ME-Objective-Paper-I

1. Which of the following parameters of fluid will increase as a result of friction while flowing adiabatically through a convergent divergent nozzle?

(A) Available heat drop (B) Entropy

(C) Stagnation pressure (D) Stagnation temperature

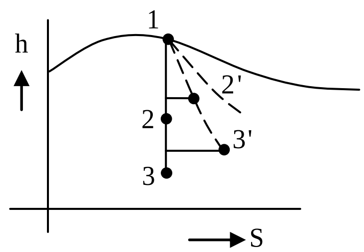
Key: (B)

Exp: The actual heat drop will be less than isentropic drop in a convergent-Divergent nozzle

1-2-3 $\rightarrow$ Isentropic heat drop

$1-2'-3' \rightarrow$ Adiabatic heat drop

Entropy increases



2. In a shockwave, the flow passes from a

(A) Subsonic to sonic state

(B) Subsonic to a supersonic state

(C) Supersonic to a sonic state

(D) Supersonic to subsonic state

Key: (D)

Exp: In a shock wave the flow always passes from supersonic to subsonic state

3. A jet of water issues from a nozzle with a velocity of 20m/s and it impinges normally on a flat plate moving away from it at 10m/s. If the cross section area of the jet is $0.01m^2$ and the density of water is taken as $1000kg/m^3$, then the force developed on the plate will be

(A) 100N (B) 200N (C) 1000N (D) 2000N

Key: (C)

Exp: $\vec{F} = \rho A\, V_{rel}^2$

$= \rho A (V - U)^2 = 10^3 \times 0.01 \times (20 - 10)^2 = 1000N$

4. A two dimensional velocity field is given by

$$V = (x^2 - y^2 + x)i - (2xy - y)j$$

The convective acceleration at (x, y) = (1, 2) is

(A) 0 (B) 14 units (C) 2 units (D) None of the above

Key: (D)

Exp: Net acceleration $\vec{a} = \frac{\partial \vec{V}}{\partial t} + U_x \frac{\partial \vec{V}}{\partial x} + V_y \frac{\partial \vec{V}}{\partial y} + W_z \frac{\partial \vec{V}}{\partial z}$

$\frac{\partial \vec{V}}{\partial t}$ → temporal acceleration

$U_x \frac{\partial \vec{V}}{\partial x} + V_y \frac{\partial \vec{V}}{\partial y} + W_z \frac{\partial \vec{V}}{\partial z}$ → Convective acceleration

$$\vec{a}_{conv} = (x^2 - y^2 + x)((2x+1)\hat{i} - 2y\hat{j}) + (-2xy + y)[-2y\hat{i} - (2x-1)\hat{j}]$$

at point $(1,2)$

$$\vec{a}_{conv} = -2\times(3\hat{i} - 4\hat{j}) + (-2)\times(-4\hat{i} - \hat{j})$$

$$= -2[-\hat{i} - 5\hat{j}]$$

$$|\vec{a}_{conv}| = 2\sqrt{26}$$

$$= 10.2 \text{ units}$$

5. Jet pumps are often used in process industry for their

(A) Large capacity

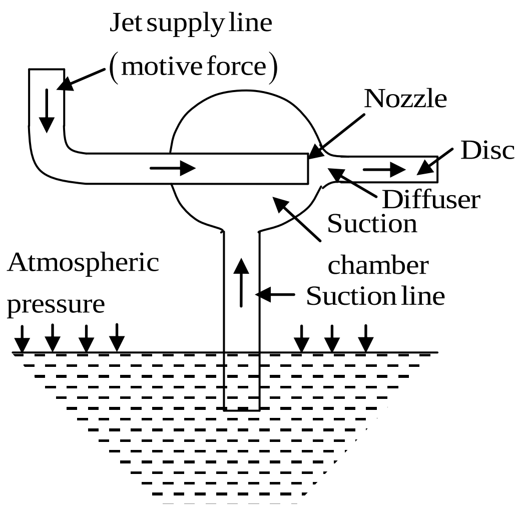
(B) High efficiency

(C) Capacity to transport gases, liquids and mixtures of both

(D) None of the above

Key: **(C)**

Exp: A jet pump has no moving parts. A simple jet pump, consists of a jet supply line, a jet or nozzle, a suction line, a suction chamber, a diffuser, and a discharge line.



In a jet pump, pumping action is created as a fluid (water, steam, or air) passes at a high velocity through a nozzle and into a chamber that has an inlet and outlet opening.

Principle of a jet pump: Upon starting up, the rapidly moving jet fluid pushes on and gives sufficient motion to the air (or whatever substance may be in the suction chamber) to carry it out through the discharge line. Displacement of the air from the suction chamber creates a partial vacuum within the suction chamber, causing fluid to flow through the suction line. The fluid entering the chamber from the suction line is picked up by the high velocity fluid, thus providing continuous pumping action. Eductor (a kind of jet pump) is designed to pump large volumes of water and Portable educator used for emergency dewatering of a flooded compartment.

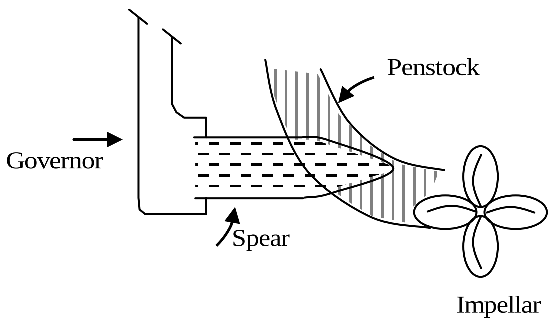
6. Mainly hydraulic turbines are used to drive the electrical alternators which require maintaining the peripheral speed constant even at part load conditions to avoid the change in frequency of electric power. The governing of the hydraulic turbine is done by

(A) Controlling the flow area (B) Controlling the Velocity

(C) Using the fly wheel (D) Combined control flow area and velocity

Key: (A)

Exp: Governors in hydraulic turbine only controls & maintains the impeller velocity as required, by only controlling the flow through spear which controls the area (or dia) of penstock.



