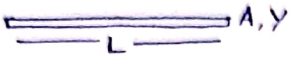
Tutorial - 1

1. $\cancel{E}\ \tau_i \longrightarrow \tau_f$



$$Y = \frac{L}{A}\left(\frac{\partial \tau}{\partial L}\right)_T$$

$$dW = \tau \, dL$$

$$d\tau = \left(\frac{\partial \tau}{\partial L}\right)_T dL + \left(\frac{\partial \tau}{\partial T}\right)_L \cancelto{0}{dT}$$

$$d\tau = \left(\frac{\partial \tau}{\partial L}\right)_T dL$$

$$d\tau = \frac{AY}{L} dL$$

$$W = \cancel{E}\ \frac{L}{AY}\int_{\tau_i}^{\tau_f} \tau \, d\tau$$

$$= \frac{L}{2AY}\left(\tau_f^2 - \tau_i^2\right)$$

2. $$dW = \mu_0 H \, dm$$

$$m = m(H, T)$$

$$\cancel{E}\ dm = \left(\frac{\partial m}{\partial H}\right)_T dH + \left(\frac{\partial m}{\partial T}\right)_H \cancelto{0}{dT}$$

$$dm = \left(\frac{\partial m}{\partial H}\right)_T dH$$

$$m = \frac{CH}{T}$$

$$\left(\frac{\partial m}{\partial H}\right)_T = \frac{C}{T}$$

$$dW = \mu_0 H \frac{C}{T} dH$$

$$= \frac{\mu_0 C}{T}\int_{H_i}^{H_f} H \, dH$$

$$dW = \frac{\mu_0 C}{T}\left[H_f^2 - H_i^2\right] = \cancel{\frac{\mu_0 C}{C}}\ \frac{\mu_0 T}{C}\left(m_f^2 - m_i^2\right) \quad \left(\because m = CH/T\right)$$

3. $\ln\left(\frac{V}{V_0}\right) = -A(p-p_0)$

$$dW = -p\,dV$$

$$dV = \left(\frac{\partial V}{\partial p}\right)_T dp + \left(\frac{\partial V}{\partial T}\right)_p \cancelto{0}{dT}$$

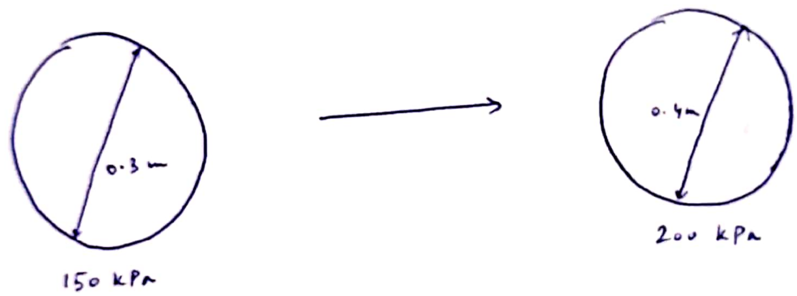
! $$dV = -AV\,dp$$

$$W = A\int pV\,dp$$

$$W \approx AV\int p\,dp$$ Liquid's volume is insensitive to pressure

$$= \frac{AV}{2}\left(p_f^2 - p_i^2\right)$$

4.



$$p \propto d$$

$$V = \frac{\pi d^3}{6}$$

$$p \propto d$$
$$p = cd$$
$$p = c \times \left(\frac{6V}{\pi}\right)^{1/3}$$

$$c = \frac{p_1}{V_1^{1/3}}\left(\frac{\pi}{6}\right)^{1/3} = \frac{p_2}{V_2^{1/3}}\left(\frac{\pi}{6}\right)^{1/3}$$

a) $$W = -\int p\,dV$$

$$= -\int \left(\frac{6}{\pi}\right)^{1/3} c \; V^{1/3}\,dV$$

$$= \frac{-3}{4}\left(p_2V_2 - p_1V_1\right)$$

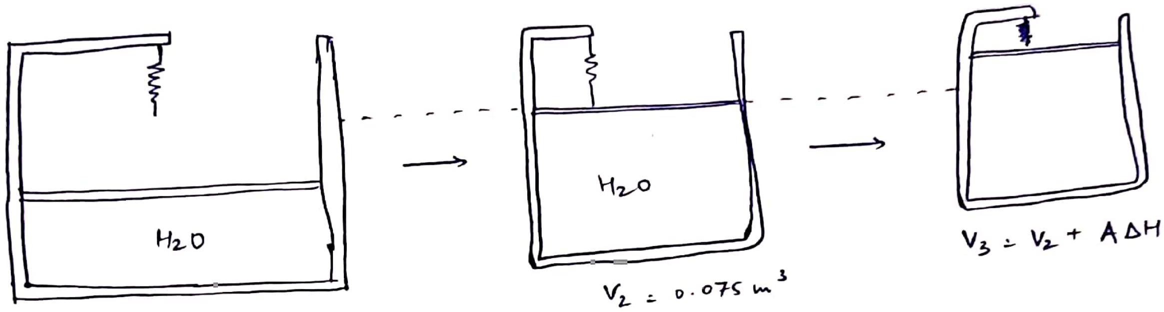
$$= -3.438 \text{ kJ}$$

b) $W_{\text{balloon on atmosphere}} = +P_{atm} \int_{V_1}^{V_2} dV$

$= +P_{atm}(V_2 - V_1)$

$= 1.94 \text{ kJ}$

5.



$V_1 = 0.03 \, m^3$ $\quad V_2 = 0.075 \, m^3$ $\quad V_3 = V_2 + A\Delta H$

$F_{piston \to spring} = A \Delta p$

$F_{restoring} = k \Delta H$

$A = 0.06 \, m^2$

~~Equib~~ Equilibrium $\quad k\Delta H = A \Delta p$

$\Delta H = \dfrac{A \Delta p}{k}$

$W_{I \to II} = p \int_{V_1}^{V_2} dV$

$= p(V_2 - V_1)$

$= 300 \text{ k} \times 0.045$

$= 300 \times 45$

$= 13500 \text{ J}$

$\Delta p = p_3 - p_2$

$V_3 = V_2 + A\Delta H$

$V_3 = V_2 + A^2 \Delta p / k$

$V_3 = 0.075 + (0.06)^2 \times \dfrac{7000 - 300}{360}$

$V_3 = 0.142 \, m^3$

$W_{II \to III} = \dfrac{p_2 + p_3}{2} \int_{V_2}^{V_3} dV$

$= \dfrac{(p_2 + p_3)}{2}(V_3 - V_2)$

$W_{I \to III} = 258.05 \text{ kJ}$

6. ~~σ~~ $\underset{\text{stress}}{\sigma} = \dfrac{\tau}{A} = Y\underset{\text{strain}}{e}$

$de = \dfrac{dl}{l} \Rightarrow dl = l \, de$

$\cancel{dW = AY}$

$$dW = \tau \, dl = AYl \, e \, de$$

$$W = AYl \int_0^e e \, de$$

$$= \frac{1}{2} AYl e^2$$

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