# Project/Problem Based Learning Template

<table>
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<tr>
<th>Created By: Hannah Raymond</th>
<th>Topic: Solar Power</th>
<th>Grade Level or Subject: 9th grade STEM</th>
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**Engineering Standards:**

**Introduction to Engineering (PLTW):**

PLTW O2.5 - Develop models to represent design alternatives and generate data to inform decision making, test alternatives, and demonstrate solutions.

PLTW O4.2 Create technical drawings to fully detail an object or part.

PLTW O11.1 Communicate effectively with an audience based on audience characteristics.

**Science Standards (NGSS High School)**

HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*

HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
Math Standards (Geometry):

G.CO.A.1 Know precise definitions of angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line and distance along a line.

ELA & Other Content Area Standards:

9-10.L.VAU.5 Acquire and accurately use general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the postsecondary and workforce readiness level; demonstrate independence in building vocabulary knowledge when considering a word or phrase important to comprehension or expression.

PBL Summary: Write a few sentences describing this PBL unit.

This PBL unit will focus on renewable resources. Students will explore the benefits and challenges to using renewable resources. At the end of the unit, students will design, construct and race a solar car built by them. The car will meet the same specification (or modified/scaled, dependant on class sets of material) required for Memphis Light, Gas and Water’s A-Blazing Race. The school wide winners will be able to represent the school in this race.

Multi-Dimensional Question/Driving Question: Think of a relevant problem with multiple solutions that will drive student learning.

How can we use solar energy to act as supplemental energy for our daily lives?

By the end of the unit, my students will:

<table>
<thead>
<tr>
<th>Master the Following Content:</th>
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<tbody>
<tr>
<td>1. Understanding how renewable resources can be used</td>
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<tr>
<td>2. Utilization of technical design</td>
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<tr>
<td>3. Construction of Solar Powered Car</td>
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<tr>
<th>Develop a solution to the following problem:</th>
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<tr>
<td>Students will construct a solar powered car that will travel 60 feet in the shortest time using solar power in a car that they designed, tested and constructed.</td>
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</table>
4. Following the Engineering Design Process from beginning to end in a project

<table>
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<tr>
<th>21st Century Skills Addressed</th>
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<tbody>
<tr>
<td>Creativity</td>
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<tr>
<td>Collaboration</td>
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<tr>
<td>Critical Thinking</td>
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<tr>
<td>Communication</td>
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**Culminating Event:** What final student learning products will show student mastery of the content area standards?

By the end of the unit, students will have designed and built a car, matching the specifications given, that is powered by solar energy. Each class will be able to race their cars against their classmates; the winners from each class will be able to race each other. The top 2 cars will be able to race in the A-Blazing Race that is sponsored Memphis Light, Gas and Water. The event is hosted at the University of Memphis’ Engineering Day each October.

Each group must also submit a notebook that correlates to their car and car design. The notebooks must include:

1. Title Page
2. Table of Contents
3. Project log documenting the process of designing, building, testing, etc.
4. Design Drawings - In my class, we spend most of the beginning of the semester on technical drawing skills and different views. Students must submit isometric, side, front and top view of their cars. Drawings must be neat, to scale and labeled. (More detail in rubric)
5. Specification page - size, wheel size, gear ratio, specification of motor and the solar component used
6. List of components list
7. Page of trials run - Each team must complete 3 trials. The time each car takes must be recorded and then changes made of the design, along with justification for the design.
   ** Most of this is required to compete in the final event at the A-Blazing Race

Students will also be required to turn in individual reflections from the unit, along with some short answer questions with their opinions about renewable resources, feasibility for residential and/or commercial use, benefits/challenges, etc.
**Hook Event:** Develop an introductory activity that will spark student interest and further questions.

Students will build solar ovens to serve as an entry activity into solar energy.

