National University of Computer & Emerging Sciences, Lahore
Department of Electrical Engineering
(FALL 2024)

ME2002 – Applied Thermodynamics
Assignment # 1 on CLO # 01 (Total Marks = 70)

Notes:

1. **Submit the hardcopy at the very start of the lecture. Use A4 sheets for the answers.**
2. **No late submissions.**
3. **Any help from the internet, solution manuals, or any other source is strictly prohibited. Violation may lead to serious consequences.**
4. **Draw the diagrams where necessary.**

Date of Submission: Friday 20th September 2024

Problem # 01: Determine whether water at each of the following states is a compressed liquid, a superheated vapor, or a mixture of saturated liquid and vapor (if quality exists, find it). **[12 Marks]**

a. P = 10 MPa, v = 0.003 m^3/kg
b. 1 MPa, 190°C
c. 200°C, 0.1 m^3/kg
d. 10 kPa, 10°C

Also show the states in a sketch of the P–v diagram.

Problem # 02: Give the missing property of P, T, v, and x for Ammonia at: **[8 Marks]**

a. T = -10°C, P = 170 kPa
b. T = 30°C, v = 0.192 m^3/kg

Problem # 03: Fill out the missing quantities in the following table for substance water (Show All Steps). **[5 Marks]**

P[KPA]	T[Degree C]	v[m^3/kg]	x
500	20		
500		0.2	
1400	200		
	300		0.8

Problem # 04: A sealed rigid vessel has volume of 1 m^3 and contains 2 kg of water at 100 degree C. The vessel is now heated. If a safety pressure valve is installed, at what pressure should the valve be set to have a maximum temperature of 200 degree C? **[5 Marks]**

Problem # 05: Two tanks are connected as shown in Fig. 1 below, both containing water. Tank A is at 200 kPa, v = 0.5 m3/kg, VA = 1 m^3, and tank B contains 3.5 kg at 0.5 MPa and 400◦C. The valve is now opened and the two tanks come to a uniform state. Find the final specific volume. **[10 Marks]**

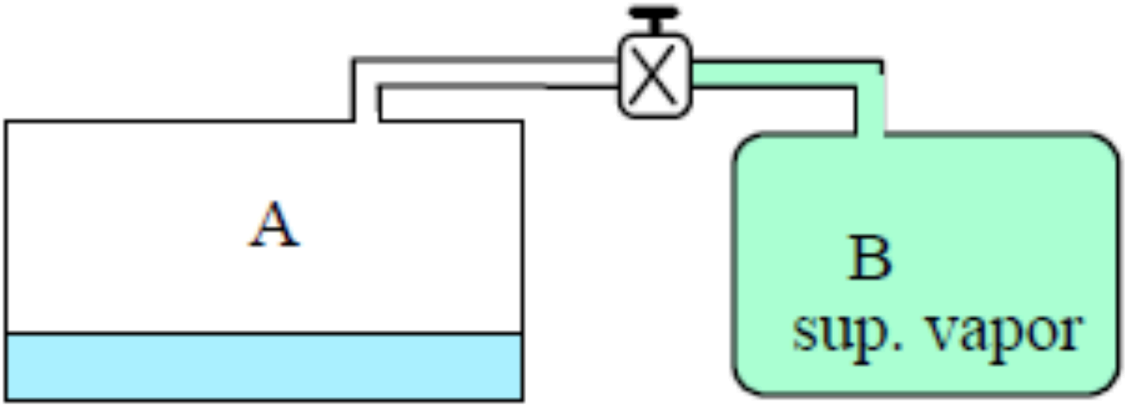

Fig 1

Problem # 06: A piston/cylinder arrangement is loaded with a linear spring and the outside atmosphere. It contains water at 5 MPa, 400◦C, with the volume being 0.1 m^3, as shown in Fig. 2 below. If the piston is at the bottom, the spring exerts a force such that Plift = 200 kPa. The system now cools until the pressure reaches 1200 kPa. Find the mass of water and the final state (T_2, v_2) and plot the P–v diagram for the process. **[10 Marks]**

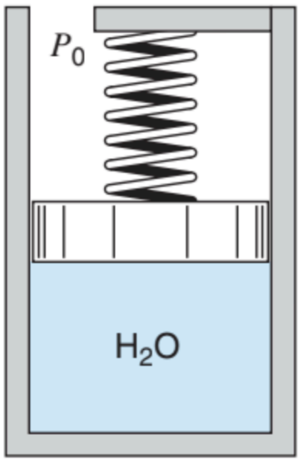

Fig. 2

Problem # 07: Ammonia at 10◦C with a mass of 10 kg is in a piston/cylinder assembly with an initial volume of 1 m^3. The piston initially resting on the stops has a mass such that a pressure of 900 kPa will float it. Now the ammonia is slowly heated to 50◦C. Find the final pressure and volume. **[10 Marks]**

