Reg No.:_______________ 03000ME322052002 Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Sixth semester B.Tech degree examinations (S), September 2020

Course Code: ME322

Course Name: Heat transfer

Max. Marks: 100 Duration: 3 Hours

Answers should be brief and to the point
Use of Standard Heat Transfer Data book is permitted

PART A

Answer any three full questions, each question carries 10 marks. Marks

1 a) Steady state temperature distribution in a large slab of 50 mm thickness is given by $T(x) = 200 + 2000\,x^2$. The thermal conductivity k of the slab is 50 W/m/K. Find the heat generation rate in the slab as well as the heat fluxes at both the wall faces. Using these values, show that the energy balance occurs across the thickness of the slab. (5)

b) A long 20 mm dia copper tube carries heated water and the steady wall temperature of the tube is 80 deg C. The heat transfer coefficient by free convection h_c equals 6 W / m^2 / K and the surrounding ambient temperature is 20 deg C. Find the heat loss by convection and radiation from the external surface of the pipe per unit length of the pipe. (5)

2 a) An orange, whose shape can be approximated as a 10 cm diameter sphere, is initially at a uniform temperature of 30 deg C. It is placed then inside a refrigerator in which air is at a temperature of 2 deg C and the convective heat transfer coefficient is 50 W / m^2 / K. Find the time taken by the orange when its center temperature reaches 10 deg C. Assume that the thermal diffusivity of the orange $\alpha = 1.4 \times 10^{-7}$ m^2 /s and its conductivity k is 0.59 W / m / K. (4)

b) An electrical cable 5 mm diameter is made from stainless steel wire and has an electrical resistance of 6×10^{-4} ohms / meter. It carries a current of 700 amperes (6) and operates in an environment where the ambient temperature is 30 deg C and the convective heat transfer coefficient h_c = 25 W / m^2 / K. Find the surface temperature of the cable when it is bare and also if it is provided with an insulation outer layer with a material having a thermal conductivity coefficient k = 0.5 W / m / K and whose thickness satisfies just the critical thickness.

3 a) A vertical plate 30 cm high and 1 m wide is maintained at a uniform surface temperature of 120 deg C and is exposed to an ambient temperature of 30 deg C, calculate the average heat transfer coefficient by free convection from the plate and the total heat transfer rate from the plate to the air. (5)

b) Describe how the first derivative of temperature can be represented by forward, backward and central finite differences on a uniform grid. Using these expressions derive the central difference representation of the second derivative of the temperature. (5)

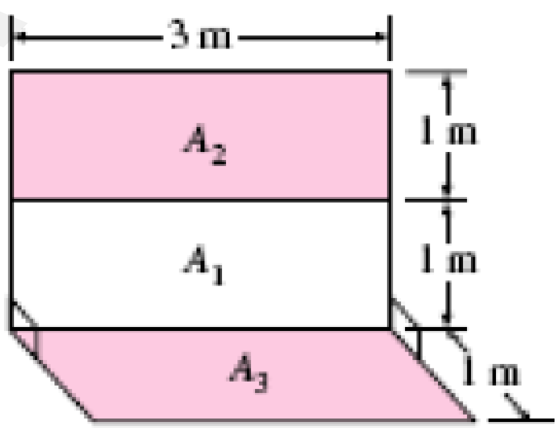
4 a) Air at a pressure of 6 KN/m^2 and a temperature of 300 deg C flows over a 0.5 m long flat plate at a velocity of 10 m / s. Estimate the amount of cooling necessary to maintain the plate surface at a temperature of 27 deg C. (7)

b) Explain what is meant by similar solutions to boundary layer flows. (3)

PART B

Answer any three full questions, each carries 10 marks.

5 a) (7)



Find the view factor F_{23} of the figure shown above using the view factor relations.

	b)	What is meant by a grey surface and a diffuse surface?	(3)
6	a)	Two large plates that are at temperatures T_1 and T_2 and having an emissivity of 0.5, exchange heat by radiation. Find the emissivity of a plate that is to be placed in between these plates which acts as a shield, so that the heat flux reduces to one fourth.	(5)
	b)	The temperature of an electrical incandescent filament bulb is 2500 deg K. Assuming that its emission is close to black body radiation, estimate the fraction of its total radiation heat energy emitted that is in the visible spectrum. What is the wave length at which the emitted energy is maximum? Comment on your answer.	(5)
7	a)	In a heat exchanger hot fluid enters at 60 deg C and leaves at 48 deg C. The cold fluid enters at 35 deg C and leaves at 44 deg C. Find the mean temperature difference for (a) parallel flow (b) counter flow and (c) single pass cross flow (unmixed) configurations.	(5)
	b)	What are the two major approaches to heat exchanger design? Discuss their relative advantages and limitations.	(5)
8	a)	What is fouling of heat exchangers? Explain how this is taken care of in heat exchanger design.	(5)
	b)	A one-shell pass two tube-pass heat exchanger is to be designed to heat 0.5 Kg/s of water entering the shell side at 10 deg C, The hot fluid oil enters the tube at 80 deg C with a mass flow rate of 0.3 Kg/s and leaves at 30 deg C. the overall heat transfer coefficient U = 250 W/m^2/K. Assume the specific heat of oil Cp is 2 KJ/kg/K calculate the surface area of the heat exchanger required.	(5)

PART C

Answer any four full questions, each carries 10 marks.

9	a)	Air free saturated steam at 65 ^{0}C condenses on the surface of a vertical tube of outer diameter 2.5 cm. The tube surface is maintained at a uniform temperature of 35 ^{0}C. Calculate the length of the tube required to have a condensate flow rate of 6 x 10 $^{-3}$ kg/s.	(5)

b) What are the five non-dimensional parameters that are key to the characterisation of boiling and condensation process? (5)

10 a) Explain the drop wise condensation and film condensation. (5)

b) Air free saturated steam at 70 ^{0}C condenses on the outer surface of a 2.5 cm OD vertical tube whose outer surface is maintained at a uniform temperature of 50 ^{0}C. What length of the tube would produce turbulent film condensation? (5)

11 Water at 1 atm (saturation temperature = 100 deg C) is boiling on a brass surface from below and which is maintained at 108 deg C. Determine the heat flux and compare it with critical heat flux. Identify the regime of boiling that this situation corresponds to. (10)

12 a) What is radiation cooling and explain with sketches how this method is adopted in the cooling of a liquid propellant rocket nozzle. (5)

b) What is difference between total (stagnation) temperature and adiabatic wall temperature? How these two temperatures are related? (5)

13 a) Mention some of the high temperature materials that are used for thermal protection of structures. (4)

b) Describe with diagrams the regenerative cooling of liquid rocket engine combustion chambers. (6)

14 a) Taking the one dimensional heat transient conduction equation $T_t - \alpha T_{yy} = 0$ (suffixes denote differentiation and α is the thermal diffusivity) as the basis, transform this equation to an ablating surface that moves with an ablation velocity of V_a (5)

b) A missile that has a spherical cap is flying at an altitude where the ambient temperature is 250 deg K It is protected by a thermal protection material which has a density of 1800 Kg/m^3 , specific heat of 1 KJ/Kg/K and heat of ablation of 200 KJ/Kg. The material ablates at a temperature of 650 deg K. Calculate the rate of ablation of the material, if the impinging heat flux is 20 W/ cm^2 (5)

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