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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

Third Semester, B.E. - Mechanical Engineering

Semester End Examination; March - 2021

Basic Thermodynamics

Time: 3 hrs *Max. Marks: 100*

Course Outcomes

The Students will be able to:

CO1: Understand the basic concepts and definitions used in engineering thermodynamics.

CO2: Apply the first laws of thermodynamics and the concepts of thermodynamics to basic energy systems.

CO3: Understand the properties of pure substances.

CO4: Understanding of the second law of thermodynamics and analysis in different applications.

CO5: Calculate entropy for various simple real life systems.

***Note:** **I) PART - A** is compulsory. **Two** marks for each question.*

***II) PART - B**: Answer any **Two** sub questions (from a, b, c) for Maximum of **18 marks** from each unit.*

***III)** Use of thermodynamic data handbook and steam tables are permitted.*

Q. No.	Questions	Marks	BLs	COs	POs
	I : PART - A	**10**			
I a.	What do you mean by thermodynamic equilibrium? What are the conditions necessary to establish thermodynamic equilibrium to a system?	2	L1	CO1	PO1
b.	Show that for an ideal gas, $C_p - C_v = R$.	2	L1	CO2	PO1
c.	Define sensible heat and latent heat.	2	L1	CO3	PO1
d.	What are the limitations of first law of thermodynamics? Also state the importance of second law of thermodynamics.	2	L1	CO4	PO1
e.	State Clausius theorem.	2	L1	CO5	PO1
	II : PART - B	**90**			
	UNIT - I	**18**			
1 a.	Distinguish between; i) Establish a relationship between Celsius scale and Fahrenheit scale ii) What are the similarities and dissimilarities between heat and work interactions?	9	L1	CO1	PO1
b.	It is proposed to construct a new scale with the value 5°N assigned to ice point and 20°N to steam point. The pressure of an ideal gas at constant volume is considered as a thermometric property. Set up a linear relationship between pressure and temperature in °N on a new scale. What is the Kelvin absolute zero on this scale?	9	L2	CO1	PO3

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c.	A quantity of gas is compressed in a piston cylinder from a volume of 0.8611 m^3 to a final volume of 0.17212 m^3. The pressure (in bar) as a function of volume (m^3) is given by, $P = \frac{0.86110}{V} - \frac{8.60673\times10^{-5}}{V^2}$ i) Find the amount of work done in kJ ii) If the atmospheric pressure, i.e., 1 bar acting on the other side of piston is considered, find the net work done in kJ.	9	L3	CO1	PO3
	UNIT - II	**18**			
2 a.	What is a steady flow process? Derive the steady flow energy equation and state the significance of various terms involved.	9	L2	CO2	PO2
b.	Air initially at 60 kPa pressure, 800 K temperature and 0.1 m^3 volume is compressed isothermally until the volume is halved, and subsequently the air is cooled at constant pressure till the volume is halved again. Sketch the process on a P-V plane and determine; i) Total work interaction ii) Total heat interaction Assume ideal gas behavior for air and take C_P = 1.005 kJ/kg-K.	9	L3	CO2	PO3
c.	Air flows steadily at the rate of 0.5 kg/s through an air compressor, entering at 7 m/s velocity 100 kPa pressure and 0.95 m^3/kg specific volume and leaving at 5 m/s, 700 kPa and 0.19 m^3/kg, respectively. The internal energy of the air leaving is 90 kJ/kg greater than that of air entering. Cooling water in the compressor jackets absorbs heat from the air at the rate of 58 kW. i) Compute the power input to the compressor ii) Ratio of inlet pipe diameter to outlet pipe diameter	9	L3	CO2	PO3
	UNIT - III	**18**			
3 a.	Explain the phase transformation process of water from freezing state to superheated state using a T-V diagram.	9	L2	CO3	PO2
b.	Find the internal energy of 1 kg of steam at a pressure of 10 bar, when the condition of steam is? i) Wet with a dryness fraction of 0.85 ii) Dry and saturated iii) Superheated, the degree of super heat being 50°C The specific heat of superheated steam at constant pressure is 2.01 kJ/kg-K.	9	L3	CO3	PO3

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Q.No.	Question	Marks	BT	CO	PO
c.	A combined separating and throttling calorimeter was used to determine the dryness fraction of steam flowing through a steam main at a pressure of 9 bar. The pressure and temperature of steam after throttling were 1.25 bar and 115°C, respectively. The mass of steam condensed after throttling was 2.2 kg and the mass of water collected in the separator was 0.20 kg. Estimate the dryness fraction of steam in the main. Take specific heat for superheated steam as 2.1 kJ/kg-K.	9	L4	CO3	PO3
	UNIT - IV	**18**			
4 a.	State Kelvin Plank and Clausius's statements of second law of thermodynamics and prove that they are equivalent to each other.	9	L2	CO4	PO1
b.	A reversible heat engine operates between two reservoirs at 600°C and 40°C. The engine drives a reversible refrigerator which operates between the same 40°C reservoir and a reservoir at −18°C. The heat transfer to the heat engine is 2100 K and there is a net work output of 370 kJ from the combined plant. Evaluate the heat transfer to the refrigerator and the net heat transfer to the 40°C reservoir.	9	L4	CO4	PO3
c.	Two Carnot engines are working in series between a source and a sink. The first engine receives heat from a reservoir at a temperature of 1000 K and rejects the waste heat to another reservoir at the temperature T_2. The second heat engine receives the heat energy rejected by the first engine. It converts some of energy into useful work and rejects the rest to a reservoir at temperature of 300 K. i) If both engines deliver equal power, determine the efficiency of each engine ii) If thermal efficiency of both engines are same, determine the intermediate temperature Deduce for intermediate temperature for both the cases.	9	L2	CO4	PO2
	UNIT - V	**18**			
5 a.	State and prove Clausius inequality.	9	L2	CO5	PO1
b.	1.5 kg of air at 1 bar 300 K is contained in a rigid insulated tank. During the process, 18 kJ of work is done on the gas through a paddle-wheel mechanism. Determine the final temperature, final pressure of air in the tank and change in entropy. Assume specific heats of air to be constant.	9	L3	CO5	PO2
c.	Briefly explain the following: i) Principle of increase of entropy ii) Clausius Theorem iii) Characteristic equation of gases	9	L2	CO5	PO2

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