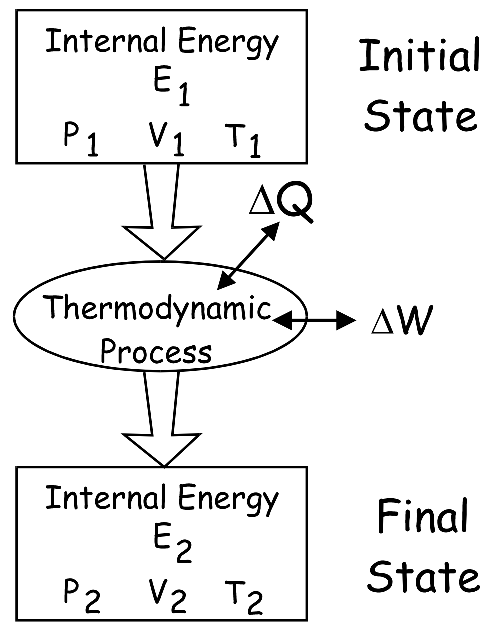
AP Physics -- Thermo 3 LP

Thermodynamic process ≡ addition or subtraction of heat

internal energy ≡ ***U***

Heat ≡ ***Q***

work ≡ ***W***



First Law:

$$\Delta U = Q + W$$

Heat ***-- positive when added to system***

negative -- lost by system

Work ***-- output work is negative***

-- input work is positive

Thermodynamic process system can:

- gain heat or
- gain heat and have work done on it
- lose heat or
- lose heat and do work on something

After -- ends up at some new, final equilibrium

final internal energy

final temperature, pressure, and volume.

examples of the first law in action.

- Rub the palms of your hands rapidly
- hands' internal energy will increase.
- No heat added to system
- work done
- Bend paper clip back and forth quickly.
- paper clip gets very warm
- internal energy increased by work on it

Match ignites -- work done on it

- Match head rubbed
- Increases its internal energy
- chemicals on match head ignite

- Joules' experiment to equivocate mechanical work with thermal energy

Adding heat to system increases internal energy

Pot of water on stove

Heat engines operate by adding heat to system then system does work

Car engine

- In a thermodynamic process, a system absorbs 450 kJ of heat and does 87 kJ of work on its surroundings. By what amount did the system's internal energy increase?

$$\Delta U = Q + W$$

$$\Delta U = 450\ kJ + \left(-87\ kJ\right) = \boxed{360\ kJ}$$

P-V Diagram

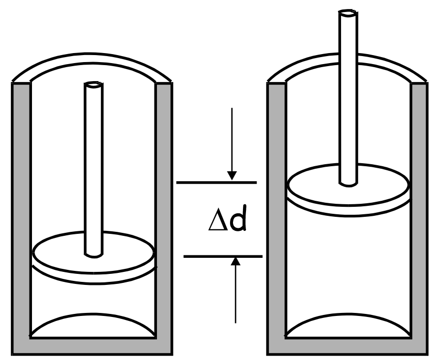
- Piston can move in cylinder
- Push down on piston -- gas gets compressed
- Pull up on piston -- gas expands
- When piston moves -- does work.

Add heat to cylinder -- gas expands

Pushes piston upward

work is done

Assume ***P*** is constant as gas expands



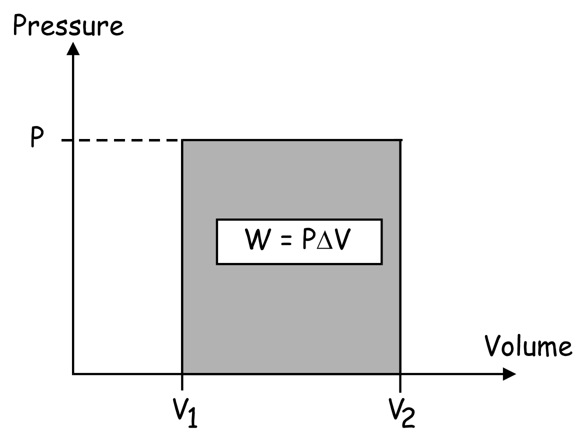
Gas expands at constant pressure moving piston a distance Δd

