CONDUCTION

1) Explain the following terms
   a) Radiation
   b) Thermal resistance
   c) Thermal diffusivity
   d) Thermal conductivity **(DEC-2011)**
2) Write general heat conduction equation for non-homogeneous material, self heat generating and unsteady three-dimensional heat flow in cylindrical coordinates. Name and state the unit of each variable.
   Step 1. Reduces above equation to one dimensional
   Step 2. Reduces step 1 equation for steady and without heat generation
   Step 3. Reduces step 2 equation for homogeneous and isotropic material
   Step 4. Reduces step 3 equation to r (dt/dr) = constant. **(MAY-2013)**
3) Derive general heat conduction equation in spherical co-ordinates. **(DEC-2011)**
4) Explain thermal Contact resistance. How contact pressure effects thermal contact resistance? **(MAY-2015)**
5) Derive general heat conduction equation in cylindrical coordinate system. **(DEC-2013)**
6) Derive general heat conduction equation in Cartesian co-ordinates. Also deduce the equation for (i) Steady state conduction (ii) No heat sources (iii) No heat source and steady state condition (iv) One dimensional heat conduction equation without heat generation under steady state **(JAN-2013, MAY-2011)**
7) Derive equation of heat transfer by conduction through composite wall. **(DEC-2014)**
8) Derive equation of heat transfer by conduction through a multi layer cylindrical wall. **(DEC-2014)**
9) State and explain (i) Critical thickness of insulation(ii) efficiency of fins (iii) effectiveness of fins
10) What do you mean by critical radius of insulation? Derive critical radius of insulation rc = k / ho **(MAY-2015, MAY-2013, JAN-2013)**
11) Derive an expression for heat transfer for an adequately long of Rectangular fin with insulated tip. **(DEC-2013, MAY-2015, DEC-2011, JAN-2013, DEC-2014)**
12) Derive the governing differential equation for temperature distribution of constant cross-sectional area fin. Hence derive expression for temperature distribution for long fin stating the assumption made. **(MAY-2013)**
13) (i) Define the effectiveness of fin? How to increase the effectiveness of fin? What happens if εfin = 1, εfin < 1 and εfin > 1 **(MAY-2011)**
14) Derive the relation for temperature variation with respect to time, instantaneous heat transfer rate and total heat transfer using lumped parameter analysis. **(MAY-2013)**
15) Differentiate between steady state and transient heat conduction. Explain two examples of heat conduction under unsteady state. **(MAY-2014)**
16) Derive the one dimensional radial steady state heat conduction through hollow cylinder without heat generation. Also obtain the expression of logarithmic mean are for hollow cylinder. **(MAY-2012)**
17) What are Fourier and Biot Number? What is the physical significance of these number? **(DEC-2013)**

18) A pipe carrying the liquid at -20oC is 10mm in outer diameter and is exposed to ambient at 25oC with convective heat transfer coefficient of 50W/m2K. It is proposed to apply the insulation of material having thermal conductivity of 0.5W/mK. Determine the thickness of insulation beyond which the heat gain will be reduced. Also calculate the heat loss for 2.5mm, 7.5mm and 15mm thickness of insulation over 1m length. Which one is more effective thickness of insulation? **(MAY-2015)**

19) A furnace wall is made up of three layers of thickness 250 mm,100mm and 150mm with thermal conductivity of 1.65,k and 9.2 W/m·C respectively .The inside is exposed to gases at 1250·C with a convection coefficient of 25 W/m2·C and the inside surface is at 1100·C,the outside surface is exposed to air at 25·C with convection coefficient of 12 W/m2·C.

