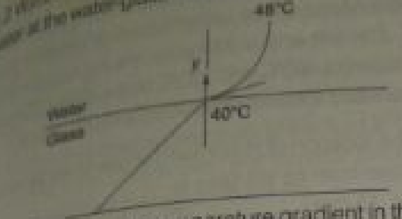
...W/mK. The spatial gradient of temperature in the water at the water-glass interface is $dT/dy = 1 \times 10^4$ K/m



1.9 The value of the temperature gradient in the glass at the water-glass interface in K/m is

(a) -2×10^4 (b) 0.0
(c) 0.5×10^4 (d) 2×10^4

[2003 : 2 Marks]

1.10 The heat transfer coefficient h in W/m²K is

(a) 0.0 (b) 4.8
(c) 6 (d) 750

[2003 : 2 Marks]

1.11 One dimensional unsteady state heat transfer equation for a sphere with heat generation at the rate of q can be written

Remember

(a) $\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r}\right)+\frac{q}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$

(b) $\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial T}{\partial r}\right)+\frac{q}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$

(c) $\frac{\partial^2 T}{\partial r^2}+\frac{q}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$

(d) $\frac{\partial^2}{\partial r^2}(rT)+\frac{q}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$

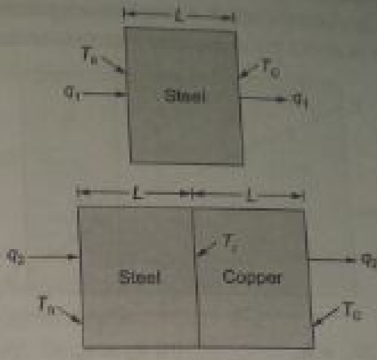
[2004 : 1 Mark]

1.12 A stainless steel tube (k_s = 19 W/mK) of 2 cm *ID* and 5 cm *OD* is insulated with 3 cm thick asbestos (k_a = 0.2 W/mK). If the temperature difference between the inner most and outermost surfaces is 600°C, the heat 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

[2004 : 2 Marks]

1.13 A well machined steel plate of thickness L is kept such that the wall temperature are T_h and T_c as seen in the figure below. A smooth copper plate of the same thickness L is now attached to the steel plate without any gap as indicated in the figure below. The temperature at the interface is T_i. The temperatures of the outer walls are still the same at T_h and T_c. The heat transfer rates are q_1 and q_2 per unit area in the two cases respectively in the direction shown. Which of the following statements is correct?



(a) $T_h > T_i > T_c$ and $q_1 < q_2$
(b) $T_h < T_i < T_c$ and $q_1 = q_2$
(c) $T_h = (T_i + T_c)/2$ and $q_1 > q_2$
(d) $T_i < (T_h + T_c)/2$ and $q_1 > q_2$

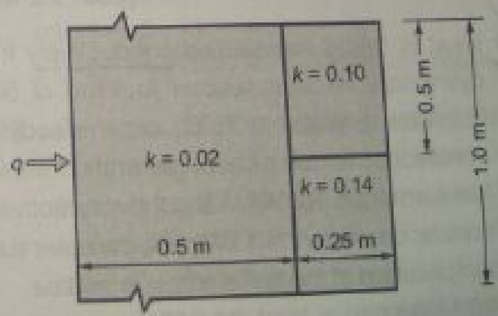
[2005 : 1 Mark]

1.14 In a case of one dimensional heat conduction in a medium with constant properties, T is the temperature at position x, at time t. Then $\frac{\partial T}{\partial t}$ is proportional to

(a) $\frac{T}{x}$ (b) $\frac{\partial T}{\partial x}$
(c) $\frac{\partial^2 T}{\partial x \partial t}$ (d) $\frac{\partial^2 T}{\partial x^2}$

[2005 : 1 Mark]

