There fore,

$$\frac{dp}{P} = -\frac{gM}{RT}\,dh$$

$$\therefore \boxed{\frac{dT}{dh} = -\frac{\gamma-1}{\gamma}\frac{gM}{R}}$$

If we plugin the numbers, $\frac{dT}{dh} = 9.7°C/Km$

Observational → $7°C/Km$.

We can apply this to many other systems.

30th Jan 2024

○ Second Law of Thermodynamics →

When we throw a ball up, the ball comes down and has the same velocity but opp direction ⇒ It has the same K.E.

But it can have any direction ⇒ It does not violate Energy conservation that way.

So energy conservation does not give us enough info to fix dynamics of a system.

So, similarly, the first law does not tell us what processes can happen, and what cannot happen.

→ We need the 2nd law to tell us what is feasible and what is not feasible.

(*) A amount of heat energy can never be converted completely to work.

○ Engine :

System operating in cycles that converts heat to work.

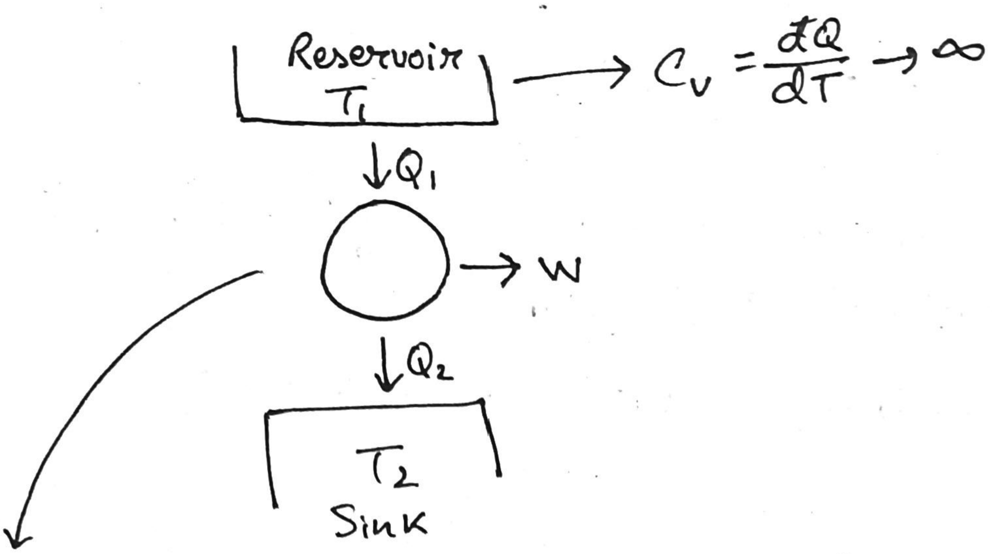
○ Heat Engine :

Q_1 → heat absorbed by system

Q_2 → heat rejected by system.

$W \rightarrow$ work done by engine.

We can think of such an engine as,



After one complete cycle, the system comes back to its original state $\Rightarrow \Delta U = 0$ for each cycle.

$$\Delta U = \Delta Q + \Delta W$$

$$\Rightarrow (Q_1 - Q_2) + W = 0$$

$$\Rightarrow W = -(Q_1 - Q_2)$$

(*) W is $-$ve if $Q_1 > Q_2 \Rightarrow$ System works on surroundings.

$$\eta \equiv \frac{|W|}{Q_1} = 1 - \frac{Q_2}{Q_1} < 1$$

Why can I not make an engine with only one reservoir?

o Convention (follow whatever you like) $\rightarrow$

$$\Delta U = \Delta Q + \Delta W$$

$\Delta Q \equiv +$ve for addition of heat energy to system.

