2019

RANK IMPROVEMENT WORKBOOK

Mechanical Engineering

Heat Transfer

Answer Key of Objective & Conventional Questions

MADE EASY Publications

1 Conduction

LEVEL 1 Objective Questions

1. (30)
2. (468)
3. (93.33)
4. (630)
5. (a)
6. (c)
7. (a)
8. (a)
9. (a)
10. (61.69)

LEVEL 2 Objective Questions

11. (a)
12. (82.18)
13. (140.42)
14. (15.94)
15. (0.044)
16. (57.36)
17. (b)
18. (c)
19. (b)
20. (a)
21. (b)
22. (a)
23. (0.188)
24. (42.76)
25. (a)
26. (c)
27. (209.77)
28. (a)
29. (a)
30. (d)
31. (12.5)
32. (12)

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LEVEL 3 Conventional Questions

Solution : 33

Critical thickness = 35.28 mm

Heat loss with critical radius of insulation = 22.026 W

Heat loss with 20 mm insulation = 21.11 W

Heat loss with 60 mm insulation = 21.41 W

Solution : 34

(i) Reduction in heat loss

% Reduction = 82.96 %

(ii) Insulated, heat loss is Q = 257.28 W

Without insulation

Q = 1510.27 W

(iii) Daily savings = Rs. 67.66 per day

Solution : 35

$$\dot{Q}_{\text{per meter}} = 296.49 \text{ Watt/m}$$

$$x = 0.955$$

Solution : 36

(a)

$$q_{r=0} = 0$$

$$q_{r=0.025} = 0.9818 \times 10^5 \text{ W/m}$$

(b) ,

$$\frac{\partial T}{\partial t} = 56.82 \text{ K/s}$$

Solution : 37

$$\dot{q}_g = 2.298 \text{ MW/m}^3$$

$$t_s = 609.49°\text{C}$$

$$t_{max} = 609.528°\text{C}$$

Solution : 38

Thickness of plastic layer = 2.988 mm.

$$T_1 = 49.9574°\text{C}$$

$$T_2 = 29.6514°\text{C}$$

Solution : 39

$$Q = 325.66 \text{ W}$$

Heat transfer rate from total surface of the wall

$$= 108.55 \times 10^3 \text{ W} = 108.55 \text{ kW}.$$

$$T_2 = 278°\text{C}$$

$$T_3 - T_4 = 81.415°\text{C}$$

Solution : 40

$$q = 1.3785 \text{ kW}$$
$$t_2 = 986.6°\text{C}$$
$$t_3 = 766.04°\text{C}$$
$$t_4 = 214.64°\text{C}$$
$$t_5 = 96.5°\text{C}$$

Solution : 41

$$\text{Critical thickness of insulation} = 0.33 \text{ cm}$$

$$\frac{Q_{\text{with}}}{Q_{\text{without}}} = 1.035$$

$$\frac{Q_{\text{with}}}{Q_{\text{without}}} = 0.8316$$

Solution : 42

$$T(x) = T_1 + (T_1 - T_2)\left[\frac{\left(\frac{1}{x}\right) - \left(\frac{1}{x_1}\right)}{\left(\frac{1}{x_1}\right) - \left(\frac{1}{x_2}\right)}\right]$$

$$q_x = \frac{\pi(0.25)^2 \times 3.46 \text{W} / \text{m} \cdot K(400 - 600)\text{K}}{4\left(\frac{1}{0.05 \text{ m}} - \frac{1}{0.25 \text{ m}}\right)}$$

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2 Heat Transfer from Extended Surface (FINS)

LEVEL 1 Objective Questions

1.	(b)
2.	(b)
3.	(d)
4.	(b)
5.	(c)
6.	(c)
7.	(25.66)
8.	(b)
9.	(d)
10.	(a)
11.	(c)

LEVEL 2 Objective Questions

12.	(c)
13.	(d)
14.	(b)
15.	(a)
16.	(a)
17.	(c)
18.	(4)
19.	(51.136)

