Practice Sets
CIVIL ENGINEERING
[Useful for Railway & Other Engineering (Diploma) Exams.]
Piyush Gupta
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Practice Sets
CIVIL ENGINEERING
1. Consider the following statements:
   The Fourier heat conduction equation
   \[ Q = kA \frac{dT}{dx} \]
   presumes
   1. Steady-state conditions
   2. Constant value of thermal conductivity.
   3. Uniform temperatures at the wall surfaces
   4. One-dimensional heat flow.
   Of these statements:
   (a) 1, 2 and 3 are correct
   (b) 1, 2 and 4 are correct
   (c) 2, 3 and 4 are correct
   (d) 1, 3 and 4 are correct

2. The temperature variation in a large plate, as shown in the given figure would correspond to which of the following conditions?
   \[ T_1 \]
   \[ T_2 \]
   1. Unsteady heat.
   2. Steady-state with variation of k.
   Select the correct answer using the codes given below:
   (a) 2 alone
   (b) 1 and 2
   (c) 1 and 3
   (d) 1, 2 and 3

3. A 0.5 m thick plane wall has its two surfaces kept at 300°C and 200°C. Thermal conductivity of the wall varies linearly with temperature and its values at 300°C and 200°C are 25 W/mK and 15 W/mK, respectively. Then the steady heat flux through the wall is:
   (a) 5kW/m²
   (b) 5kW/m²
   (c) 4kW/m²
   (d) 3kW/m²

4. A 320 cm high vertical pipe at 150°C wall temperature is in a room with still air at 10°C. This pipe supplies heat at the rate of 8 kW into the room air by natural convection. Assuming laminar flow, the height of the pipe needed to supply 1 kW only is:
   (a) 10 cm
   (b) 20 cm
   (c) 40 cm
   (d) 80 cm

5. The average Nusselt number in laminar natural convection from a vertical wall at 180°C with still air at 20°C is found to be 48. If the wall temperature becomes 30°C, all other parameters remaining same, the average Nusselt number will be:
   (a) 8
   (b) 16
   (c) 24
   (d) 32

6. A fluid of thermal conductivity 10 W/mK flows in fully developed flow with Reynolds number of 1500 through a pipe of diameter 10 cm. The heat transfer coefficient for uniform heat flux and uniform wall temperature boundary conditions are, respectively:
   (a) 36.57 \( \frac{W}{m^2K} \)
   (b) 43.64 \( \frac{W}{m^2K} \)
   (c) 43.64 \( \frac{W}{m^2K} \) for both the cases
   (d) 36.57 \( \frac{W}{m^2K} \) for both the cases

7. Two large parallel grey plates with a small gap, exchange radiation at the rate of 1000 W/m² when their emissivities are 0.5 each. By coating one plate, its emissivity is reduced to 0.25. Temperature remain unchanged. The new rate of heat exchange shall become:
   (a) 500 W/m²
   (b) 600 W/m²
   (c) 700 W/m²
   (d) 800 W/m²

8. Two long parallel plates of same emissivity 0.5 are maintained at different temperatures and have radiation heat exchange between them. The radiation shield of emissivity 0.25 placed in the middle will reduce radiation heat exchange to:
   (a) \( \frac{1}{2} \)
   (b) \( \frac{1}{4} \)
   (c) \( \frac{3}{10} \)
   (d) \( \frac{3}{5} \)

9. Match List-I (Type of radiation) with List-II (Characteristic) and select the correct answer using the codes given below the lists:

<table>
<thead>
<tr>
<th>List-I (Type of radiation)</th>
<th>List-II (Characteristic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Black body</td>
<td>1. Emissivity does not depend on wavelength</td>
</tr>
<tr>
<td>B. Grey body</td>
<td>2. Mirror-like reflection</td>
</tr>
<tr>
<td>C. Specular</td>
<td>3. Zero reflection</td>
</tr>
<tr>
<td>D. Diffuse</td>
<td>4. Intensity same in all directions</td>
</tr>
</tbody>
</table>

**Codes:**
(a) 2 1 3 4
(b) 3 4 2 1
(c) 2 4 3 1
(d) 3 1 2 4
10. Match List-I (Type of heat transfer) with List II (Governing dimensionless parameter) and select the correct answer using the codes give below the lists:

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Forced convection</td>
<td>1. Reynolds, Grashoff and Prandtl number</td>
</tr>
<tr>
<td>B. Natural convection</td>
<td>2. Reynolds and Prandtl number</td>
</tr>
<tr>
<td>C. Combined free and forced convection</td>
<td>3. Fourier modulus and Biot number</td>
</tr>
<tr>
<td>D. Unsteady conduction with convection at surface</td>
<td>4. Prandtl number and Grashoff number</td>
</tr>
</tbody>
</table>

Codes:

(a) 2 1 4 3  
(b) 3 4 1 2  
(c) 2 4 1 3  
(d) 3 1 4 2

11. The insulated tip temperature of a rectangular longitudinal fin having an excess (over ambient) root temperature of $\theta_0$ is:

(a) $\theta_0 \tanh (ml)$  
(b) $\frac{\theta_0}{\sin (hml)}$  
(c) $\frac{\theta_0 \tan (hml)}{(ml)}$  
(d) $\frac{\theta_0}{\cos (hml)}$

12. Consider the following statements pertaining to large heat transfer rate using fins:
1. Fins should be used on the side where heat transfer coefficient is small.
2. Long and thick fins should be used.
3. Short and thin fins should be used.
4. Thermal conductivity of fins material should be large.

Which of the above statements are correct?

(a) 1, 2 and 3  
(b) 1, 2 and 4  
(c) 2, 3 and 4  
(d) 1, 3 and 4

13. Using thermal-electrical analogy in heat transfer, match List-I (Electrical quantities) with List-II (Thermal quantities) and select the correct answer using the codes given below the lists:

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Voltage</td>
<td>1. Thermal resistance</td>
</tr>
<tr>
<td>B. Current</td>
<td>2. Thermal capacity</td>
</tr>
<tr>
<td>C. Resistance</td>
<td>3. Heat flow</td>
</tr>
<tr>
<td>D. Capacitance</td>
<td>4. Temperature</td>
</tr>
</tbody>
</table>

Codes:

(a) 2 3 1 4  
(b) 4 1 3 2  
(c) 2 1 3 4  
(d) 4 3 1 2

14. Prandtl number of a flowing fluid greater than unity indicates that hydrodynamic boundary layer thickness is:

(a) greater than thermal boundary layer thickness  
(b) equal to thermal boundary layer thickness  
(c) greater than hydrodynamic boundary layer thickness  
(d) independent of thermal boundary layer thickness:

15. Consider the following statements:
The flow configuration in a heat exchanger, whether counterflow or otherwise, will not matter if
1. a liquid is evaporating  
2. a vapour is condensing  
3. mass flow rate of one of the fluids is far greater

Of these statements:

(a) 1 and 2 are correct  
(b) 1 and 3 are correct  
(c) 2 and 3 are correct  
(d) 1, 2 and 3 are correct

16. Consider the following statements regarding condensation heat transfer.
1. For a single tube, horizontal position is preferred over vertical position for better heat transfer.
2. Heat transfer coefficient decreases if the vapour stream moves at high velocity
3. Condensation of steam on an oily surface is dropwise.
4. Condensation of pure benzene vapour is always dropwise.

