1	C	2	385 to 390	3	C	4	D	5	B	6	D	7	D	8	B	9	A	10	D
11	D	12	A	13	A	14	B	15	A	16	A	17	B	18	A	19	B	20	B
21	D	22	C	23	A	24	0.36 to 0.37	25	5918	26	0	27	178 to 179	28	61	29	A	30	100000
31	B	32	B	33	A	34	1122	35	A	36	A	37	868.5	38	934	39	17.33	40	1.11
41	92.6	42	3.09	43	14.5	44	A	45	61.7	46	50	47	0.64	48	1700 to 1710	49	A	50	A
51	B	52	C	53	191	54	0.5	55	3.69×10^4	56	B	57	B	58	D	59	B	60	D
61	D	62	A	63	B	64	D	65	B										

1. $Wt = \rho A.L \Big| \quad (R_{th})_{cond.} = \dfrac{L}{kA}$

$= \rho.A.(R_{th})_{cond.}.k.A$

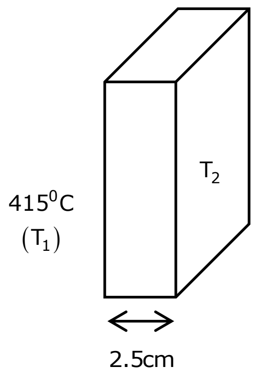
$= (\rho.k)A^2.(R_{th})_{cond.}$

2. $q_{cond.} = -kA\dfrac{dT}{dx} = kA\dfrac{T_1 - T_2}{L}$

$5 \times 10^3 = 0.2 \times 20 \times \dfrac{415 - T_2}{2.5 \times 10^{-2}}$

$\Rightarrow 31.25 = 415 - T_2$

$\Rightarrow T_2 = 415 - 31.25 = 387.75^0C$



8. $T(x) = \dfrac{\dot{q}L^2}{2k}\left(1 - \dfrac{x^2}{L^2}\right) + \left(\dfrac{T_{S2} - T_{S1}}{L}\right)\dfrac{x}{L} + \dfrac{T_{S1} + T_{S2}}{2}$

9. Gas has lower convection co-efficient, which will increase the fin effectiveness

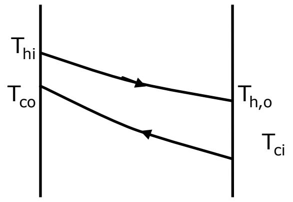
$\epsilon_f = \left(\dfrac{kP}{hA_C}\right)^{1/2}$

10. For infinite long fin,

$q = (kPhA_C)^{1/2}\ \theta_b = \left[k(\pi D)h\left(\dfrac{\pi}{4}D^2\right)\right]^{\frac{1}{2}}\ \theta_b = \dfrac{\pi}{2}(hk)^{\frac{1}{2}} D^{\frac{3}{2}}\theta_b$

$\dfrac{q(3D)}{q(D)} = 3^{\frac{3}{2}} = 5.2 \quad \therefore 420\%$ increase

20.



$T_{co} > T_{ho}$ (It is possible only in counter flow heat exchanger)

24. $$F_{2-1} = \frac{A_1 F_{12}}{A_2} = \frac{2RL}{\pi RL} \times 1.0 = \frac{2}{\pi} = 0.637$$

$$F_{22} = 1 - F_{2-1} = 1 - 0.637 = 0.363$$

25. $\lambda_{max} T = 2900 \mu m - k$ $\qquad$ $\lambda_{max} T = 2898 \mu m - k$ or $2900 \mu m - k$

$$\Rightarrow T = \frac{2900}{0.49} = 5918k$$

26. Heat equation

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} = \frac{1}{\alpha}\frac{\partial T}{\partial t} \qquad T = x^2 - 2y^2 + z^2 - xy + 2yz$$

$$\Rightarrow \frac{\partial}{\partial x}(2x - y) + \frac{\partial}{\partial y}(-4y - x + 2z) + \frac{\partial}{\partial z}(2z + 2y) = \frac{1}{\alpha}\frac{\partial T}{\partial t}$$

$$\Rightarrow 2 - 4 + 2 = \frac{1}{\alpha}\frac{\partial T}{\partial t} \Rightarrow \frac{\partial T}{\partial t} = 0$$

