Friday, May 8/15
Science 122

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1. Questions?
   Cutnell - Page 413: #28, 30-33, 36
2. Thermodynamics and Systems
3. Zeroth Law of Thermodynamics
4. First Law of Thermodynamics
5. Thermal Processes

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6. Worksheet - Thermal Processes
7. Second Law of Thermodynamics
8. Heat Engines
9. Cutnell – Page 446: #40-45

Thermodynamics

Thermodynamics is the branch of physics that is built upon the fundamental laws that heat and work obey.

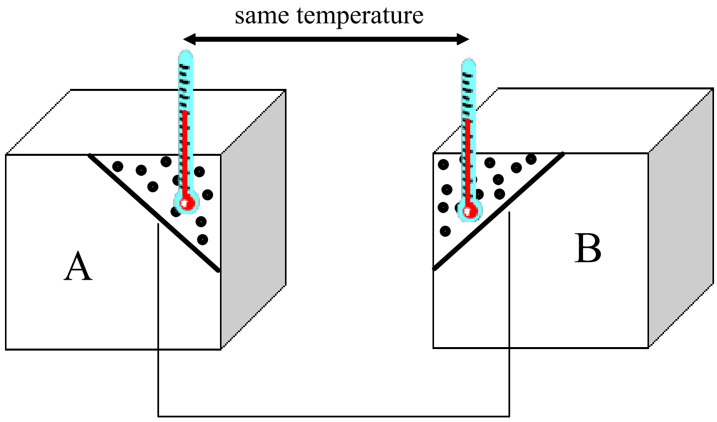
NOTE: A collection of objects on which attention is being focused is called a system, while everything else in the environment is called the surroundings.

To understand what the laws of thermodynamics have to say about the relationship between heat and work, it is necessary to describe the physical condition or state of a system.

The state of the system can be specified by giving values for the **pressure**, **volume**, **temperature** and **mass of the system**.

Zeroth Law of Thermodynamics
(Cutnell Page 417)

Study the two systems, A and B, below.



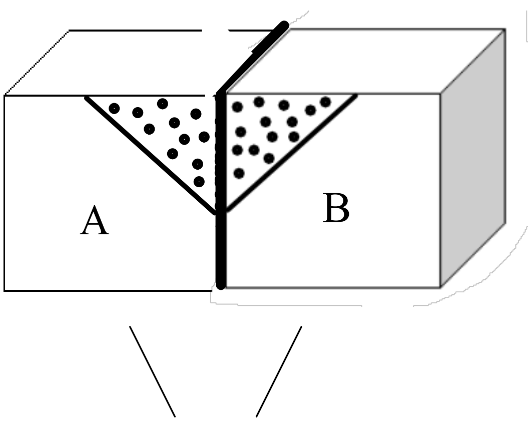
adiabatic walls

(walls that do not allow heat to flow between the systems and the surroundings)

A is in thermal equilibrium with the thermometer.

B is in thermal equilibrium with the thermometer.

Zeroth Law of Thermodynamics: Two systems individually in thermal equilibrium with a third system are in thermal equilibrium with each other - there is no net flow of heat because the systems have the same temperature.



diathermal walls

(walls that permit heat to flow through them)

The First Law of Thermodynamics
(Cutnell Page 419)

The First Law of Thermodynamics: The internal energy of a system changes from an initial value U_i to a final value of U_f due to heat, Q, and work, W:

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

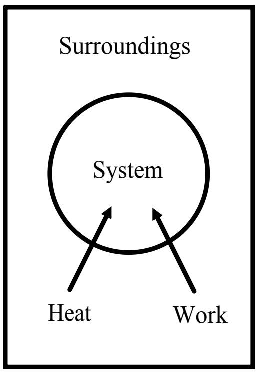
$\Delta U = Q - W$

Sign Conventions

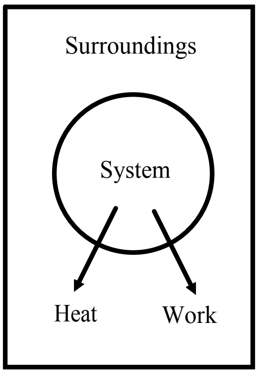
1. Q is positive when the system gains heat and negative when the system loses heat.
2. W is positive when work is done by the system and negative when work is done on the system. on

