ENGI-3015-AA : Engineering Thermodynamics & Heat Transfer

$\boxed{\text{HW \# 1}}$ (Library Reserve)

2-31 The pressure in a tank is given. The tank's pressure in various units are to be determined.

Analysis Using appropriate conversion factors, we obtain

Schematic: N/A

(*a*) $$P = (1500\ \text{kPa})\left(\frac{1\ \text{kN/m}^2}{1\ \text{kPa}}\right) = \mathbf{1500\ kN/m^2}$$

(*b*) $$P = (1500\ \text{kPa})\left(\frac{1\ \text{kN/m}^2}{1\ \text{kPa}}\right)\left(\frac{1000\ \text{kg}\cdot\text{m/s}^2}{1\ \text{kN}}\right) = \mathbf{1{,}500{,}000\ kg/m\cdot s^2}$$

(*c*) $$P = (1500\ \text{kPa})\left(\frac{1\ \text{kN/m}^2}{1\ \text{kPa}}\right)\left(\frac{1000\ \text{kg}\cdot\text{m/s}^2}{1\ \text{kN}}\right)\left(\frac{1000\ \text{m}}{1\ \text{km}}\right) = \mathbf{1{,}500{,}000{,}000\ kg/km\cdot s^2}$$

HW # 1 (Library Reserve)

Schematic: See textbook (P. 48)

2-41 The pressure in chamber 2 of the two-piston cylinder shown in the figure is to be determined.

Analysis Summing the forces acting on the piston in the vertical direction gives

$$F_2 + F_3 = F_1$$

$$P_2 A_2 + P_3 (A_1 - A_2) = P_1 A_1$$

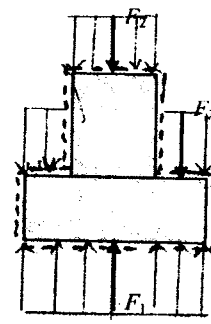
$$\boxed{+\uparrow \Sigma F_y = 0}$$

Condition

Assumptions
- Frictionless Device
- At equilibrium

which when solved for P_2 gives

$$P_2 = P_1 \frac{A_1}{A_2} - P_3\left(\frac{A_1}{A_2} - 1\right)$$



S.B.

F.B.D.

since the areas of the piston faces are given by $A = \pi D^2 / 4$ the above equation becomes

$$P_2 = P_1\left(\frac{D_1}{D_2}\right)^2 - P_3\left[\left(\frac{D_1}{D_2}\right)^2 - 1\right]$$

$$= (1000 \text{ kPa})\left(\frac{10}{4}\right)^2 - (500 \text{ kPa})\left[\left(\frac{10}{4}\right)^2 - 1\right]$$

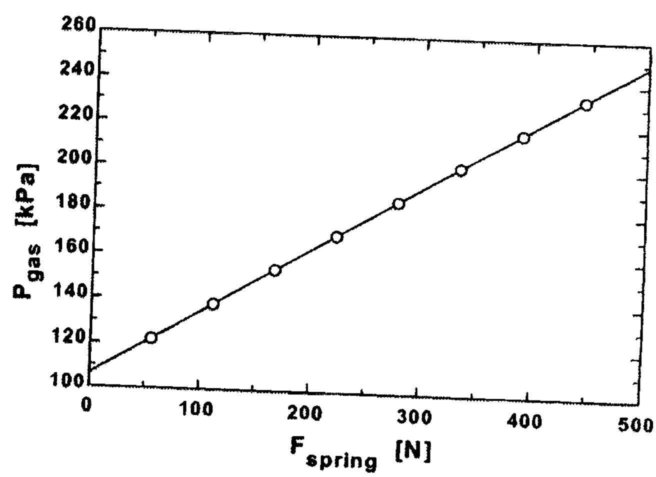
$$\boxed{= 3625 \text{ kPa}}$$

Given info. (See textbook)

2-52: For sample of Calculation, see Example (2-3) (class notes)

Final Results

F_{spring} [N]	P_{gas} [kPa]
0	106.2
55.56	122.1
111.1	138
166.7	153.8
222.2	169.7
277.8	185.6
333.3	201.4
388.9	217.3
444.4	233.2
500	249.1



2-73 The pressure in chamber 1 of the two-piston cylinder with a spring shown in the figure is to be determined. Schematic: (See textbook, P. 52)

- Frictionless Device
- System at Equilibrium

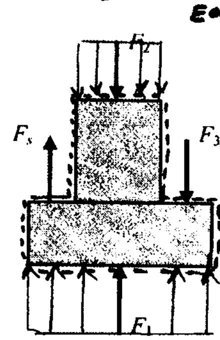
Analysis Summing the forces acting on the piston in the vertical direction gives

$$F_s + F_1 = F_2 + F_3$$
$$kx + P_1 A_1 = P_2 A_2 + P_3 (A_1 - A_2)$$

$\boxed{+\uparrow \sum F_y = 0}$ condition

which when solved for the P_3 and substituting $A = \pi D^2/4$ gives

$$P_1 = P_2 \frac{A_2}{A_1} + P_3\left(1 - \frac{A_2}{A_1}\right) - \frac{kx}{A_1}$$
$$= P_2\left(\frac{D_2}{D_1}\right)^2 + P_3\left[1 - \left(\frac{D_2}{D_1}\right)^2\right] - \frac{4kx}{\pi D_1^2}$$
$$= (8000\text{ kPa})\left(\frac{3}{7}\right)^2 + (300\text{ kPa})\left[1 - \left(\frac{3}{7}\right)^2\right] - \frac{4(1200\text{ kN/m})(0.05\text{ m})}{\pi(0.07\text{ m})^2}$$
$$= 13{,}880\text{ kPa} = \boxed{13.9\text{ MPa}}$$



F.B.D.

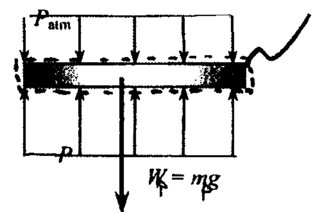
2-90 The pressure of a gas contained in a vertical piston-cylinder device is measured to be 250 kPa. The mass of the piston is to be determined. Required: $m_p = ?$

Assumptions There is no friction between the piston and the cylinder.

Analysis Drawing the free body diagram of the piston and balancing the vertical forces yield

$$W = PA - P_{atm}A$$
$$mg = (P - P_{atm})A$$
$$(m_p)(9.81\text{ m/s}^2) = (250 - 100\text{ kPa})(30\times10^{-4}\text{ m}^2)\left(\frac{1000\text{ kg/m}\cdot\text{s}^2}{1\text{kPa}}\right)$$

It yields $\boxed{m_p = 45.9\text{ kg}}$



F.B.D.

Assumptions:
- Frictionless Device
- System at Equilibrium