Advanced Manufacturing Challenge

Launchpad (make.skills21.org) Deadlines:
Team Profile Draft: March 9, 2018
Open Judging Begins: May 8, 2018

Sponsors: Skills21 (EdAdvance) and Connecticut Technical High School System

Manufacturing Design Challenge CTHSS
Precision Machining Programs
Expo Fest: May 19, 2018

ENERGY TRANSFORMATION – MAKING A BICYCLE-POWERED GENERATOR

Overview

You are part of a startup entrepreneurial manufacturing team whose mission is to create environmentally friendly solutions to difficult problems in the world and to capitalize on them. You have been contacted by a climate change research team. They have asked you to present a bicycle-powered electrical generator for use in areas where sunshine is limited, such as in a rainforest or in the arctic during seasons other than summer. The research team needs the generator to power and charge its communication and computer equipment.

The challenge will be done in three steps, or Missions. In Mission One, you will research and design your bicycle-powered generator and produce a research report and a set of CAD drawings. In Mission Two, you will manufacture and test your bicycle-powered generator and produce a prototype and a manufacturing and test report. In Mission Three, you will present and demonstrate your bicycle-powered generator at CT Expo Fest. The three Missions are based on following an engineering design process.

Challenge Background

Scientists in the field require electricity for communication, testing, and computing using a variety of electronic devices. All of these devices run off DC electrical power supplied by a power supply or an internal battery. These batteries need to be charged. Solar powered chargers are portable and easy to use, but they require a reasonable amount of sunshine. Wherever the daylight is limited, an alternative way to generate electricity is needed. Wind turbines work if there is a steady wind, but they need to be large enough to produce a reasonable amount of power, so they are not very portable. Since bicycles are found throughout the globe, they provide a potential source of power. The average adult pedaling a bicycle can produces a few hundred Watts of mechanical power. If this power can be efficiently converted to electrical power, then it can easily be used to power and charge electronic devices.

Electrical charging systems must provide enough electrical potential or voltage to overcome the internal impedance of the battery, typically rated at 6 to 12 volts. Students are allowed to select their own power generation source. Therefore, if the generator produces about 14 volts, it will be able to overcome the battery's impedance and charge the battery. The motor/generator used for the challenge is capable of

producing more than 14 volts, depending on the revolutions per minute (RPM) of the generator. Therefore, the design must be capable of driving the generator at the correct RPM to produce a minimum of 12 volts of output—any less may fail to charge a 12-volt battery, but too much more may damage the battery or waste energy.

Converting mechanical to electrical power can happen at very different efficiency rates. Efficiency is highest when there is very little slippage or friction in the mechanical parts. If the system has too much inefficiency, then the person pedaling the bicycle may not be able to pedal fast enough or may find it too difficult to pedal to generate sufficient electricity.

Problem Statement: Scientists operating in remote areas with limited sunshine have no electricity and do not have the capability to use solar powered electrical generation to power or charge their computers, cell phones, and other electronic devices.

Solution Statement: Design, manufacture, assemble, and market a bicycle-powered electrical generator that can help scientists power and charge their electronic devices in a remote area where sunshine is limited.

Criteria:

- The finished system must be capable of using any adult-size bicycle power to produce approximately 14 volts of direct current (DC) electricity to power or charge a 12-volt DC system.
- The electrical generation system design must be driven by a bicycle operating at a normal rate, i.e., pedaled at a reasonable rate that can be sustained by an average adult for approximately thirty minutes.

****SAFETY NOTE****
Students should not operate any motor/generator without proper training and an adult qualified to teach electrical systems present. The motor/generator used in the challenge could cause severe shocks if used improperly.

****SAFETY NOTE****
Charging batteries incorrectly can cause them to explode.
Do not attempt to charge a battery in this challenge.

Constraints/Assumptions:

- Each team will be provided the same bike.
- No outside or additional power devices are allowed.
- Teams may use the bicycle mechanical power to drive the DC motor/generator in any safe, efficient manner, i.e., the method of transmitting power is open.
- The finished electrical generating system must accommodate an adult two-wheel bicycle ridden at a normal rate for testing and judging.
- All teams will be provided the same one-speed men's bike.
- The bicycle must be held in a safe, stable position while the rider is

generating power.

- If the bicycle needs to be disassembled or modified in any way, the team's design must include tools and instructions that any adult could easily use.
    - Acceptable example: A wheel must be removed before use.
    - Unacceptable example: A part must be welded onto the bicycle before use.
- The finished electrical generation system must produce a minimum of 12 volts of DC electricity steadily for two minutes to be judged successful.
- The entire assembly (including the DC motor/generator, but not including the bicycle) must be easily portable, weighing no more than 30 pounds for ease of transportation and safety.
- Teams are allowed to utilize any non-hazardous materials in the production of their electrical generation system.
- Lubrication is allowed but must be contained in the device with no leaking or dripping.
- Teams may use generators they find and adapt but we recommend that it is not purchased off the shelf.

