Physics 161

Lecture 15  Summ
First Law of Thermodynamics

October 24, 2017
Lecture 15: learning objectives

You will be able to define and calculate the work done on or by a gas.

You will be able to state and apply the first law of thermodynamics.

You will be able to identify and define the four most common thermal processes.
Thermodynamic work

Work done on a gas:
The work done on a gas at constant pressure is the (negative of the) product of the pressure and the change in volume.

\[ W = -P\Delta V \]

Note that the change in volume for compression is negative, so for compression the work done on the gas is a positive number. In this case the work done by the gas is negative.

If the gas expands, the work done on the gas is negative. The work done by the gas is positive.
First law of thermodynamics

First law:
The change in thermal (internal) energy ($U$) of the system is equal to the heat ($Q$) added to the system plus the work ($W$) done on the system.

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

$Q$ is positive when heat is transferred into the system.

$Q$ is negative when heat is transferred out of the system.
Thermal processes

There are four common types of thermal process.

**Isobaric:**
Pressure is constant throughout the process.

**Isovolumetric:**
Volume is constant throughout the process.

**Adiabatic:**
No heat is transferred to or from the system \((Q=0)\) during the process.

**Isothermal:**
Temperature is constant throughout the process.
Thermal processes

There are four common types of thermal process.

Table 12.2 The First Law and Thermodynamic Processes (Ideal Gases)

<table>
<thead>
<tr>
<th>Process</th>
<th>$\Delta U$</th>
<th>$Q$</th>
<th>$W$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isobaric</td>
<td>$nC_v \Delta T$</td>
<td>$nC_p \Delta T$</td>
<td>$-P \Delta V$</td>
</tr>
<tr>
<td>Adiabatic</td>
<td>$nC_v \Delta T$</td>
<td>0</td>
<td>$\Delta U$</td>
</tr>
<tr>
<td>Isovolumetric</td>
<td>$nC_v \Delta T$</td>
<td>$\Delta U$</td>
<td>0</td>
</tr>
<tr>
<td>Isothermal</td>
<td>0</td>
<td>$-W$</td>
<td>$-nRT \ln \left( \frac{V_f}{V_i} \right)$</td>
</tr>
<tr>
<td>General</td>
<td>$nC_v \Delta T$</td>
<td>$\Delta U - W$</td>
<td>(PV Area)</td>
</tr>
</tbody>
</table>