Determine:-

a) The unknown thermal conductivity k
b) The overall heat transfer coefficient
c) All Surface temperatures **(DEC-2011)**

20) A heater of 150 mm × 150 mm size and 800 W rating is placed between two slabs A and B. Slab A is 18 mm thick with k = 55 W/m K. slab B is 10 mm thick with k = 0.2 W/m K. Convective heat transfer coefficients on outside surface of slab A and B are 200 W/m^2 K and 45 W/m^2 K respectively. If ambient temperature is 27°C, calculate maximum temperature of the system and outside surface temperature of both slabs. **(JAN-2013)**

21) A gas turbine blade made of stainless steel (k =32 W/m·C) is 70 mm long ,500 mm2 cross sectional area and 120 mm perimeter .The temperature of the root of blade is 500·C and it is exposed to the combustion product of the fuel passing from turbine at 830·C.If the film coefficient between the blade and the combustion gases is 300 W/m2·C,

Determine:

a) The temperature at the middle of blade
b) The rate of heat flow from the blade **(DEC-2011)**

22) A composite wall has three layers of material held together by 3 cm diameter aluminium rivet per 0.1m2 of surface. The layer of material consists of 10 cm thick brick with hot surface at 200oC, 1cm thick wood with cold surface at 10oC. These two layers are interposed by third layer of insulating material 25cm thick. The conductivity of the material are: kbrick = 0.93 W/mK, kinsulation = 0.12 W/mK kwood =0.175 W/mK, kaluminium =20.4W/mK Assuming one dimensional heat flow, calculate the percentage change in heat transfer rate due to rivets. **(MAY-2015)**

23) A wall 30 mm thick of size 5m X 3m made of red bricks (k=0.35 W/mK). It is covered on both sides by the layers of plaster 2cm thick (k=0.6 W/mK). The wall has a window of size 1m X 2m. The 12 mm thick window glass is having thermal conductivity of 1.2 W/mK. Estimate the rate of heat flow through the wall. The temperatures of inner and outer face are 10oC and 40oC respectively. . **(MAY-2011)**

24) Two rods A and B of equal diameter and equal length, but of different materials are used as fins. The both rods are attached to a plain wall maintained at 160^{o}C, while they are exposed to air at 30^{o}C. The end temperature of rod A is 100^{o}C while that of the rod B is 80 ^{o}C. If thermal conductivity of rod A is 380 W/mK, calculate the thermal conductivity of rod B. These fins can be assumed as short with end insulated. **(MAY-2011)**

25) Two rods A and B of equal diameter and equal length, but of different materials are used as fins. The both rods are attached to a plain wall maintained at 160^{o}C, while they are exposed to air at 30oC. The end temperature of rod A is 100^{o}C and that of the rod B is 80^{o}C. If the thermal conductivity of rod A is 380 W/mK, calculate the thermal conductivity of rod B. This fin can be assumed as short with end insulated. **(MAY-2015)**

26) A 240 mm dia. steam pipe, 200 meter long is covered with 50mm of high temperature insulation of thermal conductivity 0.092 W/m0C and 50mm of low temperature insulation of thermal conductivity 0.062 W/m0C. The inner and outer surface temperatures are maintained at 3400C and 350C respectively. Calculate: (i) The total heat loss per hour (ii) The heat loss per m^2 of pipe surface (iii) The heat loss per m^2 of outer surface (iv) The temperature between interfaces of two layers of insulation. Neglect heat conduction through pipe material. **(MAY-2011)**

27) A hot gas at 330oC with convection coefficient 222 W/m2K is following through a steel tube of outside diameter 8 cm and thickness 1.3 cm. It is covered with an insulating material of thickness 2 cm, having conductivity of 0.2 W/mK. The outer surface of insulation is exposed to ambient air at 25oC with convection coefficient of 55 W/m2K.Calculate: (1) Heat loss to air from 5 m long tube.(2) The temperature drop due to thermal resistance of the hot gases,steel tube, the insulation layer and the outside air. Take conductivity of steel = 50 W/m2K. **(MAY-2012)**

28) A steel tube of 5 cm inner diameter and 8 cm outer diameter (k = 16 W/mK), is covered with an insulation of 3 cm thickness (k = 0.3 W/mK). A hot gas at 350oC h = 400 W/m2K flows. Calculate the heat loss from the tube for 20 meter length. Also calculate the temperature at the interface of insulation and steel. **(MAY-2012)**