Elements to Consider:

- Safety
- Ease of assembly and use
- Weight
- Cost
- Material selection
- Portability
- Durability against wide ranging environmental conditions

Project Requirements

- This challenge requires the team to design and manufacture a system that takes the mechanical power of a bicycle and most efficiently converts it to electrical power.
- All requirements for the challenge must be submitted in Skills21 *Launchpad (make.skills21.org)*, except for the final presentation and demonstration that will be given at CT Expo Fest on May 19, 2018.
- Teams may earn a maximum of 325 points overall in this challenge.
- Mission One requirements—due in Skills21 *Launchpad (make.skills21.org)* on **December 4, 2017** and worth 75 points maximum:
    - Detailed documentation that gives appropriate background information justifying the team's bicycle-powered generator. Teams can choose to present this information in any format (research paper, PowerPoint, Prezi, video, etc.). The critical mission is to justify the team's project design.
    - An initial set of CAD part and assembly drawings for all the parts to be manufactured. Drawings can be submitted as .pdf, .jpeg, .idw, .dwg or as .doc. If a team has a question about drawing submission contact Liz Radday at radday@edadvance.org.
    - NOTE: If a team submits a Mission One product in *Launchpad (make.skills21.org)* more than 48 hours late, then that product will receive only half the computed points. See rubrics for details.

- Mission Two requirements—due in Skills21 *Launchpad (make.skills21.org)* on **April 2, 2018** and worth 100 points maximum:
    - A set of manufactured parts that have been tested and assembled to make the bicycle-powered generator.
    - A three page minimum manufacturing and test report documenting how the parts were manufactured, including photos of the parts and final assembly with explanations of any changes made to the original designs.
    - CAD part and assembly drawings of the assembled prototype after testing with any changes to the parts or assembly clearly labeled.
    - NOTE: If a team submits a Mission Two product in *Launchpad (make.skills21.org)* more than 48 hours late, then that product will receive only half the computed points. See rubrics for details.
- Mission Three requirements—due at CT Expo Fest on **May 19, 2018** and worth 150 points maximum:
    - A three to five minute presentation of the prototype ending with a demonstration to show its operation.
    - The presentation must include:
        - An introduction to your team's "company" that includes company name, details, mission statement, and logo.
        - A brief marketing plan that describes the features and benefits that will differentiate the team's solution from other prospective vendors.

- NOTE: If a team is unable to present or demonstrate its final product at CT Expo Fest for any reason, then it will receive zero points for the presentation or demonstration.

Mission One: Research & Design (75 Points Maximum)

Research: Before designing a bicycle-powered electrical generator, your team will need to research this concept. After you complete your research, document what you learned in a five- to ten-page report. You may also include a summary of your team's brainstorming to use the research to select a design. Some topics that you may want to research include:

- Environments where bicycle-powered generators make sense.
- Direct current (DC) electrical power generation systems.
- Methods of transferring pedal power to electrical power.
- Safety
- Flexibility of use, adaptability to different bikes
- Methods of transmitting the slower rotational rate of a bicycle to the faster rotational rate of a generator.

Design: After your team completes its research, you will need to select a design and make CAD drawings of it. For each manufactured part, you will need to produce a standard CAD part drawing showing appropriate views of the part with all dimensions and other required information to manufacture the part. Similarly, you will need to make an initial CAD assembly drawing(s).

Required Products and Deadlines: Your team's submission for Mission One must include the following products that are uploaded into the Skills21 *Launchpad (make.skills21.org)* no later than **December 4, 2017.**

- Documentation that gives appropriate information justifying the team's bicycle-powered generator (25 points maximum).
- An initial set of CAD part and assembly drawings for the parts to be manufactured (25 points maximum).
- Design must adhere to challenge constraints listed in rubric (25 points maximum).

Mission One – Research and Design Report Rubric

The Research Report counts for a maximum of 25 points. The team must submit all work for Mission One in *Launchpad (make.skills21.org)* by 11:59PM on **December 4, 2017**. The Research Report will be scored using the following rubric, and the team will receive the score and feedback by December 18, 2017.

Scores: Categories:	**Outstanding**	**Professional**	**Satisfactory**	**Developing**
1. **Accuracy** in language, engineering, science, and math.	All or almost all technical terms are accurate and appropriate; all or almost all scientific reasoning, calculations and measurements are accurate and realistic. (5 points)	Most technical terms are accurate and appropriate; most scientific reasoning, calculations and measurements are accurate and realistic. (4 points)	Generally, technical terms are accurate and appropriate; generally, scientific reasoning, calculations and measurements are accurate and realistic. (3 points)	Some technical terms are accurate and appropriate; some scientific reasoning, calculations and measurements are accurate and realistic. (2 points)
2. **Precision** in language, engineering, science, and math.	All or almost all spelling and grammar are error-free; almost all or all scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met. (5 points)	Most spelling and grammar are error-free; most scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met. (4 points)	Generally, spelling and grammar are error-free; generally, scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met. (3 points)	Some spelling and grammar are error-free; some scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met. (2 points)
3. **Clarity** in in language, engineering, science, and math.	All or almost all arguments are clearly made, terms are clearly explained, and graphics, calculations and measurements are clearly labeled. (5 points)	Most arguments are clearly made, terms are clearly explained, and graphics, calculations and measurements are clearly labeled. (4 points)	Generally, arguments are clearly made, terms are clearly explained, and graphics, calculations and measurements are clearly labeled. (3 points)	Some arguments are clearly made, terms are clearly explained, and graphics, calculations and measurements are clearly labeled. (2 points)

