

An SLS Learning Experience with GeoGebra Apps on the First Law of Thermodynamics

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Introduction

Our work in designing a SLS-based lesson on The First Law of Thermodynamics is targeted at addressing several learning issues with a student-centric and ICT-enabled approach. Among the learning issues identified are : the sign convention for work done by/on a gas, the relationship between work done, heat transfer and internal energy change for thermodynamic processes¹ and the application of the First Law to a cycle.

This poster demonstrates how resources from the web (e.g. videos and GeoGebra apps) can be integrated effectively in a blended-learning package within SLS. To ensure an active learning experience with an emphasis on measureable learning outcomes, the lesson design is done with reference to the SLS Pedagogical Scaffold. Each activity within the learning experience is designed with a quick checking of students' understanding with hinge point questions in the SLS, which include automatic targeted feedback based on students' selected response. The upcoming student-teacher interaction feature in SLS (release 9, est. Feb 2019) can also be utilised to facilitate students' co-construction of knowledge.

The lesson can be used for either blended or self-directed learning and can be shared with any school within SLS and further customised, either collaboratively or by the school itself to suit its own instructional needs.

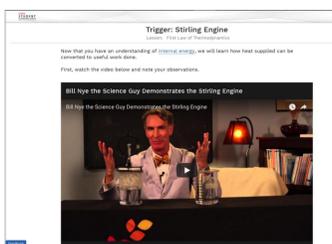
Lesson Outline

Prior Knowledge	<ul style="list-style-type: none"> Internal energy is determined by the state of the system and that it can be expressed as the sum of a random distribution of kinetic and potential energies associated with the molecules of a system.
Key Concepts	<ul style="list-style-type: none"> Simplified microscopic models can be used to explain macroscopic properties such as pressure and temperature in a system. Law of Conservation of Energy, of which First Law of Thermodynamics is a special case
Learning Outcomes	<ul style="list-style-type: none"> show an understanding that relate a rise in temperature of a body to an increase in its internal energy recall and use the first law of thermodynamics expressed in terms of the increase in internal energy, the heat supplied to the system and the work done on the system.

Activating Learning with a Stirling Engine

The lesson starts with students watching a YouTube video embedded into the SLS lesson on the basic working principle of a gamma-type Stirling engine. The Stirling engine is chosen as the associated thermodynamic processes are easy to understand, is a closed system (so macro-variables can be simplified to be p, V and T only) and the device is also affordable (S\$30) and accessible should teachers want a physical set for in-class demonstration.

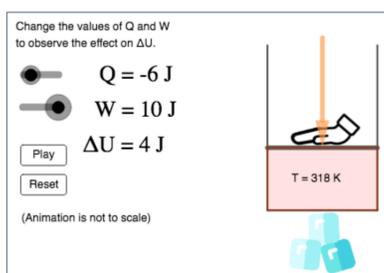
This video is followed by a Claim-Support-Question Thinking Routine question created using SLS. From Feb 2019, this question type will allow for students and teachers to reply to each others' comments in order to critique and refine their explanations.



Bill Nye demonstrating how the Stirling Engine works

Promoting Thinking and Discussion using Apps and Questions

After an introduction to the First Law of Thermodynamics, students will interact with a GeoGebra app to observe how heat absorbed Q and work done on a system W affects the change in internal energy U . This app addresses a misconception that heat supplied must always be accompanied by a rise in temperature and vice versa.

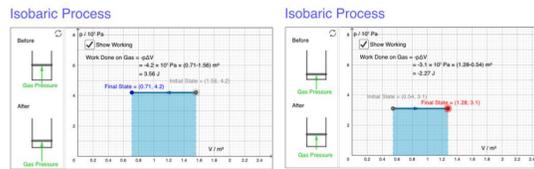


Using a GeoGebra app to understand First Law of Thermodynamics

Work Done for an Isobaric Process

Work done on a gas is revisited with the activity on Isobaric Process with an emphasis on the sign of the value of work as a result of whether a gas is compressed or expanded.

A GeoGebra app is used for students to observe how work done is calculated, in relation to the initial and final states of a gas.

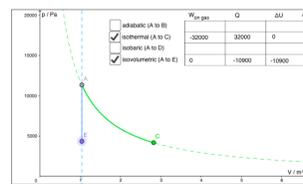


GeoGebra app demonstrating how work done is calculated with p-V diagram for isobaric process

Isochoric and Isothermal Processes

Through another GeoGebra app, students will observe that when the volume or temperature of a gas is kept constant, pressure can be changed by transferring heat to or from the surroundings.

