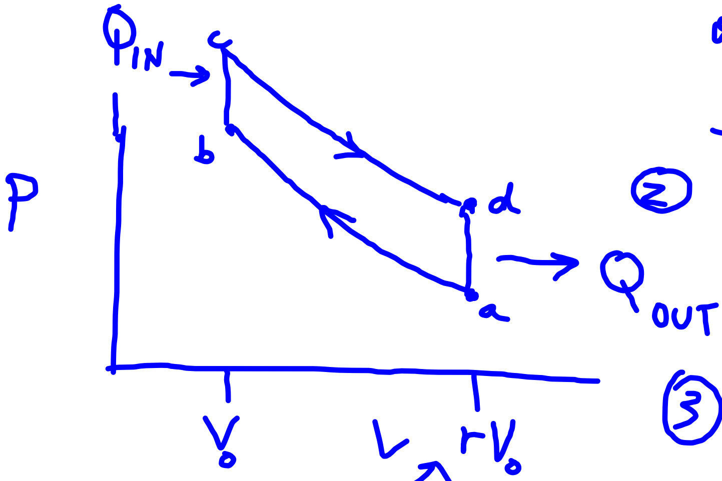
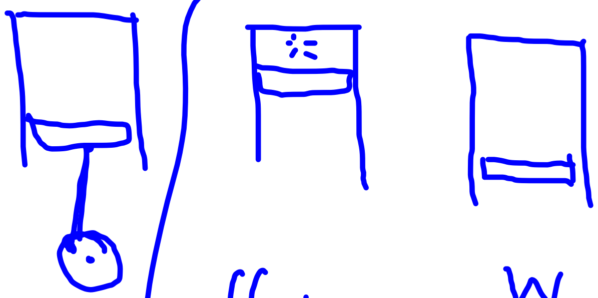
Internal Combustion Engines

Otto Cycle





① Adiabatic compression of fuel-air mixture to higher pressure

② Heat added by spark-plug initiated burning of gasoline

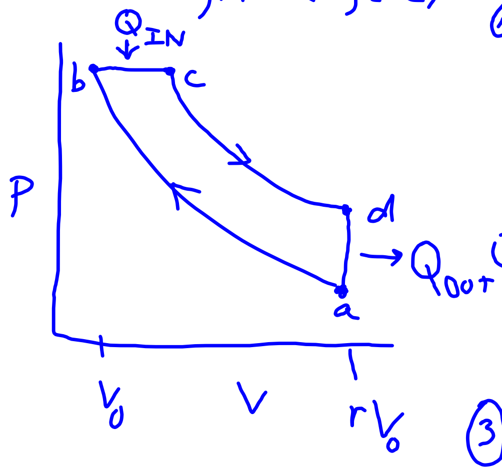
③ Power stroke. Piston expands and does work

④ Heat lost to environment as expanded piston loses heat

$$\text{efficiency} = \frac{W}{Q_{IN}}$$

r = compression ratio (~8 for cars)

Diesel Engine (cycle)



① (a→b) Compression stroke air compressed to high pressure & temperature. No fuel in cylinder.

② (b→c) Heat added as fuel is injected and begins to burn due to high temp

③ (c→d) Power stroke. Engine does work as cylinder expands

④ Cylinder cools giving off heat to environment (d→a)

Advantage over the otto cycle — No "knocking" (premature ignition of fuel). So higher compression ratios are possible.

