Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UPES

End Semester Examination, May 2025

Course: Automotive Thermal Management **Semester : 6^{th}**

Program: B. Tech-Automotive Design Engineering **Time : 03 hrs.**

Course Code: MECH-3027 **Max. Marks: 100**

Instructions: Assume any missing data and mention it clearly.

SECTION A

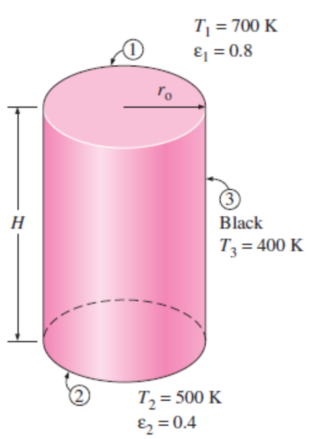
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Explain the Fourier's Law of heat conduction.	**4**	**CO1**
Q 2	What is Reynolds Number? State its importance.	**4**	**CO2**
Q 3	Distinguish between free and forced convective heat transfer by taking suitable example.	**4**	**CO3**
Q 4	Analyze the role of a black body in radiation heat transfer and evaluate how emissivity affects heat transfer in real-world systems. Compare and contrast black bodies and gray bodies, and provide examples of each in engineering applications, assessing their impact on system design.	**4**	**CO4**
Q 5	Evaluate the critical radius of insulation and explain why insulation might increase heat loss in some cases. Using a practical example of a pipe, analyze how the insulation thickness impacts heat transfer and justify when adding insulation reduces or increases heat loss.	**4**	**CO5**

SECTION B

(4Qx10M= 40 Marks)

S. No.		Marks	CO
Q 6	A small copper sphere of diameter 2 cm is initially at a temperature of 300°C and is suddenly immersed in a fluid at 50°C with a convective heat transfer coefficient of h=120 W/m² ^{0}C Assume properties of copper: • ρ=8950 kg/m^3 • cp=385 J/kg K • k=400 W/m ^{0}C Determine: 1. Whether lumped system analysis is applicable. 2. The temperature of the sphere after 60 seconds.	**10**	**CO2**
Q 7	Deduce mathematical formulation for three-dimensional heat conduction equation with internal heat generation in cylindrical coordinates.	**10**	**CO3**
Q 8	Engine oil at 80°C flows over a flat surface at 40°C for cooling purpose, the flow velocity being 2 m/s. Determine the hydrodynamic and thermal	**10**	**CO4**

	boundary layer thickness at a distance of 0.4 m from the leading edge. Also determine the local and average values of friction and convection coefficients. Take the following properties kinetic viscosity = 83×10^{-6} m^2/s, Pr= 1050. Thermal conductivity = 0.1407 W/m K.		
Q 9	A straight aluminum fin of rectangular cross-section (thickness = 2 mm, width = 50 mm, length = 100 mm) is attached to a wall maintained at 150°C. The surrounding air is at 30°C, and the convective heat transfer coefficient is h=60 W/m² ^{0}C. The thermal conductivity of aluminum is k=200 W/m ^{0}C. Assume steady-state, one-dimensional heat conduction with adiabatic tip. Determine: 1. The fin efficiency. 2. Explain what the result implies about the fin's performance. **OR** A cylindrical pin fin of length 5 cm and diameter 6 mm is used on a surface at 120°C, exposed to air at 25°C. The heat transfer coefficient is h=45 W/m² ^{0}C, and the thermal conductivity of the fin material is k=15 W/m ^{0}C. Determine: 1. The effectiveness of the fin. 2. Comment on whether adding this fin is beneficial.	**10**	**CO5**
SECTION-C (2Qx20M=40 Marks)			
Q 10	Consider a cylindrical furnace with radius and height of 1 m, as shown in figure. The top (surface 1) and the base (surface 2) of the furnace has emissivity ε_1=0.8 and ε_2=0.4, respectively, and are maintained at uniform temperatures T_1=700 K and T_2=500 K. The side surface closely approximates a black body and is maintained at a temperature of T_3=400 K. Determine the net rate of radiation heat transfer at each surface during steady operation and explain how these surfaces can be maintained at specified temperatures.  	**20**	**CO5**

<table>
<tr><td>Q 11</td><td>A counter-flow heat exchanger is used to heat cold water from 20°C to 60°C using hot oil that enters at 120°C and leaves at 80°C. The mass flow rates are:
• Water: $\dot{m}_c$=1 kg/s, Cp_c=4180 J/kg ^{0}C
• Oil: $\dot{m}_h$=2 kg/s, Cp_h=2100 J/kg ^{0}C
Assume:
• No heat loss to surroundings.
• Constant specific heats.
Determine
1. The effectiveness of the heat exchanger.
2. The heat transfer rate.
3. The required heat exchanger area if the overall heat transfer coefficient is U=300 W/m² ^{0}C

OR

In a parallel-flow heat exchanger, hot gases at 300°C enter at a flow rate of 2 kg/s with Cp_h=1000 J/kg ^{0}C while cold water at 25°C enters at 1.5 kg/s with Cp_c=4180 J/kg ^{0}C
After heat exchange:
• Hot gas exits at 150°C
• Cold water exits at 100°C
Assume U=200 W/m² ^{0}C
Determine
1. The rate of heat transfer.
2. LMTD
3. The required surface area of the heat exchanger</td><td>20</td><td>CO5</td></tr>
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