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NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA
(An Autonomous Institute Affiliated to AKTU, Lucknow)

B.Tech

SEM: III - THEORY EXAMINATION (2025 - 2026)

Subject: Thermodynamics and Heat Transfer

Time: 3 Hours

Max. Marks: 100

General Instructions:

IMP: Verify that you have received the question paper with the correct course, code, branch etc.

1. This Question paper comprises of **three Sections -A, B, & C**. It consists of Multiple Choice Questions (MCQ's) & Subjective type questions.

2. Maximum marks for each question are indicated on right -hand side of each question.

3. Illustrate your answers with neat sketches wherever necessary.

4. Assume suitable data if necessary.

5. Preferably, write the answers in sequential order.

6. No sheet should be left blank. Any written material after a blank sheet will not be evaluated/checked.

SECTION-A

20

1. Attempt all parts:-

- 1-a. A closed thermodynamic system is one in which (CO1, K1) 1
- (a) There is no energy or mass transfer across the boundary
- (b) There is no mass transfer, but energy transfer exists
- (c) There is no energy transfer, but mass transfer exists
- (d) Both energy and mass transfer take place across the boundary, but the mass transfer is controlled by valves
- 1-b. By first law of thermodynamics, (CO1, K1) 1
- (a) $Q = \Delta E - W$
- (b) $Q = \Delta E + W$
- (c) $Q = -\Delta E - W$
- (d) $Q = -\Delta E + W$
- 1-c. For a spontaneous reaction (CO2, K1) 1
- (a) ΔS must be negative
- (b) $(\Delta H - T\Delta S)$ must be negative
- (c) ΔH must be negative
- (d) $(\Delta H + T\Delta S)$ must be negative
- 1-d. Which of the following is true for the entropy of an isolated system? (CO2, K1) 1
- (a) It can never increase
- (b) It can never decrease
- (c) It can never be zero
- (d) None of the mentioned

- 1-e. Which one of the following expresses the thermal diffusivity of a substance in terms of thermal conductivity (k), mass density (ρ) and specific heat (c)... (CO3, K1) 1
- (a) $k^2\rho c$
 (b) $1/\rho kc$
 (c) $k/\rho c$
 (d) ρc
- 1-f. Upto the critical radius of insulation: (CO3, K1) 1
- (a) Added insulation increases heat loss
 (b) Added insulation decreases heat loss
 (c) Convection heat loss is less than conduction heat loss
 (d) Heat flux decreases
- 1-g. Which one of the following numbers represents the ratio of kinematic viscosity to the thermal diffusivity? (CO4, K1) 1
- (a) Grashoff number
 (b) Prandtl number
 (c) Mach number
 (d) Nusselt number
- 1-h. What is the value of the shape factor for two infinite parallel surface separated by a distance d ? (CO4, K1) 1
- (a) 0
 (b) Infinity
 (c) 1
 (d) 0.5
- 1-i. What are the compact heat exchangers? (CO5, K1) 1
- (a) The heat exchangers having small surface area per unit volume
 (b) The heat exchangers having large surface area per unit volume
 (c) The heat exchangers having small surface area per unit weight
 (d) The heat exchangers having large surface area per unit weight
- 1-j. The effectiveness of a parallel and counter flow heat exchanger is of same value: (CO5, K1) 1
- (a) Transient conditions
 (b) Steady state conditions
 (c) Transient/steady state conditions
 (d) None
2. Attempt all parts:-
- 2.a. Explain the concept of continuum. (CO1, K2) 2
- 2.b. What is the difference between a heat engine and a reversed heat engine ? (CO2, K2) 2
- 2.c. Write the equation for conduction thermal resistance for a hollow cylinder. (CO3, K2) 2
- 2.d. Explain the physical significance of dimensionless numbers for forced convection 2

analysis. (CO4, K2)

2.e. Explain overall heat transfer coefficient in a heat exchanger. (CO5, K2) 2

SECTION-B 30

3. Attempt all parts:-

3.a. Answer any one of the following:-

3.a.(i) In an internal combustion engine, during the compression stroke the heat rejected to the cooling water is 50 kJ/kg and the work input is 100 kJ/kg. Calculate the change in internal energy of the working fluid stating whether it is a gain or loss. (CO1, K3) 6

3.a.(ii) Derive Steady Flow Energy equation. (CO1, K3) 6

3.b. Answer any one of the following:-

3.b.(i) Show that coefficient of performance of heat pump and refrigerator can be related as;
$$\text{COP}_{\text{Ref}} = \text{COP}_{\text{HP}} - 1 \quad (\text{CO2, K2})$$
 6

3.b.(ii) A Carnot engine operating between certain temperature limits has an efficiency of 30%. Determine the ratio of refrigerating effect and work required for operating the cycle as a heat pump between the same temperature limits. (CO2, K3) 6