Of these statements:

(a) 1 and 2 are correct  
(b) 1 and 3 are correct  
(c) 2 and 4 are correct  
(d) 3 and 4 are correct

17. Given that:

$\text{Nu} = \text{Nusselt number. Re} = \text{Reynolds number, Pr} = \text{Prandtl number, Sh} = \text{Sherwood number, Sc} = \text{Schmidt number and Gr} = \text{Grashoff number}$

the functional relationship for free corrective mass transfer is given as:

(a) $\text{Nu} = f(G, Pr)$  
(b) $\text{Sh} = f(Sc, Gr)$  
(c) $\text{Nu} = f(Re, Pr)$  
(d) $\text{Sh} = f(Re, Sc)$

18. What is the value of the shape factor for two infinite parallel surfaces separated by a distance $d$?

(a) 0  
(b) $\infty$  
(c) 1  
(d) $d$

19. If the temperature of a solid surface changes from $27^\circ C$ to $627^\circ C$, then its emissive power changes which ratio?

(a) 6 : 1  
(b) 9 : 1  
(c) 27 : 1  
(d) 81 : 1

20. In case of liquids, what is the binary diffusion coefficient proportional to?

(a) Pressure only  
(b) Temperature only  
(c) Volume only  
(d) All the above
21. A copper block and an air mass block having similar dimensions are subjected to symmetrical heat transfer from one face of each block. The other face of the block will he reaching to the same temperature at a rate:
   (a) Faster in air block
   (b) Faster in copper block
   (c) Equal in air as well as copper block
   (d) Cannot be predicted with the given information

22. The equation of effectiveness 
\( \epsilon = 1 - e^{-NTU} \) for a heat exchanger is valid in the case of:
   (a) Boiler and condenser for parallel flow
   (b) Boiler and condenser for counter flow
   (c) Boiler and condenser for both parallel flow and counter flow
   (d) Gas turbine for both parallel flow and counter flow

23. Thermal diffusivity of a substance is:
   (a) Inversely proportional to thermal conductivity
   (b) Directly proportional to thermal conductivity
   (c) Directly proportional to the square of thermal conductivity
   (d) Inversely proportional to the square of thermal conductivity

24. Air can be best heated by steam in a heat exchanger of:
   (a) Plate type
   (b) Double pipe type with fins on steam side
   (c) Double pipe type with fins on air side
   (d) Shell and tube type

25. A metal plate has a surface area of 2 m², thickness 10 mm and a thermal conductivity of 200 W/mK. What is the thermal resistance of the plate?
   (a) 4 \times 10^4 \text{ K/W}
   (b) 2.5 \times 10^{-3} \text{ K/W}
   (c) 1.5 \times 10^{-3} \text{ K/W}
   (d) 2.5 \times 10^{-3} \text{ K/W}

26. Which one of the following expresses the thermal diffusivity of a substance in terms of thermal conductivity \( k \), mass density \( \rho \) and specific heat \( c \)?
   (a) \( k^2 \rho c \)
   (b) \( 1/\rho c \)
   (c) \( k \rho c \)
   (d) \( \rho c / k^2 \)

27. Which one of the following non-dimensional numbers is used for transition from laminar to turbulent flow in free convection?
   (a) Reynolds number
   (b) Grashof number
   (d) Peclet number
   (d) Rayleigh number

28. For calculation of heat transfer by natural convection from a horizontal cylinder, what is the characteristic length in Grashof number?
   (a) Diameter of the cylinder
   (b) Length of the cylinder
   (c) Circumference of the base of the cylinder
   (d) Half the circumference of the base of the cylinder

29. For a fluid having Prandtl number equal to unity, how are the hydrodynamic boundary layer thickness \( \delta \) and the thermal boundary layer thickness \( \delta_t \), related?
   (a) \( \delta = \delta_t \)
   (b) \( \delta > \delta_t \)
   (c) \( \delta < \delta_t \)
   (d) \( \delta = \delta_t^{1/3} \)

30. Consider the diagram given above in figure. Which one of the following is correct?
   (a) Curve A is for gray body, Curve B is for black body, and Curve C is for selective emitter
   (b) Curve A is for selective emitter, Curve B is for black body, and Curve C is for gray body
   (c) Curve A is for selective emitter, Curve B is for gray body, and Curve C is for black body
   (d) Curve A is for black body, Curve B is for gray body, and Curve C is for selective emitter

31. Which one of the following statements is correct? For a hemisphere, the solid angle is measured:
   (a) in radian and its maximum value is \( \pi \)
   (b) in degree and its maximum value is \( 180^\circ \)
   (c) in steradian and its maximum value is \( 2\pi \)
   (d) in steradian and its maximum value is \( \pi \)

32. For the radiation between two infinite parallel planes of emissivity \( \varepsilon_1 \) and \( \varepsilon_2 \) respectively, which one of the following is the expression for emissivity factor?
   (a) \( \varepsilon_1 \varepsilon_2 \)
   (b) \( \frac{1}{\varepsilon_1 + \varepsilon_2} \)
   (c) \( \frac{1}{\varepsilon_1 + \varepsilon_2} \)
   (d) \( \frac{1}{\varepsilon_1 + \varepsilon_2 - 1} \)

33. What is the radiation intensity in a particular direction?
   (a) Radiant energy per unit time per unit area of the radiating surface
   (b) Radiant energy per unit time per unit solid angle per unit area of the radiating surface
   (c) Radiant energy per unit time per unit solid angle per unit projected area of the radiating surface in the given direction
   (d) Radiant energy per unit time per unit projected area of the radiating surface in the given direction

34. Match List-I with List-II and select the correct answer using the code given below the lists:

List-I
- A. Heat Exchangers
- B. Turbulent flow
- C. Free convection
- D. Radiation heat

List-II
- 1. View factor
- 2. Effectiveness
- 3. Nusselt number
- 4. Eddy diffusivity transfer

Codes:
- A B C D
- (a) 3 1 2 4
- (b) 2 4 3 1
- (c) 3 4 2 1
- (d) 2 1 3 4
35. A wall of thickness 0.6 m has width with normal area 1.5 m² and is made up of material of thermal conductivity 0.4 W/mK. The temperatures on the two sides are 800°C and 100°C what is the thermal resistance of the wall?
(a) 1 W/K
(b) 1.8 W/K
(c) 1 K/W
(d) 1.8 K/W

36. For conduction through a spherical wall with constant thermal conductivity and with inner side temperature greater than outer wall temperature (on dimensional heat transfer), what is the type of temperature distribution?
(a) Linear
(b) Parabolic
(c) Hyperbolic
(d) None of the above

37. A composite wall having three layers of thickness 0.3 m, 0.2 m and 0.1 m and of thermal conductivities 0.6, 0.4 and 0.1 W/mK, respectively, is having surface area 1 m². If the inner and outer temperatures of the composite wall are 1840 K and 340 K, respectively, what is the rate of the heat transfer?
(a) 150 W
(b) 1500 W
(c) 75 W
(d) 750 W

38. What is the expression for the thermal conduction resistance to heat transfer through a hollow sphere of inner radius \( r_1 \) and outer \( r_2 \), and thermal conductivity \( k \)?
(a) \( \frac{(r_2 - r_1)r_1r_2}{4\pi k} \)
(b) \( \frac{4\pi k(r_2 - r_1)}{\eta r_2} \)
(c) \( \frac{r_2 - r_1}{4\pi kr_1r_2} \)
(d) None of above

39. Usually fins are provided to increase the rate of heat transfer. But fins also act as insulation. Which one of the following non-dimensional numbers decides this factor?
(a) Eckert number
(b) Biot number
(c) Fourier number
(d) Peclet number

