Boundary Work: 1st TD Law on closed system

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Work, heat & Energy in Thermodynamics

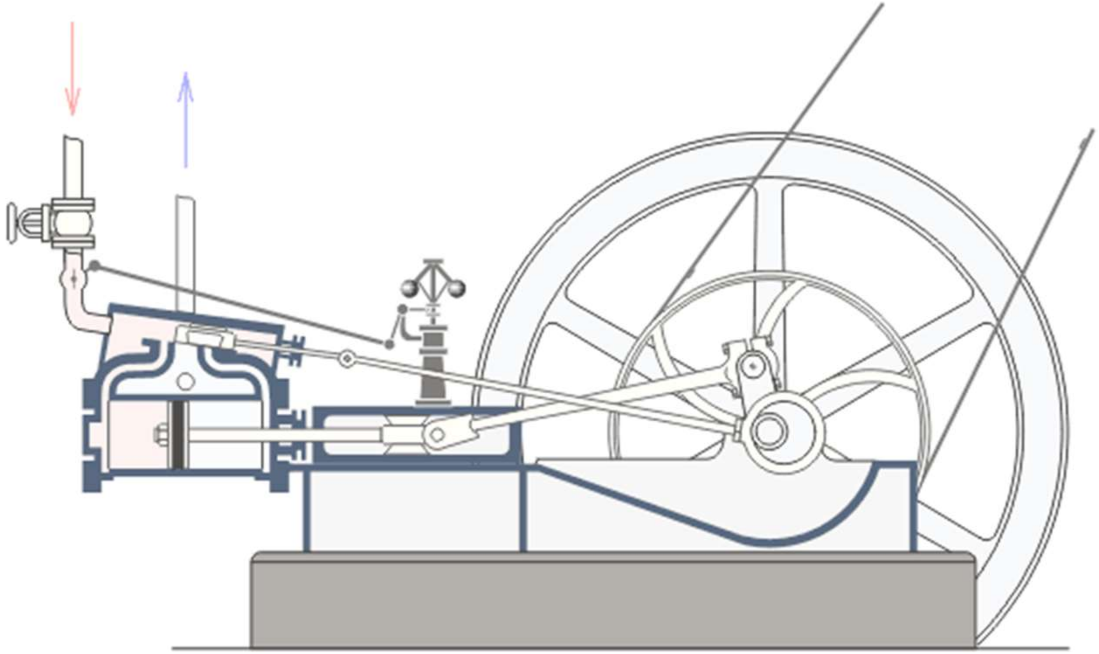
- Generalizing work-energy theorem and conservation of energy beyond mechanics, sign conventions, exact & inexact differentials

$$\Delta U = Change\ in\ Internal\ Energy\ U = Heat\ \&\ work\ exchange = q - W$$

