

Department	Mechanical		Program	B.Tech	
Subject Name	Engineering Thermodynamics		Subject Code	MEC 304	
Semester	3rd	Credits	3	Teacher Incharge/Mentor	Prof. Adnan Qayoum
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Unit I

Text book to be consulted:

1. “**Fundamentals of Engineering Thermodynamics**” by Moran and Shapiro, 4th Edition, John Wiley.

Links to the resources:

1. <https://www.youtube.com/watch?v=9GMBpZZtjXM>
2. <https://www.youtube.com/watch?v=xQwi9fveGTQ>
3. <https://www.youtube.com/watch?v=0jXeNaSM5Xc&index=3&list=PLD8E646BAB3366BC8>
4. <https://www.youtube.com/watch?v=sUDfpFD0xX4&index=4&list=PLD8E646BAB3366BC8>
5. https://www.youtube.com/watch?v=bCToK4_dmbU&index=5&list=PLD8E646BAB3366BC8

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Numerical Problems

1. A system consisting of 1 lb of a gas undergoes a process during which the relation between pressure and volume is $pV = \text{constant}$. The process begins with $p_1 = 100 \text{ lbf/in}^2$, $V_1 = 1.5 \text{ ft}^3$ and ends with $p_2 = 40 \text{ lbf/in}^2$. Determine the final volume, V_2 , in ft^3 and plot the process on a graph of pressure versus volume.
2. Determine the gage pressure, in lbf/in^2 , equivalent to a manometer reading of 1 in. of
 - (a) Water (density = 62.4 lb/ft^3)
 - (b) mercury (the density of mercury is 13.59 times that of water)
3. A gas expands from an initial state where pressure is 340 kPa and volume is 0.0425 m^3 to a final state where pressure is 136 kPa. The relationship between pressure and volume during the process is $pV^2 = \text{constant}$. Sketch the process on a p - V diagram and determine the work, in kJ.
4. A gas undergoes two processes in series:
Process 1–2: constant volume from $p_1 = 50 \text{ lbf/in}^2$ to $p_2 = 10 \text{ lbf/in}^2$
Process 2–3: compression with $pV^{1.3} = \text{constant}$ from state 2 to $p_3 = 50 \text{ lbf/in}^2$ and $V_3 = 1 \text{ ft}^3$
Sketch the processes on a p - V diagram and determine the work.
5. A gas in a piston–cylinder assembly is compressed from $p_1 = 3.4 \text{ bar}$, $V_1 = 0.0283 \text{ m}^3$ to $p_2 = 8.2 \text{ bar}$ in a process for which the relation between pressure and volume is $pV^{1.2} = \text{constant}$. The mass of the gas is 0.183 kg. During the process, the heat transfer from the gas is 2.2 kJ. Determine the change in specific internal energy of the gas, in kJ/kg. Kinetic and potential energy effects are negligible.
6. A gas undergoes a thermodynamic cycle consisting of three processes beginning at an initial state where $p_1 = 1 \text{ bar}$, $V_1 = 1.5 \text{ m}^3$, and $U_1 = 512 \text{ kJ}$. The processes are as follows
Process 1–2: compression with $pV = \text{constant}$, from $p_2 = 2 \text{ bar}$, $U_2 = 690 \text{ kJ}$
Process 2–3: $W_{23} = 0$, $Q_{23} = -150 \text{ kJ}$
Process 3–1: $W_{31} = +50 \text{ kJ}$
There are no significant changes in kinetic or potential energy. Determine the heat transfer Q_{12} and Q_{31} each in kJ.
7. A gas undergoes a process from state 1, where $p_1 = 20 \text{ lbf/in}^2$ to state 2, where $p_2 = 60 \text{ lbf/in}^2$ and $V_2 = 1.5 \text{ ft}^3$. The pressure volume relation during the process is $pV = \text{constant}$. The internal energy of the gas increases by 10,000 ft.lbf, and there are no changes in kinetic or potential energy during the process. Determine the heat transfer, in Btu.
8. Determine the phase or phases in a system consisting of H_2O at the following conditions and sketch p - v and T - v diagrams showing the location of each state.
 - (a) $p = 5 \text{ lbf/in}^2$, $T = 500^\circ \text{F}$.
 - (b) $p = 50 \text{ lbf/in}^2$, $T = 300^\circ \text{F}$.

- (c) $p = 500 \text{ lbf/in}^2$, $T = 600^\circ \text{ F}$.
 (d) $p = 20 \text{ lbf/in}^2$, $T = 5^\circ \text{ F}$.
 (e) $p = 1000 \text{ lbf/in}^2$, $T = 200^\circ \text{ F}$.

9. A two phase liquid vapor mixture of H_2O at 200 lbf/in^2 has a specific volume of $1.5 \text{ ft}^3 / \text{lb}$. Determine the specific volume of a two phase liquid vapor mixture at 100 lbf/in^2 with the same quality.
10. A two phase liquid vapor mixture of H_2O has a temperature of 300° C and a quality of 75%. The mixture occupies a volume of 0.05 m^3 . Determine the masses of saturated liquid and vapor present each in kg.
11. Water vapor initially at 0.3 MPa and 160° C expands to 0.1 MPa in a piston cylinder assembly according to $pv^{1.2} = \text{constant}$. Determine the specific volume at the final state, in m^3/kg , and sketch the process on a carefully labeled p - v diagram. For 1 kg of water vapor, calculate the work in kJ.
12. A rigid well insulated tank contains 3 kg of a two phase liquid vapor mixture of water, initially at 200 kPa with a quality of 84%. A paddle wheel stirs the mixture until only saturated vapor remains in the tank. Kinetic and potential energy effects are negligible. For the water, determine the amount of energy transferred by work in kJ.
13. Saturated water vapor initially at 40 lbf/in^2 is contained in a closed rigid tank with a volume of 1.5 ft^3 . Heat transfer from the water occurs and its pressure drops to 20 lbf/in^2 . Calculate the amount of heat transfer, in Btu and the masses of saturated liquid and vapor present at the final state, in lb. Kinetic and potential energy effects are negligible.
14. A system consisting of 2 kg of H_2O undergoes a cycle composed of the following processes:
Process 1–2: Expansion with $pv = \text{constant}$ from saturated vapor at 100 bar to 10 bar
Process 2–3: constant pressure process to $v_3 = v_1$
Process 3–1: constant volume heating
 Sketch the cycle on p - v and T - v diagrams. Neglecting kinetic and potential energy effects, determine the net work for the cycle and the heat transfer for each process, all in kJ.
15. Argon (Ar) gas initially at 500 kPa , 100 K undergoes a polytropic process with $n = k$ to a final temperature of 300 K . determine the work and heat transfer for the process, each in kJ per kg or argon. Assume ideal gas behavior and neglect kinetic and potential energy effects.

Reference books:

1. Cengel, Y., Boles, "Thermodynamics", *Mc-Graw Hill*, 2001.
2. Van-Wylen, G.J., "Fundamentals of Classical Thermodynamics", *John Wiley*, 2001.

Any other information:

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