29) The temperature of an air stream flowing with a velocity of 3 m/s is measured by a copper-constantan thermocouple which may be approximated as sphere of 3 mm in diameter. Initially the junction and air are at a temperature of 25 oC. The air temperature suddenly changes to and is maintained at 200 oC. Take ρ=8685 kg/m3, Cp = 383 J/kg oC and k =29 W/m oC and h=150 W/m2 oC. Determine: (i) Thermal time constant and temperature indicated by the thermocouple at that instant (ii) Time required for the thermocouple to indicate a temp. of 199 Oc (iii) Discuss the suitability of this thermocouple to measure unsteady state temperature of fluid then the temperature variation in the fluid has a time period of 30 seconds. **(MAY-2013)**

30) A potato with mean diameter of 4cm is initially at 30^oC. It is placed in boiling water for 5 minute and 30 seconds and found to be boiled perfectly. For how long should be a similar potato for the same consumer be boiled when taken from cold storage at 4^oC. Use lumped system analysis and take thermo physical properties of potato as ρ= 1250 kg/m3, k=12 W/mK, h=125 W/m2K, and C=2000 J/kgK **(MAY-2015)**

31) A steel rod (k=30 W/m oC), 12 mm in diameter and 60 mm long, with an insulated end is to be used as spine. It is exposed to surrounding with a temperature of 60 oC and heat transfer coefficient of 55 W/m2 oC. The temperature at the base is 100 oC. Determine : (i) The fin effectiveness (ii) The fin efficiency (iii) The temperature at the edge of the spine (iv) The heat dissipation **(MAY-2013)**

32) A solid sphere of 1 cm made up of steel is at initially at 3000Ctemperature. Properties of steel : k =60 WmK Density = 7800 kg/m3, sp. Heat =434J/kg K Calculate the time required for cooling it up to 500Cin the following two cases (i) cooling medium is air at 250Cwith h = 20 W/m2 K (ii) cooling medium is water at 250C with h =100 W/m2K **(DEC-2013)**

33) During a heat treatment process, spherical balls of 12 mm diameter are initially heated to 800°C. Then they are cooled to 100°C by immersing them in an oil bath of 35°C with convection coefficient 20 W/m^2 K. Determine time required for cooling process. What should be the convection coefficient if it is intended to complete the cooling process in 10 minutes?

Thermo-physical properties of the balls are ρ = 7750 kg/m^3, c_p = 520 J/kg K, k = 50 W/m K. **(JAN-2013)**

34) A refrigeration suction line having outer diameter 30 mm is required to be thermally insulated. The outside air convective heat transfer coefficient is 12 W/m2 oC. The thermal conductivity of the insulating material is 0.3 W/m oC. Determine: (i) Whether the insulation will be effective (ii) Estimate the maximum value of thermal conductivity of insulating material to reduce heat transfer (iii) The thickness of cork insulation to reduce the heat transfer to 20% (k=0.04 W/m oC) **(MAY-2013)**

35) An electronic semiconductor device generates 0.16 kj/hr of heat. To keep the surface temperature at the upper safe limit of 750c. it is desired that the generated heat should be dissipated to the surrounding environment which is at 300c. The task is accomplished by attaching aluminum fins, 0.5mm2 square and 10 mm to the surface. Calculate the number of fins if thermal conductivity of fin material is 690 kj/m-hr-deg and the heat transfer coefficient is 45 kj/m2-hr-deg. Neglect the heat loss from the tip of the fin. **(DEC-2014)**

36) A hot fluid is being conveyed through a long pipe of 4 cm outer dia. And covered with 2 cm thick insulation. It is proposed to reduce the conduction heat loss to the surroundings to one-third of the present rate by further covering with some insulation. Calculate the additional thickness of insulation. **(DEC-2014)**

CONVECTION

1) What is the difference between the natural and forced convection? **(DEC-2011)**