40. Match List-I with List-II and select the correct answer using the code given below the lists:

<table>
<thead>
<tr>
<th>List-I (Non-dimensional Number)</th>
<th>List-II (Application)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Grashof number</td>
<td>1. Mass transfer</td>
</tr>
<tr>
<td>B. Stanton number</td>
<td>2. Unsteady state</td>
</tr>
<tr>
<td>C. Sherwood number</td>
<td>3. Free convection</td>
</tr>
<tr>
<td>D. Fourier number</td>
<td>4. Forced convection</td>
</tr>
</tbody>
</table>

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

41. The NTU' (Number of Transfer Units) in a heat exchanger is given by which one of the following?

(a) \( \frac{UA}{\min C} \)
(b) \( \frac{UA}{\max C} \)
(c) \( \frac{UA}{C} \)
(d) None of above

42. The temperature distribution curve for a heat exchanger as shown in the figure above (with usual notations) refers to which one of the following:

(a) Tubular parallel flow heat exchanger
(b) Tube in tube counter flow heat exchanger
(c) Boiler
(d) Condenser

43. Which one of the following is correct?

The effectiveness of a fin will be maximum in an environment with:
(a) Free convection
(b) Forced convection
(c) Radiation
(d) Convection and radiation

44. A fin of length, \( l \) protrudes from a surface held at temperature \( T_0 \), it being higher than the ambient temperature \( T_a \). The heat dissipation from the free end of the fin is stated to be negligibly small. What is the temperature gradient \( \frac{dT}{dx} \) at the tip of the fin?

(a) Zero
(b) \( \frac{T_0 - T_1}{l} \)
(c) \( h(T_0 - T_a) \)
(d) \( \frac{T_1 - T_a}{T_0 - T_a} \)

45. Two walls of same thickness and cross sectional area have thermal conductivities in ratio 1 : 2. If same temperature difference is maintained across the two faces of both the walls, what is the ratio of heat flow \( Q_1/Q_2 \)?

(a) 1/2
(b) 1
(c) 2
(d) 4
46. Match List-I with List-II and select the correct answer using the code given below the lists:

<table>
<thead>
<tr>
<th>List-I (Law)</th>
<th>List-II (Effect)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Fourier’s law</td>
<td>1. Mass transfer</td>
</tr>
<tr>
<td>B. Stefan Boltzmann law</td>
<td>2. Conduction</td>
</tr>
<tr>
<td>C. Newton’s law of cooling</td>
<td>3. Convection</td>
</tr>
<tr>
<td>D. Ficks law</td>
<td>4. Radiation</td>
</tr>
</tbody>
</table>

**Codes:**
- (a) 3 1 2 4
- (b) 2 4 3 1
- (c) 3 4 2 1
- (d) 2 1 3 4

47. Which non-dimensional number relates the thermal boundary layer and hydrodynamic boundary layer?
- (a) Rayleigh number
- (b) Peclet number
- (c) Grashoff number
- (d) Prandtl number

48. Match List-I with List-II and select the correct answer using the code given below the lists:

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Gas to liquid</td>
<td>1. Compact</td>
</tr>
<tr>
<td>B. Space vehicle</td>
<td>2. Shell and Tube</td>
</tr>
<tr>
<td>C. Condenser</td>
<td>3. Finned tube</td>
</tr>
<tr>
<td>D. Air pre-heater</td>
<td>4. Regenerative</td>
</tr>
</tbody>
</table>

**Codes:**
- (a) 2 4 3 1
- (b) 3 1 2 4
- (c) 2 1 3 4
- (d) 3 4 2 1

49. Which one of the following is correct?
- (a) Increasing the temperature difference
- (b) Increasing the effective surface area
- (c) Increasing the convective heat transfer coefficient
- (d) None of the above.

50. The value of thermal conductivity of thermal insulation applied to a hollow spherical vessel containing very hot material is 0.5 W/m.K. The convective heat transfer coefficient at the outer surface of insulation is 10 W/m² K. What is the critical radius of the sphere?
- (a) 0.1 m
- (b) 0.2 m
- (c) 1.0 m
- (d) 2.0 m

51. A composite wall of a furnace has 2 layers of equal thickness having thermal conductivities in the ratio of 3 : 2. What is the ratio of the temperature drop across the two layers?
- (a) 2 : 3
- (b) 3 : 2
- (c) 1 : 2
- (d) \( \log_e 2 : \log_e 3 \)

52. In which one of the following materials, is the heat energy propagation minimum due to conduction heat transfer?
- (a) Lead
- (b) Copper
- (c) Water
- (d) Air

53. Match List-I with List-II and select the correct answer using the code given below the lists:

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Heat transfer through solid</td>
<td>1. Radiation heat transfer</td>
</tr>
<tr>
<td>B. Heat transfer from surrounding fluid</td>
<td>2. Fourier’s law of heat conduction to</td>
</tr>
<tr>
<td>C. Heat transfer in boiling liquid</td>
<td>3. Convection heat transfer</td>
</tr>
<tr>
<td>D. Heat transfer from one body to another body separated in space</td>
<td>4. Newton’s law of cooling</td>
</tr>
</tbody>
</table>

**Codes:**
- (a) 3 1 2 4
- (b) 2 4 3 1
- (c) 2 1 3 4
- (d) 3 4 2 1

54. A wall as shown in the given figure is made up of two layers (A) and (B). The temperatures are also shown in the sketch. The ratio of thermal conductivity of two layers is:

\[
\frac{k_A}{k_B} = 2
\]

What is the ratio of the thickness of two layers?
- (a) 0.105
- (b) 0.213
- (c) 0.555
- (d) 0.840

55. What is the critical radius of insulation for a sphere equal to?

\[
\begin{aligned}
 & w = \text{thermal conductivity in } \frac{\text{W}}{\text{mK}} \\
 & h = \text{heat transfer coefficient in } \frac{\text{W}}{\text{m}^2 \text{K}} \\
\end{aligned}
\]

- (a) \( 2kh \)
- (b) \( 2 \frac{k}{h} \)
- (c) \( \frac{k}{h} \)
- (d) \( \sqrt{2kh} \)
56. The heat exchange between a small body having emissivity $\varepsilon_2$ and area $A_1$ and a large enclosure having emissivity $\varepsilon_2$ and area $A_2$ is given by:

$$ q_{1-2} = A_1\varepsilon_1(\varepsilon_1 - \varepsilon_2) $$

What is the assumption for this equation?

(a) $\varepsilon_1 = 1$
(b) $\varepsilon_2 = 0$
(c) $A_1$ is very small as compared to $A_2$
(d) Small body is at centre of enclosure.

57. What is the equivalent emissivity for radiant heat exchange between a small body (emissivity $= 0.4$) in a very large enclosure (emissivity $= 0.5$)?

(a) 0.5  
(b) 0.4  
(c) 0.2  
(d) 0.1

58. Schmidt number is ratio of which of the following?

(a) Product of mass transfer coefficient and diameter to diffusivity of fluid
(b) Kinematic viscosity to thermal diffusivity of fluid
(c) Kinematic viscosity to diffusion coefficient of fluid
(d) Thermal diffusivity to diffusion coefficient of fluid.

59. Natural convection heat transfer coefficients over surface of a vertical pipe and vertical flat plate for same height and fluid are equal. What is/are the possible reason(s) for this?

