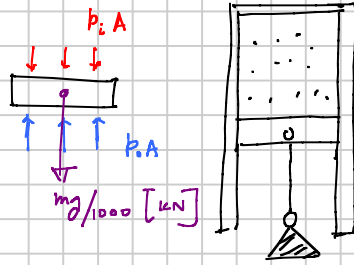


Quiz - 1 (online)

FBD of piston :



A vertical force balance (no accel) produces

$$p_i A + \frac{mg}{1000} = p_o A$$

$$\begin{aligned} \Rightarrow m &= (p_o - p_i) A * 1000 / g \\ &= (100 - 50) * \frac{\pi (0.05)^2}{4} * \frac{1000}{9.81} \\ &= 10 \text{ kg} \end{aligned}$$

Finding p & v

are trivial since m & A were supplied

Quiz - 2

#1

180 Calorie in a food label means

$$180 * 4.187 \text{ kJ} \quad \left[\begin{array}{l} \text{Calorie means bio Calorie} \\ = 1 \text{ kcal} \end{array} \right]$$

$$\Rightarrow 42 \text{ g releases } 180 * 4.187 \text{ kJ} \approx 4.2 \text{ kJ}$$

$$1 \text{ kg " } \frac{180 * 4.187 * 1000}{42} = 17.94 * 10^3 \text{ kJ}$$

Heating value of granola bar = 17.94 MJ Ans

From table heating value of gasoline = 47.3 MJ

$$\text{We will need to burn } \frac{47.3}{17.94} = 2.637 \text{ kg}$$

$$\text{of granola bar or } \frac{2.637}{(42/1000)} \approx \text{63 bars} \quad \text{Ans}$$

to get the same amount of heat.

#2.

$$\begin{aligned} \dot{m} &= \rho A V \\ &= \frac{\rho A V}{V} \end{aligned}$$



$$\Rightarrow v = \frac{AV}{\dot{m}}$$

$$= \frac{\pi (0.05)^2}{4} \times \frac{50}{0.2} \frac{\text{m}^3}{\text{kg}}$$

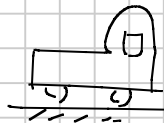
$$= 0.49 \frac{\text{m}^3}{\text{kg}}$$

$$\dot{V} = AV \left[= \frac{\text{m}^3}{\text{s}} \right] = \frac{\pi (0.05)^2}{4} \times 50 \frac{\text{m}^3}{\text{s}}$$

$$= 0.098 \frac{\text{m}^3}{\text{s}}$$

#3

$$KE = \frac{mV^2}{2000} \text{ kJ}$$



$$= \frac{20,000 \times (70 \times 0.447)^2}{2000} \text{ kJ} \quad \left[\begin{array}{l} \text{Using TEST} \\ \text{Unit Converter} \end{array} \right]$$

$$= 9790.6 \text{ kJ}$$

$$= 9.79 \text{ MJ}$$

(b) 50% of KE will be stored

$$\therefore \text{Stored energy} = 0.5 \times 9.79 = 4.89 \text{ MJ}$$

$$= 4.89 \times 0.277 = 1.354 \text{ kWh}$$

#3.

N_2 :

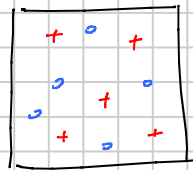
$$m = 14 \text{ kg}$$

(a)

$$\bar{M} = 28 \text{ kg/kmol}$$

\therefore

$$n = \frac{m}{\bar{M}} = 0.5 \text{ kmol}$$



(b)