Problem # 08: In your refrigerator, the working substance evaporates from liquid to vapor at $-20^\circ C$ inside a pipe around the cold section. Outside (on the back or below) is a black grille, inside of which the working substance condenses from vapor to liquid at $+45^\circ C$. For each location, find the **pressure** and the **change in specific volume (v)** if the substance is: **[10 Marks]**

a. Ammonia
b. R-134a
c. R-140a

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EE2002 – APPLIED THERMODYNAMICS

Assignment # 1 on CLO # 01

Name:	**Roll Number:**
Date of Submission: 19th September 2024	**Section: BEE-5A**

Instructor: Huzaifa Rauf

Instructions:

1. Assignment must be handed over to the instructor at the very start of the class.
2. Late submission will not be accepted.
3. Only submit your own work. Do not copy from others. Plagiarism will be dealt seriously and it will be treated according to the University disciplinary rules.
4. Submit assignment on **A4 size paper**.
5. Use blue or black ink only. Figures may be in color.
6. Handwriting must be legible. Otherwise, your assignment may be returned ungraded.

Problems ↓ [Marks]	Score	CLO # 01				
		Exemplary (5)	Proficient (4)	Developing (3)	Beginning (2)	Novice (1)
P1 [12]						
P2 [8]						
P3 [5]						
P4 [5]						
P5 [10]						
P6 [10]						
P7 [10]						
P8 [10]						
Total [70]						

Oath: *I have solved all the questions by myself and taken no help from internet, solution manuals, colleagues, or any other unfair means. It is my work only.*

Signature:________________________

Attach this sheet to the front of submitted work.

Q. No. 1

(a)

$P = 10 MPa$, $v = 0.003\ m^3/kg$

Table B 1.2 ⇒ $T_{sat} = 311.06°C$ and $0.001452 < v < 0.01803\ m^3/kg$

Hence, given state is a mixture of liquid and ~~water~~ vapour

As $v = v_f + x v_{fg}$

$$\Rightarrow x v_{fg} = v - v_f$$

$$x = \frac{v - v_f}{v_{fg}}$$

$$x = \frac{0.003 - 0.001452}{0.01657}$$

$$x = 0.0934$$

(b)

$P = 1\ MPa$, $T = 190°C$

Table B1.2 ⇒ $T_{sat} = 179.91°C$

As $T > T_{sat}$, given state is ~~a~~ superheated vapour

(c)

$T = 200^\circ C$, $v = 0.1\ m^3/kg$

Table B1.1 $\Rightarrow$ $P_{sat} = 1553.8$ kPa and $0.001156 < v < 0.12736\ m^3/kg$

Hence, given state is mixture of liquid and vapour.

$$\Rightarrow x = \frac{v - v_f}{v_{fg}} = \frac{0.1 - 0.001156}{0.12620}$$

$x = 0.7832$

(d)

$P = 10$ kPa , $T = 10^\circ C$

Table B.1.1 $\Rightarrow$ $P_{sat} = 1.2276$ kPa

As $P > P_{sat}$, hence given state is compressed Liquid.

Q. No. 2

(a)

$T = -10°C$, $P = 170 kPa$

Table B2.1 ⇒ $P_{sat} = 290.9 kPa$

As $P < P_{sat}$, given state is superheated vapours.

⇒ $v > v_g \Rightarrow v \approx v_g$

⇒ $v = 0.41808 \ m^3/kg$

$$\Rightarrow x = \frac{v - v_f}{v_{fg}} = \frac{0.41808 - 0.001534}{0.41655}$$

⇒ $x = 0.9999$

x: quality in 2-phase only (not possible)

(b)

$T = 30°C$, $v = 0.192 \ m^3/kg$

Table B2.1 ⇒ $P_{sat} = 1167.0 kPa$

As $v > v_g = 0.11049 \ m^3/kg$, given state is superheated vapours

$$\Rightarrow x = \frac{v - v_f}{v_{fg}} = \frac{0.192 - 0.001680}{0.10881}$$

$x = 1.7491$ (not possible as x should be $0 \le x \le 1$)

①

Q. No. 3

(a)

$P = 500\ kPa$, $T = 20^\circ C$

Table B1.2 ⇒ $T_{sat} = 151.86^\circ C$

As $T < T_{sat}$, given state is compressed liquid

~~⇒ $v < v_f$ ⇒~~ $v \approx v_f$ Table B1.4 ⇒ $v = 0.001002\ m^3/kg$

~~⇒ $v = 0.001093\ m^3/kg$~~

$$\Rightarrow x = \frac{v - v_f}{v_{fg}} = \frac{0.001002 - 0.001093}{0.37380}$$

$x = -2.4345 \times 10^{-4}$ (not possible)

} x is quality in two-phase only. Hence not possible in compressed liquid state or superheated vapour state

(b)

$P = 500\ kPa$, $v = 0.2\ m^3/kg$

Table B1.2 ⇒ $T_{sat} = 151.86^\circ C$ and $0.001093 < v < 0.37489$

Hence, given state is mixture of liquid and vapour

$$\Rightarrow x = \frac{v - v_f}{v_{fg}} = \frac{0.2 - 0.001093}{0.37380}$$

$x = 0.5321$

(c)

$P = 1400\ kPa$, $T = 200^\circ C$

Table B1.2 ⇒ $T_{sat} = 195.07^\circ C$

As $T > T_{sat}$, given state is superheated vapour

Table B1.3 ⇒ $v = 0.14302\ m^3/kg$

$$\Rightarrow x = \frac{v - v_f}{v_{fg}} = \frac{0.14302 - 0.001149}{0.13969}$$

$x = 1.0156$ (not possible)

} x: quality in two phase only

(d)

$T = 300^\circ C$, $x = 0.8$

Table B1.1 $\Rightarrow$ $P_{sat} = 8581.0$ kPa

As quality (x) is given, hence given state is two-phase (Liq.+vap.)