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LEVEL 3 Conventional Questions

Solution : 20

$$T_0 - T_L = 95 - 25.28 = 69.72°C$$

Solution : 21

Hence the total heat transfer = 1711.5 W

Solution : 22

$$Q = 10.235 \text{ Watts}$$

Solution : 23

$$Q = 15.028 \text{ Watts}$$

Solution : 24

$$Q_{fin} = 9.82 \text{ W}$$

Solution : 25

$$k_B = 15 \text{ W/mK}$$

$$\frac{Q_A}{Q_B} = \sqrt{\frac{k_A}{k_B}} = 2$$

Solution : 26

$$Q_1 = 41.0 \text{ W}$$

$$Q_2 = 32.8 \text{ W}$$

$$= 8.2 \text{ W}$$

Solution : 27

(i) Optimum fin spacing, $\delta = 7.243$ mm

Heat transfer coefficient for optimum spacing

$$Q = 41.118 \text{ W}$$

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3 Convection

LEVEL 1 Objective Questions

1.	(c)
2.	(c)
3.	(c)
4.	(1.2)
5.	(70.71)
6.	(a)
7.	(a)
8.	(6.80)
9.	(90)
10.	(5.943)
11.	(0.474)
12.	(b)
13.	(a)
14.	(c)
15.	(1.25)
16.	(b)
17.	(a)
18.	(b)
19.	(27.46)
20.	(a)
21.	(0.06)

LEVEL 2 Objective Questions

22.	(a)
23.	(c)
24.	(c)
25.	(c)
26.	(d)
27.	(d)
28.	(a)
29.	(c)

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LEVEL 3 Conventional Questions

Solution : 30

$$h = 4.816 \text{ W/m}^2\text{K}$$
$$Q = 385.25 \text{ Watt}$$

Solution : 31

$$\delta = 16.55 \text{ mm}$$
$$= 7424.5 \text{ watts}$$

Solution : 32

$$u_\infty = 9.15 \text{ m/s}$$

Solution : 33

$$h = 40.96 \text{ W/m}^2\text{-K}$$
$$Q = 3290.775 \text{ W}$$

Solution : 34

$$Q = 12.073 \text{ W}$$
$$= 12.073\%$$

Solution : 35

$$Q = 823.0 \text{ W}$$

Solution : 36

$$Q_1 = 29.64 \text{ W}$$
$$Q_2 = 14.82 \text{ W}$$
$$Q_3 = 22.9 \text{ W}$$

Solution : 37

$$h = 6.1 \text{ W/m}^2\text{K}$$
$$\frac{dT}{dt} = -7.32°\text{C/min.}$$
$$t = 21.44 \text{ min}$$

Solution : 38

$$Q_c = 39.64 \text{ W}$$
$$Q_r = 15.37 \text{ W}$$

Solution : 39

$$\bar{h} = 26832.32 \text{ W/m}^2\text{K}$$

Heat transferred, $Q = 4230355 \text{ W}$

$$L = 21.98 \text{ m}$$

Solution : 40

The property values are taken at 20°C

ρ = 1000 kg/m^3, ν = 1.006 × 10^{-6} m^2/s, Pr = 7.02,

k = 0.5978 W/mK, c = 1178 J/kgK, P_{50} = 990 kg/m^3.

v_{50} = 5675 × 10^{-6} m^2/s

Friction factor is found from pressure drop and analogy is used to solve from in

$$\Delta P = f \cdot \rho \frac{L}{D}\frac{u^2}{2}, u = 0.001 \times \frac{4}{\pi} \times 0.025^2 \text{ m/s} = 2.0372 \text{ m/s}$$

Substituting
$$f = 7000 \times 0.025 \times \frac{2}{1000} \times 1.5\left(\frac{0.001 \times 4}{\pi \times 0.025^2}\right) = 0.05622$$

$$\text{Re} = \text{uD/v} = 2.0372 \times \frac{0.025}{1.006} \times 10^{-6} = 50626$$