So temperature is every where independent of time at that instant

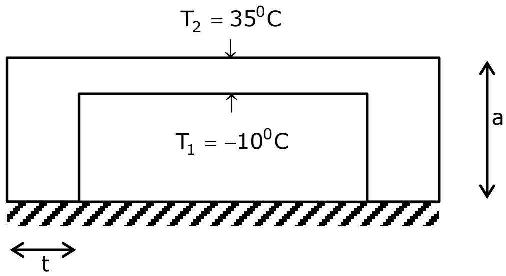
27. $$q = -kA\frac{dT}{dx} = (1.5)(44)\frac{(17-12)}{0.2} = 1650W$$

$$\text{cost} = \frac{1650 \times (\text{Rs.}1/\text{MJ})}{0.8 \times 10^6 \text{J}/\text{MJ}} \times (24 \times 3600) = 178.2/\text{day}$$

28. $$q = kA\frac{dT}{dx}$$

$$A_{total} = 5 \times a^2, \Rightarrow 1000 = .03 \times (5 \times 3^2)\frac{(35 - -10)}{t}$$

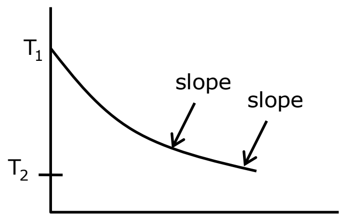
$$\Rightarrow t = \frac{.03 \times (5 \times 3^2) \times 45}{1000} = .061m \approx 61mm$$



29. $q_x = -kA_x\frac{dT}{dx}$ $\qquad$ q_x = constant=Heat rate within object is constant.

k = constant property

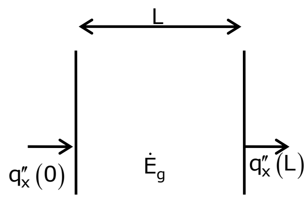
$$\therefore A_x\frac{dT}{dx} = \text{const}, \Rightarrow \text{As area increased} \left(\frac{dT}{dx}\right), \text{slopeofthecurve} T - x, \text{will decrease.}$$



30. Heat equation is,

$$\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(k\frac{\partial T}{\partial y}\right) + \frac{\partial}{\partial z}\left(k\frac{\partial T}{\partial z}\right) + \dot{q} = \rho C_P \frac{\partial T}{\partial t}$$

Condition



- one dimensional
- steady state
- constant thermal conductivity

Heat equation reduces to

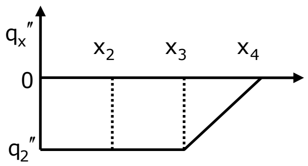
$$k\frac{\partial^2 T}{\partial x^2}+\dot{q}=0$$

$$\Rightarrow \dot{q}=-k\frac{\partial^2 T}{\partial x^2}=-50\frac{\partial^2}{\partial x^2}\left(a+bx^2\right)=-50.2b=-50\times 2\times\left(-1000\frac{{}^0C}{m^2}\right)$$

$$\dot{q}=10^5 W/m^3$$

32. Parabolic temperature distribution in "C" implies existence of heat generation. Hence $\frac{dT}{dx}$ increases with decreasing in (x) so heat flux in (c) increases with decreasing (x) $q_3'' > q_4''$. Linear temperature distribution in "A" & "B" shows no heat penetration $\therefore q_2''=q_3''$.

33.



