

# ME 201

## Thermodynamics

### First Law for Closed Systems Guide

Recall that for a closed system there are no mass inflows or mass outflows, so the mass of the closed system remains constant throughout the process or

$$m_2 = m_1$$

Also, due to our quasi-static equilibrium assumption, we can not have any shaft work out of a closed system. We can re-write our 1st law equation as

$$m(e_2 - e_1) = Q - W_{sh} - W_{bnd}$$

For most closed systems we can neglect kinetic energy and potential energy changes. We call these simple closed systems and can write our energy conservation as

$$m(u_2 - u_1) = Q - W_{sh} - W_{bnd}$$

Some examples of simple closed systems include

Piston-Cylinder System  
Rigid Tank or Container  
Balloon

In solving simple closed system problems, we need to identify the unknowns, so we will know how to proceed. The possible unknowns are

Heat Transfer  
Shaft Work  
Boundary Work  
Initial State (State 1)  
Final State (State 2)

We first observe that heat transfer and shaft work can only be calculated from the first law. This means only one of them can be unknown. If shaft work is not explicitly mentioned, i.e. there is no mention of a stirrer or paddle wheel, etc., then we can assume that the shaft work is zero. We can only assume that the heat transfer is zero if we are told that the system is adiabatic or insulated.

There are several types of problem associated with a simple closed system. Let's outline some of them.

**Final State, Heat Transfer and Boundary Work Unknown:** Use process description to fix the final state. Solve for boundary work from integral of  $Pdv$ , then solve for heat transfer from the 1<sup>st</sup> law.

**Heat Transfer and Final State Unknown:** Final state is determined from the process description or from the specification of boundary work and using integral of  $Pdv$ , then solve for heat transfer from 1<sup>st</sup> law.

**Final State, Shaft Work and Boundary Work Unknown:** Use process description to fix the final state. Solve for boundary work from integral of  $Pdv$ , then solve for shaft work from the 1<sup>st</sup> law.

**Shaft Work and Final State Unknown:** Final state is determined from the process description or from the specification of boundary work and using integral of  $Pdv$ , then solve for shaft work from 1<sup>st</sup> law.

**Final State and Boundary Work Unknown:** Using the process description solve the integral of  $Pdv$  equation and the 1<sup>st</sup> law equation simultaneously for the final state and then use integral of  $Pdv$  to solve for the boundary work.

**Final State Unknown:** Use the process description along with the 1<sup>st</sup> law equation to fix the final state.

It is uncommon for the initial state to be unknown, but it can be solved for much like the final state is solved for above.

A key aspect to closed system energy problem is the determination of the mass. This should be the first task in solving the problem. The mass can normally be determined from the total volume and the specific volume or

$$m = \frac{V}{v}$$

where the specific volume is normally obtained from the state information for the substance, tables for compressible and incompressible substances or ideal gas law for ideal gases. If a total volume is not provided then it is appropriate to work the problem on a per mass basis.