AE2024 HEAT TRANSFER
PART A
2 Marks
UNIT- I

1. What is the difference between diffusion and radiation heat transfer ?

Diffusion heat transfer is due to random molecular motion. Neighboring molecules move randomly and transfer energy between one another - however there is <u>no bulk motion</u>. Radiation heat transfer, on the other hand, is the transport of heat energy by electromagnetic waves. All bodies emit thermal radiation. In particular, notice that unlike diffusion, radiation heat transfer does not require a medium and is thus the only mode of heat transfer in space. The time scale for radiative heat transfer is much smaller than diffusive heat transfer.

2. How is natural convection different from forced convection ?

In <u>natural convection</u>, the movement of the fluid is due entirely to density gradients within the fluid (e.g. hot air rises over cold air). There is no external device or phenomenon which causes fluid motion. In <u>forced convection</u>, the fluid is forced to flow by an external factor - e.g. wind in the atmosphere, a fan blowing air, water being pumped through a pipe. Typically heat transfer under forced convection conditions is higher than natural convection for the same fluid.

3. Define a black surface

A black surface is defined by three criteria:

- it absorbs all radiation that is incident on it
- it emits the maximum energy possible for a given temperature and wavelength of radiation (according to Planck's law)
- the radiation emitted by a blackbody is not directional (it is a diffuse emitter)

A black surface is the perfect emitter and absorber of radiation. It is an idealized concept (no surface is exactly a black surface), and the characteristics of real surfaces are compared to that of an ideal black surface.

4. What is the range of values for the emissivity of a surface ?

The emissivity □ ranges between 0 and 1.

5. What are the conditions to be satisfied for the application of a thermal circuit ?

The problem must be a steady state, one-dimensional heat transfer problem.

6. Will the thermal resistance of a rectangular slab be increased or decreased if:
    a. the thermal conductivity is increased ?b.the cross sectional area is increased ?
    c.the thickness of the slab is increased ?
        a. resistance will decrease
        b. resistance will decrease
        c. resistance will increase

7. State the condition which must be satisfied to treat the temperature distribution in a fin as one-dimensional.

When ht/k <<1 where h is the convective heat transfer coefficient, t is the thickness of the fin and k is the thermal conductivity of the fin, one can consider that the temperature gradient in the thickness direction is very small and the analysis can be considered as one-dimensional.

8. Define and state the physical interpretation of the Biot number.
   The Biot number is given by:
   $Bi = hL/k$
   where
   h = convective heat transfer coefficient,
   k = thermal conductivity
   L = characteristic length.

It is a ratio of the temperature drop in the solid material and the temperature dropthe solid and the fluid. So when the $Bi << 1$, most of the temperature drop is in the fluid and the solid may be considered isothermal

9. What is a lumped system ?

A lumped system is one in which the dependence of temperature on position (spatial dependence) is disregarded. That is, temperature is modeled as a function of time <u>only</u> .

10. When can the unsteady temperature in a spatial body be considered uniform ?
    When the Biot number is small ($Bi << 0.1$).

UNIT -II

11. What is the Fourier number ?
    The Fourier number is defined as:
    $Fo = \square t/L^2$
    where
    □□□thermal diffusivity,
    t = time
    L = characterisitic length
    The Fourier number is a <u>dimensionless</u> measure of time used in transient conduction problems.

12. What is internal energy generation ? Give examples where internal energy generation occurs.

    Internal energy generation is the generation of heat within a body by a chemical, electrical or nuclear process. Examples are the heating of a nuclear fuel rod (due to fission within the rod), the heating of electrical wires (due to the conversion of electrical to heat energy), microwave heating and the generation of heat within the Earth. The heat generated in each case is being converted from some other form of energy.

13. What do you understand by stability criterion for the solution of transient problems ?

    When solving transient problems using finite-difference methods, it is possible that the solution undergoes numerically induced oscillations and becomes unstable i.e. the temperature values diverge. The stability criterion is a restriction on the values of □t and □x which ensures that the solution remains stable and converges. The criterion is usually expressed as a function of Fourier's number. For example, for an interior node in a two dimensional system the stability criterion is :

Fo< 1/4 or

□□t/(□x)^2< 1/4

14. Both the Nusselt number and the Biot number have the same form. What are the differences between them in terms of the variables employed and their physical significance ?

Both the Biot number and the Nusselt number are of the form (hL/k). However, for the Biot number, the thermal conductivity k used is that for the solid; for calculating Nusselt number the k value as that of the fluid. The Biot number is a measure of the ratio of the temnperature drop in the solid material and the temperature drop between the solid and the fluid. The Nusselt number is a dimensionless version of the temperature gradient at the surface between the fluid and the solid, and it thus provides a measure of the convection occurring from the surface.