on

Q +
W −

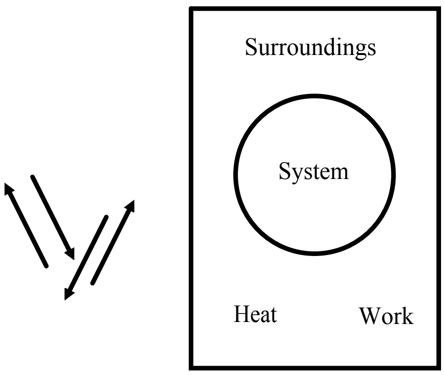


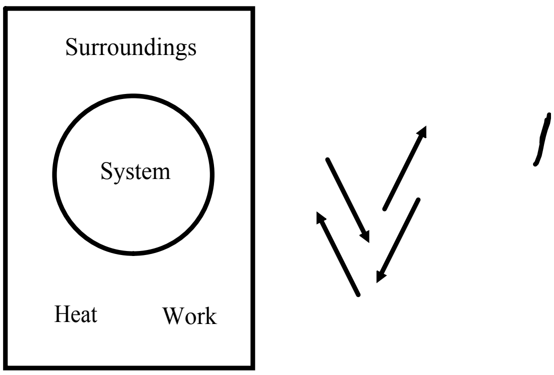
System gains energy in the form of heat and gains energy because work is done on the system.



System loses energy in the form of heat and loses energy because work is done by the system.

Q −
W +





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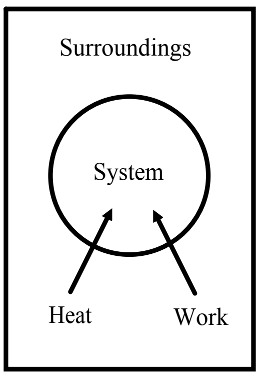

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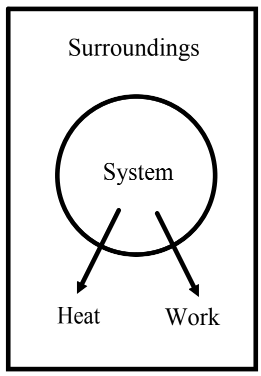

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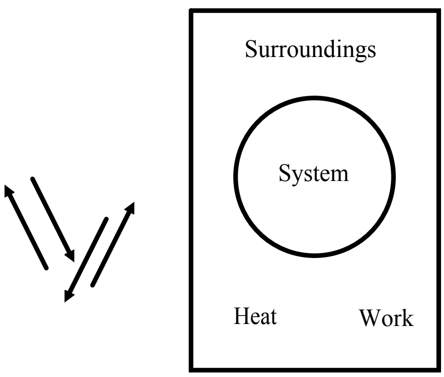
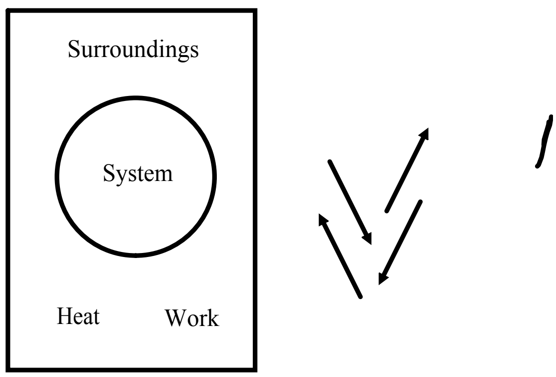
Q −
W +



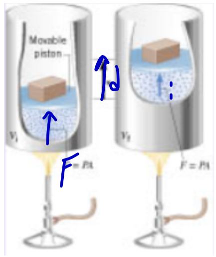


Thermal Processes
(Cutnell Page 420)

A quasi-static process occurs slowly enough so that a uniform pressure and temperature exist throughout all regions of the system at all times. We will assume that the four thermal processes below are quasi-static.

1. Isobaric Process - occurs at constant pressure

Study the diagram below.



The susbtance in the chamber expands isobarically because the pressure is held constant by the external atmosphere and the weight of the piston and the brick.