7. The a hydraulic coupling

(A) The magnitudes of input and output torques are equal

(B) The magnitude of input torque is greater than output torque

(C) The magnitude of input torque is less than output torque

(D) The magnitude of input torque is negligible as compared to output torque

Key: (A)

Exp: Hydraulic Coupling

Hydraulic coupling is used to transmit power from driving to driven shaft which consists mainly of two elements i.e. centrifugal pump impeller connected to driving shaft and a turbine wheel runner on driven shaft.

Power = Torque * Angular Velocity

8. Considering the flow of steam through a Convergent-Divergent nozzle under real conditions, where supersaturation occurs, the difference between the saturation temperature corresponding to the pressure and the supersaturated temperature is defined as degree of

(A) Under cooling (B) Superheat

(C) Reaction (D) Saturation

Key: (B)

9. For maximum discharge of hot gases through a chimney, the height of hot column producing draught is

(A) Twice the height of chimney

(B) Equal to the height of chimney

(C) Half the height of chimney

(D) None of the above

Key: (B)

Exp: for $(\theta)_{max}$; $h_{chimney} = h_{hot\,column}$

10. Consider the following statements:

(1) In natural convection turbulent flow over heated vertical plate, h is independent of the characteristic length

(2) In turbulent flow, non-dimensional heat transfer coefficient for natural convection over a heated vertical plate is given by

$$Nu = c(Pr)^{\frac{1}{3}}$$

Which of the above statements is/are correct?

(A) 1 only (B) Both 1 and 2 (C) 2 only (D) Neither 1 nor 2

Key: (D)

Exp: In natural convection through turbulent flow over heated vertical plate,

$$\bar{h} = 1.32\left(\frac{\Delta T}{L}\right)^{\frac{1}{3}}$$

$$10^9 < R_a < 10^{12}$$

11. For accelerating an ideal gas isentropically from rest to supersonic speed, we require a convergent-divergent nozzle. To decelerate an ideal gas isentropically from supersonic speed to subsonic speed the diffuser should be

(A) Diverging (B) Converging

(C) Convergent-divergent (D) Divergent-convergent

Key: (D)

Exp: For decelerating an ideal gas isentropically, we should use a divergent-convergent diffuser such that the flow will be supersonic to subsonic.

12. Consider the following statements with regard to steam turbines:

(1) A single stage impulse turbine has a nozzle angle α. The maximum blade efficiency of the turbine will be $\cos^2\alpha$

(2) For a reaction steam turbine with identical stator and rotor blades, the blade velocity for maximum blade efficiency is equal to inlet steam velocity

(3) Velocity compounded impulse steam turbine gives less speed and less efficiency

Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (A)

Exp: Velocity compounded impulse turbine will not give less speed

13. Surging is the phenomenon of

(A) Steady, periodic and reversed flow

(B) Unsteady, periodic and reversed flow

(C) Unsteady, periodic and uniform flow

(D) 1-dimensional steady and uniform flow

Key: (B)

14. In an axial flow compressor, the ratio of pressure in the rotor blades to the pressure rise in the compressor in one stage is known as

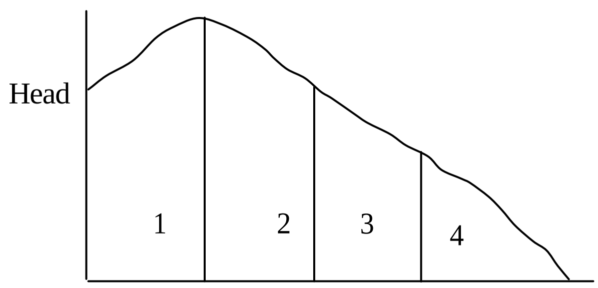
(A) Work factor (B) Slip factor

(C) Degree of reaction (D) Pressure coefficient

Key: (C)

Exp: Degree of reaction $= \dfrac{\Delta P_R}{\Delta P_s + \Delta P_R}$

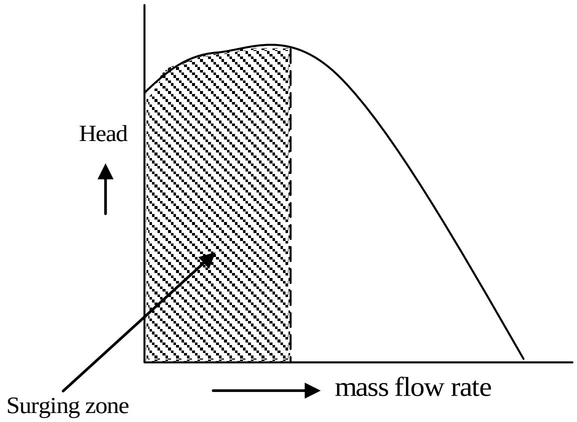
15. In the following diagram, for axial flow compressors, surging is likely to occur in



(A) 4^{th} zone (B) 2^{nd} zone (C) 1st zone (D) 3rd zone

Key: (C)

Exp:



16. In a centrifugal compressor, an increase in speed at a given pressure ratio causes

(A) Increase in flow and increase in efficiency

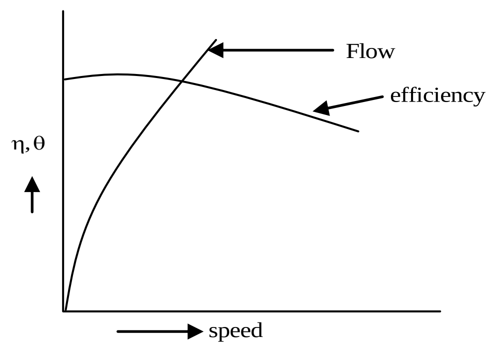
(B) Increase in flow and decrease in efficiency

(C) Decrease in flow and decrease in efficiency

(D) Decrease in flow and increase in efficiency

Key: (B)

Exp:



