Tomorrow: Review of material in Chapters 5, 6, 7 (in style of pre-midterm summary)

HEAT & WORK – not examinable, but useful

First Law of Thermodynamics

$$dU = \tau d\sigma - pdV + \mu dN$$

"Heat" $\quad "đQ" \equiv \tau d\sigma$

"Work" $\quad "đW" = pdV - \mu dN$

then $dU = "đQ" - "đW"$

Q: Why do I put quotes around & crosses on these?

A: Because they are not d of anything!

Math language: not exact differentials

(e.g. $d("đQ") = d(\tau d\sigma) = d\tau \wedge d\sigma \neq 0$)

Physics language: path-dependence of integrals

Physics -

$\int$"dQ" is not a sensible function -

it depends on the path in configuration space

$\int$"dW" is similarly ill-defined.

It was amazing in history to people who didn't have benefit of 20-20 hindsight that

(a) $dU =$ "dQ" $-$ "dW" is a state function!

(b) $d\sigma = \frac{\text{"}dQ\text{"}}{T}$ - in other words, that the temperature is an integrating factor for the heat!

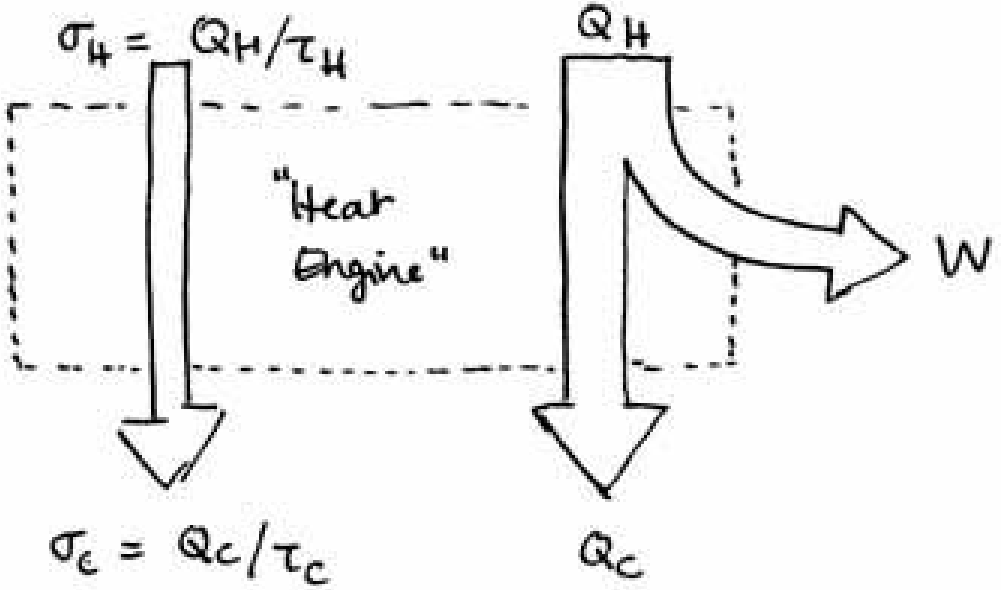
Principles regarding heat and work

(1) All forms of work are convertible between each other. This does not affect entropy.

(2) Work can be completely converted into heat - this is OK because entropy increases.

(3) Heat cannot be completely converted into work - what happens to the entropy? It can't build up... have to shed entropy (in a cyclic device)

Solution: put more heat in to start with at temperature T_H and eject entropy at $T_C < T_H$:



Work $W = Q_H - Q_C$

$$= Q_H - \frac{T_C}{T_H} Q_H = Q_H \left[1 - \frac{T_C}{T_H}\right]$$

$$\eta_C \equiv \left(\frac{W}{Q_H}\right)_{\text{reversible}} = 1 - \frac{T_C}{T_H} < 1$$

↑ Carnot Efficiency

⇒ No Such Thing As Perpetual Motion Machine

↑ since by 3rd law can never get to $T_C = 0$ via physical process

- (Fridges are heat engines "operating in reverse" - see text)

Real engines typically have significantly lower efficiency than Carnot, partly due to losses going irreversibly to friction, etc.

Car Gasoline engines about 10%...

- Carnot Cycle -
  2 isotherms
  & 2 adiabats.

ETC.