|| Jai Sri Gurudev ||

Sri AdichunchanagiriShikshana Trust®

SJB INSTITUTE OF TECHNOLOGY

(Affiliated to Visvesvaraya Technological University, Belagavi & Approved by AICTE, New Delhi. Accredited with NAAC 'A' grade)

Department of Mechanical Engineering

ASSIGNMENT QUESTIONS

BASIC THERMODYNAMICS

Semester &Section: **3rd Semester**

Subject Name: **Basic Thermodynamics**

Subject Code: **18ME33**

Academic year**: ODD Semester-2021-2022**

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Vision of the Institute

- To become a recognized technical education center with global perspective.

Mission of the Institute

To provide learning opportunities that fosters students ethical values, intelligent development in science & technology and social responsibility so that they become sensible and contributing members of the society.

Vision of the Department

- To become a center of excellence and a platform in diversified fields for the aspirants in Mechanical Engineering.

Mission of the Department

- To impart comprehensive education in the field of mechanical engineering to produce highly accomplished graduates
- To endow high profile technical & soft skill trainings to foster professionalism and ethical values among students
- To inculcate innovative thinking among students through projects and research work

PROGRAMOUTCOMES

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineeringfundamentals, and an engineering specialization to the solution of complex engineeringproblems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineeringsciences.
3. **Design/development of solutions**: Design solutions for complex engineering problemsanddesignsystemcomponentsorprocessesthatmeetthespecifiedneedswithappropriate consideration for the public health and safety, and the cultural, societal, andenvironmentalconsiderations.
4. **Conduct investigations of complex problems**: Use research-based knowledge andresearch methods includingdesign ofexperiments, analysisand interpretation ofdata,andsynthesisoftheinformationtoprovidevalidconclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, andmodernengineeringandITtoolsincludingpredictionandmodelingtocomplexengineeringactivitieswithanu nderstandingofthelimitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge toassesssocietal,health,safety,legalandculturalissuesandtheconsequentresponsibilitiesrelevanttotheprofessi onalengineeringpractice.
7. **Environment and sustainability**: Understand the impact of the professional engineeringsolutions in societal and environmental contexts, and demonstrate the knowledge of, andneedforsustainabledevelopment.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities andnormsoftheengineering practice.
9. **Individual and teamwork**: Function effectively as an individual, and as a member orleaderindiverseteams, andinmultidisciplinarysettings.
10. **Communication**: Communicate effectively on complex engineering activities with theengineering community and with society at large, such as, being able to comprehend andwrite effective reports and design documentation, make effective presentations, and giveand receiveclearinstructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of theengineering and management principles and apply these to one’s own work, as a memberandleaderinateam, tomanageprojectsandinmultidisciplinaryenvironments.
12. **Life-long learning**: Recognize the need for and have the preparation and ability toengage in independent and life-long learning in the broadest context of technologicalchange.

PROGRAM EDUCATIONAL OBJECTIVES (PEO'S)

Enable the Graduates in Mechanical Engineering to:

PEO-1: Progress their career as a professionalin mechanical engineering and Inter-disciplinary fields.

PEO-2: Become successful entrepreneur with social responsibilities and ethical values.

PEO-3: Pursue higher education and involve in research of allied areas in Mechanical Engineering.