4. **Support** of arguments and conclusions.	All or almost all arguments and conclusions are supported by valid and appropriate sources that are cited accurately and appropriately. (5 points)	Most arguments and conclusions are supported by valid and appropriate sources that are cited accurately and appropriately. (4 points)	Generally, arguments and conclusions are supported by valid and appropriate sources that are cited accurately and appropriately. (3 points)	Some arguments and conclusions are supported by valid and appropriate sources that are cited accurately and appropriately. (2 points)
5. **Professionalism** in communications, products, and punctuality.	All or almost all of the submitted report is professionally formatted with appropriate spacing, fonts, and graphics.. Submission is on time, at or before 11:59PM on December 4, 2017. (5 points)	Most of the submitted report is professionally formatted with appropriate spacing, fonts, and graphics. Submission is late, between 12:00AM and 11:59AM on December 5, 2017. (4 points)	Generally, the submitted report is professionally formatted with appropriate spacing, fonts, and graphics. Submission is late, between 12:00PM and 11:59PM on December 5, 2017. (3 points)	Some of the submitted report is professionally formatted with appropriate spacing, fonts, and graphics. Submission is late, between 12:00AM and 11:59AM on December 6, 2017. (2 points)
Totals:				
Total R &D Points (out of 25)				

Mission One – Initial CAD Drawings Rubric

The initial CAD drawings count for a maximum of 25 points. The team must submit all work for Mission One in *Launchpad (make.skills21.org)* by 11:59PM on December 4, 2017. The initial CAD drawings will be scored using the following rubric, and the team will receive the score and feedback by December 18, 2017.

Scores: Categories:	**Outstanding**	**Professional**	**Satisfactory**	**Developing**
1. **Modeling** – parts and assembly are modeled correctly and accurately.	All or almost all drawings depict the parts and assembly accurately and realistically. (5 points)	Most drawings depict the parts and assembly accurately and realistically. (4 points)	Generally, drawings depict the parts and assembly accurately and realistically. (3 points)	Some drawings depict the parts and assembly accurately and realistically. (2 points)
2. **Drawing Views** – drawings have appropriate views showing all features.	All or almost all views are appropriate and show all features. (5 points)	Most views are appropriate and show most features. (4 points)	Generally, views are appropriate and show key features. (3 points)	Some views are appropriate and show key features. (2 points)
3. **Dimensioning** – drawings show appropriate dimensions.	All or almost all dimensions follow ANSI standards and are realistic and clearly labeled. (5 points)	Most dimensions follow ANSI standards and are realistic and clearly labeled. (4 points)	Generally, dimensions follow ANSI standards and are realistic and clearly labeled. (3 points)	Some dimensions follow ANSI standards and are realistic and clearly labeled. (2 points)
4. **Title/Labels** – drawings have appropriate title blocks and labels.	All or almost all drawings have title blocks that are filled out correctly; almost all or all drawings have other appropriate labels to clearly explain the part or assembly. (5 points)	Most drawings have title blocks that are filled out correctly; most drawings have other appropriate labels to clearly explain the part or assembly. (4 points)	Generally, drawings have title blocks that are filled out correctly; generally, drawings have other appropriate labels to clearly explain the part or assembly. (3 points)	Some drawings have title blocks that are filled out correctly; some drawings have other appropriate labels to clearly explain the part or assembly. (2 points)
5. **Professionalism** in communications,	All or almost all of the submitted drawings are professionally formatted with	Most of the submitted drawings are professionally formatted with	Generally, the submitted drawings are professionally formatted with	Some of the submitted drawings are professionally formatted with

products, and punctuality.	appropriate spacing, fonts, and graphics. All part and assembly drawings are submitted. Submission is on time, at or before 11:59PM on December 4, 2017. (5 points)	appropriate spacing, fonts, and graphics. All part and assembly drawings are submitted. Submission is late, between 12:00AM and 11:59AM on December 5, 2017. (4 points)	appropriate spacing, fonts, and graphics. All part and assembly drawings are submitted. Submission is late, between 12:00PM and 11:59PM on December 5, 2017. (3 points)	appropriate spacing, fonts, and graphics. All part and assembly drawings are submitted. Submission is late, between 12:00AM and 11:59AM on December 6, 2017. (2 points)
Totals:				
Total CAD Points (out of 25)				

M**ission 1: Design Research Report and Drawings to Support Challenge Features Rubric**

The initial design counts for a maximum of 25 points. No additional work needs to be submitted for this rubric. Judges will use CAD drawings and the research report to complete the rubric. Mission One in *Launchpad (make.skills21.org)* by 11:59PM on December 4, 2017. The initial design will be scored using the following rubric, and the team will receive the score and feedback by December 18, 2017.