15. What is the effect of the Prandtl number of a fluid on the relative thicknesses of velocity and temperature boundary layers when the fluid flow is parallel to a flat plate ?

For laminar flow, the ratio of the boundary layer thickness to that of the thermal boundary layer,

The higher the Prandtl number, the larger is the ratio.

16. Two fluids, with different properties, flow with equal free stream velocities parallel to a flat plate. What property of the fluid determines whether the velocity boundary layer of one is thicker than the other ?

The thickness of the boundary layer depends on the Reynolds number

17. What do you understand by the terms fully developed velocity and temperature profile regions in internal flow ?

In the fully developed region, the cross-sectional velocity/temperature profile is of a constant shape at any axial location. Thus the profile has ceased to change. Also there is no radial component of velocity i.e. every particle of fluid is flowing purely in the axial direction.

18. Do you expect the convective heat transfer coefficient in the thermally developing region to be higher or lower than the convective heat transfer coefficient in the fully developed temperature profile region ? Support your answer with qualitative logic.

We should expect that the convective heat transfer coefficient is higher in the thermally developing region. Near the tube entrance, the thickness of the boundary layer is very small, and the temperature gradients at the surface will be high, implying high rates of convective heat transfer. As the flow develops, the thickness of the boundary layer increases and the temperature gradients decreases, decreasing h. In the fully developed region, the temperature gradients are constant and h is also a constant.

19. Explain why the temperature boundary layer grows much more rapidly than the velocity boundary layer in liquid metals.

Liquid metals are characterised by very low Prandtl numbers since their thermal conductivity is high, hence the heat diffusion is much faster than momentum diffusion.

20. You are told that in a particulat case of fluid flow over a flat plate the temperature boundary layer thickness is much smaller than the velocity boundary layer thickness. What can you conclude about the nature of the fluid ?

You can conclude that the fluid is a high Prandtl number fluid e.g.oil.

UNIT-III

21. What is a gray surface ?

A gray surface is defined as one for which the emissivity and the absorptivity are independent of wavelength

22. What is a diffuse surface ?

A diffuse surface is defined as one for which the emissivity and the absorptivityare independent of direction

23. Define a view factor.

A view factor is defined in the context of two surfaces A and B. It is defined as the fraction of radiation leaving A which is incident directly on surface B. A view factor must be defined in terms of surface A to surface B (F_{AB}).

24. If a surface emits 200 W at a temperature of T, how much energy will it emit at a temperature of 2T ?

Since $E = T^4$, a 2-fold increase of temperature brings a (2^4) = 16-fold increase in energy. Thus the surface will emit (16)(200) = 3200 W.

25. You might have observed early morning frost on a clear day even when the minimum air temperature during the night was above 0□ C. On a clear day, the effective sky temperature can be as low as -45^0 C. explain how such frost formulation takes place.

The frost is created because of radiative losses to the sky

26. A greenhouse has an enclosure that has a high transmissivity at short wavelengths and a very low transmissivity (almost opaque) for high wavelengths.
Why does a greenhouse get warmer than the surrounding air during clear days ?
Will it have a similar effect during clear nights ?

Solar radiation is skewed towards shorter wavelengths. On a clear day the glass of the greenhouse admits a large proportion of the incident radiation. Inside the greenhouse, the various surfaces (plants etc.) reflect the radiation; but the reflected radiation is spectrally different, having more of a high wavelength contribution. Thus the reflected radiation is not transmitted well by the glass, and is reflected back into the greenhouse. The interior heats up due to this 'trapped' radiation. The same effect will not be seen on a clear night, since there is no solar radiation.

27. Define overall heat transfer coefficient.

The overall heat transfer coefficient is defined in terms of the total thermal resistance between two fluids. If there are a number of thermal resistances between the two fluids, the overall heat transfer coefficient is given by:

U = 1/□R

28. Your friend asserts that, in a heat exchanger, it is impossible for the exit temperature of the cold fluid to be greater than the exit temperature of the hot fluid when both fluids are single phase fluids. What is your response ?

The statement is true for a parallel flow heat exchanger. However, in a counterflow heat exchanger the outlet temperature of the cold fluid can in fact exceed the outlet temperature of the hot fluid.

30. State Kirchoff's law.

Kirchoff's law also states that the emissivity of a black body is equal to its absorptivity when the body remains in thermal equilibrium with its surrounding.

