BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2008-2009

ME UC331 TRANSPORT PHENOMENA II

TEST 1

DATE: 21-09-07

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

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1. Derive the expression for the critical radius of insulation for a cylinder. Also explain the critical insulation thickness with a graph of insulation thickness versus the total resistance and the heat flow rate. **3**

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. **3**

3. Copper wire of 0.8 mm diameter is insulated with plastic to an outer diameter of 2.5mm. The wire is expected to withstand an environment temp of 35°C. Calculate the maximum steady current in amps that the wire can carry with out heating the inner surface of the plastic above 90°C. Take K_{copper} = 380 W/m-K, $K_{plastic}$ = 0.4 W/m-K, the resistivity of the copper wire as = $2*10^{-6}$ ohm-cm and the heat transfer coefficient from the outer surface of the plastic to atmosphere as 10W/m^2-K. Also calculate the maximum temp of the copper wire. **5**

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. **4**

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BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2008-2009

ME C331 TRANSPORT PHENOMENON II TEST2 (Open book)
DURATION: 50 MINUTES MAXIMUM MARKS: 15 WEIGHTAGE: 15%

(Only text book and hand written notes are allowed)

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1. 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 **(2.5)**

2. A cylindrical ingot 25mm radius and 250mm height initially at 800° C is dipped in water at 25° C with convective heat transfer coefficient of 2.5W/m^2-°C and dipping continues till the temperature drops to 400°C. Subsequently the ingot is kept exposed to air at 25°C with convective coefficient of 27.5 W/m^2-°C till it attains a temperature of 80°C. If the ingot material has thermal conductivity of 65W/m-°C, specific heat 250J/kg-K and density 820 kg/m^3, using lumped system analysis make calculations for the total time required for the ingot to reach the temperature from 800 to 80°C. **(5)**

3. A black body has a temperature 627 ^{o}C and surface area 0.15 m^2. Calculate
(a) Total emissive power,
(b) The intensity of normal radiation,
(c) The wavelength of maximum monochromatic emissive power and
(d) The maximum monochromatic emissive power **(4)**

4. 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. **(3.5)**

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A

BITS, PILANI-DUBAI , DUBAI
FIRST SEMESTER 2008-2009

ME UC331 TRANSPORT PHENOMENON II **QUIZ1**
DURATION: 15 MINUTES MAXIMUM MARKS: 5 WEIGHTAGE: 5%

Date-23-09-08

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

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1. Write the three dimensional heat conduction equation in cylindrical co ordinates. Explain the different terms
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 what will happen to the heat transfer? Explain with reasons.
4. Write the expression for temp distribution along the rectangular fin when the tip of the fin is insulated. Explain the various terms with their units.
5. Give the expression for the overall heat transfer coefficient in case of a cylindrical pipe with a fluid flowing inside and atmospheric air outside with combined conduction and convection heat transfer.

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B

BITS, PILANI-DUBAI , DUBAI
FIRST SEMESTER 2008-2009

ME UC331 TRANSPORT PHENOMENON II QUIZ1
DURATION: 15 MINUTES MAXIMUM MARKS: 5 WEIGHTAGE: 5%

Date-23-09-08

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

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1. 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 what will happen to the heat transfer? Explain with reasons.
2. Give the expression for the overall heat transfer coefficient in case of a cylindrical pipe with a fluid flowing inside and atmospheric air outside with combined conduction and convection heat transfer.
3. Write the expression for temp distribution along the rectangular fin when the tip of the fin is insulated. Explain the various terms with their units.
4. What is thermal diffusivity? Give its units.
5. Write the three dimensional heat conduction equation in cylindrical co ordinates. Explain the different terms

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BITS, PILANI-DUBAI , ACADEMIC CITY, DUBAI
FIRST SEMESTER 2008-2009

ME C331 TRANSPORT PHENOMENON II QUIZ2
DURATION: 15 MINUTES MAXIMUM MARKS: 5 WEIGHTAGE: 5%

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

1. Define the BIOT and FOURIER numbers.
2. What is the use of HEISLER charts and under what conditions it is applicable?
3. State the solution for temp distribution for a rectangular plate considering two dimensional heat conduction when three sides of the plate are at a constant temp and in the upper side sine wave temp distribution is impressed upon.
4. What is a black body? Does a blackbody actually exist?
5. What is the range of wave length for thermal radiation? What is the range for the visible portion in it?