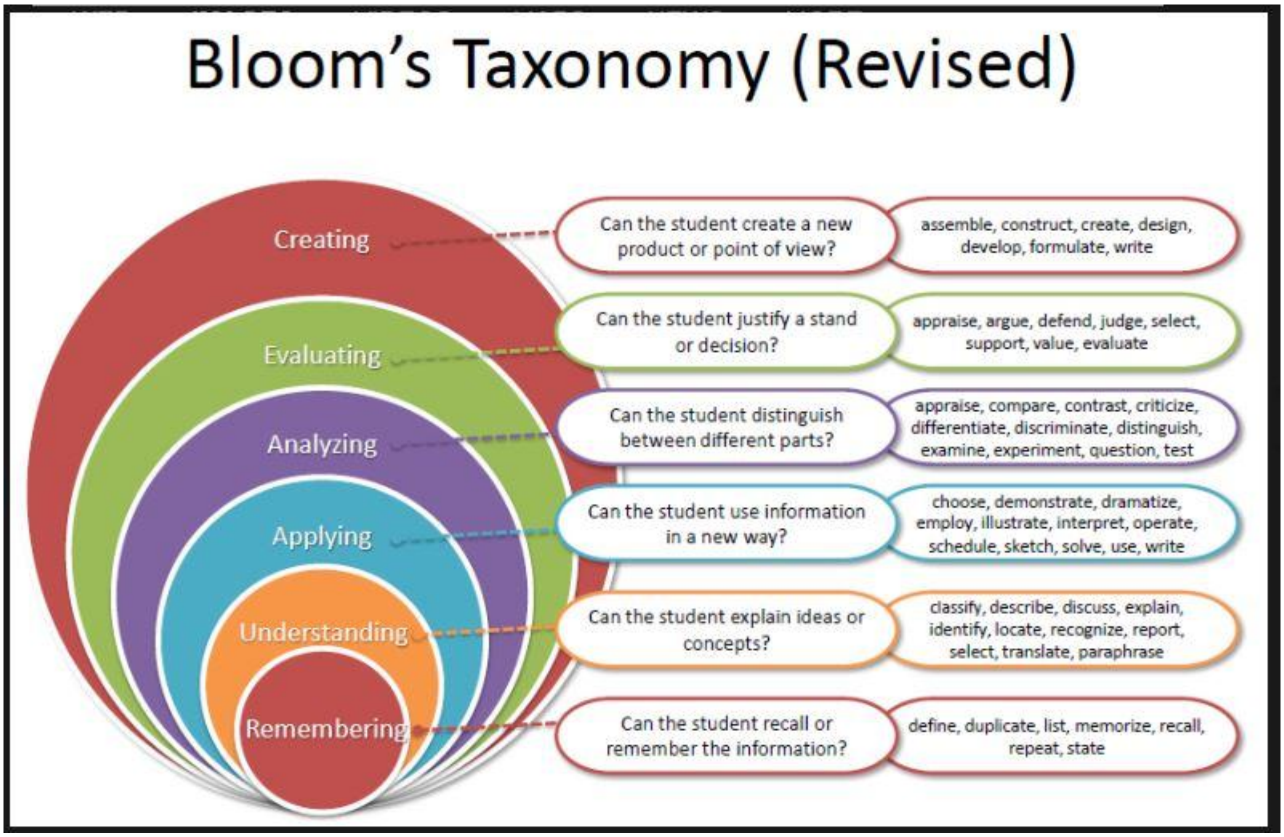
PROGRAM SPECIFIC OUTCOMES (PSO'S)

After successful completion of Mechanical Engineering program, the graduates will be able to:

PSO1: Apply the Knowledge & Skill of Mechanical Engineering on Design, Manufacturing and Thermal platforms to address the real-life problem of the society.

PSO2: Design and implement new ideas with the help of CAD/CAM and Industrial Automation tools.

Blooms Taxonomy



B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III
BASIC THERMODYNAMICS

Course Code 18ME33	CIE Marks 40
Teaching Hours/Week (L:T:P) 3:0:0	SEE Marks 60
Credits 03	Exam Hours 03

Course Learning Objectives:

- Learn about thermodynamic system and its equilibrium
- Understand various forms of energy - heat transfer and work
- Study the basic laws of thermodynamics including, zeroth law, first law and second law.
- Interpret the behaviour of pure substances and its application in practical problems.
- Study of Ideal and real gases and evaluation of thermodynamic properties

Module-1

Fundamental Concepts & Definitions: Thermodynamic definition and scope, Microscopic and Macroscopic approaches. Some practical applications of engineering thermodynamic Systems, Characteristics of system boundary and control surface, examples. Thermodynamic properties; definition and units, intensive, extensive properties, specific properties, pressure, specific volume, Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic; processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium, Zeroth law of thermodynamics, Temperature; concepts, scales, international fixed points and measurement of temperature. Constant volume gas thermometer, constant pressure gasthermometer, mercury in glass thermometer.