UNIT - IV

31. Wien's displacement law

A peak value of monochromatic emissive power occurs at a particular wavelength. This law gives a relationship between temperature of body and the wavelength at which the maximum value of monochromatic emissive power occurs.

A/c to Wien's law

$\lambda_{max} . T = \text{constant}$

$\lambda_{max} . T = 2898\ \mu mk$

It is used to predict very high temperature through measurement of wavelength.

32. Lambert's cosine law

This law states that total emissive power $E\theta$ from a diffuse radiating surface in any particular direction is directly proportional to the cosine of the angle between the direction under consideration and normal to the surface (θ) Let En be total emissive power of the surface in the direction normal to its surface then,

$$E\theta = En \cos\theta$$

33. Effectiveness NTU method or Discuss effectiveness of heat exchanger

When inlet and outlet temperatures of fluids flowing through the heat exchanger are known, the LMTD approach can be easily utilized to analyze the heat exchanger. But in cases where fluids inlet and outlet temperature are unknown, the method based on effectiveness of heat exchanger gives an easy way for analysis of heat exchanger. This method is also advantageous for comparing various heat exchangers for selecting a type best suited for a particular heat transfer objective. The heat exchanger effectiveness is defined as the ratio of heat transfer to the maximum possible heat transfer. It is denoted by ϵ.

Effectiveness = ϵ =Actual heat transfer/maximum possible heat transfer

34. What is mean by fouling of heat exchanger. Write down the equation of overall heat transfer coefficient considering fouling of heat exchanger

It may possible that fluids flowing through heat exchanger contains impurities and during flow of this fluid containing impurities through heat exchanger, the impurities get deposited on the surface of tubes. This phenomenon of formation and deposition of fluid impurities on the tube surfaces is called as fouling. Due to this deposition of scale on the surface of heat exchanger tubes, the thermal resistance increases which tend to reduce the efficiency of heat exchanger.

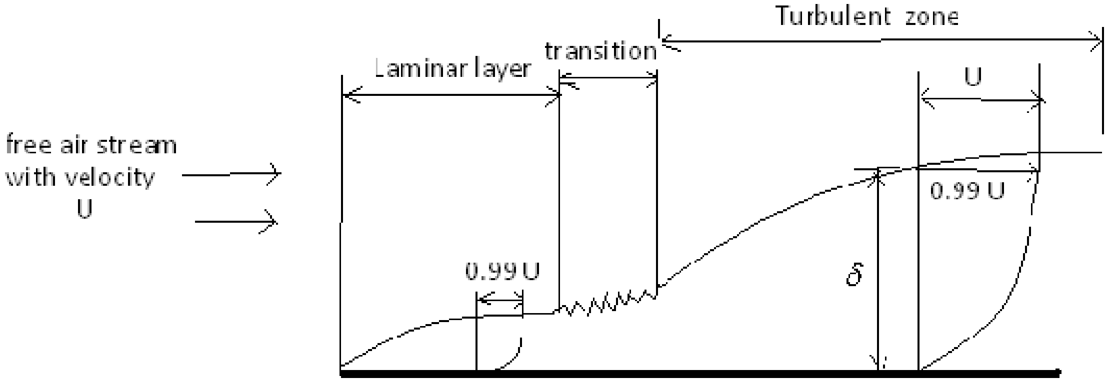
35. Displacement thickness :

It is the distance, measured perpendicular to the boundary by which the main free stream is displaced on account of formation of boundary layer. Or It is an additional wall thickness that would have to be added to compensate for the reduced flow rate an account of boundary layer formation

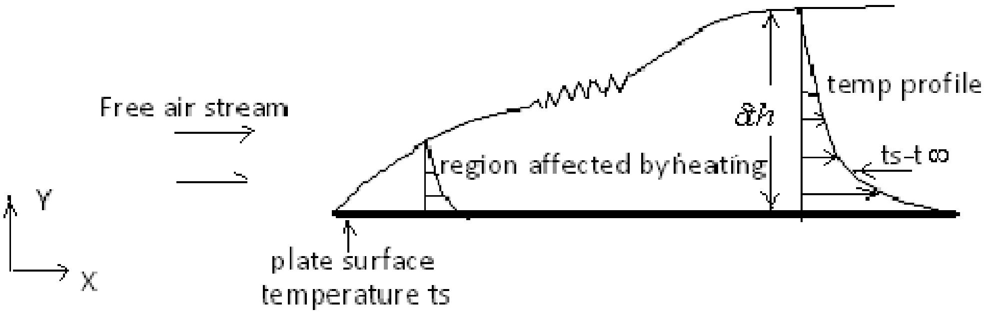
36. Momentum thickness:

It may also be defined as the distance, measured perpendicular to the boundary of the solid body, by the boundary should be displaced to compensate for reduction in ,momentum of the flowing fluid an account of boundary layer formation.

