Registration No:

Total Number of Pages: 02

M.TECH

P1MEBC03

1^{ST} Semester Regular Examination 2016-17
ADVANCED HEAT TRANSFER
Branch: MECHANICAL ENGINEERING(SYSTEM DESIGN,THERMAL POWER ENGINEERING, PEOM,TPE,TFE,DD,TE,PE,MSD,ME,MD,MSDD,HPE,HPTE,CAD/CAM)
Time: 3 Hours
Max Marks: 100
Q.CODE:Y850
Answer Question No.1 which is compulsory and any five from the rest.
The figures in the right hand margin indicate marks.

1

a) Write one dimensional heat conduction equation in rectangular coordinate system. 2

b) Define long fin. 2

c) What is the physical significance of Biot number? Write formula for it. 2

d) How transient system analysis is different from lumped system analysis? 2

e) Define spectral blackbody radiation intensity. 2

f) Write reciprocity relation of radiation. 2

g) Write backward difference scheme for $\partial u / \partial x$. 2

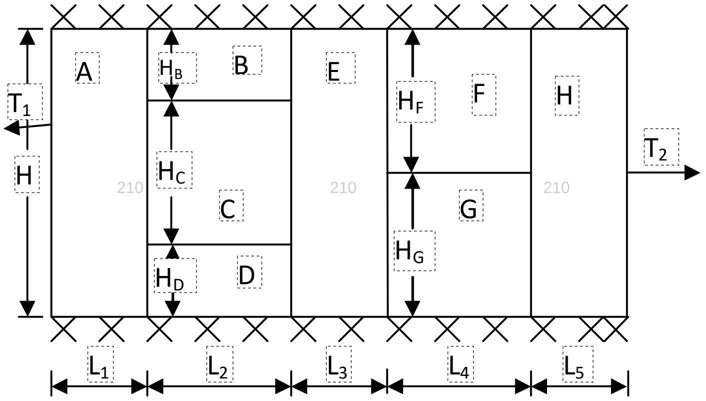
h) What is Fick's law of diffusion? Write the unit for mass diffusity. 2

i) Write the formula for Rayleigh number and express it in the form of product of two non-dimensional numbers. 2

j) Write the formula for Nusselt number. What is it's physical significance? 2

2 a) The temperature distribution of a hollow cylinder is given by $\frac{d}{dr}\left[kr\frac{dT(r)}{dr}\right]=0$ for $a<r<b$. The boundary conditions are: at $r=a, \mathrm{T(r)}=\mathrm{T}_1$ and at $r=b, \mathrm{T(r)}=\mathrm{T}_2$. Assuming k=constant, develop an expression for the thermal resistance of a cylinder of length H. (10)

b) The composite material whose dimensions are: H = 1m, $H_B = H_D = 0.3$m, $H_c = 0.4$m, $H_F = H_G = 0.5$m, $L_1 = L_3 = L_5 = 1$m, $L_2 = L_4 = 3.5$m and thermal conductivities are: $K_A = 0.16$ W/(m^{0}C), $K_B = 0.21$ W/(m^{0}C), $K_C = 0.04$ W/(m^{0}C), K_D=0.17 W/(m^{0}C), K_E=0.18W/(m^{0}C), K_F=0.20 W/(m^{0}C), K_G=0.18W/(m^{0}C), K_H=0.19 W/(m^{0}C) where the subscripts represent material name. If T_1=600^{0}C, T_2=150^{0}C; calculate the heat transfer in the composite wall and thermal resistance of the wall. (10)



