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UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program: B.Tech-MehE | **Semester – V**
Subject (Course): Heat Transfer | **Max. Marks : 100**
Course Code : GNEG 357 | **Duration : 3 Hrs**
No. of page/s: 3

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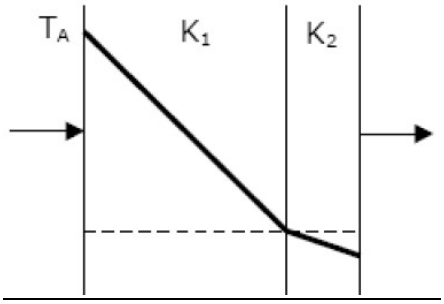
i. There are three sections viz. Section A, Section B and Section C. Section A carries 20 marks, Section B carries 40 marks and Section C carries 40 marks
ii. Attempt all the questions in Section A, Section B and section C
iii. Make appropriate assumptions wherever required

Section A (20 Marks)

Q.1 Explain clearly what you understand by the terms velocity boundary layer and thermal boundary layer. Give their importance in the field of engineering. **(5 Marks)**

Q.2 The temperature variation under steady state heat conduction across a composite slab of two material with thermal conductivities K_1 and K_2 is shown in figure. Compare K_1 and K_2?



(5 Marks)

Q.3 The spectral emissive power E_λ for diffusely emitting surface is: **(5 Marks)**

$E_\lambda = 0$ for $\lambda = 3\mu m$
$E_\lambda = 150$ W/m$^2\mu$m for $3 < \lambda < 12\mu m$
$E_\lambda = 300$ W/m$^2\mu$m for $12 < \lambda < 25\mu m$
$E_\lambda = 0$ for $\lambda > 25\mu m$

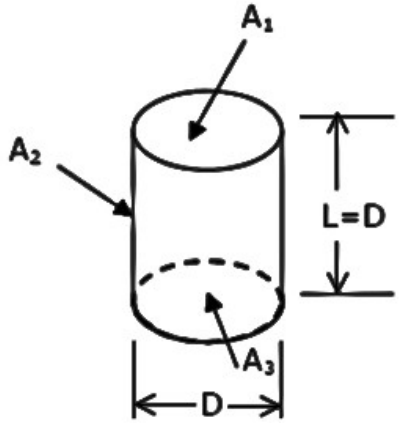
Find total emissive power of the surface over the entire spectrum.

Q.4 After expansion from the gas turbine, the hot exhaust gases are used to heat the compressed air from compressor with the help of a cross flow compact heat exchanger of 0.8 effectiveness. What is the number of transfer unit of the heat exchanger? **(5 Marks)**

Section B (40 Marks)

Q.5 Explain mechanism of conduction, convection and radiation. For the circular tube of equal length and diameter shown below, the view factor F_{13} is 0.17. Find view factor F_{12}.

(10 Marks)



Q.6 Steam condensing on the outer surface of a thin walled circular tube of diameter D = 50 mm and L = 6m maintains a uniform outer surface temperature of 100^0C. Water flows through the tube at rate of $\dot{m} = 0.25\ kg/s$, and its outlet and inlet temperature are $T_{mi} = 15^0$C and $T_{mo} = 57^0$C **(10 Marks)**

Q.7 Air at 25^0C flows over thin plate with a velocity of 2.5 m/s. The plate is 2 m long and 1m wide. Estimate the thermal boundary layer thickness at the trailing edge of the plate and total drag force experienced by the plate. At 25^0C, the density of air is 1.2 kg/m^3 and kinematic viscosity is $15\text{x}10^{-6}$ m^2/s. Prandtl number for air is 0.69. **(10 Marks)**

Q.8 What do you understand by critical thickness of insulation for pipes? Derive an expression for optimal critical radius and show the variation of heat transfer with radius. Give some practical examples of using critical thickness of insulation. **(10 Marks)**

Section C

Q.9 Air with an average velocity of 10 m/s at 300K enters a copper tube of 11.2 mm diameter and 2.5 m length. The tube wall is maintained at 373K by condensing steam at atmospheric pressure. Using LMTD method, determine the temperature of air at outlet of tube. Average properties of air are:

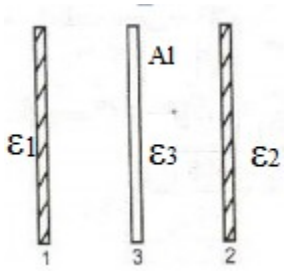
K = 0.02624 W/m-K, C_p = 1.005 kJ/kg-K, ρ = 1.174 kg/m^3, υ = $1.568\text{x}10^{-5}$ m^2/s, Pr = 0.7

Nu = $3.66 + \frac{0.668\left(\frac{d}{L}\right)Re\ Pr}{1+0.04(d\ Re\ \text{Pr})}$: Re< 2300

Nu = 0.023 $\text{Re}^{0.8}$ $\text{Pr}^{0.4}$: Re > 2300

Where d and L are diameter and length of tube respectively. Assume heat transfer coefficient to be constant and neglect conduction thermal resistance of copper **(20 Marks)**

Q.10 Calculate the net radiant heat exchange per m^2 area for two large parallel plates at temperatures of 427^0 C and 27^0C. Є (hot plate) = 0.9 and Є (cold plate) = 0.6. If a polished aluminum shield is placed between them, find the % reduction in the heat transfer Є (shield) = 0.4 **(20 Marks)**



OR

The side of a building of height H = 7 m and length W = 30 m is made entirely of glass. Estimate the heat loss through this glass (Ignore the thermal resistance of the glass) when the temperature of the air inside the building is 20^0 C, the outside air temperature is -15^0C and a wind of 15 m/s blows parallel to the side of the building. Select the appropriate correlation from those listed below of local Nusselt number to estimate the average heat transfer coefficient. For air take: $\rho = 1.2$ kg/m^3, $\mu = 1.8 \times 10^{-5}$ kg/m s, $C_p = 1$ kJ/kg K and Pr = 0.7.

(20 Marks)

- Free convection in air, laminar ($Gr_x < 10^9$): $Nu = 0.3\ Gr_x^{1/4}$
- Free convection in air, turbulent ($Gr_x > 10^9$): $Nu = 0.09\ Gr_x^{1/3}$
- Forced convection, laminar ($Re_x < 10^5$): $Nu = 0.33\ Re_x^{0.5}\ Pr^{1/3}$
- Forced convection, turbulent ($Re_x > 10^5$): $Nu = 0.029\ Re_x^{0.8}\ Pr^{1/3}$