Centrifugal compressor characteristics

17. The optimum ratio of blade speed to tangential component of jet speed for the de Laval and Parsons turbine are

(A) 1 for both

(B) ½ for de Laval turbine and 1 for Parsons turbine

(C) 1 for de Laval turbine and ½ for Parsons turbine

(D) 1/2 for both

Key: (B)

Exp: For Impulse turbine $\Rightarrow \left(\frac{V_b}{V_J}\right) = \frac{1}{2}$; For Reaction turbine (50%) $\Rightarrow \left(\frac{V_b}{V_J}\right) = 1$

18. What is the correct sequence in increasing order of air handling/ compressing machines based on the pressure ratios?

(A) Air blower, axial flow fan, centrifugal compressor and reciprocating compressor

(B) Axial flow fan, centrifugal compressor, air blower and reciprocating compressor

(C) Air blower, centrifugal compressor, axial flow fan, and reciprocating compressor

(D) Axial flow fan, air blower, centrifugal compressor and reciprocating compressor

Key: (A)

Exp: Pressure rating varies as

$$\text{Fan}(1\text{bar}) < \text{Blower}(1.2\text{bar}) < \text{axial flow compressor}(2\text{bar}) < \text{centrifugal compressure}(2.5\text{bar}) < \text{Reciprocating compressor}(\text{more than } 5\text{bar})$$

19. The head developed is maximum (Keeping other parameters such as rotor diameter, speed, width, inlet angle, etc. constant) for a centrifugal compressor with

(A) Rotor with backward curved blades

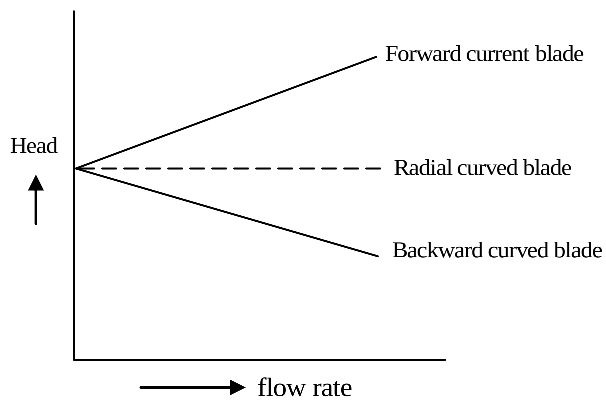
(B) Rotor with forward curved blades

(C) Rotor with radial blades

(D) All of the above

Key: (B)

Exp:



20. The velocity of a gas flowing through a duct is 300m/s; its temperature is $127^{O}C$; Gas constant R = 0.25 kJ/kg K, the ratio of specific heat is $C_p/C_v = \gamma = 1.6$. What is the value of Mach number?

(A) 0.70 (B) 0.72 (C) 0.75 (D) 0.77

Key: (C)

Exp: $$m = \frac{300}{\sqrt{\gamma RT}}$$

$$\therefore m = \frac{300}{\sqrt{1.6 \times 0.25 \times 10^3 \times 400}} = \frac{300}{400} = 0.75$$

21. A body of mass 20kg falls freely in vacuum. It has fallen through a vertical distance of 50m. The gravitational acceleration may be assumed as $10\,m/s^2$. What is the thermodynamic work done by the body?

(A) 1000Nm (B) 10kJ (C) 0 (D) 1kNm

Key: **(C)**

Exp: As the body falls freely in vacuum, the thermodynamic work will be zero.

22. When a system is taken from state 'x' to state 'y', 30kJ of heat flows into the system and the system does 10kJ of work. When the system is returned from 'y' to 'x' along another path, work done on the system is 8 kJ. What is the amount of heat liberated or absorbed?

(A) 12kJ of the heat liberated (B) 28 kJ of heat liberated

(C) 12kJ of the heat absorbed (D) 28 kJ of heat absorbed

Key: **(B)**

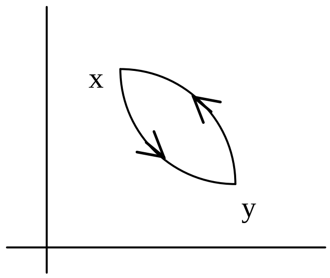
Exp: Process X – Y:-

Heat supplied to system (θ_{x-y}) = 30 kJ

Work done by system $(W_{x-y}) = 10\text{ kJ}$

Process Y-X:-

Work done on system $(W_{y-x}) = 8\text{kJ}$



During Cyclic Process,

Net heat transferred = Net work done

$\theta_{x-y} + \theta_{y-x} = W_{x-y} + W_{y-x}$

$30 + \theta_{y-x} = 10 - 8$

$\theta_{y-x} = 2 - 30$

$\theta_{y-x} = -28\text{kJ}$

$\therefore$ 28 kJ of Heat is liberated

23. A closed gaseous system undergoes a reversible constant pressure process at 2 bar in which 100kJ of heat is rejected and the volume change from $0.2m^3$ to $0.1m^3$. The change in the internal energy of the system is

(A) $-100\,kJ$ (B) $-80\,kJ$ (C) $-60\,kJ$ (D) $-40\,kJ$

Key: **(B)**

Exp: Process $\rightarrow$ Reversible Constant pressure process

Heat Rejected $(Q) = 100\text{ kJ}$

Pressure $(P) = 2\text{ bar} = 2\times10^2\text{ kPa}$

Initial volume $(V_1) = 0.2\text{ m}^3$

Final volume $(V_2) = 0.1\text{ m}^3$

$$Q = dU + W$$
$$-100 = dU + P(V_2 - V_1)$$
$$= dU + \{2\times10^2(0.1-0.2)\}$$
$$\therefore \quad dU = -80kJ$$

24. A Carnot engine receives 100kJ of heat at 600K. Heat is rejected at 300 K. The displacement volume is 0.2 m^3. The mean effective pressure is

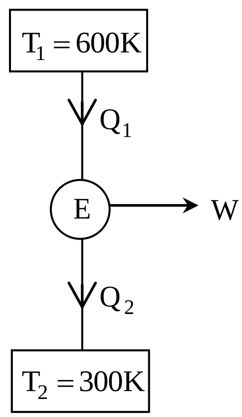
(A) 2 bar (B) 2.5 bar (C) 3 bar (D) 3.5 bar

