HW1 – Thermodynamics I Review

Submission instructions: Complete all questions below, scan and upload your solution to the assignment on canvas.

Note: If you want to use CamScanner to scan your work with your phone, here is a nice tutorial. LINK

Note: Use the DISCUSSION SECTION ON CANVAS for online help outside of office hours

Question 1: Create a single slide in PowerPoint to describe yourself, following the in Figure 1. **Please make sure I can see your face in the photo!** You are welcome to include a *second* slide with a few more bullets about your background, hobbies, interests or anything else you want to share.

Please upload this as a separate file on your canvas submission

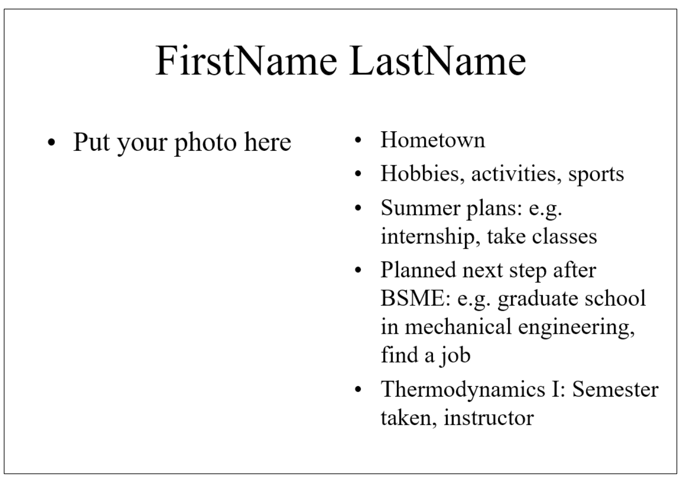


Figure 1: Slide Template for Part 1

For remaining problems, note that all the property tables from the Moran/Shapiro Text are provided on Canvas in files in the folder "Handouts and other References" section.

1.26 As shown in Fig. P1.26, a vertical piston–cylinder assembly containing a gas is placed on a hot plate. The piston initially rests on the stops. With the onset of heating, the gas pressure increases. At what pressure, in bar, does the piston start rising? The piston moves smoothly in the cylinder and g = 9.81 m/s^2.

2.A-2 Determine the boiling temperature (°F) of water:
a.) at normal atmospheric pressure (P_{atm} = 14.7 psi, which corresponds to sea-level),
b.) in Denver, where the pressure is P = 24.58 inch Hg, and
c.) at the summit of Mount Everest, where the pressure is P = 30 kPa.

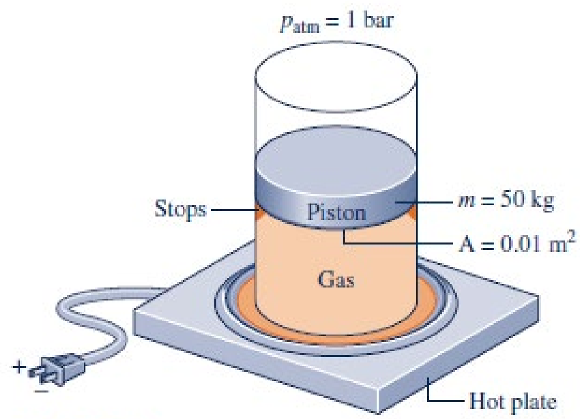


Fig. P1.26

3.21 As shown in Fig. P3.21 0.1 kg of water is contained within a piston–cylinder assembly at 100°C. The piston is free to move smoothly in the cylinder. The local atmospheric pressure and acceleration of gravity are 100 kPa and 9.81 m/s^2, respectively. For the water, determine the pressure, in kPa, and volume, in cm^3.

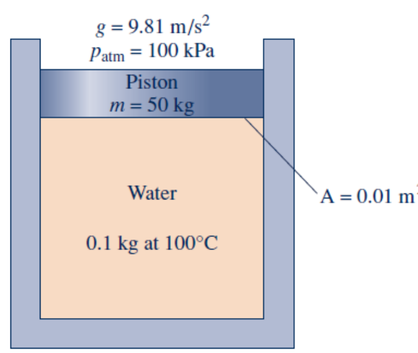


Fig. P3.21

2.A-3: A rigid tank with volume $V = 8000$ cm3 is filled with water with quality $x_1 = 0.05$ and temperature $T_1 = 140°C$.
a.) What is the specific volume (m3/kg) and the pressure (kPa) of the water.
b.) What is the total mass of water in the tank (kg)? What is the mass of liquid (kg) and the mass of vapor (kg) in the tank?
c.) What are the volumes of liquid and vapor in the tank (m3)?
The water in the tank is heated to $T_2 = 200°C$. The tank is rigid (i.e., its volume doesn't change) and leak tight.
d.) What is the pressure (kPa) and quality of the water in the tank at state 2?
e.) What is the mass of liquid (kg) in the tank at state 2?

4.007 SI Ammonia enters the expansion valve of a refrigeration system at a pressure of 10 bar and a temperature of 20°C and exits at 3.0 bar. The refrigerant undergoes a throttling process. Determine the temperature, in °C, and the quality of the refrigerant at the exit of the expansion valve.

Step 1: Determine the temperature of the refrigerant at the exit, in °C.

Step 2: Determine the quality of the refrigerant at the exit of the expansion valve.

4.75 An air-conditioning system is shown in Fig. P4.75 in which air flows over tubes carrying Refrigerant 134a. Air enters with a volumetric flow rate of 50 m^3/min at 32°C, 1 bar, and exits at 22°C, 0.95 bar. Refrigerant enters the tubes at 5 bar with a quality of 20% and exits at 5 bar, 20°C. Ignoring heat transfer at the outer surface of the air conditioner, and neglecting kinetic and potential energy effects, determine at steady state

(a) the mass flow rate of the refrigerant, in kg/min.
(b) the rate of heat transfer, in kJ/min, between the air and refrigerant.

