

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Regular/Backlog), November-December 2017

M. Tech. in Mechanical Engineering, Semester: 1st

Roll No.....

TEMTech103: Convective Heat & Mass Transfer

Time: 3 hours

Max. Marks: 100

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

Q.1A Objective type multiple choice questions (10 questions @ 1 mark)

10

- i. When all the conditions are identical in case of flow through pipe with heat transfer, The velocity profile will be identical for
 - (a) Liquid heat and liquid cooling
 - (b) Gas heating and gas cooling
 - (c) Liquid heating and gas cooling
 - (d) Heating and cooling of any fluid
- ii. In the case of turbulent flow through a horizontal cylinder of diameter 'D', free convection heat transfer coefficient for the cylinder will
 - (a) be independent of diameter
 - (b) vary as $D^{\frac{1}{4}}$
 - (c) vary as $D^{\frac{3}{4}}$
 - (d) vary as $D^{\frac{1}{2}}$
- iii. The Nusselt number is related to Reynold's number in laminar and turbulent flows respectively as
 - (a) $Re^{-\frac{1}{2}}$ and $Re^{0.8}$
 - (b) $Re^{-\frac{1}{2}}$ and $Re^{-\frac{1}{8}}$
 - (c) $Re^{\frac{1}{2}}$ and $Re^{0.8}$
 - (d) $Re^{\frac{1}{2}}$ and $Re^{-0.8}$
- iv. Given that Pr, Nu, Sh, Re, Sc, Gr has their respective meanings, The functional relationship for free convective mass transfer is given as
 - (a) $Nu = f(Gr, Pr)$
 - (b) $Nu = f(Re, Pr)$
 - (c) $Sh = f(Sc, Gr)$
 - (d) $Sh = f(Re, Sc)$
- v. The velocity and temperature distribution in a pipe flow are given by $u(r)$ and $T(r)$. If u_m is bulk mean velocity at any section of pipe, The bulk mean temperature at that section is
 - (a) $\int_0^{r_0} u(r)T(r)r^2 dr$
 - (b) $\int_0^{r_0} \frac{u(r)}{3r} \frac{T(r)}{2r} dr$
 - (c) $\int_0^{r_0} \frac{u(r)T(r)}{2\pi r^3} dr$
 - (d) None of these
- vi. For fully developed turbulent flow in a pipe with heating, the Nusselt number (Nu), varies with Reynold's number (Re) and Prandtl number (Pr) as

- (a) $Re^{0.5} Pr^{\frac{1}{3}}$ (b) $Re^{0.5} Pr^{0.2}$ (c) $Re^{0.5} Pr^{0.4}$ (d) $Re^{0.5} Pr^{0.3}$
- vii. For a pipe flow heat transfer coefficient is given by $Nu_D = 4.36$, Which of the following would apply
- Laminar flow and constant wall temperature
 - Turbulent flow and constant wall heat flux
 - Turbulent flow and constant wall temperature
 - Laminar flow and constant wall heat flux
- viii. In case of liquids, what is binary diffusion coefficient proportional to?
- Pressure only
 - Temperature only
 - Volume only
 - All of these
- ix. What is hydraulic diameter used in place of diameters for non-circular ducts equal to? (A = area of flow, m = perimeter)
- A/m
 - $4A/m$
 - $A/4m$
 - $4m/A$
- x. In laminar flow in air ($Pr = 0.7$) over a heated plate a δ and δ_T denote the hydrodynamic and thermal boundary layer respectively, then
- $\delta = \delta_T$
 - $\delta > \delta_T$
 - $\delta_T > \delta$
 - $\delta = 0$ but $\delta_T \neq 0$
- Q.2 Define and discuss the physical significance of 4×2.5
- Biot Number and how it is differ from Nusselt Number (Nu)
 - Nusselt Nuber (Nu)
 - Prandtl Number (Pr)
 - Differentiate between fin efficiency and fin effectiveness.
- Q.3A Air at 25 °C flows over a thin plate with a velocity of 2.5 m/s. The plate is 2m long and 1 m wide. Estimate the thermal boundary layer thickness at trailing edge of the plate and total drag force experienced by the plate. At 25 °C, the density of air is 1.2 kg/m³ and kinematic viscosity is 15×10^{-6} m²/s. ($Pr = 0.69$) 05
- Q.3B Derive momentum equation for thermal boundary layer. 05
- Q.4A An iron plate of thickness 'L' and thermal conductivity 'k' is subjected to a constant heat flux q_0 W/m² ab boundary surface at $X=l$, the heat is dissipated by convection into the fluid at temperature T_0 with heat transfer coefficient h , Derive expression for temperature T_1 , T_2 at surface $X= 0$ and $X= L$ respectively. 05
- Q.4B Define mass transfer coefficient in detail with suitable example. 05
- Q.5A Derive and explain Reynolds Analogy. 05
- Q.5B A commercial aero plane is modelled as a flat plate which is maintained at 20 °C. The aeroplane is flying at a speed 800 km/hr in air at 0°C and 60 cm of Hg pressure. Calculate the heat loss from wing if the flow is made to flow parallel to the width of the wing. The properties of air at average temperatue of 10°C, $K = 2.511 \times 10^{-2}$ W/m.K, $W = 14.6 \times 10^{-6}$ m²/sec, $Pr = 0.705$. 05
- Q.6A Determine the time required in minutes for a 50 mm diameter steel sphere ($\rho = 7800$ kg/m³, $C_p = 0.46$ kJ/kg.K and $K = 35$ W/mK) to cool from 600 °C to 100 °C temperature if exposed too a cooling air at 30 °C. The convection heat transfer coefficient is 10 W/m.K. 05

