Quiz #1

MEMS 0051 - Introduction to Thermodynamics

Assigned: May 21th, 2020
Due: May 22nd, 2020, 11:59 pm

Problem #1

A large, cylindrical container has a diameter of 20 [cm] and contains three layers of different liquids at 25 °C of varying heights. The three liquids are, from top to bottom, engine oil, water, and mercury. The surface of the engine oil is exposed to an atmospheric pressure of 101.3 [kPa]. If the height of the engine oil is 30 [cm], the height of the water is 20 [cm], and the height of mercury is 5 [cm], determine the following:

a) the overall (average) specific volume, ν_{avg}, in the container;

The average specific volume, ν_{avg}, can be found from the following equations:

$$\forall_{\text{total}} = \forall_{\text{engine oil}} + \forall_{\text{water}} + \forall_{\text{mercury}}$$

$$m_{\text{tot}}\nu_{\text{tot}} = m_{\text{oil}}\nu_{\text{oil}} + m_{\text{w}}\nu_{\text{w}} + m_{\text{Hg}}\nu_{\text{Hg}}$$

We need to find the volume of each liquid and the total volume of the container:

$$\forall_{\text{tot}} = \frac{\pi}{4}(0.2\ [\text{m}])^2(0.3\ [\text{m}]) + \frac{\pi}{4}(0.2\ [\text{m}])^2(0.2\ [\text{m}]) + \frac{\pi}{4}(0.2\ [\text{m}])^2(0.05\ [\text{m}])$$

$$\forall_{\text{tot}} = 0.009425\ [\text{m}^3] + 0.006283\ [\text{m}^3] + 0.001571\ [\text{m}^3] = 0.01728\ [\text{m}^3]$$

Since the temperature is 25 °C, we can take the values of density for the different liquids directly from Table A.4. Now we can solve for the total mass:

$$m_{\text{tot}} = (885\ [\text{kg/m}^3])(0.009425\ [\text{m}^3]) + (997\ [\text{kg/m}^3])(0.006283\ [\text{m}^3]) + (13580\ [\text{kg/m}^3])(0.001571\ [\text{m}^3])$$

$$m_{\text{tot}} = 8.3411\ [\text{kg}] + 6.2642\ [\text{kg}] + 21.3342\ [\text{kg}] = 35.94\ [\text{kg}]$$

Finally, we can determine the average specific volume in the container by diving the total volume by the total mass:

$$\nu_{\text{avg}} = \frac{\forall_{\text{tot}}}{m_{\text{tot}}} = \frac{0.01728\ [\text{m}^3]}{35.94\ [\text{kg}]} = \boxed{0.000481\ [\text{m}^3/\text{kg}]}$$

Note this is equivalent to a density of:

$$\rho_{\text{avg}} = \frac{1}{\nu_{\text{avg}}} = 2079\ [\text{kg/m}^3]$$

Academic Integrity Statement:

I hereby attest that I have received no assistance (from a friend, from another student, from an on-line resource, such as Chegg, etc.), and that I have provided no assistance to another student, during this examination. All the work presented within is solely my own work.

Signature: _____

Date: _____