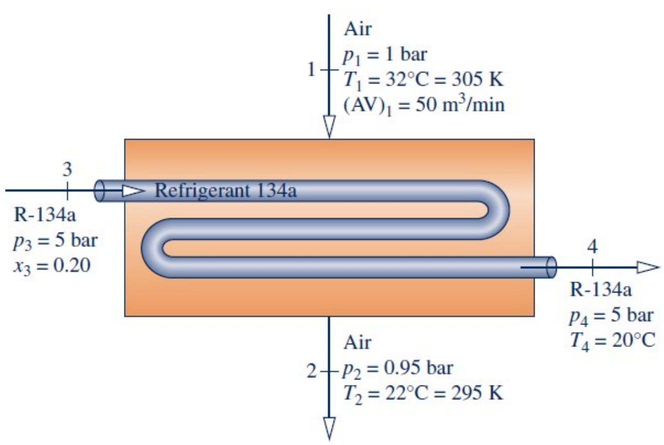
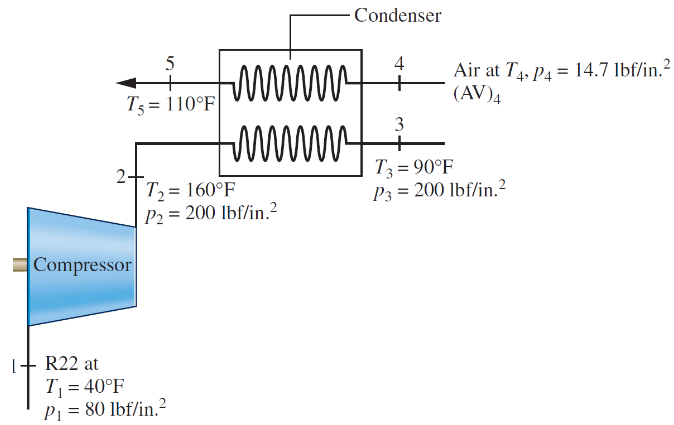
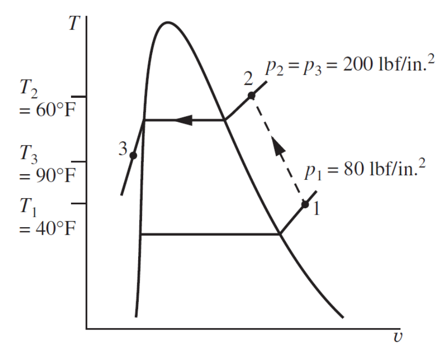


Fig. P4.75

4.009 As shown in the figure, Refrigerant 22 enters the compressor of an air conditioning unit operating at steady state at 40°F, 80 lb$_f$/in^2 and is compressed to 160°F, 200 lb$_f$/in^2. The refrigerant exiting the compressor enters a condenser where energy transfer to air





as a separate stream occurs, and the refrigerant exits as a liquid at 200 lb$_f$/in^2, 90°F. Air enters the condenser at 1°F, 14.7 lb$_f$/in^2 with a volumetric flow rate of 1 ft^3/min and exits at 110°F. Neglect stray heat transfer and kinetic and potential energy effects, and assume ideal gas behavior for the air.

Determine the mass flow rate of refrigerant, in lb/min, and the compressor power, in horsepower.

Step 1: Determine the mass flow rate of refrigerant, in lb/min.

Step 2: Determine the compressor power, in horsepower.

6.77 The heat pump cycle shown in Fig. P6.77 operates at steady state and provides energy by heat transfer at a rate of 15 kW to maintain a dwelling at 22°C when the outside temperature is −22°C. The manufacturer claims that the power input required for this operating condition is 3.2 kW. Applying energy and entropy rate balances evaluate this claim.

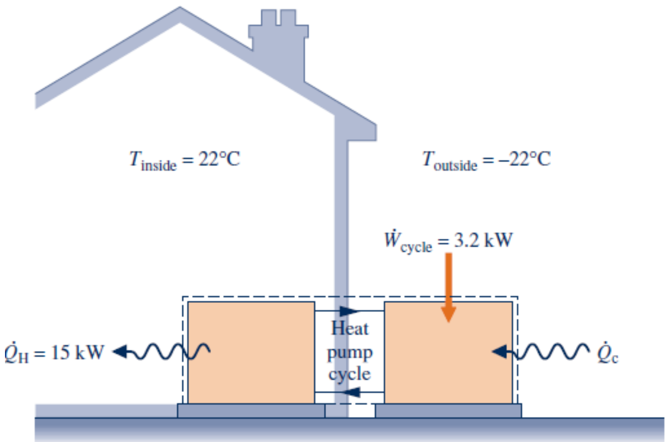


Fig. P6.77

6.145 Air enters the compressor of a gas turbine power plant operating at steady state at 290 K, 100 kPa and exits at 330 kPa. Stray heat transfer and kinetic and potential energy effects are negligible. The isentropic compressor efficiency is 90.3%. Using the ideal gas model for air, determine the work input, in kJ per kg of air flowing.

6.007 SI A pump operating at steady state receives 1.2 kg/s of liquid water at 50°C, 1.5 MPa. The pressure of the water at the pump exit is 15 MPa. The magnitude of the work required by the pump is 21 kW. Stray heat transfer and changes in kinetic and potential energy are negligible. Determine the work required by a reversible pump operating with the same conditions, in kW, and the isentropic pump efficiency.

Step 1: Determine the work required by a reversible pump operating with the same conditions, in kW.

Step 2: Determine the isentropic pump efficiency.