

consider the entire chamber as the control volume. No heat transfer

$$\text{change in total internal energy} = \text{work done on fluid}$$

pressure raises weight W through height L

$$W = P_f A$$

$$\text{work done on fluid} = -P_f AL = -P_f V_{cyl}$$

$$e_f V_f P_f - e_i V_i P_i = -P_f V_{cyl}$$

$$C_v T_{cyl f} V_{cyl} P_f - C_v T_i V_c P_i = -P_f V_{cyl}$$

\uparrow initial energy only due to fluid in left chamber
 \uparrow final energy split between chamber and cylinder.

use

$$P_f = \rho_f R T_{cyl f} \quad P_f = \rho_{cf} R T_{cf}$$

$$P_i = \rho_i R T_i$$