Key: (B)

Exp: Heat absorbed $(Q_1) = 100$ kJ

Swept Volume $(V_s) = 0.2\ m^3$

Carnot engine



$$\Rightarrow 1 - \frac{T_2}{T_1} = 1 - \frac{Q_2}{Q_1}$$
$$\Rightarrow Q_2 = \frac{T_2}{T_1}\times Q_1$$
$$= \frac{300}{600}\times100$$
$$= 50\ kJ$$

$\therefore$ Heat rejected $(Q_2) = 50kJ$

Work done $(W) = Q_1 - Q_2 = 100 - 50 = 50$ kJ

$$\text{Mean effective pressure} = \frac{\text{Work done}}{\text{Swept volume}} = \frac{50}{0.2} = 250\ kPa$$

$P_{mean} = 2.5$ bar

25. The values of heat transfer and work transfer for the process of a thermodynamic cycle are given below:

Process	**Heat transfer (kJ)**	**Work transfer (kJ)**
1	300	300
2	00	250

3	-100	-100
4	00	-250

The thermal efficiency of the cycle and the work ratio will be respectively:

(A) 33% and 0.66 (B) 66% and 0.36

(C) 36% and 0.66 (D) 33% and 0.36

Key: (B)

Exp:

Process	**Heat transfer (kJ)**	**Work transfer (kJ)**
1	300	300
2	0	250
3	-100	-100
4	0	-250

$$\text{Thermal efficiency } (\eta_{th}) = \frac{\text{Net workdone}}{\text{Heat supplied}} = \frac{300+250-100-250}{300} = \frac{200}{300} = 66\%$$

$$\text{Work ratio } = \frac{\text{Net workdone}}{\text{Gross work}} = \frac{300+250-100-250}{300+250} = \frac{200}{550} = 0.36$$

26. The performance of reciprocating compressors with provision of cooling cylinder is compared with

(A) Mechanical efficiency (B) Isothermal efficiency

(C) Adiabatic efficiency (D) Isentropic efficiency

Key: (B)

Exp: Ideal efficiency of compressor tends towards isothermal when the processes which are adiabatic are tending to isothermal processes.

27. A body of mass 2kg and Cp = 1.00kJ/kg K is available at 600 K. If the atmosphere is 300K and ln 2 = 0.693, the maximum work obtainable from the body till it comes to equilibrium with the atmosphere is

(A) 150kJ (B) 142kJ (C) 184.2kJ (D) 190.5kJ

Key: (C)

Exp: Mass of body (m) = 2kg

Specific Heat (C_P) = 1 kJ/kgK

Body temperature T_1 = 600 K

Surrounding temperature, $T_0 = 300\text{ K}.$

*l*n 2 = 0.693

Maximum work $= Q_1 - T_0(S_1 - S_0)$

$$= \{mc_p(T_1 - T_0)\} - \left\{T_0 \times mc_p \ln\left(\frac{T_1}{T_0}\right)\right\}$$

$$= \{2\times1\times(600-300)\} - \{300\times2\times1\times l\text{n}\,2\}$$

$$= 184.2\text{ kJ}$$

28. A liquid of heat capacity 5 J/K in an insulated container is heated electrically from 300 K to 600 K. If In 2 = 0.693, entropy generation of the universe would be

(A) 6.93 J/K (B) 3.465 J/K (C) 34.65 J/K (D) 10.65 J/K

Key: (B)

Exp: Heat capacity $(mC_p) = 5\text{ J/K}$

Initial temperature $(T_1) = 300\text{ K}$

Final temperature $(T_2) = 600\text{ K}$

Ln 2 = 0.693

$$\Delta s = mc_p \ln\left(\frac{T_2}{T_1}\right)$$

$$= 5\times0.693$$

$$= 3.465\ {}^{J}\!/\!_{K}$$

29. Which of the following relationships represents the change of entropy of perfect gas?

(i) $Cp\dfrac{dT}{T} + \dfrac{R}{V}dV$

(ii) $Cp\dfrac{dT}{T} - \dfrac{R}{V}dP$

(iii) $Cv\frac{dP}{P}+Cp\frac{dV}{V}$

(iv) $Cp\frac{dp}{p}-Cv\frac{dV}{V}$

(A) 1, 2 and 4 only (B) 1, 2 and 3 only

(C) 2, 3 and 4 only (D) 1, 2, 3 and 4

Key: (B)

30. Consider the following statements regarding availability:

(i) It is generally conserved

(ii) It can either be negative or positive

(ii) It is the maximum theoretical work obtainable

(iv) It can be destroyed in irreversibility

Which of the above statements are correct?

(A) 3 and 4

(B) 1 and 2

(C) 1 and 3

(D) 2 and 4

Key: (A)

Exp: Available energy is the maximum theoretical work that can be obtained and is called exergy. It will be destroyed by Irreversibility.

31. During a thermodynamic process, 100 kJ of heat is transferred from a reservoir at 800K to a sink at 400K. The ambient temperature is 300 K. The loss of available energy is

(A) 27.5 kJ (B) 32.5kJ (C) 37.5kJ (D) 62.5kJ

Key: (C)

Exp: Source Temperature $(T_1)=800K$

Sink temperature $(T_2)=400\text{ K}$

Ambient temperature $(T_0)=300K$

Heat transferred $(Q_1)=100kJ$

$$\frac{100}{800}-\frac{Q_2}{400}=0$$

$$Q_2=50\text{ kJ}$$

$$\frac{100}{800}-\frac{Q_0}{300}=0$$

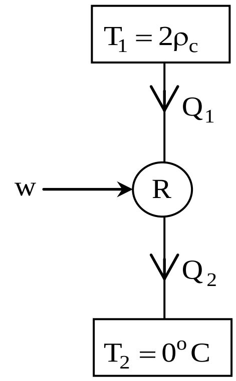
$$Q_0=37.5\text{ kJ}$$

32. A refrigerator that operates on a Carnot cycle is required to transfer 2000kJ/min to the atmosphere at $27^{O}C$, where the low temperature reservoir is a $0^{O}C$. What is the power required?