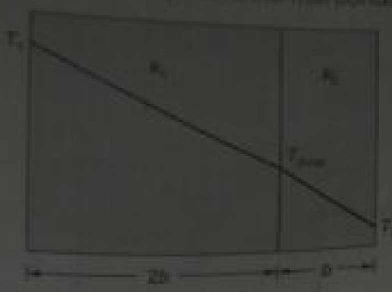
1.15 Heat flows through a composite slab, as shown below. The depth of the slab is 1 m. The k values are in W/mK. The overall thermal resistance in K/W is



(a) 17.2 (b) 21.9
(c) 28.6 (d) 39.2

[2005 : 2 Marks]

1.16 In a composite slab, the temperature at the interface (T_{inter}) between two materials is equal to the average of the temperature at the two ends. Assuming steady one dimensional heat conduction, which of the following statements is true about the respective thermal conductivities?



(a) $2k_1 = k_2$ (b) $k_1 = k_2$
(c) $2k_1 = 3k_2$ (d) $k_1 = 2k_2$

[2006 : 1 Mark]

1.17 With an increase in the thickness of insulation around a circular pipe, heat loss to surroundings due to

(a) convection increases, while that due to conduction decreases
(b) convection decreases, while that due to conduction increases
(c) convection and conduction decreases
(d) convection and conduction increases

[2006 : 2 Marks]

1.18 A long glass cylinder of inner diameter = 0.03 m and outer diameter = 0.05 m carries hot fluid inside. If the thermal conductivity of glass = 1.05 W/mK, the thermal resistance (K/W) per unit length of the cylinder is

(a) 0.031 (b) 0.077
(c) 0.17 (d) 0.34

[2007 : 2 Marks]

1.19 Heat is being transferred conductively from a cylindrical nuclear reactor fuel rod of 50 mm diameter to water at 75°C, under steady state condition, the rate of heat generation within the fuel element is 10^6 W/m^3 and the convective heat transfer coefficient is 1 kW/m^{2}K, the outer surface temperature of the fuel element would be

(a) 700 K (b) 625 K
(c) 360 K (d) 400 K

[2007 : 2 Marks]

Linked Answer Questions Q.1.20 and Q.1.21

Consider steady one-dimensional heat flow in a plate of 20 mm thickness with a uniform heat generation of 80 MW/m^3. The left and right faces are kept at constant temperatures of 160°C and 120°C respectively. The plate has a constant thermal conductivity of 200 W/mK.

1.20 The location of maximum temperature within the plate from its left face is

(a) 15 mm (b) 10 mm
(c) 5 mm (d) 0 mm

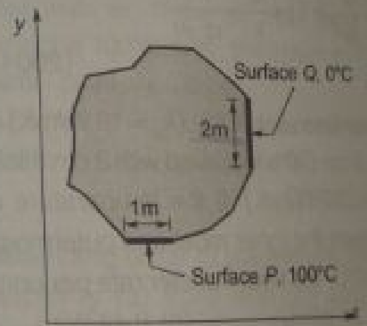
[2007 : 2 Marks]

1.21 The maximum temperature within the plate in °C is

(a) 160 (b) 165
(c) 200 (d) 250

[2007 : 2 Marks]

1.22 Steady two-dimensional heat conduction takes place in the body shown in the figure below. The normal temperature gradients over surface P and Q can be considered to be uniform. The temperature gradient $\frac{\partial T}{\partial x}$ at surface Q is equal to 10 K/m. Surfaces P and Q are maintained at constant temperatures as shown in the figure, while the remaining part of the boundary is insulated. The body has a constant thermal conductivity of 0.1 W/mK. The values of $\frac{\partial T}{\partial y}$ and $\frac{\partial T}{\partial x}$ at surface P are



(a) $\frac{\partial T}{\partial x} = 20$ K/m, $\frac{\partial T}{\partial y} = 0$ K/m

(b) $\frac{\partial T}{\partial x} = 0$ K/m, $\frac{\partial T}{\partial y} = 10$ K/m

