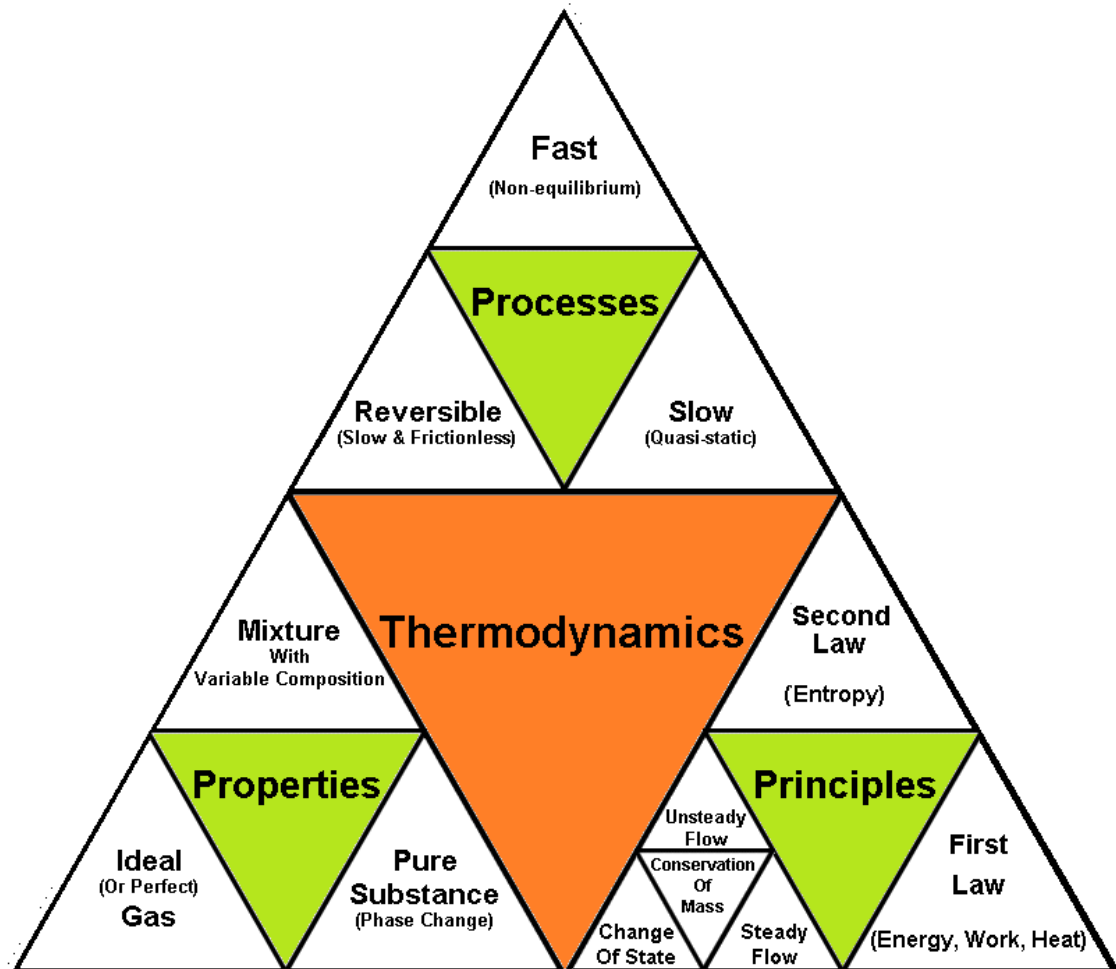


CLASS: SECOND YEAR 3rd SEMESTER

10M

BRANCH: MECHANICAL ENGINEERING



THERMODYNAMICS (23MEC233)

QUESTION BANK

(Updated on Sep 2024)

Prepared by

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Course Educational Objectives:

1. Familiarize concepts of heat, work, energy and governing rules for conversion of one form to other.
2. Explain relationships between properties of matter and basic laws of thermodynamics.
3. Teach the concept of entropy for identifying the disorder and feasibility of a thermodynamic process.
4. Introduce the concept of available energy for maximum work conversion and power cycles.
5. Provide fundamental concepts of Refrigeration and Psychrometry.

Unit – I: BASIC CONCEPTS OF THERMODYNAMICS**(9)**

Introduction: Basic Concepts : System, boundary, Surrounding, control volume, Universe, Types of Systems, Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium, State, Property, Process, Cycle – Reversibility – Quasi static Process, Irreversible Process, Causes of Irreversibility

Unit –II: FIRST LAW OF THERMODYNAMICS**(9)**

Energy in State and in Transition, Types, Work and Heat, Point and Path function. Zeroth Law of Thermodynamics – PMM-I, Joule's Experiment – First law of Thermodynamics and applications. Limitations of the First Law – Enthalpy, Thermal Reservoir, Heat Engine, Heat pump, Parameters of performance.

