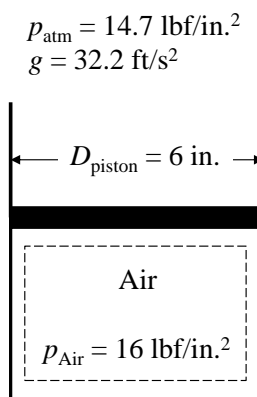


1.41 As shown in Figure P1.41, air is contained in a vertical piston-cylinder assembly such that the piston is in static equilibrium. The atmosphere exerts a pressure of 14.7 lbf/in.^2 on top of the 6-in.-diameter piston. The absolute pressure of the air inside the cylinder is 16 lbf/in.^2 . The local acceleration of gravity is $g = 32.2 \text{ ft/s}^2$. Determine (a) the mass of the piston, in lb, and (b) the gage pressure of the air in the cylinder, in psig.

KNOWN: A piston-cylinder assembly contains air such that the piston is in static equilibrium.

FIND: (a) The mass of the piston, in lb, and (b) the gage pressure of the air in the cylinder, in psig.

SCHEMATIC AND GIVEN DATA:



ENGINEERING MODEL:

1. The air is a closed system.
2. The piston is in static equilibrium.
3. Atmospheric pressure is exerted on the top of the piston.
4. Local gravitational acceleration is 32.2 ft/s^2 .

ANALYSIS:

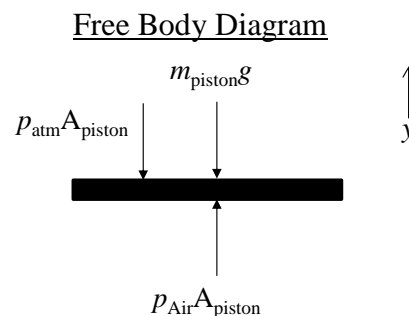
(a) Draw a free body diagram indicating all forces acting on the piston. Taking upward as the positive y -direction, the sum of the forces acting on the piston in the y -direction must equal zero for static equilibrium of the piston.

$$\uparrow \Sigma F_y = 0$$

$$p_{\text{Air}} A_{\text{piston}} - p_{\text{atm}} A_{\text{piston}} - m_{\text{piston}} g = 0$$

Solving for the mass of the piston,

$$m_{\text{piston}} = \frac{p_{\text{Air}} A_{\text{piston}} - p_{\text{atm}} A_{\text{piston}}}{g}$$



$$m_{\text{piston}} = \frac{(p_{\text{Air}} - p_{\text{atm}})A_{\text{piston}}}{g}$$

The area of the piston is determined from the piston diameter

$$A_{\text{piston}} = \frac{\pi}{4} D^2 = \frac{\pi}{4} (6 \text{ in.})^2 = 28.3 \text{ in.}^2$$

Substituting values and solving for the mass of the piston,

$$m_{\text{piston}} = \frac{\left(16 \frac{\text{lbf}}{\text{in.}^2} - 14.7 \frac{\text{lbf}}{\text{in.}^2}\right)(28.3 \text{ in.}^2)}{32.2 \frac{\text{ft}}{\text{s}^2}} \left| \frac{32.2 \frac{\text{lb} \cdot \text{ft}}{\text{s}^2}}{1 \text{ lbf}} \right| = \underline{\underline{36.8 \text{ lb}}}$$

(b) Gage pressure of the air is given by Eq. 1.14

$$p(\text{gage}) = p(\text{absolute}) - p_{\text{atm}}(\text{absolute}) = 16.0 \text{ psia} - 14.7 \text{ psia} = \underline{\underline{1.3 \text{ psig}}}$$