PROBLEM 1.25

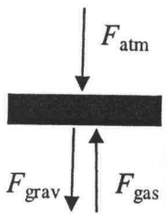
The FBD of the piston is as shown with a downward force due to the atmosphere (F_{atm}) where $F_{atm} = p_{atm} A_{piston}$ and A_{piston} is the cross sectional area of the piston. Another downward force is due to gravity (F_{grav}) where $F_{grav} = m_{piston} g$ and m_{piston} is the mass of the piston. The upward force (F_{gas}) is due to the pressure exerted on the bottom face of the piston by the substance where $F_{gas} = p_{gas} A_{piston}$ and p_{gas} is the pressure of the gas. Summing forces yields the following equation that can be rearranged to explore whether p_{gas} is constant. It is assumed that up is positive.

$$F_{gas} = F_{grav} + F_{atm}$$

$$F_{gas} = p_{gas} A_p \qquad F_{grav} = m_{piston} g \qquad F_{atm} = p_{atm} A_{piston}$$

$$p_{gas} A_{piston} = m_{piston} g + p_{atm} A_{piston}$$

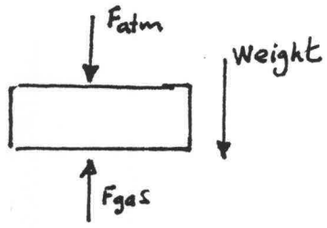
$$p_{gas} = \frac{m_{piston} g}{A_{piston}} + \frac{p_{atm} A_{piston}}{A_{piston}} = \frac{m_{piston} g}{A_{piston}} + p_{atm}$$



Since each of the four quantities on the right-side of the above equation is constant, it follows that the pressure acting on the bottom of the piston remains constant. ←
Volume change occurs as the gas is heated or cooled. ←

PROBLEM 1.26

Since the piston moves smoothly within the cylinder, the piston begins to rise when the force exerted by the gas exceeds the resisting force composed of the piston weight and the force exerted by the atmospheric pressure. That is,



$$F_{gas} \geq \text{Weight} + F_{atm}$$

$$P_{gas} A \geq mg + P_{atm} A$$

$$\Rightarrow \quad P_{gas} \geq \frac{mg}{A} + P_{atm}$$

$$\geq \left[\frac{(50\,kg)(9.81\,m/s^2)}{0.01\,m^2}\right] \left|\frac{1\,bar}{10^5\,N/m^2}\right| \left|\frac{1\,N}{1\,kg\cdot m/s^2}\right| + 1\,bar$$

$$\geq 1.49\,bar \quad \leftarrow$$