OR

1) Differentiate between mechanisms of heat transfer by free convection and force convection.Mention some areas where these mechanisms are predominant. **(DEC-2014)**
2) What is physical significance of dimensionless parameters? Explain in brief. **(MAY-2015)**
3) For natural convection heat transfer, show that Nu $= f(\text{Gr}, \text{Pr})$. **(MAY-2011, MAY- 2013, MAY-2015, DEC-2013, DEC-2014)**
4) By dimensional analysis show that for forced convection heat transfer the Nusselt number can be expressed as a function of Prandtl number and Reynolds number. **(MAY-2012)**
5) Discuss the concept of thermal boundary layer in case of flow over the plates. How it differ from velocity boundary? **(JAN-2013)**
6) Explain with neat sketch Boundary Layer concept and show velocity boundary layer growth due to flow over plate. **(DEC-2013)**
7) What do you understand by hydrodynamic and thermal boundary layer? Illustrate with reference to flow over a flat heated plate. **(DEC-2014)**
8) Define and discuss velocity boundary layer and thermal boundary layer over a flat plate. Show the thickness of these layers for different Prandtl numbers. **(MAY-2012)**
9) State the general equation for the rate of heat transfer by convection and hence define the coefficient of heat transfer. What are the various factors on which the value of this coefficient depends? **(JAN-2013)**
10) Derive momentum equation for hydrodynamic boundary layer over a flat plate. **(DEC-2011)**
11) Differentiate:1. Mean film temp and bulk mean temp 2. Velocity and thermal boundary layer**(MAY-2013)**
12) Differentiate between pool boiling and forced convection boiling. **(DEC-2011)**
13) Show physical significance of Following non-dimensional numbers: Nu (Nusselt Number), Gr (Grashof Number) and Pr (Prandtl Number), Re (Reynold Number). **(MAY-2011, DEC-2011)**
14) Define following terms related to mass transfer
    a) Prandtal Number Pr
    b) Schmidt number Sc
    c) Lewis number Le
    d) Sherwood number **(DEC-2013)**
15) A hot plate of 400 mm × 400 mm at 100°C is exposed to air at 20°C. Calculate heat loss from both the surfaces of the plate if (a) the plate is kept vertical (b) plate is kept horizontal.

    Air properties at mean temperature are $\rho = 1.06$ kg/m^3, k = 0.028 W/m K, $c_p = 1.008$ kJ/kg K, and $\nu = 18.97 \times 10^{-6}$ m^2/s

    Use following correlations. $Nu = 0.125\,(Gr\,Pr)^{0.33}$ for vertical plate $Nu = 0.72\,(Gr\,Pr)^{0.25}$ for upper surface

    $Nu = 0.35\,(Gr\,Pr)^{0.25}$ for lower surfaces **(JAN-2013)**
16) 750 kg/hour of cream at 10oC is pumped through 1.75 m length of 8 cm inner diameter tube which is maintained at 95oC. Estimate the temperature of cream leaving the heated section

and the rate of heat transfer from the tube to the cream. The relevant thermo physical properties of cream are: ρ=1150 kg/m3 μ=22.5 kg/ms CP=2750 J/kg-deg k=0.42 W/m-deg Use the following correlation for flow of cream inside a tube: **(MAY-2015)**

$$Nu = 3.65 + \frac{0.067\left(\frac{D}{L} R_{e_D} \ Pr\right)}{1 + 0.04\left(\frac{D}{L} R_{e_D} \ Pr\right)^{1/3}}$$

17) Explain the significance of Reynolds numbers, Grashof number, Prandtl number, Nusselt number and Stanton number. Explain convection heat transfer coefficient variation along the flow direction for the horizontal flow over a thin parallel isothermal plate. **(JAN-2013)**

18) What is the significance of Biot number in Lumped parameter analysis? **(JAN-2013)**

19) A copper pipe is maintained at 500C. It is having dimension of 50 mm diameter and length 1 m . It is placed in atmosphere, where air is having temperature of 300C and flowing at speed of 3m/s. Use the co-relation Nu = 0.023 (Re) 0.805 calculate the heat loss from the pipe. **(DEC-2013)**