$H_2 + N_2$:

$$n = 0.5 + 1 = 1.5 \text{ kmol}$$

(c)

$$m = 14 + n_{H_2} \bar{M}_{H_2} = 14 + 2 = 16 \text{ kg}$$

$$\Rightarrow \bar{M} = \frac{m}{n} = \frac{16}{1.5} = 10.67$$

Quiz - 3

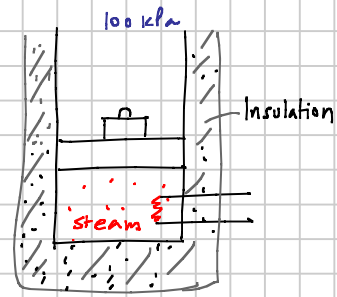
#3

$$(a) \quad v_1 = \frac{V_1}{m_1} = 0.712 \frac{\text{m}^3}{\text{kg}}$$

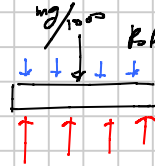
$$\text{Final volume} = 2 V_1$$

$$\text{Final mass } m_2 = m_1$$

$$\Rightarrow \text{Final sp. vol} = \frac{2 V_1}{m_1} = 2 v_1 = 1.424 \frac{\text{m}^3}{\text{kg}}$$



(b) A FBD of the piston produces:



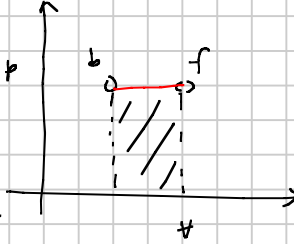
$$pA = p_0 A + \frac{mg}{1000} \quad [\text{kN}]$$

$$\Rightarrow m = \frac{(p - p_0) A \times 1000}{g} = \frac{(300 - 100) \pi (0.2)^2 \times 1000}{4 \times 9.81}$$

$$= \underline{640.5 \text{ kg}} \quad \underline{\text{Ans}}$$

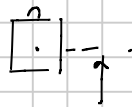
(c) $W_g = \int_b^f p dx$

= area of the rectangle as the pressure remains constant.




$$= 300 \times (2 - 1) = \underline{300 \text{ kJ}} \quad \underline{\text{Ans}}$$

(d) The weight is pushed upward by a distance of



$$\frac{\Delta V}{A} = \frac{1}{\pi \cdot 2^2 / 4} = 31.8 \text{ m}$$

The work done $W = \int F dx$



$$= \frac{mg}{1000} \times \Delta x$$

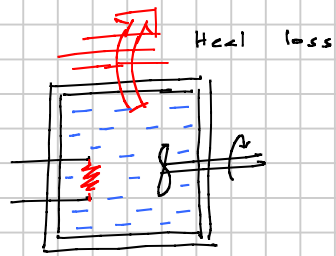
$$= \frac{640.5 \times 9.81}{1000} \times 31.8 = \underline{200 \text{ kJ}} \quad \underline{\text{Ans}}$$

(e) Since steam temperature increases, it must be receiving more energy from heater than it is delivering through boundary work (300 kJ). So my pick is 1300 kJ. Ans

Please work through this problem carefully. You will learn a lot of thermo just from this single problem. Ask yourself, if steam does 300 kJ of work, & the weight needs only 200 kJ, then what happens to the difference? After all, energy cannot be created or destroyed.

#2.

$$\begin{aligned} \text{(A)} \quad |\dot{W}_{sh}| &= 2\pi n T \\ &= 2\pi \frac{1000}{60} \frac{100}{1000} \text{ kN}\cdot\text{m} \\ &= \frac{2\pi \times 10}{6} \text{ kJ} \\ &= 10.47 \end{aligned}$$



With sign $\dot{W}_{sh} = -10.47 \text{ kJ}$

$$\text{(b)} \quad |\dot{W}_{el}| = \frac{VI}{1000} = \frac{110 \times 10}{1000} = 1.1 \text{ kW}$$

$$\dot{W}_{el} = -1.1 \text{ kW}$$

$$\therefore W_{el} = \dot{W}_{el} \Delta t = -11 \text{ kJ}$$

(c) energy coming in by work

$$= 10.47 + 1.1 = 11.57 \text{ kW}$$

$$\therefore \dot{Q} = \underline{-11.57 \text{ kW}} \quad \underline{A_3}$$

#1

(A) closed, (B) adiabatic

(C) isolated

#1.

