ENGINEERING THERMODYNAMICS AND HEAT TRANSFER
ENME 310

Year/Part: III/I (3-1-1.5)

Teaching Schedule				**Examination Scheme**							**Total**
				Theory			**Practical**				
L	**T**	**P**	**Total**	**Assessment Marks**	**Final**		**Assessment Marks**	**Final**			
					Duration (Hrs)	**Marks**		**Duration (Hrs)**	**Marks**		
3	1	1.5	5.5	40	3	60	25	0	0		125

Depth Codes

D- Definition	**E-** Explanation	**I-** Illustration	**DV-** Derivation
DW- Drawing	**P-** Proof	**NUM-** Numerical	**EXP-** Experiment
S- State	**PS-** Problem Solving	**QA-** Question Answer	**MT-** Mid Term Test

Unit	**Topic/Subtopic**	**Depth Code**	**Description of Depth**	**L**	**T**	**P**	**Week**
1	**Basic Concepts**			**4**	**1**	**1.5**	**1,2**
	1.1 Definition and scope of engineering thermodynamics	(D, E)	Define thermodynamics and explain its scope in engineering systems.				
	1.2 Value of energy to society	(E, I)	Discuss the role of energy in industrial development and societal needs.				
	1.3 Microscopic versus macroscopic viewpoint	(E, I)	Compare and contrast the two viewpoints with physical examples.				
	1.4 Concepts and definitions	(D, E, DW)	Define and illustrate system boundaries. Differentiate intensive and extensive properties. Explain state, equilibrium and various types of thermodynamic processes.				
	1.5 Specific volume, pressure and pressure measurement devices, temperature and temperature measurement	(D, E, I)	Define specific volume and pressure. Explain working principles of measurement devices.				
	1.6 Zeroth law of thermodynamics, equality of temperature	(S, E)	State the Zeroth Law and its significance in establishing temperature equality.				

Unit	Topic/Subtopic	Depth Code	Description of Depth	L	T	P	Week
2	**Energy and Energy Transfer**			**3**	**1**	**0**	**2,3**
	2.1 Energy and its meaning	(D, E)	Define energy in the context of thermodynamics.				
	2.2 Stored energy and transient energy; Total energy	(E, I)	Differentiate between energy stored within a system and energy in transition.				
	2.3 Energy transfer	(D, E, I)	Define heat and work transfer using the standard sign convention.				
	2.4 Expressions for displacement work transfer	(DV)	Derive mathematical expressions for displacement work for various processes.				
	2.5 Other examples of work: Electrical work and mechanical forms of work	(E, I)	Explain electrical and mechanical work as boundary phenomena.				
3	**Properties of Common Substances**			**6**	**2**	**0**	**3,4**
	3.1 Pure substance and state postulate	(D, E)	Define a pure substance and explain the state postulate for compressible systems.				
	3.2 Ideal gas and ideal gas relations	(E, NUM)	Discuss the ideal gas equation of state and specific heat relations.				
	3.3 Two phase (Liquid and vapor) system	(E, DW, I, NUM)	Describe phase change processes using property diagrams. Define quality and moisture content. Calculate properties of two-phase mixtures and explain the compressibility factor.				
	3.4 Development of property data: Graphical data presentation (P-h, h-s and T-s diagrams) and tabular data presentation	(E, NUM)	Demonstrate the use of steam tables and property charts to find state variables.				
4	**First Law of Thermodynamics**			**6**	**2**	**3**	**5,6**
	4.1 First law of thermodynamics for control mass	(E, DV, P)	State and prove the first law for a closed system undergoing a process.				
	4.2 First law of thermodynamics for control mass undergoing cyclic process	(E, DV)	Explain the cyclic integral of heat and work.				
	4.3 Internal energy, enthalpy and specific heats	(D, E, NUM)	Define internal energy and enthalpy as properties and evaluate properties				
	4.4 First law of thermodynamics for control volume	(DV, E)	Derive the general energy equation for open systems.				