Scores: Categories:	**Outstanding**	**Professional**	**Satisfactory**	**Developing**
1. Weight	All of the submitted drawings/report itemize component and aggregate weight (30 lbs) estimates. (3 points)	Most of the submitted drawings/report itemize component and aggregate weight (30 lbs) estimates. (2 points)	Generally the submitted drawings/report itemize component and aggregate weight (30 lbs) estimates. (1 point)	Some of the submitted drawings/report itemize component and aggregate weight (30 lbs) estimates. (0 points)
2. Durability	All of the submitted drawings/report illustrate durability features. (4 points)	Most of the submitted drawings/report illustrate durability features. (3 points)	Generally the submitted drawings/report illustrate durability features. (2 points)	Some of the submitted drawings/report illustrate durability features (1 point).
3. Flexibility/ Adaptability	All of the submitted drawings/report demonstrate how the solution can be adapted for various bike models. (4 points)	Most of the submitted drawings/report demonstrate how the solution can be adapted for various bike models. (3 points)	Generally the submitted drawings/report demonstrate how the solution can be adapted for various bike models. (2 points)	Some of the submitted drawings/report demonstrate how the solution can be adapted for various bike models. (1 point)
4. Portability	All of the submitted drawings/report outline overall product portability. (3 points)	Most of the submitted drawings/report outline overall product portability. (2 points)	Generally the submitted drawings/report outline overall product portability. (1 point)	Some of the submitted drawings/report outline overall product portability. (0 points)
5. Safety	All of the submitted drawings/report address safety features. (4 points)	Most of the submitted drawings/report address safety features. (3 points)	Generally the submitted drawings/report address safety features. (2 points)	Some of the submitted drawings/report address safety features. (1 point)

6. Ease of assembly and use	All of the submitted drawings/report clarify the assembly and use of the product (4 points)	Most of the submitted drawings/report clarify the assembly and use of the product (3 points)	Generally the submitted drawings/report clarify the assembly and use of the product (2 points)	Some of the submitted drawings/report clarify the assembly and use of the product (1 point)
7. Cost	All of the submitted drawings/report discuss the costs of creating the prototype. (3 points)	Most of the submitted drawings/report discuss the costs of creating the prototype. (2 points)	Generally the submitted drawings/report discuss the costs of creating the prototype. (1 point)	Some of the submitted drawings/report discuss the costs of creating the prototype. (0 points)
Totals:				
Total Design Points (out of 25)				

Mission 1 Total Points (out of 75):

Comments:

Mission Two: Manufacture & Test (100 Points Maximum)

Manufacture: Your team will need to manufacture each part as specified in your team's CAD drawings. Keep a journal of the manufacturing progress, documenting any issues or changes and including photographs of the finished parts.

Test: As you manufacture the parts and begin assembly, you will need to test how the parts fit together and operate. It is likely you will need to make changes, perhaps redesigning some parts. Your test is successful when your bicycle-powered electrical generator produces a minimum of 12 volts of output consistently. Document all of this effort with a journal and photographs. After you have tested the prototype and gotten it to work, revise the CAD part and assembly drawings as needed to reflect the final design and final version of all of the parts.

Required Products and Deadlines: Your team's submission for Mission Two must include the following products that are uploaded into the Skills21 *Launchpad (make.skills21.org)* no later than April 2, 2018.

- A three page minimum manufacturing and test report documenting how the parts were manufactured, any issues that occurred during manufacturing or testing, and including photographic proof of the parts and final assembly with explanations of any changes made to the original designs (75 points).
- Final CAD part and assembly drawings of the assembled prototype after testing with any changes to the parts or assembly clearly labeled (25 points).

****SAFETY NOTE****
Students should not operate any motor/generator without proper training and an adult qualified to teach electrical systems present. The motor/generator used in the challenge could cause severe shocks if used improperly.

****SAFETY NOTE****
Charging batteries incorrectly can cause them to explode.
Do not attempt to charge a battery in this challenge.

Mission Two – Manufacturing and Test Report Rubric

The Manufacturing and Test Report, which includes photographic proof that all parts have been manufactured and assembled, counts for a maximum of 75 points. The team must submit all work for Mission Two in *Launchpad (make.skills21.org)* by 11:59PM on April 2, 2018. It will be scored using the following rubric, and the team will receive the score and feedback by April 16, 2018.

Scores: Categories:	**Outstanding**	**Professional**	**Satisfactory**	**Developing**
1. **Accuracy** in language, engineering, science, and math.	All or almost all manufacturing and test results are accurate and appropriate; all or almost all scientific reasoning, calculations and measurements are accurate and realistic. (15 points)	Most manufacturing and test results are accurate and appropriate; most scientific reasoning, calculations and measurements are accurate and realistic. (12 points)	Generally, manufacturing and test results are accurate and appropriate; generally, scientific reasoning, calculations and measurements are accurate and realistic. (9 points)	Some manufacturing and test results are accurate and appropriate; some scientific reasoning, calculations and measurements are accurate and realistic. (6 points)
2. **Precision** in language, engineering, science, and math.	All or almost all spelling and grammar are error-free; almost all or all scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met. (15 points)	Most spelling and grammar are error-free; most scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met. (12 points)	Generally, spelling and grammar are error-free; generally, scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met. (9 points)	Some spelling and grammar are error-free; some scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met. (6 points)
3. **Clarity** in in language, engineering, science, and math.	All or almost all engineering changes are clearly explained, and graphics, calculations and measurements are clearly labeled.	Most engineering changes are clearly explained, and graphics, calculations and measurements are clearly labeled. (12 points)	Generally, engineering changes are clearly explained, and graphics, calculations and measurements are clearly labeled.	Some engineering changes are clearly explained, and graphics, calculations and measurements are clearly labeled. (6 points)

