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10MTP21

Second Semester M.Tech. Degree Examination, December 2012
Advanced Heat Transfer

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions.***
2. Use of heat transfer data hand book permitted.

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

1 a. Using fundamental principles, derive the differential equation for temperature distribution in a fin. **(06 Marks)**

b. Solve the fin equation and obtain expressions for temperature distribution and heat loss for a fin with insulated tip. **(06 Marks)**

c. Formulate the one-dimensionsl, unsteady conduction problem in a slab using Crank-Nicolson method. The slab is subject to convection on both sides. **(08 Marks)**

2 a. A rectangular slab is subject to following boundary conditions: top edge is maintained at a temperature of T_2, while remaining three edges are maintained at T_1. Using separation of variables method, obtain the expression for steady state, two-dimensional temperature distribution, without heat generation. **(12 Marks)**

b. The top edge of a square slab is maintained at 500°C, while the remaining three edges are maintained at 100°C. Solve the two-dimensional steady state conduction problem using finite difference and Gauss-Seidel iterations. Divide the slab in to three divisions in each direction and calculate the nodal temperatures. **(08 Marks)**

3 a. A frustum of cone, with a height of 4m has diameters of two end discs 6m and 4m, respectively. The larger disk, with an emissivity of 0.6 is maintained at 1200K. The smaller disc, with an emissivity of 0.9 is maintained at 600K. The lateral surface, with an emissivity of 0.8 is perfectly insulated. If all the surfaces are gray and diffuse, find the net radiative exchange between discs. **(12 Marks)**

b. Two large parallel plates at 100°C and 0°C are having emissivities 0.5 and 0.8 respectively. A radiation shield, with an emissivity of 0.1 on one side and 0.05 on the other is placed in between. Calculate the radiation heat transfer between the plates per square meter, with and without radiation shield. **(08 Marks)**

4 a. State and discuss Navier-Stokes equations. **(05 Marks)**

b. For a boundary layer flow over a flat plate, the momentum integral equation is given by

$$\frac{d}{dx}\left[\int_0^\delta u(u_\infty - u)dy\right] = \gamma.\frac{\partial u}{\partial y}\Big/_{y=0}$$

Assuming a cubic velocity profile, obtain an expression for the velocity variation. By solving the given momentum integral, obtain the expression for the local drag coefficient. **(15 Marks)**

5 a. By integrating the momentum equation, derive the momentum integral equation for a boundary layer flow. **(10 Marks)**

b. For a thermal boundary layer, obtain the energy integral equation, by integrating the energy equation. **(10 Marks)**

6 a. A net radiant energy of 800 W/m^2 is incident on a vertical metal surface 3.5m high and 2m wide. The surface loses all the heat by natural convection to surrounding air at 30°C. The back surface is insulated, for the plate. Calculate the average temperature attained by the plate, as the completely absorbed radiation is lost by convection. **(12 Marks)**

b. Calculate the natural convection heat loss from the top and bottom surfaces of a horizontal plate of size 1 × 1m. The plate is maintained at 227°C, while the air is at 27°C. **(08 Marks)**

7 a. Derive the expression for logarithmic mean temperature difference for a parallel flow heat exchanger. **(10 Marks)**

b. Air enters a cross flow heat exchanger at 16°C, with a mass flow rate of 2.1 kg/s. Water is the other fluid, which enters at 88°C, with a mass flow rate of 0.26 kg/s. The heat exchanger, in which both fluids are unmixed, has an area of 8.5m^2. The overall heat transfer coefficient is 240 W/m^2K. Calculate the exit temperatures of both fluids and the heat transfer. Standard and constant values of specific heats for air and water may be assumed. **(08 Marks)**

c. What are the limitations of LMTD method? **(02 Marks)**

8 a. Using Nusselt's theory, derive the expression for local Nusselt number for film condensation on a vertical surface. **(14 Marks)**

b. Water at atmospheric pressure and saturation temperature is boiled with a copper heating element, with an area of 0.04m^2. If the heater is maintained at 115°C, calculate the surface heat flux and the evaporation rate. **(06 Marks)**

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