BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2011-2012
ME C331 TRANSPORT PHENOMENA II

COMPREHENSIVE EXAMINATION

DATE: 07-01-12

DURATION: 3 hrs **MAXIMUM MARKS: 70** **WEIGHTAGE: 35%**

Note: Signed photo copy of the Heat and Mass Transfer data book is allowed

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1. Derive the critical insulation thickness for the pipes from the fundamentals. A pipe is insulated such that the outer radius of the insulation is less than the critical radius. Now the insulation is taken off. Will the rate of heat transfer will increase or decrease for the same pipe surface temp. Explain with a suitable graph. **6**

2. Derive an expression for the temperature distribution in terms of the surface temperature, the thermal conductivity of the material and the radius of the sphere which is generating heat at a constant rate and having a uniform surface temperature. Consider one dimensional steady state heat conduction along the radial direction of the sphere with constant thermal conductivity. **5**

3. Consider a plane wall of thickness 0.4m with K=2.3W/m-°C and cross sectional area of 20m^2.The left side of the wall is maintained at a temperature of 80°C and the right side looses heat by convection to the surrounding air which is at a temperature of 15°C with a heat transfer coefficient of h=24W/m^2-°C. Assuming constant thermal conductivity and no heat generation a. express a differential equation and the boundary conditions involving h for steady one dimensional heat conduction through wall, b. Obtain a relation for the variation of temperature in the wall by solving the differential equation and c, Evaluate the temperature at the center plane of the wall and the rate of heat transfer through the wall. **8**

4. A centrifugal pump which circulates a hot liquid of metal at 500°C is driven by an electric motor. The motor is coupled to the pump impeller by a horizontal steel shaft of 25 mm diameter. If the temperature of the motor is limited to a maximum value of 60°C, with the ambient air at 25°C, what length of the shaft should be specified between the motor and the pump? It may be assumed that the thermal conductivity of the shaft material is 25 W/m-K and the convective heat transfer coefficient between the steel shaft and the ambient air is 15.7 W/m^2-K. Treat the shaft as a fin with temps of 500°C and 60°C at both the ends and insulated at the motor end. **8**

5. What is meant by thermal boundary layer? Compare and contrast it with hydrodynamic boundary layer. What is the physical significance of Nusselt number and how is it defined **5**

6. 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 $\nu = 18 * 10^{-6}$ m^2/sec). **8**

7. A small sphere of outer diameter 10 cm with a surface temperature of 800K is located at the geometric centre of a large sphere of inner diameter of 70cm with an inner surface temperature of 400K. Calculate the fraction of emission from the inner surface of the large sphere that is incident upon the outer surface of the small sphere assuming both are black bodies. Also calculate the net heat exchange between the two spheres. If both the bodies are considered to be grey bodies with emissivities of 0.4 find the net heat exchange between them. **8**

8. What are the radiation surface and space resistances? How they are expressed? For what kind of surfaces is the radiation surface resistance zero. Differentiate between radiation intensity and radiosity. **6**

9. A 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. Calculate the number of tubes required. The tubes are to be 25mm outer diameter, 2mm thickness and 4.85m length. Also calculate the number of tube passes. The velocity of cooling water is not to exceed 2m/sec. Take Cp for cooling water=4.186kJ/kg-°C and density=1000kg/m^3. **8**

10. Hydrogen gas at 2 bar pressure and 300K flows through a rubber tubing of 10mm inside radius and 20mm outer radius .The diffusivity of the hydrogen through the rubber is stated to be $0.75 * 10^{-4}$ m^2/hr and the solubility of the hydrogen is 0.052 m^3 of hydrogen/m^3 of rubber at 1 bar. What would be the diffusion loss of hydrogen per meter length of the rubber tubing in one hour? It may be presumed that the resistance to diffusion of H_2 from the outer surface of the tube is negligible. Take gas constant for H_2=4240J/kg-C. **8**

BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2011-2012

ME C331 TRANSPORT PHENOMENA II

TEST 2 (open book) *

DATE: 11-12-11

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 95° C flows over an 8m long flat plate whose temp is 35° C with a velocity of 3m/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 65° C are given below.
ρ =983.2 kg/m^3, Pr = 2580, k = 0.259 W/m –°C, ν = 138 *10^{-6} m^2/sec. **5**