37. Sketch the Hydrodynamic boundary layer.



38. Sketch Thermal boundary layer



39.**Reynolds number:**

It is defined as the ratio of inertia force to viscous force. It is denoted by Re

40. **Nusselt number :**

It is defined as the ratio of heat flow rate by convection process under a unit temperature gradient to the heat flow rate by conduction process under a unit temperature gradient through a stationary thickness of L meters. It is the ratio of characteristic length to the thickness of a stationary fluid layer conducting the heat at the same rate as in the case of convection process under the same temp. difference.

$\Delta x = h/k$

The Nusselt number is a measure of the convective heat transfer coefficient. For a given value of the Nusselt no. the convective heat transfer coefficient is directly proportional to thermal conductivity of the fluid and inversely proportional to the length.

UNIT- V

41. Prandtl number (Pr)

It is the ratio of kinematic viscosity to the thermal diffusivity .Significance (1)Prandtl no. provides a measures of the relative effectiveness of the energy and momentum transport by diffusion.

(2) Prandtl no. is a link between the temperature field and velocity field, and its value affects relative growth of velocity boundary layer and thermal boundary layers.

42. Grashoff number (Gr)

It is defined as the ratio of the product of inertia force and buoyancy force to the square of viscous force .It is related with natural convection heat transfer.

43. Heisler Charts (for unsteady state problem)

The temperature distribution charts can be constructed by plotting dimensionless temp. against one of parameter keeping the other two parameter constant (parameter like ,fi,bi,& x/l or r/R), such charts are onstructed by Heisler & Grober. Heisler charts are commonly used in practice for plates ,cylinder and spheres.

44. What is mean by fin

Fins are nothing but extended surfaces that are used for Increasing the rate of heat transfer from a surface by increasing the heat transfer surface area.

45. Fin efficiency

The fin efficiency is defined as the ratio of actual heat transfer rate from the fin to the ideal heat transfer rate from the fin if the entire fin were at base temperature, and its value is between 0 and 1.

46. Fin effectiveness

Fin effectiveness is defined as the ratio of heat transfer rate from a finned surface to the heat transfer rate from the same surface if there were no fins, and its value is expected to be greater than 1.

47. Give the Heat flow eq in steady state condition

$$\frac{\partial^2 t}{\partial x^2} + \frac{\partial^2 t}{\partial y^2} + \frac{\partial^2 t}{\partial z^2} + \frac{qg}{k} = 0$$

$$\nabla^2 t + \frac{qg}{k} = o - poisson'\ eqn$$

48. Give the Heat flow eq in steady state condition in the Absence of internal heat generation

$$\frac{\partial^2 t}{\partial x^2}+\frac{\partial^2 t}{\partial y^2}+\frac{\partial^2 t}{\partial z^2}=0$$

$$\nabla^2 t=0$$

49. Give the Unsteady heat flow with no internal heat generation

$$\frac{\partial^2 t}{\partial x^2}+\frac{\partial^2 t}{\partial y^2}+\frac{\partial^2 t}{\partial z^2}=\frac{1}{\ell}\frac{\partial t}{\partial \tau}$$

$$\nabla^2 t=\frac{1}{\propto}\frac{\partial t}{\partial \tau}$$

50. What is meant by Thermal Contact Resistance?

The resistance that an interface offers to heat transfer per unit interface area is called thermal contact resistance, Rc . The inverse of thermal contact resistance is called the thermal contact conductance. The thermal contact resistance will be greater for rough surfaces because an interface with rough surfaces will contain more air gaps whose thermal conductivity is low.

PART – B
UNIT – I CONDUCTION

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01. A pipe consists of 100 mm internal diameter and 8 mm thickness carries steam at 170°C. The convective heat transfer coefficient on the inner surface of pipe is 75 W/m2C. The pipe is insulated by two layers of insulation. The first layer of insulation is 46 mm in thickness having thermal conductivity of 0.14 W/m°C. The second layer of insulation is also 46 mm in thickness having thermal conductivity of 0.46 W/mC. Ambient air temperature = 33°C. The convective heat transfer coefficient from the outer surface of pipe = 12 W/m2C. Thermal conductivity of steam pipe = 46 W/m°C. Calculate the heat loss per unit length of pipe and determine the interface temperatures. Suggest the materials used for insulation.

