

$$\text{Efficiency, } \eta = \frac{W}{Q_s}$$

where  
 $W$  - work done  
 $Q_s$  - heat supplied

$$W = Q_s - Q_r$$

$$\therefore \eta = \frac{Q_s - Q_r}{Q_s} = 1 - \frac{Q_r}{Q_s}$$

$$= \frac{T_H - T_L}{T_H} = 1 - \frac{T_L}{T_H}$$

$$\text{COP} = \frac{Q_r}{W}$$

$$= \frac{Q_r}{Q_s - Q_r}$$

$$= \frac{T_L}{T_H - T_L}$$

$$\text{COP (HP)} = \frac{Q_s}{W}$$

$$= \frac{Q_s}{Q_s - Q_r}$$

$$= \frac{T_H}{T_H - T_L}$$

$$= \frac{T_H}{T_H - T_L}$$

$$= \frac{T_L}{T_H - T_L}$$

Corollaries of the Second law of Thermodynamics.

The statements which can be proved with help of reversible cycles are corollaries of the Second law of thermodynamics

Corollary I

It is impossible to construct a system which will operate in a cycle and transfer heat from a cooler to a hotter body without supplying work on the system by surroundings.

Corollary II

An engine operating between two heat reservoirs cannot have higher efficiency than that of a reversible engine operating between the same heat reservoirs.

Corollary III

All reversible engines operating between the same two reservoirs have the same efficiency.

Corollary IV

The efficiency of any reversible engine operating between more than two reservoirs must be less than that of reversible engine operating b/w two reservoirs which have equal temperature.

# Reversibility

In Reversible process when the same process is reversed, it attains the initial state by a path in the same manner as that of process. The work is reversible work or maximum work or ideal work.

# Irreversibility

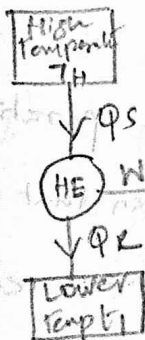
If any process is reversed it does not follow the same path as original process. It produces a change and path traced is different. Therefore the work is called irreversible work.

## Causes of irreversibility

- (i) Lack of equilibrium
- (ii) Heat transfer through a finite temperature difference
- (iii) Lack of pressure equilibrium
- (iv) Free expansion
- (v) Dissipative effects.

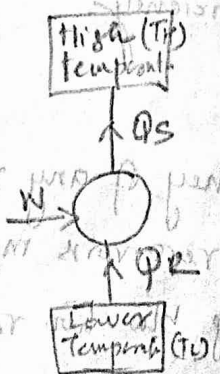
## Heat engine

Heat engine is a device which operates in thermodynamic cycle and produces work by supplying heat from hot reservoir.



## Refrigerator

It is used to remove heat from a cold system. It is used to maintain the temp below the surroundings.



## Heat pump

It is used to supply heat to a hot system. Maintain temperature higher than surroundings.