2. A hot plate of 2m length and 0.6m width with a surface temperature of 150°C is exposed to the ambient still air at 30°C with the length of the plate held vertically. Calculate the rate of heat loss from both the sides of the plate.
The properties of air at the mean film temperature are ρ =1.129 kg/m^3, Pr = 0.794, k = 0.031 W/m –°C, ν = 23.5 *10^{-6} m^2/sec. **5**

3. A spherical tank of diameter 2 m is filled with liquid nitrogen at 100K is kept at the center of an evacuated cubic enclosure whose sides are 3m long. The emissivities of the spherical tank and the inner surface of the cubical enclosure are 0.1 and 0.8 respectively. If the inner surface temperature of the cubical enclosure was measured to be 240K, determine the net rate of heat transfer to the liquid nitrogen. If the latent heat of vaporization of liquid nitrogen is 259.35 kJ/kg find the rate of evaporation per hour of the liquid nitrogen. **5**

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BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2011-2012

ME C331 TRANSPORT PHENOMENA II

TEST 1

DATE: 16-10-11

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

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1. a. Write down the one dimensional transient heat conduction equation for a long cylinder with constant thermal conductivity and heat generation and indicate what each variable represent.

   b. A pipe is insulated such that the outer radius of the insulation is less than the critical radius. Now the insulation is taken off. Will the rate of heat transfer from the pipe increase or decrease for the same pipe surface temperature? Explain the reasons for your answer.

   c. Give an expression for the thermal resistance of a hollow sphere in one dimensional steady state heat conduction in terms of inner & outer radius and the thermal conductivity of the material of the sphere. **4**

2. The wall of a building is a composite consisting of a 100 mm layer of common brick (K_b=1.3 W/m-K), a 100mm layer of glass fiber (K_{gl}=0.038 W/m-K), a 10mm layer of gypsum plaster (K_{gy}=0.17 W/m-K), and a 6mm layer of pine panel (K_p=0.12 W/m-K). If the inside convection coefficient is 10W/m^2-K and the outside convection coefficient is 70W/m^2-K. Calculate the total thermal resistance and the overall heat transfer coefficient for the composite wall. **4**

3. A solid cylindrical rod of diameter 10mm and length 150 mm is insulated on its cylindrical surfaces. Determine the heat flow rate through the rod if K= 0.78W/m-K. The temperatures at the ends of the rod are 0°C and 100°C respectively. **3**

4. A current of 30A is passed through a stainless steel wire having a thermal conductivity K=20W/m-K, diameter 3mm, and electrical resistivity R = 0.95 Ω. The length of the wire is 1m. The wire is submerged in a liquid at 150°C, and the heat transfer coefficient is 4 kW/m^2-K. Calculate the centre temperature of the wire at steady state condition. **4**

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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-30-11-11

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

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

2. Define monochromatic emissivity.

3. Give the statement of Wien's displacement law.

4. 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

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

6. Consider two parallel infinite plates exchange heat by radiation. How much % of heat transfer is reduced if two plates are placed in between them with all the plates are having equal emissivities.

7. Give the exact solution and the approximate solution of boundary layer thickness for a laminar flow over a flat plate.

8. Give an expression for the temperature distribution for the thermal boundary layer for the laminar flow over a flat plate.

9. For a laminar flow over a flat plate how will you calculate the average heat transfer coefficient for the entire plate?

10. Give the *"Reynolds – Colburn"* equation which expresses the relation between fluid friction and heat transfer for laminar flow on a flat plate and explain the various terms in the equation.

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BITS, PILANI-DUBAI, DUBAI
FIRST SEMESTER 2011-2012

ME C331 TRANSPORT PHENOMENO II QUIZ1
DURATION: 20 MINUTES MAXIMUM MARKS: 10 WEIGHTAGE: 5%
Date-02-11-11

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. Explain what fin efficiency is. Give an expression for the fin efficiency incase of an end insulated fin.

5. State the governing equation for the fin with conduction and convection heat transfer and give the general solution of the equation.