

Code No: 5221AV

R15

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech II Semester Examinations, February - 2017

CONVECTIVE HEAT TRANSFER

(Thermal Engineering)

Time: 3hrs

Max.Marks:75

Note: This question paper contains two parts A and B. Part A is compulsory which carries 25 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

PART - A

5 × 5 Marks = 25

- 1.a) What are the advantages of non-dimensionalizing the convection equations? [5]
- b) Write any five empirical correlations for forced convection. [5]
- c) What is natural convection? How does it differ from forced convection? What force causes natural convection currents? [5]
- d) What is the approximate criterion for transition to turbulence in a free convection boundary layer? [5]
- e) What is Prandtl number? How Prandtl number is useful in heat transfer. [5]

PART - B

5 × 10 Marks = 50

- 2.a) What is a similarity variable and what is it used for? For what kinds of functions can we expect a similarity solution for a set of partial differential equations to exist?
 - b) Engine oil at 60°C flows over the upper surface of a 5m long flat plate whose temperature is 20°C with a velocity of 2m/sec. Determine the total drag force and the rate of heat transfer per unit width entire plate. [5+5]
- OR
- 3.a) What is external forced convection? How does it differ from internal forced convection? Can a heat transfer system involve both internal and external convection at the same time?
 - b) Consider a 5cm diameter shaft rotating at 2500 rpm in a 10cm long bearing with a clearance of 0.5mm. Determine the power required to rotate the shaft if the fluid in the gap is air, water and oil at 40°C at 1 atm. [5+5]
- 4.a) If velocity distribution in laminar boundary layer over a flat plate is assumed to be given by second order polynomial $u=a+by+cy^2$. Determine its form using the necessary boundary conditions.
 - b) Air is flowing over a flat plate 5m long and 2.5m wide with a velocity of 4m/sec at 15°C. If $\rho=1.208\text{kg/m}^3$ and $\nu=1.47\times 10^{-5}\text{m}^2/\text{sec}$. Calculate the length of plate over which the boundary layer is laminar and thickness of the boundary layer (laminar), shear stress at the location where boundary layer ceases to be laminar. [5+5]

OR

5.a) A plate of length 750mm and width 250mm has been placed longitudinally in a stream of crude oil which flows with a velocity of 5m/sec. If the oil has a specific gravity of 0.8 and kinematic viscosity of 1 stoke. Calculate Boundary layer thickness at the middle of plate, shear stress at the middle of plate and friction drag on one side of the plate.

b) Air flows over a plate 0.5m long and 0.6 wide with a velocity of 4m/sec. The velocity profile is in the form of $\frac{u}{U} = \sin\left(\frac{\pi y}{2 \delta}\right)$ if $\rho = 1.24 \text{ kg/m}^3$ and $\nu = 0.15 \times 10^{-4} \text{ m}^2/\text{sec}$.

Calculate the boundary layer thickness at the end of the plate, shear stress at 250mm from the leading edge and drag force on one side of the plate. [5+5]

6.a) Physically, what does the Grashof number represent? How does the Grashof number differ from the Reynolds number?

b) Consider a 0.6m by 0.6m thin square plate in a room at 30°C. One side of the plate is maintained at a temperature of 90°C, while the other side is insulated. Determine the rate of heat transfer from the plate by natural convection if the plate is vertical, horizontal with hot surface facing up and horizontal with hot surface facing down. [5+5]

OR

7.a) When is natural convection negligible and when is it not negligible in forced convection heat transfer?

b) Consider three similar double pane windows with air gap widths of 5, 10 and 20mm. for which case will the heat transfer through the window will be a minimum? [5+5]

8.a) Is the heat transfer rate through the glazing of a double pane window higher at the centre or edge section of the glass area? Briefly explain it.

b) Consider a 5m long vertical plate at 60°C in water at 25°C. Determine the forced motion velocity above which natural convection heat transfer from this plate is negligible. Take $\beta = 0.0004 \text{ K}^{-1}$ for water. [5+5]

OR

9.a) What functional form of equation is normally used for correlation of free convection heat transfer data? Explain few correlation equations with suitable example.

b) Derive an expression for the maximum velocity in the free convection boundary layer on a vertical flat plate. At what position in the boundary layer does this maximum velocity occur? [5+5]

10.a) Write a short note on energy equation for convective heat transfer.

b) Derive the formula for derived convection heat transfer. [5+5]

OR

11.a) Write a short note on Natural convection in porous media for convective heat transfer.

b) What is the physical mechanism that causes the friction factor to be higher in turbulent flow? [5+5]

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