BITS, PILANI-DUBAI CAMPUS, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2007-2008

ME UC331 TRANSPORT PHENOMENA II

COMPREHENSIVE EXAMINATION

DATE: 26-12-07

DURATION: 3 hrs **MAXIMUM MARKS: 80** **WEIGHTAGE: 40%**

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1. Derive the general three dimensional heat conduction equation in Cartesian coordinates from the fundamentals. **8**

2. A thick walled stainless steal (Ks= 20W/m-°C) with 2cm inner diameter and 4cm outer diameter is covered with a 3cm layer of asbestos insulation (Ka=0.3W/m-°C). If the inner wall temperature of the pipe is maintained at 600°C calculate the heat loss per meter length of the pipe. Also calculate the tube insulation interface temp. The temperature of the outer temperature of the insulation is 100°C. **10**

3. A current of 200A is passed through a stainless steel wire having a thermal conductivity K=19W/m-K, diameter 3mm, and electrical resistivity R = 0.99 Ω. The length of the wire is 1m. The wire is submerged in a liquid at 110°C, and the heat transfer coefficient is 4 kW/m^2-K. Calculate the centre temperature of the wire at steady state condition. **10**

4. Derive the governing equation for heat transfer through a rectangular fin and temperature distribution along the length of the fin considering the fin is very long and the temperature at the end of the fin is that of the surrounding fluid. **10**

5. Derive the governing equation for the transient heat conduction under the lumped system analysis. Write some important observations from the equation. Explain the importance of Biot number in the lumped system analysis. **10**

6. In a certain pharmaceutical process castor oil at 35°C flows over a flat pate at 6 cm/sec. The plate is 6 m long and heated uniformly and maintained at a surface temperature of 95°C. Determine a. the hydrodynamic and thermal boundary layer thickness at the trailing edge of the plate, b. local heat transfer at the end of the plate and c. total heat transfer from the surface per unit width.
   At the mean film temp of 60°C the relevant properties of castor oil are $\alpha = 7.2 * 10^{-8}\ m^2/sec$, $v = 0.65 * 10^{-4}\ m^2/sec$, K= 0.213 W/m-k , $\rho = 956.8\ kg/m^3$ **12**

7. Calculate the net radiant heat exchange per meter square for two large parallel plates at temperatures 800K and 250K, respectively, ε(hotplate) = 0.7 and ε(cold plate) = 0.3.If a polished aluminum shield with ε = 0.5 on both sides is placed between them, find the percent reduction in heat transfer. **12**

8. Exhaust gases (Cp=1.12 kJ/kg-K) flowing through a tubular heat exchanger at the rate of 1000kg/hr are cooled from 500°C to 200°C. The cooling is affected by water (Cp=4.18 kJ/kg-K) that enters the system at 10°C at the rate of 1500kg/hr. If the overall heat transfer coefficient is 500kJ/m^2-hr-°C. What heat exchanger area is required to handle the load for a parallel flow and the counter flow? **8**

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BITS, PILANI-DUBAI CAMPUS, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2007-2008

ME UC331 TRANSPORT PHENOMENON II

TEST 2

DATE: 18-11-07

DURATION: 50 MINUTES MAXIMUM MARKS: 30 WEIGHTAGE: 15%

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1. What is lumped capacity analysis? When is it applicable? What is the physical significance of the Biot number? **5**

2. The heat transfer coefficient for air flowing over a sphere is to be determined by observing the temperature- time history of a sphere fabricated from pure copper. The sphere which is 12.7 mm in diameter is at 66° C before it is inserted into an air stream having a temperature of 27°C. A thermocouple on the outer surface of the sphere indicates 55°C, 69 seconds after the sphere is inserted into an air stream. Assume, and then justify, that the sphere behaves as a space-wise isothermal object and calculate the heat transfer coefficient.

   From table of properties, for pure copper ρ=8933 kg/m^3, c_p=389 J/kg.K, k=389W/m.K **8**

3. A furnace emits radiation at 3000 K. Treating it as a black body radiation calculate
   a. Monochromatic radiation flux density at 1 μ wave length
   b. Wave length at which emission is maximum
   c. Total emissive power. **7**

4. A 10mm outside diameter pipe carries a cryogenic fluid at 100K temperature. Another pipe of 13mm outside diameter and 280K surrounds it coaxially and the space between the pipes is completely evacuated. Determine the radiant heat flow for 3m length of pipe if the surface emissivity for both surfaces is0.2. Proceed to calculate the percentage reduction in heat flow if a shield of 11.5 mm diameter and 0.05 surface emissivity is placed between the pipes. **10**

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BITS, PILANI-DUBAI CAMPUS, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2007-2008

ME UC331 TRANSPORT PHENOMENON II

TEST 1

DATE: 30-09-07

DURATION: 50 MINUTES MAXIMUM MARKS: 30 WEIGHTAGE: 15%

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1. State the general three dimensional heat conduction equation in cylindrical coordinates and deduce the steady state one dimensional heat conduction equation with heat generation from it.
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2. The composite wall of an oven consists of three materials, two of which are known thermal conductivity, k_A=20W/m.K and k_C=50W/m.K, and known thickness, L_A=0.30m and L_C=0.15m. The third material, B, which is sandwiched between materials A and C, is of known thickness, L_B=0.15m, but unknown thermal conductivity k_B. Under steady-state operating conditions, measurements reveal an outer surface temperature of $T_{s,o}$=20°C, an inner surface temperature of $T_{s,i}$=600°C and an oven air temperature of T =800°C. The inside convection coefficient h is known to be 25W/m.K. What is the value of k_B?
8

3. An insulated steam pipe of 16cm diameter is covered with 4cm thick layer of insulation (k=0.9 W/m-°C) and carries process steam .Determine the percentage change in the rate of heat loss if an extra 2 cm thick layer of lagging (k= 1.25 W/m-°C) provided . Given the surrounding temperature remains constant and heat transfer coefficient for both the configurations is 12 W/m^2-°C.
8

4. A plane wall of 6 cm thick generates heat internally at the rate of 0.3MW/m^3.One side of the wall is insulated and the other side is exposed to an environment at 93°C. The convection heat transfer coefficient between the wall and the environment is 570 W/m^2-°C. The thermal conductivity of the wall is 21 W/m-°C. Derive the expression for the maximum temperature of the wall and calculate it.
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