The Maine High School Wind Blade Design Challenge
2016 Guidelines and Rules

www.mainewindbladechallenge.com

The Maine Wind Blade Challenge was created in cooperation with the Maine Composites Alliance, the Maine Wind Industry Initiative, and the University of Maine College of Engineering and Advanced Structures and Composites Center. Wind Blade Challenge is possible thanks to the generous support of Maine companies and organizations committed to the development of STEM in Maine.

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The Maine **Composites** Alliance

MAINE OCEAN & WIND INDUSTRY INITIATIVE

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1. Introduction

Thank you for participating in Maine Wind Blade Challenge, hosted in cooperation with Maine Composites Alliance, Maine Wind Industry Initiative and the College of Engineering and the Advanced Structures and Composite Center at the University of Maine. This event is a fun and interesting learning opportunity for Maine's high school students. Each year this event continues to evolve and grow. As you delve into this Challenge you will find the Maine Guiding Principles applied though out the processes. You will also meet the specific Science and Technology content standard B2 (Skills and Traits of Scientific Inquiry and Technological Design) which states: **Students use a systematic process, tools and techniques, and a variety of materials to design and produce a solution or product that meets new needs or improves existing designs** (Please see appendix for more information).

2. Mission

The overall goal of this challenge is to provide a comprehensive learning opportunity that allows students to explore composite manufacturing technologies and wind energy concepts. Through the exploration of the use of composite materials, we want to ensure that students and teachers are exposed to new, safe and clean processes. The event has been designed to allow participation of student teams with a diverse range of experience; we encourage and invite schools with no experience, as well as schools with advanced experience. The materials and methods have been structured to ensure limited tooling requirements and safety for all of those involved. We have purposely limited the amount of time necessary to participate so the event does not compete with other necessary educational activities.

3. Problem Statement

Each team is to independently design and fabricate a wind blade assembly that will generate the most energy over a given time period (3 minutes or less). The wind blade assembly is to consist of a set of blades attached to a center hub. The wind blades are to be made using only the materials provided and fabricated using the Vacuum Infusion Process (VIP). The hub may be made of any material as long as it meets the design requirements outlined in Section 7.

4. Material provided to each team

Each team will be provided with a kit that includes the following materials:

- Three (3) - 18" X 3" X 6" Polyisocyanurate Foam blocks - Polyisocyanurate foam is a very easy medium to sculpt and work with. The foam can be shaped and carved easily with simple knives, sand paper or clay sculpting tools. It is advisable to wear respiratory protection from the dust that can be created when shaping the foam.
- Fiberglass Cloth – The same **uniform weight** cloth will be provided to each team. **The fiberglass cloth may not be substituted by an alternative weight or weave fiber reinforcement.** Each team will need to prepare the cloth prior to bringing the blades to your regional composite lab (cut to size and shape). By rule, blade exterior surfaces must be a complete rigid fiberglass surface. If by the nature of the fiberglass there are small gaps or imperfections caused by uncontrollable material shifts the blade will still be acceptable.
- Polyester or Vinyl ester Resin – The resin used to infuse the blades will be provided at each team's infusion site.
- **It is important that any use of other materials or adhesives be done with clear guidance from the team's composite technical assistance advisor (advanced composites school or composites business) to ensure compatibility with all provided materials.**

5. Safety

Material Safety

- Fiber Glass can be an irritant and it is important to be sure all participants wear protective clothing, eye wear, and dust masks when handling.
- Sanding and shaping any of the materials used during this project should only be done while using proper safety equipment including protective eye wear and dust masks.
- Composite materials, in particular chemical resins, require specific safety handling, use and storage procedures. It is important to use these materials only in an equipped setting with the supervision of individuals trained in proper safe handling procedures. **It is also important that use of all other adhesives and paints be verified for compatibility with the materials provided in the kits.**
- It is possible for the blade assembly to become unstable during the test. When designing the hub and hub/blade attachment, care should be taken to ensure the connection is a tight, solid connection to minimize the risk of a blade breaking off the assembly.

