Texas Alliance for Minorities in Engineering

2017 STATE STEM COMPETITION: ENGINEERING DESIGN CHALLENGE

WIND IT UP!

During the 1980s, Boeing engineers built the largest wind turbines in history and constructed the first "wind farm". Many of the ideas developed in those projects are used today in developing wind turbines and wind farms across the world.

A wind turbine is a device that converts the wind's kinetic energy into electrical power. There are three components to a traditional wind turbine –

- **The rotor, which includes the blades for converting wind energy to low speed rotational energy.**
- The generator, which includes the electrical generator, the control electronics, and components for converting the low speed incoming rotation to high speed rotation suitable for generating electricity.
- The structural support which includes the tower and rotor yaw mechanism. The yaw mechanism ensures that the wind turbine rotor is always facing the wind.

Aerodynamic modeling is used to determine the optimum tower height, control systems, number of blades and blade shape.

Project Overview: You have 60 minutes to **design, test, build, and demonstrate the rotor** for a wind turbine. All teams will have access to the same generator and structural support at the testing and judging station.

Your team will use the materials provided to design and build one or more blades that can be attached to the turbine hub. The hub will be connected to the generator and the turbine will be powered by a fan placed near the unit. When the blades turn in the wind, the turbine hub spins and the generator produces electricity. A multimeter will be used to measure the electric current generated at different fan speeds. Three measurements will be taken at each speed, and teams will earn more points if their wind turbine produces a consistent level of electric current at each speed.

Information about a wind turbine built using similar materials is included in this packet. Your challenge is to build a wind turbine that is more cost efficient (uses fewer materials) and is more conversion efficient (produces more electricity, measured in microamps). Your team must test the wind turbine you build at least once before time is called and record the electric current generated at this test. You must then use this information to describe to the judges why your design is less expensive to build and more efficient.

In any real world project, cost is an important consideration. Teams are encouraged to carefully consider the materials they use in building this turbine. Team will be awarded points for materials returned unused at the end of the building phase.

Awards: Six teams will win awards for performance and three teams will be recognized for teamwork, innovation and efficient use of materials. The Innovation Award is sponsored by the Texas Board of Professional Engineers.

SUPPLY LIST – CHECK IMMEDIATELY!

You have five minutes to replace any missing items

RAW MATERIALS, MAY BE ALTERED			
4 sheets of paper	4 pieces of cardstock	2 sheets of chip board	2 styrofoam cups
6 dowels	4 rubber bands	6 binder clips	masking tape
1 paper clip	curling ribbon	1 gallon zip bag	
MAY NOT BE ALTERED: Turbine hub, 2 tickets to the testing station			
OTHER RESOURCES, MAY NOT BE ALTERED OR USED IN PROTOTYPE			
1 pair of scissors	1 pencil	design challenge instructions	team number sign

DESIGN BRIEF

- Introduce yourself to your team. Decide who will take on the different roles. Each team member must have an assigned role and all roles must be assigned. If your team has less than six members, some team members will serve in more than one role. (Engineering Team Members, page 4)
- Draw the design on the team documentation form. (Design Drawing, page 5)
- Review the scoring rubric and determine how you can meet the requirements and maximize points. (Scoring, page 3)
- Test as you build to make sure the wind turbine works as planned at all speeds. (Answer all questions on page 6).
- Be creative and have fun with this project!
- Good luck!

MATERIALS, REQUIREMENT AND TIME CONSTRAINTS

MATERIALS:

- Only the materials provided and listed in this document may be used**.**

REQUIREMENTS:

- Teams must test their turbine at least once before time is called, and record the electric current generated by their turbine. Teams must compare their turbine's performance to the sample turbine performance (on page 5) and explain why their design is better.
- Teams must return all unused material when time is called. Teams will earn points for each unused item they return.
- The team-designed turbine blades must be attached to the hub provided. This hub must be mounted on the generator and start from rest.
- Blades must be shorter than 15 inches, the height of the tower on which the wind turbine will be mounted. When connected to the generator, the blades may not touch the table on which the testing tower is placed.
- The Structural Engineer will connect the turbine hub to the generator
- All energy supplied to the turbine must come from the wind (a fan will be used to ensure this is consistent between teams).
- The Test Engineer may get the blades rotating by gently spinning the turbine. If the blades fall off or the turbine breaks as a result of this spin, the teams will not be able to make any repairs and will not receive any scores for performance.
- The fan will be turned on at low speed at the start of testing, with the multimeter connected to the wind turbine. The multimeter reading (in microamps) will be recorded 20 seconds after the fan is turned on. Two more multimeter readings will be taken at this fan speed, and they will be spaced 20 seconds apart. The fan speed will be increased to medium and 3 measurements will be taken at this speed, in 20 second intervals. The fan speed will then be increased to high and 3 measurements will be taken at this speed, at 20 second intervals. The fan will be turned off only after all 9 measurements are recorded.
- Team members may not touch the wind turbine once testing begins.
- The fan will stay on throughout the testing period, and only the fan speed will be changed between measurements.

TIME:

- Teams will have 60 minutes to design, build and test the wind turbine
- After 60 minutes, time will be called and construction will be halted. Teams will move their turbine hub to the judging area. All blades must be attached to the turbine hub when time is called.
- Each team will have 1 minute to deliver their presentation to the judges.
- Other team members may watch the judging from a distance, as specified by the judges.