02. A long rod is exposed to air at 298°C. It is heated at one end. At steady state conditions, the temperature at two points along the rod separated by 120 mm are found to be 130°C and 110°C respectively. The diameter of the rod is25mmOD and its thermal conductivity is 116 W/m°C. Calculate the heat transfer coefficient at the surface of the rod and also the heat transfer rate.

03. (i) A furnace wall consists of three layers. The inner layer of 10 cm thickness is made of firebrick (k =1.04 W/mK). The intermediate layer of 25 cm thickness is made of masonry brick (k = 0.69 W/mK) followed by a 5 cm thick concrete wall (k = 1.37 W/mK). When the furnace is in continuous operation the inner surface of the furnace is at 800°C while the outer concrete surface is at 50°C. Calculate the rate of heat loss per unit area of the wall, the temperature at the interface of the firebrick and masonry brick and the temperature at the interface of the masonry brick and concrete.

(ii) An electrical wire of 10 m length and 1 mm diameter dissipates 200 W in air at 25°C. The convection heat transfer coefficient between the wire surface and air is 15 W/m2K. Calculate the critical radius of insulation and also determine the temperature of the wire if it is insulated to the critical thickness of insulation.

04. (i) An aluminium rod (k =204 W/mK) 2 cm in diameter and 20 cm long protrudes from a wall which is maintained at 300°C. The end of the rod is insulated and the surface of the rod is exposed to air at 30°C. The heat transfer coefficient between the rod's surface and air is 10 Vl/m2K. Calculate the heat lost by the rod and the temperature of the rod at a distance of 10 cm from the wall.

(ii) A large iron plate of 10 cm thickness and originally at 800°C is suddenly exposed to an environment at O°C where the convection coefficient is 50 W/m2K. Calculate the temperature at a depth of 4 em from one of the faces 100 seconds after the plate is exposed to the environment. How much energy has been lost per unit area of the plate during this time? (9)

05. (i)) Explain the different modes of heat transfer with appropriate expressions. (6)

(ii) A composite wall consists. of 10 cm thick layer of building brick, k = 0.7 W/mK and 3 cm thick plaster, k = 0.5 W/mK. An insulating material of k = 0.08 W/mK is to be added to reduce the heat transfer through the wall by 40%. Find its thickness.

06. Circumferential aluminium fins of rectangular profile (1.5cmwide and 1mm thick) are fitted on to a 90 mm engine cylinder with a pitch of 10 mm. The height of the cylinder is 120 mm. The cylinder base temperature before and after fitting the fins are 200°C and 150°C respectively. Take ambient at 30°C and h(average) =100 W/m2K. Estimate the heat dissipated from the finned and the unfinned surface areas of cylinder body.

07. (i) Derive the heat conduction equation in cylindrical co-ordinates using an elemental volume for a stationary isotropic solid.

(8) (ii) A 3 cm OD steam pipe is to be covered with two layers of insulation each having a thickness of 2.5 cm. The average thermal conductivity of one insulation is 5 times that of the other. Determine the percentage decrease in heat transfer if better insulating material is next to pipe than it is the outer layer. Assume that the outside and inside temperatures of composite insulation are fixed.

08. (i) Explain briefly the concept of critical thickness of insulation and state any two applications of the same. (ii) A 6 em long copper rod (k = 300 W/mK) 6mm in diameter is exposed to an environment at 20°C. The base temperature of the rod is maintained at 160°C. The heat transfer co-efficient is 20 W/m2K. Calculate the heat given by the rod and efficiency and effectiveness of the rod.

09. (i) Define the Biot and Fourier numbers.

(ii) What is meant lumped capacity? What are the physical assumptions necessary for a lumped capacity unsteady state analysis to apply? (4) (iii)A slab of Aluminum 5 cm thick initially at 200°C is suddenly immersed in a liquid at 70°C for which the convection heat transfer co-efficient is 525 W/m2K. Determine the temperature at a depth of 12.5 mm from one of the faces 1 minute after the immersion.

Also calculate the energy removed per unit area from the plate during 1 minute of immersion. Take P = 2700 bar, Cp = 0.9 kJlkg. OK, k=215W/mK, ά = 8.4X 10-5 m2/s.