(c) $\frac{\partial T}{\partial x} = 10$ K/m, $\frac{\partial T}{\partial y} = 10$ K/m

(d) $\frac{\partial T}{\partial x} = 0$ K/m, $\frac{\partial T}{\partial y} = 20$ K/m

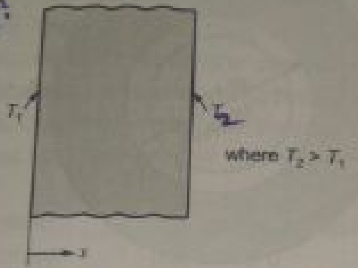
[2008 : 2 Marks]

1.23 A coolant fluid at 30°C flows over a heated flat plate maintained at a constant temperature of 100°C. The boundary layer temperature distribution at a given location on the plate may be approximated as $T = 30 + 70\exp(-y)$ where y (in m) is the distance normal to the plate and T is in °C. If thermal conductivity of the fluid is 1.0 W/mK, the local convective heat transfer coefficient (in W/m²K) at that location will be

(a) 0.2 (b) 1
(c) 5 (d) 10 **[2009 : 1 Mark]**

1.24 Consider one-dimensional steady state heat conduction, without heat generation, in a plane wall; with boundary conditions as shown in the figure below. The conductivity of the wall is given by $k = k_0 + bT$; where k_0 and b are positive constant, and T is temperature.

why not from this $\frac{dT}{dx} = 0$, as no heat gen & steady state?



As x increases, the temperature gradient (dT/dx) will

(a) remains constant (b) be zero
(c) increase (d) decrease

[2013 : 1 Mark]

1.25 Consider one-dimensional steady state heat conducting along x-axis ($0 \le x \le L$), through a plane wall with the boundary surfaces ($x = 0$ and $x = L$) maintained at temperature of 0°C and 100°C. Heat is generated uniformly through out the wall. Choose the CORRECT statement

(a) The direction of heat transfer will be from the surface at 100°C to the surface of 0°C.
(b) The maximum temperature inside the wall must be greater than 100°C
(c) The temperature distribution is linear within the wall
(d) The temperature distribution is symmetric about the mid-plane of the wall

[2013 : 1 Mark]

1.26 Consider a long cylindrical tube of inner and outer radii, r_i and r_o, respectively, length L and thermal conductivity, k. Its inner and outer surfaces are maintained at T_i and T_o, respectively ($T_i > T_o$). Assuming one-dimensional steady state heat conduction in the radial direction, the thermal resistance in the wall of the tube is

(a) $\frac{1}{2\pi kL}\ln\left(\frac{r_i}{r_o}\right)$ (b) $\frac{L}{2\pi r_i k}$

(c) $\frac{1}{2\pi kL}\ln\left(\frac{r_o}{r_i}\right)$ (d) $\frac{1}{4\pi kL}\ln\left(\frac{r_o}{r_i}\right)$

[2014 : 1 Mark, Set-3]

1.27 As the temperature increases, the thermal conductivity of a gas

(a) increases
(b) decreases
(c) remains constant
(d) increases up to a certain temperature and then decreases

[2014 : 1 Mark, Set-4]

1.28 Match **Group** A with **Group** B:

Group A
A : Biot number
B : Grashoff number
C : Prandtl number
D : Reynolds number

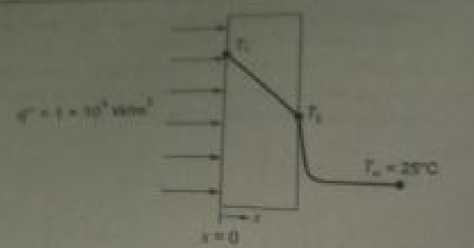
Group B
1 : Ratio of buoyancy to viscous force
2 : Ratio of inertia force to viscous force
3 : Ratio of momentum to thermal diffusivities
4 : Ratio of internal thermal resistance to boundary layer thermal resistance

