BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2012-2013

ME C331 TRANSPORT PHENOMENA II

COMPREHENSIVE EXAMINATION

DATE: 06-1-13

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

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1. Prove from the governing equation the temperature distribution in a cylinder for one dimensional steady state heat conduction with heat generation is give by $(T-T_W)/(T_0-T_W) = 1-(r/R)^2$ **4**

2. A reactor wall of 320mm total thickness is made up of inner layer of fire brick **(k=0.84 W/m-°C)** covered with a layer of insulation **(k=0.16 W/m-°C)**. The reactor operates at a temperature of 1325 °C and the ambient temperature is 25 °C. Determine the thickness of the fire brick and insulation under steady state operation and calculate the heat loss per unit area presuming that the insulating material has a maximum temperature of 1200 °C. **4**

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 **4**

4. A steel rod of (K= 50W/m-°C) of 2cm in diameter and 10cm long protrudes from a wall which is maintained at 200°C. The rod is insulated at the tip and is exposed to the ambient with a heat transfer coefficient of h= 100 W/m^2-°C and with the ambient temperature of 40°C. Calculate the fin efficiency, temp at the tip of the fin and the rate of heat dissipation **4**

5. a. What is meant by thermal boundary layer? Compare and contrast it with hydrodynamic boundary layer
b. Describe with the help of relevant diagrams what velocity profiles you are likely to get for fluid flow in smooth tubes when the flow is (a) inviscid, (b) laminar, (c) turbulent? **4**

6. Air is flowing over a flat plate of 5m long and 2.5 m wide with a velocity of 4m/sec at 15°C if Pr=0.7, density = 1.208 kg/m^3 and kinematic viscosity = $1.47 * 10^{-5}$ m^2/sec.
a. calculate the length of the plate over which the boundary layer is laminar b. calculate the laminar boundary layer thickness at the point of transition and c. calculate the thickness of the thermal boundary layer at 1.5 m distance from the leading edge assuming the plate is heated over the entire length. **5**

7. A long cylindrical rod of diameter 0.01m is coated with a new material and is placed in an evacuated long cylindrical enclosure of diameter 0.1m and an emissivity of 0.95 which is cooled externally and maintained at a temperature of 200 K at all times . The rod is heated by passing electric current through it. When steady operating condition is reached it is observed that the rod is dissipating electric power at a rate of 8W per unit of its length and its surface temperature is 500K.Based on these measurements determine the emissivity of the coating on the rod. **5**

8. A parallel flow heat exchanger is to be designed to condense 8kg/sec of an organic liquid(t_{sat}=80°C, h_{fg} = 600kJ/kg) with cooling water available at 15°C and at a flow rate of 60kg/sec.The overall heat transfer coefficient is 480W/m^2-°C. Take Cpw = 4.186 kJ/kg-k and calculate
a. the number of tubes required. The tubes are to be 25mm outer diameter, 2mm thickness and 4.85m length.
b. the number of tube passes. The velocity of cooling water is not to exceed 2m/sec. **5**

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FIRST SEMESTER 2012-2013

ME C331 TRANSPORT PHENOMENA II

TEST 2 (open book) *

DATE: 09-12-12

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

*Only prescribed textbook and hand written notes are allowed

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1. Engine oil at 60° C flows over an 5m long flat plate whose temp is 20° C with a velocity of 2m/sec. Determine the total drag force and rate of heat transfer over the entire plate per unit width. The properties of the engine oil at the mean film temperature of 40° C are given below. ρ =876 kg/m^3, Pr = 2870, k = 0.144 W/m –°C, ν = 242 *10^{-6} m^2/sec. **6**

2. A furnace is shaped like a semi cylindrical duct of diameter D=50cm.The base and the dome of the furnace has the emisivities of 0.5 and 0.9 and are maintained at uniform temperatures of 500K and 1500K respectively. Determine the net rate of heat transfer from the dome to the base surface per unit length during steady operation. **4**

3. A radiation shield that has the same emissivity ε_3 on both sides is placed between two large parallel plates which are maintained at a uniform temperatures of T_1= 650 K and T_2= 400K and has emissivities of ε_1=0.6 and ε_2 = 0.9 respectively. Determine the emissivity of the radiation shield if the radiation heat transfer between the plates is to be reduced to 15 percent of that without the radiation shield. **5**

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BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2012-2013

ME C331 TRANSPORT PHENOMENA II

TEST 1

DATE: 15-10-12

DURATION: 50 MINUTES **MAXIMUM MARKS: 15** **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. A flat wall is exposed to the environment temperature of 27°C. The wall is covered with two layers of insulation of 2.5 mm thickness each whose thermal conductivities are 1.4 and 1.7 W/m-K respectively. The wall loses heat to the environment by convection. Compute the value of the convection heat transfer coefficient which must be maintained on the outer surface of the insulation to ensure that the outer surface temperature does not exceed 41°C. The innermost surface is maintained at a temp of 70°C. **4**

3. 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. **6**

4. A steel rod of (K= 50W/m-°C) of 2cm in diameter and 10cm long protrudes from a wall which is maintained at 200°C. The rod is insulated at the tip and is exposed to the ambient with a heat transfer coefficient of h= 100 W/m^2-°C and with the ambient temperature of 40°C. Calculate temp at the tip of the fin. **3**

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BITS, PILANI-DUBAI, DUBAI
FIRST SEMESTER 2012-2013

ME C331 TRANSPORT PHENOMENO II **QUIZ1**
DURATION: 20 MINUTES MAXIMUM MARKS: 10 WEIGHTAGE: 5%
Date-06-11-11

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

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1. What is lumped system in transient heat conduction analysis? How Biot number is useful in the lumped system analysis.

2. What is the physical significance of Fourier number? Give an expression for the Fourier number.

3. Consider a medium in which the finite difference formulation of a general interior node is given in its simplest form as
$T_{node} = (T_{left} + T_{top} + T_{bottom} + T_{right}) / 4$

a. Is heat transfer in this medium steady or transient? -
b. Is heat transfer one, two or three dimensional? -
c. Is there heat generation in the medium? -
d. Is the nodal spacing constant or variable? -
e. Is the thermal conductivity of the medium constant or variable -

4. Thermal radiation lies in the range of --------------------------- wavelength while the visible-light portion of the spectrum is in the range of --------------------------- wave length.

5. Give an expression for the radiation shape factor between the two surfaces in terms of the areas of the surfaces and the angles measured between the normal to the surface and the line drawn between area elements