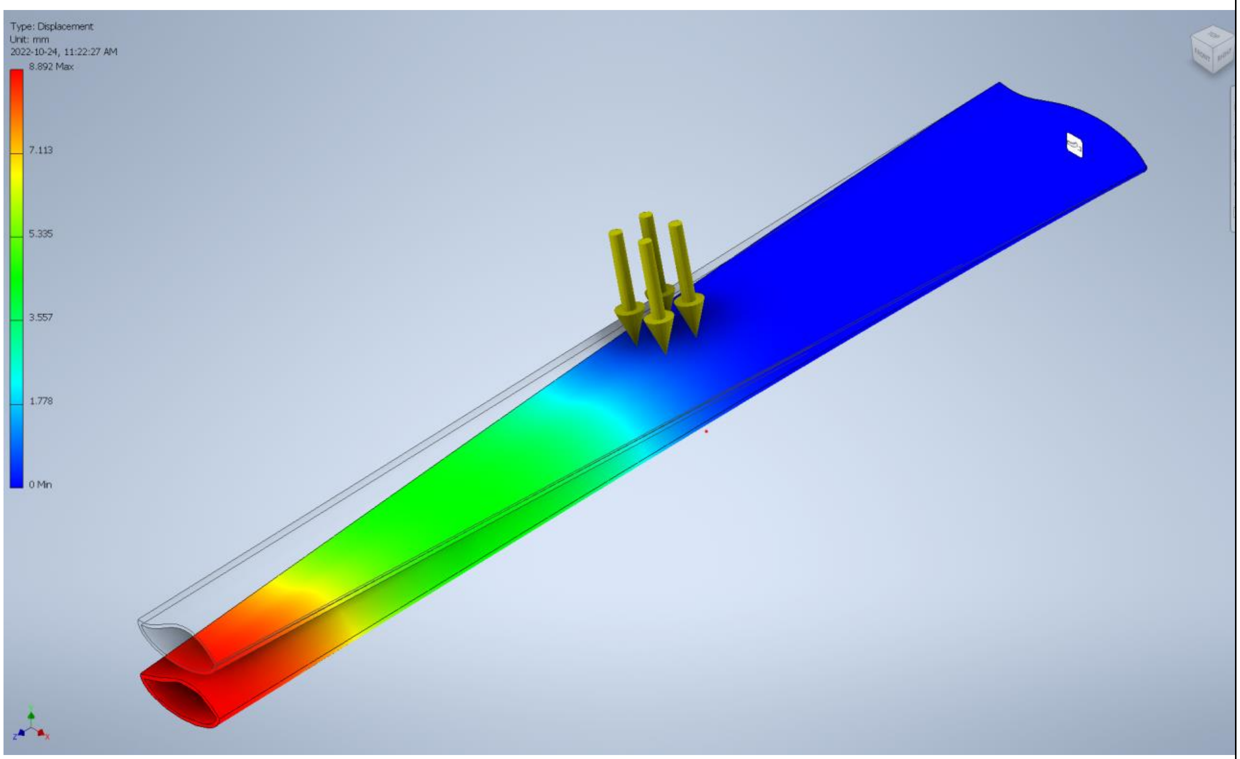
Full Name:	**MacID:**
Mohammad Bilal	Bilalm14
Shreya Gopalakrishnan	gopals4
Iris Lin	lini8

Any student that is ***not*** present for Design Studio will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their P-1 grade.

MILESTONE 4 (STAGE 2) – REFINE THICKNESS REQUIREMENT

Team ID:	Mon-11

1. Refine Thickness Requirement to Satisfy Deflection Constraint

Refined turbine blade thickness *t* (mm):	27
Insert screen captures of the refined deflection simulation and provide evidence that the deflection satisfies the design constraint. **8.892 mm is the max deflection.**  	

MILESTONE 4 (STAGE 3) – PEER INTERVIEW

Team ID: Mon-11

1. Peer Interview Notes

Discuss what you have learned from another group.

Group 12 was commissioned to build a clean wind turbine for the government of Sweden. The country wishes to gravitate towards clean energy to fight climate change. Group 12's primary objectives were to minimize CO_2 emissions and energy usage & production. Energy usage during production tends to be the main producer of greenhouse gases so limiting how much energy goes into production will reduce the amount of GHGs. The material they chose was *medium carbon steel* as it was the most practical of their top three options (the others being bamboo and wood). Bamboo is the most sustainable but steel is more sensible given their objectives. Medium carbon steel is weather resistant and so requires less maintenance and care (which is important considering there will be *many* wind turbines per wind farm). It's often used in construction because it's also recyclable (so it can be reused in other ways), lightweight, and low-cost. And although wood performed best for mpi, that only considered the environmental aspects of the material and neglected actual functionality, at which the medium carbon steel won. They decided on a final thickness of 25 mm which resulted in a maximum deflection of 9.5 mm when they ran their simulation. Our group's objectives differed in that minimal size and cost did matter. For them it did not because they were assigned wind farms and government funding. Our top priority was to make the wind turbines functional and affordable for the average homeowner. However, as both our materials were in the metal family, we had similar benefits. Low alloy steel is also weather resistant, lightweight, and low-cost.

Note: Please be mindful that you are expected to write a short reflection on what you have learned from the other team in your final deliverable.