1. Same height
2. Both vertical
3. Same fluid
4. Same fluid flow pattern.

Select the correct answer using the code given below:

(a) 1 only  
(b) 1 and 2  
(c) 3 and 4  
(d) 4 only

60. A sphere, a cube and a thin circular plate, all made of same material and having same mass are initially heated to a temperature of 250°C and then left in air at room temperature for cooling. Then, which one of the 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.

61. A plane wall is 25 cm thick with an area of 1 m², and has a thermal conductivity of 05 W/mK. If a temperature difference of 60°C is imposed across it, what is the heat flow?

(a) 120 W  
(b) 140 W  
(c) 160 W  
(d) 180 W

62. Which of the following are holier mountings?

1. Fusible plug
2. Blow-off cork

3. Steam trap
4. Feed check valve

Select the correct answer using the code given below:

(a) 1, 2 and 3  
(b) 2, 3 and 4  
(c) 1, 3 and 4  
(d) 1, 2 and 4

63. Intensity of radiation at a surface in perpendicular direction is equal to:

(a) Product of emissivity of surface and $1/\pi$
(b) Product of emissivity of surface and $\pi$
(c) Product of emissive power of surface and $1/\pi$
(d) Product of emissive power of surface and $\pi$

64. In a mass transfer process of diffusion of hot smoke in cold air in a power plant, the temperature profile and the concentration profile will become identical when:

(a) Prandtl No. = 1  
(b) Nusselt No. = 1  
(c) Lewis No. = 1  
(d) Schmidt No. = 1

65. Which one of the following numbers represents the ratio of kinematic viscosity to the thermal diffusivity?

(a) Grashoff number  
(b) Prandtl number  
(c) Mach number  
(d) Nusselt number

66. After expansion from a gas turbine, the hot exhaust gases are used to heat the compressed air from a compressor with the help of a cross flow compact heat exchanger 0.8 effectiveness. What is the number of transfer units of the heat exchanger?

(a) 2  
(b) 4  
(c) 8  
(d) 16

67. A thin flat plate $2m \times 2m$ is hanging freely in air. The temperature of the surrounding is 25°C. Solar radiation is falling on one side of the plate at the rate of 500 W/m². What should be the convective heat transfer coefficient in W/m²°C, if the temperature of the plate is to remain constant at 30°C?

(a) 25  
(b) 50  
(c) 100  
(d) 200

68. In order to achieve maximum heat dissipation, the fin should be designed in such a way that:

(a) It should have maximum lateral surface at the root side of the fin
(b) It should have maximum lateral surface towards the tip side of the fin
(c) It should have maximum lateral surface near the centre of the fin
(d) It should have minimum lateral surface near the centre of the fin

69. A composite hollow sphere with steady internal heating is made of 2 layers of materials of equal thickness with thermal conductivities in the ratio of 1 : 2 for inner to outer layers. Ratio of inside to outside diameter is 0.8. What is ratio of temperature drop across the inner and outer layers?

(a) 0.4  
(b) 1.6  
(c) 2 ln 0.8  
(d) 2.5
70. Up to the critical radius of insulation:
(a) Added insulation increases heat loss
(b) Added insulation decreases heat loss
(c) Convection heat loss is less than conduction heat loss
(d) Heat flux decreases

71. Match List-I (Governing Equations of Heat Transfer) with List-II (Specific Cases of Heat Transfer) and select the correct answer using the code given below the lists:

List-I
(Governing Equations of Heat Transfer)
A. \[ \frac{d^2T}{dr^2} + \frac{2dT}{rdr} = 0 \]
B. \[ \frac{\partial^2T}{\partial x^2} = \frac{1}{\alpha} \frac{\partial T}{\partial t} \]
C. \[ \frac{d^2T}{dr^2} = \frac{1}{r} \frac{dT}{dr} = 0 \]
D. \[ \frac{d^2\theta}{dx^2} = -m^2\theta = 0 \]

List-II
(Specific Cases of Heat Transfer)
1. Pin Fin 1-D case
2. 1-D conduction in cylinder
3. 1-D conduction in sphere
4. Plane slab

(Symbols have their usual meanings)

Codes:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>(b)</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(c)</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>(d)</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

75. Heisler charts are used to determine transient heat flow rate and temperature distribution when:
(a) solids possess infinitely large thermal conductivity
(b) internal conduction resistance is small and convective resistance is large
(c) internal conduction resistance is large and the convective resistance is small
(d) both conduction and convection resistance are almost of equal significance.

76. The heat flow equation through a cylinder of inner radius \( r_1 \) and outer radius \( r_2 \) is desired in the same form as that for heat flow through a plane wall. The equivalent area \( A_m \) is given by:
(a) \[ A_m = A_1 + A_2 \]
(b) \[ A_m = 2\log_e \left( \frac{A_2}{A_1} \right) \]
(c) \[ A_m = A_1 - A_2 \]
(d) \[ A_m = \frac{A_2 - A_1}{2\log_e \left( \frac{A_2}{A_1} \right)} \]

78. The hydrodynamic boundary layer thickness is defined as the distance from the surface where the:
(a) velocity equals the local external velocity
(b) velocity equals the approach velocity
(c) momentum equals 99% of the momentum of the free stream
(d) velocity equals 99% of the local external velocity.

80. If the temperature of a solid surface changes from 27°C to 627°C, then its emissive power will increase in the ratio of:
(a) 3
(b) 9
(c) 27
(d) 81
81. A spherical aluminium shell of inside diameter 2 m is evacuated and used as a radiation test chamber. If the inner surface is coated with carbon black and maintained at 600 K, the irradiation on a small test surface placed inside the chamber is (Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8} \, \text{W/m}^2\cdot\text{K}^4$)

(a) 1000 W/m²  
(b) 3400 W/m²  
(c) 5680 W/m²  
(d) 7348 W/m²

82. Match List-I with List-II and select the correct answer using the codes given below the lists:

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Stefan-Boltzmann law</td>
<td>$q = hA(T_1 - T_2)$</td>
</tr>
<tr>
<td>B. Newton’s law of cooling</td>
<td>$E = \sigma A_b$</td>
</tr>
<tr>
<td>C. Fourier’s law</td>
<td>$q = kA(T_1 - T_2)$</td>
</tr>
<tr>
<td>D. Kirchoff’s low</td>
<td>$q = \sigma A(T_1^4 - T_2^4)$</td>
</tr>
</tbody>
</table>

Codes:
(a) 4 1 3 2  
(b) 4 5 1 2  
(c) 2 1 3 4  
(d) 2 5 1 4

83. A cross-flow type air-heater has an area of 50 m². The overall heat transfer coefficient is 100 W/m² K and heat capacity of both hot and cold stream is 1090 W/K. The value of NTU is:

(a) 1000  
(b) 500  
(c) 5  
(d) 0.2

84. Saturated steam is allowed to condense over a vertical flat surface and the condensate film flows down the surface. The local heat transfer coefficient for condensation:

(a) remains constant at all locations of the surface  
(b) decreases with increasing distance from the top of the surface  
(c) increases with increasing thickness of condensate film  
(d) increases with decreasing temperature differential between the surface and vapour

85. A fin of length ‘l’ protrudes from a surface held at temperature greater than the ambient temperature $t_a$. The heat dissipation from the free end of the fin is assumed to be negligible. The temperature gradient at the fin tip $\left(\frac{dT}{dx}\right)_{x=l}$ is:

(a) Zero  
(b) $\frac{t_l - t_a}{t_0 - t_a}$  
(c) $h(t_0 - t_l)$  
(d) $\frac{t_0 - t_l}{l}$

