BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2010-2011

ME C331 TRANSPORT PHENOMENA II

COMPREHENSIVE EXAMINATION

DATE: 30-12-10

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

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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. **3**

2. A reactor wall 320mm thick 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 which gives the minimum heat loss and calculate the heat loss per unit area presuming that the insulating material has a maximum temperature of 1200 °C. **5**

3. A 3mm diameter stainless steel wire **(K=20 W/m-°C, resistivity $\rho = 10*10^{-8}$ ohm-m)** 100m long has a voltage of 100V impressed on it. The outer surface of the wire is maintained at 100 °C. Calculate the center temperature of the wire. If the heated wire is submerged in a fluid maintained at 50 °C find the heat transfer coefficient on the surface of the wire, **5**

4. What is lumped capacity analysis? When is it applicable? What is the physical significance and the use of Biot number and Fourier number in transient heat conduction analysis? **4**

5. 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 $\alpha = 7.2 * 10^{-8}$ m²/sec, $\nu = 0.65 * 10^{-4}$ m²/sec, K= 0.213 W/m-k, $\rho = 956.8$ kg/m³ **5**

6. 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.
Take $\sigma = 5.67 * 10^{-8}$ W/m²-K⁴ **5**

7. State and explain the Fick's law of diffusion and obtain the units of diffusion coefficient from it **3**

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/m²-°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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BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2010-2011

ME C331 TRANSPORT PHENOMENA II

TEST 2 (open book) *

DATE: 12-12-10

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

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

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1. Two concentric spheres 210mm and 300mm diameters with the space between them evacuated are to be used to store liquid air (-153°C) in a room at 27°C. The liquid air is placed inside the inner sphere. The surfaces of the spheres are flushed with aluminium ($\varepsilon = 0.03$) and latent heat of vaporization of liquid air is 209.35 kJ/kg. Calculate the fraction of emission from the inner surface of the large sphere that is incident upon the outer surface of the small sphere and the rate of evaporation of liquid air per hour. Take $\sigma = 5.67 * 10^{-8}$ W/m^2-K^4. **5**

2. Air at 1 bar and at a temperature of 30°C ($\mu = 0.06717$ kg/hour-m) flows at a speed of 1.2m/sec over a flat plate .Determine the boundary layer thickness at distance of 250mm and 500mm from the leading edge of the plate. Also calculate the mass entrainment between these two sections. **5**

3. When 0.5 kg of water per minute is passed inside a tube of 20mm outer diameter, it is found to be heated from 20°C to 50°C .The heating is accomplished by condensing steam on the surface of the tube and subsequently the surface temperature of the tube is maintained at 85°C. Determine the length of the tube required for fully developed flow. Take the thermo physical properties of water at the mean film temperature of 60°C as $\rho = 983.2$ kg/m^3, Cp = 4.178 kJ/kg-K, k = 0.659 W/m –°C, $\nu = 0.478 * 10^{-6}$ m^2/sec. **5**

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BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2010-2011

ME C331 TRANSPORT PHENOMENA II

TEST 1

DATE: 31-10-10

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

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1. A standard cast iron pipe (inner diameter = 50mm and outer diameter = 55 mm) is insulated with 85% magnesium insulation (k = 0.02 W/m-°C).Temperature at the interface between the pipe and insulation is 300°C .The allowable heat loss through the pipe is 600 W/m length of the pipe and for the safety, the temperature of the outside surface of insulation must not exceed 100°C. Determine the minimum thickness of insulation required and the temperature at the inside surface of the pipe assuming its thermal conductivity 20 W/m-°C **5**

2. One end of a long rod, 35mm in diameter is inserted in to a furnace with the other end projecting in the outside air .After the steady state is reached the temperature of the rod is measured at two points, one at the base of the rod and other at the farthest end, 180mm apart and found to be 180°C and 145°C. The ambient temperature is 25°C. If the heat transfer coefficient at the rod's surface is 65 W/m^2-°C, calculate the thermal conductivity of the rod assuming that the end of the rod is insulated. **5**

3. An aluminium alloy plate of 400 mm *400 mm *4 mm size at 200°C is suddenly quenched into liquid oxygen at -183 °C. Determine the time required for the plate to reach the temperature of -70°C. Assume the heat transfer coefficient for the plate surface is h= 20000 kJ/m^2-hr-°C, Cp = 0.8 kJ/kg-°C , density ρ = 3000 kg/m^3 and k = 214 W/m-°C for aluminum. **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-22-11-10

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

1. 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.

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 monochromatic emissive power E_λ? How it is calculated?

4. Find out the total black body emissive power of a body of area 0.12 m^2 with a surface temperature of 527 °C. Also find out the intensity of normal radiation.

5. Radiation from a black body has peak at wave length λmax = 0.5 μ-m. Find its temperature.

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BITS, PILANI-DUBAI, DUBAI
FIRST SEMESTER 2010-2011

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

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

1. Write the expression for thermal resistance between the hot fluid and atmospheric air for a composite cylinder having some insulation thickness in which hot fluid is flowing inside the pipe. Explain the various terms (nomenclature) used in the expression.

2. When a current is passed through a stainless steel wire (k = 20W/m- °C) of 2.5mm diameter the heat generated per unit volume is $2.5*10^{9}$ watts. The length of the wire is 1m. The wire is submerged in a liquid, if the surface temperature of the wire is 60 °C; find the centre temperature of the wire at steady state condition.

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. A spherical vessel of 0.5m outside diameter is insulated with 0.2m thickness of insulation of thermal conductivity 0.04 W/m- °C. The surface temperature of the vessel is -195 °C and the outside air is at 10 °C. Determine the heat conducted through the vessel.