	(15 points)		(9 points)	
4. **Support** of arguments and conclusions.	All or almost all arguments and conclusions are supported by valid and appropriate data or sources that are cited accurately and appropriately. (15 points)	Most arguments and conclusions are supported by valid and appropriate data or sources that are cited accurately and appropriately. (12 points)	Generally, arguments and conclusions are supported by valid and appropriate data or sources that are cited accurately and appropriately. (9 points)	Some arguments and conclusions are supported by valid and appropriate data or sources that are cited accurately and appropriately. (6 points)
5. **Professionalism** in communications, products, and punctuality.	All parts have been manufactured and assembled; all or almost all parts and the assembly are photographed accurately and clearly. All or almost all of the submitted report is professionally formatted with appropriate spacing, fonts, and graphics. Submitted report page count matches requirements. Submission is on time, at or before 11:59PM on April 2, 2018. (15 points)	All parts have been manufactured and assembled; most parts and the assembly are photographed accurately and clearly. Most of the submitted report is professionally formatted with appropriate spacing, fonts, and graphics. Submitted report page count matches requirements. Submission is late, between 12:00AM and 11:59AM on April 3, 2018. (12 points)	All parts have been manufactured and assembled; generally, parts are photographed accurately and clearly. Generally, the submitted report is professionally formatted with appropriate spacing, fonts, and graphics. Submitted report page count matches requirements. Submission is late, between 12:00PM and 11:59PM on April 3, 2018. (9 points)	All parts have been manufactured and assembled; some parts and the assembly are photographed accurately and clearly. Some of the submitted report is professionally formatted with appropriate spacing, fonts, and graphics. Submitted report page count matches requirements. Submission is late, between 12:00AM and 11:59AM on April 4, 2018. (6 points)
Totals:				
Total Manufacturing and Test Points (out of 50)				

Mission Two – Final CAD Drawings Rubric

The final CAD drawings count for a maximum of 25 points. The team must submit all work for Mission Two in *Launchpad (make.skills21.org)* by 11:59PM on April 2, 2018. It will be scored using the following rubric, and the team will receive the score and feedback by April 16, 2018.

Scores: Categories:	**Outstanding**	**Professional**	**Satisfactory**	**Developing**
1. **Modeling** – parts and assembly are modeled correctly and accurately.	All or almost all drawings depict the parts and assembly accurately and realistically. (5 points)	Most drawings depict the parts and assembly accurately and realistically. (4 points)	Generally, drawings depict the parts and assembly accurately and realistically. (3 points)	Some drawings depict the parts and assembly accurately and realistically. (2 points)
2. **Drawing Views** – drawings have appropriate views showing all features.	All or almost all views are appropriate and show all features. (5 points)	Most views are appropriate and show most features. (4 points)	Generally, views are appropriate and show key features. (3 points)	Some views are appropriate and show key features. (2 points)
3. **Dimensioning** – drawings show appropriate dimensions.	All or almost all dimensions follow ANSI standards and are realistic and clearly labeled. (5 points)	Most dimensions follow ANSI standards and are realistic and clearly labeled. (4 points)	Generally, dimensions follow ANSI standards and are realistic and clearly labeled. (3 points)	Some dimensions follow ANSI standards and are realistic and clearly labeled. (2 points)
4. **Title/Labels** – drawings have appropriate title blocks and labels.	All or almost all drawings have title blocks that are filled out correctly; almost all or all drawings have other appropriate labels to clearly explain the part or assembly. (5 points)	Most drawings have title blocks that are filled out correctly; most drawings have other appropriate labels to clearly explain the part or assembly. (4 points)	Generally, drawings have title blocks that are filled out correctly; generally, drawings have other appropriate labels to clearly explain the part or assembly. (3 points)	Some drawings have title blocks that are filled out correctly; some drawings have other appropriate labels to clearly explain the part or assembly. (2 points)
5. **Professionalism** in	All or almost all of the submitted drawings are	Most of the submitted drawings are	Generally, the submitted drawings are	Some of the submitted drawings are

communications, products, and punctuality.	professionally formatted with appropriate spacing, fonts, and graphics. All part and assembly drawings are submitted. Submission is on time, at or before 11:59PM on December 4, 2017. (5 points)	professionally formatted with appropriate spacing, fonts, and graphics. All part and assembly drawings are submitted. Submission is late, between 12:00AM and 11:59AM on December 5, 2017. (4 points)	professionally formatted with appropriate spacing, fonts, and graphics. All part and assembly drawings are submitted. Submission is late, between 12:00PM and 11:59PM on December 5, 2017. (3 points)	professionally formatted with appropriate spacing, fonts, and graphics. All part and assembly drawings are submitted. Submission is late, between 12:00AM and 11:59AM on December 6, 2017. (2 points)
Totals:				
Total CAD Points (out of 25)				

Mission 2 Total Points:

Comments:

Mission Three: Present and Demonstrate (150 Points Maximum)

The final presentation and demonstration of your team's prototype will be the last part of the challenge, and both will be scored to compute your team's final overall score on **May 19, 2018** at CT Expo Fest.