20) The air at atmospheric pressure and temperature of 30oC flows over one side of plate of a velocity of 90 m/min. This plate is heated and maintained at 100oC over its entire length. Find out the following at 0.3 and 0.6 m from its leading edge. (1) Thickness of velocity boundary layer and thermal boundary layer. (2) Mass flow rate which enters the boundary layer between 0.3 m and 0.6 m per metre depth of plate. Assume unit width of plate. Properties of air at 30oC: ρ = 1.165 kg/m3, v = 16 × 10-6 m2/s, Pr = 0.701, Cp = 1.005 kJ/kgk, k = 0.02675 W/mK. **(MAY-2012)**

21) Air at 20oC and at atmospheric pressure flows at a velocity 4.5 m/s past a flat plate with a sharp leading edge. The entire plate surface is maintained at a temperature of 60oC. Assuming that the transition occurs at a critical Reynolds number of 5 × 105, find the distance from the leading edge at which the boundary layer changes from laminar to turbulent. At the location calculate: (1) thickness of hydrodynamic and thermal boundary layer, (2) Local and average heat transfer coefficients, (3) Heat transfer rate from both sides per unit width of plate. Use Nuxc = 0.332 (Rexc)1/2(Pr)1/3 . Assume cubic velocity profile and approximate method. Thermophysical properties of air at mean film temperature of 40oC are, ρ =1.128 kg/m3, v = 16.96 × 10-6 m3/s, k = 0.02755 W/mk and Pr=0.7. **(MAY-2012)**

22) A large fireplace has a glass fire screen which covers a vertical opening in the fireplace. The opening is 1.2m high and *2.50* m wide. Its surface temperature is 2300*C* and the ambient air temperature is 24°C. Determine the convective rate of heat transfer from the fireplace to the room. The air properties at mean film temperature are : *k* = 0.033 65 W/m.K, *v* = 25.90 X 10-6 m2/s Pr = 0.689 Use correlation for given condition **(MAY-2011)**

$$\overline{Nu} = \left\{0.825 + \frac{0.387(Gr.Pr)^{1/6}}{[1 + (0.492/Pr)^{9/16}]^{8/27}}\right\}^2$$

23) Air at 200C and 1 atmosphere pressure is forced through a 25 mm diameter tube 400 mm long, at an average velocity of 0.33 m/sec. calculate the rate of heat transfer if the tube wall is maintained at 1800C. The air properties at mean film temperature are : *k* = 3.208 W/m.0C, *v* = 23.13 X 10-6 m2/s Pr = 0.688 Use correlation for given condition **(MAY-2011)**

$$\overline{Nu} = 1.671\left[Re.Pr\left(\frac{D}{L}\right) + 0.012\left(Re.Pr\left(\frac{D}{L}\right)(Gr)^{1/3}\right)^{4/3}\right]^{1/3}$$

24) A cold storage room has walls made of 200 mm of brick on the outside, 80 mm of plastic foam, and finally 20 mm of wood on the inside. The outside and inside air temperatures are 25 oC and -3 oC respectively. If the outside and inside convective heat transfer coefficients are respectively 10 and 30 W/m2 oC, and the thermal conductivities of brick, foam and wood are 1.0, 0.02 and 0.17 W/ m oC respectively.Determine: (a) overall heat transfer coefficient (b) the rate of heat removed by refrigeration if the total wall area is 100 m2 (c) outside and inside surface temperatures and mid-plane temperatures of composite wall. **(MAY-2013)**

25) Water at 10 oC, flows over a flat plate (at 90 oC) measuring 1 m X 1 m, with a velocity of 2 m/s. Properties of water at 50 oC are ρ=988 kg/m3, ν = 0.556 X 10-6 m2/s, Cp = 4.18 kJ/kg oC and k = 0.648 W/m oC. Determine (a) The length of plate over which the flow is laminar (b) The rate of heat transfer upto the above length (c) The rate of heat transfer from the entire plate. Useful co-relation: Nu= 0.332 (Rex)1/2 (Pr)1/3 local Nusselt number for laminar flow –Nu= [0.036 (ReL)0.8 – 836](Pr)1/3 average Nusselt number for mixed flow. **(MAY-2013)**