Codes:

	A	B	C	D
(a)	4	1	3	2
(b)	4	3	1	2
(c)	3	2	1	4
(d)	2	1	3	4

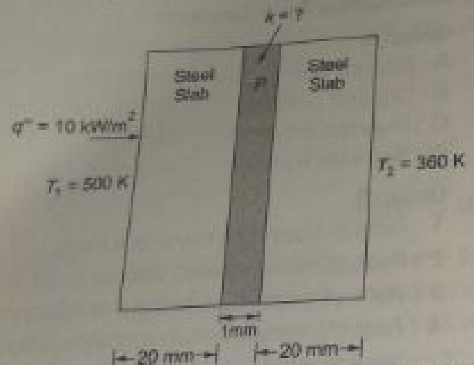
[2014 : 1 Mark, Set-4]

1.29 Consider one dimensional steady state heat conduction across a wall (as shown in figure below) of thickness 30 mm and thermal conductivity 15 W/mK. At $x = 0$, a constant heat flux, $q'' = 1 \times 10^5$ W/m² is applied. On the other side of the wall, heat is removed from the wall by convection with a fluid at 25°C and heat transfer coefficient of 250 W/m²K. The temperature (in °C), at $x = 0$ is ______.



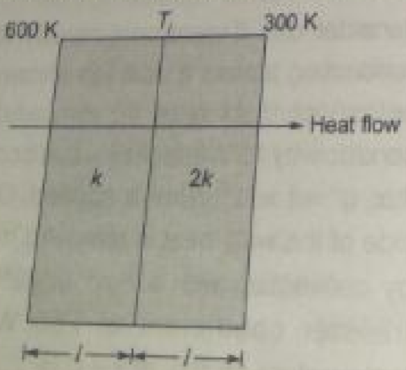
[2014 : 2 Marks, Set-1]

1.30 A material *P* of thickness 1 mm is sandwiched between two steel slabs, as shown in the figure below. A heat flux 10 kW/m² is supplied to one of the steel slabs as shown. The boundary temperatures of the slabs are indicated in the figure. Assume thermal conductivity of this steel is 10 W/mK. Considering one-dimensional steady state heat conduction for the configuration, the thermal conductivity (*k*, in W/mK) of material *P* is ______



[2014 : 2 Marks, Set-2]

1.31 Heat transfer through a composite wall is shown in figure. Both the sections of the wall have equal thickness (l). The conductivity of one section is k and that of the other is 2k. The left face of the wall is at 600 K and the right face is at 300 K.



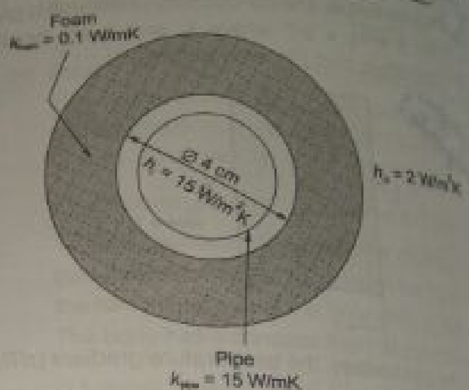
The interface temperature T_i (in K) of the composite wall is ______

[2014 : 2 Marks, Set-3]

1.32 A plane wall has a thermal conductivity of 1.15 W/mK. If the inner surface is at 1100°C and the outer surface is at 350°C, then the design thickness (in meter) of the wall to maintain a steady heat flux of 2500 W/m² should be ______

[2014 : 2 Marks, Set-4]

1.33 If a foam insulation is added to a 4 cm outer diameter pipe as shown in the figure, the critical radius of insulation (in cm) is ______



[2015 : 1 Mark, Set-2]