Figure 15.5 - Cutnell
p.420

Work is done by force F in the diagram:

$W = F\Delta d$
$W = PA\Delta d$
$W = P\Delta V$
$W = P(V_f - V_i)$

Applies to any system (solid, liquid or gas) as long as pressure is constant while volume changes

A system expands isobarically when work is done by the system:

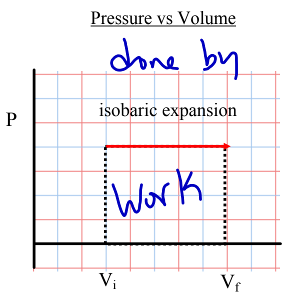
$V_f > V_i$ so W -> +

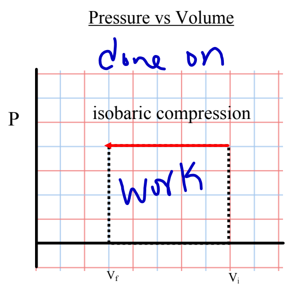
A system compresses isobarically when work is done on the system:

$V_f < V_i$ so W -> -

1st Law $\Delta U = Q - W$
$\Delta U = Q - P\Delta V$

PV Diagrams





-> horizontal straight line
-> area = work

$W = P\Delta V$

☆

2. Isochoric (Isovolumetric) Process - occurs at constant volume

Figure 15.7 - Cutnell

A substance is heated in a rigid container which keeps the volume constant. Pressure increases and the substance exerts more and more force on the walls of the container.

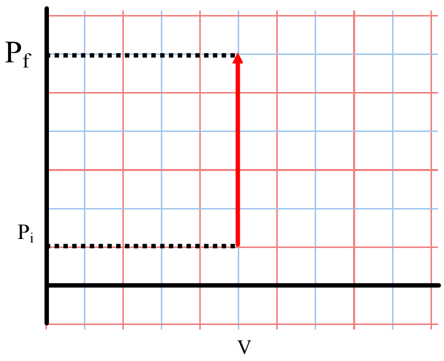
No work is done as the walls do not move.

$\Delta U = Q - W$ W = 0J

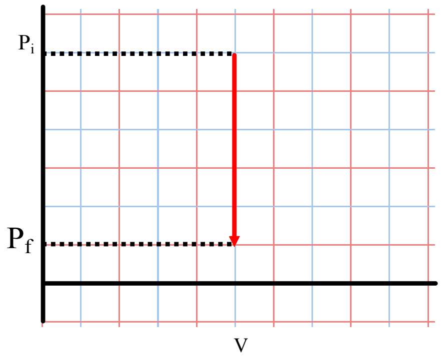
$\Delta U = Q$

PV Diagrams

Pressure vs Volume



Pressure vs Volume



-> vertical straight line

-> area = work = 0 J

☆

3. Isothermal Process - occurs at constant temperature

The following involves the features of an isothermal process when the system is an ideal gas. *

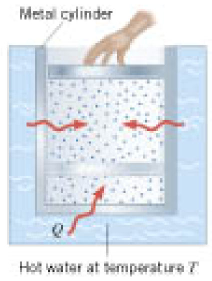


Figure 15.9 (a) - Cutnell

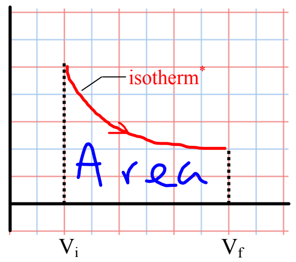
The diagram shows an ideal gas in the cylinder expanding isothermally at temperature T.

PV Diagram

Pressure vs Volume

Pressure

$P = \frac{nRT}{V}$



*The solid red line is called an isotherm and represents the relationship between the pressure and volume when the temperature is held constant.

$$W \neq P\Delta V$$

The work done by the gas is given by the area under the graph. Using integral calculas gives the following for W:

$$W = nRT \ln\left(\frac{V_f}{V_i}\right)$$ *

Since the internal energy of any ideal gas is proportional to the Kelvin temperature (U = 3/2 nRT), the internal energy remains constant throughout an isothermal process and ΔU is zero.