IMPORTANT:

It is very important for all parties to understand and act with safety in mind first. Wind blades have the potential of moving with a great amount of speed. It is possible for wind blades to become dangerous and unstable. NSAI and MCA only intend for these blades to be used solely for this competition and not to be used in other uncontrollable situations. Testing will take place at University of Maine by Advanced Structures & Composites Center staff. The Composite Center will do this testing in a controlled atmosphere to ensure the safety of all attending participants. MCA and MOWII will not take any responsibility for any attempt to use these blades out of the testing procedures.

6. Competition Requirements

Each team will be scored on how well they meet the following competition requirements according to the scoring rubric listed in Appendix A.

6.1 Each team is to design and fabricate a new wind blade assembly each year consisting of the blades and hub according to the following requirements:

i. Dimensions – The general profile of the blades and assembly is at the discretion of each team. However, the following design and construction rules must be followed:
   1. Each team will be responsible for research and design of their blades
   2. Each team will shape their own blades
   3. No blade is to exceed 18-inches in length (straight line measure)
   4. Each team must create the hub with a 5/8" diameter hole for mounting their blade assembly to the testing platform.
   5. The hub attachment may only extend into or along any edge of a blade for a maximum of 4”. (i.e. wood dowels or similar cannot be inserted through the whole length.)
   6. The overall diameter of the blade assembly (including hub) cannot exceed 42-inches
   7. The testing platform will be capable of accepting horizontal axis blades only.

ii. Construction – *The blade exterior surfaces must be a complete rigid fiberglass surface created by the infusion process. Failure to meet this requirement will result in disqualification.* **Points will be deducted if the foam is not used as part of the structure.** Other materials may be used to create forms/molds in the making of your blades (carved wood, plastics, etc.); however the final product may only contain: materials provided in the kits, the hub material, and materials used to attach the blades to the hub. It is allowable for a team to cut the provided blocks and use any and all pieces you may create from the allotted foam materials, providing the final assembly meets the dimension requirements listed in Section 6.1. There is not a requirement (minimum or maximum) for the number of blades fabricated for the final blade assembly.

iii. Blade Infusion – Each team will travel to a regional composite lab with their blades on a scheduled day. The team's teacher and the business/ composite educational facility will coordinate the times to go to the lab to infuse blades. The Maine Wind Blade coordinator will determine which business each team will use. In some cases, schools may have the ability to perform the infusion independently. All teams must verify use of the infusion process within their competition report presentation.

This day will be an integral part of the learning experience. Each lab may be hosting a number of teams at one time and the interaction and sharing of ideas is intended to spur additional learning. The composite labs will guide and instruct/demonstrate for the teams the vacuum infusion process.

It is important to note that there will only be time to set up and infuse your parts one time. Therefore you must come prepared to create all your parts at one time. There will probably not be time to re-use one mold numerous times.

6.2 Oral Presentation - Each team will prepare a 3.5 minute presentation discussing the following areas:

a. Technical Design and Engineering Process Used (see Appendix D)
b. Wind Blade Science/Physics Pertaining to the Chosen Design
c. Definition of Composites and Their Use in the Project
d. The Vacuum Infusion Process
e. Use of Problem Solving and Optimization of Solutions in the Design Process

Judges will time each presentation and teams will be notified of the end time of 3.5 minutes. Teams are encouraged to use various types of media to illustrate their design and fabrication process. This includes, but is not limited to scale models used, drawing/sketches, notes, resources used. Presentations will take place in designated locations away from the blade testing area. Each team should be prepared to quickly set up any visual aids for their presentations. Teams will need to notify the Maine Wind Blade Coordinator if they will need power for their display prior to the competition. There will be no time allowed for questions from the judges, thus teams should prepare as thorough a presentation as possible to fit within the time requirement.

Some Presentation Considerations

- Method of delivery: clarity; conciseness; use of proper presentation etiquette
- How did the team choose their design and how it works?
- What were problems encountered and how were they addressed?
- Was an engineering notebook kept to document the design process?
- How were composite materials used in the project and why?

7. Testing Platform and Hub Requirements

The Composite Center will provide the testing platform that consists of a motor and a shaft to which each team's turbine assembly will be mounted. Each team will need to arrive at the University on the testing/competition day with their wind blade assembly fully assembled and prepared to be mounted on the shaft. Your hub may be made of any material you wish, with a maximum thickness of 1". Hub examples are shown in Figure 1.