1.34 A 10 mm diameter electrical conductor is covered by an insulation of 2 mm thickness. The conductivity of the insulation is 0.08 W/mK and the convection coefficient at the insulation surface is 10 W/m²K. Addition of further insulation of the same material will

(a) increase heat loss continuously
(b) decrease heat loss continuously
(c) increase heat loss to a maximum and then decrease heat loss
(d) decrease heat loss to a minimum and then increase heat loss

[2015 : 2 Marks, Set-1]

1.35 A brick wall ($k = 0.9$ W/mK) of thickness 0.18 m separates the warm air in a room from the cold ambient air. On a particular winter day, the outside air temperature is – 5°C and the room needs to be maintained at 27°C. The heat transfer

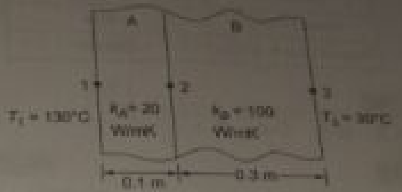
coefficient associated with outside air is 20 W/m²K. Neglecting the convective resistance of the air inside the room, the heat loss, in (W/m²), is
(a) 88 (b) 110
(c) 128 (d) 160
[2015 : 2 Marks, Set-3]

1.36 A cylindrical uranium fuel rod of radius 5 mm in a nuclear is generating heat at the rate of 4×10^7 W/m³. The rod is cooled by a liquid (convective heat transfer coefficient 1000 W/m²K) at 25°C. At steady state, the surface temperature (in K) of the rod is
(a) 308 (b) 398
(c) 418 (d) 448
[2015 : 2 Marks, Set-2]

1.37 A plastic sleeve of outer radius r_o = 1 mm covers a wire (radius r = 0.5 mm) carrying electric current. Thermal conductivity of the plastic is 0.12 W/mK. The heat transfer coefficient on the outer surface of the sleeve exposed to air is 25 W/m²K. Due to the addition of the plastic cover, the heat transfer from the wire to the ambient will
(a) increase (b) remain the same
(c) decrease (d) be zero
[2016 : 1 Mark, Set-1]

1.38 A hollow cylinder has length L, inner radius r_1, outer radius r_2, and thermal conductivity k. The thermal resistance of the cylinder for radial conduction is
(a) $\dfrac{\ln(r_2/r_1)}{2\pi kL}$ (b) $\dfrac{\ln(r_1/r_2)}{2\pi kL}$
(c) $\dfrac{2\pi kL}{\ln(r_2/r_1)}$ (d) $\dfrac{2\pi kL}{\ln(r_1/r_2)}$
[2016 : 1 Mark, Set-2]

1.39 Steady one-dimensional heat conduction takes place across the faces 1 and 3 of a composite slab consisting of slabs A and B in perfect contact as shown in the figure, where k_A, k_B denote the respective thermal conductivities. Using the data as given in the figure, the interface temperature T_2 (in °C) is ______



[2016 : 1 Mark, Set-3]

** 1.40 Heat is generated uniformly in a long solid cylindrical rod (diameter = 10 mm) at the rate of 4×10^7 W/m³. The thermal conductivity of the rod material is 25 W/mK. Under steady state conditions, the temperature difference between the centre and the surface of the rod is ______ °C.
[2017 : 2 Marks, Set-1]

Answers Conduction

1.1 (b)	1.2 (b)	1.3 (d)	1.4 (b)	1.5 (c)	1.6 (a)	1.7 (b)	1.8 (c)
1.9 (c)	1.10 (d)	1.11 (b)	1.12 (c)	1.13 (d)	1.14 (d)	1.15 (c)	1.16 (d)
1.17 (a)	1.18 (b)	1.19 (c)	1.20 (c)	1.21 (b)	1.22 (d)	1.23 (b)	1.24 (d)
1.25 (b)	1.26 (c)	1.27 (a)	1.28 (a)	1.34 (c)	1.35 (c)	1.36 (b)	1.37 (a)
1.38 (a)							