Present: Your team is competing to have its design selected by the customer. Therefore, it is important that you market it as the best available design option. To do this, you will need to present your design to the judges using the following guidelines:

- Treat this presentation as a formal, business presentation – dress and act appropriately.
- This presentation should summarize your work in Missions One and Two, and you should explain any changes to your design since the Mission Two submission.
- The presentation should be in Microsoft Powerpoint or a similar format that can be uploaded to computer and projected on May 19, 2018 at CT Expo Fest. You may bring the presentation to CT Expo Fest in a USB memory drive, or you may access it through an online link – there will be WIFI connections at CT Expo Fest. Teams are encouraged to have more than one way to access and give the presentation in case of technical problems. ***Failure to give this presentation for any reason will result in zero points for the final presentation.***
- The presentation should take between three and five minutes, including a demonstration of your prototype to show its operation.

Demonstrate: Immediately after giving your presentation, your team will demonstrate its design prototype. This means you will show how your design generates DC electrical power at about 14 volts using bicycle power—someone on your team will ride the bicycle, while other team members show the electrical output. Rehearse this demonstration beforehand so that you know what each team member's role is during the demonstration. The goal is to show that your design works and that it is the best option. Explain any changes to your design since your submission of Mission Two. Every member of your team should be involved in the demonstration

Required Products and Deadlines: Your team's submission for Mission Three must include the following products that are presented at the CT Expo Fest on May 19, 2018.

- A three to five minute presentation including a demonstration of the product prototype.
- The presentation (50 points maximum) must include:
    - An introduction to your team's "company" that includes company name, details, mission statement, and logo.
    - A brief marketing plan that describes the features and benefits that will differentiate the team's solution from other prospective vendors.
- The demonstration (50 points maximum) should show your prototype meets all criteria, constraints and requirements of the challenge

Mission Three – Final Presentation Rubric

Scores: Categories:	**Outstanding**	**Professional**	**Satisfactory**	**Developing**
1. **Accuracy** in language, engineering, science, and math.	All or almost all explanations are accurate and appropriate; all or almost all scientific reasoning, calculations and measurements are accurate and realistic. (10 points)	Most explanations are accurate and appropriate; most scientific reasoning, calculations and measurements are accurate and realistic. (8 points)	Generally, explanations are accurate and appropriate; generally, scientific reasoning, calculations and measurements are accurate and realistic. (6 points)	Some explanations are accurate and appropriate; some scientific reasoning, calculations and measurements are accurate and realistic. (4 points)
2. **Precision** in language, engineering, science, and math.	All or almost all spelling and grammar are error-free; almost all or all scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met. (10 points)	Most spelling and grammar are error-free; most scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met. (8 points)	Generally, spelling and grammar are error-free; generally, scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met. (6 points)	Some spelling and grammar are error-free; some scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met. (4 points)
3. **Clarity** in in language, engineering, science, and math.	All or almost all aspects of the product are clearly explained, and graphics, calculations and measurements are clearly labeled. (10 points)	Most aspects of the product are clearly explained, and graphics, calculations and measurements are clearly labeled. (8 points)	Generally, aspects of the product are clearly explained, and graphics, calculations and measurements are clearly labeled. (6 points)	Some aspects of the product are clearly explained, and graphics, calculations and measurements are clearly labeled. (4 points)
4. **Support** of arguments and conclusions.	All or almost all arguments and conclusions are supported by valid and appropriate data or sources that are cited accurately and appropriately.	Most arguments and conclusions are supported by valid and appropriate data or sources that are cited accurately and appropriately. (8 points)	Generally, arguments and conclusions are supported by valid and appropriate data or sources that are cited accurately and appropriately.	Some arguments and conclusions are supported by valid and appropriate data or sources that are cited accurately and appropriately. (4 points)

	(10 points)		(6 points)	
5. **Professionalism** in communications, products, and punctuality.	All or almost all of the presentation is professionally formatted with appropriate spacing, fonts, and graphics. Presentation length matches requirements. All team members participate and present in a professional manner. The team is on time, ready to present at CT Expo Fest. (10 points)	Most of the presentation is professionally formatted with appropriate spacing, fonts, and graphics. Presentation length matches requirements. Most team members participate and present in a professional manner. The team is on time, ready to present at CT Expo Fest. (8 points)	Generally, the presentation is professionally formatted with appropriate spacing, fonts, and graphics. Presentation length matches requirements. About half the team members participate and present in a professional manner. The team is on time, ready to present at CT Expo Fest. (6 points)	Some of the presentation is professionally formatted with appropriate spacing, fonts, and graphics. Presentation length matches requirements. Few (less than half) of the team members participate and present in a professional manner. The team is on time, ready to present at CT Expo Fest. (4 points)
Totals:				
Total Presentation Points (out of 50)				