$$\begin{aligned}
 \dot{W}_{sh} &= \eta \dot{K}E \\
 &= \eta \dot{m} (ke) \\
 &= \eta \dot{m} \left(\frac{V^2}{2000 \times \cancel{m}} \right) = \eta \frac{\dot{m} V^2}{2000} \\
 &= \eta \frac{\rho A V \cdot V^2}{2000} \\
 &= 0.53 \times \frac{(1.1) (\pi) (50)^2 (20 \times 0.447)^2}{4 \times 2000} \\
 &= \underline{409 \text{ kW}} \quad \underline{\text{Ans}}
 \end{aligned}$$

#2.

$$Q = \underline{20 \text{ kJ}} \quad \underline{\text{Ans}}$$

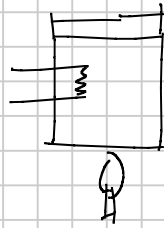
$$W_{ext} = W_{A1} + W_B$$

$$= -10 + 5$$

$$= \underline{-5 \text{ kJ}} \quad \underline{\text{Ans}}$$

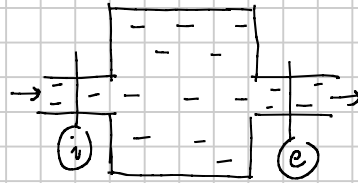
$$\text{Net transfer of energy} = 20 + 10 - 5 = 25 \text{ kJ}$$

Ans



#3.

$$\begin{aligned} \dot{W}_{F,i} &= (\rho AV)_i \\ &= (\rho AV)_i \cdot \frac{p}{\rho_i} \\ &= \frac{\dot{m}_i p_i}{\rho_i} \\ &= \frac{200 \times 100}{1000} = 20 \text{ kW} \end{aligned}$$

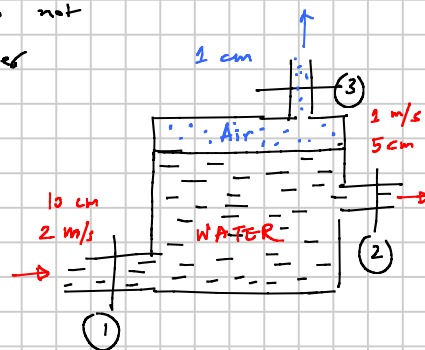


$$\begin{aligned} \dot{KE} &= \dot{m} (KE) = \dot{m} \frac{V^2}{2000} \\ &= (200) \left(\frac{10^2}{2000} \right) = 10 \text{ kW} \end{aligned}$$

#4. Because air & water do not mix, we can write for water

$$\frac{dm}{dt} = \dot{m}_1 - \dot{m}_2$$

$$\begin{aligned} \dot{m}_1 &= \rho_1 A_1 V_1 = (1000) \left(\pi \frac{0.1^2}{4} \right) (2) \\ &= 15.71 \text{ kg/s} \end{aligned}$$



$$\dot{m}_2 = \rho_2 A_2 V_2 = (1000) \left(\pi \frac{0.05^2}{4} \right) (1) = 1.96 \text{ kg/s}$$

$$\frac{dm}{dt} = \dot{m}_1 - \dot{m}_2 = 15.71 - 1.96 = 13.75 \text{ kg/s}$$

$$\frac{dm}{dt} = \frac{d}{dt} (\rho V) = \rho \frac{dV}{dt}$$

$$\Rightarrow \frac{dV}{dt} = \frac{13.75}{1000} \left[\frac{\text{kg}}{\text{s}} \frac{\text{m}^3}{\text{kg}} = \frac{\text{m}^3}{\text{s}} \right]$$

This must also be the rate at which air is being expelled.

$$\text{Therefore, } \dot{V}_3 = 0.0137 \frac{\text{m}^3}{\text{s}}$$

$$\text{Given } \rho_{\text{air}} = 1 \text{ kg/m}^3 \quad \dot{m}_3 = 0.0137 \frac{\text{kg}}{\text{s}}$$

$$\dot{m}_3 = \rho_3 A_3 V_3 \Rightarrow 0.0137 = (1) \left(\pi \frac{0.01^2}{4} \right) V_3$$

$$\Rightarrow V_3 = 174 \text{ m/s}$$