10. A composite wall is formed of a 2.5 cm copper plate (k = 355 W/m.K), a 3.2 mm layer of asbestos (k = 0.110 W/m.K) and a 5 cm layer of fiber plate (k = 0.049 W/m.K). The wall is subjected to an overall temperature difference of 560°C (560°C on the Cu plate side and O°C on the fiber plate side). Estimate the heat flux through this composite ~all and the interface temperature between asbestos and fiber plate.

11. A steel tube k=43.26 W/mKof 5.08 cm 10 and 7.62 cm 00 is covered with 2.54 cm of asbestos Insulation k=0.208 W/mKThe inside surface of the tube receives heat by convection from a hot gas at a -temperature of 316°C with heat transfer coefficient ha=284 W/m2K while the outer surface of Insulation is exposed to atmosphere air at 38°C with heat transfer coefficient of 17 W/m2K Calculate heat loss to atmosphere for 3 m length of the tube and temperature drop across each layer.

12. (i) A plane wall 20 cm thickness generates heat at the rate of 5 x 104 W/m3 when an electric current is passed through it. The convective heat transfer coefficient between each face of the wall and the ambient air is 60 W/m2K. Determine.

- The surface temperature
- The maximum temperature in the wall. Assume ambient air temperature to be 25°C and the thermal conductivity of the wall material to be 16 W/mK.

(ii) A steel ball 100 mm diameter was initially at 50~C and is placed in air which is at35°C. Calculate time required to attain 400°C and 300°C. (8) k steel = 35 W/mKc = 0.46 kJIkgK p = 7800 kglm3 h = 10 W/m2K

UNIT – II
CONVECTION

01. Air at 200 kPa and 200°C is heated as it flows through a tube with a diameter of 25 mm at a velocity of 10 m./sec. The wall temperature is maintained constant and is 20°C above the air temperature all along the length of tube. Calculate:

(i) The rate of heat transfer per unit length of the tube.

(ii) Increase in the bulk temperature of air over a 3 m length of the tube.

02. (i) Write down the momentum equation for a steady, two dimensional flow of an incompressible, constant property newtonian fluid in the rectangular coordinate system and mention the physical significance of each term.
(ii) A large vertical plate 5 m high is maintained at 100°C and exposed to air at 30°C Calculate the convection heat transfer coefficient.
03. Sketch the boundary layer development of a flow over a flat plate and explain the significance of the boundary layer. (ii) Atmospheric air at 275 K and a free stream velocity of 20 m/s flows over a flat plate 1.5 m long that is maintained at a uniform temperature of 325 K. Calculate the average heat transfer coefficient over the region where the boundary layer is laminar, the average heat transfer coefficient over the entire length of the plate and the total heat transfer rate from the plate to the air over the length 1.5 m and width 1 m. Assume transition occurs at Ree = 2xl05
04.(i) What is Reynold's analogy? Describe the relation between fluid friction and heat transfer? (4) (ii) Air at 25°C flows over 1 m x 3 m (3 m long) horizontal plate maintained at 200°C at 10 mls. Calculate the average heat transfer coefficients for both laminar and turbulent regions. Take Re (critical) = 3.5 x 105
05. (i) Define Reynold's, Nusselt and Prandtl numbers. (ii) A steam pipe 10 cm outside diameter runs horizontally in a room at 23°C. Take the outside surface temperature of pipe as 165°C. Determine the heat loss per unit length of the pipe.
06. (i) Explain for fluid flow along a flat plate:
(1) Velocity distribution in hydrodynamic boundary layer
(2) Temperature distribution in thermal boundary layer
(3) Variation of local heat transfer co-efficient along the flow.
(ii) The water is heated in a tank by dipping a plate of 20 cm X 40 cm in size. The temperature of the plate surface is maintained at 100°C. Assuming the temperature of the surrounding water is at 30° C, Find the heat loss from the plate 20 cm side is in vertical plane.
07. Air at 400 K and 1 atm pressure flows at a speed of 1.5 m/s over a flat plate of 2 m long. The plate is maintained at a uniform temperature of 300 K. If the plate has a width of 0.5 m, estimate the heat transfer coefficient and the rate of heat transfer from the air stream to the plate. Also estimate the drag force acting on the plate.
08. Cylindrical cans of 150 mm length and 65 mm diameter are to be cooled from an initial temperature of 20°C by placing them in a cooler containing air at a temperature of 1°C and a pressure of 1 bar. Determine the cooling rates when the cans are kept in horizontal and vertical positions.
09. A circular disc heater 0.2m in diameter is exposed to ambient air at 25°C. One surface of the disc is insulated at 130°C. Calculate the amount of heat transferred from the disc when it is.
10. (i) Distinguish between free and forced convection giving examples.
(ii) A steam pipe 10 cm OD runs horizontally in a room at 23° C. Take outside temperature of pipe as 165 ° C. Determine the heat loss per unit length of the pipe. Pipe surface temperature reduces to 80° C with 1.5 cm insulation. What is the reduction in heat loss?

