QUESTIONS

THERMODYNAMICS PRACTICE PROBLEMS FOR NON-TECHNICAL MAJORS

Thermodynamic Properties

1. If an object has a weight of 10 lbf on the moon, what would the same object weigh on Jupiter?

   $g_{Jupiter} = 75 \frac{ft}{sec^2}$ $\quad g_{Moon} = 5.4 \frac{ft}{sec^2}$ $\quad g_c = 32 \frac{lbm\text{-}ft}{lbf\text{-}sec^2}$

2. An object that weighs 50 lbf on earth is moved to Saturn where its new weight is 105 lbf. What is the acceleration due to gravity on Saturn?

   $g_{Earth} = 32 \frac{ft}{sec^2}$ $\quad g_c = 32 \frac{lbm\text{-}ft}{lbf\text{-}sec^2}$

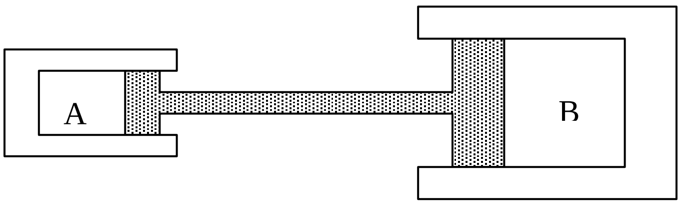
3. Define, using equations, specific volume (v) and density (ρ). What is the mathematical relationship between these two terms?

Temperature and Pressure Measurements

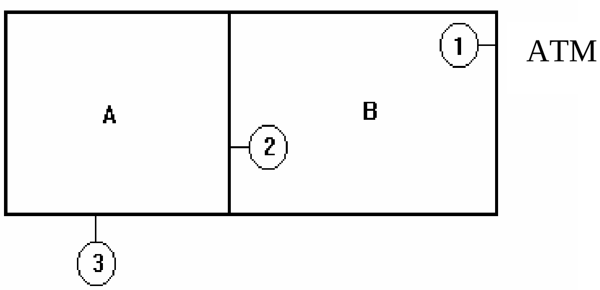
4. (a) Define temperature.
   (b) What is the absolute temperature scale corresponding to Fahrenheit?
   (c) Convert 100° F to that absolute scale.

5. Define pressure.

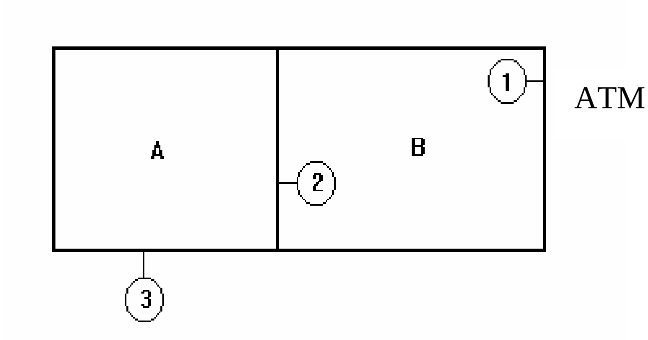
6. If $P_A = P_B$, in which direction will the piston move? Explain, using equations.



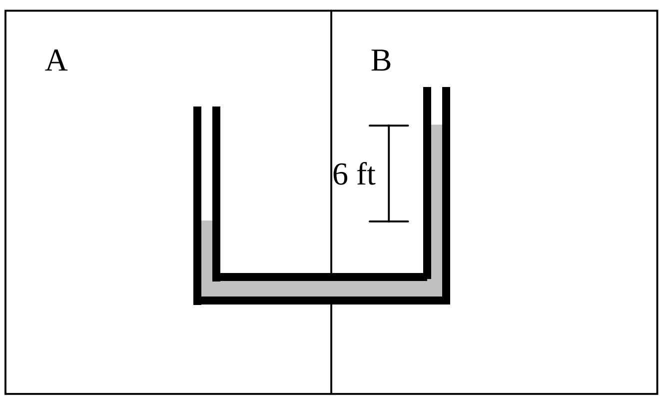
7. Given: $P_1 = 4$ psig, $P_{ATM} = 15$ psia, and $P_2 = 10$ psig
   Find P_A and P_B.



8. Given: P_{ATM} = 15 psia, P_2 =6 psiv, and P_3 = 7 psig
   Find P_A and P_B.



9. Given the conversion factor 1 inch H_2O = 0.0361 psid and that the manometer below employs water, find the difference in pressure between compartments A and B.