3.c. Answer any one of the following:-

3.c.(i) The wall of a furnace is constructed from 15 cm thick fire brick having constant thermal conductivity of 1.6 W/mK. The two sides of the wall are maintained at 1400 K and 1100 K, respectively. What is the rate of heat loss through the wall which is 50 cm × 3 m on a side? (CO3, K3) 6

3.c.(ii) Simplify the three dimensional heat conduction equation in Cartesian coordinates to obtain one dimensional steady state heat conduction with heat generation and constant thermal conductivity. (CO3, K2) 6

3.d. Answer any one of the following:-

3.d.(i) Explain the Reynolds analogy for turbulent flow over a surface. (CO4, K2) 6

3.d.(ii) Discuss the concept of thermal boundary layer in case of flow over the flat plate. How it differs from Hydrodynamic boundary layer? (CO4, K2) 6

3.e. Answer any one of the following:-

3.e.(i) Draw and explain the temperature profile for (a) Condenser (ii) Evaporator (CO5, K2) 6

3.e.(ii) In a heat exchanger, hot fluid enters at 180°C and leaves at 118°C. The cold water enters at 99°C and leaves at 119°C. Find the LMTD, NTU and effectiveness for Counter flow if both flow have same mass flow rates. (CO5, K3) 6

SECTION-C 50

4. Answer any one of the following:-

4-a. Derive a relation of work done in a polytropic process for a closed system undergoing quasi static process. (CO1, K3) 10

4-b. Gas from a cylinder of compressed helium is used to inflate an inelastic flexible balloon, originally folded completely flat, to a volume 0.6 cubic meter. If the barometer reads 760 mm Hg, what is the amount of work done upon the atmosphere 10

by the balloon ? (CO1, K3)

5. Answer any one of the following:-

- 5-a. A turbine operates under steady flow conditions, receiving steam at the following state: Pressure 1.2 MPa, temperature 188°C, enthalpy 2785 kJ/kg, velocity 33.3 m/s and elevation 3 m. The steam leaves the turbine at the following state: Pressure 20 kPa, enthalpy 2512 kJ/kg, velocity 100 m/s, and elevation 0 m. Heat is lost to the surroundings at the rate of 0.29 kJ/s. If the rate of steam flow through the turbine is 0.42 kg/s, what is the power output of the turbine in kW? (CO2, K3) 10
- 5-b. A nozzle is a device for increasing the velocity of a steadily flowing stream. At the inlet to a certain nozzle, the enthalpy of the fluid passing is 3000 kJ/kg and the velocity is 60 m/s. At the discharge end, the enthalpy is 2762 kJ/kg. The nozzle is horizontal and there is negligible heat loss from it. 10
- (a) Find the velocity at exists from the nozzle.
- (b) If the inlet area is 0.1 m^2 and the specific volume at inlet is $0.187 \text{ m}^3/\text{kg}$, find the mass flow rate.
- (c) If the specific volume at the nozzle exit is $0.498 \text{ m}^3/\text{kg}$, find the exit area of the nozzle. (CO2, K3)

6. Answer any one of the following:-

- 6-a. Hot air at a temperature of 65°C is flowing through steel pipe of 120 mm diameter. The pipe is covered with two layers of different insulating materials of thickness 60 mm and 40 mm and their corresponding thermal conductivities are 0.24 and 0.4 W/mK. The inside and outside heat transfer coefficients are $60 \text{ W/m}^2 \text{ K}$ and $12 \text{ W/m}^2 \text{ K}$ respectively. The atmosphere is at 20°C. Find the Rate of heat loss from 60 m length of pipe. (CO3, K3) 10
- 6-b. Derive a general heat conduction equation for rectangular coordinate system. (CO3, K3) 10

7. Answer any one of the following:-

- 7-a. Explain the physical significance of following dimensionless numbers. (i) Nusselt number (ii) Prandtl number (iii) Grashof number (iv) Reynold number (v) Stanton number (vi) Peclet number (CO4, K2) 10
- 7-b. The large parallel plates with emissivities 0.3 and 0.8 exchange heat. Find the percentage reduction when a polished aluminum shield of emissivity 0.04 is placed between them. Use the method of electrical analogy. (CO4, K3) 10

8. Answer any one of the following:-

- 8-a. Derive an expression for effectiveness in terms of NTU and capacity rate ratio (C) for counter flow. (CO5, K3) 10
- 8-b. A counter flow heat exchanger is used to heat oil from 200C to 800C at the rate of 1.2 kg/sec. The heating is obtained by using geothermal water available at 1600C at a mass flow rate of 2kg/sec. The inner tube is thin walled and has a diameter of 1.5cm. If the overall heat transfer co-efficient is $640 \text{ W/m}^2 \text{ K}$. Calculate the length of the heat exchanger required to achieve the desired heating by using NTU method. Take specific heat of geothermal water as 4.30 kJ/kgK and for oil is 4.18 kJ/kgK . (CO5, K3) 10