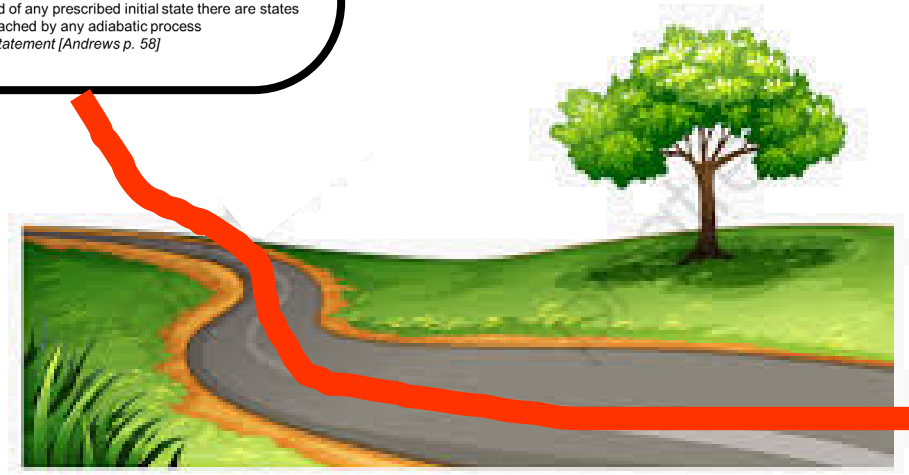
Preface to Lectures 9-10

2nd Law Phenomenological Observations

1. Macroscopic properties of an isolated system eventually assume constant values (e.g. pressure in two bulbs of gas becomes constant; two block of metal reach same T) *[Andrews. p37]*
2. It is impossible to construct a device that operates in cycles and that converts heat into work without producing some other change in the surroundings. *Kelvin's Statement [Raff p 157]; Carnot Cycle*
3. It is impossible to have a natural process which produces no other effect than absorption of heat from a colder body and discharge of heat to a warmer body. *Clausius's Statement, refrigerator*
4. In the neighborhood of any prescribed initial state there are states which cannot be reached by any adiabatic process
   ~ Caratheodory's statement [Andrews p. 58]



$$\Delta S = \int \frac{đq_{rev}}{T}$$

S is state function

$\Delta S_{UNIVERSE} > 0$

disorder

STEP 1: Ideal Gas Carnot cycle (reversible)

efficiency $\varepsilon_{Carnot\_ig} = \frac{\text{(total work done ON SURROUNDINGS)}}{\text{(heat INPUT)}}$

in terms of T_U and T_L of the isothermal steps

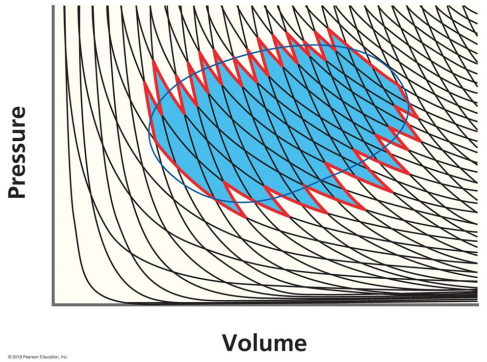
BIG DEAL REAL WORLD MACHINES
DON'T USE IDEAL GASSES !!!

OK, SO

STEP 2: For any Carnot cycle (reversible , any 'working substance' i.e. ideal gas) substance $\varepsilon_{Carnot} = \varepsilon_{Carnot\_ig}$

why: if any reversible Carnot had $\varepsilon_{rev} \neq \varepsilon_{Carnot\_ig}$ it would violate one of the statements of the second law

BIG DEAL MOST MACHINES DON'T OPERATE BETWEEN JUST T_U AND T_L IN THE 4-STAGE CARNOT CYCLE !!!



OK, OK

STEP 3: Any REVERSIBLE CYLIC MACHINE CAN BE CONSTRUCTED AS A SUM OF CARNOT CYCLES

UT OH MAYBE THER IS SOMETHING REAL WORLD ABOUT THIS ε THING, BUT WHAT ABOUT REAL WORLD IRREVERSIBLE MACHINES

OK, OK,OK

STEP 4: $\varepsilon_{rev} \geq \varepsilon_{irrev}$

since an irreversible machine cannot be run 'in reverse' as a heat pump, then coupling the irreversible machine with a reversible heat pump of (greater) ε_{rev} ***will not violate the SECOND LAW of THERMODYNAMICS***

And one more thing we will show:

$$\varepsilon_{rev} = \frac{T_U}{T_U - T_L} = \frac{-w_{sys}}{q_U} \Rightarrow \frac{(q_{rev})_U}{T_U} + \frac{(q_{rev})_L}{T_L} = 0$$

$$\oint \frac{dq_{rev}}{T} = 0 \quad \left[(q_{rev})_{II} = (q_{rev})_{IV} = 0 \text{ for adiabatic steps} \right]$$

do we have a new STATE FUNCTION ??

end of PREFACE

to

lectures 9–10