(A) 200W (B) 32.93kW (C) 200kW (D) 3.33kW

Key: (D)

Exp: Heat extracted = 2000 kJ/min



Carnot cycle , $\frac{T_2}{T_1 - T_2} = \frac{Q_2}{W}$

$$\frac{273}{27} = \frac{2000/60}{W}$$

$W = 3.33\,kW$

33. Consider the following statements:

(1) Carnot, Ericsson and Stirling cycles are ideal power cycles that are completely reversible

(2) Ericsson cycle is not a practical engine cycle

(3) Stirling cycle is the only practical power cycle among the above

(4) All these cycles have the same thermal efficiency

Which of the above statements are correct?

(A) 1, 2, 3 and 4 (B) 1, 2 and 4 only (C) 2, 3 and 4 only (D) 1, 2 and 3 only

Key: (B)

Exp: Stirling, Ericsson & Carnot cycle have same thermal efficiency when operating under same temperature limits. All these cycles are ideal cycles and are reversible.

34. The Vapour pressure of a liquid at any arbitrary temperature can be estimated approximately with the help of

(A) Gibbs equation (B) Joule-Kelvin equation

(C) Clausius-Clapeyron equation (D) Gibbs-Duhem equation

Key: (C)

Exp: Clausius – Clapeyron equation is used to determine the vapour pressure of a liquid at any temperature.

35. In order to determine the quality of wet steam by a separating and throttling calorimeter, the steam should be first separated and then throttled such that the final state is

(A) Saturated vapour only

(B) Superheated vapour only

(C) At a pressure higher than the original pressure

(D) A mixture of saturated liquid and vapour

Key: (B)

Exp: In a separating & throttling calorimeter, the steam is first separated and then throttled such that the final state of steam obtained is superheated

36. The work done in a steady flow process is equal to $-\int$ vdp. In the Rankine cycle, the turbine work is much greater than the pump work because
(A) The specific volume of water is much higher than that of steam
(B) The specific volume of steam is much higher than that of water
(C) The pressure drop in the turbine is much higher than that in the pump
(D) There is less irreversibility in the turbine than in the pump

Key: **(B)**

Exp: $(V)_{steam} >>> (V)_{H_2O}$

37. The maximum net specific work obtainable in an ideal Brayton cycle of T_{max} = 900K and $T_{min} = 400K$ is given by
(A) 100Cp (B) 500Cp (C) 700Cp (D) 800Cp

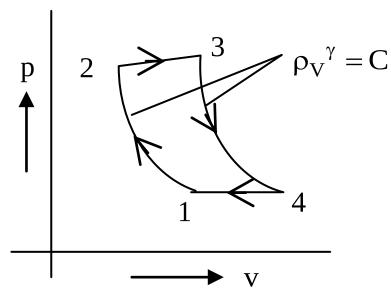
Key: **(A)**

Exp: $T_3 = T_{max} = 900\text{ K}$

$T_1 = T_{min} = 400K$

Conduction for maximum work

$$r_p = \left(\frac{T_{max}}{T_{min}}\right)^{\frac{\gamma}{2(\gamma-1)}} = \left(\frac{T_3}{T_1}\right)^{\frac{\gamma}{2(\gamma-1)}}$$



Work done is Brayton cycle

$$= C_p[T_3 - T_2 - T_4 + T_1]$$

$$= C_p\left[T_3 - (T_1.T_3)^{1/2} - (T_1.T_3)^{1/2} + T_1\right]$$

$$= C_p\left[900 - 2[900 \times 400]^{1/2} + 400\right]$$

$$= C_p[1300 - 1200]$$

$$= 100\ C_p$$

$$T_2 = T_1.(r_p)^{\frac{\gamma-1}{\gamma}}$$

$$= T_1\left[\left(\frac{T_3}{T_1}\right)^{\frac{\gamma}{2(\gamma-1)}}\right]^{\frac{\gamma-1}{\gamma}}$$

$$= (T_1.T_3)^{1/2}$$

38. The tendency of detonation is high in engines of larger cylinder diameter because of

(A) Higher intake pressure in larger cylinder

(B) Higher fuel/air ratio in larger cylinder

(C) Flame having to travel longer distance in larger cylinder

(D) Sparks are advanced more in larger cylinder

Key: (A)

Exp: The flame requires a longer time to travel across the combustion chamber of a larger engine. Therefore, a larger engine has a greater tendency for knocking or detonation than a smaller engine since there is more time for the end gas to auto-ignite.

39. Consider the following statements

(1) The only practical way of improving efficiency of Otto cycle is to increase the compression ratio of an internal combustion engine

(2) Ericsson cycle needs heat transfer in all the processes

(3) Ericsson and Stirling cycles employ regenerative heat exchangers for reversible heat transfer

(4) Atkinson cycle has a greater specific work than a comparable Otto cycle engine

Which of the above statements are correct?

(A) 1, 2, 3 and 4 (B) 1, 2, and 4 only

(C) 2, 3 and 4 only (D) 1, 2, and 3 only

Key: (D)

Exp: 1. Efficiency of Otto cycle increases with increase in compression ratio.

2. In Ericsson of Otto cycle, two isothermal and two isobaric processes are present and heat transfer takes place in all processes.

3. Stirling & Ericsson cycles are both external combustion engines with regenerators.

4. Due to greater expansion ratio in Atkinson cycle the specific work obtainable is greater when compared to Otto cycle.

40. For a multistage reciprocating compressor; which of the following statements are correct?

(1) It decreases volumetric efficiency

(2) The work of compression is reduced

(3) The high pressure cylinder is smaller in size

(A) 1 and 2 only (B) 2 and 3 only

(C) 1 and 3 only (D) 1, 2 and 3

Key: (B)

Exp: For a multi-stage compression we observe

(i) Improved overall volumetric efficiency

(ii) A reduction in work required per stroke and therefore the total driving power.