Unit – III: SECOND LAW OF THERMODYNAMICS AND THERMODYNAMIC RELATIONS**(9)**

Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements and their Equivalence / Corollaries, PMM-II, Carnot's principle, Carnot cycle and its specialties, Thermodynamic scale of Temperature, Clausius Inequality, Entropy, Principle of Entropy Increase – Energy Equation, Availability and Irreversibility – Thermodynamic Potentials, Gibbs and Helmholtz Functions, Maxwell Relations – Clausius - Clapeyron Equation – Elementary Treatment of the Third Law of Thermodynamics.

Unit – IV: PROPERTY OF PURE SUBSTANCES AND POWER CYCLES**(9)**

Pure Substances, P-V-T- surfaces, T-S and h-s diagrams, Mollier Charts, Phase Transformations – Triple point at critical state properties during change of phase, Dryness Fraction – Property tables. Mollier charts – Various Thermodynamic processes and energy Transfer – Steam Calorimetry. Air Power cycles: Assumptions and working of Otto and Diesel cycles – Comparison of air standard and actual cycles. Vapour Power cycles: Rankine cycle – Schematic layout.

Unit – V: REFRIGERATION AND AIR CONDITIONING**(9)**

Introduction to Refrigeration: Working of Air, Vapour compression and absorption refrigeration system – VCR and VAR system Components – COP – Refrigerants. Introduction to Air Conditioning: Psychrometric properties and processes – Characterization of sensible and latent heat loads – Load concepts of SHF. Requirements of human comfort and concept of effective temperature – Comfort chart – Comfort air conditioning and load calculations.

Total Hours: 45

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COURSE OUTCOMES:

On successful completion of the course, students will be able to		POs
CO1	Explain the importance of thermodynamic properties related to conversion of heat energy into work.	PO1, PO2, PO4
CO2	Apply the Zeroth and First Law of Thermodynamics.	PO1, PO2, PO4
CO3	Understand Second Law of Thermodynamics.	PO1, PO2, PO4
CO4	Analyze the Mollier charts, T-S and h-s diagrams, Steam calorimetry, Phase Transformations and understand the basics of power cycles.	PO1, PO2, PO4
CO5	Evaluate the COP of refrigerating systems and properties, processes of psychrometry and sensible and latent heat loads.	PO1, PO2, PO4

TEXT BOOKS:

1. P.K.Nag, Engineering Thermodynamics, 6/e, Tata McGraw Hill, 2017.
2. Claus Borgnakke Richard E. Sonntag, Fundamentals of Thermodynamics, 10/e, Wiley, 2020.

REFERENCE BOOKS:

1. J.B. Jones, and R.E. Dugan, Engineering Thermodynamics, 1/e, Prentice Hall, 1996.
2. Y.A.Cengel & M.A.Boles, Thermodynamics – An Engineering Approach, 9/e, McGraw Hill, 2019.
3. P.Chattopadhyay, Engineering Thermodynamics, 2/e, Oxford University Press, 2016.
4. CP Arora, Refrigeration and Air-conditioning, 4/e, McGraw Hill, 2021.
5. P.K.Nag, Basic and Applied Thermodynamics, 2/e, Tata McGraw Hill, 2017.

NOTE: Use of standard thermodynamic tables, Mollier diagram, Psychometric chart and Refrigerant property tables are permitted.

ONLINE LEARNING RESOURCES:

- <https://www.edx.org/learn/thermodynamics>.
- <https://archive.nptel.ac.in/courses/112/106/112106310>.
- https://kp.kiit.ac.in/pdf_files/02/Study-Material_3rd-Semester_Winter_2021_Mechanical-Engg.-_Thermal-Engineering-1_Abhijit-Samant.pdf
- <https://www.coursera.org/learn/thermodynamics-intro>
- https://onlinecourses.nptel.ac.in/noc19_me56/preview
- <https://www.classcentral.com/course/swayam-engineering-thermodynamics-7904>

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO.1	3	2	-	1	-	-	-	-	-	-	-	-
CO.2	3	2	-	1	-	-	-	-	-	-	-	-
CO.3	3	2	-	1	-	-	-	-	-	-	-	-
CO.4	3	2	-	1	-	-	-	-	-	-	-	-
CO.5	3	2	-	1	-	-	-	-	-	-	-	-
CO*	3	2	-	1	-	-	-	-	-	-	-	-

Bloom's Taxonomy

Bloom's Level	Descriptions	Bloom's Level	Descriptions
BT 1	Remember	BT 2	Understand
BT 3	Apply	BT 4	Analyze
BT 5	Evaluate	BT 6	Create