Unit	Topic/Subtopic	Depth Code	Description of Depth	L	T	P	Week
	4.5 Control volume analysis: Steady state analysis	(E, NUM)	Explain the conditions and mass conservation for steady state flow.				
	4.6 Control volume steady state work and flow applications	(E, I, NUM)	Apply the steady flow energy equation to nozzles, diffusers, turbines and compressors.				
	4.7 First law of thermodynamics for an isolated system and PMM-I type	(D, E)	Define an isolated system and explain the impossibility of Perpetual Motion Machines of the first kind.				
5	**Second Law of Thermodynamics**			**6**	**2**	**3**	**7,8**
	5.1 Necessity of formulation of second law	(E, I)	Discuss process directionality and energy quality.				
	5.2 Concepts and definitions	(D, E)	Define basic terms related to the second law.				
	5.3 Two phase (Liquid and vapor) systems	(D, E, DW)	Define and illustrate cyclic devices. Explain reversible processes and causes of irreversibility.				
	5.4 Kelvin-Planck and Clausius statements of the second law of thermodynamics and their equivalence	(S, E, P)	State both statements and demonstrate their logical equivalence.				
	5.5 Carnot cycle and Carnot efficiency	(E, DV, DW)	Describe the Carnot cycle and derive the expression for maximum thermal efficiency.				
	5.6 Clausius inequality and entropy	(D, DV, NUM)	Derive the Clausius inequality and define entropy as a thermodynamic property.				
	5.7 Second law of thermodynamics for an isolated system	(E, P)	Explain the principle of increase of entropy.				
	5.8 Entropy changes of an ideal gases, liquids and solids from Gibbs equation	(DV, NUM)	Calculate entropy changes using standard thermodynamic relations.				
	5.9 Concepts of change in entropy of control mass and control volume	(E, NUM)	Analyze entropy transfer and generation in closed and open systems.				
	5.10 Isentropic processes for an ideal gases, liquids and solids	(E, DV)	Define isentropic processes and derive related state equations.				
	5.11 Isentropic efficiencies of steady state applications	(E, DV, NUM)	Define and calculate isentropic efficiencies for turbines, compressors and nozzles.				

Unit	Topic/Subtopic	Depth Code	Description of Depth	L	T	P	Week
6	**Gas Power Cycles**			**8**	**3**	**0**	**9,10,11**
	6.1 Classification of cycles	(E)	Categorize power cycles based on phase and operation.				
	6.2 Air standard assumptions	(E)	List the fundamental assumptions for air-standard analysis.				
	6.3 Brayton cycle	(E, DW, DV, NUM)	Analyze the simple Brayton cycle. Discuss modifications for efficiency improvement and illustrate plant layout.				
	6.4 Internal combustion cycles	(E, DW, DV, NUM)	Analyze Otto and Diesel cycles with P-v and T-s diagrams. Derive thermal efficiencies and compare mean effective pressures.				
	6.5 Diesel power plant	(DW, I, NUM)	Illustrate Diesel plant layout. Discuss performance parameters like indicated and brake power.				
7	**Vapor Power Cycles and Vapor Compression Refrigeration Cycles**			**4**	**1**	**6**	**12**
	7.1 Rankine cycle	(E, DW, DV, NUM)	Analyze ideal and actual Rankine cycles. Describe reheat and regenerative modifications. Illustrate plant components and layout.				
	7.2 Vapor compression refrigeration cycle and its performance measurement	(E, DW, NUM)	Explain the VCR cycle using property diagrams and calculate the Coefficient of Performance.				
8	**Heat Transfer**			**8**	**3**	**9**	**13,14,15**
	8.1 Basic concepts and modes of heat transfer	(D, E, I)	Define conduction, convection and radiation.				
	8.2 One dimensional steady state heat conduction through a plane wall	(DV, NUM)	Derive and apply Fourier's law for a plane wall.				
	8.3 Radial steady state heat conduction through a hollow cylinder	(DV, NUM)	Derive and apply conduction equations for cylindrical geometry.				
	8.4 Heat flow through composite structures	(E, DW, NUM)	Analyze heat transfer through multi-layer systems.				
	8.5 Critical radius of insulation for cylinders	(E, DV, NUM)	Explain and derive the critical radius of insulation.				
	8.6 Electrical analogy for thermal resistance	(E, DW)	Use thermal resistance networks to solve steady state problems.				
	8.7 Combined heat transfers and overall heat transfer coefficient for plane and composite wall and tube	(E, NUM)	Calculate the overall heat transfer coefficient for mixed mode transfer.				