26) A spherical heater of 20 cm dia and 600c temp. is immersed in a tank of water at 20 ℃. Determine the value of convective heat transfer coefficient. At mean film temperature of 40 ℃ the thermo physical properties of water are, density 992.2 kg/m3 , Pr = 4.34, k = 0.633 w/m-deg β = 0.00041 per degree Kelvin and v = 0.659 * 106 m2/sec.
Use the general co relation Nu = 2 + 0.43 (Gr Pr)0.25**(DEC-2014)**

RADIATION

1) Define: (i) Emissivity, (ii) Radiosity, (iii) Monochromatic emissive power, (iv) Irradiation, (v) Absorptivity, (vi) Total emissive power, (vii) Solid angle. (viii) Opaque body (ix) Radiation intensity **(MAY-2011, MAY-2015)**
2) What is black body? How does it differ from gray body? Give examples of each. **(DEC-2011)**
3) State and explain Stefan boltzman law. **(DEC-2014)**
4) Explain Wein's displacement law of radiation. **(JAN-2013)**
5) Explain emissivity and absorptivity of a surface. Also differentiate between black body and grey body. **(JAN-2013)**
6) Explain Kirchoff's law of radiation. **(JAN-2013)**
7) Define absorptivity,reflectivity and transmissivity with respect to radiation heat transfer. **(DEC-2011)**
8) Derive the expression for radiant heat exchange between two finite black surfaces by radiation. **(MAY-2012)**
9) Derive expression for Radiation Heat exchange between two concentric infinite long grey cylinder
10) Define intensity of radiation and prove that the intensity of normal radiation is $1/\pi$ times the total emissive power. Also explain Planck's law radiation heat transfer. **(JAN-2013, DEC-2014)**
11) Derive a general relation for the radiation shape factor in case of radiation between two surfaces. **(JAN-2013)**
12) Enumerate the factors on which the rate of emission of radiation by body depends. **(DEC-2011)**
13) Define shape factor. Discuss salient features of shape factor. **(DEC-2014)**
14) Calculate the net radiation heat transfer per m2 area of two large plates placed parallel to each other at temperatures of 427oC and 27oC respectively. ε(Hot plate)= 0.9 and ε(Cold plate)=0.6. If a polished aluminum shield is placed between them, find the % reduction in heat transfer, ε(Shield)=0.04. **(MAY-2015)**
15) Two large parallel plates with emissivity (ε) = 0.5 each, are maintained at different temperatures and are exchanging heat only by radiation. Two equally large radiation shields with surface emissivity 0.05 are introduced in parallel to the plates. Find percentage reduction in net radiative heat transfer. **(MAY-2011)**
16) Determine net radiation heat transfer per m^2 for two infinite parallel plates held at temperature of 800 K and 500 K respectively. Emissivities of hot and cold plates are 0.6 and 0.4 respectively. Now it is intended to reduce the heat transfer to 40% of original value by placing a radiation shied between the plates. Calculate the emissivity of the shield and its equilibrium temperature. **(JAN-2013)**
17) Estimate the diffusion coefficient of carbon monoxide through air in which mole fraction of each constituents are: O_2 = 0.18, N_2 = 0.72, CO = 0.1. The gas mixture is at 300 K and 2 bar total pressure. Take diffusivity of carbon monoxide in oxygen is 18.5×10^{-6} m^2/s at 273 K and 1 bar and diffusivity of carbon monoxide in nitrogen is 19.2×10^{-6} m^2/s at 288 K and 1 bar. **(JAN-2013)**

18) A steam pipe 8 cm in diameter is covered with 3 cm thick layer of insulation which has a surface emissivity of 0.9.The surface temperature of the insulation is 80·C and the pipe is placed in atmospheric air at 24·C.Considering heat loss by both radiation and natural convection calculate:

a) The heat loss from the 7 m length of pipe.

b) The overall heat transfer coefficient and the heat transfer coefficient due to radiation alone.

