Seat No.: _____ Enrolment No._____

# GUJARAT TECHNOLOGICAL UNIVERSITY

**BE - SEMESTER–VII (NEW) EXAMINATION – SUMMER 2022**

**Subject Code:3171911 Date:10/06/2022**

**Subject Name:Advanced Heat Transfer**

**Time:02:30 PM TO 05:00 PM Total Marks: 70**

**Instructions:**

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

| | | | MARKS |
|---|---|---|---|
| **Q.1** | **(a)** | Hot air is to be cooled as it is forced to flow through the tubes exposed to atmospheric air. Fins are to be added in order to enhance heat transfer. Would you recommend attaching the fins inside or outside the tubes? Why? When would you recommend attaching fins both inside and outside the tubes? | **03** |
| | **(b)** | Derive the expression of temperature distribution in plane wall with uniform heat generation. | **04** |
| | **(c)** | A 60 mm thick large steel plate ( $k = 42.6$ W/m°C, $\alpha = 0.043$ m$^2$/h), initially at 440°C is suddenly exposed on both side to an environment with convective heat transfer coefficient 235 W/m$^2$°C and temperature of 50°C. Take time $\tau$ = 4.3 minutes. Calculate temperature at mid-plane using chart given in Fig.1. | **07** |
| **Q.2** | **(a)** | What are the initial and boundary condition in conduction heat transfer problem? | **03** |
| | **(b)** | What is lumped parameter analysis? How it is differ from Heisler's chart analysis? | **04** |
| | **(c)** | How do numerical solution methods differ from analytical ones? Explain finite difference method for solving multi-dimensional steady state heat conduction problems. | **07** |
| | | **OR** | |
| | **(c)** | A cylindrical shell of inner and outer radii, $r_i$ and $r_o$ respectively, is filled with a heat generating material that provides a uniform volumetric generation rate (W/m$^3$) of qgen. The inner surface is insulated, while the outer surface of the shell is exposed to a fluid at $T_\alpha$ and a convection coefficient h.<br>1) Obtain an expression for the steady state temperature distribution, T(r), in the shell, in terms of ri, ro, qgen, h, $T_\alpha$ and thermal conductivity k of the shell material.<br>2) Determine an expression for the heat rate, at the outer radius of the shell in terms of $q_{gen}$ and shell dimensions. | **07** |
| **Q.3** | **(a)** | Consider heat transfer between two identical hot solid bodies and their environments. The first solid is dropped in a large container filled with water, while the second one is allowed to cool naturally in the air. For which solid is the lumped system analysis more likely to be applicable? Why? | **03** |

**(b)** Discuss different modes condensation process with their application. Why dropwise condensation is more preferred over other type of condensation? **04**

**(c)** Explain importance of Reynold and Nusselt number for convection analysis. **07**

An electric wire of 1.25 mm diameter and 250 mm long is laid horizontally and submerged in water at 7 bar. The wire has an applied voltage of 2.2 V and carries a current of 130 amperes. If the surface of the wire is maintained at 200°C and hot surface facing up, make calculation for the heat flux and boiling heat transfer coefficient. Saturation temperature corresponding to 7 bar is 165°C.

**OR**

**Q.3** **(a)** Define Biot number and Fourier number? State their significances? **03**

**(b)** Explain the principle of heat pipe. **04**

**(c)** Draw the boiling curve and identify the burnout point on the curve. Explain how burnout is caused. Why is the burnout point avoided in the design of boilers? **07**

**Q.4** **(a)** Define fin. List at least six practical and specific examples in which different type of fins are used. **03**

**(b)** Explain the concept of free and forced convection with suitable examples. **04**

**(c)** Air at 2 atm and 200$^{o}$C is heated as it flows through a tube with a diameter of 1 inch at a velocity of 10 m/s. Calculate the heat transfer per unit length of tube if a constant heat flux condition is maintained at the wall and the wall temperature is 20°C above the air temperature, all along the length of the tube. How much would the bulk temperature increase over a 3 m length of the tube? Assume Prandtl number, viscosity, thermal conductivity and specific heat of air are 0.681, 2.57X10-5 kg/m.s, 0.0386 W/m°C and 1.025 kJ/kg°C respectively. Assume flow is turbulent and use **07**

$$N_u=0.023(R_e)^{0.8}(P_r)^{0.4}$$

**OR**

**Q.4** **(a)** Define following finite difference terms: **03**

1) Node
2) Volume element
3) Network

**(b)** Discuss various theoretical and empirical equations available to predict natural convection heat transfer coefficient. **04**

**(c)** Water at 5 atm flows inside a tube of 2.54 cm diameter under local boiling conditions where the tube wall temperature is 10°C above the saturation temperature. Estimate the heat transfer in a 1.0 m length of tube. Use following correlation for forced-convection local boiling inside vertical tubes **07**

$$h = 2.54(\triangle T_x)^3(e)^{\frac{p}{1.551}} \quad \frac{W}{m^2.^\circ C}$$

**Q.5** **(a)** Define intensity of the radiation. How the solid angle is measured? **03**

**(b)** Explain heat transfer mechanism from human body. **04**

**(c)** The overall heat transfer coefficient due to convection and radiation for a steam pipe at 200°C running in a large room at 30°C is 18 w/m$^2$K. Calculate heat transfer coefficient due to convection and radiation taking the emissivity of the pipe surface as 0.81. **07**

