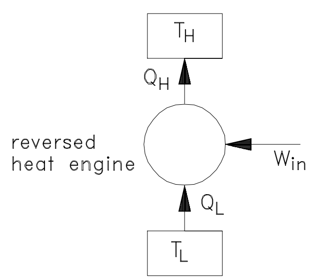
Week 5: Lecture 1

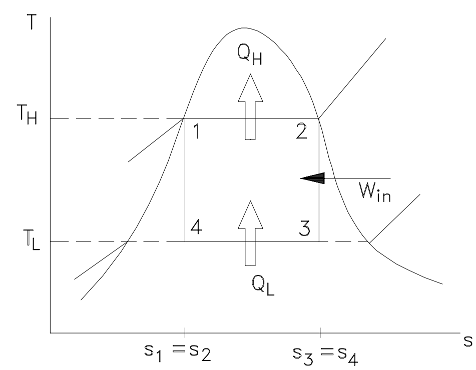
Refrigeration Cycle

A refrigeration system removes thermal energy from a low-temperature region and transfers heat to a high-temperature region.

The Carnot cycle can serve as the initial model of the ideal refrigeration cycle.

- operates as a reversed heat cycle engine
- transfer a quantity of heat, Q_L from a cold source at temperature, T_L





where:

$$
\begin{aligned}
Q_L &= T_L(s_3 - s_2) \\
Q_H &= T_H(s_4 - s_1) \\
W_{in} &= Q_{net} \\
&= (T_H - T_L)(s_3 - s_2)
\end{aligned}
$$

Coefficient of Performance

$$COP = \frac{benefit}{cost}$$

$$COP_{refrig} = \frac{Q_L}{W_{in}} = \frac{1}{\dfrac{T_H}{T_L} - 1} = \frac{T_L}{T_H - T_L}$$

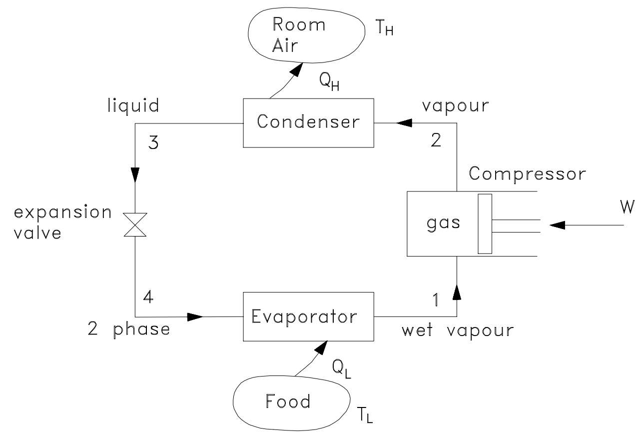
$$COP_{heat\ pump} = \frac{Q_H}{W_{in}} = \frac{1}{1 - \dfrac{T_L}{T_H}} = \frac{T_H}{T_H - T_L}$$

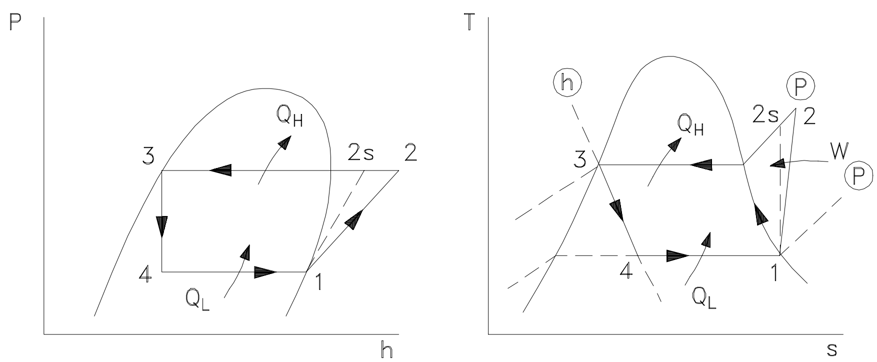
Week 5: Lecture 1

Vapour Compression Refrigeration Cycle

Assumptions for Ideal VCRC

- irreversibilities within the evaporator, condenser and compressor are ignored
- no frictional pressure drops
- refrigerant flows at constant pressure through the two heat exchangers
- stray heat losses to the surroundings are ignored
- compression process is isentropic





1-2s:	isentropic compression of the refrigerant
2s-3:	heat transfer from the refrigerant as it flows at constant pressure through the condenser
3-4	throttling process from state 3 to a two phase liquid-vapour mixture at state 4
4-1	heat transfer to the refrigerant as it flows at constant pressure through the evaporator

Common Refrigerants

R12	- CCl_2F_2 - dichlorofluoromethane
R22	- $CHClF_2$ - has less chlorine, a little better for the environment
R134a	- $C_2H_2F_4$ - tetrafluorethane - no chlorine
Ammonia	- NH_3 - corrosive and toxic

How to Choose a Refrigerant

- the heat of vaporization of the refrigerant should be high. The higher h_{fg}, the greater the refrigerating effect per kg of fluid circulated
- the specific heat of the refrigerant should be low. The lower the specific heat, the less heat it will pick up for a given change in temperature during the throttling or in flow through the piping, and consequently the greater the refrigerating effect per kg of refrigerant
- the specific volume of the refrigerant should be low to minimize the work required per kg of refrigerant circulated
- the cirtical temperature of the refrigerant should be higher than the condesning pressure to prevent excessive power comsumption
- since evaporation and condenser temperatures are fixed by the temperatures of the surroundings - selection is based on operating pressures in the evaporator and the condenser
- selection is based on the suitability of the pressure-temperature relationship of the refrigerant
- other factors include:
  - chemical stability
  - toxicity
  - cost
  - environmental friendliness
  - does not result in very low pressures in the evaporator (air leakage)
  - does not result in very high pressures in the condenser (refrigerant leakage)