$$\Delta E = \Delta U + \Delta \mathrm{KE} + \Delta \mathrm{PE}$$

- Impossibility of perpetual motion machines 

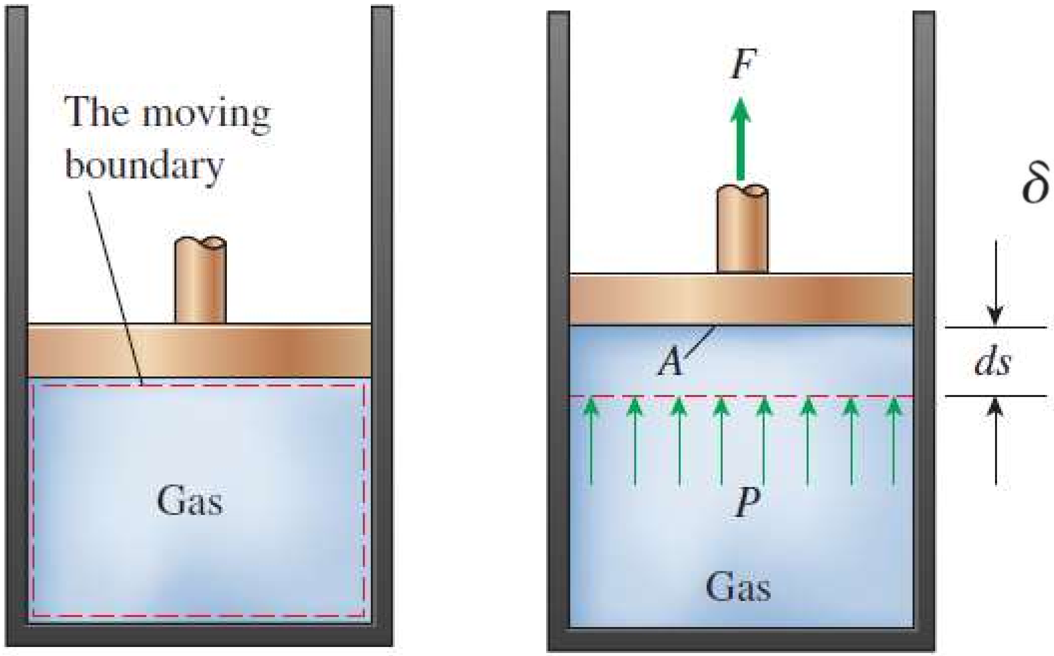
Pistons are coupled to engines and compressors…



- Cyclic linear motion of the piston→ Rotatory motion
- Quasi-static vs. real processes
- Bounds: Work output maximum and minimum work input

https://en.wikipedia.org/wiki/Reciprocating_motion

Moving boundary: PdV work



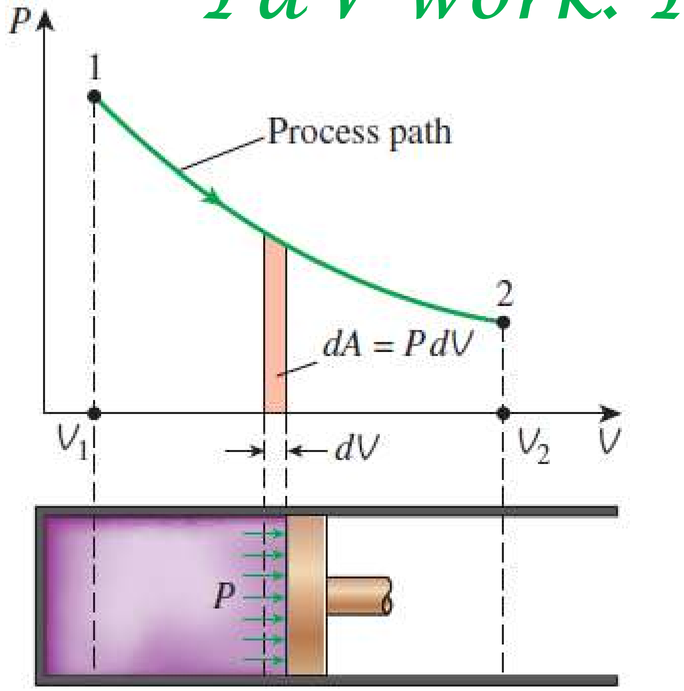
$$\delta W_b = F\,ds = PA\,ds = P\,dV$$

$$W_b = \int_1^2 P\,dV \qquad \text{(kJ)}$$

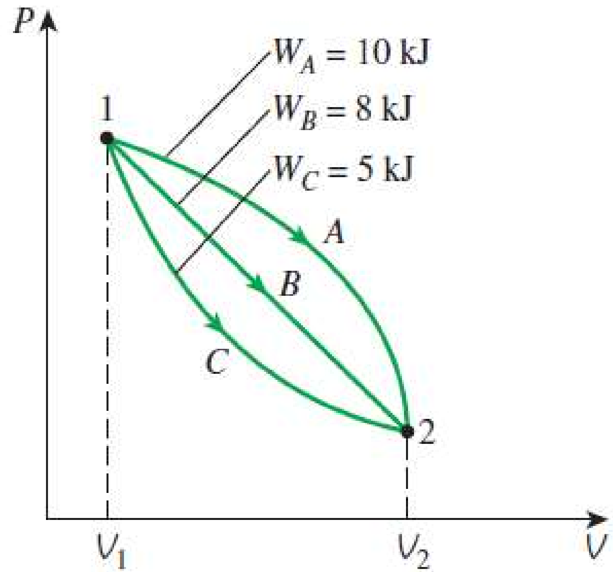
- Quasi equilibrium
- $\Delta \boldsymbol{U}$=q-W
- W_e is positive $\rightarrow$ for expansion
- W_c is negative $\rightarrow$ for compression