Module-2

Work and Heat: Mechanics, definition of work and its limitations.Thermodynamic definition of work; examples, sign convention. Displacement work; as a part of a system boundary, as a whole of a system boundary, expressions for displacement work in various processes through p-v diagrams. Shaft work; Electrical work. Other types of work. Heat; definition, units and sign convention. Problems.

First Law of Thermodynamics: Joules experiments, equivalence of heat and work. Statement of the First law of thermodynamics, extension of the First law to non - cyclic processes, energy, energy as a property, modes of energy, Extension of the First law to control volume; steady flow energy equation(SFEE), important

Module-3

Second Law of Thermodynamics: Limitations of first law of thermodynamics, Thermal reservoir, heat engine and heat pump: Schematic representation, efficiency and COP. Reversed heat engine, schematic representation, importance and superiority of a reversible heat engine and irreversible processes, internal and external reversibility. Kelvin - Planck statement of the Second law of Thermodynamics; PMM I and PMM II, Clausius statement of Second law of Thermodynamics, Equivalence of the two statements; Carnot cycle, Carnot principles. Problems

Entropy: Clausius inequality, Statement- proof, Entropy- definition, a property, change of entropy, entropy as a quantitative test for irreversibility, principle of increase in entropy, entropy as a coordinate.

Module-4

Availability, Irreversibility and General Thermodynamic relations. Introduction, Availability (Exergy), Unavailable energy, Relation between increase in unavailable energy and increase in entropy. Maximum work, maximum useful work for a system and control volume, irreversibility. Pure Substances: P-T and P-V diagrams, triple point and critical points. Sub-cooled liquid, saturated liquid, mixture of saturated liquid and vapor, saturated vapor and superheated vapor states of pure substance with water as example. Enthalpy of change of phase (Latent heat). Dryness fraction (quality), T-S and H-S diagrams, representation of various processes on these diagrams. Steam tables and its use. Throttling calorimeter, separating and throttling calorimeter.

Module-5

Ideal gases: Ideal gas mixtures, Daltons law of partial pressures, Amagat's law of additive volumes, evaluation of properties of perfect and ideal gases, Air- Water mixtures and related properties.
Real gases: Introduction, Van-der Waal's Equation of state, Van-der Waal's constants in terms of critical properties, Beattie-Bridgeman equation, Law of corresponding states, compressibility factor; compressibility chart. Difference between Ideal and real gases.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Explain fundamentals of thermodynamics and evaluate energy interactions across the boundary of thermodynamic systems.
CO2: Evaluate the feasibility of cyclic and non-cyclic processes using 2nd law of thermodynamics.
CO3: Apply the knowledge of entropy, reversibility and irreversibility to solve numerical problems and apply 1st law of thermodynamics to closed and open systems and determine quantity of energy transfers and change in properties.
CO4: Interpret the behavior of pure substances and its application in practical problems.
CO5: Recognize differences between ideal and real gases and evaluate thermodynamic properties of ideal and real gas mixtures using various relations.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbooks

1. Basic and Applied Thermodynamics, P.K.Nag, Tata McGraw Hill 2nd Ed., 2002
2. Basic Engineering Thermodynamics, A.Venkatesh Universities Press, 2008
3. Basic Thermodynamics,, B.K Venkanna, Swati B. Wadavadagi PHI, New Delhi 2010

Reference Books

1. Thermodynamics- An, Engineering Approach, YunusA.Cenegal and Michael A.Boles Tata McGraw Hill publications 2002
2. An Introduction to Thermodynamcis, Y.V.C.Rao Wiley Eastern 1993,
3. Engineering Thermodynamics .B.Jones and G.A.Hawkins John Wiley and Sons.