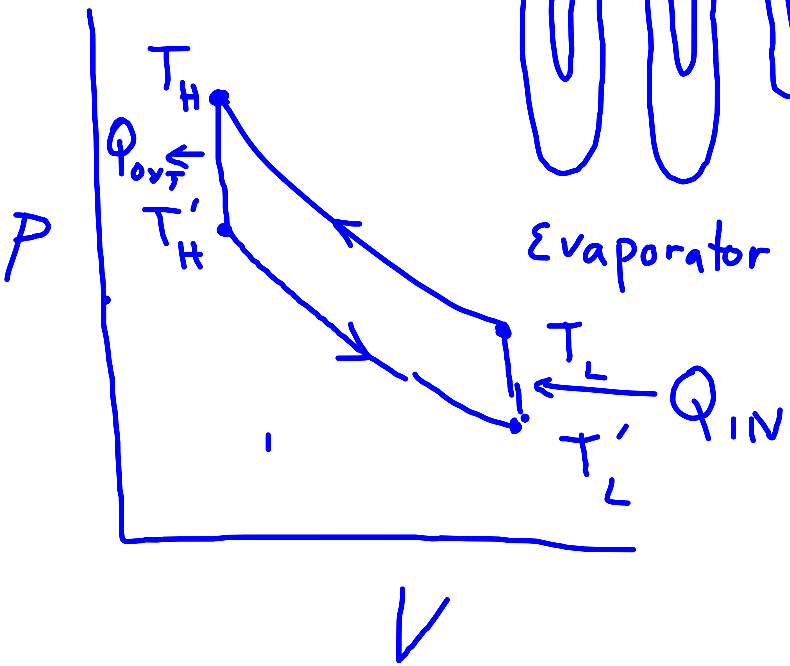
$r \approx 15\text{-}20$

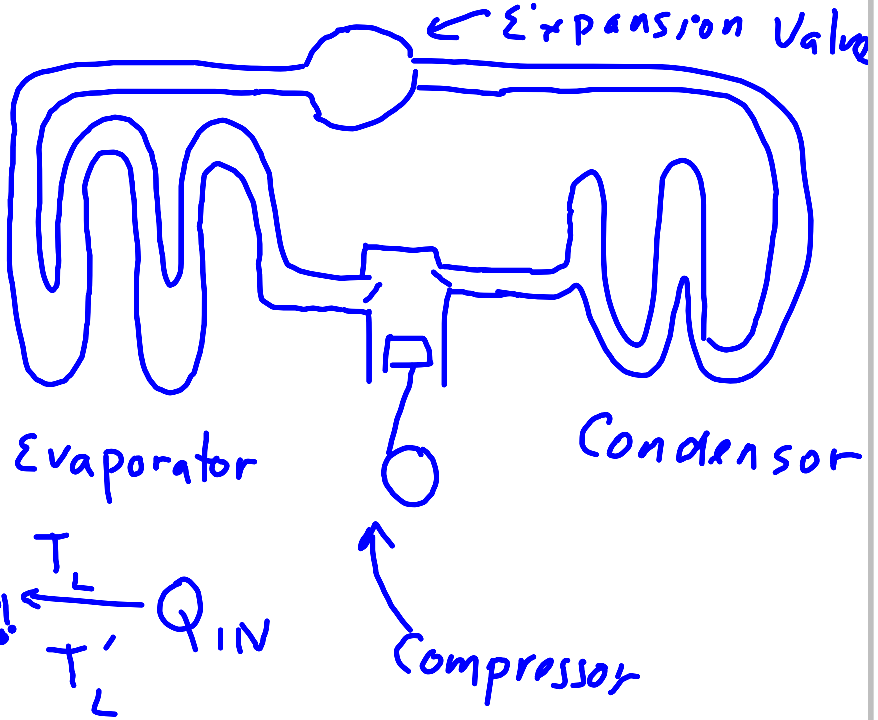
↑ requires large cylinder

⇒ large engine.

[best used for trucks, buses]

Refrigerator





$T_H > T_{OUTSIDE}$ ($\leq T_H'$

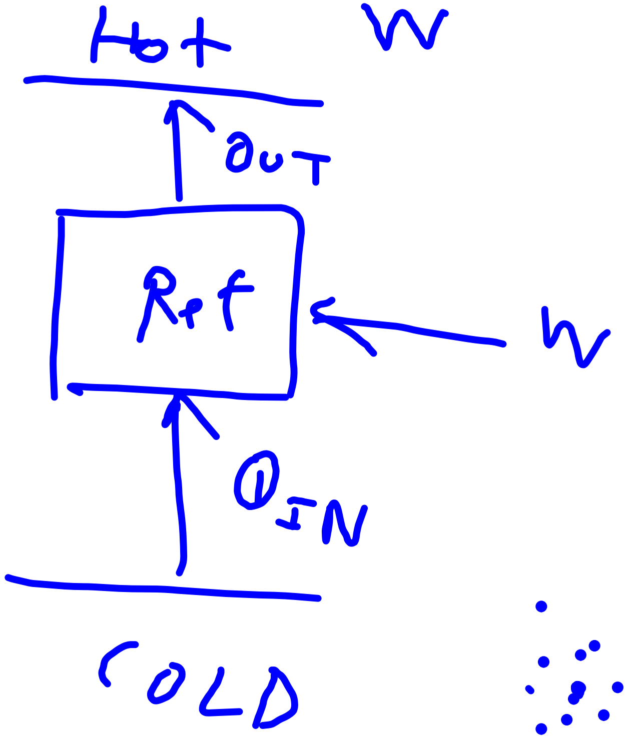
$T_L' < T_{INSIDE}$ ($\geq T_L$

Refrigerator requires INPUT of mechanical work.

[Heat engine delivers OUTPUT of mechanical work]

Performance of Fridge

$$\text{perf} = \frac{Q_{IN}}{W}$$



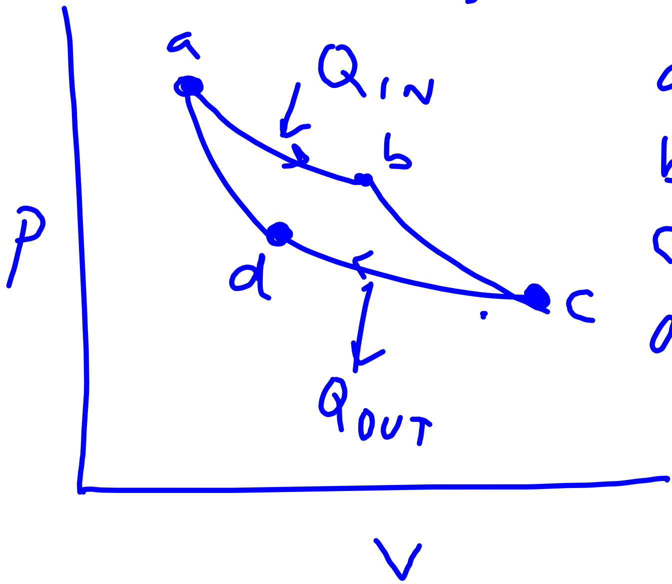
2nd Law:

perf cannot be infinite

i.e. $W > 0$

Most Efficient Engine Possible

Carnot Engine



a-b: isothermal
b-c: adiabatic
c-d: isothermal
d-a: adiabatic

$Temp_{a-b} = T_H$

$Temp_{c-d} = T_C$

efficiency: $e = 1 - \frac{T_C}{T_H}$

$$\frac{Q_{OUT}}{Q_{IN}} = \frac{-T_C}{T_H}$$