BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2009-2010

ME C331 TRANSPORT PHENOMENA II

COMPREHENSIVE EXAMINATION

DATE: 27-12-09

DURATION: 3 hrs **MAXIMUM MARKS: 35** **WEIGHTAGE: 35%**

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1. Derive the general three dimensional heat conduction equation in Cartesian coordinates from the fundamentals. Deduce the unsteady state two dimensional conduction equation with out heat generation from it. **4**

2. A 2mm diameter wire with 0.8 mm thick layer of insulation (K= 0.15 W/m-K) is used in an electric heating application. The insulated surface is exposed to atmosphere with convective heat transfer coefficient 40 W/m^2-K. What percentage change in heat transfer rate would occur if critical thickness of insulation is used? It may be assumed that temp difference between the surface of the wire and surrounding air remains unchanged. **4**

3. A current of 300A is passed through a stainless steel wire having a thermal conductivity K=20W/m-K, diameter 3mm, and electrical resistivity R = 0.095 Ω / km. The length of the wire is 1m. The wire is submerged in a liquid at 150°C, and the heat transfer coefficient is 4 W/m^2-K Calculate the centre temperature of the wire at steady state condition. **5**

4. Stainless steel balls (ρ=8085 kg/m^3, k=30 W/m-°C, Cp=0.480 kJ/kg-K and α =3.91 * 10^{-6} m^2/sec) having a diameter 1.2 cm are to be quenched in water. The balls leave the oven at a uniform temperature of 900°C and are exposed to air at 30°C for a while before they are dropped in to the water. If the temperature of the balls is not to fall below 850°C prior to quenching and heat transfer co-efficient in the air is 2475 W/ m^2-°C, determine how long they can stand in the air before being dropped in to the water.

   Constants to be used in one term solution.

Bi	-	A_1	-	λ_1
0.1	-	1.0298	-	0.5423
0.2	-	1.0592	-	0.7593

4

5. Air is flowing over a flat plate of 7m long and 3 m wide with a velocity of 6m/sec at 27°C if Pr=0.7, density = 1.208 kg/m^3 and kimematic viscosity = 1.47 *10^{-5} m^2/sec, K= 0.213 W/m-K
   a. calculate the length of the plate over which the boundary layer is laminar
   b. calculate the thickness of the thermal boundary layer and the local heat transfer coefficient at 0.75 m distance from the leading edge assuming the plate is heated over to 97 °C the entire length.
   c. calculate the over all heat transfer . **5**

6. From the fundamentals derive the expressions for the surface resistance and space resistance in case of non black body radiation. Using this deduce the expression for the radiation heat exchange between the two large parallel rectangular plates. Also derive the expression for the relation between the heat transfers between the two large parallel plates and the heat transfer between the same plates with N no of shields of equal emissivities placed between them. **4**

7. Derive an expression for LMTD (log mean temp difference) from the fundamentals for a double pipe heat exchanger in terms of inlet and outlet temperatures of the hot and cold fluids for parallel and counter flow arrangement. **4**

8. State and explain the Fick's law of diffusion. A binary mixture of oxygen and nitrogen with partial pressures in the ratio of 0.21 and 0.79 is contained in a vessel at 300 K. If the total pressure of the mixture is 1 bar make calculations for the molar concentration, the mass density, the molar fraction and the mass fraction of each species. Further proceed to calculate the average molecular weight and overall mass density of the mixture. **5**

BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2009-2010

ME C331 TRANSPORT PHENOMENA II

TEST 2 (open book) *

DATE: 10-12-09

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

***Only prescribed textbook and hand written notes are allowed**

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1. A thermal energy storage unit consists of a large rectangular channel, which is well insulated on its outer surface and enclosed alternating layers of the storage material and the flow passage. Each layer of the storage material is aluminium slab of width=0.05m which is at an initial temperatures of 25°C. consider the conditions for which the storage unit is charged by passing a hot gas through the passages, with the gas temperature and convection coefficient assumed to have constant values of T=600°C and h=100W/m^2-K throughout the channel how long will it take to achieve 75% of the maximum possible energy storage? What is the temperature of the aluminium at this time?
From the table of properties for Aluminum k=231W/m-K, Cp = 1033 J/kg-K, ρ=2702kg/m^3. **5**

2. 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. What will be the heat flow if a shield of 11.5 mm diameter and 0.05 surface emissivity is placed between the pipes? **5**

