FACULTY OF ENGINEERING AND ARCHITECTURE

MECHANICAL ENGINEERING DEPARTMENT

ME 211 THERMODYNAMICS I

CHAPTER 1

EXAMPLE PROBLEMS SOLUTIONS

Fall 2018

1) A gas is held in a vertical, frictionless cylinder-piston assembly. The pressure of the gas is such that it lifts the piston of mass 4 kg and compresses the spring above the piston. At equilibrium, the compressed spring exerts a force of 60 n on the piston (area of the cross section is 35cm^2). If the atmospheric pressure is 95 kPa, determine the pressure of the gas inside the cylinder.

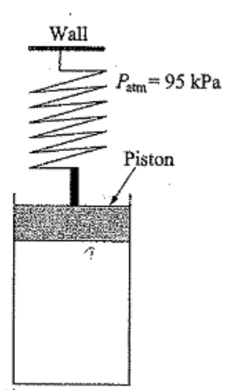


Fig. P1.5 A cylinder-piston assembly.

Hint: Gas pressure inside = Total external pressure acting on the piston

Net downward force

1. Wt. of the piston = 4 kg × 9.81 m s^{-2}
2. Spring force on the piston = 60 N

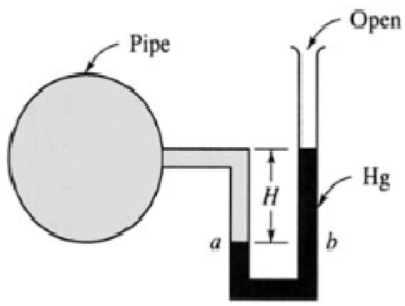
Net downward force = 99.24 N

Total downward pressure

$$= P_{atm} + (99.24 \text{ N}/35 \times 10^{-4} \text{m}^2)$$

$$p = 95 + \frac{\left(\dfrac{99.24}{(35 \cdot 10^{-4})}\right)}{1000} = 123.35 \text{ kPa}$$

P.2) The manometer shown in figure is used to measure the pressure in the water pipe. Determine the water pressure if the manometer reading is 0.6 m. Mercury is 13.6 times heavier than water.



Solution

To solve the manometer problem we use the fact that $P_a = P_b$. The pressure P_a is simply the pressure P in the water pipe plus the pressure due to the 0.6 m of water; the pressure P_b is the pressure due to 0.6 m of mercury. Thus,

$$P + (0.6\ \text{m})(9810\ \text{N/m}^3) = (0.6\ \text{m})(13.6)(9810\ \text{N/m}^3)$$

This gives $P = 74\ 200$ Pa or 74.2 kPa gage.

P.3) *A temperature scale of certain thermometer is given by the relation*

$$T = a \ln x + b$$

where a and b are constants and x is the thermometric property of the fluid in the thermometer. If at the ice point and steam point the thermometric properties are found to be 1.5 and 7.5 respectively what will be the temperature corresponding to the thermometric property of 3.5 on Celsius scale.

Solution $$T = a \ln x + b$$

On Celsius scale :

Ice point = 0°C, and

Steam point = 100°C

∴ From given conditions, we have

$$0 = a \ln 1.5 + b$$

and $$100 = a \ln 7.5 + b$$

i.e., $$0 = a \times 0.4054 + b$$

and $$100 = a \times 2.015 + b$$

Subtracting (*iii*) from (*iv*), we get

$$100 = 1.61a$$

or $$a = 62.112$$

Substituting this value in eqn. (*iii*), we get

$$b = -0.4054 \times 62.112 = -25.18$$

∴ When $p = 3.5$ the value of temperature is given by

$$T = 62.112 \ln (3.5) - 25.18 = \mathbf{52.63°C.}$$