Stirling Engines and the Stirling Cycle

Schreiber and Kamal

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Background: Up to this point, we know that in engineering that similar ideas doesn't mean similar products. We move on from our last unit to a new unit based on energy and the performance of engines. The goal is for us to learn how the transferring of energy works and how it plays into engines.

The main engines that will be focused on in this unit is Stirling Engines. However you could modify this lesson to fit any type of engine. Stirling engines are the easiest to make with homemade materials.

Stage 1: Desired Results

Established Goals:

Explain relationship between different models and representations of Energy transfer. Understand the concepts behind Engine cycles with specific knowledge on the Stirling engine cycle.

Apply knowledge of engines to create simplified engines of the student own.

PA State Science Standards:

3.1.12.B: Apply concepts of models as a method to predict and understand science and technology.

3.1.12.E: Evaluate change in nature, physical systems and man made systems.

3.1.12.E.1: Evaluate fundamental science and technology concepts and their development over time (e.g., DNA, cellular respiration, unified field theory, energy measurement, automation, miniaturization, Copernican and Ptolemaic universe theories).
3.1.12.E.2: Analyze how models, systems and technologies have changed over time (e.g., germ theory, theory of evolution, solar system, cause of fire).
3.2.12.B: Evaluate experimental information for appropriateness and adherence to relevant science processes.

Anticipated Misconceptions:

Students need to be able to distinguish between the different engine cycles when describing engines.

Students need to be able to distinguish between different forms of motion.

For some Engine cycles. Certain chemical reactions such as combustion may need to be explained.

Students will be able to:

Use the concepts of engines they have learned to build a stirling engine. Students should be able to go into detail about the different cycles of engines as well as how certain engines work. Students should be able to explain the importance of knowing different engine types.

Meaning:

Understandings: An engine requires extensive background knowledge in order for it to function the way you would like it to. The design process changes as data is researched and testing is done.

Essential Questions: Why are the design of engines important? Why can't there be engines of any design?

Acquisition:

Students will be able to present their designs to the class

Students will be able to give a written description for select engine cycles. The stirling engine cycle in particular.

Stage 2: Evidence

Transfer Task:

Mini-Project: Using the engineering process and the concept of engine cycles, build a makeshift stirling engine using materials given in class. Using this process determine the importance of engines in everyday life. This will include a physical design that is made a writing from within the engineering notebooks. This will conclude with a written report on the design process and importance of engine by digital submission.

Evaluative Criteria:

Design that is made as well as report submissions.

Other Evidence:

Lab Notebooks

In class discussions

Whiteboard Activities

Lab report

Evaluative criteria:

Use of evidence to support reasoning

Stage 3: Learning Plan

Summary of key events:

This plan outlines all of the key points that will help students understand the Engine cycles. Most of the beginning lessons will be coordinated by the teacher, but the major parts of the lesson require students to ask themselves questions for the project and decide the correct way to follow the engineering process. The teacher should periodically check in to each group and have the students come together for a discussion at the beginning of each class.

Prior to introducing the project:

Students should begin observing the way engines work in different vehicles. Depending on how early on this lesson is introduced, students should begin observing the engineering process if they have not done so in prior units.

Cycles Research:

Students will learn about the main engines cycles as well as the stirling engine cycle through ether research that they do themselves or a presentation given by the teacher. Students will put all of the important information found into their lab notebooks. It is critical that a class discussion happens after research is completed. If having the students do individual research, it is recommended to have students to discuss with their group ideas and questions about engines. It is also critical that students notice the different aspects of engines such as pistons, turbines, nozzles, etc.

DIscussions:

Due to the technical nature that comes to building advanced engines, it is important that students know everything that is researched. Students will lead a discussion with the teacher on what they know and what they infer through other means. It is important for the teacher to lead each point that the students come up with to the main concepts of engines and their function with pistons, turbines, nozzles, etc. This discussion should be when the project is introduced and groups for it are made.

Project:

Students will come together to design a stirling engine. The students will be experimenting with the engineering process as well as the complications that come with designing an engine. The goal of the student is to build a working stirling engine, however the teacher should grade the student based on effort and the lab report. Students may design the stirling engine is any way they like as long as the material is from home or in the classroom and the engine follows the stirling engine cycle (explained below). The endgame of the project is for students to look at their design as well as others and create a lab report where they discuss their design, how to improve on it, and reflect on the process of designing the engine.

