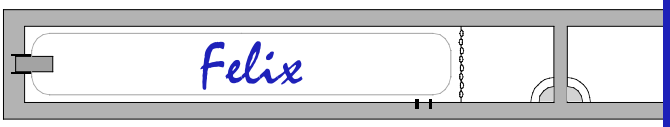
PhyzSpringboard: First Law of Thermodynamics

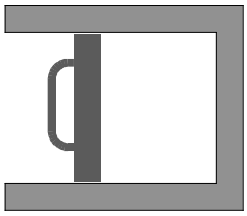


GAS GIVES ME WORK

1. During a Monarchs' game, Ticha passes the ball to Yolanda. Yolanda catches the ball. What kind of work did each woman do on the ball? Defend your answer with a sketch that includes the appropriate vectors.

Ticha: F ll d so W is + ; gained KE
Yolanda: F anti ll to d so W is – ; lost KE

2. Consider a container of gas. The gas is enclosed within a cylindrical container with a sliding piston inside.



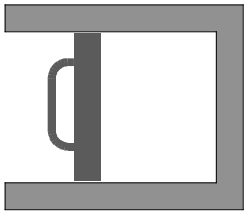
a. How could the piston be used to **increase** the energy of the gas molecules?

Push the piston: squeeze the gas!

b. We would refer to such a procedure as having done

_____positive_____ work on the gas.

c. How could the piston be used to **decrease** the energy of the gas molecules?



Pull the piston: expand the gas!

d. We would refer to such a procedure as having done

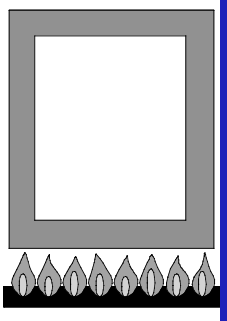
_____negative_____ work on the gas.

e. Under what circumstances—if any—would the piston do **no** work on the gas?

No push; no pull.

CONSTRUCTING THE FIRST LAW OF THERMODYNAMICS

1. Consider a closed container (such as a can) of gas placed over a flame for a period of time.



a. What is the name and symbol of the energy added to the gas by the flame?

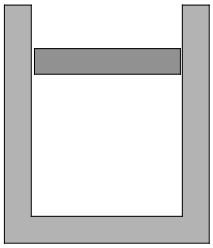
Heat, Q

b. *Temperature* is a measure of the **average** kinetic energy of the random motion of the particles. What is the name and symbol of the physical quantity associated with the **total** energy of the particles?

Internal energy, U

c. How does the increase in _____internal energy_____ compare to the _____heat_____ added? Write a statement and a mathematical expression.

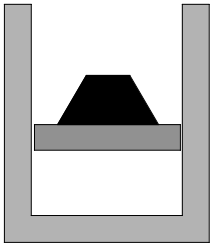
The increase in internal energy of the gas is equal to the heat added to the gas: $U = Q$.



2. Suppose the can were replaced by a cylinder with frictionless walls and a piston. A weight is placed on the piston and the piston descends. The temperature of the gas increases (even though no heat has been added).

a. What happened to the internal energy of the gas?

It increased.



b. What was the source of this change?

The work done on the gas.

c. How does the increase in internal energy compare to the _____work_____ _____done_____ _____on_____ the gas? Write a statement and a mathematical expression.

The increase in internal energy of the gas is equal to the work done on the gas: $U = W$.

3. Suppose the gas were being heated **and** a weight had been placed on the cylinder, causing the gas to be compressed. Write a statement and an expression to describe the resulting change in the internal energy of the gas.

The increase in internal energy of the gas is equal to the sum of the heat added to the gas and work done on the gas: $U = Q + W$.

The expression above is commonly known as the **first law of thermodynamics.** The idea that the internal energy of a gas can be increased by heat added to it or by work done on it is the thermodynamic expression of the principle of conservation of energy: energy is never created or destroyed, although it often changes form.

In our study of **mechanics,** we once analyzed the energy transformations involved in shooting a toy dart into the air. Back then, the work, elastic potential energy, kinetic energy, and gravitational energy seemed easy to discern. In **thermodynamics,** the changes in internal energy and flows of heat are not always so obvious. The means of keeping track of these changes, *PV*-diagrams, take some getting used to. But with practice, these things do become manageable.