Phys141 – Fri 12/8

TODAY: Chapter 20

SKIP: Chapter 21 Chapter 22

No Pre-Class Quiz

Last HW due next week Monday

Final exam Sat Dec 16, 8am

The First Law of Thermodynamics

$\Delta E_{int} = Q + W$

Change in internal energy of object is heat transferred to object (Q) plus work done on object (W).

The First Law of Thermodynamics is a special case of the Law of Conservation of Energy

Problem 20.29

Work in Thermodynamics

Piston pushed down by a force **F** through a displacement of *d***r**:

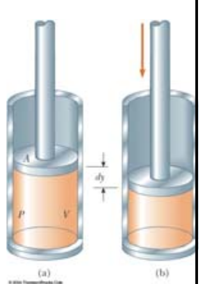
dW = F *d***r** = - *F dy* = - P A dy

A·dy is the change in volume of the gas, *dV*

work done on gas: $dW = -P\,dV$

- gas compressed: positive
- gas expands: negative
- volume constant: zero

The total work done is: $W = -\int_{V_i}^{V_f} P\,dV$



Demo pressure apparatus

“Simple” thermodynamic system: GAS

In an “ideal” gas all internal energy of gas is kinetic energy of atoms/molecules. Collisions with the walls exert pressure on the walls. Higher pressure on wall due to

- Smaller volume (i.e. more collisions per unit time) OR
- Higher temperature (I.e. particles move faster when colliding w/ wall).

Ideal gas law $P \sim T / V$ or $PV \sim T$

$$PV = nRT$$

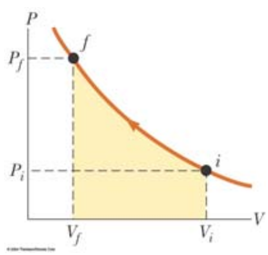
Where n is the number of moles of gas and R is the Universal Gas Constant $R = 8.314$ J/mol · K

Problem 19.28

Work and heat in a gas: PV Diagrams

The pressure and volume of a gas are plotted at each step of some process
-> ***PV* diagram**

How are p and V related?
-> pV=nRT



Work done on a gas: negative of the area under the curve on the *PV* diagram between the initial and final states

$$W = -\int_{V_i}^{V_f} P\, dV$$

Pressure of gas can exert LARGE forces:
Demo: Magdeburg hemispheres

Adiabatic Process: No heat released

Adiabatic: no energy enters or leaves the system by heat

$Q = 0$

This is achieved by:

- Thermally insulating the walls of the system **OR**
- Having the process proceed so quickly that no heat can be exchanged

-> $\Delta E = W$

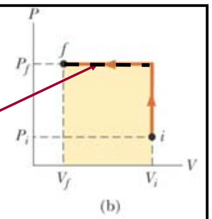
Specific paths: Isobaric Processes

Isobaric: constant pressure P

heat and work generally both nonzero

The work done can be simplified to

$W = P\,(V_f - V_i)$

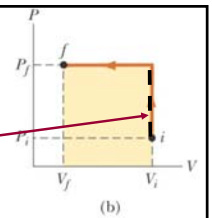


Specific paths: Isovolumetric Processes

Isovolumetric: Constant volume

volume does not change -> $W = 0$

From the first law, $\Delta E_{int} = Q$



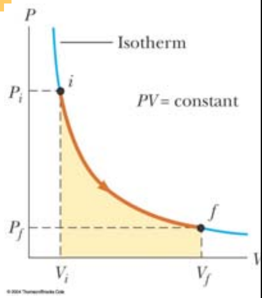
Specific paths: Isothermal Process

Isothermal: Constant temperature

No change in temperature -> $\Delta E_{int} = 0$

From the first law: $Q = -W$

Energy that enters the system as heat must leave the system as work



Combining processes into a Loop

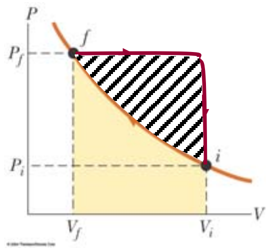
Loop in the ***PV* diagram**

$$W = -\int_{V_i}^{V_f} P\,dV$$

More area under the curve from V_f to V_i than under curve from V_i to V_f

-> More work done by system than work done on the system

-> System does net work in each cycle (equal to dashed area)



ENGINES
-> Chapter 22

Heat Engine

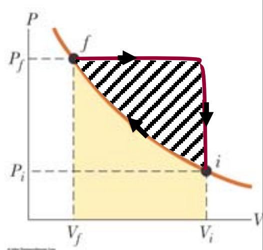
For a cyclical process, $\Delta E_{int} = 0$

- Initial and final internal energies are the same

-> $Q_{net} = W_{eng}$

(Work done by the engine = net heat absorbed by engine

Work equals the dashed area enclosed by the curve of the *PV* diagram



Heat Pump Process

- Energy is extracted from the cold reservoir, Q_C
- Energy is transferred to the hot reservoir, Q_h
- Work must be done *on* the engine, *W*
- Devices that do this are called **heat pumps** or **refrigerators**
- Examples
  - refrigerator
  - air conditioner