<table>
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<tr>
<th>Community Partners: List potential business or industry partners that could add to the learning experience for students. Include websites or contact info.</th>
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<tbody>
<tr>
<td>1. Memphis Light, Gas &amp; Water</td>
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<tr>
<td>2. University of Memphis</td>
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<tr>
<td>3. West Tennessee Solar Farm or Millington Solar Farm (Possible Field Trips)</td>
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<th>What do you need from these partners (i.e. guest speaker, field trip, help facilitate an activity)?</th>
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<tbody>
<tr>
<td>1. Facilitation of the A-Blazing Race by MLGW and the University of Memphis</td>
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<tr>
<td>2. Field Trip - options include the Solar Farm in Millington, TN or near Brownsville, TN off of I-40</td>
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**Topics that will be covered:**
1. Renewable Energy
2. How the sun powers the car
3. Engineering Design Process - how we are going to follow this process and each step. Students will continuously be going back to different parts as they design, build and test.
   a. Define the problem
   b. Generate concepts
   c. Develop a solution
   d. Construct and Test Prototype
   e. Evaluate Solution
   f. Present Solutions
4. Design - benefits, importance of design, terminology
   a. Wheels
   b. Bearings
   c. Power Source
   d. Chariss
   e. Body Shell/Aerodynamics
   f. Axle
5. Gear Ratios
6. Technical Drawing
   a. Isometric Drawing
   b. Front View
   c. Side View
   d. Top View
   e. Drawings are labeled according to the vocabulary students are learning in geometry
      i. Must be labeled: angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line, distance along a line,
7. Presentation Skills
8. Teamwork
9. Critical Thinking
10. Technical Writing Skills

**Daily Activities:** What activities will students complete to answer the multi-dimensional/driving question (that reinforces content from the standards)?

**Activity:**

**Resources/Materials Needed:**
1. Technical Drawing Practice - As part of their curriculum, students spend the first 2-3 weeks on technical drawing skills (front, side, top, isometric views, etc).

2. Solar Power Research
   - Students will spend the first part of the project exploring and researching solar power.
   - We will spend time researching how Tennessee and Memphis are implementing solar energy - what are the pros? the cons?
     - MLGW provided some great information about how solar energy in Memphis that will be shared and discussed
   - Students will watch PBS Video - “Rethinking the utility company as solar power heats up”
     - Students will answer the following questions and then discuss as a class:
       - Has anyone ever been in a power-outage? What was it like?
       - Why are some people installing their own solar panels?
       - Why did the McMahon’s business still have energy even though others in the area lost power?
       - If you were given the opportunity, would you install solar panels in your house? Why or why not?
     - Depending on time, PBS provides a great lesson plan for building circuits and having students explore how solar panels can affect the electrical grid as an extension of this. ([https://www.pbs.org/newshour/extra/lessons-plans/lesson-plan-is-solar-power-the-future-of-energy/](https://www.pbs.org/newshour/extra/lessons-plans/lesson-plan-is-solar-power-the-future-of-energy/))

3. Solar Oven Build (1 Class Period)
   Groups: 2-3 students
   Materials: Cardboard, Scissors/Box Cutter, Tape, Aluminum Foil, Cling Wrap, Construction Paper, Ruler, Thermometers

For the A-Blazing Race, MLGW will give the school one solar panel, one motor and two eyelets, for up to 2 cars.

For class sets (or enough for 5-6 groups per class):
   - Solar panels
   - Motors
   - Eyelets
   - Materials to build the car out of (cardboard, poster board, tape) - Students can bring in any material as long as the cost is less than $20.
Students will be given 45 minutes to design and create a solar oven using material provided. They will be able to test and redesign as many times as necessary. Students’ end goal is to be able to make s’mores by cooking marshmallows in the oven.

Students must have at least 3 thermometer readings from 3 different testings. These will be recorded.

Follow Up Questions:
1. What was the initial temperature of your oven on your first test? What was the highest temperature your oven got to?
2. What did you change/adjust about your design?
3. What changes helped increase the temperature? Why do you think that these changes made a difference?
4. How did you use what you know about design and about solar energy to influence your design?

4. Initial Design of the Car
Students will be given their challenge of designing and building a car powered by solar energy.

The A'Blazing Race’s Specification: (The specification may be altered slightly depending on supplies for class sets)
1. The vehicle must be safe to contestants and spectators, e.g., no sharp edges, projectiles, etc.
2. The vehicle must fit the following dimensions: 12 inches wide by 24 inches long by 12 inch high
3. The sun’s light is the only energy source that may be used to power the vehicle, unless MLGW determines that batteries will be used. MLGW will supply the batteries if batteries are used. No other batteries or energy storage devices are permitted.
4. Any energy enhancing devices, like mirrors, must be attached to vehicle.
5. The vehicles must be steered by the guide wire using two eyelets affixed to the vehicle, one at the front center and one at the back center of the vehicle with the center of the eyelets ¾” from the ground. The vehicle must be easily removable from the guide wire, without disconnecting the guide wire.