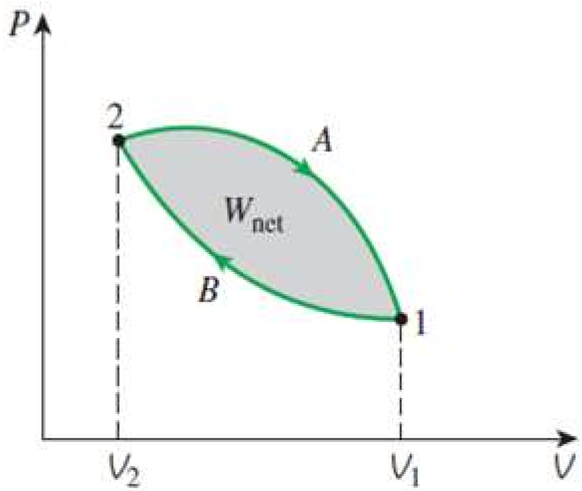
Figs: Cengel & Boles: TD

PdV work: Path/Inexact differential



$$\text{Area} = A = \int_1^2 dA = \int_1^2 P\, dV$$

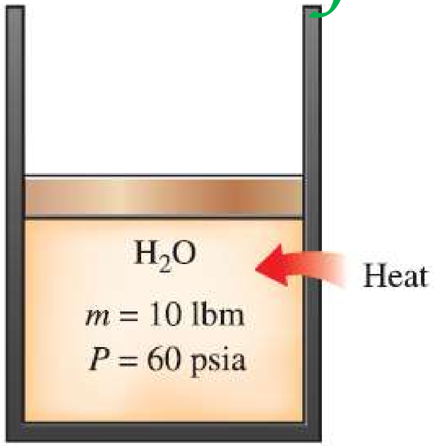


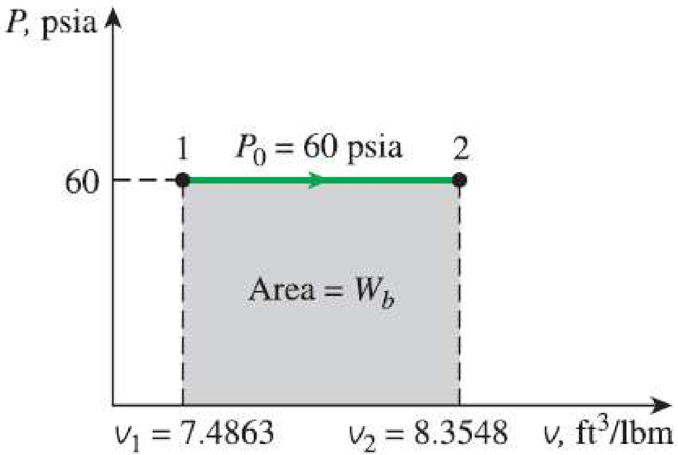


- Net work in a cycle=Work done (by system-on system)
- If work were not a path fxn, No net work is possible from cyclic processes!

