Science Objectives

- Students will observe how the relationship between a change in volume and the work that is done.
- Students will relate this information to a graph with a slope equal to the pressure of the system.
- Student will develop the equation for amount of work done when compressing a gas.
- Students will calculate the heat loss from the internal energy equation and the work done.

Vocabulary

- heat
- height
- internal energy
- pressure
- radius
- volume
- work

About the Lesson

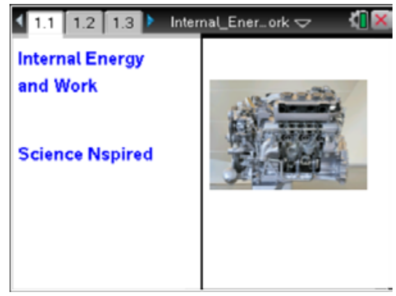
- This lesson allows students to develop the equation for work by observing the relationship between volume change and work done in a cylinder and piston at constant pressure.
- As a result, students will:
  - Understand how to calculate work done.
  - Measure work needed to change volume.
  - Calculate heat loss given the total energy of a system.

TI-Nspire™ Navigator™

- Send out the *Internal_Energy_and_Work.tns* file.
- Monitor student progress using Screen Capture.
- Use Live Presenter to spotlight student answers.

Activity Materials

- *Internal_Energy_and_Work.tns* document
- TI-Nspire™ Technology



TI-Nspire™ Technology Skills:

- Download a TI-Nspire document
- Open a document
- Move between pages
- Use minimized sliders

Tech Tips:

Make sure that students understand how to change values of minimized sliders by clicking the arrows.

Lesson Materials:

Student Activity

- Internal_Energy_and_Work _Student.doc
- Internal_Energy_and_Work _Student.pdf

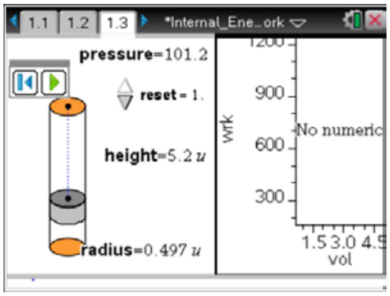
TI-Nspire document

- Internal_Energy_and_Work .tns

Discussion Points and Possible Answers

Move to pages 1.2 and 1.3.

1. Students should read the explanation of the simulation on page 1.2 and then follow directions for animating the cylinder. They should observe the relationship between the distance between the piston and the cylinder as it moves up and down. The points will only appear when work has been done on the piston.



> **Tech Tip:** To remove all data that has been graphed, students can click on the down arrow for reset. The value for reset will remain one.

Move to page 1.4.

Have students answer the question on either the handheld, on the activity sheet, or both.

Q1. Examine the diagram. What is the relationship between the change in height and the work done on the piston?

Answer: Height and work are directly related. As the height increases, so does the work.

Move to page 1.5

2. To determine the effect of the radius on the simulation, move back to the simulation. Grab the top circle of the cylinder and drag it to change the radius. Then reanimate and determine the best fit line for the work and height. Compare the slopes of each equation generated.

> **Tech Tip:** Students can change the radius of the cylinder by grabbing the top circle of the cylinder and dragging it. Moving the hand away from the center will enlarge the radius. Moving the hand toward the center will shrink it.

Move to page 1.6.

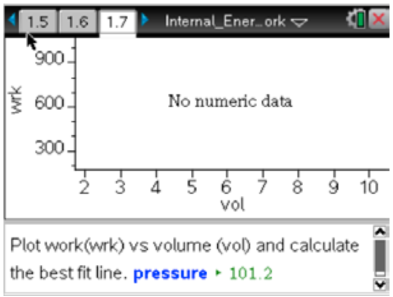
Have students answer the question on either the handheld, on the activity sheet, or both.

Q2. Does the radius of the cylinder affect how much work is done on the piston?

Answer: The radius will affect work. The greater the radius, the greater the work needed to move the cylinder. The radius affects the total area of the cylinder and will affect the volume of the cylinder.

Move to page 1.7.

3. Students should plot work vs. volume.



Move to pages 1.8–1.10.

Have students answer the questions on either the handheld, on the activity sheet, or both.

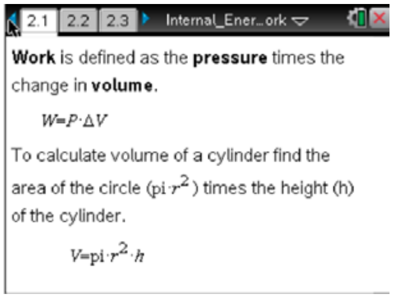
Q3. What does the slope represent in the linear equation generated for work vs. volume?