86. A furnace wall is constructed as shown in the given figure transfer coefficient across the centre casing will be:

(a) 80 W/m² K  
(b) 40 W/m² K  
(c) 20 W/m² K  
(d) 10 W/m² K

87. For laminar flow over a flat plate, the local heat transfer coefficient $'h_x'$ varies as $x^{-1/2}$, where $x$ is the distance from the leading edge ($x = 0$) of the plate. The ratio of the average coefficient $'h_a'$ between the leading edge and some location ‘A’ at $x = x_1$ on the plate the heat transfer coefficient $'h_x'$ at A is:

(a) 1  
(b) 2  
(c) 4  
(d) 8

88. Match List-I (Surfaces with Orientations) with List-II (Equivalent Emissivity) and select the correct answer using the codes given below the lists:

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Infinite parallel planes</td>
<td>$\epsilon_1$</td>
</tr>
<tr>
<td>B. Body 1 completely enclosed by body 2 but body 1 is very small</td>
<td>$\frac{1}{\epsilon_1 + \frac{1}{\epsilon_2} - 1}$</td>
</tr>
<tr>
<td>C. Radiation exchange between two small gray bodies</td>
<td>$\frac{1}{\epsilon_1 + \frac{A_1}{A_2} \left( \frac{1}{\epsilon_2} - 1 \right)}$</td>
</tr>
<tr>
<td>D. Two concentric cylinders with large lengths</td>
<td>$\epsilon_1 \cdot \epsilon_2$</td>
</tr>
</tbody>
</table>

Codes:
(a) 3 1 4 2  
(b) 2 4 1 3  
(c) 2 1 4 3  
(d) 3 4 1 2

89. Two spheres A and B of same material have radii 1 m and 4 m and temperature 4000 K and 2000 K respectively. Which one of the following statements is correct?

The energy radiated by sphere A is:

(a) greater than that of sphere B  
(b) less than that of sphere B  
(c) equal to that of sphere B  
(d) equal to double that of sphere B
90. For an opaque plane surface, the irradiation, radiosity and emissive power are respectively 20, 12 and 10 W/m². What is the emissivity of the surface?  
(a) 0.2  
(b) 0.4  
(c) 0.8  
(d) 1.0

91. Two long parallel surfaces, each of emissivity 0.7, are maintained at different temperatures and accordingly have radiation exchange between them. It is desired to reduce 75% of this radiant heat transfer by inserting thin parallel shields of equal emissivity (0.7) on both sides. What would be the number of shields?  
(a) 1  
(b) 2  
(c) 3  
(d) 4

92. The earth receives at its surface radiation from the sun at the rate of 1400 W/m². The distance of centre of sun from the surface of earth is 1.5 × 10¹¹ m and the radius of sun is 7.0 × 10⁸ M. What is approximately the surface temperature of the sun treating the sun as a black body?  
(a) 3650 K  
(b) 4500 K  
(c) 5800 K  
(d) 6150 K

93. A composite plane wall is made up of two different materials of the same thickness and having thermal conductivities of $k_1$ and $k_2$ respectively. The equivalent thermal conductivity of the slab is:  
(a) $k_1 + k_2$  
(b) $k_1k_2$  
(c) $k_1 + k_2$  
(d) $2k_1k_2$  
$\frac{k_1 + k_2}{k_1k_2}$

94. A copper wire of radius 0.5 mm is insulated with a sheathing of thickness 1 mm having a thermal conductivity of 05 W/m.K. If the thickness of insulation sheathing is raised by 10 mm, then the electrical current carrying capacity of the wire will:  
(a) increase  
(b) decrease  
(c) remain the same  
(d) vary depending upon the electric conductivity of the wire.

95. For the fully developed laminar flow and the transfer in a uniformly heated long circular tube, if the velocity is doubled and the tube diameter 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.

96. For an air conditioning plant above 300 ton, which one of the following system would normally he preferred?  
(a) Ammonia reciprocating compressor  
(b) Centrifugal Chiller  
(c) Absorption refrigeration system  
(d) Hermetic compressor

97. Fresh air intake (air change per hour) recommended for ventilation purposes in the air conditioning system of an office building is:  
(a) 1/2  
(b) 3/2  
(c) 9/2  
(d) 25/2

98. Air refrigeration cycle is used in:  
(a) Commercial refrigerators  
(b) Domestic refrigerators  
(c) Gas liquefaction  
(d) Air-conditioning

99. The flash chamber in a single stage simple vapour compression cycle:  
(a) Increase the refrigerating effect  
(b) Decreases the refrigerating effect  
(c) Increases the work of compression  
(d) Has no effect on refrigerating effect

100. Consider the following statements:  
In a vapour compression system, a thermometer placed in the liquid line can indicate whether the:  
1. Refrigerant flow is too low  
2. Water circulation is adequate.  
3. Condenser is fouled.  
4. Pump is functioning properly.  
Of these statement:  
(a) 1, 2 and 3 are correct  
(b) 1, 2 and 4 are correct  
(c) 1, 3 and 4 are correct  
(d) 2, 3 and 4 are correct

101. Match List-I with List-II and select the correct answer using the codes given below the Lists.  

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Bell Column refrigeration</td>
<td>1. Compressor</td>
</tr>
<tr>
<td>B. Vapour compression refrigeration</td>
<td>2. Generator</td>
</tr>
<tr>
<td>C. Absorption refrigeration</td>
<td>3. Flash chamber</td>
</tr>
<tr>
<td>D. Jet refrigeration</td>
<td>4. Expansion cylinder</td>
</tr>
</tbody>
</table>

Codes:  
(a) 1  
(b) 4  
(c) 3  
(d) 2

102. The maximum COP for the absorption cycle is given by ($T_c =$ generator temperature $T_e =$ environment temperature, $T_E =$ refrigerated space temperature)  
(a) $\frac{T_E(T_G - T_C)}{T_G(T_C - T_E)}$  
(b) $\frac{T_G(T_C - T_E)}{T_E(T_G - T_C)}$  
(c) $\frac{T_C(T_G - T_E)}{T_G(T_C - T_E)}$  
(d) $\frac{T_G(T_C - T_E)}{T_C(T_G - T_E)}$

103. In milk chilling plants, the usual secondary refrigerant is:  
(a) Ammonia solution  
(b) Sodium Silicate  
(c) Glycol  
(d) Brine
104. The desirable combination of properties of a refrigerant include:
(a) High specific heat and low specific volume
(b) High heat transfer coefficient and low latent heat
(c) High thermal conductivity and low freezing point
(d) High specific heat and high boiling point.

105. Which of the following method(s) is/are adopted in the design of air duct system
1. Velocity reduction method
2. Equal friction method
3. Static regain method.
Select the correct answer using the codes given below:
Codes:
(a) 1 alone (b) 1 and 2
(c) 2 and 3 (d) 1, 2 and 3

106. To fix the stale point in respect of air-vapour mixtures, three intrinsic properties are needed. Yet, the psychrometric chart requires only two because:
(a) Water vapour is in the superheated state
(b) The chart is for a given pressure
(c) The chart is an approximation to true values
(d) The mixtures can be treated as a perfect gas

107. During sensible cooling of air:
(a) Its wet bulb temperature increases and dew point remains constant
(b) Its wet bulb temperature decreases and the dew point remains constant
(c) Its wet bulb temperature increases and the dew point decreases
(d) It wet bulb temperature decreases and dew point increases.