Figs: Cengel & Boles: TD

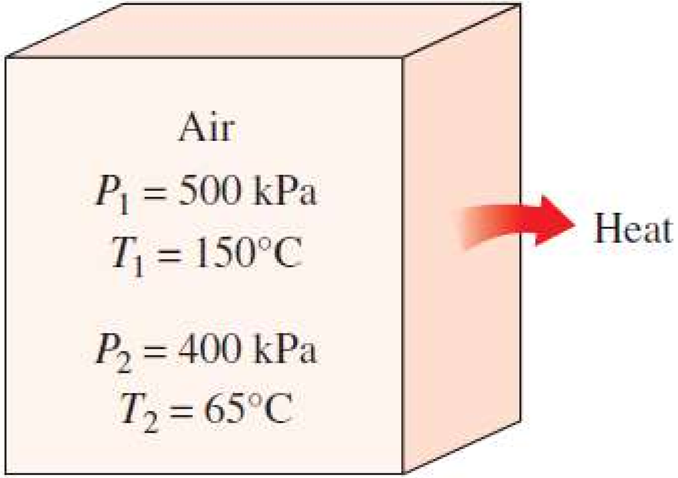
Boundary work: Constant P & V processes

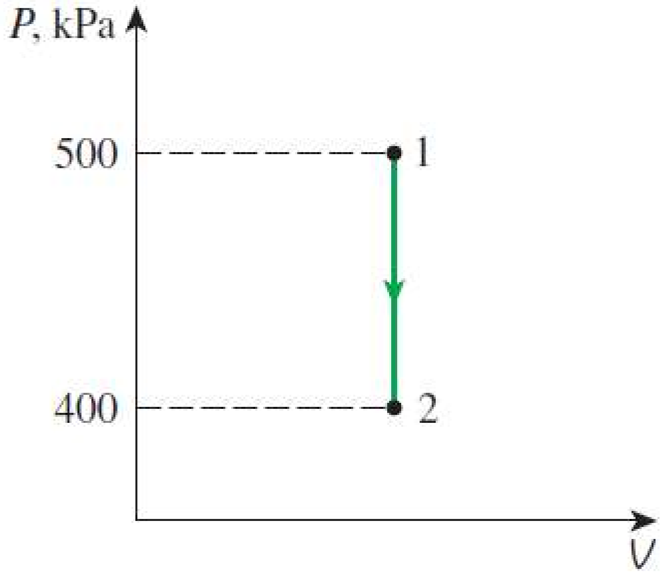




$$W_b = \int_1^2 P\,dV = P_0 \int_1^2 dV = P_0(V_2 - V_1)$$

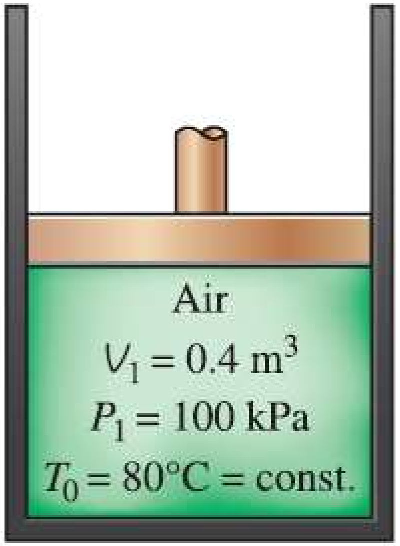
$$W_b = mP_0(v_2 - v_1)$$





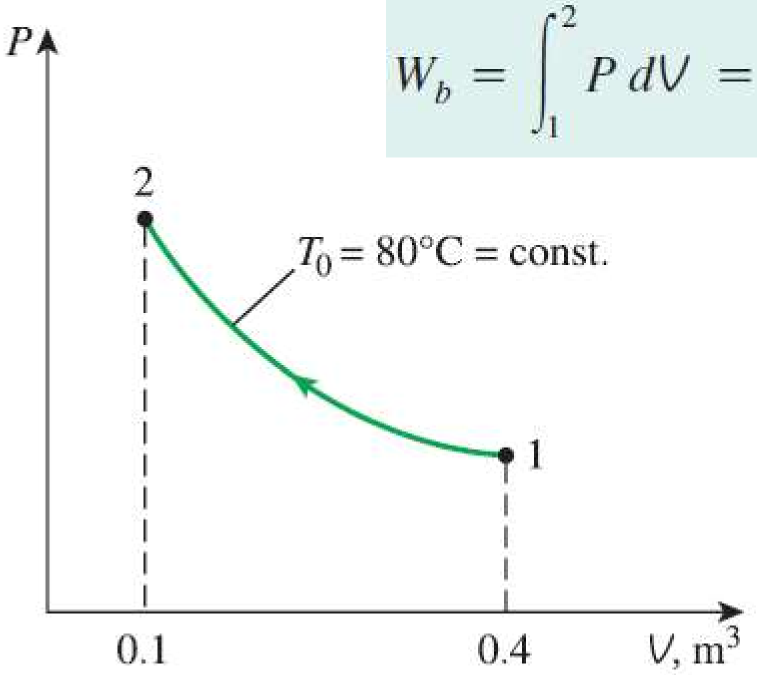
Figs: Cengel & Boles: TD

Boundary work: Isothermal compression process



$$PV = mRT_0 = C \quad \text{or} \quad P = \frac{C}{V}$$

