Question: “What is the difference between thermodynamics and a stick?

Answer: “A stick has two ends and no beginning. Thermodynamics has two ‘beginnings’ (the first and second law) and no end.”

Lecture 2 :- Review of Thermodynamics

Two fundamental assumptions behind thermodynamic treatment of a system.

① Continuum

② Equilibrium (State)

Q:- So what does this mean for a fluid flow?

Define

1. Mechanical equilibrium (P)
2. Thermal " (T)
3. Chemical " (n)

Thermodynamic equillibrium = 1 + 2 + 3

$P = P(v, T)$ Thermal eqⁿ of state

$e = e(v, T)$ Caloric eqⁿ of state

Any functional form that satisfies Reciprocity relations is valid.

Ⓐ Ideal / Perfect gas

Ⓑ Real gas. → High density gases Van-der Waal's equation.

$$p v = R T$$

$$p = \rho R T$$

Gas Constant specific to a gas.

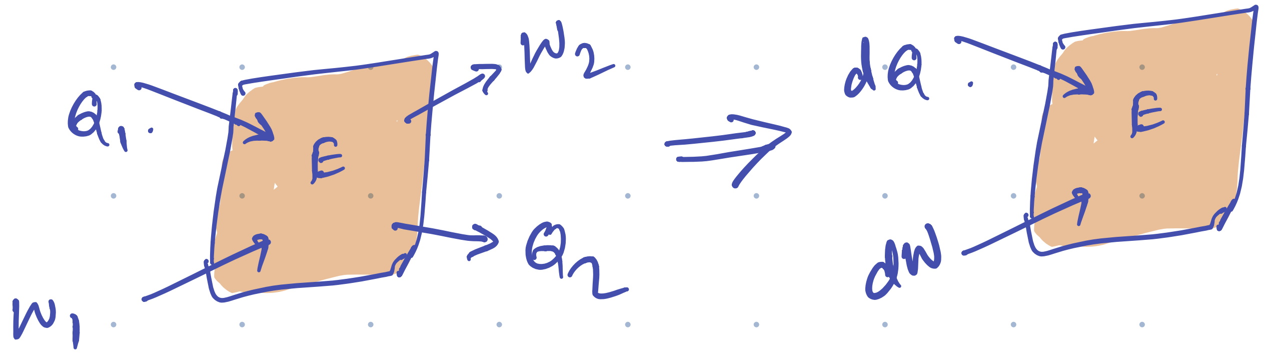
Q: Which model is valid for hypersonic flows?

It can be shown experimentally OR from statistical mechanics that for ideal gas,

$$E = E(T)$$ → Thermally perfect gas

If $E = \text{constant} \cdot T$, then the gas is called calorically perfect gas.

① First law



$$dE = dQ + dW$$

Intensive quantities $\quad de = dq + dw$

RHS → Path variables

LHS → State variable

So now, the question is,

how do I calculate E/e ?

Also,

how do I link Q/q & W/w to state variables?

→ Answer depends on the kind of process we are working with.

First law applied to a reversible process

We know, $de = dq - p\,dv$

& define $c = \dfrac{dq}{dT}$

Specific heat

Since defining c for any two processes will yield c for all processes,

& define, $c_v = \left.\dfrac{dq}{dT}\right|_v$, $c_p = \left.\dfrac{dq}{dT}\right|_p$

For a thermally perfect gas,

$$c_p(T) - c_v(T) = R$$

In addition to E, we define enthalpy (H) as

$$H = E + pV$$

$$h = e + p\vartheta$$

It can be shown that 1st law can be expressed as

$$dh = dq + \vartheta dp$$

Q: $h = h(T)$ under what assumptions? → Thermally ~~pe~~ perfect gas

$h = \text{const.} \cdot T \Rightarrow$ Calorically "

"

Adiabatic reversible $\Longrightarrow$ Isentropic

$$\rho_2/\rho_1 = \left(T_2/T_1\right)^{(1/\gamma-1)}$$

$$p_2/p_1 = \left(T_2/T_1\right)^{(\gamma/\gamma-1)}$$