Final Demonstration Rubric

Scores: Categories:	**Outstanding**	**Professional**	**Satisfactory**	**Developing**
1. **Accuracy** in language, engineering, science, and math.	All or almost all explanations are accurate and appropriate; all or almost all scientific reasoning, calculations and measurements are accurate and realistic. (10 points)	Most explanations are accurate and appropriate; most scientific reasoning, calculations and measurements are accurate and realistic. (8 points)	Generally, explanations are accurate and appropriate; generally, scientific reasoning, calculations and measurements are accurate and realistic. (6 points)	Some explanations are accurate and appropriate; some scientific reasoning, calculations and measurements are accurate and realistic. (4 points)
2. **Precision** in language, engineering, science, and math.	All or almost all technical terms are error-free; almost all or all scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met and the bicycle-powered generator produces 14 volts steadily for two minutes. (10 points)	Most technical terms are error-free; most scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met and the bicycle-powered generator produces between 12 and 16 volts for two minutes. (8 points)	Generally, technical terms are error-free; generally, scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met and the bicycle-powered generator produces between 10 and 18 volts for two minutes. (6 points)	Some technical terms are error-free; some scientific reasoning, calculations and measurements are precisely explained in detail. All criteria and constraints are met and the bicycle-powered generator produces between 8 and 20 volts for two minutes. (4 points)
3. **Clarity** in in language, engineering, science, and math.	All or almost all aspects of the prototype and its performance are clearly explained. (10 points)	Most aspects of the prototype and its performance are clearly explained. (8 points)	Generally, aspects of the prototype and its performance are clearly explained. (6 points)	Some aspects of the prototype and its performance are clearly explained. (4 points)
4. **Support** of arguments and conclusions.	All or almost all arguments and conclusions are	Most arguments and conclusions are supported by	Generally, arguments and conclusions are	Some arguments and conclusions are supported by

	supported by valid and appropriate data or sources that are cited accurately and appropriately. (10 points)	valid and appropriate data or sources that are cited accurately and appropriately. (8 points)	supported by valid and appropriate data or sources that are cited accurately and appropriately. (6 points)	valid and appropriate data or sources that are cited accurately and appropriately. (4 points)
5. **Professionalism** in communications, products, and punctuality.	All or almost all of the demonstration is conducted professionally. All team members participate and present in a professional manner. The team is on time, ready to present at CT Expo Fest. (10 points)	Most of the demonstration is conducted professionally. Most team members participate and present in a professional manner. The team is on time, ready to present at CT Expo Fest. (8 points)	Generally, the demonstration is conducted professionally. About half the team members participate and present in a professional manner. The team is on time, ready to present at CT Expo Fest. (6 points)	Some of the demonstration is conducted professionally. Few (less than half) of the team members participate and present in a professional manner. The team is on time, ready to present at CT Expo Fest. (4 points)
Totals:				
Total Demonstration Points (out of 50)				

Mission Three – Final Design Rubric

Scores: Categories:	**Outstanding**	**Professional**	**Satisfactory**	**Developing**
1. Weight	The prototype weighs significantly less than 30 pounds.	The prototype weighs 30 pounds or less.	The prototype weighs slightly more than 30 pounds.	The prototype weighs significantly more than 30 lbs.
2. Durability	The prototype addresses durability to all weather conditions in all parts of the world.	The prototype addresses durability to most weather conditions.	The prototype addresses durability to some weather conditions.	The prototype does not address durability to different weather conditions.
3. Flexibility/ Adaptability	The prototype works on any bike.	The prototype works on most bikes.	The prototype works on one type of bike/there are many constraints to using it on different types of bikes.	The prototype only works on the bike provided.
4. Portability	The prototype easily fits into one backpack and has additional features to ease portability.	The prototype fits easily into one backpack and is easily carried.	The prototype fits into one backpack awkwardly.	The prototype does not fit into one backpack.
5. Safety	The prototype can be used safely and goes above and beyond minimal safety requirements.	The prototype is safe for use for any adult and meets all standard safety requirements. .	The prototype meets most standard safety requirements.	The prototype meets few standard safety requirements.
6. Ease of assembly and use	The prototype is easy to assemble and use by nearly any adult.	The prototype is fairly easy to assemble and use by most people with some experience.	The prototype requires some expertise for assembly or use.	The prototype is difficult to assemble and/or requires significant time and expertise.

7. Cost	The cost of the prototype is quantified and give good value for the cost.	The cost of the prototype is quantified and is reasonable for use in most communities.	The cost of the prototype is quantified but is expensive to build.	The prototype cost is not quantified or is exorbitant.
Totals:				
Total Design Points (out of 50)				

Mission 3 Total Points:

Comments:

Research Resources (not a complete list, but only suggested to get started)

1. NASA: Engineering design process: https://aerospaceandengineeringacademy.files.wordpress.com/2015/09/nasa-engineering-design-process-explained.pdf
2. National Geographic Society: Information on rain forests: https://www.nationalgeographic.org/encyclopedia/rain-forest/
3. National Geographic Society: Information on arctic: https://www.nationalgeographic.org/encyclopedia/arctic/
4. Alternative Energy Tutorials: Article on how wind turbine generators work (similar design challenge to bicycle-powered generators—both take low RPM mechanical input and transmit it to make high RPM electrical motor/generator output): http://www.alternative-energy-tutorials.com/wind-energy/wind-turbine-generator.html
5. Alternative Energy Tutorials: Permanent magnet DC generator (same basic DC motor/generator as used in challenge): http://www.alternative-energy-tutorials.com/wind-energy/pmdc-generator.html
6. International Technology and Engineering Educators Association (ITEEA): Basics of mechanical transmission systems: https://www.iteea.org/File.aspx?id=86474&v=1f65c88e

NOTE: There are already bicycle-powered electrical generation systems that exist, but none exactly like what the challenge requires. Students should learn from these other designs, but not feel constrained to copy them in any way.

