

# ME 201

## Thermodynamics

### First Law Practice Problems

1. Consider a balloon that has been blown up inside a building and has been allowed to come to equilibrium with the inside temperature of  $25^{\circ}\text{C}$  and inside pressure of 100 kPa. The diameter of the balloon is measured and found to be 0.13 m. The balloon is then taken outside and allowed to come to equilibrium with the outside temperature of  $-5^{\circ}\text{C}$  and outside pressure of 100 kPa. Determine the boundary work, heat transfer, and final balloon diameter.
2. Air at 1800 K and 800 kPa enters an ideal turbine at 2.3 kg/s. The power output required of this turbine is 700 kW. Determine the exhaust temperature and pressure.
3. Refrigerant-134a as saturated liquid at  $32^{\circ}\text{C}$  enters a valve and exits at 0.16 MPa. What is the fluid phase at the exit?
4. A tank contains Refrigerant-134a as saturated vapor at 100 kPa. There is heat transfer to the tank of 66 kJ/kg. Determine the final temperature and pressure.
5. Consider a 300 gallon hot water heater which is to provide water a  $180^{\circ}\text{F}$  and 20 psia. If a typical shower consumes 3 gallons/minute, last 15 minutes, and requires that the hot water should stay above  $160^{\circ}\text{F}$ , determine the heat transfer rate required. Water is supplied at  $63^{\circ}\text{F}$  and 22 psia and 2 gallons/minute.
6. A piston cylinder system contains gas at 2300 K, 2500 kPa, and 0.03 liters. The gas then undergoes a polytropic expansion with a polytropic exponent of 1.15 to 0.3 liters. Compare the work performed in kJ for air as the gas versus hydrogen as the gas.
7. In an open feedwater, subcooled liquid water is heated to saturated liquid by mixing directly with steam. In a given situation water at 10 MPa and  $200^{\circ}\text{C}$  enters an open feedwater heater at 12 kg/s. Steam at 10 MPa and  $350^{\circ}\text{C}$  is available to be added to this water to produce saturated liquid at 10 MPa. How much steam in kg/s must be added?

8. Most of the time during the winter Dr. Somerton turns down the thermostat to  $50^{\circ}\text{F}$  when he leaves in the morning. When he is in the house he likes to have the temperature at  $68^{\circ}\text{F}$ . The house may be considered to be composed of air, occupying a volume of  $10,000\text{ ft}^3$ , and structural material (mostly wood) of  $11,000\text{ lb}_m$ . Determine the total heat transfer required to bring the house up to  $68^{\circ}\text{F}$ . What fraction of this total goes to heating up the air and what fraction goes to heating up the structural material?
9. Oil enters an ideal pump at  $100^{\circ}\text{F}$  and  $12\text{ psia}$  and leaves at  $17\text{ psia}$ . The oil flow rate is  $0.04\text{ lb}_m/\text{s}$ . The pump inlet has a diameter of 5 inches and the pump outlet has a diameter of 2 inches. What pumping power is required?
10. The exhaust process for an internal combustion engine may be modeled as transient system undergoing an isobaric process with boundary work. Just before the exhaust valve opens the cylinder of 0.5 liters contains air at  $200\text{ kPa}$  and  $500\text{ K}$ . At the end of exhaust the volume is 0.0833 liters. Assume that the process is adiabatic. Determine the final temperature and mass and the boundary work.