34. $$\frac{\theta}{\theta_i}=\frac{T-T_\infty}{T_i-T_\infty}=\exp\left(-B_i\times F_0\right)$$

$$\Rightarrow \ell n\frac{T-T_\infty}{T_i-T_\infty}=-B_i\times\frac{\alpha t}{L_C^2}$$

$$\Rightarrow t=(-)\frac{L_C^2}{B_i\times\alpha}\ell n\left(\frac{T-T_\infty}{T_i-T_\infty}\right)=(-)\frac{\left(\frac{6\times 10^{-3}}{3}\right)^2}{.001\times 8.57\times 10^{-6}}\ell n\left[\frac{400-325}{1150-325}\right]=1122.2\,\text{sec}\approx 1122\,\text{sec}$$

36. $$m=\int_0^\delta \rho u dy=\int_0^\delta \rho\left[U\left\{\frac{3}{2}\left(\frac{y}{\delta}\right)-\frac{1}{2}\left(\frac{y}{\delta}\right)^3\right\}\right]dy\,,\ \boxed{m=\frac{5}{8}\rho U\delta}$$

36. Parallel to 500mm

$$\bar{h}=.664\left(R_{eL}\right)^{1/2}(Pr)^{1/3}\left(\frac{k}{L}\right)\Bigg|\quad R_L=\frac{2\times 0.5}{18.9\times 10^{-6}}=5.27\times 10^4$$

$$Q=\bar{h}A_s\left(t_s-t_\infty\right),\frac{Q_{500}}{Q_{200}}=\frac{\bar{h}_{500}}{\bar{h}_{200}}\cdot\frac{A_s\left(t_s-t_\infty\right)}{A_s\left(T_s-t_\infty\right)}=\frac{\bar{h}_{500}}{\bar{h}_{200}}$$

$$\frac{\bar{h}_{500}}{\bar{h}_{200}}=\frac{.664\left(R_L\right)_{500}^{1/2}(Pr)^{1/3}\frac{k}{L_{500}}}{.664\left(R_L\right)_{200}^{1/2}(Pr)^{1/3}\frac{k}{L_{200}}}$$

$$\Rightarrow\frac{\bar{h}_{500}}{\bar{h}_{200}}=\left(\frac{L_{500}}{L_{200}}\right)^{1/2}\times\frac{L_{200}}{L_{500}}=\left(\frac{.5}{.2}\right)^{1/2}\left(\frac{.2}{.5}\right)=\sqrt{\frac{.2}{.5}}=0.63$$

37. $$Re_L=\frac{UL}{\upsilon}=\frac{25\times 0.8}{17.95\times 10^{-6}}=1.114\times 10^6$$

$Re_L > 5\times10^5$, Flow is turbulent, $\bar{N}u = \frac{\bar{h}L}{k} = .036\left(Re_L\right)^{0.8}\left(Pr\right)^{0.333}$

$$\Rightarrow \bar{h} = \frac{k}{L}\times .036\times\left(Re_L\right)^{0.8}\left(Pr\right)^{0.333}$$

$$= \frac{.02824}{0.8}\times .036\times\left(1.114\times10^6\right)^{0.8}\left(0.698\right)^{.333} = 77.55W/m^2-^0C$$

$$Q = \bar{h}A\left(T_S - T_\infty\right) = 77.55\times\left(.8\times.2\right)\left(85-15\right) = 868.56W$$

38. $U = \frac{30\times1000}{60\times60} = 8.33m/s$

$$Re = \frac{UD}{\nu} = \frac{8.33\times.350}{15\times10^{-6}} = 1.94\times10^5$$

$$Nu = \frac{\bar{h}D}{k} = .027 Re^{.805} Pr^{.33}$$

$$\Rightarrow \bar{h} = .027\times\frac{2.59\times10^{-2}}{35}\times\left(1.94\times10^5\right)^{.805}\left(.707\right)^{.33} = 32.18W/m^2-^0C$$

Heat lost by man, $Q=\bar{h}A_s\left(t_s - t_\infty\right) = 32.18\times\left(\pi\times.35\times1.65\right)\left(28-12\right)$