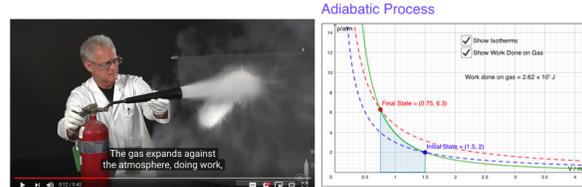
PV diagram for an Ideal Gas



GeoGebra app with p-V diagram for simple thermodynamic processes

Adiabatic Process

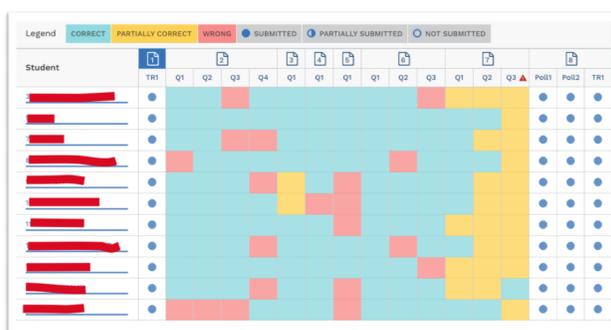
Video demonstrations of adiabatic compression and expansion are used together with a GeoGebra app to apply the First Law to situations where there is no heat transfer.



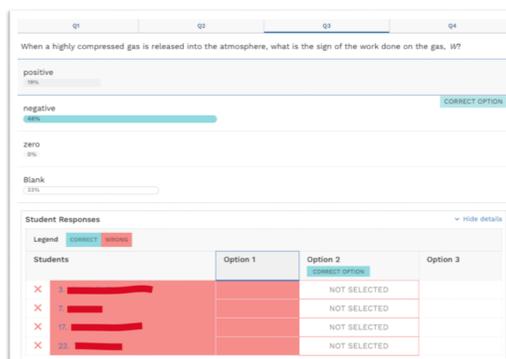
Video demonstrations of adiabatic processes, coupled with a GeoGebra app, to help students compare associated the p and V changes.

Facilitating Demonstration of Learning

SLS questions in the form of fill-in-the-blank, free response and thinking routines were used to facilitate students' demonstration of their learning. Among the questions was one based on the idealised Stirling cycle² to apply their learning to the trigger example.



Learning activities are interspersed with questions for quick checking of understanding. A Heatmap allows teachers to identify problematic questions or students who need help in one glance.



Teachers can zoom into each question and filter to see students who chose a specific option.



Automated feedback given to students after answers are submitted.

Student Feedback

I have a better understanding of the First Law of Thermodynamics after this SLS Lesson.

Strongly Agree

44%

Agree

52%

Disagree

4%

Strongly Disagree

0%

What Students Like About the Lesson

Formative Assessment

"I liked that information is **bite-sized** and **readable**. I also liked that **explanations** were given for the correct answer."

"1. There are short **questions** to test for basic understanding once something new is covered before moving on. 2. There are videos we can watch to help us **visualize** what is going on."

Videos and GeoGebra

"It is **interactive** and I can do activities hands-on. I like that when I submit my answers I can **straightaway see where I go wrong**."

"It is simple to understand and complete. The **diagrams and graphs** helped me to better solidify my understanding and test out different scenarios for myself (especially for the adiabatic process)."

"Videos and graphics, especially GeoGebra which really helped me **visualise** the process."

Areas for Improvement

System Enhancement

"have more than one chance to choose an answer"

"can you pls make this website suitable for mobile devices either?"

Lesson Design

"perhaps attach more examples the students can try out for each section"

"Maybe include more questions with ascending difficulty levels."

GeoGebra in Your SLS Lesson

GeoGebra is an open source Math tool commonly used for creating interactive apps for geometry and graphs. Apps relevant to physics can also be found easily through the onsite search function at <https://www.geogebra.org>. An active local community creating apps for the Singapore curriculum can be found at <https://www.geogebra.org/group/stream/id/VFX2EG8xa>

Teacher can use GeoGebra resources with SLS by linking out or by embedding as html5 packages. For instructions on how to do so, follow the link or QR code below.

The fastest way to adapt this lesson, along with its apps and quizzes, is to have us share the lesson with you via SLS. (See below.)

Get in Touch!

Visit the following webpage (scan the QR code) to:

- 1) have the SLS lesson shared with you within SLS so you don't have to design it from scratch!
- 2) learn how to create GeoGebra apps,
- 3) access curated lists of GeoGebra apps for the O-level and A-level Physics syllabi,
- 4) learn how to embed GeoGebra into SLS, or
- 5) get in touch with us for future collaborations.



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