Stirling Cycle:

A stirling engine typically fits in a stirling cycle where a piston moves back in forth typically being moved by heat and then comes back down as the piston cools down. The piston is placed inside an airtight container that can easily transfer heat. An external heat source is used to heat the outside of the container causing the air trapped inside the container

to rise. The piston is then able to rise from the heat and press down as the air cools down. In small scale examples (like the one the students are designing) it is common for the pistons to be connected to a crank that moves the piston up and down until it can sustain itself. In order for the student's engine to fit these guideline, the engine must work through this stirling cycle system and be able to sustain itself once put in motion.

Additional Research/Brainstorm:

It is encouraged for students to begin this project by doing additional research on stirling engines. This can be done through researching other concepts of the engines as well as designs other people have made. Students will then brainstorm with their groups on whiteboards an idea web for different aspects of their design such as requirements, constraints, materials, etc.

Design:

Students should spend each given work period with their groups working on their designs. This work includes testing the designs and improving on the designs to get it into a working fashion. The teacher is recommended to visit each group and discuss any conflicts and issues they will be facing.

Start of Class Discussions (Spark Plugs)

It’s important that the spark plugs engages the students into critical thinking. At first the spark plugs should be about the students’ early concept of engines. After the project has been given out, spark plugs should be based on what the teacher believes needs to be discussed using information from when they talked to each of the groups. This is so any general

questions that are asked can be answered by the group so they may focus further on their design.

Lab Notebook

Student should keep all of the information they learn in their lab notebook. It should contain the web that was mentioned above as well as drawings of their designs. Entries should be dated and should contain the groundwork for the lab report the student will hand in near the end of the unit. The books themselves will be looked at the end of the quarter or when the teacher decides to look at them.

Presenting

Students will come together and present their engines to the other groups. While it will be good if their engines work, the main goal should be the students learning from everyone's engines on how to improve their own. The teacher should end the class with a class discussion on how you can harness the energy from each engine for the everyday world.

Lab Report

The lab report should be individual report that contains information about the student's design as well as most of their information from their lab book. The student should put photo of their idea web from before and drawings of their design. The most critical parts of the report should be the analysis and the reflection. The analysis should contain what the student believes will improve their design with their information backed up with evidence from the testing. The reflection portion should contain the student's view on the overall idea of engines. How can they use what they learned and apply it to engines in the real world?

SLA Core Values

Inquiry:

What are the importance of engines in the modern world?

Research:

How can we make quality observations in the design process.

Collaboration:

How can we collaborate to understand why engines need to be so complex?

Presentation:

Student will design a stirling engine as well as a lab report on their process.

Reflection:

How well did groups your work together?

What did you learn about engines and the engineering process?

Week	Class 1	Class 2
1	**Spark Plug:** List all the things you know Engines are used for. **Discussion:** A discussion should be made about engines and how they relate	**Spark Plug:** What are the major things made out of? What do you think is the importance of all the parts? **Research:** Students will research the basic designs

	for to the engineering process.	for engines. This will include parts that are common for all engines as well as the most important parts.
2	**Spark Plug:** Now that we have talked about engines, what do you think an engine cycle is? **Research**: Students will research different engine cycles and how each one is similar and different from each other. The students should be trying to solve how the engine cycle relates to form and function.	**Spark Plug:** We will be having a discussion on engines. Write down any questions about them for the class to discuss. **Project**: Describe the project to the class. Pick students to be in groups of 3. Explain the schedule for the next few weeks
3	**Research:** Have students immediately research the stirling engine cycle and types of stirling engines. This is so student can begin coming up with their design. Students should come up with their idea web for their design. **Discussion:** After the researching, groups should discuss the different design ideas that they have.	**Design:** Students should begin work on their design.
4	**Spark Plug:** The Spark Plug should be based on any common issues group are facing. **Design:** Students should begin work on their design.	**Spark Plug:** The Spark Plug should be based on any common issues group are facing. **Design:** Students should begin work on their design.
5	**Spark Plug:** The Spark Plug should be based on any common issues group are facing.	**Spark Plug:** The Spark Plug should be based on any common issues group are facing.

	Design: Students should begin work on their design.	**Design:** Students should begin work on their design.
6	**Presenting Day:** Groups should be presenting their stirling engines to the class.	*Can be an additional presenting day if needed.* **Spark Plug:** What makes a good lab report Work Period for Lab Report
7	Work Period for Lab Report	Lab Reports due.

* This lesson is based on the Engineering class schedule which is only twice a week. If this changes please adjust the schedule accordingly.