$\boxed{Q = 934W}$

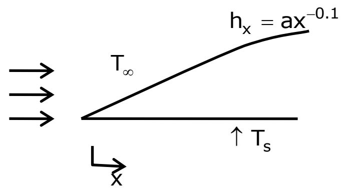
39. $Re = \frac{UD}{\nu} = \frac{0.4\times.065}{2.08\times10^{-5}} = 1250$

$$\bar{N}u = \frac{\bar{h}D}{k} = 0.37\left(Re\right)^{0.6} \Rightarrow \bar{h} = \frac{0.37\left(1250\right)^{0.6}\times.03}{.065} = 1232W/m^2-^0C$$

$$Q = \bar{h}A_s\left(t_s - t_\infty\right) = 12.32\times\left[4\pi\times\left(\frac{.065}{2}\right)^2\right]\left(130-24\right) = 17.33W$$

$$\%Power = \frac{17.33}{100}\times100 = 17.33\%$$

40.



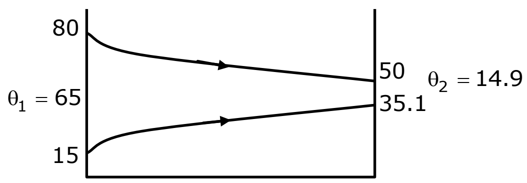
$$\bar{h}_x = \frac{1}{x}\int_0^x h_x\left(x\right)dx = \frac{1}{x}\int_0^x ax^{-0.1}dx = \frac{a}{x}\left(\frac{x^{.9}}{.9}\right) = 1.11ax^{-0.1}$$

$$\Rightarrow \bar{h}_x = 1.11ax^{-.1} \Rightarrow \bar{h}_x = 1.11h_x\left(x\right) \Rightarrow \boxed{\frac{\bar{h}_x}{h_x\left(x\right)} = 1.11}$$

41. Electric power = Total convection loss

$$= h.A.\left(t_s - t_w\right) = 3275\times\left(\pi\times1.5\times10^{-3}\times200\times10^{-3}\right)\left(130-100\right) = 92.5W$$

42.



$$LMTD = \frac{\theta_2 - \theta_1}{\ell n\left(\frac{\theta_2}{\theta_1}\right)} = \frac{14.9 - 65}{\ell n\left(\frac{14.9}{65}\right)} = \frac{-50.1}{-1.47} = 34.01^0C$$

$$Q = UA\theta_{\ell m}$$

$$\Rightarrow m_h c_{p.h}\left(T_{h,i} - T_{h,o}\right) = UA\theta_{\ell m}$$

$$\Rightarrow A = \frac{m_h c_{p.h}\left(T_{hi} - T_{h.o}\right)}{U\theta_{\ell m}} = \frac{2 \times 3500 \times (80 - 50)}{2000 \times 34.01} = 3.09m^2$$

43. $A_{counter} = 2.64m^2$

$A_{parallel} = 3.09m^2$

$$\% \text{ Reduction} = \frac{3.09 - 2.64}{3.09} = 14.5\%$$

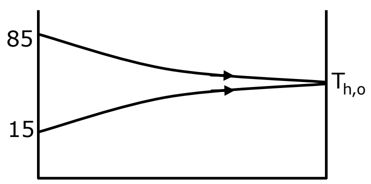
44.

	Hot	Cold
C_{hot}	$= \rho_h.\text{Flow Rate}.(C_P)_h$	$= 1247 \times \frac{16}{3600} \times 2564$
	$= 997 \times \frac{14}{3600} \times 4179$	$= 14210.3$
	$= 16202.9$	

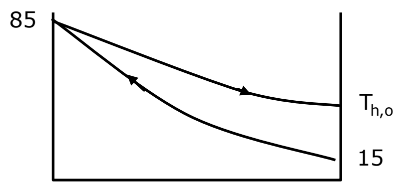
Maximum possible heat transfer rate = $C_{mn} \times$ temp.diff

$C_{min} =$ cold fluid

45.