108. The expression \( \frac{0.622 p_e}{p_r \cdot P_r} \) is used to determine:
(a) Relative humidity (b) Specific humidity
(c) Degree of saturation (d) Partial pressure

109. The effective temperature is a measure of the combined effects of:
(a) Dry bulb temperature and relative humidity
(b) Dry bulb temperature and air motion
(c) Wet bulb temperature and air motion
(d) Dry bulb temperature, relative humidity and air motion.

110. In air-conditioning design for summer months, the condition inside a factory where heavy work is performed as compared to a factory in which light work is performed should have:
(a) Lower dry bulb temperature and lower relative humidity
(b) Lower dry bulb temperature and higher relative humidity
(c) Lower dry bulb temperature and same relative humidity
(d) Same dry bulb temperature and same relative humidity.

111. For low by pass factor a cooling coil, the fin spacing and the number of tube rows will be respectively:
(a) High and high (b) High and low
(c) Low and high (d) Low and low

112. In vapour compression plant, if certain temperature differences are to be maintained in the evaporator and condenser in order to obtain the necessary heat transfer, then the evaporator saturation temperature must be:
(a) Higher than the derived cold-region temperature and the condenser saturation temperature must be lower than the available cooling water temperature by sufficient amounts
(b) Low than the derived cold-region temperature and the condenser saturation temperature must be lower than the available cooling water temperature by sufficient amounts
(c) Lower than the derived cold-region temperature and the condenser saturation temperature must be higher than the available cooling water temperature by sufficient amounts
(d) Higher than the derived cold-region temperature and the condenser saturation temperature must be higher than the available cooling water temperature by sufficient amounts.

113. One ton refrigeration is equivalent to:
(a) 3.5 kW (b) 50 kJ/s
(c) 1000 J/min (d) 1000 kJ/min

114. The correct sequence of the given components of a vapour compression refrigerator is:
(a) Evaporator, compressor, condenser and throttle valve
(b) Condenser, throttle valve, evaporator and compressor
(c) Compressor, condenser, throttle valve and evaporator
(d) Throttle valve, evaporator, compressor and condenser

115. The coefficient of performance of a refrigerator working on a reversed Carnot cycle is 4 the ratio of the highest absolute temperature to the lowest absolute temperature is:
(a) 1.2 (b) 1.25
(c) 3.33 (d) 4

116. When a burnt out hermetic compressor is replaced by a new one it is desirable to include in the system a large drier-cum-strainer also. This is to be placed in:
(a) Liquid line (b) Suction line
(c) Hot gas line (d) Discharge line

117. A good refrigerant should have:
(a) Large latent heat of vaporization and low operating pressures
(b) Small latent heat of vaporization and high operating pressures
(c) Large latent heat of vaporization and large operating pressures
(d) Small latent heat of vaporization and low operating pressures

118. The most common type of absorption system in use in industrial applications is based on the refrigerant-absorbent combination of:
(a) Air-Water
(b) Lithium bromide-air
(c) Carbon dioxide-Water
(d) Ammonia-Water

119. Solar energy be directly used in:
(a) Vapour compression refrigeration system
(b) Vapour absorption refrigeration system
(c) Air refrigeration system
(d) Jet refrigeration system

120. The equation $f = \frac{p}{ps}v$ is used to calculate the:
(a) Relative humidity
(b) Degree of saturation
(c) Specific humidity
(d) Absolute humidity

Answer with explanations

1. (b) 2. (a)
3. (c) $(k_a)_{avg} = \frac{1}{2}(25 + 15) = 20 \text{ W/m}.K$
   
   $\frac{Q}{A} = (k_a)_{avg} \frac{(t_1 - t_2)}{\Delta x}$
   
   $=\frac{200(300-200)}{0.5} = 4 \text{ kW/m}^2$

4. (b) $Q \propto hL$
   
   $h \propto \sqrt[4]{\frac{\Delta T}{L}}$
   
   $Q \propto L^{3/4}$
   
   $8 \frac{1}{1} = \left(\frac{320}{L}\right)^{3/4}$

   $L = 20 \text{ cm}$

5. (c) $\tilde{N}_u = Gr^{1/4}$ and $Gr \propto T$
   
   $\frac{\tilde{N}_{u2}}{\tilde{N}_{u1}} \propto \left[ \frac{30-20}{180-20} \right] \propto \left( \frac{1}{16} \right)^{1/4} \propto \frac{1}{2}$

   $\tilde{N}_{u2} = \frac{48}{2} = 24$

6. (b) For laminar flow with constant heat flux, $\frac{h_d}{k} = 4.364$

\[ h = \frac{4.364 \times 1}{0.1} = 43.64 \text{ W/m}^2.K \]

And with constant wall temperature,
\[ \frac{h d_0}{k} = 3.657 \]

\[ h = \frac{3.657}{0.1} = 36.57 \text{ W/m}^2.k \]

7. (b) $Q \propto \frac{1}{1 + \frac{1}{e_1^2} - 1} \propto \frac{1}{0.5 + \frac{1}{0.5} - 1} \propto \frac{1}{3}$

\[ Q \propto \frac{1}{0.5 + 0.25 - 1} \propto \frac{1}{0.25 + 0.5 - 1} \propto \frac{1}{5 + 5} \propto \frac{1}{10} \]

With radiation shield,
\[ Q \propto \frac{3}{Q} \]

9. (d) 10. (c) 11. (c) 12. (d) 13. (d)

14. (a) For $Pr > 1, \delta_b > \delta_1$

15. (a) 16. (a) 17. (a)

18. (c) Shape factor for two infinite parallel surfaces,
\[ f_{12} = \frac{1}{\frac{1}{e_1} + \frac{1}{e_2} - 1} = \frac{1}{\frac{1}{e_1} + \frac{1}{e_2} - 1} \]

19. (d) $E \propto T^4$

\[ \frac{E_2}{E_1} = \left( \frac{T_2}{T_1} \right)^4 = \left( \frac{900}{300} \right)^4 = 81 \]

20. (d) 21. (c) 22. (c) 23. (b) 24. (b)

25. $R = \frac{dx}{kA} = \frac{10 \times 10^{-3}}{200 \times 2} = 2.5 \times 10^{-5} \text{ k/W}$

26. (c) 27. (d) 28. (a) 29. (a) 30. (d)

31. (c) 32. (d) 33. (c) 34. (b) 35. (c)

36. (c)
37. (d) \[ Q = \frac{(t_f - t_i)A}{h_1 + h_2 + h_3} = \frac{(1840 - 340) \times 1}{0.3 + 0.2 + 0.1} = \frac{1500}{0.6} = 750 \text{ W} \]

38. (c) 39. (c) 40. (b) 41. (a) 42. (d)

43. (a) 44. (b)

45. (a) \[ Q = kA \frac{dt}{dx} \]
\[ \frac{Q_1}{Q_2} = \frac{k_1}{k_2} = \frac{1}{2} \]

46. (b) 47. (d) 48. (c) 49. (a)

50. (a) \[ r_2 = \frac{2k}{h_0} = \frac{2 \times 0.5}{10} = 0.1 \text{ m} \]

51. (a) \[ \Delta t = \frac{1}{k} \]
\[ \frac{\Delta t_1}{\Delta t_2} = \frac{k_1}{k_2} = \frac{2}{3} \]

52. (d) 53. (b)