3. Air at 27°C and one atmosphere flows over a flat plate at a speed of 2m/sec .The plate is 40cm wide and is heated uniformly throughout its entire length and is maintained at a surface temperature of 73°C. Calculate the hydrodynamic and thermal boundary layer thickness at a distance of 60cm from the leading edge of the plate. Also determine the total drag force on the plate. Take the following properties for the air at the mean film temperature of 50°C. ρ= 1.16 kg/m^3, k= 0.023 W/m-°C, Cp = 1010 J/kg-K and v = 18 * 10^{-6} m^2/sec). **5**

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BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2009-2010

ME C331 TRANSPORT PHENOMENA II

TEST 1

DATE: 18-10-09

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

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1. A 3mm diameter and 5m long electric wire is tightly wrapped with a 2mm thick plastic cover whose thermal conductivity is 0.15W/m-°C.Electrical measurements indicate that a current of 10 A passes through the wire and there is a voltage drop of 8V along the wire. If the insulated wire is exposed to a medium at 30°C with a heat transfer coefficient of 12W/m^2-°C, determine temperature at the interface of the wire and the plastic cover in steady operation. Also determine whether doubling the thickness of the plastic cover will increase or decrease the heat transfer for the same interface temperature. If heat transfer is to be reduced what is the minimum thickness of insulation required. **5**

2. 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. **5**

3. A horizontal steel shaft 30mm diameter and 600mm long has a first bearing located 100mm from the end connected to the impeller of a centrifugal pump. If the impeller is immersed in a hot liquid metal at 500°C work out the temperature at the bearings under the conditions

   a. the shaft is very long and

   b. the heat is transferred to the surroundings from the end.

   The temperature and the convection coefficients associated with the fluid adjoining the shaft are 35°C and 68 kW/m^2-°C.For the steel shaft the thermal conductivity K= 72 kW/m-°C. **5**

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BITS, PILANI-DUBAI , DUBAI
FIRST SEMESTER 2009-2010
ME C331 TRANSPORT PHENOMENA II QUIZ2
DURATION: 20 MINUTES MAXIMUM MARKS: 10 WEIGHTAGE: 5%

Date-18-11-09

Name of the student: ---------------------------------- Id.: ---------------------------

1. Give an expression to find out the radiation energy exchange between two concentric cylinders if the outer surface of the inner cylinder is at a temp of T1 with a emissivity of $\varepsilon 1$ and the inner surface of the outer cylinder is at a temperature of T2 with a emissivity of $\varepsilon 2$ and T1 is greater than T2.

2. Consider two parallel infinite plates exchange heat by radiation. How much % of heat transfer is reduced if a third plate is placed in between them with all the plates are having equal emissivities. What is the percentage reduction in heat transfer if three plates are placed in between and all are having equal emissivities?

3. What is the physical significance of the Biot and Fourier numbers? State the use of them in transient heat conduction problems.

4. Find out the total black body emissive power of a spherical ball of 20cm diameter with a surface temperature of 527 °C

5. Radiation from a black body has peak at wave length λmax = 0.75 μ-m. Find its temperature.

BITS, PILANI-DUBAI , DUBAI
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ME C331 TRANSPORT PHENOMENON II **QUIZ1**
DURATION: 30 MINUTES MAXIMUM MARKS: 10 WEIGHTAGE: 5%

Date-30-09-09

Name of the student: ------------------------------------ Id.: ----------------------------

1. Write the general three dimensional heat conduction equation in cylindrical co ordinates. Derive the steady state one dimensional heat conduction equation with out heat generation from it.

2. What is thermal diffusivity? Give its units.

3. A pipe is insulated such that the outer radius is less than the critical insulation radius. If the insulation is taken of assuming same surface temp will the heat transfer increase or decrease? Explain with reasons.

4. Write the expression for temp distribution along the rectangular fin when the tip of the fin is conducting heat. Explain the various terms with their units.

5. A furnace wall is made up of two materials the inner material is of 50cm thickness with a thermal conductivity of 0.25W/m-K and outer insulation of 3 cm thickness with thermal conductivity 0.015 W/m-K. If the innermost temp of the furnace wall is 500 °C and outermost surface temp is 300 °C, considering unit cross sectional area of the furnace wall find the heat conducted out in Watts and the overall heat transfer coefficient of the wall in W/m^2-K.