BACHELOR OF TECHNOLOGY (C.B.C.S.) (2014 COURSE)
B.Tech.Sem - V MECHANICAL : : SUMMER - 2022
SUBJECT : HEAT & MASS TRANSFER

Day : Thursday
Date : 2/6/2022

S-13448-2022

Time : 10:00 AM-01:00 PM
Max. Marks : 60

N.B.:

1) All questions are **COMPULSORY**.
2) Figures to the right indicate **FULL** marks.
3) Use of non-programmable **CALCULATOR** is allowed.
4) Assume suitable data if necessary.

Q.1 a) Derive an expression for three dimensional heat conduction equation in Cartesian coordinate for an isotropic material for steady state condition. **(05)**

b) Consider a person standing in a room maintained at 22°C at all times. The inner surface of the walls, floors and the ceiling of the house are observed to be at an average temperature of 10°C in winter and 25°C in summer. Determine the rate of radiation heat transfer between this person and the surrounding surfaces if the exposed surface area and the average outer surface temperature of the person are $1.4 m^2$ and 30°C, respectively. Take emissivity of a person $\varepsilon = 0.95$. **(05)**

OR

Q.1 a) What do you understand by thermal diffusivity? Give its physical significance. **(04)**

b) A furnace wall is of three layers, first layer of insulation brick of 12 cm thickness of conductivity 0.6 W/mK. The face is exposed to gases at 870°C with a convection coefficient of 110 W/m^2K. This layer is backed by a 10 cm layer of firebrick of conductivity 0.8 W/mK. There is a contact resistance between the layers of 2.6×10^{-4} $m^2\,°C/W$ the third layer is the plate backing of 10 mm thickness of conductivity 49 W/mK. The contact resistance between the second and third layers is 1.5×10^{-4} $m^2\,°C/W$. The plate is exposed to air at 30°C with a convection coefficient of 15 W/m^2K. Determine the heat flow, the surface temperatures and the overall heat transfer coefficient. **(06)**

Q.2 a) A fuse wire of diameter 2 mm with resistivity of 5 micro ohm cm is to be used in a circuit. The convection coefficient to surroundings at 30°C is 6 W/m^2K. If the wire melts at 800°C, determine the rating. Thermal conductivity = 357 W/mK. **(05)**

b) A copper pipe carrying refrigerant at -20°C is 10 mm in OD and is exposed to convection at 50 W/m^2K to air at 25°C. It is proposed to apply insulation of conductivity 0.5 W/mK. Determine the thickness beyond which the heat gain will be reduced. Calculate the heat gains for 2.5 mm, 5.0 mm and 7.5 mm thickness for 1 m length. The convection coefficient remains constant. **(05)**

OR

Q.2 a) What do you understand by Critical Radius of Insulation? Give its physical significance. **(04)**

b) Heat is generated in a slab of 120 mm thickness with a conductivity of 200 W/mK at a rate of 106 W/m^3. Determine the temperature at the mid and quarter planes if the surface of the solid on both sides are exposed to convection at 30o°C with a convection coefficient of 500 W/m^2K. Also find the heat flow rate at these planes and the temperature gradients at these planes. **(06)**

Q.3 a) What do you understand by fin efficiency and fin effectiveness? **(04)**

b) A long rod of 12 mm square section made of low carbon steel protrudes into air at 35°C from a furnace wall at 200°C. The convective heat transfer coefficient is estimated at 22 W/m^{2}K.The conductivity of the material is 51.9 W/mK. Determine the location from the wall at which the temperature will be 60°C. Also calculate the temperature at 80 mm from base. **(06)**

OR

Q.3 a) What is lumped heat capacity analysis? **(04)**

b) One end of long rod 1cm diameter having a thermal conductivity of 45 W/mK is placed in a furnace. The rod is exposed to air at 30°C over its surface and the convection coefficient is estimated at 35 W/m^{2}K. If the temperature is read as 264°C at a distance of 39 mm from the furnace end, determine the base temperature of the rod. **(06)**

Q.4 a) What is Prandtl number? Give its physical significance. **(04)**

b) Air at -10°C flows over a flat surface at 10°C with a free stream velocity of 80 m/s. The length of the plate is 3.1 m. Determine the location at which the flow turns turbulent. Also determine the local and average value of convection coefficient assuming that the flow is turbulent although. The properties of air for film temperature of 0°C are: **(06)**

$\nu = 13.28\times10^{-6} m^2/s,\ Pr = 0.707,\ k = 0.02442 W/mK.$

OR

Q.4 a) Using the method of dimensional analysis obtain the dimensionless numbers in the case of natural convection. **(05)**

b) Air 30°C flows across a steam pipe of 0.2 m dia. At a surface temperature of 130°C, with a velocity of 6 m/s. the properties of air at 80°C are: **(05)**

$\nu = 21.09\times10^{-6} m^2/s,\ Pr = 0.692,\ k = 0.03047 W/mK,$

$\mu = 21.08\times10^{-6} kg/ms.$

Determine the value of convective heat transfer coefficient using following equation:

$$Nu = 0.0266(Re)^{0.805}(Pr)^{0.333}.$$

Q.5 a) What is different between film and drop wise condensation? **(05)**

b) State and prove Kirchhoff's law for heat transfer by radiation. **(05)**

OR

Q.5 a) What are the different flow regimes in case of internal flow boiling? **(04)**

b) A filament is in the shape of a cylinder of 1 mm dia. And 25 mm length and is in an evacuated space enclosed by transparent medium. The filament is initially maintained at 2900K by power supply. Determine the time needed for the filament to cool to 1300K after power supply is cut. Density = 19350 kg/m^3, specific heat = 134 J/kg K. Emissivity of the filament = 0.45. **(06)**

Q.6 a) What is Flick's Law of diffusion? Give its physical significance. **(04)**

b) The inlet and outlet temperature of hot and cold fluids in a double pipe heat exchanger are 220°C, 100°C and 80°C and 120°C respectively. Determine whether the heat exchanger is parallel flow or counter flow. Also determine the LMTD and effectiveness of the exchanger. **(06)**

OR

Q.6 a) What are the different modes of mass transfer? **(05)**

b) Derive the expression for the effectiveness of a parallel flow heat exchanger. **(05)**

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