

--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

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

B.Tech

SEM: V - THEORY EXAMINATION (2025 - 2026)

Subject: Heat and Mass 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 stainless steel tube ($k_s = 19 \text{ W/mK}$) of 2 cm ID and 5 cm OD is insulated with 3 cm thick asbestos ($k_a = 0.2 \text{ W/mK}$). If the temperature difference between the innermost and outermost surfaces is 600°C , the heat transfer rate per unit length is:(CO1,K1) 1
- (a) 0.94 W/m
(b) 9.44W/m
(c) 944.72W/m
(d) 9447.21W/m
- 1-b. Upto the critical radius of insulation (CO1,K1) 1
- (a) Convection heat loss will be less than conduction heat loss
(b) Heat flux will decrease
(c) Added insulation will increase heat loss
(d) Added insulation will decrease heat loss
- 1-c. In order to achieve maximum heat dissipation, the fin should be designed in such a way that:(CO2,K1) 1
- (a) It should have maximum lateral surface at the root side of the fin
(b) It should have maximum lateral surface towards the tip side of the fin
(c) It should have maximum lateral surface near the centre of the fin
(d) It should have minimum lateral surface near the centre of the fin
- 1-d. If the fin is sufficiently thin, so heat flows pertain to. [CO2,K1] 1
- (a) One dimensional heat conduction
(b) Two dimensional heat conduction

- (c) Three dimensional heat conduction
- (d) No heat flow is there
- 1-e. The ratio of inertia force to viscous force is known as(CO3,K1) 1
- (a) Grashof number
- (b) Reynolds number
- (c) Fourier number
- (d) Nusselt number
- 1-f. Free convection heat flow does not depend on(CO3,K1) 1
- (a) Density
- (b) Coefficient of viscosity
- (c) Gravitational force
- (d) Velocity
- 1-g. Fraction of radiative energy leaving one surface that strikes the other surface is called (CO4,K2) 1
- (a) Radiative flux
- (b) Emissive power of the first surface
- (c) View factor
- (d) Re-radiation flux
- 1-h. Which phenomenon is related to the term radiation? (CO4,K2) 1
- (a) magnetic phenomenon
- (b) gravity
- (c) electromagnetic phenomenon
- (d) none of the above
- 1-i. For evaporators and condensers, for the given conditions, the logarithmic mean temperature difference (LMTD) for parallel flow is:(CO5,K1) 1
- (a) Equal to that for counter flow
- (b) Greater than that for counter flow
- (c) Smaller than that for counter flow
- (d) Very much smaller than that for counter flow
- 1-j. The two fluids are not mixed and kept separated as they both flow through heat exchanger in(CO5,K1) 1
- (a) Transfer type heat exchanger or recuperator
- (b) Storage type heat exchanger or regenerator
- (c) Direct contact type heat exchanger or mixer
- (d) None of the above
2. Attempt all parts:-
- 2.a. What are different modes of heat transfer? Explain their potential for occurrence.(CO1,K2) 2
- 2.b. What is Biot number?(CO2,K1) 2
- 2.c. State Newton's law of cooling. (CO3,K2) 2
- 2.d. Define Emissivity of a surface.(CO4,K1) 2