Unit	Topic/Subtopic	Depth Code	Description of Depth	L	T	P	Week
	8.8 Nature of convection; Free and forced convection	(D, E, I)	Distinguish between natural buoyancy-driven and forced fluid flow convection.				
	8.9 Heat transfer from extended surfaces; Fins, types of fins, fin equation, fin performance, fins effectiveness, proper length of fin	(E, DW, DV)	Analyze heat transfer enhancement using extended surfaces and calculate fin efficiency.				
	8.10 Heat radiation, Stefan's law, emissivity, absorptivity, reflectivity and transmissivity; Black body, white body and gray body	(D, S, E)	Define radiation properties. State Stefan-Boltzmann law and define ideal vs real radiating bodies.				

2. Model Question Paper (60 Marks- Final Exam)

Model (Sample) Question Set

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEEING
Examination Control Division
2082 Chaitra

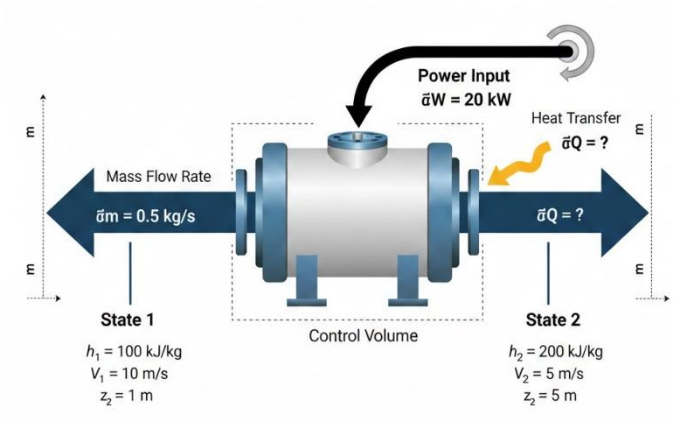
Exam	**Regular**		
Level	BE/BAR	**Full Marks**	60
Program	BEL	**Pass Marks**	24
Year / Part	III / I	**Time**	3 Hrs

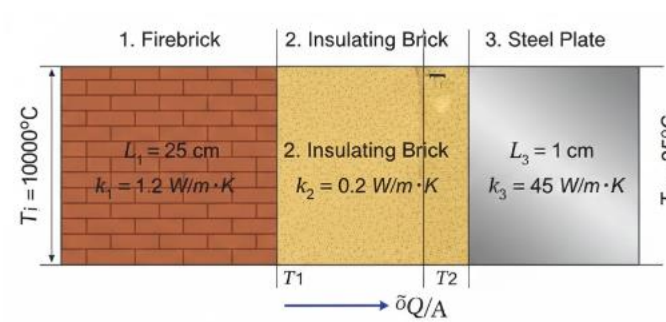
Subject :- Engineering Thermodynamics and Heat Transfer

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt **All** questions.
- ✓ The figures in the margin indicate **Full marks.**
- ✓ Assume suitable data if necessary.
- ✓ Use of steam table is allowed.

