Ex/ME/T/214/2019

B.E. MECHANICAL ENGINEERING SECOND YEAR FIRST SEMESTER - 2019

HEAT TRANSFER

Time: Three hours | Full Marks: 100

Answer any ***five*** questions
All questions carry equal marks

1 (a)	**When does thermal diffusivity play a more significant role than thermal conductivity of a** material in analysis of heat conduction?	3
(b)	A cylindrical resistor element on a circuit board dissipates 1.2 W of power. The resistor is 2 cm long, and has a diameter of 0.4 cm. Assuming heat to be transferred uniformly from all surfaces, determine (a) the amount of heat this resistor dissipates during a 24-hour period, (b) the heat flux, and (c) the fraction of heat dissipated from the circular flat surfaces together and comment on the results.	5
(c)	Starting from the appropriate governing equation, solve for the temperature distribution and the heat transfer rate from the outer surface of an infinitely long cylinder of radius R subject to convection at the outer surface with consideration of constant thermal conductivity, constant heat transfer coefficient, fixed ambient temperature, constant and uniform volumetric heat generation, and one-dimensional steady state heat flow. Draw the temperature distribution.	10 2
2 (a)	Oxy-fuel combustion power plants use pulverized coal particles as fuel to burn in a pure oxygen environment to generate electricity. Before entering the furnace, pulverized spherical coal particles with an average diameter of d, are being transported at velocity V through a long heated tube while suspended in hot air. The air temperature in the tube is kept constant at T_a and the average convection heat transfer coefficient is h. The diameter and the length of the heated tube are D and L, respectively. Determine the temperature of the coal particles at the exit of the heated tube using Lumped system analysis of particles, if the initial temperature of the particles is T_{in}. If the mass fraction of coal particles is m_{coal}. transported per kg, find the rate of heat supply required to keep the temperature of air constant at T_a.	7
(b)	Define fin efficiency and fin effectiveness. Describe a situation when fins don't work.	6
(c)	Derive temperature distribution in a very long pin fin. The fin is operated under steady state condition. Assume steady and one-dimensional heat conduction. All thermophysical properties are assumed to be constant. Also determine the heat transfer rate. Start from the appropriate differential equation.	7
3.	The space between two infinite parallel plates, separated by a very small distance L, is filled up with an incompressible fluid having viscosity μ, specific heat c_p, and thermal conductivity k. The lower plate is moving with a uniform velocity U whereas the upper one is stationary. Under steady state, both the plates are maintained at a constant temperature T_0. Determine the maximum temperature in the fluid between the plates. And	20

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	the heat flux across the two walls.	
4.	Derive the Nusselt number for flow of oil ($Pr>1$) over a flat plate subjected to laminar and forced convection. This derivation can be made considering cubic approximation for velocity and constant wall temperature.	20
5 (a)	What are the common approximations made in the analysis of heat exchangers?	3
(b)	What is effectiveness of a heat exchanger? When is ε-NTU method preferred for calculation of a heat exchanger?	4
(c)	Derive the effectiveness of heat exchangers for a counter flow heat exchanger as given below: $$\varepsilon = \frac{1-\exp\left[-N(1-C)\right]}{1-C\exp\left[-N(1-C)\right]}$$ where, $N \equiv NTU = U_m A/C_{\min}$ and $C = C_{\min}/C_{\max}$ Hence find the effectiveness for the same heat exchanger when the temperature rise of the cold fluid is equal to the temperature drop of the hot fluid?	13
6 (a)	Write the boundary layer equations for a vertical plate for heat transfer under natural convection. Write the physical significance of Grashof number.	6
(b)	Derive a parameter which indicates the nature of convection (free or forced).	7
(c)	Using scale analysis, find Nusselt number in terms of relevant dimensionless parameters for natural convection along a vertical flat plate with boundary layer flow of a fluid with $Pr<1$.	7
7 (a)	Derive the radiation view factor between two finite surfaces.	8
(b)	Write the properties of the view factor. What is the surface resistance to radiation for reradiating surface?	5
(c)	Show mathematically that the radiation heat exchange between two parallel plates reduces by keeping another plate in between two plates.	7