The mounting system on the testing platform consists of **two 4 ½" plates with a 5/8" threaded center hole,** threaded on a 5/8" threaded rod and locked with locking nuts, shown in Figure 2. Each team's center hub will be sandwiched between the two plates as shown in Figure 3. **Your turbine will need to have a hub with flat faces on the front and rear surface with a clear area greater than 4 ½" and with a 5/8" hole in the center.** It is important that no part of the blades or fastenings interfere with the two testing platform clamping plates, i.e. these items must be clear of a 4 ¼ diameter circle as shown in Figure 4.

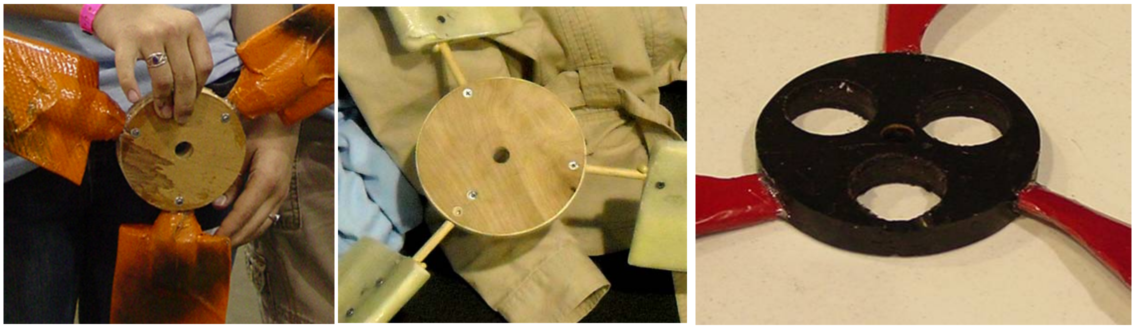

Figure 1: Examples of 2009 hub structures and blade connections

Figure 2: Hub attachment plates

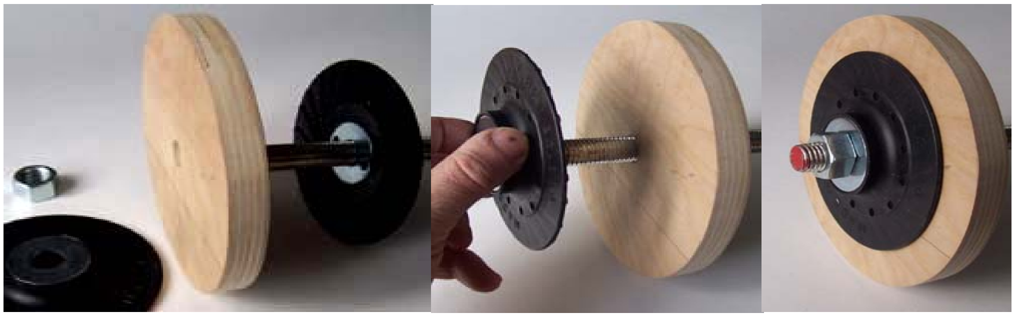

Figure 3: Photo showing sample hub sandwiched between plates

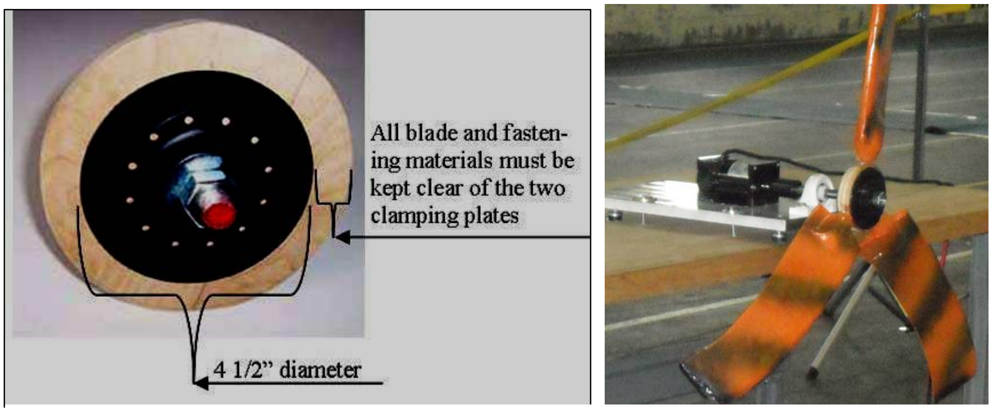

Figure 4: Clearance required on assembly hub (left) and the 2009 test

Figure 5: Prep area

8. Testing/Competition Procedure

1. All Teams will register immediately upon arrival at UMaine.
2. Upon arrival a judge will inspect the wind blade assembly for compliance with the design criteria at the registration table.
3. Each team will set up their presentation display and material on their assigned table. *Upon arrival at the event each team will be given a specific presentation and testing schedule.*
4. Teams are encouraged to use the pre-test prep area prior to their test run to ensure blades turn and to make final adjustments on the hub. Figure 5 is a picture of the pre-test prep area.
5. Testing will take place in the order of previously assigned team positions.
6. When called to test, teams will assist in the installation of their blade/hub assembly on the generator shaft. The generator is attached to a system that will measure energy output. An artificial wind will be generated from one direction only. The wind will be at a set speed between the range of 10 and 15 MPH.
7. Each set of wind blades will be allowed to generate energy for 2 minutes. The test will begin with the fans/wind source being turned on and the timer started.
    a. During the first 30 seconds there will be no load on the wind blade.
    b. After 30 seconds a 20 ohm load (approximately 5 Christmas tree lights) will be switched on.
    c. After 60 seconds, another 20 ohm set lights will be switched on in parallel.
    d. After 90 seconds, a third set of 20 ohm lights will be switched on in parallel.
8. A computer data acquisition system will measure the energy generated by wind blade assembly over the 2 minute testing time as follows:
    a. Peak Voltage: The peak voltage output during each of the four 30 second intervals will be recorded by the data acquisition system.
    b. Energy Score: This will be calculated as the sum of the four peak voltage readings.
    c. The Energy Score for each team will be converted to a 64 point scale. The wind blade that creates the highest Energy Score will acquire the maximum 64 points.

9. Scoring

Each team will receive scores from a team of three (3) judges that will assign scores according to the attached rubric. Scoring will be based on the following:

1. Design Criteria (16 points)
2. Presentation: Delivery (16 points) Content (32 points)
