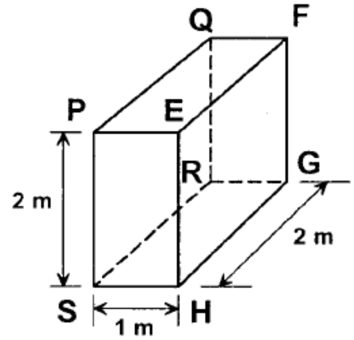
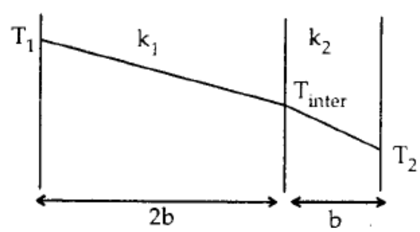
Q.1. For the three-dimensional object shown in thefigure below, five faces are insulated. Thesixth face (PQRS), which is not insulated,interacts thermally with the ambient, with aconvective heat transfer coefficient of 10 W/m2.K. The ambient temperature is 30°C. Heatis uniformly generated inside the object at the rate of 100 W/m3. Assuming the face PQRS tobe at uniform temperature, its steady statetemperature is:



(a) 10°C (b) 20°C

(c) 30°C (d) 40°C

Q.2. In a composite slab, the temperatureat the interface (Tinter) between twomaterials is equal to the average ofthe temperatures at the two ends.Assuming steady one-dimensionalheat conduction, which of thefollowing statements is true aboutthe respective thermalconductivities?



(a) 2k1 = k2 (b) k1 = k2 (c) 2k1 = 3k2 (d) k1 = 2k2

Q.3.A stainless steel tube (ks = 19 W/mK) of 2 cm ID and 5 cm OD isinsulated with 3 cm thick asbestos (ka = 0.2 W/mK). If the temperaturedifference between the innermost and outermost surfaces is 600°C, theheat transfer rate per unit length is:

(a) 0.94 W/m (b) 9.44 W/m (c) 944.72 W/m (d) 9447.21 W/m

Q.4.steel steam pipe 10 cm inner diameter and 11 cm outer diameter iscovered with insulation having the thermal conductivity of 1 W/mK. Ifthe convective heat transfer coefficient between the surface ofinsulation and the surrounding air is 8 W / m2K, then critical radius of insulation is:

(a) 10 cm (b) 11 cm (c) 12.5 cm (d) 15 cm

Q.5.A fin has 5mm diameter and 100 mm length. The thermal conductivityof fin material is 400 Wm−1K−1. One end of the fin is maintained at 130ºCand its remaining surface is exposed to ambient air at 30ºC. If theconvective heat transfer coefficient is 40 Wm-2K-1, the heat loss (in W) from the fin is:

(a) 0.08 (b) 5.0 (c) 7.0 (d) 7.8

Q.6. The temperature distribution in a stainless fin (thermal conductivity0.17 W/cm°C) of constantcross -sectional area of 2 cm2 and length of 1 cm, exposed to ambient of 40°C (with a surface heat transfer coefficientof 0.0025 W/cm20C) is given by (T – T∞) = 3x2 – 5x + 6, where T is in °C andx is in cm. If the base temperature is 100°C, then the heat dissipated bythe fin surface will be:

(a) 6.8 W (b) 3.4 W (c) 1.7 W (d) 0.17 W

Q.7.A small copper ball of 5 mm diameter at 500 K is dropped into an oilbath whose temperature is 300 K. The thermal conductivity of copper is400 W/mK, its density 9000 kg/m3 and its specific heat 385 J/kg.K.1f theheat transfer coefficient is 250 W/m2K and lumped analysis is assumedto be valid, the rate of fall of the temperature of the ball at thebeginning of cooling will be, in K/s.