Parallel flow



Counter flow

For very long exchanger, parallel flow, $T_{h,o}$ and $T_{c,o}$ will be same

$\dot{m}_h = 2\dot{m}_c$

$(c_P)_h = c_{P.c}$

$\Rightarrow c_h = 2.c_c$

$T_{h,o} = T_{c,o}$

Heat gain by cold water = Heat lost by hot water

$$\Rightarrow C_C\left[T_{c,o} - T_{c,i}\right] = C_h\left[T_{h,i} - T_{h,o}\right]$$

$$\Rightarrow C_C\left[T_{h,o} - T_{c,i}\right] = 2.C_C\left[T_{h,i} - T_{h,o}\right]$$

$$\Rightarrow 3T_{h,o} = 2T_{h,i} + T_{c,i}$$

$$\Rightarrow T_{h,o} = \frac{2T_{h,i} + T_{c,i}}{3} = \frac{(2 \times 85) + 15}{3} = 61.7^0C$$

46. For very long heat exchanger, $T_{h,i} = T_{c,o}$

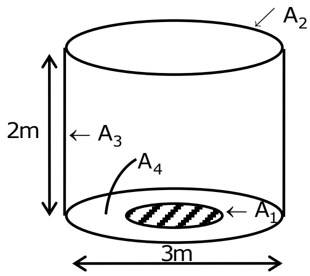
$$C_C\left[T_{c,o} - T_{c,i}\right] = C_h\left[T_{h,i} - T_{h,o}\right]$$

$$\Rightarrow C_C\left[T_{h,i} - T_{c,i}\right] = 2.C_C\left[T_{h,i} - T_{h,o}\right]$$

$$\Rightarrow 85 - 15 = 2\left[85 - T_{h,o}\right]$$

$$\Rightarrow 35 = 85 - T_{h,o} \Rightarrow T_{h,o} = 85 - 35 = 50$$

47. $F_{11} + F_{12} + F_{13} + F_{14} = 1$



$F_{11} = 0 | F_{14} = 0|$

$$\Rightarrow F_{12} = \frac{D^2}{D^2 + 4L^2} \left(\begin{array}{c} \text{when a circular disk of diameter D} \\ \text{is located parallel to small area} \end{array} \right)$$

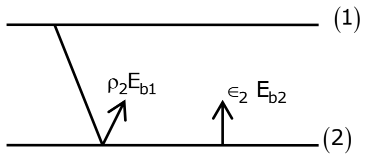
$$= \frac{3^2}{3^2 + 4(2)^2} = 0.36$$

$F_{13} = 1 - F_{12} = 1 - 0.36 = 0.64$

48. $q_{1-3} = A_1 F_{13} \sigma \left(T_1^{\ 4} - T_3^{\ 4} \right)$

$= .05 \times 0.64 \times \left(5.67 \times 10^{-8}\right)\left(1000^4 - 500^4\right) = 1700$

49.



$$G_{upper} = \left[\begin{array}{c} \text{Flux emitted by} \\ \text{surface (2)} \end{array} \right] + \left[\begin{array}{c} \text{Reflection by surface (2)} \\ \text{of flux emitted by (1)} \end{array} \right]$$

$= \in_2 E_{b2} + \rho_2 E_{b1}$

$= \in_2 \sigma T_2^{\ 4} + (1 - \in_2) \sigma T_1^{\ 4}$

$= \left[0.8 \times 5.67 \times 10^{-8} \times (500)^4 \right] + \left[(1 - 0.8) \times 5.67 \times 10^{-8} \times 1000^4 \right]$

$= 2835 + 11340 = 14175 \text{ W/m}^2$

50. 2- opening

1- inner surface

<u>Cone</u>:

$F_{21} + F_{22} = F_{21} + 0 = 1 \Rightarrow \boxed{F_{21} = 1}$

$$F_{12} = \frac{A_2 F_{21}}{A_1} = \frac{\left(\frac{\pi}{4} d^2 \right)}{\frac{\pi d}{2} \left[L^2 + \left(\frac{d}{2} \right)^2 \right]^{\frac{1}{2}}} = \frac{1}{2} \left[\left(\frac{L}{d} \right)^2 + \frac{1}{4} \right]^{\frac{-1}{2}}$$