**OR**

| | | | |
|---|---|---|---|
| **Q.5** | **(a)** | State three special features of radiation from gases. | **03** |
| | **(b)** | Explain radiation effect on temperature measurement. | **04** |
| | **(c)** | A sphere of 4 cm diameter has its surface temperature 827°C and surface emissivity 0.6. This sphere is surrounded by a thin concentric spherical shell of emissivity 0.8 and diameter 10 cm. The outer shell attains a steady state temperature of 227°C in an atmosphere of 27°C air temperature. Determine (i) heat transfer from sphere to shell by radiation neglecting convection (ii) heat transfer from shell to atmosphere by radiation and (iii) the convection heat transfer co efficient at the outer surface of the shell. | **07** |

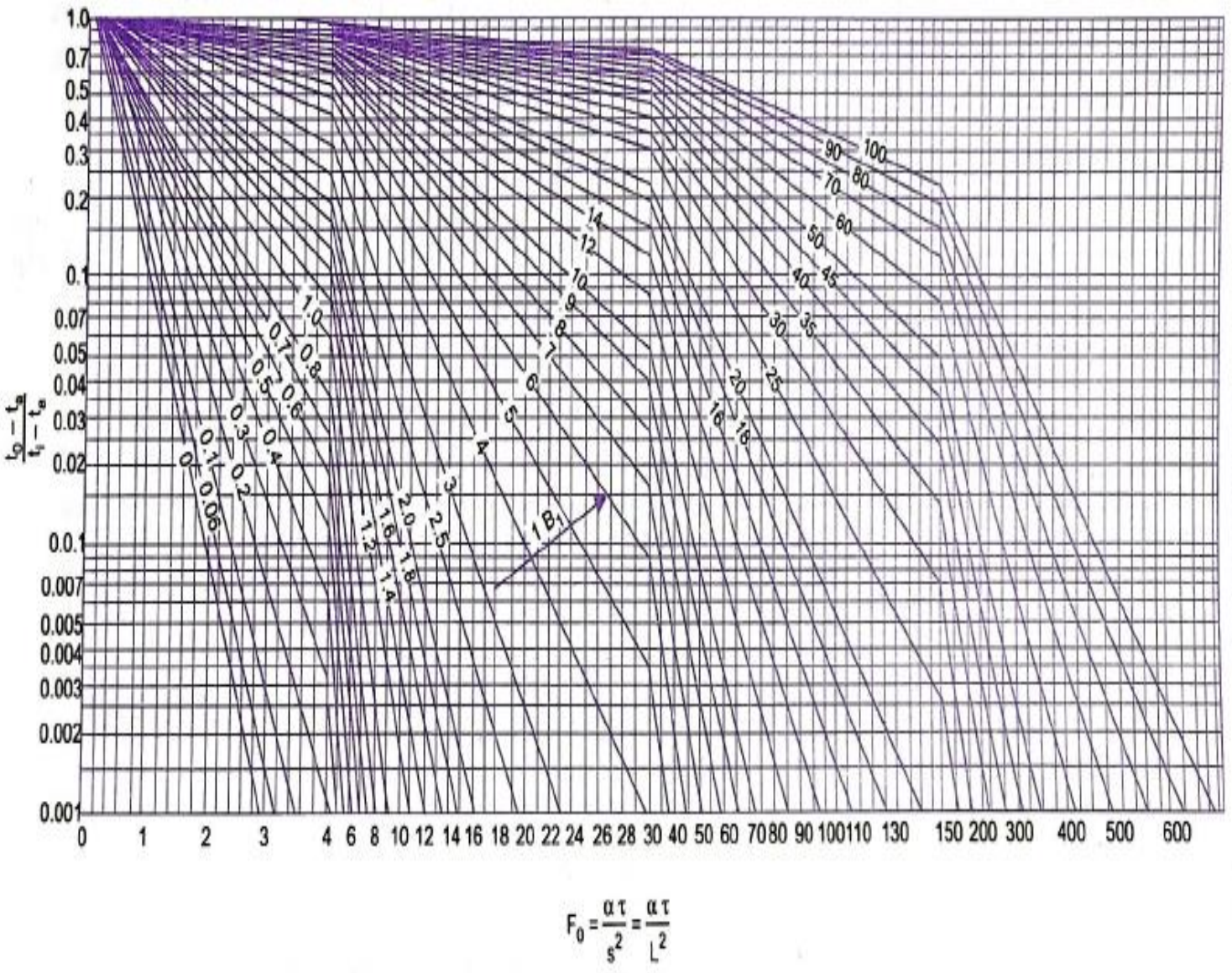


Fig.1 Midplane temperature for an infinite plate of thickness 2*L* full scale.

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