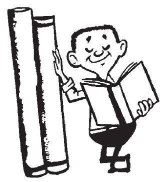
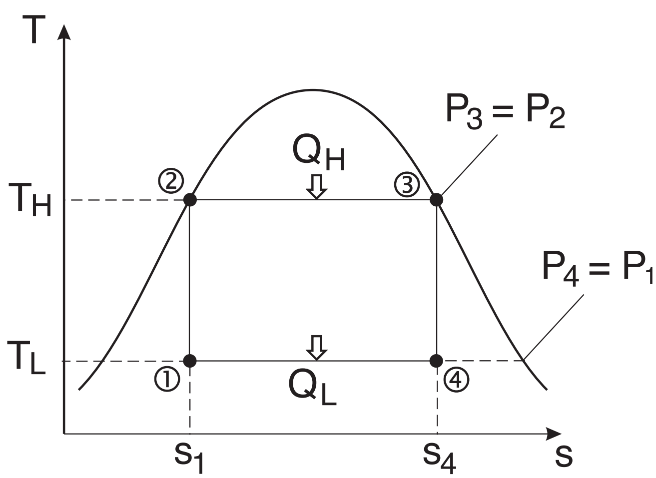
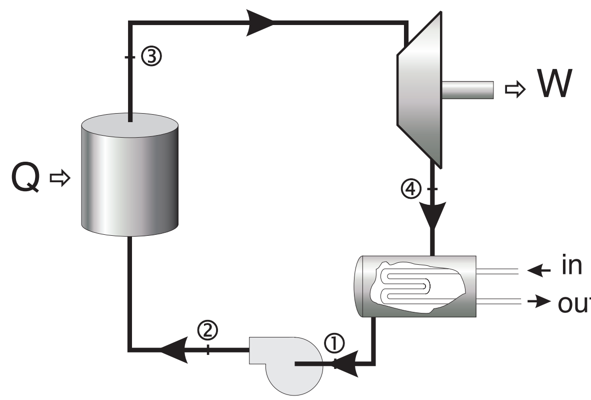
Carnot Cycle



Reading	Problems
8-2, 9-1	

- an ideal theoretical cycle that is the most efficient conceivable
- based on a fully reversible heat engine - it does not include any of the irreversibilities associated with friction, viscous flow, etc.
- in practice the thermal efficiency of real world heat engines are about half that of the ideal, Carnot cycle





Process	State Points	Description
Pump	$1 \longrightarrow 2$	isentropic compression from $T_L \longrightarrow T_H$ to return vapour to a liquid state
Heat Supply	$2 \longrightarrow 3$	heat is supplied at constant temperature and pressure
Work Output	$3 \longrightarrow 4$	the vapour expands isentropically from the high pressure and temperature to the low pressure
Condenser	$4 \longrightarrow 1$	the vapour which is wet at 4 has to be cooled to state point 1

Cycle Efficiency

- defined as the net work output divided by the gross heat supplied

$$\begin{aligned} \eta &= \frac{W_{net}}{Q_H} \\ &= \frac{Q_H - Q_L}{Q_H} \\ &= 1 - \frac{T_L}{T_H} \end{aligned}$$

From the figure the gross heat supplied is

$$Q_H = area(s_1 \rightarrow s_4 \rightarrow 3 \rightarrow 2 \rightarrow s_1) = T_H(s_4 - s_1)$$

The net work output is

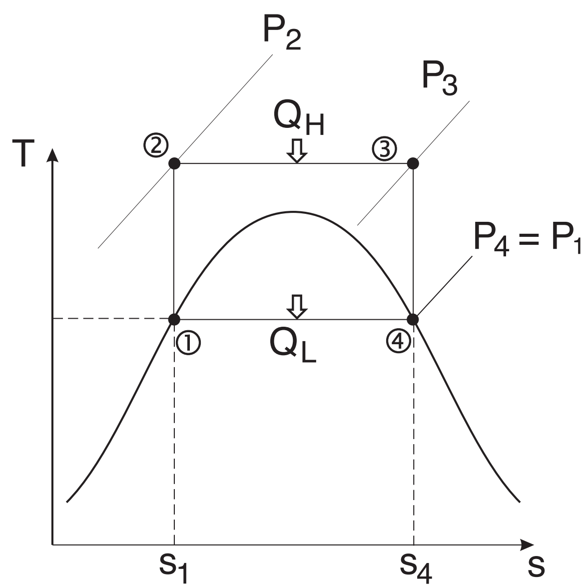
$$Q_H - Q_L = area(1 \rightarrow 4 \rightarrow 3 \rightarrow 2) = (T_H - T_L)(s_4 - s_1)$$

Therefore the Carnot efficiency is

$$\eta = \frac{(T_H - T_L)(s_4 - s_1)}{T_H(s_4 - s_1)} = 1 - \frac{T_L}{T_H}$$

Practical Problems

- at state point 1 the steam is wet at T_L and it is difficult to pump water/steam (two phase) to state point 2
- the pump can be sized smaller if the fluid is 100% liquid water
- the pump is smaller, cheaper and more efficient
- can we devise a Carnot cycle to operate outside the wet vapour region



  - between state points 2 and 3 the vapour must be isothermal and at different pressures - this is difficult to achieve
  - the high temperature and pressure at 2 and 3 present metallurgical limitations

The net effect is that the Carnot cycle is not feasible for steam power plants.