51. <u>Cylinder</u>:

$F_{21} = 1$

$$F_{12} = \frac{A_2 F_{21}}{A_1} = \frac{\frac{\pi}{4} d^2}{\pi d L + \frac{\pi}{4} d^2} = \left[1 + \frac{4L}{d} \right]^{-1}$$

52. <u>Sphere</u>:

$F_{12} = 1$

$$F_{12} = \frac{A_2F_{21}}{A_1} = \frac{\frac{\pi}{4}d^2}{\pi D^2 - \frac{\pi}{4}d^2} = \left[4D^2/d^2 - 1\right]^{-1}$$

53. $$q_{12} = \frac{\sigma A_1\left[T_1^4 - T_2^4\right]}{\frac{1}{\epsilon_1} + \frac{1-\epsilon_2}{\epsilon_2}\left(\frac{r_1}{r_2}\right)^2} = \frac{\left(5.67\times10^{-8}\right)\left(\pi\times0.8^2\right)\left(400^4 - 300^4\right)}{\frac{1}{0.5} + \frac{1-0.05}{.05}\left(\frac{0.4}{0.6}\right)^2} = 191\text{W}$$

54. $$\frac{(Q)_{n-\text{shield}}}{(Q)_{\text{without shield}}} = \frac{1}{n+1}$$

55. $$q_{21} = A_2F_{21}\sigma\left(T_2^4 - T_1^4\right)$$
$$= (490.87)\left(5.67\times10^{-8}\right)\left(288^4 - 273^4\right)$$
$$= 3.69\times10^4\text{W}$$

$$A_2F_{21} = A_1F_{12}$$
$$= \left(\frac{\pi}{4}D_1\right)^2.1$$
$$= \frac{\pi}{4}\times25^2$$
$$= 490.87$$

60. If the given number $5668\times25y$ is divisible by 48, it means the number is divisible by both 8 & 6.

As per division rule, 25y should be divisible by 8; So y gets 6

The same way the sum of 5 + 6 + 6 + 8 + x + 2 + 5 + y should be divisible by 3

32 x + y = 38 + x $\therefore$ x can get 1; Required number = x + y = 6 + 1 = 7

62. Lets assume the value of x to be 10%.

Therefore, the number of sheep's in the herd at beginning of year 2001 (end of 2000) will be 1 million + 10% of 1 million = 1.1 million

In 2001, the numbers decrease by y% at the end of year

The number of sheep's in the herd = 1 million

i.e., 0.1 million sheep have died in 2001

In terms of the percentage of the number of sheep's at the beginning of 2001, it will be

$\frac{0.1}{1.1}\times100\% = 9.09\%$; So, it is clear that x > y

63. $$\text{2nd term} = \left(\frac{\text{1st term} - 8}{2}\right) = \frac{888-8}{2} = 440$$

$$\text{3rd term} = \left(\frac{\text{2nd term} - 8}{2}\right) = \frac{440-8}{2} = 216$$

$$\text{5th term} = \left(\frac{\text{4th term} - 8}{2}\right) = \left(\frac{104-8}{2}\right) = 48$$

64. Let T be the total number of tourists from India. Now, the number of tourists visiting other countries = 20% of T = 0.2T. Of these, percentage of tourists visiting Switzerland = 25% of 0.2T = 0.05 T = 25 lakhs. Therefore, T = 500 lakhs. Now, percentage of total tourists falling in the 30 – 39 age group = 15% = 0.15T = 0.15 $\times$ 500 = 75 lakhs

65. A's speed $=\left(\frac{5\times5}{18}\right)\text{m / sec}=\frac{25}{18}\text{m / sec}$

Time taken by A to cover 100m = $\left(\frac{100\times18}{25}\right)\text{sec}=72\ \text{sec}$

$\therefore$ Time taken by B to cover 92m = (72 + 8) = 80 sec

$\therefore$ B's speed $=\left(\frac{92}{80}\times\frac{18}{5}\right)\text{kmph}=4.14\ \text{kmph}$