QUESTION BANK

Question No.	Questions	Bloom's Level
PART-B (Ten Marks Questions)		
UNIT 1 - BASIC CONCEPTS OF THERMODYNAMICS		
1a	A fluid at of pressure of 3 bar and with volume of 0.18 m ³ /kg contained in cylinder behind a piston expands reversibly to a pressure of 0.6 bar. According to law a $P = C/V^2$, where C is a constant. Calculate the workdone by the fluid on the piston.	BT4
1b	A temperature scale of certain thermometers is given by the relation: $t = a \ln(p) + b$, where 'a' and 'b' are constant and 'p' is the thermometric property of the fluid in the thermometer. If at the ice point and steam point of the thermometric properties are found to be 1.5 and 7.5 respectively. What will be the temperature corresponding to the thermometric property of 3.5 on Celsius scale.	BT4
2	Prove that $C_p - C_v = R$ and determine the relationship between C_p , C_v , R and also find the adiabatic index (γ).	BT2
3a	The properties of a closed system change following the relation between pressure and volume as $PV=3$, where p in bar, V in m ³ . Calculate the workdone when the pressure increases from 1.5bar to 7.5bar.	BT4
3b	A barometer reads 76cm of Hg. What would be the absolute pressure if; (i) A pressure gauge connected to turbine inlet reads 28bar and (ii) A vacuum gauge connected in the outlet line of the same turbine reads 70cm of Hg.	BT4
4a	Determine the work done by the air which enters into an evacuated vessel from atmosphere when the valve is opened. The atmosphere pressure is 1.013 bar and 1.5m ³ air at atmosphere condition enters into the vessel.	BT4
4b	A mass of 1.5kg air is compressed in a quasi-static process from 0.1MPa to 0.7MPa for which $PV = \text{constant}$. The initial density of air is 1.16 kg/m ³ . Find the workdone by the piston to compress the air.	BT4
5	State law's of perfect gases and how the laws are governed by variables?	BT2
UNIT 2 - FIRST LAW OF THERMODYNAMICS		
1	State the first law of thermodynamics and prove that first law is the law of conservation of energy for a non-flow process and it leads to the energy equation $\delta Q = dU + \delta W$.	BT2
2a	A stationary mass of gas is compressed without friction from an initial state of 0.3 m ³ and 0.105 MPa to a final state of 0.15m ³ and 0.105 MPa. The pressure remains constant during the process. There is a transfer of 37.6 kJ of heat from the gas during the process. How much does the internal energy of the gas change?	BT4
2b	A mass of 0.25 kg of air in a closed system from 2 bar, 60°C to 1 bar, 40°C, while receiving 1.005kJ of heat from a reservoir at 100°C. The surrounding atmosphere is at 0.95 bar and 27°C. Determine the maximum work.	BT4
3	List out the heating and expansion of gases in non-flow processes and derive the expression for P-V-T relation, workdone, change in internal energy, heat supplied and change in enthalpy by using constant volume process.	BT2
4	List out the heating and expansion of gases in non-flow processes and derive the expression for P-V-T relation, workdone, change in internal energy, heat supplied and change in enthalpy by using constant pressure process.	BT2
5	A certain gas occupies a space of 0.3m ³ at a pressure of 2 bar and temperature of 77°C. It is heated at a constant volume until the pressure is 7 bar. Determine: (i) temperatures at the end of the process, (ii) mass of the gas, (iii) change in internal energy and (iv) change in enthalpy during the process. Assume $C_p = 1.005 \text{ kJ/kg.K}$, $C_v = 0.712 \text{ kJ/kg.K}$.	BT4