Q.No	Question	Marks	Unit
1	a) Define thermodynamic system and differentiate between closed and open system with one example for each.	3	1(1.4.1)
	b) A mercury manometer is used to measure the pressure in steam pipe. The level of the mercury in the manometer is 97.5 mm. Find the absolute pressure of steam inside the pipe. If the reading of the manometer drops to 80 mm, what is the new pressure of steam? [Take specific gravity of Hg = 13.6, P_{atm}= 760 mm of Hg and g=9.81 m/s^2]	4	1 (1.5)

Micro Syllabus

2	Explain the concept of heat and work transfer in thermodynamics. Also mention the sign convention with illustration.	3	2 (2.3)
3	a) What is the state postulate? Explain with reference to pure substance. b) A boiler contains 1.8 kg of steam at 10 bar with initial dryness fraction 0.85. It is heated at constant pressure until it becomes dry saturated steam. Determine: i. Initial and final specific enthalpy ii. Total heat added to the system iii. Comment on how phase quality affects intensive and extensive properties	3 5	3 (3.1) 3 (3.3)
4	a) Starting from the general statement of the First Law of Thermodynamics for a closed system derive the relationship between heat, work and internal energy for a system undergoing an Isochoric process. b) A gas compressor operates under steady-state conditions that processes air at a mass flow rate of 0.5 kg/s. Air enters the compressor at a specific enthalpy of 100 kJ/kg and a velocity of 10 m/s at an elevation of 1 m. The air exits at a specific enthalpy of 200 kJ/kg and a reduced velocity of 5 m/s at an elevation of 5 m. Given that the compressor requires a shaft power input of 20 kW and assuming the acceleration due to gravity is 9.81 m/s^2, determine the rate of heat transfer in kilowatts (kW) between the compressor and its surroundings. Also clearly state the direction of this heat transfer. 	4 5	4 4
5	a) Define the Heat Engine and the Refrigerator in the context of cyclic operations. Explain how the fundamental operation and physical possibility of each device are related to and restricted by the statements of the Second Law of Thermodynamics. b) A reversible heat engine operates between a high-temperature thermal reservoir maintained at 800 K and a low-temperature sink at 300 K. During each cycle of operation, the engine is observed to reject 150 kJ of heat to the lower-temperature sink. Based on this steady-state performance, determine the following: i. thermal efficiency, ii. amount of heat supplied to the engine by the high-temperature reservoir per cycle, iii. net work output of the engine per cycle, in kJ, and iv. Coefficient of Performance (COP_R) if a reversible refrigerator were to operate between the exact same two thermal reservoirs.	4 5	5 (5.3, 5.4) 5 (5.5)

6	a) Describe the four fundamental thermodynamic processes that constitute the Ideal Brayton Cycle. Illustrate the cycle by sketching its representation on a T-s diagram. b) An ideal Diesel engine operates with a maximum temperature of 2200 K and a minimum temperature of 300 K. The engine has a compression ratio of 20:1. The heat addition process cuts off when the volume reaches 5% of the initial volume. Take specific heat ratio (γ) as1.4. Now, calculate: i. the cut-off ratio of the cycle, ii. the thermal efficiency, and iii. the maximum theoretical work output per unit mass, in kJ/kg, if the heat supplied is 1500 kJ/kg.	4 5	6 (6.3) 6 (6.4)
7	List the four fundamental thermodynamic processes of an Ideal Rankine Cycle and show them in P-v diagram. Also, state the functions of the four main components of steam power plant.	5	7 (7.1)
8	a) Describe the basic modes of heat transfer. Distinguish between free and forced convection with two examples of each. b) A three-layer composite wall of a furnace has the following geometry and material properties: an inner layer of firebrick with a thickness of 25 cm and thermal conductivity of 1.2 W/m·K; a middle layer of insulating brick with a thickness of 15 cm and thermal conductivity of 0.2 W/m·K; and an outer layer of steel plate with a thickness of 1 cm and thermal conductivity of 45 W/m·K. If the inner surface temperature of the firebrick is maintained at 1000 ˚C and the outer surface temperature of the steel plate is maintained at 35 ˚C, determine the following: i. total thermal resistance per unit area of the composite wall, ii. rate of steady-state heat loss through the composite wall per unit area, and iii. temperature at the interface between the firebrick and the insulating brick. 	5 5	8 (8.8) 8 (8.4)