If we assume smooth pipe, $f = (1.82 \log \text{Re} - 1.64)^{-2} = 0.02087$

So the pipe considered should be a rough pipe,

Using Colburn analogy

$$\therefore \quad \text{StPr}^{2/3} = \frac{f}{8}$$

$$\text{Nu} = \left(\frac{f}{8}\right)\text{Re.Pr}^{1/3} = \frac{0.05622}{8} 50626 \times 7.02^{0.333}$$

$$= 681.22$$

Solution : 41

$$\bar{h}_c = 1.57 \times 10^2 \text{ W/(m}^2\text{K)}$$

$$L = 0.419 \text{ m}$$

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4 Heat Exchanger

LEVEL 1 Objective Questions

1.	(d)
2.	(c)
3.	(a)
4.	(c)
5.	(c)
6.	(b)
7.	(d)
8.	(1.5)
9.	(a)
10.	(c)
11.	(0.56)
12.	(d)
13.	(0.25)
14.	(3)
15.	(a)

LEVEL 2 Objective Questions

16.	(1.57)
17.	(1.62)
18.	(a)
19.	(c)
20.	(0.857)
21.	(40)
22.	(0.25)
23.	(19.7)
24.	(b)
25.	(15.7)
26.	(c)
27.	(a)
28.	(0.533)
29.	(a)
30.	(a)

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LEVEL 3 Conventional Questions

Solution : 31

$$\frac{A_{CF}}{A_{PF}} = 3\left[\frac{\ln\left\{\dfrac{0.5(T_{h,i}+T_{h,o})-T_{c,i}}{T_{h,o}-T_{c,i}}\right\}}{\ln\left\{\dfrac{T_{h,o}-T_{c,i}}{1.5T_{h,o}-0.5T_{h,i}-T_{c,i}}\right\}}\right] = 0.877$$

Solution : 32

Hot fluid: $T_{h,\,o} = 47.72°C$

$T_{c,\,o} = 56.135°C$

$T_m = 53.33°C$

Maximum possible effectiveness in parallel flow mode:

For the hot fluid, $\varepsilon = 0.667$

Solution : 33

No. of tubes = 1990

$L = 2.02$ m

length per pass = 1.01 m

Solution : 34

$\in = 0.402$

$T_{ce} = 32.69°C$

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5 Radiation

LEVEL 1 Objective Questions

1.	(c)
2.	(c)
3.	(b)
4.	(162.313)
5.	(0.9)
6.	(c)
7.	(c)
8.	(d)
9.	(4)
10.	(c)
11.	(b)
12.	(d
13.	(b)
14.	(64.16)
15.	(0.8)
16.	(a)

LEVEL 2 Objective Questions

17.	(894)
18.	(0.927)
19.	(c)
20.	(0.4444)
21.	(132.576)
22.	(2)
23.	(0.78)
24.	(51.176)
25.	(a)
26.	(a)
27.	(759.36)
28.	(c)
29.	(d)
30.	(1)
31.	(91.58)
32.	(0.75)
33.	(c)
34.	(d)

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LEVEL 3 Conventional Questions

Solution : 35

$$\delta = 26.8 \text{ cm}$$

Solution : 36

Heat transfer to N_2 tube (1) from tube (2) per unit length = 0.5 watt

% change in heat gained by liquid N_2 per unit length of tube = 49.4%

Solution : 37

$$\frac{Q}{L} = 5606.5 \text{ W/m}$$

The radiation heat exchange between pipe and a conduit = 5414 W/m

$$\frac{Q}{L} = 5454.2 \text{ W/m}$$

Solution : 38

$$\frac{Q_2}{Q_1} = 2.82$$

Solution : 39

$$\frac{q_{12}}{A} = 19.5 \text{ kW/m}^2$$

Solution : 40

$$T_2 = 280.86 \text{ K}$$

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