6. Two 1 inch by 1 inch surfaces must be available for the car number, which should be easily visible when the vehicle is in the ready race position.

7. The body of the car must be 3 - Dimensional. Teams are not allowed to bolt the axles and wheels to the solar cell.

The track will be 2 feet wide and 60 feet long.

Students will be asked to complete technical drawings of their initial design. The drawings must be to scale. They will include an isometric drawing, top, side and front view. Drawings must be labeled with measurements and materials that will be used. Each group will turn in one drawing.

5. Construction/Testing Process of the Car:

Students will be given 1 week in class to build, test and redesign their cars.

Students will be given “Solar Powered Vehicle Design Tips” sheet provided by MLGW.

6. Portfolios Due and Final Presentation:

8. Title Page
9. Table of Contents
10. Project log documenting the process of designing, building, testing, etc.
11. Design Drawings - These are the drawings that were due before the initial build of the car
12. Specification page - size, wheel size, gear ratio, specification of motor and the solar component used
13. List of components used in the build
14. Page of trials run - Each team must complete 3 trials. The time each car takes must be recorded and then changes made of the design, along with justification for the design.
** Most of this is required to compete in the final event at the A-Blazing Race

**Technology Integration:** How is technology embedded into this PBL unit?

Students will use technology for research.

**Capstone Presentation:** How will students present what they've learned publicly? This can be the culminating event if that event is presenting what has been learned publicly.

1. Students will be required to present their product to the class. (All projects that students do require a final presentation and use the same rubric.)
2. Students will race their solar cars against their classmates.
### Performance Based Rubric

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<tr>
<th>Standards</th>
<th>Developing</th>
<th>On-Target</th>
<th>Mastery</th>
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<tbody>
<tr>
<td>Science</td>
<td>Students are able to design, build and refine a car within the constraints given that is able to travel the distance of within 0-29 ft using only solar energy.</td>
<td>Students are able to design, build and refine a car within the constraints given that is able to travel the distance of within 30-59 ft using only solar energy.</td>
<td>Students are able to design, build and refine a car within the constraints given that is able to travel the distance of 60 ft using only solar energy.</td>
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<td>Math</td>
<td>Students must complete technical sketching of the solar car they will build. Sketching includes proper utilization and labeling of at least 1 of the following: angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line and distance along a line.</td>
<td>Students must complete technical sketching of the solar car they will build. Sketching includes proper utilization and labeling of at least 3 of the following: angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line and distance along a line.</td>
<td>Students must complete technical sketching of the solar car they will build. Sketching includes proper utilization and labeling of all of the following: angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line and distance along a line.</td>
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<tr>
<td>ELA</td>
<td>STEM</td>
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<td><strong>9-10.L.VAU.5</strong> Acquire and accurately use general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the postsecondary and workforce readiness level; demonstrate independence in building vocabulary knowledge when considering a word or phrase important to comprehension or expression.</td>
<td><strong>PLTW 02.5</strong> - Develop models to represent design alternatives and generate data to inform decision making, test alternatives, and demonstrate solutions.</td>
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| | Students are able to present their findings of their car and design meeting all the following criteria: not much of some of the academic vocabulary acquired during the unit and mediocre presentation skills (as judged by the rubric used for presentations during class) | Students are able to present their findings of their car and design meeting all the following criteria: use of some of the academic vocabulary acquired during the unit and average presentation skills (as judged by the rubric used for presentations during class) | Students are able to present their findings of their car and design meeting all the following criteria: use of academic vocabulary acquired during the unit and strong presentation skills (as judged by the rubric used for presentations during class) |

| | Students use only one of the following to guide them towards their final model of their solar car: develop models to represent the design, generate and use data to inform their decision making as they make adjustments and changes, run multiple tests to determine alternative to lead to the final design product. | Students use at least 3 of the following to guide them towards their final model of their solar car: develop models to represent the design, generate and use data to inform their decision making as they make adjustments and changes, run multiple tests to determine alternative to lead to the final design product. | Students use all of the following to guide them towards their final model of their solar car: develop models to represent the design, generate and use data to inform their decision making as they make adjustments and changes, run multiple tests to determine alternative to lead to the final design product. |