(iii) Multi-cylinder give more uniform torque and better mechanical balance thus needing smaller fly wheel.

41. In a convergent divergent nozzle, the velocity at throat of nozzle is given by

(A) $V = \left[\dfrac{2np_1v_1}{n-1}\right]^{\frac{1}{2}}$ (B) $V = \left[\dfrac{2np_1v_1}{n+1}\right]^{\frac{1}{2}}$

(C) $V = \left[2np_1v_1\right]^{\frac{1}{2}}$ (D) $V = \left[np_1v_1\right]^{\frac{1}{2}}$

Where p_1 = initial entry pressure, v_1 = initial entry specific volume and n = isentropic index of expansion

Key: (B)

Exp: Rate of flow (m) $= A_2\sqrt{\dfrac{2n}{(n-1)}P_1\rho_1\left[\left(\dfrac{P_2}{P_1}\right)^{\frac{2}{n}} - \left(\dfrac{P_2}{P_1}\right)^{\frac{n+1}{n}}\right]}$

Let $\dfrac{P_2}{P_1} = r$

$$m = A_2\sqrt{\frac{2^n}{(n-1)}P_1\rho_1\left[r^{\frac{2}{n}} - r^{\frac{n+1}{n}}\right]}$$

$$m = f\left(n, A_2, \rho_1, P_1, r\right)$$

Let us assume all the parameters except "r" remain same m = f(r)

For maximum flow rate

$$\frac{dm}{dr} = 0$$

$$r = \left(\frac{2}{n+1}\right)^{\left(\frac{n}{n-1}\right)}$$

Velocity at exit $= \dfrac{m}{\rho_2 A_2} = \sqrt{\left(\dfrac{2n}{n+1}\right)p_1V_1}$

42. Which of the following refrigeration systems is not suitable for solar cooling?

(A) Ejector refrigeration system

(B) Vapour absorption system

(C) Desiccant refrigeration system

(D) Vortex tube refrigeration system

Key: (B)

Exp: Vapour absorption system is most suitable for solar cooling.

43. A tank of length, breadth and height in the ratio of 2:1:2 is full of water. The ratio of hydrostatic force at the bottom to that at any larger vertical surface is

(A) 1 (B) 4 (C) 2 (D) 3

Key: (A)

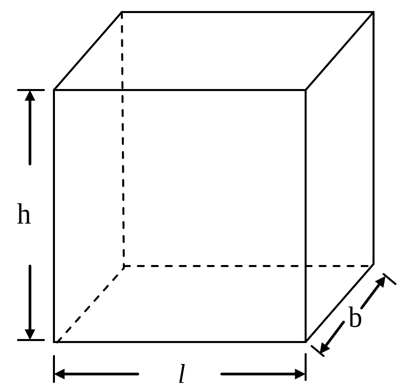
Exp: $l:b:h = 2:1:2$

Area of bottom = $l \times b$

Force on bottom surface $(f_b) = \rho gh \times l \times b$

Max surface Area of vertical wall = $l \times h$

Force on larger vertical surface $(f_v) = \frac{1}{2} \times \rho gh \times h \times l$



$$\frac{f_b}{f_v} = \frac{\rho gh\, lb}{\frac{1}{2}\rho gh\, lh} = 2\left(\frac{b}{h}\right)$$

$$= 2 \times \frac{1}{2}$$

$$\frac{f_b}{f_V} = 1$$

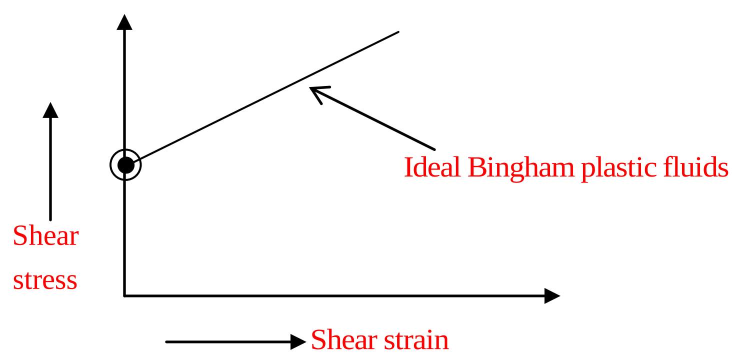
44. Which of the following fluids exhibit a certain shear stress at zero shear strain rate followed by a straight line relationship between shear stress and shear strain rate?

(A) Newtonian fluids (B) Ideal Bingham plastic fluids

(C) Pseudo-plastic fluids (D) Dilatent fluids

Key: (B)

Exp:



45. What is the specific gravity of a marble stone, which weighs 400 N in air, and 200 N in water? ($g = 10 m/s^2$)

(A) 8 (B) 6 (C) 4 (D) 2

Key: (D)

Exp: Weight of stone in air $=\rho_s \times V \times g$

Weight of stone in water $=\rho_s Vg-\rho_l V\times g$

$$\rho_s Vg = 400$$

$$(\rho_s-\rho_l)Vg = 200$$

$$\frac{(\rho_s-\rho_l)}{\rho_s} = \frac{200}{400}$$

$$[1-0.5] = \frac{\rho_l}{\rho_s}$$

$$\frac{\rho_s}{\rho_l} = 2$$

46. What is the intensity of pressure in the following SI units, when specific gravity of mercury is 13.6 and the intensity of pressure is 400 KPa?

(A) 0.3 bar or 4.077 m of water or 0.299 m of Hg

(B) 4 bar of 5.077 m of water or 0.399 m of Hg

(C) 0.3 bar or 5.077 m of water or 0.599 m of Hg

(D) 4 bar or 4.077 m of water or 0.299 m of Hg

Key: (D)

Exp: Given that pressure = 400 Kpa & Specific gravity = 13.6

$$P = \rho gh$$

$$400 = 13.6\times 9.81\times h$$

$$h = \frac{400}{13.6\times 9.81}$$

$$h = 2.99 \text{ m of}$$

$$400 = \rho_w gh$$

$$h = \frac{400}{9.01}$$

$$= 40.77 \text{ m of water}$$

47. Consider the following statements:

(1) If a small upward displacement is given to a floating body, it results in the reduction of the buoyant force acting on the body

(2) A slight horizontal displacement does not change either the magnitude or the location of the buoyant force

Which of the above statements is/are correct?