E = hf

$E = \frac{hc}{\lambda}$

* $U \propto T$

$\Delta U = 0$
$\Delta U = Q - W$
$Q = W$
$Q = nRT \ln\left(\frac{V_f}{V_i}\right)$

The energy for the work originates in the hot water. Heat flows into the gas from the water.

If the gas is compressed isothermally, heat flows out of the gas into the water.

4. Adiabatic Process - no heat flows into or out of the system

* Monatomic ideal gas..

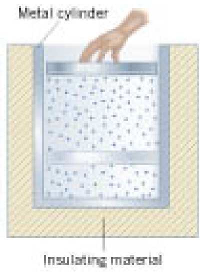


Figure 15.10 (a) - Cutnell

The arrangement is similar to the one for an isothermal process, but the amount of work done is different because the cylinder is surrounded by insulating material that prevents the flow of heat, Q = 0J.

$U = \frac{3}{2}nRT$

$\Delta U = Q - W$

$\Delta U = -W$

$U_f - U_i = -W$

$\frac{3}{2}nRT_f - \frac{3}{2}nRT_i = -W$

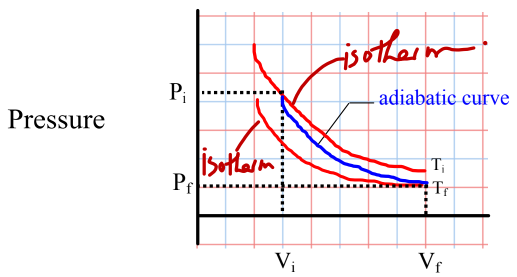
$\frac{3}{2}nR(T_f - T_i) = -W$

$W = \frac{3}{2}nR(T_i - T_f)$

When an ideal gas expands adiabatically, it does positive work so T_f is less than T_i. The internal energy is reduced to provide the energy necessary to do the work and since U is proportional to temperature, it decreases.

PV Diagram

Pressure vs Volume



The adiabatic curve intersects the isotherms at T_i and T_f. The work done is given by the area under the adiabatic curve.

When a gas compresses adiabatically, W is negative so T_i is less than T_f. The energy provided by the agent doing the work increases the internal energy of the gas - the gas becomes hotter.

Summary of Thermal Processes
Page 425

Type of Thermal Process	Work Done	First Law

Complete using textbook.

Friday, May 8/15
Physics 122

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1. Rewrite -> Quiz U2-S2: IS Today

2. Test: Unit 2 - Monday, May 11/15

3. Charging by Induction -> To Be Continued

4. Electric/Electrostatic Force

5. Textbook: Page 638, #4-5
   Handout: Charge and Coulomb's Law } HW - Tuesday

6. Coulomb's Law - Three Charges

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Friday, May 8/15
Science 10

1. Return -> Quiz: SD, Certainty Rule, Precision Rule, Rearranging Equations and Metric Conversions

2. Check:
   Understanding Concepts - Page 358: #3-6, 8
   Worksheet: Matching a Graph to a Story
   Worksheet - Distance vs. Time Graphs (Add to Task Sheet)
   Omit #1c, #4

3. Types of Physical Quantities

4. Direction

5. Position and Displacement

6. Demo - Gecko

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7. 100 Acre Wood - Add to Task Sheet

8. Resultant Displacement

9. Velocity

10. Calculating Velocity

11. Average Velocity

Understanding Concepts - Page 358: #3-6, 8

#3 a) 5.2 km/h

b) 14 km/h

c) 7.6 km

d) 4.8 h

#4. 225 km

#5. Show that 1 m/s = 3.6 km/h

#6. a) 26 m/s

b) 76 km/h

#8. a) 1.77 s

b) 1227.7 km/h -> 1.23×10^3 km/h

Distance Time Graphs

#1. (a) (i) 30 min or 0.5 hour

(ii) 120 km

(b) 60 km/h ← calc. slope = V_{av}

(3, 200)
(5, 320)

(c) omit

#2. (a) 15 min

(b) 15 km

(c) Complete graph.

#3. (a) 45 min

(b) 5 km

#4. Omit

#5. (a) 1 km

(b) 5 minutes

(c) 2 km