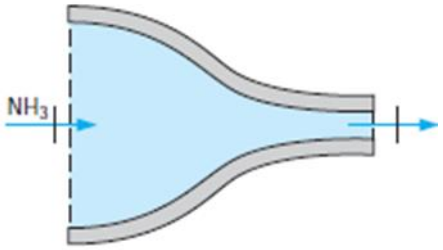
Tutorial-III
First law (Open Systems)

1. Two kg of water at 500 kPa, 20°C is heated in a constant pressure process (SSSF) to 1700°C. Estimate the heat transfer in this process.

2. An un-insulated mixing chamber receives 2 kg/s of R-22 at 1 MPa, 40°C in one line and 1 kg/s of R-22 at 30°C, quality 50% in another line. The outgoing flow is at 1 MPa, 60°C. Find the rate of heat transfer to the mixing chamber.

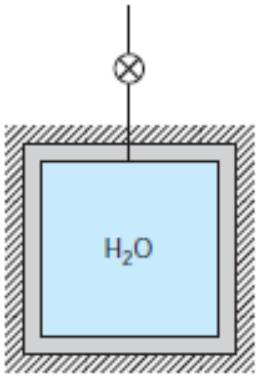
3. Superheated vapor ammonia enters an insulated nozzle at 20°C, 800 kPa, shown in Fig. with a low velocity and at the steady rate of 0.01 kg/s. The ammonia exits at 300 kPa with a velocity of 450 m/s. Determine the temperature (or quality, if saturated) and the exit area of the nozzle.



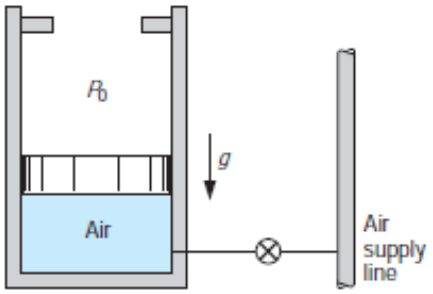
4. A rigid 100-L tank contains air at 1 MPa, 200°C. A valve on the tank is now opened and air flows out until the pressure drops to 100 kPa. During this process, heat is transferred from a heat source at 200°C, such that when the valve is closed, the temperature inside the tank is 50 C. What is the heat transfer?

5. A 1-m^3 tank contains ammonia at 150 kPa, 25°C. The tank is attached to a line flowing ammonia at 1200 kPa, 60°C. The valve is opened, and mass flows into the tank until the tank is half full of liquid, by volume at 25°C. Calculate the heat transferred from the tank during this process.

6. A 2-m^3 insulated vessel, shown in Fig. contains saturated vapor steam at 4 MPa. A valve on the top of the tank is opened, and steam is allowed to escape. During the process any liquid formed collects at the bottom of the vessel, so that only saturated vapor exits. Calculate the total mass that has escaped when the pressure inside reaches 1 MPa.



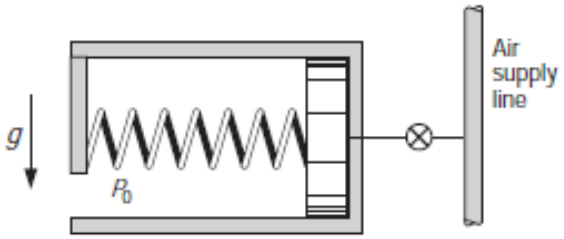
7. A mass-loaded piston/cylinder, shown in Fig. containing air at 300 kPa, 17°C with a volume of 0.25 m^3, while at the stops V=1 m^3. An air supply line at 500 kPa and 600 K, is connected by a valve that is then opened until a final inside pressure of 400 kPa is reached, at which point T=350 K. Find the air mass that enters, the work and heat transfer.



8. An elastic balloon behaves such that pressure is proportional to diameter and the balloon initially contains 0.5 kg air at 200 kPa, 30°C. The balloon is momentarily connected to an air line at 400 kPa, 100°C. Air is let in until the volume doubles, during which process there is a heat transfer of 50 kJ out of the balloon. Find the final temperature and the mass of air that enters the balloon.

9. A cylinder with a constant load on the piston contains water at 500 kPa, 20°C and volume of 1 L. The bottom of the cylinder is connected with a line and valve to a steam supply line carrying steam at 1 MPa, 200°C. The valve is now opened for a short time to let steam in to a final volume of 10 L. The final uniform state is two phase and there is no heat transfer in the process. What is the final mass inside the cylinder?

10. An insulated spring-loaded piston/cylinder device, shown in Fig., is connected by a valve to an air supply line flowing air at constant pressure $P_{line}(>P_0)$ and temperature T_{line}. Initially, the cylinder is empty and the spring force is zero. The valve is then opened until the cylinder pressure reaches $P_2 = \frac{P_{line}}{2}$. Find an expression for the final temperature of air inside cylinder in terms of constant specific heat capacities of air, P_{line}, T_{line} and P_0.



ANSWER KEY

1. 12.8 MJ
2. 148.7 Kw
3. x=0.95, A=8.56×10^{-6} m^2
4. 25.7 kJ
5. -379.7 MJ
6. 27.24 kg
7. 3.082kg, 225kJ, -819.2 kJ
8. 43.4°C, 0.707 kg
9. 1.276 kg
10. $$\frac{C_p T_{line}}{C_v + \left(\frac{P_0 + 0.5 P_{line}}{P_{line}} \right) R}$$