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6	The values of specific heats at constant pressure and at constant volume for an ideal gas are 0.984 kJ/kg.K and 0.728 kJ/kg.K. Find the values of characteristic gas constant (R) and ratio of specific heats for the gas. If 1 kg of this gas is heated at constant pressure from 25°C to 200°C. Estimate the heat added, ideal workdone and change in internal energy. Also calculate the pressure and final volume. If the initial volume was 2m ³ .	BT4
7	Derive the expression of first law of thermodynamics to a steady flow process.	BT2
8	Derive the steady flow energy equations for the flowing applications in engineering systems: (i) Boiler, (ii) Nozzle, (iii) turbine, (iii), Condenser and (iv) Compressor.	BT2
UNIT 3 - SECOND LAW OF THERMODYNAMICS AND THERMODYNAMIC RELATIONS		
1	State the second law of thermodynamics and find COP of heat pump and refrigerator.	BT2
2	Derive the expression for Carnot cycle and what reasons it cannot be performed in practice?	BT2
3	Derive the expression of change in entropy of a perfect gas in the process of constant volume and constant pressure.	BT2
4	Derive the expression of change in entropy of a perfect gas in polytropic process.	BT2
5a	A vessel of 2.5m ³ capacity contains 1kg-mole of nitrogen at 100°C. If the gas cooled to 30°C. Calculate the change in specific entropy. The ratio of specific heats is 1.4 and 1kg-mole nitrogen is 28kg.	BT4
5b	Cold air from atmosphere is circulated through an air heating system, where the temperature of air is increased from 7.2°C to 21.2°C without any pressure loss. If the hourly consumption of warm air at 21.2°C is 850m ³ . Calculate: (i) how much heat per hour must be imparted to the air, (ii) what will be the change in entropy of air circulated per hour? Assume proper values of the specific heat of air.	BT4
6	A fluid undergoes a reversible adiabatic compression from 4bar, 0.3m ³ to 0.08m ³ . According to the law, $PV^{1.25}=C$. Determine: (i) change in enthalpy, (ii) change in internal energy, (iii) change in entropy and (iv) heat and work transfer during the process.	BT4
7	Drive the expression of “Maxwell equations”.	BT2
8	Explain about the “Helmholtz function” and “Gibbs function” and determine the workdone of these functions.	BT2
UNIT 4 - PROPERTY OF PURE SUBSTANCES AND POWER CYCLES		
1	Explain about the formation of steam with the help of T-dQ diagram.	BT2
2	Explain the following indicator diagram for a pure substance: (i) Pressure - Temperature (P-T), (ii) Temperature - Volume (T-V), (iii) Temperature – Specific Enthalpy (T-h), (iv) Pressure - Volume - Temperature (P-V-T) surface and (v) Specific Enthalpy - Specific Entropy(h-s)	BT2
3	A vessel having capacity of 0.05 m ³ contains a mixture saturated water and saturated steam at a temperature of 245°C. The mass of the liquid present is 10kg. Find the following: (i) The pressure, (ii) the mass, (iv) the specific volume, (iv) the specific entropy and (v) the specific internal energy.	BT4
4	Find the dryness fraction, specific volume and specific internal energy of steam at 7bar and enthalpy 2550 kJ/kg.	BT4
5	Two boilers one with superheater and other without superheater are delivering equal quantities of steam into a common main. The pressure in the boilers and main is 20 bar. The temperature of steam from a boiler with a superheater is 350°C and temperature of the steam in the main is 250°C. Determine the quality of steam supplied by the other boiler. Take; $C_{p_s} = 2.25$ kJ/kg.K	BT4
6	Derive the expression of air standard efficiency of an Otto cycle with p-V and T-S diagrams.	BT2

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7	Derive the expression of air standard efficiency of a Diesel cycle with p-V and T-S diagrams.	BT2
8	Distinguish between: (i) Air standard and actual cycles & (ii) Otto and Diesel cycles.	BT2
UNIT 5 - REFRIGERATION AND AIR CONDITIONING		
1	Explain the main components in vapour compression refrigeration system with neat sketch.	BT2
2	Explain with a flow diagram, the working of aqua-ammonia vapour absorption refrigeration system.	BT2
3	In refrigerating plant, water at 20.5°C is converting to producing as ice at -3°C at 450kg per hour. Calculate the power required to drive the compressor for production of ice. Assume, latent heat of ice is 340 kJ/kg, specific heat of ice is 2.1kJ/kg.K.	BT4
4	Explain about physical, safe working and thermodynamic properties of a ideal refrigerant?	BT2
5	List out the various psychrometric properties of air and explain each.	
6	Draw the psychrometric chart and explain the properties of Psychrometry.	BT2
7a	200 m ³ of air at 15°C dry bulb temperature and 75% relative humidity is heated until its temperature is 25°C. Find: (i) relative humidity of heated air, (ii) wet bulb temperature of heated air and (iii) Heat added to air/min.	BT4
7b	Atmosphere air at a dry bulb temperature of 16°C and 25% relative humidity passes through a furnace and then through a humidifier, in such a way that the final dry bulb temperature is 30°C and relative humidity 50%. Find the heat and moisture added to the air. Also determine the sensible heat factor of the process.	BT4
8a	Atmosphere air at 30°C dry bulb temperature and 45% relative humidity is to be conditioned to 17°C dry bulb temperature and 15°C wet bulb temperature. Find the amount of heat rejected by the air. Also find the sensible heat factor of the process.	BT4
8b	One kg of air at 40°C dry bulb temperature and 50% relative humidity is mixed with 2kg of air at 20°C dry bulb temperature and 20°C dew point temperature. Calculate the temperature and specific humidity of the mixture.	BT4

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