Energy, Work, and Heat

10. Define energy.

11. Define, using equations, the total kinetic energy, total potential energy, and enthalpy.

12. Given the following information about a system, calculate specific enthalpy (in Btu/lbm).

$P = 100\ \text{psia} \qquad \nu = 1.6\frac{\text{ft}^3}{\text{lbm}} \qquad u = 600\frac{\text{Btu}}{\text{lbm}} \qquad \text{Note: } 778\ \text{ft-lbf} = 1\ \text{Btu}$

13. Given the following information about a system, calculate specific internal energy (in Btu/lbm).

$P = 200\ \text{psia} \qquad \nu = 2.8\frac{\text{ft}^3}{\text{lbm}} \qquad h = 1000\frac{\text{Btu}}{\text{lbm}} \qquad \text{Note: } 778\ \text{ft-lbf} = 1\text{Btu}$

14. A 5 lbm system was taken from 50° F to 150° F. How much energy in the form of heat was added to the system to produce this temperature increase?

$c_p = 1.6\frac{\text{Btu}}{\text{lbm-F}}$

15. A 10 lbm metal ball has a temperature of 200° F when it is placed in a 50 lbm bath of water at room temperature (72° F). Heat transfer occurs between the two substances until equilibrium is reached. Find this equilibrium temperature.

$c_{p_{Water}} = 1.0\frac{\text{Btu}}{\text{lbm-F}} \qquad c_{p_{Metal}} = 4.3\frac{\text{Btu}}{\text{lbm-F}}$

16. During a phase change, the specific entropy of a 20 lbm system increases from $0.31\frac{Btu}{lbm-R}$ to $1.61\frac{Btu}{lbm-R}$ while the temperature of the substance is a constant 212°F. Find the heat transfer into this system.
Hint: Must convert temperature to Rankine.

17. A nuclear power plant is found to generate 80 MW of power. A typical Honda civic is capable of producing 150 HP. How many Honda Civic's would be required to generate the equivalent power of this nuclear power plant?
Use the energy and power equivalences found in the DOE Fundamentals Handbook (see Pages 23 and 24 of the "Energy, Work, and Heat" module).

Thermodynamic Systems and Processes

18. Define isolated system, closed system, and open system.

19. Can a system be in steady state yet have the fluid passing through it undergoing a phase change? Reconcile your answer with the definition of steady state.

Change of Phase

20. Describe the difference between an intensive and an extensive property. Give 2 examples of each type of property.

21. A system contains 250 lbm of saturated liquid and 10 lbm of saturated vapor. What is the quality of the system?

Property Diagrams and Steam Tables

22. Steam enters a turboexpander as a saturated vapor at 500 psia and is expanded at constant entropy to 5 psia. Using the Mollier diagram in Appendix A (Figure A-1), find the Δh for this process.

23. Use the excerpt from the steam tables in Appendix A (Figure A-2) to find h, v, and s for water:

    Saturated liquid, P = 350 psia

    Saturated vapor, P = 400 psia

    Saturated liquid, T = 468° F

    Superheated steam, P = 400 psia and T=700° F

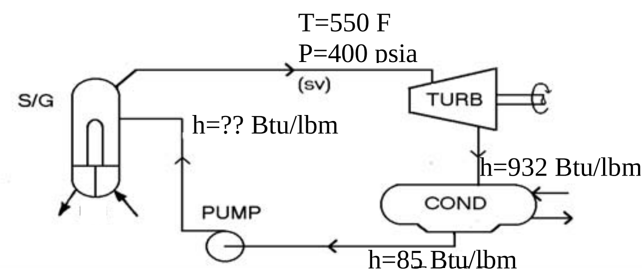
24. Use the steam tables and the concept of quality to find h and ν for water at a pressure of 260 psia if entropy is known to be $0.725 \frac{Btu}{lbm-R}$.

25. Calculate specific internal energy for a 200 psia system of saturated liquid. Hint: Review the definition of enthalpy.

First Law of Thermodynamics

26. State the First Law of Thermodynamics.

27. The following schematic of a simple Rankine cycle consists of steam leaving a boiler at T=550° F and P=400 psia and passes through a turboexpander where it does work and exhausts with an enthalpy of 932 Btu/lbm. The exhaust is then condensed to an enthalpy of 85 Btu/lbm before being pumped back into the boiler.



Given $\dot{W}_{turb} = 4.15\times10^6 \frac{Btu}{lbm}$ and $\dot{Q}_{boiler} = 1.43\times10^7 \frac{Btu}{lbm}$, find the mass flow rate of the system ($\dot{m}_{system}$), the total heat transfer out at the condenser ($\dot{Q}_{Cond}$), and the enthalpy of the fluid after leaving the pump and before entering the boiler.

Second Law of Thermodynamics

28. What is the maximum possible cycle efficiency of a heat engine operating between a heat source at 400 ^{o}F and a heat sink at 32 ^{o}F?

29. An inventor claims to have invented a device which absorbs 2500 Btu of heat and produces 2000 Btu of work. If the heat sink for the device is ice water, what would be the minimum source temperature?

30. What is the efficiency of a turbine which receives dry, saturated steam at 100 psia and exhausts a wet vapor at 1 psia, while producing 230 Btu/lbm of real work?

Compression Processes

31. State the ideal gas law. Explain the meaning of each symbol.

32. When can a fluid be considered incompressible? Give an everyday example of such a fluid.