

Warm-Up

First Law of Thermodynamics

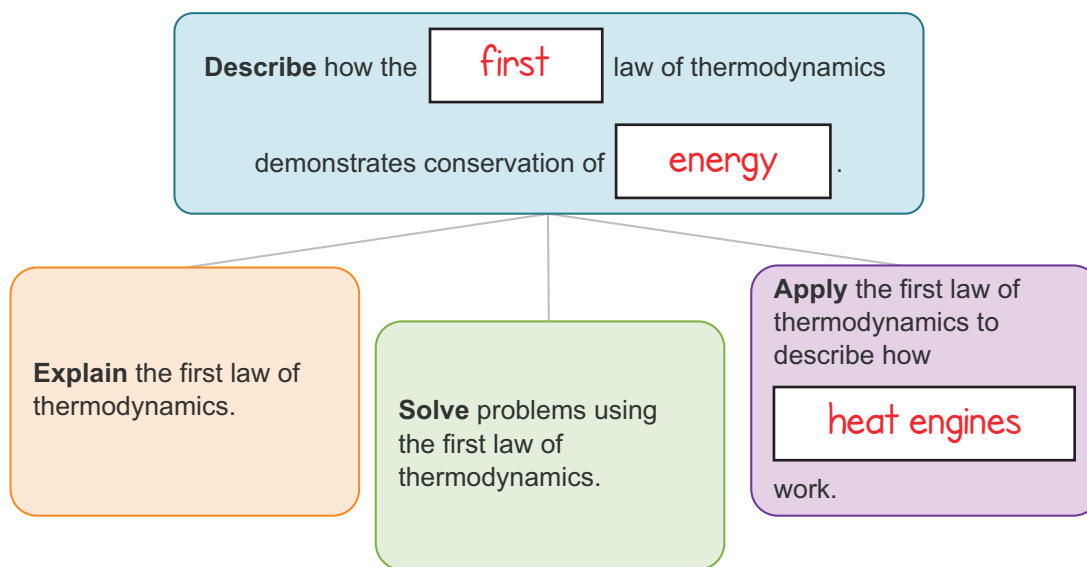


Lesson Question

How does the first law of thermodynamics demonstrate energy conservation?



Lesson Goals



Words to Know

Fill in this table as you work through the lesson. You may also use the glossary to help you.

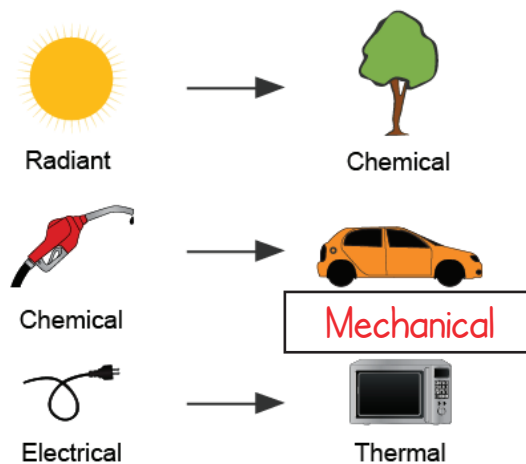
heat engine	a device that uses heat to do useful work
adiabatic process	a process involving the compression and expansion of gases within a system where no heat is absorbed or released by the system
thermodynamics	the branch of physics that studies the relationship between thermal energy and other forms of energy
system	a group of related objects that interact and form a complex whole
first law of thermodynamics	the law that states that energy can be transformed and transferred but not created or destroyed; also known as conservation of energy



The Law of Conservation of Energy

- The law of conservation of energy states that energy cannot be created or destroyed; it can only be **transformed**.

- Mechanical
- Thermal
- Electromagnetic
- Electrical
- Chemical
- Nuclear



Instruction

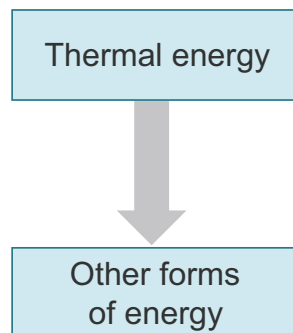
First Law of Thermodynamics

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Thermodynamics

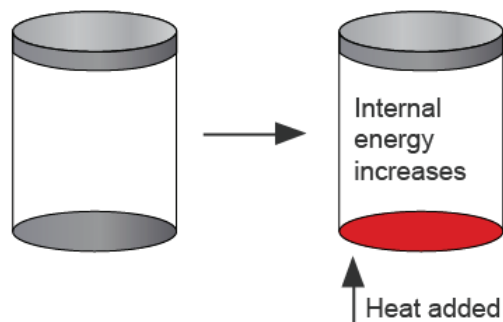
- **Thermodynamics** is the branch of physics that studies the relationship between **thermal** energy and other forms of energy.