54. (b) \[ Q = -kA \frac{\Delta T}{\Delta x} \]
\[ k_A(1325 - 1200) = k_B(1200 - 25) \]
\[ \frac{2 \times 125}{x_1} = \frac{1175}{300 - x_1} \]
\[ 300 - x_1 = 4.7x_1 \]
\[ x_1 = \frac{300}{5.7} = 52.63 \text{ mm} \]
\[ x_2 = 300 - 52.63 = 247.37 \text{ mm} \]
\[ x_1 = \frac{52.63}{247.37} = 0.213 \]

55. (b)

56. (a) \[ \varepsilon_{1-2} = \frac{1}{1 + \varepsilon_1} \left( T_1^4 - T_2^4 \right) \]
\[ \therefore \varepsilon_2 = 1 \]

57. (b) For a small body 1 of emissivity \( \varepsilon_1 \) enclosed in very large body of emissivity \( \varepsilon_2 \) the equivalent emissivity, \( \varepsilon_{eq} = \varepsilon_1 = 0.4 \)

58. (c) 59. (c) 60. (a)

61. (a) \[ Q = -kA \frac{\Delta T}{\Delta x} \]
\[ = 0.5 \times 1 \times \left( \frac{-60}{0.25} \right) = 120 \text{ W} \]

62. (a) 63. (c) 64. (d) 65. (b)

66. (b) \[ \varepsilon = \frac{NTU}{1 + NTU} \]
\[ 0.8 = \frac{NTU}{1 + NTU} \]
\[ 1 + NTU = 1.25 \text{ NTU} \]
\[ NTU = 4 \]

67. (a) \[ Q = hA \Delta T \]
\[ 500 = h \times (2 \times 2) \times (30 - 25) \]
\[ h = \frac{500}{4 \times 5} = 25 \text{ W/m}^2 \cdot \text{°C} \]

68. (a)

69. (d) \[ T_1 - T_2 = \frac{Q(r_2 - \eta)}{4\pi kr_2} \]
\[ T_2 - T_3 = \frac{Q(r_3 - r_2)}{4\pi kr_3} \]
\[ r_2 - r_1 = r_3 = r_2 - r_1 \]
\[ \frac{T_1 - T_2}{T_2 - T_4} = \frac{k_2}{k_1} \times \frac{r_3}{r_1} = \frac{2}{0.8} = 2.5 \]

70. (c) 71. (d)

72. (b) \[ Q = kA \frac{dT}{dx} \]
\[ \Delta T = \frac{6 \times 10^3}{100 \times 60 \times 100 \times 10 \times 10^{-4}} \]

73. (b) \[ Q = kA \frac{dT}{dx} \]
\[ k = \frac{30 \times 10 \times 10^{-2}}{10} = 0.3 \text{ W/m.K} \]

74. (c) 75. (d) 76. (d)

77. (b) \[ q = \frac{T_B - T_A}{h} \]
\[ 800 = \frac{T_B - 25}{h} \]
\[ T_B = 35 \text{°C} \]

78. (d)

79. (a) \[ Nu = \frac{hdt}{k} \]
\[ 25 = \frac{0.1h}{0.03} \]
\[ h = 75 \text{ W/m}^2 \cdot \text{K} \]
80. (d) $\varepsilon \propto T^4$

\[
\varepsilon_2 - \varepsilon_1 = \left[ \frac{273 + 627}{273 + 27} \right] = \left[ \frac{900}{300} \right] = 81
\]

81. (d) $E = \sigma T^4 = 5.67 \times 10^{-8} \times 600^4 = 7348 \text{ W/m}^2$

82. (c)

83. (c) $\text{NTU} = \frac{\text{AU}}{C_{\text{min}}} = \frac{50 \times 100}{1000} = 5$

84. (a)

85. (a)

86. (d) $\frac{Q}{A} = \frac{T_1 - T_2}{\Delta x_1 + \Delta x_2} = \frac{1000 - 120}{\frac{0.3 + 0.3}{k_1 + k_2}} = \frac{880}{1.1} = 800$

For outer casing, $\frac{Q}{A} = \frac{120 - 40}{\frac{1}{h}} = 800$

$h = \frac{800}{80} = 10 \text{ W/m}^2 \cdot \text{K}$

87. (b) $h_x = \frac{h}{\sqrt{x}}$

$h = \frac{1}{x} \int_0^{x} \frac{h}{\sqrt{x}} dx = \frac{2h}{\sqrt{x}}$

$h_x = h = 2$

88. (c)

89. (c) $\frac{E_A}{E_B} = \left( \frac{A_A}{A_B} \right) \left( \frac{T_A}{T_B} \right)^4 = \left( \frac{A_A}{A_B} \right) \left( \frac{T_A}{T_B} \right)^4$

$= \left( \frac{1}{4} \right) \left( \frac{4000}{2000} \right)^4 = 1$

90. (c) Radiosity, $J = \varepsilon E_h + (1 - \varepsilon)G$

where $G =$ Irradiation = 20 W/m$^2$

$E_h =$ emissive power = 10 W/m$^2$

$I = 12 \text{ W/m}^2$

$12 = \varepsilon \times 10 + (1 - \varepsilon) \times 20$

$\varepsilon = 0.8$

91. (b) Heat transfer with shields = $\left( \frac{1}{n + 1} \right) \times \text{Heat transfer without shields}$

Where $n =$ number of shields

$\frac{1}{n + 1} = \frac{1}{4}$

or $n = 3$

92. (c) Temperature of the Sun,

$T_s = \left[ \frac{L^2 G_s}{r^3 \sigma} \right]^{1/4}$

where $L =$ mean distance between the Sun and the Earth

$= 1.5 \times 10^{11} \text{ m}$

$r =$ radius of the Sun $= 7 \times 10^8 \text{ m}$

$G_s =$ rate of radiation from the Sun $= 1400 \text{ W/m}^2$

$\sigma =$ Stefan-Boltzmann constant

$= 5.67 \times 10^{-8} \text{ W/(m}^2 \text{K}^{-4})$

$T_s = \left[ \frac{(1.5 \times 10^{11})^2 \times 1400}{(7 \times 10^8)^3 \times 5.67 \times 10^{-8}} \right]^{1/4}$

$= 5800 \text{ K}$

$= 900 \text{ W/m}_2$

93. (d) 94. (c) 95. (c) 96. (a) 97. (c)

98. (a) 99. (d) 100. (d) 101. (d) 102. (a)

103. (c) 104. (c) 105. (d) 106. (b) 107. (b)

108. (b) 109. (d) 110. (d) 111. (c) 112. (c)

113. (a) 114. (c)

115. (b) COP = $\frac{T_2}{T_1 - T_2} = \frac{1}{\frac{T_1}{T_2} - 1} = 4$

$\frac{4T_1}{T_2} - 4 = 1$

$T_1 = \frac{5}{4} = 1.25$

116. (d) 117. (a) 118. (d) 119. (b) 120. (a)
1. If the governing equation for a flow field is given by \( \nabla^2 \phi = 0 \) and the velocity is given by \( \vec{V} = \nabla \phi \), the:
   (a) \( \nabla \times \vec{V} = 0 \)
   (b) \( \nabla \times \vec{V} = 1 \)
   (c) \( \nabla^2 \times \vec{V} = 1 \)
   (d) \( (\nabla \cdot \vec{V}) \vec{V} = \frac{\partial \vec{V}}{\partial t} \)

2. Decrease in temperature, in general, results in:
   (a) an increase in viscosities of both gases and liquids
   (b) a decrease in the viscosity of liquids and gases
   (c) an increase in the viscosity of liquids and a decrease in that of gases
   (d) a decrease in the viscosity of liquids and an increase in that of gases