2.e.	Discuss the advantage of NTU method over the LMTD method.(CO5,K2)	2
SECTION-B		30
3. Attempt all parts:-		
3.a. Answer any <u>one</u> of the following:-		
3.a.(i)	A plane composite slab with unit cross sectional area is made up material A, (100 mm thick, $k_A = 60 \text{ W/m.K}$) and material B (10 mm thick, $k_B = 2 \text{ W/m.K}$). Thermal contact resistance at the interface is $0.003 \text{ m}^2\text{.K/W}$. The temperature of open side of slab A is 300°C and that of open side of slab B is 50°C . Calculate: (i) Rate of heat flow through the slab. (ii) Temperature on both sides of interface.(CO1,K4)	6
3.a.(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.(CO1,K3)	6
3.b. Answer any one of the following:-		
3.b.(i)	A long stainless steel rod ($k = 16 \text{ W/m.K}$) has a square cross-section $12.5 \text{ cm} \times 12.5 \text{ cm}$ and has one end maintained at 250°C . It is exposed into a fluid at 90°C with $h = 40 \text{ W/m}^2\text{.K}$. Calculate the heat lost by the rod.(CO2,K3)	6
3.b.(ii)	Derive the heat dissipation equation through pin fin with insulated end.[CO2,K3]	6
3.c. Answer any one of the following:-		
3.c.(i)	Write down physical significance of dimensionless numbers for forced convection(CO3,K3)	6
3.c.(ii)	Define laminar and turbulent flow and write the corresponding values of Reynolds number for flow over flat plate and circular tube.(CO3,K2)	6
3.d. Answer any one of the following:-		
3.d.(i)	Define absorptivity, reflectivity and transmissivity. (CO4,K2)	6
3.d.(ii)	What do you mean by opaque body and white body ? (CO4,K2)	6
3.e. Answer any one of the following:-		
3.e.(i)	Consider the following parallel flow heat exchanger specification cold flow enters at 40°C : $C_c = 20,000 \text{ W/K}$ hot flow enters at 150°C : $C_h = 10,000 \text{ W/K}$, $A = 30 \text{ m}^2$, $U = 500 \text{ W/m}^2\text{.K}$. Determine the heat transfer rate and the exit temperatures.(CO5,K4)	6
3.e.(ii)	A double pipe heat exchanger is constructed of 0.287 cm thick steel tubing ($k = 35 \text{ W/m.K}$) with 2.09 cm inner tube and 2.66 cm outer tube. The inside and outside coefficients of heat transfer are $1135 \text{ W/m}^2\text{.K}$ and $5677 \text{ W/m}^2\text{.K}$, respectively, and the inner fouling factor is $9.98 \times 10^{-5} \text{ m}^2\text{.K/W}$. Calculate the overall coefficient of heat transfer. (CO5,K4)	6

SECTION-C 50

4. Answer any <u>one</u> of the following:-		
4-a.	Derive general heat conduction equation in Cartesian coordinates and mention the assumptions for this derivation. (CO1,K4)	10
4-b.	The temperature of the inner side of a furnace wall is 640°C and that of on other side is 240°C and it is exposed to an atmosphere at 40°C . In order to reduce the heat loss from the furnace, its wall thickness is increased by 100%. Calculate the percentage decrease in the heat loss due to increase in wall thickness. Assume no change in properties except temperature.(CO1,K4)	10

5. Answer any one of the following:-

- 5-a. Derive the governing equation of fins of uniform cross-section.(CO2,K4) 10
- 5-b. A HSS sphere of 20 mm in diameter initially at 600°C is exposed to a current of air at 30°C with convection coefficient of 150 W/m².K. Calculate the Time required to cool the sphere to 100°C. Take properties of mild steel as : k = 43 W/m.K, $\rho = 7850$ kg/m³, C = 474 J/kg.K, $\alpha = 0.045$ m²/s.(CO2,K4) 10

6. Answer any one of the following:-

- 6-a. Calculate Reynolds numbers and state the type of flow, whether it is laminar or turbulent for the following : (a) A 15 m long yacht sailing at 15 km/h in sea water ($\rho = 1000$ kg/m³ and $\mu = 1.3 \times 10^{-3}$ kg/ms).(CO3,K4) 10
- 6-b. Deduce the expression for local convective heat transfer coefficient at a certain position x from leading edge of flat plate, (CO3,K4) 10

7. Answer any one of the following:-

- 7-a. Derive the expression for net radiation heat exchange between two parallel infinite planes. (CO4,K4) 10
- 7-b. Two parallel plates have emissivity of 0.8 and 0.5. A radiation shield having same emissivity on both sides is placed between them. Calculate the emissivity of the shield in order to reduce the radiation losses from the system to one-tenth of that of without shield.(CO4,K4) 10

8. Answer any one of the following:-

- 8-a. Derive an expression for log mean temperature difference of parallel flow heat exchanger. (CO5,K4) 10
- 8-b. Cold water at 1495 kg/h enters at 25°C through a parallel flow heat exchanger to cool 605 kg/h of hot water entering at 70°C and leaving at 50°C. Find the area of the heat exchanger. The individual heat transfer coefficients on both sides are 1590 W/m².K. Use LMTD and NTU methods.(CO5,K4) 10