3. Energy generated (64 points)
    a. 10 points will be deducted from final energy output score if a team member has to manually start the wind blade assembly.
    b. If a team's wind blade fails before the completion of the timed test, the team will have the opportunity to repair the wind blade. Following wind blade repair, the team can retest their wind blade after all other teams have had a turn. In such a case 15 points will be deducted from the final energy score.
4. A team will be disqualified for entering a previous years blade assembly.

The judges will be announced at the beginning of the competition. All rulings are final and may not be appealed. Awards will be given to the top three (3) scoring teams.

APPENDIX A- Scoring Rubric

WIND BLADE DESIGN CHALLENGE CONTEST RUBRIC 2016 TEAM______________________________________

Maine Learning Results--Science and Technology (B2): Students use a systematic process, tools and techniques, and a variety of materials to design and produce a solution or product that meets new needs or improves existing designs.

Design Criteria: *(zero points will be given for any of these criteria if not met)*	Max Points	Points Given
☐ *Wind blade was fabricated using the Vacuum Infusion Process (VIP)*	4	
☐ *Wind blade incorporates all the materials provided*	4	
☐ *Diameter of blade assembly doesn't exceed 42-inches*	4	
☐ *Each team must create mechanism hub with a 5/8" hole for mounting their blade to the testing platform.*	4	
maximum potential points	**16**	
Presentation Delivery Criteria: *(zero points will be given for any of the first three criteria if not met)*	Max Points	Points Given
☐ *Within 3.5 minutes in length*	2	
☐ *All members present*	1	
☐ *Use of multiple presenters*	2	
☐ *Use of proper presentation etiquette (including non-speaking members)*	0-2	
☐ *Multiple media used to enhance delivery of content*	0-3	
☐ *Clear and concise*	0-3	
☐ *Style points (such as enthusiasm, creativity, team appearance, professionalism)*	0-3	
maximum potential points	**16**	
Presentation Content Criteria:	Max Points	Points Given
☐ *Explanation of technical design/ engineering process*		
• *Team defined and researched the problem*	0-6	
• *Team generated and evaluated solutions*	0-6	
• *Team use of problem solving and trade-offs to optimize outcome*	0-6	
☐ *Conveys the science behind the function of their chosen blade design*	0-6	
☐ *Defines composite materials and how they were used in this project*	0-4	
☐ *Explanation/ demonstration of understanding of infusion process*	0-4	
maximum potential points	**32**	
Energy Score:	Max Points	Points Given
Each set of wind blades will be tested for an energy score on the test generator platform. The peak voltage output of each wind blade will be recorded by a data acquisition system four times during a two minute test. There will be no load during the first 30 seconds. After 30 seconds a load of approximately 20 ohms will be added to the test. After 60 seconds another 20 ohms will be added in parallel. After 90 seconds, a third set of 20 ohm lights will be switched on in parallel. The four voltage readings will be added and converted to a 64 point scale. The team that acquires the highest energy score will receive the full 64 points.	**64**	