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BITS, PILANI-DUBAI , ACADEMIC CITY, DUBAI
FIRST SEMESTER 2008-2009

ME C331 TRANSPORT PHENOMENON II QUIZ2
DURATION: 15 MINUTES MAXIMUM MARKS: 5 WEIGHTAGE: 5%

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

1. State the solution for temp distribution for a rectangular plate considering two dimensional heat conduction when three sides of the plate are at a constant temp and in the upper side sine wave temp distribution is impressed upon.
2. What is the use of HEISLER charts and under what conditions it is applicable?
3. What is the range of wave length for thermal radiation? What is the range for the visible portion in it?
4. Define the BIOT and FOURIER numbers.
5. What is a black body? Does a blackbody actually exist?

A

BITS, PILANI-DUBAI , ACADEMIC CITY, DUBAI
FIRST SEMESTER 2008-2009

ME C331 TRANSPORT PHENOMENON II QUIZ3
DURATION: 15 MINUTES MAXIMUM MARKS: 10 WEIGHTAGE: 5%

25-11-08

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 a emissivity of ε1 and the inner surface of the outer sphere is at a temperature of T2 with a emissivity of ε2 and T1 is greater than T2.
2. What is fouling factor? Give an expression for the same.
3. Under what conditions can a counter flow heat exchanger have an effectiveness of one? What would be your answer for a parallel flow heat exchanger?
4. 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?
5. Give an expression for the effectiveness of the counter flow heat exchanger in terms of NTU and C.

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BITS, PILANI-DUBAI , ACADEMIC CITY, DUBAI
FIRST SEMESTER 2008-2009

ME C331 TRANSPORT PHENOMENON II QUIZ3
DURATION: 15 MINUTES MAXIMUM MARKS: 10 WEIGHTAGE: 5%

25-11-08

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

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1. What is fouling factor? Give an expression for the same.
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. 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 a emissivity of $\varepsilon 1$ and the inner surface of the outer sphere is at a temperature of T2 with a emissivity of $\varepsilon 2$ and T1 is greater than T2.
4. Give an expression for the effectiveness of the counter flow heat exchanger in terms of NTU and C.
5. Under what conditions can a counter flow heat exchanger have an effectiveness of one? What would be your answer for a parallel flow heat exchanger?

BITS, PILANI-DUBAI , ACADEMIC CITY, DUBAI
FIRST SEMESTER 2008-2009

ME C331 TRANSPORT PHENOMENA II

COMPREHENSIVE EXAMINATION

DURATION: 3 hrs **MAXIMUM MARKS: 35** **DATE: 23-12-08** **WEIGHTAGE: 35%**

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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. **4**

2. Derive an expression for the temperature distribution in the radial direction for a hollow cylinder of inner radius of r_i and outer radius of r_o with a uniformly distributed heat source in terms of inner and outer temperatures of T_i and T_o. Consider one dimensional steady state heat transfer in the radial direction. **4**

3. 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**

4. 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 and the Fourier number in the lumped system analysis. **4**

5. Air at 27°C and one atm flows over a flat plate at a speed of 2m/sec .Calculate the boundary layer thickness at a distance of 20 and 40cm from the leading edge of the plate .Derive the expression and calculate the mass flow rate that enters the boundary layer between these two sections. The viscosity of air at 27 °C is 1.85 * 10^{-5} kg/m-sec. Assume unit depth in Z direction. **5**

6. Two large parallel plates with emissivity 0.4are maintained at different temperatures and exchange heat only by radiation. What percentage reduction in net radiation heat transfer would occur if two equally large radiation shields with surface emissivities 0.04 are introduced in between and parallel to the plates? **5**

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. In a surface condenser the water flowing through a series of tubes at the rate of 200 kg/hr is heated from 15°C to 75°C. The steam condenses on the outside surface of the tubes at the atmospheric pressure and the overall heat transfer coefficient is estimated to be 860kJ/m^2-hr-C.Use NTU method to work out the length of the tube and the steam condensation rate. Presume that the tube is 25mm in diameter. At the condensation pressure the steam has a saturation temp of 100°C with a latent heat of vaporization of 2160kJ/kg. The steam is initially just saturated and the condensate leaves the exchanger without subcooling. Take specific heat of water 4kJ/kg-K. **5**

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