SCORING

Judges will score the design, performance and creativity of the wind turbine as follows:

- Judges will verify that the team tested their turbine at least once and recorded the electric current generated.
- Judges will record the unused materials that are returned before testing begins.
- The judges will record the electric current generated at 3 different fan speeds. Consistent current generation will be measured by recording the electric current generated 3 times at each fan speed in 20 second intervals.
- The following formulas will be used to score the performance of each wind turbine –

  Performance Score = (4 * Final Low Speed + 3 * Final Medium Speed + 2 * Final High Speed)

  Total Score = Design score + (Presentation Score * Cost Factor) + Performance Score

TASK	SCORE
Design	
Wind Turbine has a name	5
Presentation	
Team verifies that they tested wind turbine at least once	5
Team can explain why their wind turbine is better (Cost, design innovation, electricity produced, etc.)	1 - 5
Team can explain how they designed the blades and why they picked the specific number of blades	1-5
Teamwork	1-5
Overall presentation skills	1-5

Cost Factor: Only materials that have not been modified or partially used may be returned	
Turbine Cost Factor = Total points assigned to the returned materials	Paper, rubber bands – 1 point each Cardstock, dowels – 2 points each Chip board, cups, binder clips – 3 points each

Performance						
Fan Speed	Reading 1 (microamps)	Reading 2 (microamps)	Reading 3 (microamps)	Average Reading	Standard Deviation	Average – Standard Deviation: Used in calculating performance score
Low						**Final Low Speed**
Medium						**Final Medium Speed**
High						**Final High Speed**

NOTE: The completeness of documentation will be used to break any ties.

PROJECT DOCUMENTATION

Team Number: _____

Wind Turbine Name: _____

ENGINEERING TEAM MEMBERS

If you have fewer than six members on your team, a student should be assigned multiple roles.

- **SYSTEM ENGINEER** will verify that the team-designed wind turbine has a name, team members have specific roles, and documentation is complete. She/he will make sure that the turbine is tested at least once before time is called.

- **DESIGN ENGINEER** will lead the overall design and is responsible for including the design drawing(s) in the documentation. She/he will lead the team in developing a strategy to maximize points earned.

- **STRUCTURAL ENGINEER** will attach the team-designed wind turbine to the generator shaft at the testing station and later at the judging station. She/he will verify that the turbine is well constructed and properly attached to the generator shaft.

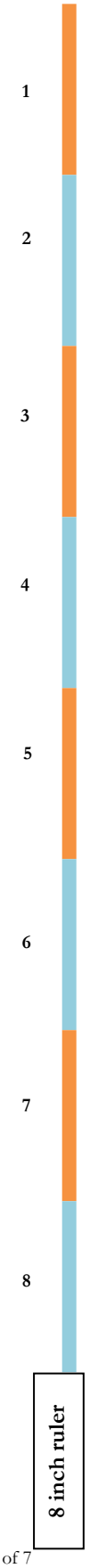
- **MATERIALS ENGINEER** will review all the supplies provided and lead the team in selecting the appropriate materials for blade design keeping in mind that the more items that are returned, the more points are earned. She/he will return unused materials when time is called.

- **SALES ENGINEER** will lead the team in developing the presentation to the judges and will make the presentation. She/he will include a comparison between the team's wind turbine and the sample wind-turbine information and design strategy.

- **TEST ENGINEER** is responsible for testing the turbine during the build phase, recording the current generated during this test. She/he will also ensure that the turbine starts rotating in the first 20 seconds of testing, turning the blades gently, if necessary. Only the test engineer may touch the turbine in the first 20 seconds of testing and judging.

ROLE	FIRST NAME	LAST NAME	SCHOOL
SYSTEM ENGINEER			
DESIGN ENGINEER			
STRUCTURAL ENGINEER			
MATERIALS ENGINEER			
SALES ENGINEER			
TEST ENGINEER			

DESIGN DRAWING(S) AND NOTES



A student team in Wyoming used the same materials to build a wind turbine called 'Windswept'. At the end of the challenge, they returned the following items: paper (4 pages), rubber bands (4), dowels (2), binder clip (2), chipboard (4). Their wind turbine produced 400 microamperes when the fan was at low-speed setting, 450 microamperes at medium-speed and 475 microamperes at high-speed setting.

Compare the construction and performance of your wind turbine to Windswept and explain your design choices to the judges. Answer the following questions.

SYSTEM

What was your team's approach in designing the blades on your turbine?

DESIGN

How many blades did you attach? Why? Did it work the first time? Were there any revisions?

IDEAL WORLD/REAL WORLD

What additional supplies/tools would have helped your team build a better blades? What was your most challenging task as a team?

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JUDGES SCORING SHEET

Team number: **Turbine Name:**

Wind turbine was tested at the following fan-speed: Low Medium High	Reading 1		Reading 2		Reading 3	
Materials returned Count and enter number returned	Paper	Cardstock	Chipboard	Dowel		
	Binder Clip	Cup	Rubber Band			
Wind turbine has a name	Yes		No			
Explanation - Why their wind turbine is better (Cost, design innovation, electricity produced)	0	1	2	3	4	5
Team can explain how they designed the blades and why they picked the specific number of blades	0	1	2	3	4	5
Teamwork	0	1	2	3	4	5
Overall presentation skills	0	1	2	3	4	5

Performance: Verify multimeter is set at microamps. Start fan at low speed. Take reading after 20 seconds. Press 'hold' on multimeter to freeze and record data. When data has been recorded, press 'hold' again, to toggle on the multimeter and record score after 20 seconds. After 3 readings, change fan to medium speed. After recording 3 readings, change fan to high speed. Turn off fan after all 9 readings are recorded.

Fan Speed	Reading 1	Reading 2	Reading 3
Low			
Medium			
High			

VERIFICATION

_____ _____

Judge's name – please print Judge's name – please print

1 2 3 4 5 6 7 8

8 inch ruler