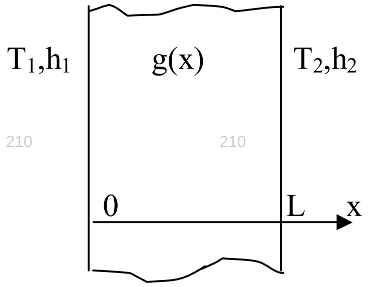
3 a) A slab of thickness 'L' is initially at a uniform temperature T_i. Suddenly at time t=0, the temperature of the both (left and right) surfaces are lowered to and maintained at T_∞ for all t>0. Develop an expression for the temperature distribution T(x,*t*) in the slab. (10)

b) A solid body of arbitrary shape of volume V, total surface area A, thermal conductivity K, (10) density ρ, specific heat C_p at a uniform temperature T_0 is suddenly dipped at time t=0 in a fluid which is at uniform temperature T_∞.. The heat transfer coefficient for fluid is h. Assuming uniform temperature distribution within the solid at any time find the temperature distribution of the solid body at any time.

4 a) Derive the finite difference equation using energy balance method. (10)

b) The equation for the slab with is: (10)

$\frac{d^2T(x)}{dx^2}+\frac{g(x)}{K}=0$ for $0<x<L$. The boundary conditions are: at x=0, $h_1(T_1 - T(0)) = - K\frac{\partial T(0)}{\partial x}$ and at x=L, $h_2(T(L) - T_2) = - K\frac{\partial T(L)}{\partial x}$ where K is the thermal conductivity of the slab, g(x) is the internal heat generation of the slab. Calculate the temperature distribution of the slab along x-direction.



5 a) A black body of 0.2 m^2 area has an effective temperature of 800^0K. Calculate (a) the total rate of energy emission per unit area, (b) the intensity of normal radiation, (c) the intensity of radiation along a direction 60^0 to the normal, and (iv) the wavelength of maximum monochromatic emissive power. (10)

b) Write short notes of the following (i) View-factor, (ii) Black body, (iii) Kirchhoff's Law and (iv) Specular reflection. (10)

6 a) The boundary layer thickness δ(x) for free convection on a vertical plate subjected to uniform surface temperature is given by $\frac{\delta(x)}{x}=3.93\,\mathrm{Pr}^{-0.5}(0.952+\mathrm{Pr})^{0.25}\,Gr_x^{-0.25}$. Calculate local and mean Nusselt number assuming plate temperature (T_w) is higher than ambient temperature (T_∞). The temperature profile within the boundary layer is $\frac{T(x,y)-T_\infty}{T_w-T_\infty}=\left(1-\frac{y}{\delta}\right)^2$ where y is the distance measured normal to the vertical plate. (10)

b) If the above square plate is 0.4mx0.4m and maintained at T_w=400^0K is in quiescent atmospheric air at T_∞=300^0K. (i) Determine the boundary layer thickness δ(x) at the trailing edge of the plate at x=0.5m. (ii) Calculate the local and average heat transfer coefficient. (The properties of the fluid at 350^0K are: $\gamma = 30.75\text{x}10^{-6}$ m^2/sec, Pr=0.697, K=0.03 W/(m^{0}C)). (10)

7 a) Write short notes of the following: (i) Equimolal counter diffusion, (ii) Mass diffusivity, (iii) Sherwood number. (10)

b) Atmospheric air at T_∞=275^0K and a free-stream velocity u_∞=20m/sec flows over a flat plate L=1.5m long that is maintained at a uniform temperature T_w=325^0K. (i) calculate the average heat transfer coefficient 'h_m' over the region where the boundary layer is laminar, (ii) Find the heat transfer coefficient over the entire length L=1.5m of the plate. The physical properties of atmospheric air at 300^0K is k=0.026 W/(m^{0}C), Pr=0.708, ν=16.8x10^{-6} m^2/sec, μ_∞=1.98x10^{-5} kg/(m.sec). The correlation for the plate are: $Nu_m = 0.664\,\mathrm{Re}^{\frac{1}{2}}\,\mathrm{Pr}^{\frac{1}{3}}$ within critical Reynolds number 2x10^5 and for entire length; $Nu_m = 0.036\,\mathrm{Pr}^{0.43}\left(\mathrm{Re}_L^{\,0.8}-9200\right)$. (10)