$$W_b = \int_1^2 P\,dV = \int_1^2 \frac{C}{V} dV = C \int_1^2 \frac{dV}{V} = C \ln \frac{V_2}{V_1} = P_1 V_1 \ln \frac{V_2}{V_1}$$



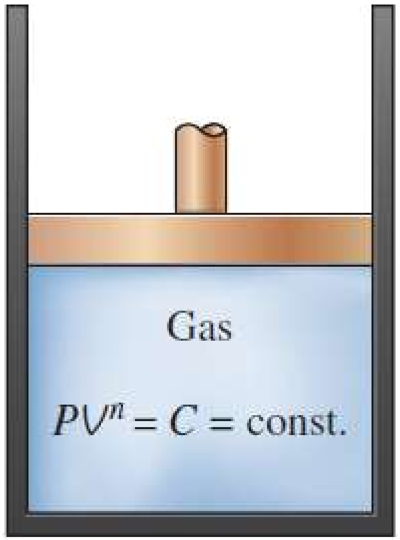
Figs: Cengel & Boles: TD

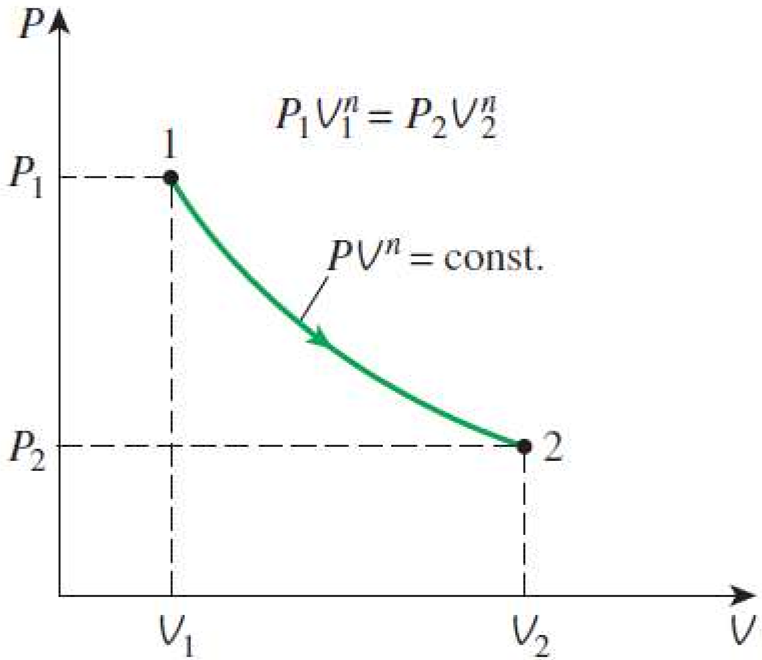
Boundary work: Polytropic process

$$PV^n = C, \qquad P = CV^{-n}$$

$$W_b = \int_1^2 P\,dV = \int_1^2 CV^{-n}\,dV = C\frac{V_2^{-n+1} - V_1^{-n+1}}{-n+1} = \frac{P_2V_2 - P_1V_1}{1-n}$$