Module 1

FUNDAMENTAL CONCEPTS AND DEFINITIONS

1 Define a thermodynamic system. Differentiate between open system, closed system and an isolated system.

Distinguish between

a) Intensive and extensive properties.

b) Microscopic and Macroscopic approaches.

c) Homogeneous system and heterogeneous system.

d) Thermal mechanical and chemical equilibrium.

e) Diathermic and adiabatic wall.

2 Explain briefly zeroth law of thermodynamics.

3 Explain quasi-static process.

4 Explain the following terms:

(i) State (ii) Process, (iii) Cycle (iv) Properties (v) path

5 Differentiate between work and heat

6 Derive a work done equation for the following process: a) P = Constant, b) V= constant, c) PV = Constant, d) PV^n = constant with p-V diagram.

7 Briefly explain about first law of thermodynamics.

8 Differentiate between Point function and path function.

9 Derive an expression for displacement work for polytropic process.

10 Show that work and heat are path functions.

11 The emf in a thermocouple with the test junction at t^0 C on gas thermometer scale and reference junction at ice point is given by:

$$\varepsilon = 0.20 \times t - 5 \times 10^{-4} \times t^2$$

The milli-voltmeter is calibrated at ice and steam points. What will this thermometer read in place where the gas thermometer reads 50^0 C.

12 The temperature T on a thermometer scale is defined in terms of property K by the relation:

T = a ln(k) + b, where a and b are constants

The values of K are found to be 1.83 and 6.78 at the ice point and steam point the temperature of which are assigned the numbers 0 and 100 respectively. Determine the temperature reading corresponding to a reading of K equal to 2.42 on the thermometer.

Module 2

Work and Heat, First Law of Thermodynamics

1. Derive Energy is a property of the system.
2. Derive the steady flow energy equation.
3. Explain a unsteady flow process.
4. Define perpetual machine of first kind.
5. Gas from a bottle of compressed helium is used to inflate a balloon originally folded completely flat, to a volume of 0.25 m^3. If the barometer reads 760 mm of mercury, how much work is done by the system comprising the helium initially in the bottle, if the balloon is light and requires no stretching. Sketch the system before and after the process.
6. Determine the work done by the air which enters an evacuated bottle from the atmosphere when the cork is opened, atmospheric air rushes into it. If the atmospheric pressure is 101.396 kPa and 0.6m^3 of air (measured at atmosphere conditions) enters the bottle.
7. A spherical balloon has a diameter of 25 cm and contains air at a pressure of 1.5 x 10^5Pa. The diameter of the balloon increases to 30 cm in a certain process and during this process the pressure is proportional to the diameter. Calculate the work done by the air inside the balloon during this process.
8. Gas from a bottle of compressed helium is used to inflate an inelastic flexible balloon, originally folded completely flat to a volume of 0.5 m^3. If the barometer reads 760 mm of Hg, what is the amount of work done upon the atmosphere by the balloon (50.66 kJ)
9. When the valve of the evacuated bottle is opened, atmosphere air rushes into it. If the atmosphere pressure is 101.325 KPa, and 1.2 m^3 of air (measured at atmosphere conditions) enters the bottle, calculate the work done by the air (-60.8 kJ).
10. A certain amount of gas is compressed from 1 bar and 0.1m^3 to 5 bar and 0.03m^3. The process is according to the law $pV^n = K$. Determine the magnitude and direction of work.

11. A system containing 5 kg of a substance is stirred with a torque of 1 N-m at a speed of 500 rpm for 24 hrs. The system mean while expands from 1.5m^3 to 2.0m^3 against a constant pressure of 5 bar. Determine the magnitude and direction of net work transfer.