- Q.6B In an oil cooler, the oil enters 10 mm diameter tubes at 160 °C and is cooled to 40 °C. The mean velocity of oil in the tube is 1.5 m/s. Calculate the mean heat transfer coefficient. For turbulent flow of liquid being cooled take $Nu = 0.0265 Re^{0.8} Pr^{0.3}$ and for laminar flow $Nu = 3.65$. Take all properties 05

T (°C)	P (kg/m ³)	V(Centi stroke)	K (W/m.K)	C (kJ/kg.K)
40	878	251	0.144	1.96
100	839	20.4	0.137	2.22
160	806	5.7	0.131	2.48

- Q.7A Stainless steel balls bearing having diameter of 1.2 cm area to be quenched in water. The balls leave the oven at 900 °C and are exposed to air at 30 °C for a while before they are dropped in water. If the temperature of the balls is not to fall below 850 °C prior to quenching and the heat transfer coefficient in air is 125 W/m²K, determine how long they can stand in the air before being dropped into the water properties, $\rho = 8085 \text{ kg/m}^3$, $C_p = 0.480 \text{ kJ/kg.K}$, $K = 15.1 \text{ W/mK}$, $\alpha = 391 \times 10^{-6} \text{ m}^2/\text{sec}$. 05

- Q.7B Air at a temperature of 30 °C flows over a flat plate of length 2 m, $T = 150 \text{ °C}$, Air velocity is 12 m/s. Find the local heat transfer coefficient at a distance of 0.5 m from the leading edge and at trailing edge, also find the length at which the pattern change. 05

Air at mean temperature (90°C), $\rho = 0.962 \text{ kg/m}^3$, $C_p = 1.01 \text{ kJ/kg.K}$, $K = 0.031 \text{ W/mK}$, $M = 2.131 \times 10^{-7} \text{ kg/m.sec}$.

Use $Nu = 0.332 Re^{0.5} Pr^{0.33}$ for laminar flow

And $Nu = 0.0296 Re^{0.8} Pr^{0.33}$ for turbulent flow

OR

- Q.7B Derive energy equation for thermal boundary layer. 05

- Q.8A A refrigerated truck carrying food stuff is spreading on a highway at 90 km/hr in a desert area where temperature is 55 °C. Truck body can be taken as rectangular box of 11m×4m×3m dimensions, Consider boundary layer on four walls to be turbulent and the heat transfer is only from four surfaces. The wall surfaces of the truck are at 10 °C. Assume flow parallel to 11 m long side. The thermos physical properties at the mean film temperature of 32.5 °C are $\rho = 1.165 \text{ kg/m}^3$, $C_p = 1.005 \text{ kJ/kg.K}$, $K = 2.673 \times 10^{-2} \text{ W/mK}$, $\nu = 16 \times 10^{-6} \text{ m}^2/\text{s}$, $Pr = 0.701$. 10

- Sketch the system and show boundary layer
- Find the heat loss from four surfaces
- Refrigeration needed (TR)
- Power required

- Q.9 What is pool boiling? Draw a neat sketch to show boiling curve and explain the following 20

- Nucleation
- Bubble growth