$$P = \frac{F}{A}$$

$$F = PA$$

$$\Delta W = Fd, \quad \text{so}$$

$$\Delta W = PA\Delta d$$



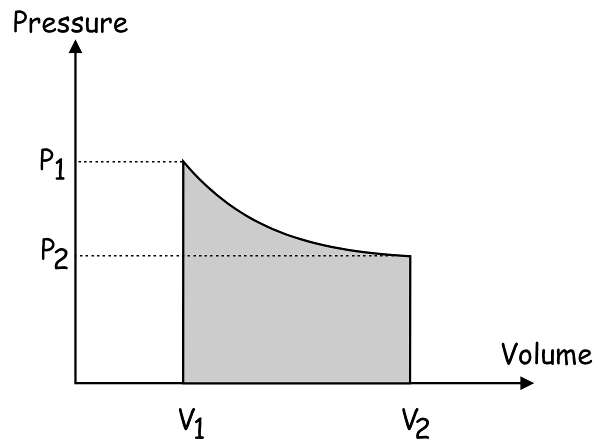
Work done when gas expands at constant pressure.

Area x distance moved = ΔV

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

Pressure vs Volume graph.

work done on the system is equal to the area under the curve on a P-V graph.



Work done when gas expands at varying pressure.

Adiabatic Processes ≡ ΔQ = zero.

"impassible"

$$\Delta U = Q + W$$

$$\Delta U = \Delta W$$

Adiabatic process ≡ a process in which there is no net heat transfer.

work is done at the expense of internal energy.

Adiabatic processes common

process happen very quickly -- little time for heat to be transferred.

car engine.

near adiabatic process.

Insulate system

Joule's experiment -- example

We can summarize in this way:

- a gas that is adiabatically expanded will lose ΔU and become cooler.
- a gas that is adiabatically compressed will gain ΔU and become warmer.

puff air onto the palm of hand -- warm

blow air lips compressed -- Cool
dry air will cool 10 °C for every 1 000 m it rises.

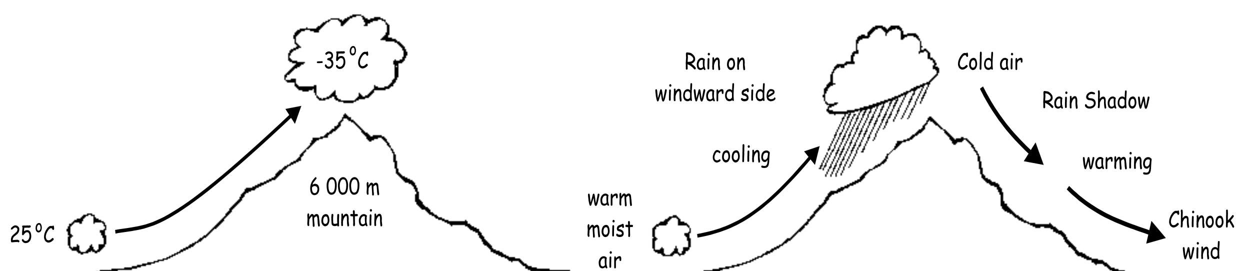
"rain shadow

Adiabatic expansion of air -- thunderheads.

Rising warm, moist air cools

Water droplets condense and form cloud.

Chinook winds in mountains.



Dry air mass, blown up the mountain by the prevailing winds, is adiabatically cooled

A warm, moist air mass, blown up the mountain by the prevailing winds, is adiabatically cooled and ends up raining near the top of the mountain

Isothermal Process $\equiv$ constant temperature process.

ΔU is zero

$$\Delta U = Q + W$$

$$Q = -W$$

fill a plastic baggie with air

bag sits in a room at room temperature

low pressure front moves in

room temperature does not change -- pressure does.

bag expands

Work done -- temperature of system stays constant

Isochoric Process $\equiv$ volume stays constant

V is constant -- $\Delta V = 0$

$\Delta W = P\Delta V = 0$

$Q = U$

Cooking food

Pressure cooker

heat water in a container of constant volume.

No work is done

internal energy of the system increases

Isobaric Process - pressure stays constant

Work can be done