3. Which of the following equations are forms of continuity equations?
   \( V \) is the velocity and \( \forall \) is volume
   1. \( A_1 \vec{V}_1 = A_2 \vec{V}_2 \)
   2. \( 1 \frac{du}{dx} + \frac{dv}{dy} = 0 \)
   3. \( \int \rho \vec{V} \ dv \ A + \int \rho \ d\forall = 0 \)
   4. \( \frac{1}{r} \frac{\partial (rv_x)}{\partial r} + \frac{\partial v_x}{\partial z} = 0 \)

Select the correct answer using the codes below:

**Codes:**
(a) 1, 2, 3 and 4  (b) 1 and 2  (c) 3 and 4  (d) 2, 3 and 4

4. Consider the following assumptions:
   1. Steady flow
   2. Inviscid flow
   3. Flow along a stream line
   4. Conservative force field

For an ideal fluid, which of the statements are correct?
(a) 1 and 2  (b) 1, 2 and 4  (c) 2, 3 and 4  (d) 1, 3 and 4

5. A pipe friction test shows that, over the range of speeds used for the test, the non-dimensional friction factor ‘f’ varies inversely with Reynolds Number. From this, one can conclude that the:
   (a) fluid must be compressible
   (b) fluid must be ideal
   (c) pipe must be smooth
   (d) flow must be laminar

6. Chezy’s formula is given by \( (m, i, C \text{ and } V \text{ are, respectively, the hydraulic mean depth, slope of the channel, Chezy’s constant and average velocity of flow}) \)
   (a) \( V = i \sqrt{mC} \)
   (b) \( V = Ci \sqrt{m} \)
   (c) \( V = mi \sqrt{C} \)
   (d) \( V = \sqrt{miC} \)

7. In rough turbulent flow in a pipe, the friction factor would depend upon:
   (a) velocity of flow
   (b) pipe diameter
   (c) type of fluid flowing
   (d) pipe condition and pipe diameter

8. The differential manometer connected to Pitot static tube used for measuring fluid velocity gives:
   (a) static pressure
   (b) total pressure
   (c) dynamic pressure
   (d) difference between total pressure and dynamic pressure

9. The speed of the air emerging from the blades of a running table fan is intended to be measured as a function of time. The point of measurement is very close to the blade and the time period of the speed fluctuation is four times the time taken by the blade to complete one revolution. The appropriate method of measurement would involve the use of:
   (a) a Pitot tube
   (b) a hot wire anemometer
   (c) high speed photography
   (d) a Schlieren system.

10. Match List-I with List-II and select the correct answer using the codes given below the lists:

**List-I**
- Rotameter
- Venturimeter
- Orificemeter
- Flow nozzle

**List-II**
- Vena contracta
- End contraction
- Tapering tube
- Convergent-divergent
- Bell mouth entry

**Codes:**
(a) A B C D
(b) 1 2 3 4
(c) 3 4 1 5
(d) 5 4 2 1

(e) 3 5 1 2
11. In turbulent flow over an impervious solid wall:
   (a) viscous stress is zero at the wall
   (b) viscous stress is of the same order of magnitude as the Reynolds’s stress
   (c) the Reynolds’s stress is zero at the wall
   (d) viscous stress is much smaller than Reynolds’s stress.

12. The ‘velocity defect law’ is so named because it governs a:
   (a) reverse flow region near a wall
   (b) slip-stream flow at low pressure
   (c) flow with a logarithmic velocity profile a little away from the wall
   (d) recirculating flow near a wall

13. The frictional head loss through a straight pipe ($h_f$) can be expressed as $h_f = \frac{1}{2} \rho u^2$ for both laminar and turbulent flows. For a laminar flow, $\nu$ is given by (Re is the Reynolds Number based on pipe diameter)
   (a) $24/\text{Re}$
   (b) $32/\text{Re}$
   (c) $64/\text{Re}$
   (d) $128/\text{Re}$

14. The laminar boundary layer thickness in zero pressure gradient flow over a flat plate along the $x$-direction varies as ($x$ is the distance from the leading edge)
   (a) $x^{-1/2}$
   (b) $x^{1/7}$
   (c) $x^{1/2}$
   (d) $x$

15. In the region of the boundary layer nearest to the wall where vorticity is not equal to zero, the viscous forces are:
   (a) of the same order of magnitude as the inertial forces
   (b) more than inertial forces
   (c) less than inertial forces
   (d) negligible

16. Drag on cylinders and spheres decrease when the Reynolds number is in the region of $2 \times 10$ since:
   (a) flow separation occurs due to transition to turbulence
   (b) flow separation is delayed due to onset of turbulence
   (c) flow separation is advanced due to transition to turbulence
   (d) flow reattachment occurs

17. Match the common observations in List-I with the explanations in List-II and select the correct answer using the codes given below the lists:

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Singing of telephone</td>
<td>1. Vortex flow</td>
</tr>
<tr>
<td>B. Velocity profile in a pipe wires is initially parabolic and then flattens</td>
<td>2. Drag</td>
</tr>
<tr>
<td>C. Formation of cyclones</td>
<td>3. Vortex shedding</td>
</tr>
<tr>
<td>D. Shape of rotameter tube</td>
<td>4. Turbulence</td>
</tr>
<tr>
<td></td>
<td>5. Compressibility</td>
</tr>
</tbody>
</table>

Codes:
A B C D
(a) 5 2 1 4
(b) 3 4 5 2
(c) 3 4 1 2
(d) 5 2 1 4

18. In turbomachinery, the relevant parameters are volume flow rate, density, viscosity bulk modulus, pressure difference, power consumption, rotational speed and a characteristic dimension. According to Buckingham $\Pi$ theorem, the number of independent non-dimensional groups for this case is:
   (a) 3
   (b) 4
   (c) 5
   (d) 6

19. List-I gives 4 dimensionless number and List-II given the types of force which are one of the constituents describing the number. Match List-I with List-II and select the correct answer using the codes given below the lists:

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Euler number</td>
<td>1. Pressure force</td>
</tr>
<tr>
<td>B. Froude number</td>
<td>2. Gravity force</td>
</tr>
<tr>
<td>C. Mach number</td>
<td>3. Viscous force</td>
</tr>
<tr>
<td>D. Webber number</td>
<td>4. Surface tension</td>
</tr>
<tr>
<td></td>
<td>5. Elastic force</td>
</tr>
</tbody>
</table>

Codes:
A B C D
(a) 2 3 4 5
(b) 3 2 4 5
(c) 2 1 3 4
(d) 1 2 4 5

20. The realization velocity potential on fluid flow indicates that the:
   (a) flow must be irrotational
   (b) circulation around any closed curve must have a finite value
   (c) flow is rotational and satisfies the continuity equation
   (d) velocity must be non-zero.

21. Both free vortex and forced vortex can be expressed mathematically as function of tangential velocity $V$ and the corresponding radius $r$. Free vortex and forced vortex are definable through $V$ and $r$ as:

**Free Vortex**
- $V = r \times \text{const.}$
- $V = r \times \text{const.}$
- $V^2 = r \times \text{const.}$
- $V^2 = r \times \text{const.}$

**Forced vortex**
- $V = r \times \text{const.}$
- $V = r \times \text{const.}$
- $V^2 = r \times \text{const.}$
- $V^2 = r \times \text{const.}$

22. The hydrostatic force on the curved surface AB shown in the given Figure acts:
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