The thermo physical properties of air at mean film temperature of 52·C are as following: ϱ=1.092 kg/m3,cp=1.007kj/kg·C,μ=19.57×10-6kg/ms, k=27.81×10-3W/m·C (where the notations have their usual meaning.) use empirical correlation for horizontal cylinders as Nu=053(Gr.Pr).25 **(DEC-2011)**

19) A gas pipe is kept in an atmosphere of 200C. The radious of pipe is 3.75cm and is lagged with insulation thickness of 2.5cm. The emissivity of the surface is 0.9. The length of pipe is 6m. surface temperature ts=800C calculate (i) The total heat loss from pipe (ii) The overall heat transfer coefficient (iii) The heat transfer co efficient due to only radiation. The property of air at 500C are : _ =1.092 kg /m3 , k = 27.81x 10-3 W/m0C, μ =19.57x10 -6 kg/ms _ =5.67x10-8 Cp = 1.007 kJ/kg 0C for convection use co-relation Nu =0.53(Gr.Pr)1/4 **(DEC-2013)**

20) A furnace emits radiation at 2000 K. treating it as a black body radiation calculate the

(1) Monochromatic radiant flux density at 1μ wave length.

(2) Wave length at which emission is maximum and corresponding radiant flux density.

(3) Total emissive power, **(DEC-2014)**

HEAT EXANGER

1) Derive equation of LMTD for parallel flow heat exchanger. **(DEC-2014, DEC-2013)**
2) Define Heat exchanger Give classification of Heat exchanger. **(DEC-2013)**
3) Derive an expression for LMTD for counter flow heat exchanger stating the assumption made. **(MAY-2013, MAY-2012)**
4) Derive the relationship between the effectiveness and number of transfer units for a counter flow heat exchangers. **(DEC-2011, MAY-2015)**
5) Define effectiveness of heat exchanger. Derive equation for effectiveness of a parallel flow heat exchanger. **(MAY-2011, MAY-2012, DEC-2014)**
6) Show that logarithmic mean temperature difference is given by

$$LMTG = \frac{\theta_1 - \theta_2}{ln\left(\frac{\theta_1}{\theta_2}\right)}$$

   What will be the value of LMTD if $\theta_1 = \theta_2$? **(JAN-2013)**
7) Sketch a shell and tube type heat exchanger. **(DEC-2011)**
8) Discuss the importance of heat exchangers for industrial use. **(DEC-2011)**
9) Explain the following in detail: (draw neat sketch if required) a)Film wise and drop wise condensation, b)Fouling factors and over all heat transfer coefficient **(DEC-2011)**
10) Water at the rate of 4 kg/sec is heated from 40·C to 55·C in a shell and tube type heat exchanger. The water is to flow inside tubes of 2 cm diameter with an average velocity of 35cm/sec.Hot water is available at 100·C and at the rate of 2kg/sec.which is used as the heating medium in shell side. If the length of the tube is of 2m calculate the number of tube passes, the number of tube per pass and the length of the tubes for one shell pass, assuming Uo=1500 W/m2K. **(DEC-2011)**
11) In a pipe in pipe heat exchanger, hot water flow at a rate of 5000 kg/hr and gets cooled from 95oC to 65oC. At the same time, 5000 kg/hr of cooling water at 30oC enters the heat exchanger. The overall heat transfer coefficient is 2270 W/m2K. Determine the heat transfer area required and the effectiveness of heat exchanger, assuming two streams are in parallel flow. Assume CP=4.2 KJ/kgK for both streams. **(MAY-2015)**
12) A heat exchanger is used to cool hot water from 80°C to 60°C by transferring heat to other stream of cold water which enters the heat exchanger at 20°C and leave at 40°C. Should this heat exchanger operate under parallel flow or counter flow conditions? Also determine the exit temperatures if the flow rates of the fluids are doubled. **(JAN-2013)**
13) A heat exchanger is to be designed to condense 8 kg/sec of an organic liquid (tsat=80·C,hfg=600 Kj/kg)with cooling water available at 15·C and at a flow rate of 60kg/sec.The overall heat transfer coefficient is 480 W/m2·C calculate: a) the number of tube required .The tubes are to be of 25 mm outer diameter ,2 mm thickness and 4.85 m length b)The number of tube passes. The velocity of the cooling water is not to exceed 2m/sec. **(DEC-2011)**
14) In a counter flow heat double pipe heat exchanger ,water is heated from 250C to 650C by oil with specific heat of 1.45 kJ/kg K and mass flow rate of 0.9 kf/s. The oil is cooled from 2300C to 1600C. If overall Heat transfer coefficient is 420 W/m2 0C. calculate following
    a) The rate of heat transfer
    b) The mass flow rate of water , and
    c) The surface area of heat exchanger **(DEC-2013)**

