

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:

$$V_{total} = V_{engine\ oil} + V_{water} + V_{mercury}$$

$$m_{tot}\nu_{tot} = m_{oil}\nu_{oil} + m_w\nu_w + m_{Hg}\nu_{Hg}$$

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

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

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

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:

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

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

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

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

Note this is equivalent to a density of:

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

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: _____