the CEED

THE CENTER FOR ENERGY EFFICIENT DESIGN

<table>
<tr><td colspan="4">Solar Race Cars</td></tr>
<tr><td>Grade Level</td><td>Middle School- 8th</td><td>Subject</td><td>Physical Science</td></tr>
<tr><td colspan="2">Objective(s):
- Design and race a solar car
- Calculate for speed using the formula distance/time
- Explore and explain the energy conversion used in the activity
- Determine which angle of the solar panel converts the greatest amount of solar energy into kinetic energy</td><td colspan="2">SOL Addressed:
PS.1b,f,g,j,k,l,n
PS.6a,b
PS.7c
PS.10a
Common Core Standards:
MS PS.3-5
MS PS.3B</td></tr>
<tr><td>Materials Needed Per Class of 30

and

Prior Knowledge</td><td colspan="3">10 “Sunny Side Up” solar car kits.
These kits are reusable and allow for students to test only one variable at a time.
One kit per group of 2-3 students
Stopwatches
Meter sticks
Calculators
Protractors
Sunny Day
If modifying the activity various art/craft supplies may be used to personalize the car.</td></tr>
<tr><td>Ways to differentiate this lesson plan</td><td colspan="3">• EXTENSION for Higher Level Learner
Students can use the solar panel and motor from the kit, but design and build their own car from scratch. (The National Renewable Energy Laboratory (NREL) has details on their website under the activities tab for this.)

• MODIFICATIONS
Also calculations can be extended to include kinetic energy, average rate of acceleration, and force. Newton’s Laws of Motion could also tie into this lesson.</td></tr>
<tr><td>Introduction/ Anticipatory Set</td><td colspan="2">Anticipatory Set: How will the teacher introduce the lesson to the students?
Have students observe and discuss examples of energy conversion. Whether simple demonstrations are brought in (Newton’s cradle, radiometer, solar calculator for example) or students go on a scavenger hunt to find and explain their own examples.</td><td>Introduction:
Students should be familiar with the forms of energy as well as using the formula for speed.

Challenge students to create the fastest solar car.</td></tr>
</table>

	Questions to ask students: • What type of energy conversion do you see? • What makes this solar calculator work? • Would it work the same way in the dark? • Does the incoming angle of light make a difference?	
Guided Practice	As time allows, let students time to research online about car design and solar panels especially if they are designing their car from scratch. Allow for enough time for student to construct their cars and run at least three trials before the race. The students should be recording their speed each after each trial and documenting the changes they made. **Sample Facilitator Questions for the Activity:** Does the angle of the solar panel make a difference? What is your car using for fuel? How can it get the most fuel? Questions for modification: Does the weight of your car make a difference? Does the shape of your car make a difference? Does the size of the wheels make a difference?	
Independent Practice	Divide students into cooperative learning teams of 2 – 3. Once their car is constructed, students should test their car. And develop a data table to show the angle of the solar panel and speed of their car. They should have at least three trials. Which trail had the fastest car? What was the angle of the solar panel for that trail?	
Closure (Summary of Lesson)	Students should have an opportunity to race their car against other groups. At the end of the race students should discuss their experiences. What did the fastest cars have in common? What would you do differently if you had to do this again? If you had unlimited supplies, would you change your car design? How?	

CEED Building Application/ Sensor Data	Students should compare the solar panel data from the CEED Dashboard to their activity results. Does the angle of the solar panel at CEED make a difference in the amount of energy produces? Use the data from the Dashboard to support your thoughts.
Assessment	Rubric Classroom presentation Data collection

INQUIRY LEARNING RESEARCH PROCESS GUIDELINES

The following table is just one guideline to use for developing your own inquiry materials. The seven steps in the Learning Research Process include not only how people learn but also how research is conducted. The heart of the design, the three-stage learning cycle of exploration, concept invention or formation, and application is embedded in the middle. In addition to these three stages, this design takes into account that learners need to be motivated to spend the time required for understanding complex subjects and that learners need to build this new knowledge onto prior knowledge. These are similar to the 5E and 7E learning models.

The Learning-Research Process

Steps in the Learning-Research Process	7E Equivalent	Component of the Activity
1. Identify a need to learn.	Engage	An issue that excites and interests is presented. An answer to the question *Why?* is given. Learning objectives and success criteria are defined.
2. Connect to prior understandings.	Elicit	A question or issue is raised, and student explanations or predictions are sought. Prerequisite material and understanding is identified.
3. Explore	Explore	A model or task is provided, and resource material is identified. Students explore the model or task in response to critical-thinking questions.
4. Concept invention, introduction, and	Explain	Critical-thinking questions lead to the identification of concepts, and understanding is developed.

formation		
5. Practice applying knowledge.		Skill exercises involved straightforward application of the knowledge.
6. Apply knowledge in new contexts.	Elaborate and Extend	Problems and extended problems require synthesis and transference of concepts.
7. Reflect on the process	Evaluate	Problem solutions and answers to questions are validated and integrated with concepts. Learning and performance are assess

Hanson, D. (2006). POGIL Instructor's Guide to Process-Oriented Guided-Inquiry Learning. Lisle, IL: Pacific Crest