UNIT – III RADIATION

01. Liquid Helium at 4.2 K is stored in a dewar flask of inner diameter = 0.48 m and outer diameter = 0.5 m. The dewar flask can be treated as a spherical vessel. The outer surface of the

inner vessel and the inner surface of the outer vessel are well polished and the emissivity of these surfaces is 0.05. The space between the two vessels is thoroughly evacuated. The inner surface of the dewar flask is at 4.2 K while the outer surface is at 300 K. Estimate the rate of heat transfer between the surfaces.

02. A thin aluminium sheet with an emissivity of 0.1 on both sides is placed between two very large parallel plates that are maintained at uniform temperatures Tl = 800 K and T2 = 500 K and have emissivities £"1 = 0.2 and £"2 = 0.7 respectively. Determine the net rate of radiation heat transfer between the two plates per unit surface area of the plates and compare the result to that without shield.

03.(i) Discuss how the radiation from gases differ from that of solids.

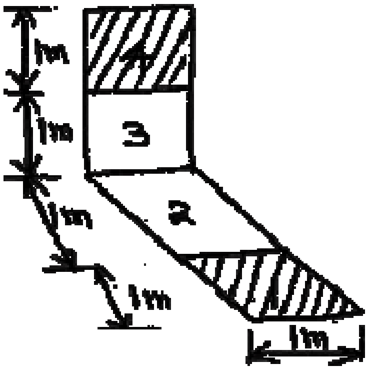
(ii) Two very large parallel plates with emissivities 0.5 exchange heat. Determine the percentage reduction in the heat transfer rate if a polished aluminium radiation shield of c = 0.04 is placed in between the plates.

04. (i) Define emissivity, absorptivity and reflectivity

(ii) Describe the phenomenon of radiation from real surfaces.

05. (i) What are the radiation view factors and why they are used?

(ii) determine the view factor (F1-4) for the figure shown below.



06. (i) State and prove the following laws: (1) Kirchoffs law of radiation

(2) Stefan - Boltzmann law

(ii} Show-from energy-balance consideration that the radiation heat transfer from a plane composite surface area A4 and made up of plane surface areas A2 and A3 to a plane surface area Al is given by: A4F41=A3F31+A2F21 & F14=F12+F13

07. (i) Using the definition of radiosity and irradiation prove that the radiation heat exchange between two grey bodies is given by the relation:

$$Q_{net} = \frac{\sigma (T^4 - T_2^4)}{\frac{1-\varepsilon_1}{-- A_1\varepsilon_1} + \frac{1}{A_1 F_{12}} + \frac{1-\varepsilon_2}{A_2 \varepsilon_2}}$$

(ii) A surface at lOOK with emissivity of 0.10 is protected from a radiation flux of 1250 W/m2 by a shield with emissivity of 0.05. Determine the percentage cut off and the shield temperature. Assume shape factor as 1.

08. Explain briefly the following: (i) Specular and diffuse reflection

(ii) reflectivity and transmissivity

(iii) reciprocity rule and summation rule

09. (i) Two parallel, infinite grey surface are maintained at temperature of 127C and 227C respectively. If the temperature of the hot surface is increased to 327°C, by what factor is the net radiation exchange per unit area increased? Assume the emissivities of cold and hot surface to be 0.9 and 0.7 respectively.
(ii) Two equal and parallel discs of diameter 25 cm are separated by a distance of 50 cm. If the discs are maintained at 600°C and 250°C. Calculate the radiation heat exchange between them.
10. Two large parallel planes with emissivities 0.35 and 0.85 exchange heat by radiation. The planes are respectively 1073K and 773K . A radiation shield having the emissivity of 0.04 is placed between them. Find the percentage reduction in radiation heat exchange and temperature of the shield.

