Week 10

Lecture 1 • Return the Midterm Exams.
• Midterm Exam Statistics:

Table 1: Midterm Exam Summary

	Q1	Q2	Q3	Exam
Max.	19	20	20	57 (95%)
Min.	1	8	3	25 (41.7%)
Avg.	13.6	15.6	14	42.4 (70.8%)
Std. Dev.	-	-	-	11.9

Questions were out of 20, and marked by: Question 1 (Edward Chan), Questions 2 and 3 (Yuri Muzychka)

• Thermodynamic Problems ffrom the Text:
• Chapter 1: 7,8,15,17,20
• Chapter 2: 3,4,6,13,22
• Chapter 4: 1,8,9,12
• Chapter 5: 5,7,9,14,19,20,22,24,26,30,32,33,37,39,42,43
• Chapter 7: 24,26
• Chapter 8: 21,22,24,26
• Chapter 9: 6,10,12,17,20,21

• Solutions are posted in the Engineering Photocopy Center, E2.

Lecture 2

• Course critique at end of lecture.
• Example: Problem 3.8
• Given:
$M = 2\,kg$ constant

$P = 1\,atm$ (constant) $= 1.013 \times 10^5\,Pa$
$T_1 = 500\,K$
$T_2 = 600\,K$
$\rho_1 = 608\,kg/m^3$
$\rho_2 = 590\,kg/m^3$
$Q = 42\,kJ$

• Fins the difference in specific internal energies bewteen initial and final states, i.e., find

$$u_2 - u_2 = \frac{U_2}{M} - \frac{U_1}{M}$$

• Solution
• FLOT for fixed mass system.

$$E_1 + W_{12} + Q_{12} = E_2$$

Assume that $KE_1 = 0, KE_2 = 0, PE_1 = 0, PE_2 = 0$ for this system. Then

$$E_2 - E_1 = U_2 - U_1 = W_{12} + Q_{12}$$

and

$$W_{12} = -\int_1^2 P dv = -P(V_2 - V_1) \quad \text{for constant pressure}$$

Now

$$U_2 - U_1 = -P(V_2 - V_1) + Q_{12}$$

Divide by total mass of system to get

$$u_2 - u_1 = -P(v_2 - v_1) + \frac{Q_{12}}{M}$$

Require the specific volumes in states 1 and 2.
• Conservation of Mass

$$M_2 = M_1 = M \quad \text{or} \quad \rho_2 V_2 = \rho_1 V_1 = M$$

therefore

$$V_2 = \frac{M}{\rho_2} = \frac{M}{\rho_1}$$

and

$$U_2 - U_1 = -P\left(\frac{M}{\rho_2} - \frac{M}{\rho_1}\right) + Q_{12}$$

now divide by M to get the relation:

$$u_2 - u_1 = -P\left(\frac{1}{\rho_2} - \frac{1}{\rho_1}\right) + \frac{Q_{12}}{M}$$

Substitute given values and compute:

$$u_2 - u_1 = -1.013 \times 10^5 \left(\frac{1}{590} - \frac{1}{608}\right) + \frac{42 \times 10^3}{2}$$

and

$$u_2 - u_1 = (-5.08 + 21,000)\,\frac{J}{kg} = 20.995\,\frac{kJ}{kg}$$

The system does work on the surroundings.

Lecture 3

- Classification of Properties:
- Extensive
- Intensive
- Specific

$$\text{Specific (Intensive) Property} = \frac{\text{Extensive Property}}{\text{Total Mass}}$$

- Example:

$$\text{Specific Volume} \quad v = \frac{V}{M} = \frac{1}{\rho} \quad \left[\frac{m^3}{kg}\right]$$

- Examples of Extensive Properties: Volume, Mass, Energy, Surface Area, Strain, Charge, Dipole-Moment, etc.
- Examples of Intensive Properties: Pressure, Temperature, Stress, Chemical Potential, Surface Tension, Electric Field, etc.

- The State Postulate:

When the **intensive properties** of a system are specified, the thermodynamic state of the system is known **intensively**. Give an example.

- Chapter 4: States of a Simple Compressible Substance (SCS).

Consider a simple (has only one work mode), compressible (work mode is pdV) substance.

- List of intensive properties: $\{T, u, P, v, \rho, s, \ldots\}$
- State Postulate says that any 2 of these will fix the remainder.

• Select the specific properties: $\{u, v\}$ for example.
Then we have the equations of state:

$$T = T(u, v), \quad P = P(u, v), \quad s = s(u, v)$$

where s is the specific entropy.
• Data could be in tabular form, graphical form, or in algebraic form.

• History of a constant pressure heating process of a fixed mass.
• See Fig. 4.1 of the text.
• Symbols denote: S is Solid, L is Liquid ,G is Gas, and $S + L$ is a Solid/Liquid Mixture, and $L + G$ is a Liquid/Gas Mixture.
• Processes:
• 1-2 S is a solid which is heated
• 2-3 $S + L$ is a phase change process at constant temperature and pressure
• 3-4 L is a liquid which is heated
• 4-5 $L + G$ is a phase change process at constant temperature and pressure
• 5-6 G is a gas or vapor which is heated

• State 2 is 100% solid and State 3 is 100% liquid
• State 4 is 100% liquid and State 5 is 100% gas

• Enthalpy or Latent Heat of Vaporization. Enthalpy of Evaporation describes the constant temperature, constant pressure process from State 4 to State 5.
