ENSC 388 Quiz #1

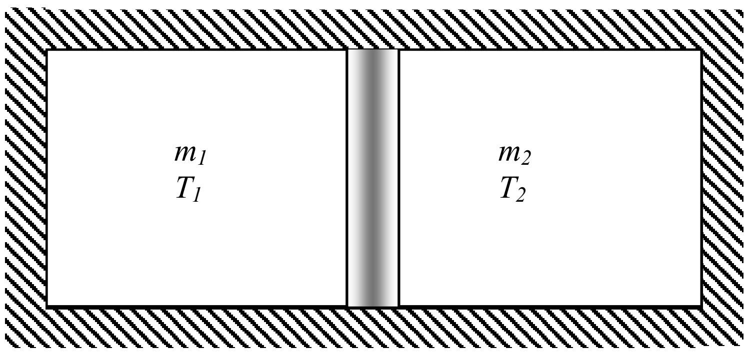
Oct. 7, 2009

Name: ……………………………………… Student ID:………………………………..

Time: 45 minutes or less. Develop answers on available place. The quiz has 5% (bonus) of the total mark. Closed books & closed notes.

Problem 1 (50%):

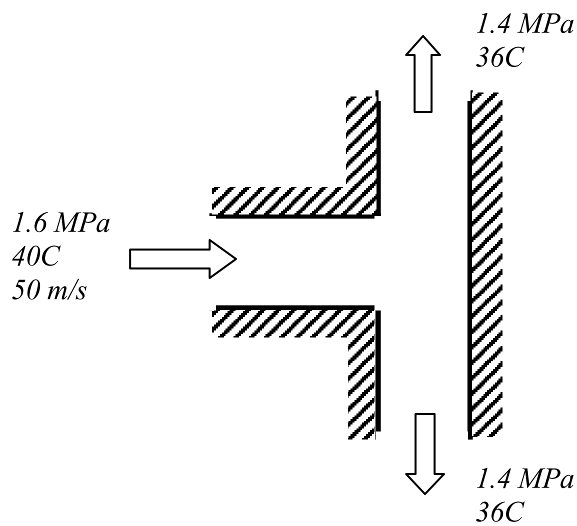
An insulated rigid tank is divided into two compartments of different volumes. Initially, each contains the same ideal gas at identical pressure but at different temperatures and masses. The wall separating the two compartments is removed and the two gases are allowed to mix. Assuming constant specific heats, find an expression for the mixture temperature T_3.



Problem 2 (50%):

The air flow in a compressed air line is divided into two equal streams by a T-fitting in the line. The compressed air enters this *2.5 cm = 0.025m* diameter fitting at *1.6 MPa* and $40^{\circ}C$ with a velocity of *50 m/s*. Each outlet has the same diameter as the inlet, and the air at these outlets has a pressure of *1.4 MPa* and a temperature of $36^{\circ}C$. Determine the velocity of the air at the outlets and the rate of change of flow energy (flow power) across the T-fitting.

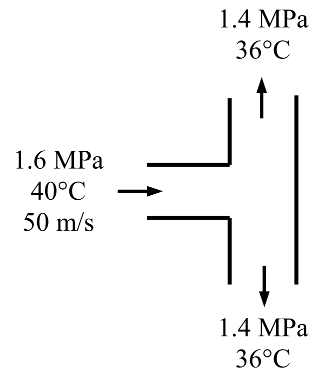
The gas constant of air is $R = 0.287(\ kPa.m^3/kg.K)$



5-157 The mass flow rate of a compressed air line is divided into two equal streams by a T-fitting in the line. The velocity of the air at the outlets and the rate of change of flow energy (flow power) across the T-fitting are to be determined.

Assumptions **1** Air is an ideal gas with constant specific heats. **2** The flow is steady. **3** Since the outlets are identical, it is presumed that the flow divides evenly between the two.

Properties The gas constant of air is R = 0.287 kPa·m^3/kg·K (Table A-1).



Analysis The specific volumes of air at the inlet and outlets are

$$\boldsymbol{v}_1 = \frac{RT_1}{P_1} = \frac{(0.287\,\text{kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(40+273\,\text{K})}{1600\,\text{kPa}} = 0.05614\,\text{m}^3/\text{kg}$$

$$\boldsymbol{v}_2 = \boldsymbol{v}_3 = \frac{RT_2}{P_2} = \frac{(0.287\,\text{kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(36+273\,\text{K})}{1400\,\text{kPa}} = 0.06335\,\text{m}^3/\text{kg}$$

Assuming an even division of the inlet flow rate, the energy balance can be written as

$$\frac{A_1V_1}{\boldsymbol{v}_1} = 2\frac{A_2V_2}{\boldsymbol{v}_2} \longrightarrow V_2 = V_3 = \frac{A_1}{A_2}\frac{\boldsymbol{v}_2}{\boldsymbol{v}_1}\frac{V_1}{2} = \frac{0.06335}{0.05614}\frac{50}{2} = \mathbf{28.21\,m/s}$$

The mass flow rate at the inlet is

$$\dot{m}_1 = \frac{A_1V_1}{\boldsymbol{v}_1} = \frac{\pi D_1^2}{4}\frac{V_1}{\boldsymbol{v}_1} = \frac{\pi(0.025\,\text{m})^2}{4}\frac{50\,\text{m/s}}{0.05614\,\text{m}^3/\text{kg}} = 0.4372\,\text{kg/s}$$

while that at the outlets is

$$\dot{m}_2 = \dot{m}_3 = \frac{\dot{m}_1}{2} = \frac{0.4372\,\text{kg/s}}{2} = 0.2186\,\text{kg/s}$$

Substituting the above results into the flow power expression produces

$$\begin{aligned}\dot{W}_{\text{flow}} &= 2\dot{m}_2P_2\boldsymbol{v}_2 - \dot{m}_1P_1\boldsymbol{v}_1\\ &= 2(0.2186\,\text{kg/s})(1400\,\text{kPa})(0.06335\,\text{m}^3/\text{kg}) - (0.4372\,\text{kg/s})(1600\,\text{kPa})(0.05614\,\text{m}^3/\text{kg})\\ &= -\mathbf{0.496\,kW}\end{aligned}$$

4-155 An insulated rigid tank is divided into two compartments, each compartment containing the same ideal gas at different states. The two gases are allowed to mix. The simplest expression for the mixture temperature in a specified format is to be obtained.

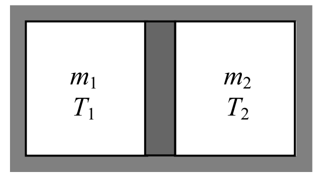
Analysis We take the both compartments together as the system. This is a closed system since no mass enters or leaves. The energy balance for this stationary closed system can be expressed as

$$\underbrace{E_{in} - E_{out}}_{\substack{\text{Net energy transfer}\\ \text{by heat, work, and mass}}} = \underbrace{\Delta E_{system}}_{\substack{\text{Change in internal, kinetic,}\\ \text{potential, etc. energies}}}$$

$$0 = \Delta U \quad (\text{since } Q = W = \text{KE} = \text{PE} = 0)$$

$$0 = m_1 c_v (T_3 - T_1) + m_2 c_v (T_3 - T_2)$$

$$(m_1 + m_2) T_3 = m_1 T_1 + m_2 T_2$$



and,

$$m_3 = m_1 + m_2$$

Solving for final temperature, we find

$$T_3 = \frac{m_1}{m_3} T_1 + \frac{m_2}{m_3} T_2$$