UNIT – IV
HEAT EXCHANGERS

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01. A tube of 2 m length and 25 mm outer diameter is to be used to condense saturated steam at 100°C while the tube surface is maintained at 92°C. Estimate the average heat transfer coefficient and the rate of condensation of steam if the tube is kept horizontal. The steam condenses on the outside of the tube.
02. Steam condenses at atmospheric pressure on the external surface of the tubes of a steam condenser. The tubes are 12 in number and each is 30 mm in diameter and 10 m long. The inlet and outlet temperatures of cooling water flowing inside the tubes are 25°C and 60°C respectively. If the flow rate is 1.1 kg/s, calculate
(i) The rate of condensation of steam
(ii) The number of transfer units
(iii) The effectiveness of the condenser.
03. (i) It is desired to boil water at atmospheric pressure on a copper surface which electrically heated. Estimate the heat flux from the surface to the water, if the surface is maintained at no°c and also the peak heat flux.
(ii) A tube of 2 m length and 25 mm OD is to be used to condense saturated steam at 100°C while the tube surface is maintained at 92°C. Estimate the average heat transfer coefficient and the rate of condensation of steam if the tube is kept horizontal. The steam condenses on the outside ofthe tube.
04. (i) Give the classification of heat exchangers.
(ii) It is desired to use a double pipe counter flow heat exchanger to cool 3 kg/s of oil (Cp = 2.1 kJ/kgK) from 120°C. Cooling water at 20°C enters the heat exchanger at a rate of 10 kg/so The overall heat transfer coefficient of the heat exchanger is 600 W/m2Kand the heat transfer area is 6 m2• Calculate the exit temperatures of oil and water.
05. (i) Discuss the general arrangement of parallel flow, counter flow and cross flow heat exchangers.
(ii) In a Double pipe counter flow heat exchanger 10000 kg/h of an oil having a specific heat of 2095 J/kgK is cooled from 80°C to 50°C by 8000 kg/h of water entering at 25°C. Determine the

heat exchanger area for an overall heat transfer coefficient of 300 W/m2K. Take Cp for water as 4180 J/kgK

06. (i) Discuss the various regimes of pool boiling heat transfer. (ii) Dry saturated steam at a pressure of 2.45 bar condenses on the surface of a vertical tube of height 1 m. The tube surface temperature is kept at 117°C. Estimate the thickness of the condensate film and the local heat transfer coefficient at a distance of 0.2m from the upper end of the tube.

07. (i) With a neat and labeled sketch explain the various regimes in boiling heat transfer.

(ii) A vertical plate 0.5 m2 in area at temperature of 92°C is exposed to steam at atmospheric pressure. If the steam is dry and saturated estimate the heat transfer rate and condensate mass per hour. The vertical length of the plate is 0.5 m. Properties of water at film temperatures of 96°C can be obtained from tables.

08. (i) Compare LMTD and NTU method of heat exchanger analysis.

(ii) Hot exhaust gases which enters a finned tube cross flow heat exchanger at 300°C and leave at 100°c, are used to heat pressurized water at a flow rate of 1 kg/s from 35 to 125°C. The exhaust gas specific heat is approximately 1000 J/kg.K, and the overall heat transfer co-efficient based on the gas side surface area is Uh = 100W/m2K. Determine the required gas side surface area Ah using the NTU method.

Take Cp,c at Tc = 80°C is 4197 J/kg.K and Cp,h = 1000 J/kg.K .

09. Water is to be boiled at atmospheric pressure in a mechanically polished stainless steel pan placed on top of a heating unit. The inner surface of the bottom of the pan is maintained at lO8°C. The diameter of the bottom of the pan is 30 cm. Assuming Csf = 0.0130. calculate (i) the rate of heat transfer to the water and ii) the rate of evaporation of water.

10. Define effectiveness of a heat exchanger. Derive an expression for the effectiveness of a double pipe parallel flow heat exchanger. State the assumptions made.

11. Water enters a cross flow Heat exchanger (both fluids unmixed) at 5°C and flows at the rate of 4600 kg/h to cool 4000 kg/h of air that is initially at 40°C. Assume the over all heat transfer coefficient value to be 150 W/m2K For an exchanger surface area of 25m2, Calculate the exit temperature of air and water.

12. (i) Describe the principle of parallel flow and counter flow heat exchangers showing the axial temperature distribution.

(ii) A parallel flow heat exchanger has hot and cold water stream running through it, the flow rates are 10 and 25 kg/min respectively. Inlet temperatures are 75° C and 25° C on hot and cold sides. The exit temperature on the hot side should not exceed 50° C. Assume hi = ho= 600W/m K. Calculate the area of heat exchanger using E -NTU approach.

UNIT – V

1. Describe about cooling process in combustion chamber.
2. What are the factors that affect the combustion chamber? & explain them.
3. Write short notes on Aerodynamic heating
4. Explain about application of heat transfer in aerospace engineering.
5. Write short notes on Ablation & ablative materials
6. Write short notes on High speed flow heat transfer