(a) 8.7 (b) 13.9 (c) 17.3 (d) 27.7

Q.8. A spherical thermocouple junction of diameter 0.706 mm is to be usedfor the measurement of temperature of a gas stream. The convectiveheat transfer co-efficient on the bead surface is 400 W/m2K.Thermophysical properties of thermocouple material are k = 20 W/mK,C =400 J/kg, K and ρ = 8500 kg/m3. If the thermocouple initially at 30°Cis placed in a hot stream of 300°C, then time taken by the bead to reach298°C, is:

(a) 2.35 s (b) 4.9 s (c) 14.7 s (d) 29.4 s:

Q.9.A coolant fluid at 30°C flows over a heated flat plate maintained at aconstant temperature of 100°C. The boundary layer temperaturedistribution at a given location on the plate may be approximated asT = 30 + 70exp(−y) where y (in m) is the distance normal to the plate andT is in °C. If thermal conductivity of the fluid is 1.0 W/mK, the localconvective heat transfer coefficient (in W/m2K) at that location will be:

(a) 0.2 (b) 1 (c) 5 (d) 10

Q.10. The properties of mercury at 300 K are: density = 13529 kg/m3, specificheat at constant pressure = 0.1393 kJ/kg-K, dynamic viscosity = 0.1523 ×10-2 N.s/m2 and thermal conductivity = 8.540 W/mK. The Prandtl numberof the mercury at 300 K is

(a) 0.0248 (b) 2.48 (c) 24.8 (d) 248

Q.11. The average heat transfer coefficient on a thin hot vertical platesuspended in still air can be determined from observations of thechange in plate temperature with time as it cools. Assume the platetemperature to be uniform at any instant of time and radiation heatexchange with the surroundings negligible. The ambient temperatureis 25°C, the plate has a total surface area of 0.1 m2 and a mass of 4 kg.The specific heat of the plate material is 2.5 kJ/kgK. The convectiveheat transfer coefficient in W/m2K, at the instant when the platetemperature is 225°C and the change in plate temperature with timedT/dt = – 0.02 K/s, is:

(a) 200 (b) 20 (c) 15 (d) 10

Q.12. If velocity of water inside a smooth tube is doubled, then turbulentflow heat transfer coefficient between the water and the tube will:

(a) Remain unchanged

(b) Increase to double its value

(c) Increase but will not reach double its value

(d) Increase to more than double its value

Q.13.A sphere, a cube and a thin circular plate, all made of same materialand having same mass are initially heated to a temperature of 250°Cand then left in air at room temperature for cooling. Then, which one ofthe following is correct?

(a) All will be cooled at the same rate

(b) Circular plate will be cooled at lowest rate

(c) Sphere will be cooled faster

(d) Cube will be cooled faster than sphere but slower than circular plate

Q.14. Assertion (A): A slab of finite thickness heated on one side and held horizontal will lose more heat per unit time to the cooler air if the hotsurface faces upwards when compared with the case where the hot surface faces downwards.

Reason (R): When the hot surface faces upwards, convection takesplace easily whereas when the hot surface faces downwards, heattransfer is mainly by conduction through air.

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is not the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

Q.15. For the fully developed laminar flow and heat transfer in a uniformlyheated long circular tube, if the flow velocity is doubled and the tubediameter is halved, the heat transfer coefficient will be:

(a) Double of the original value

(b) Half of the original value

(c) Same as before

(d) Four times of the original value

Q.16. Assertion (A): According to Reynolds analogy for Prandtl number equalto unity, Stanton number is equal to one half of the friction factor.

Reason (R): If thermal diffusivity is equal to kinematic viscosity, thevelocity and the temperature distribution in the flow will be the same.

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is not the correct explanation of A

(c) A is true but R is false [IES-2001]

(d) A is false but R is true

Q.17. In a counter flow heat exchanger, for the hot fluid the heat capacity = 2kJ/kg K, mass flow rate = 5 kg/s, inlet temperature = 150°C, outlettemperature = 100°C. For the cold fluid, heat capacity = 4 kJ/kg K, massflow rate = 10 kg/s, inlet temperature = 20°C. Neglecting heat transfer tothe surroundings, the outlet temperature of the cold fluid in °C is:

(a) 7.5 (b) 32.5 (c) 45.5 (d) 70.0

Q.18. In a condenser, water enters at 30°C and flows at the rate 1500 kg/hr.The condensing steam is at a temperature of 120°C and cooling waterleaves the condenser at 80°C. Specific heat of water is 4.187 kJ/kg K. Ifthe overall heat transfer coefficient is 2000 W/m2K, then heat transferarea is:

(a) 0.707 m^2 (b) 7.07 m^2 (c) 70.7 m^2 (d) 141.4 m^2

Q.19. The logarithmic mean temperature difference (LMTD) of a counterflowheat exchanger is 20°C. The cold fluid enters at 20°C and the hot fluidenters at 100°C. Mass fl0w rate of the cold fluid is twice that of the hotfluid. Specific heat at constant pressure of the hot fluid is twice that ofthe cold fluid. The exit temperature of the cold fluid

(a) is 40°C (b) is 60°C (c) is 80°C (d) Cannot be determined

Q.20. In a counter flow heat exchanger, hot fluid enters at 60°C and cold fluidleaves at 30°C. Mass flow rate of the hot fluid is 1 kg/s and that of thecold fluid is 2 kg/s. Specific heat of the hot fluid is 10 kJ/kgK and that ofthe cold fluid is 5 kJ/kgK. The Log Mean Temperature Difference(LMTD) for the heat exchanger in °C is:

(a) 15 (b) 30 (c) 35 (d) 45

Q.21. Hot oil is cooled from 80 to 50°C in an oil cooler which uses air as thecoolant. The air temperature rises from 30 to 40°C. The designer uses aLMTD value of 26°C. The type of heat exchanger is:

(a) Parallel flow (b) Double pipe (c) Counter flow (d) Cross flow

Q.22. In a parallel flow heat exchanger operating under steady state, theheat capacity rates (product of specific heat at constant pressure andmass flow rate) of the hot and cold fluid are equal. The hot fluid,flowing at 1 kg/s with Cp = 4 kJ/kgK, enters the heat exchanger at 102°Cwhile the cold fluid has an inlet temperature of 15°C. The overall heattransfer coefficient for the heat exchanger is estimated to be 1 kW/m2Kand the corresponding heat transfer surface area is 5 m2. Neglect heattransfer between the heat exchanger and the ambient. The heatexchanger is characterized by the following relation: $2\varepsilon = 1 - \exp(-2NTU)$. The exit temperature (in °C) for - the cold fluid is:

(a) 45 (b) 55 (c) 65 (d) 75

Q.23. Radiative heat transfer is intended between the inner surfaces of two very largeisothermal parallel metal plates. While the upper plate (designated as plate 1) isa black surface and is the warmer one being maintained at 727°C, the lower plate(plate 2) is a diffuse and gray surface with an emissivity of 0.7 and is kept at227°C.Assume that the surfaces are sufficiently large to form a two-surface enclosureand steady-state conditions to exist. Stefan-Boltzmann constant is given as 5.67×10^{-8} W/m^2K^4.

(I). The irradiation (in kW/m^2) for the upper plate (plate 1) is:

(a) 2.5 (b) 3.6 (c) 17.0 (d) 19.5

(II). If plate 1 is also a diffuse and gray surface with an emissivity value of0.8, the net radiation heat exchange (in kW/m^2) between plate 1 andplate 2 is:

(a) 17.0 (b) 19.5 (c) 23.0 (d) 31.7

Q.24.A plate having 10 cm^2 area each side is hanging in the middle of a roomof 100 m^2 total surface area. The plate temperature and emissivity arerespectively 800 K and 0.6. The temperature and emissivity values forthe surfaces of the room are 300 K and 0.3 respectively. Boltzmann'sconstant $\sigma = 5.67 \times 10^{-8}$ $W/m^2 K^4$. The total heat loss from the two surfaces of the plate is:

(a) 13.66 W (b) 27.32 W (c) 27.87 W (d) 13.66 MW

Q.25.A solid cylinder (surface 2) is located at the centre of a hollow sphere(surface 1). The diameter of the sphere is 1 m, while the cylinder has adiameter and length of 0.5 m each. The radiation configuration factor F_{11} is:

(a) 0.375 (b) 0.625 (c) 0.75 (d) 1