Sub Total Score:__________

Manual Start and/or Wind Blade Failure Deduction: _________

Total Score out of 128 Possible Points: __________

APPENDIX B - Construction Process

Each team will face a number of essential challenges in shaping and covering their blades. First, it is important that the blades be as identical to each other as possible to ensure your final blade assembly is completely balanced. Because you may be shaping a number of foam blocks or forms, it will be a challenge to replicate complex shapes.

Second, the total weight of the final product will affect the performance. Wrinkles and overlap in the fiberglass cloth will add weight from the fabric and also cause the resin to pool in those areas adding weight. Each team should make considerable effort to apply the glass cloth as uniformly as possible.

Creating Shape:

Your Team will research and design the shapes and layout of your blades/turbine assembly. Your team may choose how many blades to include in the assembly. There are a number of ways to form the fiber glass in your desired shape. Below are three examples, though there may be other possibilities:

Example 1. Carve the foam blocks into each one of your blades. Then cover the foam with the glass and resin to create a hard shell. The foam will then remain as a core part of the blade (Figure 1, #1). Because Polyisocyanurate foam can be sculpted easily, it is very important to handle your products with care. Be careful not to over shape the blades and take way more material than intended. After you have shaped the blades it is very important to handle and transport them with great care so they are not damaged prior to being infused.

Example 2. Carve the desired shape in the foam or any other material (wood, plastic, plaster) and then use the shape as a male form to apply the glass and resin to until the composite structure hardens, then remove the form. If using this technique it is important to provide a smooth non porous surface on the form. This could be done by adding a thin coat of plaster over foam, or covering a wooden form with cellophane tape or other methods. The surface will then be coated with a mold release prior to laying on the fiberglass and resin (Figure 1, #2). **

Example 3. Carve your desired shape using any chosen material. Then use that shape (the plug) to create a negative or female mold. Cover your plug with a material that can form around the plug and then harden, leaving the shape when you remove the plug (Figure 1, #3). **

** Fiberglass and resin are often used to create a male or female mold. However it is important that this technique is only used if there is appropriate supervision by an individual trained in the proper material handling safety techniques. If using a mold or plug technique you will need to create one for each blade so that all can be infused during the one visit your team will have with the composites lab.