Module 3

Second Law of Thermodynamics, Entropy

1. Define Perpetual Motion Machine of first kind.
2. State.
    1) Kelvin – Planck statement
    2) Clausius statement
3. Derive clausius theorem.
4. Prove entropy is a property of the system.
5. Explain Principle of the increase of entropy.
6. One kg of water at 273 K is brought into contact with a heat reservoir at 373 K. When the water has reached 373 K, find the entropy change of water, the heat reservoir and of the universe.
7. A gas enters a system at an initial pressure of 0.45 MPa and flow rate of 0.25 m^3/s and leaves at a pressure of 0.9 MPa and 0.09 m^3/s. During its passage through the system the increase in i.e., is 20 kJ/s. Find the change of enthalpy of the medium.
8. An engineer claims to have developed an engine which develops 3.4 kW while consuming 0.44 Kg of fuel of calorific value of calorific value of 41870 kJ / kg in one hour. The maximum and minimum temperatures recorded in the cycle are 1400° C & 350° C respectively is the claim of the engineer genuine.
9. A reversible refrigerator operates between 35° C and -12° C. If the heat rejected to reservoir is 1.3 kW, determine the rate at which to heat is leaking into the refrigerator.
10. One kg of water at 273 K is brought into contact with a heat reservoir at 373 K. When the water has reached 373 K, find the entropy change of water, the heat reservoir and of the universe.

Module 4

Availability, Irreversibility and pure substance

1. Give a neat sketch of “separating and throttling calorimeter” for dryness fraction measurement.
2. What is a pure substance?
3. Draw and explain a p-T (pressure-temperature) diagram for a pure substance.
4. What is a triple point ?
5. Explain with a neat diagram p-V-T surface.
6. Does wet steam obey laws of perfect gases ?
7. Describe the process of formation of steam and give its graphical representation also.
8. Write short notes on the following;
   a. Sensible heating c. Latent heating
   b. Critical point d. Triple point
9. The steam is heated to raise its temperature to 150°C. Show the process on a sketch of the p–v diagram, and evaluate the pressure, increase in enthalpy, increase in internal energy, increase in entropy of steam, and the heat transfer. Evaluate also the pressure at which the steam becomes dry saturated.
10. Electric calorimeter and comes out at 1 bar, 130°C. The calorimeter has two 1 kW heaters and the flow is measured to be 3.4 kg in 5 min. Find the quality in the engine exhaust. For the same mass flow and pressures, what is the maximum moisture that can be determined if the outlet temperature is at least 105°C?
11. Draw a neat sketch of throttling calorimeter and explain how dryness fraction of steam is determined ; clearly explain its limitations.

12. A sample of steam from a boiler drum at 3 MPa is put through a throttling calorimeter in which the pressure and temperature are found to be 0.1 MPa, 393K. Find the quality of the sample taken from the boiler.

Module 5

Ideal gases and Real gases

1. What is an ideal gas?
2. What is the difference between an ideal and a perfect gas?
3. What are semi-perfect or permanent gases?
4. Define 'Equation of state'.
5. State Boyle's and Charle's laws and derive an equation of the state for a perfect gas.
6. What is a *p*-*v*-*T* surface? Draw a portion of a such a surface.
7. Derive the relationship between the two principal specific heats and characteristic gas constant for a perfect gas.
8. Write a short note on Van der Waals' equation. the gas in the vessel. If the pressure of this gas is increased to 10.5 bar while the volume remains constant, what will be the temperature of the gas ? For the gas take R = 290 J/kg K.
9. The tyre of an automobile contains a certain volume of air at a gauge pressure of 2 bar and 20°C. The barometer reads 75 cm of Hg. The temperature of air in the tyre rises to 80°C due to running of automobile for two hours. Find the new pressure in the tyre. Assume that the air is an ideal gas and tyre does not stretch due to heating.
10. A tank made of metal is designed to bear an internal gauge pressure of 7 bar. The tank is filled with a gas at a pressure of 5.5 bar abs., and 15°C. The temperature in the tank may reach to 50°C when the tank stands in the sun.
    (*i*) If the tank does not expand with temperature, will the design pressure be exceeded on a day when atmospheric pressure is 1 bar and air in the tank reaches 50°C when exposed to hot sun?
    (*ii*) What temperature would have to be reached to raise the air pressure to the design limit?