(A) Both 1 and 2 (B) 1 only

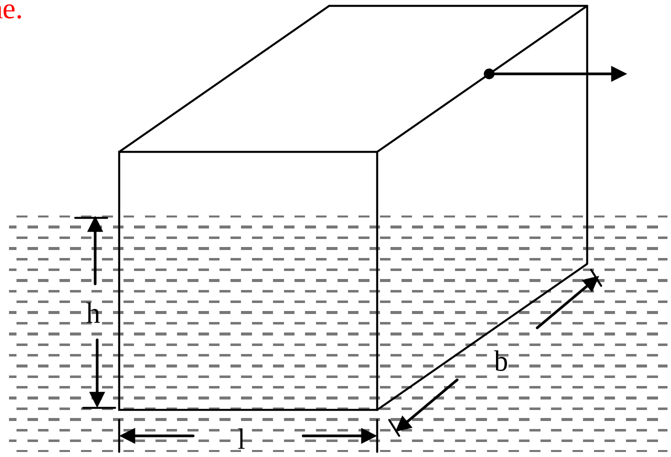
(C) 2 only (D) Neither 1 nor 2

Key: (A)

Exp: Buoyancy force $= \rho lbhg$

If body is displaced upward h decrease hence Buoyancy force decrease

If body is displaced in Horizontal direction h remain same hence Buoyancy force and its location remain same.



48. State whether following flow field is physically possible?

$y = 3xy^2 + 2x + y^2$ and $v = x^2 - 2y - y^3$

(A) Possible for Steady, incompressible flow

(B) Possible for unsteady, incompressible flow

(C) Possible for steady, compressible flow

(D) Not possible

Key: **(A)**

Exp: $$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho V_x)}{\partial x} + \frac{\partial(\rho V_y)}{\partial y} + \frac{\partial}{\partial z}(\rho V_z) = 0$$

Let e = constant (Incompressible)

$$0 + \rho\left[\frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} + \frac{\partial V_z}{\partial z}\right] = 0$$

Only we are interested is 2-D

$$\frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial_y} = 0$$

$$\frac{\partial}{\partial x}\left[3xy^2 + 2x + y^2\right] + \frac{\partial}{\partial y}\left[x^2 - 2y - y^3\right]$$

$$\left(3y^2 + 2\right) + \left(-2 - 3y^2\right) = 0$$

Hence it is only incompressible flow

49. A steady incompressible flow field is given by $u = 2x^2 + y^2$ and $v = -4xy$. The convective acceleration along x-direction at point (1, 2) is

(A) 6 units (B) 24 units

(C) -8 units (D) -24 units

Key: (C)

Exp:

$$\vec{a} = \underbrace{\frac{\partial V}{\partial t}}_{\text{temporal component}} + \underbrace{U_x \frac{\partial \vec{V}}{\partial x} + V_y \frac{\partial \vec{V}}{\partial y} + V_z \frac{\partial \vec{V}}{\partial z}}_{\text{Convective acceleration}}$$

In 2-D convective acceleration $= V_x \frac{\partial \vec{V}}{\partial x} + V_y \frac{\partial \vec{V}}{\partial y}$

$$= \left(2x^2 + y^2\right)\left[4x\hat{i} - 4y\hat{j}\right] + \left(-4xy\right)\left[2y\hat{i} - 4x\hat{j}\right]$$

$$= \left(2\times1 + 4\right)\left[4\hat{i} - 8\hat{j}\right] + \left(-8\right)\left[4\hat{i} - 4\hat{j}\right]$$

$$= 24\hat{i} - 48\hat{j} - 32\hat{i} + 32\hat{j}$$

$$= -8\hat{i} - 16\hat{j}$$

Convective acceleration is equal to (-8) units

50. Consider the following remarks pertaining to the irrotational flow:

(1) The Laplace equation of steam function $\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = 0$ must be satisfied for the flow to be potential.

(2) The Laplace equation for the velocity potential $\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = 0$ must be satisfied to fulfil the criterion of mass conservation i.e., continuity equation.

Which of the above statements is/are correct?

(A) 1 only (B) Both 1 and 2

(C) 2 only (D) Neither 1 nor 2

Key: (B)

Exp:

$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = 0 \quad \{\text{continuity eqn}\}$$

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = 0 \quad \{\text{potential flow or Irrotational flow}\}$$

51. In a two dimensional incompressible fluid flow field, the steam function at a point P (2, 1) is given by an expression $\psi = 2xy$. The value of velocity potential at P is

(A) 3 (B) 2.5 (C) 4 (D) 5

Key: (A)

Exp:

$$d\phi = \left(\frac{\partial \phi}{\partial x}\right)dx + \left(\frac{\partial \phi}{\partial y}\right)dy$$

$$= (2x)dx + (-2y)dy$$

$$d\phi = d\left(x^2 - y^2\right)$$

at point $(2,1)$

$\phi = 3$

52. In a stream line steady flow, two points A and B on a steam line are 1m a part and the flow velocity varies uniformly from 2 m/s to 5 m/s. What is the acceleration of fluid at B?