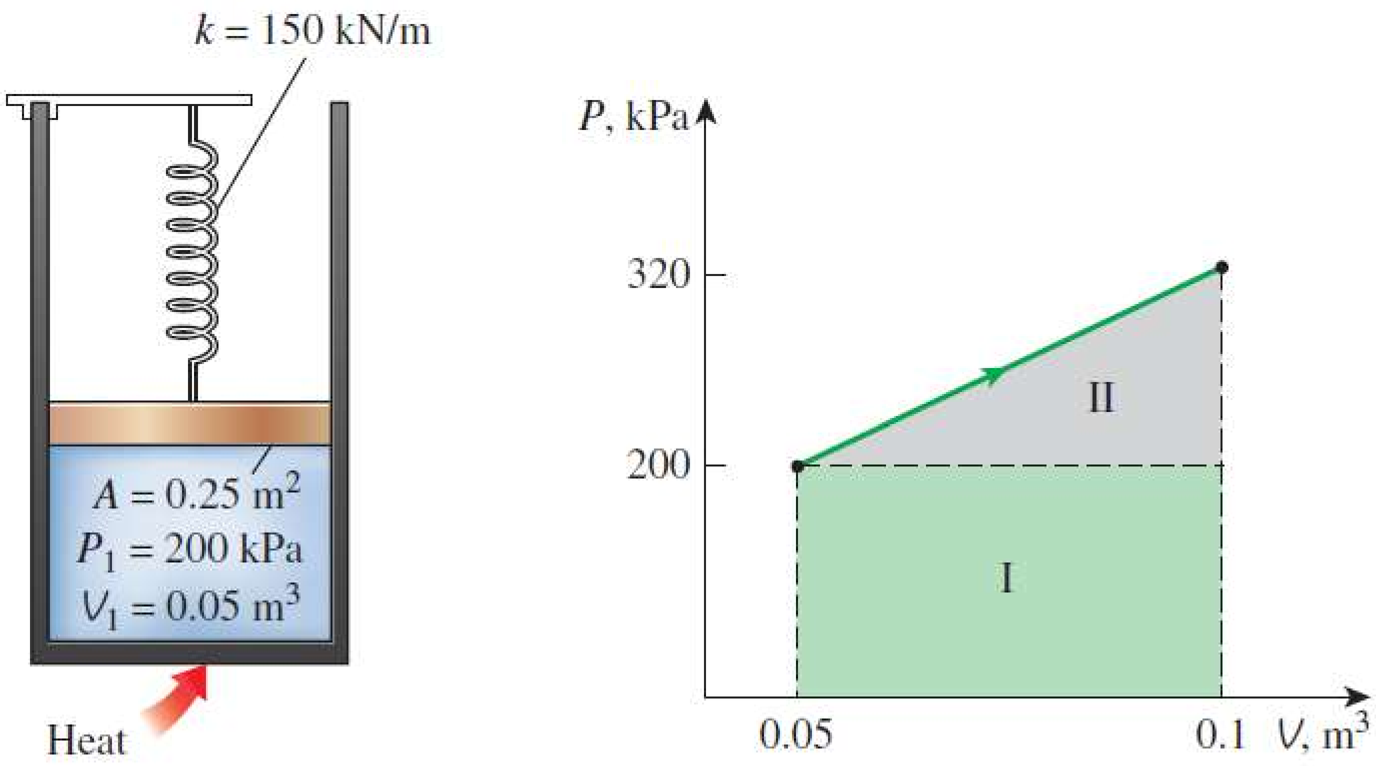
$$W_b = \frac{mR(T_2 - T_1)}{1-n}$$ For ideal gas





Figs: Cengel & Boles: TD

Expansion against spring



Figs: Cengel & Boles: TD