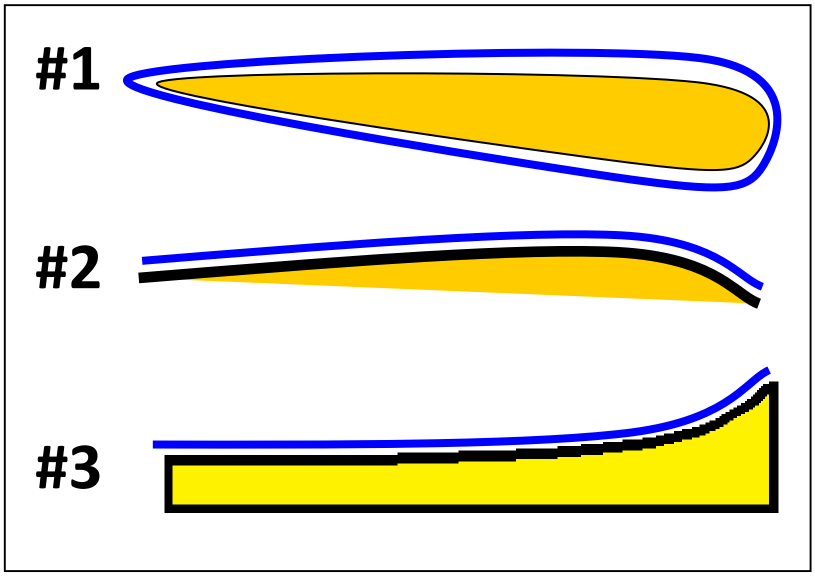

Figure 1

Creating the rigid shell/surface

Once your team has created a method to hold the shape, the fiber glass will be layered onto your mold or core. Only apply approved adhesives with supervision and guidance of your composites lab. The glass will be pressed and held into the shape by covering it with a plastic envelope, and then pulling a vacuum on the envelope. The vacuum suction is then used to pull the resins (infuse) through the fibers.

The infused blades may have some imperfections caused by the imprint of wrinkles from the plastic vacuum bag. Your school may need to sand and fair the hardened blade, and finish or paint as your team desires

VIP Resources

It may be helpful for your team to understand better the techniques of composite manufacturing prior to taking their first steps. There are a number of free resources available on the web. One resource that does a decent job of explaining VIP can be found at the following link:
http://cdn.fibreglast.com/downloads/vacuuminfusion.pdf

It may also be helpful for your team to see how infusion works. You can see West Bay Boats infusing the 2009 winning blades from Sumner High at www.youtube.com/watch?v=ALGYgJpPiFU. Also a number of other short videos can be found on www.youtube.com. Search *vacuum infusion* at the site. Some of these videos are not professionally done and it is possible to find errors in many of the techniques used in these videos. Therefore, these videos should not be used as training resources. The composite labs will have individuals with professional training to help instruct your team.

APPENDIX C - The Wind Blade Challenge and the Maine Guiding Principles

The Maine Wind Blade Challenge is a complement to the Science and Technology Maine Learning Results, specifically section B2 refers to the Skills and Traits of Scientific Inquiry and Technological Design that states: **Students use a systematic process, tools and techniques, and a variety of materials to design and produce a solution or product that meets new needs or improves existing designs.** In addition, the WBC will help develop the highlighted section of the MGP listed below.

1. A CLEAR AND EFFECTIVE COMMUNICATOR
    a. **Uses oral, written, visual, artistic and technological modes of expression**;
    b. Reads, listens to and interprets messages from multiple sources; and
    c. Uses English and at least one other language.
2. A SELF-DIRECTED AND LIFE-LONG LEARNER
    a. Created career and education plans that reflect personal goals, interests and skills, and available resources;
    b. Demonstrates the capacity to undertake independent study; and
    c. **Finds and uses information from libraries, electronic data bases and other resources**.
3. A CREATIVE AND PRACTICAL PROBLEM SOLVER
    a. Observes situations objectively to clearly and accurately define problems;
    b. Frames questions and designs data collection and analyses strategies from all disciplines to answer those questions;
    c. Identifies patterns, trends and relationships that apply to solutions to problems; and
    d. Generates a variety of solutions, builds a case for the best response and critically evaluates its effectiveness of this response.
4. A RESPONSIBLE AND INVOLVED CITIZEN
    a. Recognizes the power of personal participation to affect the community and demonstrates participation skills;
    b. Understands the importance of accepting responsibility for personal decisions and actions;
    c. Knows the means of achieving personal and community health and well-being; and
    d. Recognizes and understands the diverse nature of society.
5. A COLLABORATIVE AND QUALITY WORKER
    a. Knows the structure and functions of the labor market;
    b. Assesses individual interests, aptitudes, skills, and values in relation to demands of the work place;
    c. Demonstrates reliability, flexibility and concern for quality.
6. AN INTEGRATIVE AND INFORMED THINKER
    a. Applies knowledge and skills in and across English language arts, visual and performing arts, foreign languages, health and physical education, mathematics, science and technology, social studies, and career preparation; and
    b. Comprehends relationships among different modes of thought and methods associated with the traditional disciplines.

APPENDIX D – Sample of the Engineering and Design Process