15) The flat floor of a hemispherical furnace is at 800 K and has emissivity of 0.5. The corresponding value for the hemispherical roof are 1200 K and 0.25. Determine the net heat transfer from roof to floor.Take _b =5.67x10-8. **(MAY-2012)**

16) Define condensation process also explain film condensation and drop-wise condensation. **(MAY-2012)**

17) A parallel flow heat exchanger has its tubes of 5 cm internal and 6 cm external diameter. The air flows inside the tubes and receives heat from hot gases circulated in the annular space of the tube at the rate of 100 kW. Inside and outside heat transfer coefficients are 250 W/m2K and 400 W/m2K respectively. Inlet temperature of hot gases is 500 oC, outlet temperature of hot gases is 300 oC, inlet temperature of air 50oC, Exit temperature of air 140 oC. Calculate : (1) Overall heat transfer coefficient based on outer surface area (2) Length of the tube required to affect the heat transfer rates. Neglect the thermal resistance of the tube. (3) If each tube is 3 m length find the number of tubes required. **(MAY-2012)**

18) A chemical having a specific heat of 3.3 kJ/kg K flowing at the rate 20,000 kg/h enters a parallel flow heat exchanger at 120^{o}C. The flow rate of cooling water is 50,000 kg/h with an inlet temperature of 20^{o}C. The heat transfer area is 10 m2 and overall heat transfer coefficient is 1200 W/m2 oC. Taking specific heat of water as 4.186 kJ/kgK. Find: (1) effectiveness of the heat exchanger (2) Outlet temperature of water and chemical. **(MAY-2012)**

19) A counter flow heat exchanger is employed to cool oil of specific heat Cp=2.45 KJ/Kg0C with mass flow rate of 0.55 Kg/sec from 115^{0}C to 40^{0}C by water. The inlet and outlet temperature of cooling water are 15^{0}C and 75^{0}C respectively. The overall heat transfer co-efficient is 1450W/m2.0C. Using NTU method, calculate: (i) The mass flow rate of water (ii) The effectiveness of heat exchanger (iii) The surface area required. **(MAY-2011)**

20) Water (Cp=4.2 kJ/kg oC) is heated at the rate of 1.4 kg/s from 40 oC to 70 oC by an oil (Cp=2 kJ/kg oC) entering at 110 oC and leaving at 60 oC in a counter flow heat exchanger. If U = 350 W/m2 oC, calculate the surface area required. Using the same entering fluid temperatures and the same oil flow rate, calculate the exit temperature of oil and water and the rate of heat transfer, when the mass flow rate of water is halved. **(MAY-2013)**

21) A steam condenser is transferring 250 KW of thermal energy at a condensing temperature of 65$_{0}$c. the cooling water enter the condenser at 20$_{0}$c with a flow rate of 7500 kg/hr. calculate the log mean temperature difference. If overall heat transfer co efficient for condenser surface is 1250 w/m_{2}-deg, what surface area is required to handle this load. **(DEC-2014)**