As $v = v_f + x v_{fg}$

$= 0.001404 + (0.8)(0.02027)$

$= 0.01762 \ m^3/kg$

	P (kPa)	T (°C)	v (m³/kg)	x
a	500	20	0.001002	not possible
b	500	151.86	0.2	0.5321
c	1400	200	0.14302	not possible
d	8581.0	300	0.01762	0.8

Q. No. 4

$\Rightarrow$ $V = 1\,m^3$, $m = 2\,kg$, $T_1 = 100°C$

$\Rightarrow$ Superheated state , $T_2 = 200°C$

As $v = \frac{V}{m} = \frac{1}{2}$

$= 0.5\ m^3/kg$

Table B1.1 $\Rightarrow$ $P_{sat} = 101.3°C$ and $0.001044 < v < 1.67290\ m^3/kg$

Hence, given state is two-phase.

Q. No. 5

Tank-A: 200kPa, 0.5 m^3/kg, 1 m^3 — ①

Tank-B: 3.5kg, 0.5 MPa, 400°C — ②

As final specific volume $v_T = \frac{V_T}{m_T}$ — ③

From ①, as $v = \frac{V}{m}$

$$\Rightarrow m_A = \frac{V_A}{v_A} = \frac{1}{0.5}$$

$$= 2\ kg$$

From ②,

Table B 1.2 ⇒ $T_{sat} = 151.86$ °C

As $T > T_{sat}$, state is superheated vapour.

Table B1.3 ⇒ $v_B = 0.61728\ m^3/kg$

As $v = \frac{V}{m}$

$$\Rightarrow V_B = v_B m_B = (0.61728)(3.5)$$

$$= 2.16048\ m^3$$

From ③,

$$v_T = \frac{V_T}{m_T} = \frac{V_A + V_B}{m_A + m_B}$$

$$= \frac{1 + 2.16048}{2 + 3.5}$$

$$v_T = 0.5746\ m^3/kg$$

Q. No. 6

$\Rightarrow P_1 = 5MPa$, $T_1 = 400°C$, $V = 0.1 m^3$

$\Rightarrow P_{lift} = 200$ kPa

$\Rightarrow P_2 = 1200$ kPa , T_2 , V_2

Table B1.2 $\Rightarrow$ $T_{sat} = 263.99°C$

As $T > T_{sat}$, state is superheated vapour.

Table B1.3 $\Rightarrow$ $v = 0.05781 \ m^3/kg$

As $v = \frac{V}{m}$

$\Rightarrow m = \frac{V}{v} = \frac{0.1}{0.05781}$

$m = 1.7298$ kg

Q. No. 7

$\Rightarrow T_1 = 10°C$, $m = 10kg$, $V_1 = 1m^3$, — ①
$\Rightarrow P_1 = 900kPa$, $T_2 = 50°C$, P_2 , V_2

From ①

As $v = \frac{V}{m} = \frac{1}{10}$

$v = 0.1 \ m^3/kg$

Table B2.1 $\Rightarrow$ $P_{sat} = 615.2$ kPa and $0.001600 < v < 0.20541 \ m^3/kg$

Hence, given state is two-phase

As $x = \frac{v - v_f}{v_{fg}} = \frac{0.1 - 0.001600}{0.20381}$

$x = 0.4828$

Q. No. 8

Liquid to vapour at $T_1 = -20°C$ — ①.
Vapour to Liquid at $T_2 = 45°C$ — ② ; $P = ?$, ΔV ~~...~~ $v_{fg} = ?$

(a)

Ammonia

① Table B2.1 ⇒ $P_1 = 190.2$ kPa

and $\Delta V = v_{fg} = 0.62184$ m³/kg

② Table B2.1 ⇒ $P_2 = 1782.0$ kPa and $\Delta V = v_{fg} = 0.07073$ m³/kg

(b)

R-134a

① Table B5.1 ⇒ $P_1 = 133.7$ kPa

$\Delta V = v_{fg} = 0.14576$ m³/kg

② Table B5.1 ⇒ $P_2 = 1160.2$ kPa

$\Delta V = v_{fg} = 0.01650$ m³/kg

(c)

~~R-410a~~ R-410a

① Table B4.1 ⇒ $P_1 = 399.6$ kPa

$\Delta V = v_{fg} = 0.06400$ m³/kg

② Table B4.1 ⇒ $P_2 = 2728.3$ kPa

$\Delta V = v_{fg} = 0.00723$ m³/kg