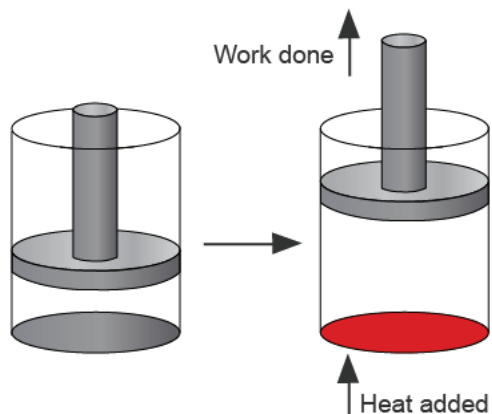
First Law of Thermodynamics

- The **first law of thermodynamics** states that energy can be transformed and transferred, but not created or destroyed.
- This law describes how heat added to a **system** is **conserved**.

- Heat increases the **internal** energy of the system.



- Heat is transformed into **work done** by the system.



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The First Law of Thermodynamics

- Variables
 - Q : heat (J)
 - ΔU : changes in internal energy (J)
 - W : work (J)
- The minus sign indicates that work is being done **by** the system on the surrounding environment.

$$Q = \Delta U + W$$



$$\Delta U = Q - W$$

The First Law of Thermodynamics

EXAMPLE

If 56 joules of heat are added to a system, and 23 joules of energy are used to do work, what is the change in internal energy?

- Given:

- Q : 56 joules

- W : 23 joules

$$\Delta U = Q - W$$

$$\Delta U = \boxed{56 \text{ J}} - 23 \text{ J}$$

$$= 33 \text{ J}$$

- Unknown: ΔU

- Formula to be used: $\Delta U = \boxed{Q} - W$

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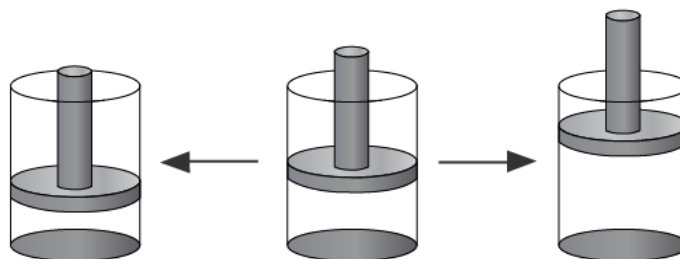
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Heat Engines

- A **heat engine** is a device that uses heat to produce useful **work**.
 - Cars
 - Trains
 - Power plants

Adiabatic Process

- Heat engines use an **adiabatic process**.
 - Rapid shift between compression of a **gas** and expansion of a gas
 - No **heat** absorbed or released by the system
 - All heat added to the system transformed into work

Compression and Expansion of Gases

Work done to the system compresses the gas and **increases** the temperature.

Work done **by** the system pushes the piston upward and decreases the temperature.

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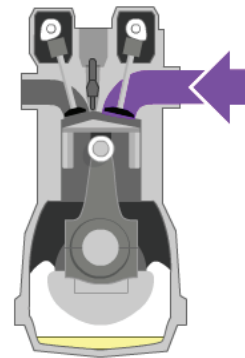
Adiabatic Process in Real Life

- A tire pump uses an adiabatic process.
 - As handle is pushed down, **air** temperature inside pump increases
 - As handle is pulled up, air temperature inside pump **decreases**

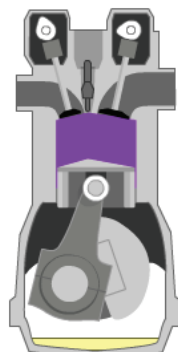
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How Heat Engines Work

- **Intake** – piston moves down, allowing fuel-air mixture to **enter** intake valve



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- **Compression** – piston moves up, compressing gas and causing an increase in the **temperature** of the gas



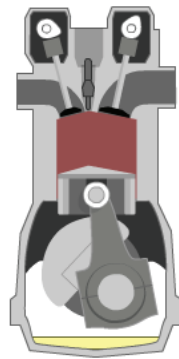
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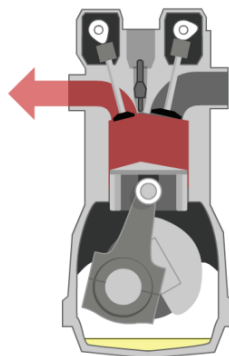
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- Intake – piston moves down, allowing fuel-air mixture to enter intake valve
- Compression – piston moves up, compressing gas and causing an increase in the temperature of the gas
- Ignition – spark plug fires, causing **combustion** of compressed gas; expansion of the gas pushes piston down



- Intake – piston moves down, allowing fuel-air mixture to enter intake valve
- Compression – piston moves up, compressing gas and causing an increase in the temperature of the gas
- Ignition – spark plug fires, causing combustion of compressed gas; expansion of the gas pushes piston down
- **Exhaust** – piston moves up, pushing burned gases through exhaust valve



Summary

First Law of Thermodynamics

**Lesson Question**

How does the first law of thermodynamics demonstrate energy conservation?

**Answer**

(Sample answer) The first law of thermodynamics demonstrates how heat added to a system is conserved by increasing the internal energy of the system and/or is transformed into useful work.

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Review: Key Concepts

- The first law of thermodynamics states that **energy** can be transformed and transferred, but not created or destroyed.
 - Describes how heat added to a system is conserved
- **Heat** added and the work done by the system affects the internal energy of a system.
 - $\Delta U = Q - W$



Summary

First Law of Thermodynamics

Use this space to write any questions or thoughts about this lesson.