$\Delta W \equiv +$ve for work done on the system.

i.e., +ve if ΔU increases due to it)

Note, $\boxed{\Delta W = -\int p\,dV}$

as, $\Delta W = -p\Delta V$

$= -p(V_f - V_i)$

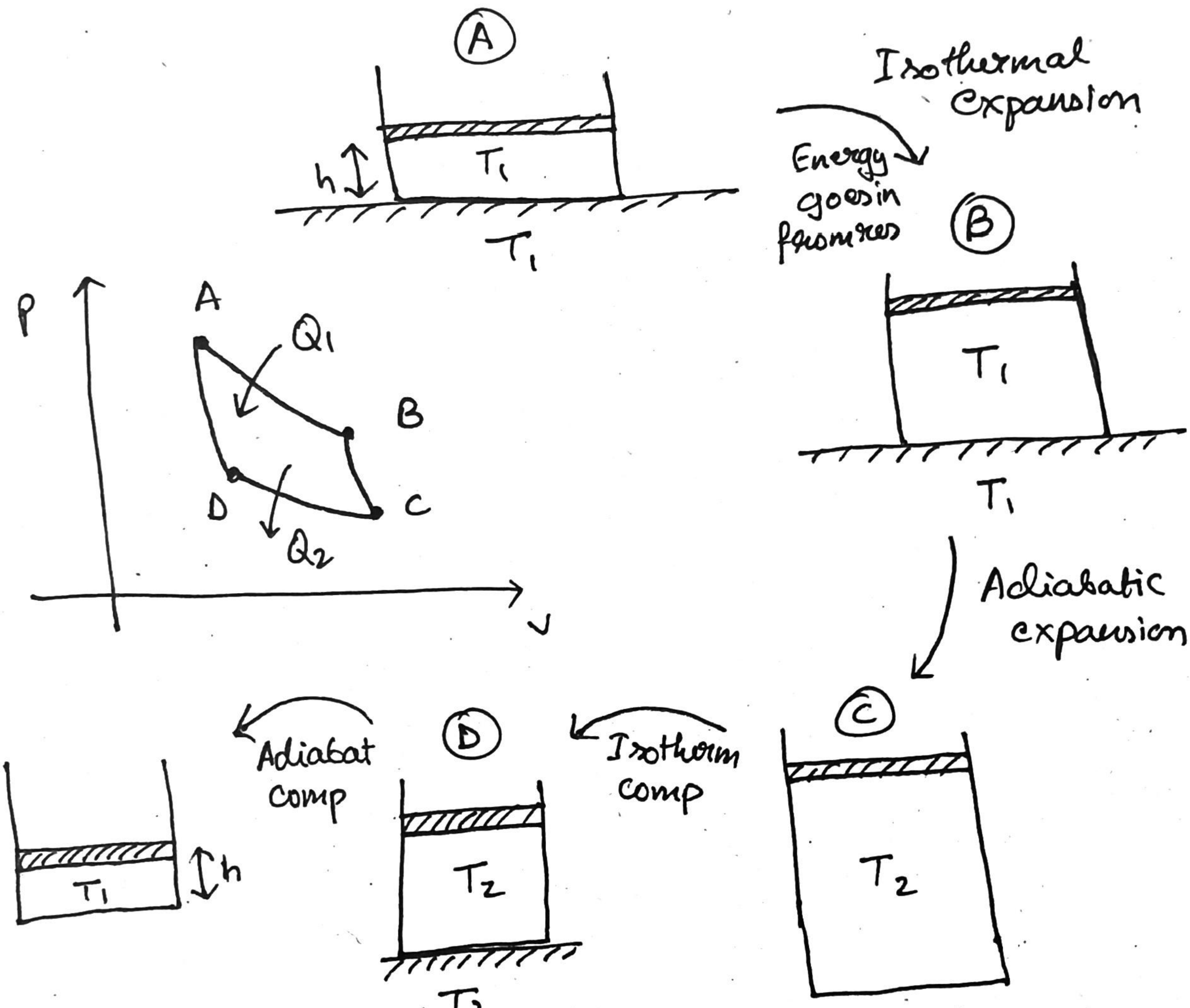
Consistent with the work convention. ← $-ve$ only if compressed, i.e work done on system.

(*) 2nd Law is also strictly empirical.

→ Source reservoir (T_1)

→ Sink reservoir (T_2)

(*) Consider ideal gas



(*) Every step, work is either being done on the system or by the system.

$$W_{Total} = W_1 + W_2 + W_3 + W_4$$

$$Q = Q_1 - Q_2$$

We calculate these so that we can calculate η.

(*) If we are given two reservoirs, ~~and~~ with one being at a higher temp than the other, and we want to construct a reversible engine, it can only be done with two isotherms and two adiabats — this is the Carnot engine.