Instructions for Teachers/Coaches

Thank you for coaching students in the Connecticut Manufacturing Design Challenge!

You may be tempted to help students "find the best solution" to each Mission's challenge – please don't. There is not one right answer to any of the Mission challenges, and it is very important that the students struggle and make mistakes as they progress toward a solution. That's what engineering is all about!

Your job is to help students where they don't have any background knowledge, such as in understanding how electric motors and generators work, how a transmission works, and other industry-specific topics outside the scope of typical high school students. You can also explain how you would go about solving each part of the challenge – don't tell them what to do, but explain the problem solving tools and techniques you would use. Explain how teams of engineers and other professionals work together, and encourage students to similarly work together. Explain how proposed solutions must be communicated clearly to get upper management's approval or a customer's acceptance for a product, and help the students document their work clearly and concisely in accordance with the challenge's requirements. Finally, help the students to get through any struggles or setbacks they have by continually encouraging them when they need it.

Instructions on what to do for each mission, how to use *Launchpad (make.skills21.org) (make.skills21.org)*, etc. will be explained by Skills21.

Here are some general guidelines:

- Emphasize to your students to use the background knowledge they already have from their other classes as a starting point when they approach each task of the challenge. Each Mission has many possible solutions, and getting started is the first step to success.
- Encourage the students to follow an engineering design process. There is one from NASA in the *Resources* section of this document.
- Don't be late! Especially don't be more than 48 hours late on the Mission One or Two submissions, because after that, the possible score drops in half.

Specific Information on Electric Motor/Generator

****SAFETY NOTE****

Students should not operate any motor/generator without proper training and an adult qualified to teach electrical systems present. The motor/generator used in the challenge could cause severe shocks if used improperly.

The electrical aspect of this challenge may distract your students, so help them realize that this is primarily a mechanical design challenge to make a transmission that takes the RPM (revolutions per minute) input of a bicycle and produces an RPM output suitable to drive an electric motor/generator. The electric motor/generator that is used for this challenge is

a 90-volt, 1/3 horsepower, 1800 RPM direct current (DC) motor with permanent magnets. This means that if 90 volts are put into this motor/generator, it is rated to spin at 1800 RPM and produce 1/3 horsepower of mechanical power. Similarly, if the motor/generator is mechanically spun at 1800 RPM, it should put out close to 90 volts as a DC generator—it actually puts out about 72 volts—the reason the output voltage is less than the input voltage (90 volts) for the same RPM (1800 RPM) is that the motor is not perfectly efficient to transform the mechanical power input to electrical power output—it was designed as a motor, not as a generator. However, it still performs reasonably well as a DC generator. The ratio of voltage output to RPM input is about .04 volts/RPM. This means that to produce about 14 volts of output, the motor/generator must be spun at about 350 RPM (14 volts/.04 volts/RPM). However, this number is approximate and should only be used as a starting point. The author of this challenge did a bench test with one of these motor/generators and got 5 volts spinning at 125 RPM and 22 volts output spinning it at 540 RPM, both of which are consistent with the expected performance. You may get something different, but it should be close to the .04 volts/RPM ratio. Use all this information as you see fit to teach your students about electrical generation.

The key thing the students need to understand is that their bicycle-powered system must steadily produce about 14 volts. Because different batteries require different methods of charging, there is no requirement to actually charge anything, as that is beyond the scope of this challenge.

****SAFETY NOTE****
Charging batteries incorrectly can cause them to explode.
Do not attempt to charge a battery in this challenge.

The only requirement is to produce a reasonable voltage (14 volts) that could be used to power and charge a 12-volt system, typical of many DC electronic systems. During the demonstration of each team's system, the judges will use a voltmeter to judge the 14-volt output.

Good luck with your team!

Instructions for Mentors (if mentors are used)

Thank you for mentoring students in the Connecticut Manufacturing Design Challenge!

You play a critical role as a mentor. Not only are you helping students perform well in the challenge, but you are also a role model, enabling them to see themselves in a challenging career in science, technology, engineering, and math (STEM).

You may be tempted to help students "find the best solution" to each Mission's challenge – please don't. There is not one right answer to any of the Mission challenges, and it is very important that the students struggle and make mistakes as they progress toward a solution. That's what engineering is all about!

Your job is to help students where they don't have any background knowledge, such as in understanding how electric motors and generators work, how a transmission works, and other industry-specific topics outside the scope of typical high school students. You can also explain how you would go about solving each part of the challenge – don't tell them what to do, but explain the problem solving tools and techniques you would use. Explain how teams of engineers and other professionals work together, and encourage students to similarly work together. Explain how proposed solutions must be communicated clearly to get upper management's approval or a customer's acceptance for a project, and help the students document their work clearly and concisely in accordance with the challenge's requirements. Finally, help the students to get through any struggles or setbacks they have by continually encouraging them when they need it.

Good luck with your team!