<u>Answer</u>: The slope is equal to the pressure.

Q4. How does the slope compare to the pressure of the system? Test your hypothesis.

<u>Answer</u>: The pressure is equal to the slope. (To test this hypothesis, students should change the radius and reanimate to see if the slope still represents the pressure.)

Q5. Write the linear equation generated for work vs. volume in terms of *W* (work), *V* (volume), and *P* (pressure).



<u>Answer</u>: $W = P \times V$ *or* $\Delta W = P \times \Delta V$

Move to page 2.1.

The work done to compress the gas is calculated by multiplying the pressure times the change in volume.

$$W = P \times \Delta V$$

To calculate volume of a cylinder, find the area of the circle ($\pi \times r^2$) times the height (h) of the cylinder.

$$V = \pi \times r^2 \times h$$

Move to pages 2.2 and 2.3.

Have students answer the questions on either the handheld, on the activity sheet, or both.

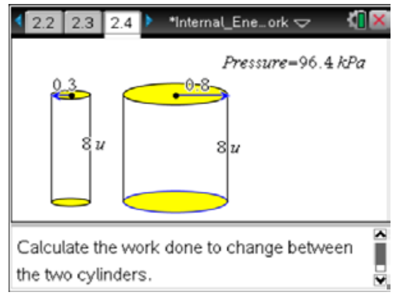
Q6. A cylinder at a pressure of 101.2 kPa with a volume of 0.500 m^3 is increased in volume to 3.00 m^3. The pressure remains constant. How much work must be done on the system?

<u>Answer</u>: W = 101.2 kPa × (3 m^3 - 0.5 m^3) = 253 kJ

Q7. A cylinder with a radius of 1.00 m has a change in piston height of 2.00 m. If the pressure in the cylinder is 200.0 kPa and is kept constant, how much work is done to the system?

<u>Answer</u>: W = 200.0 kPa × ($\pi \times 1^2 \times 2$) = 1256 kJ

Move to page 2.4.



4. Examine the diagram on page 2.4 to see how much work must be done to expand the cylinders.

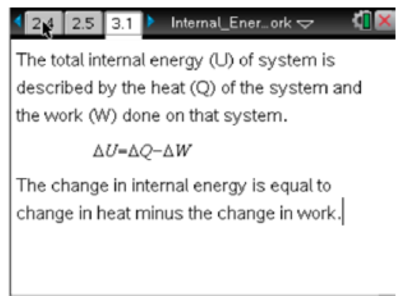
Move to page 2.5.

Students should move to page 2.5 and return to the diagram on page 2.4 for reference. They should then answer the following question on either the handheld, on the activity sheet, or both.

Q8. How much work is done to expand the cylinders on page 2.4?

<u>Answer</u>: 1333 kJ

Move to page 3.1.



5. This problem can be used to combine work to the total energy. The total internal energy (U) of system is described by the heat (Q) of the system and the work (W) done on that system.

$$\Delta U = \Delta Q - \Delta W$$

The change in internal energy is equal to change in heat minus the change in work.

Move to page 3.2.

Have students answer the question on either the handheld, on the activity sheet, or both.

Q9. Energy in the amount of 2.0 kJ is placed into a system. If a cylinder at 101.2kPa moves a .050m radius cylinder 0.100m, how much heat is released from the system?

<u>Answer</u>: 2.0 kJ $= Q -$ (101.2 kP × [π (0.050 m)^2 (0.100 m)]

$Q = 2.08$ kJ

TI-Nspire Navigator Opportunities

Use TI-Nspire Navigator to capture screen shots of student progress and to retrieve the file from each student at the end of the class period. The student questions can be electronically graded and added to the student portfolio.

Wrap Up

When students are finished with the activity, pull back the .tns file using TI-Nspire Navigator. Save grades to Portfolio. Discuss activity questions using Slide Show.

Assessment

- Formative assessment will consist of questions embedded in the .tns file. The questions will be graded when the .tns file is retrieved by TI-Nspire Navigator. The TI-Nspire Navigator Slide Show can be utilized to give students immediate feedback on their assessment.
- Summative assessment will consist of questions/problems on the chapter test, inquiry project, performance assessment, or an application/elaborate activity.