(A) $3 m/s^2$ (B) $6 m/s^2$ (C) $9 m/s^2$ (D) $15 m/s^2$

Key: (D)

Exp: $\vec{a} = \frac{\partial \vec{V}}{\partial t} + V_x \frac{\partial \vec{V}}{\partial x} + V_y \frac{\partial \vec{V}}{\partial y} + V_z \frac{\partial \vec{V}}{\partial z}$

For steady $\frac{\partial \vec{V}}{\partial t} = 0$

$\vec{a} = V_x \frac{\partial \vec{V}}{\partial x} + V_y \frac{\partial \vec{V}}{\partial y} + V_z \frac{\partial \vec{V}}{\partial z}$

If flow is along the stream line

$\vec{a} = V \frac{\partial \vec{V}}{\partial s}$

Since velocity varies linearly with distance

$\frac{\partial V}{\partial s} = \frac{\Delta s}{\Delta s} = \frac{(5-2)}{1}$

$\frac{\partial V}{\partial s} = 3$

$\overrightarrow{a_B} = 5 \times 3 = 15 m/s^2$

53. The stream function is given by $\psi = 3xy$, then the velocity at the point (2, 3) is

(A) 9 (B) -6 (C) 117 (D) 10.8

Key: (D)

Exp: $\vec{V} = \frac{\partial\psi}{\partial y}\hat{i} + \left(\frac{\partial\psi}{\partial x}\right)\hat{j}$

$\vec{V} = 3x\hat{i} - 3y\hat{j}$ at point $(2,3)$

$\vec{V} = 6\hat{i} - 9\hat{j}$

$= 3\sqrt{4+9}$

$\vec{V} = 10.8$

54. The head loss in a sudden expansion from 8cm diameter pipe to 16cm diameter pipe in terms of velocity V_1 in the smaller pipe is

(A) $\frac{1}{4}\left(\frac{V_1^2}{2g}\right)$ (B) $\frac{3}{16}\left(\frac{V_1^2}{2g}\right)$ (C) $\frac{1}{64}\left(\frac{V_1^2}{2g}\right)$ (D) $\frac{9}{16}\left(\frac{V_1^2}{2g}\right)$

Key: (D)

Exp: Sudden Expansion

$$h_1 = \frac{V^2}{2g}\left[1 - \frac{A_1}{A_2}\right]^2$$

$$= \frac{V^2}{2g}\left[1 - \left(\frac{8}{16}\right)^2\right]^2$$

$$= \frac{V^2}{2g}\left[1 - \frac{1}{4}\right]^2$$

$$h_1 = \frac{9}{16}\left(\frac{V^2}{2g}\right)$$

55. What is the ratio of momentum thickness to the boundary layer thickness δ when the layer velocity profile is given by

$\frac{u}{U_\infty} = \left(\frac{y}{\delta}\right)^{\frac{1}{2}}$?

(A) 0.133 (B) 0.333 (C) 0.166 (D) 0.136

Where u is velocity at height y above surface and U_∞ is free stream velocity of flow.

Key: (C)

Exp: $\theta = \int_0^\delta \left[\frac{U}{U_\infty} - \left(\frac{U}{U_\infty}\right)^2\right] dy$

$= \int_0^\delta \left(\sqrt{\frac{y}{\delta}} - \frac{y}{\delta}\right) dy$

$Q = \frac{2}{3}\delta - \frac{1}{2}\delta$

$\frac{\theta}{\delta} = \frac{1}{6} = 0.166$

56. The boundary layer thickness at a given distance from the leading edge of a flat plate is

(A) More for lighter fluid

(B) More for denser fluid

(C) Less for denser fluid

(D) Less for lighter fluid

Key: (A) & (C)

Exp: $\delta^* \propto \frac{1}{\sqrt{\rho}}$

Hence boundary layer thickness shall be more for lighter & less for denser fluid.

57. In laminar flow through a circular pipe, the discharge varies

(A) Linearly with fluid density

(B) Inversely with pressure drop

(C) Directly as square of pipe radius

(D) Inversely with fluid viscosity

Key: (D)

Exp: Volume flow rate for fully developed laminar pipe flow

$Q = \frac{\pi D^4 \Delta p}{128\,\mu l}$

$Q \alpha \frac{1}{\mu}$

58. A fluid is flowing over a flat plate. At distance of 8 cm from the leading edge, the Reynolds number is found to be 25600. The thickness of the boundary layer at this point is

(A) 1.5mm (B) 2.5mm (C) 4.0mm (D) 5.0mm

Key: (B)

Exp: $\delta^* = \frac{5x}{\sqrt{R_e}} = \frac{5\times 8}{\sqrt{25600}} = 0.25\,\text{cm}$

or $\delta^* = 2.5\,\text{mm}$

59. Air is flowing over a flat plate with a free steam velocity of 24m/s, and its kinematic viscosity is 72×10^{-6} m^2/s. If at a particular point, the Reynolds number is 30000, its location from the leading edge is

(A) 0.05m (B) 0.07 m (C) 0.08m (D) 0.09m

Key: (D)

Exp: $\text{Reynold Number}\left(Re_x\right) = \frac{\text{Velocity}\times x}{\text{Kinematives losely}\left(\vartheta\right)}$

$3\times 10^4 = \frac{24\times x}{72\times 10^{-6}}$

$x = 0.09\text{m}$

60. Consider the following statements pertaining to boundary layer on a flat plate:

(i) The thickness of laminar boundary layer at a distance x from the leading edge varies as $x^{1/2}$

(ii) The thickness of turbulent boundary layer at a distance x from the leading edge varies as $x^{4/5}$

(iii) Boundary layer is laminar when Reynolds number is less than 5×10^5

Which of the above statements are correct?

(A) 1, 2 and 3 (B) 1 and 2 only (C) 1 and 3 only (D) 2 and 3 only

Key: (A)

Exp: Boundary layers thickness $\frac{\delta}{x} = \frac{4.91}{\sqrt{R_{ex}}}$

$\delta = \frac{4.91x}{\sqrt{\frac{Vx}{\vartheta}}}$

$\delta \alpha \sqrt{x}$

$\frac{\delta}{x} = \frac{0.38}{\left(Re_x\right)^{1/5}}$

$\delta = \frac{0.38\,x^{\left(1-\frac{1}{5}\right)}}{\left(\frac{V}{\vartheta}\right)^{1/5}} \Rightarrow \delta \alpha x^{\frac{4}{5}}$

For flat plate critical Reynolds number $Re = 5\times 10^5$

Below thus volume it is laminar

61. An open cycle pressure gas turbine uses a fuel of calorific value 40,000 kJ/kg with air-fuel ratio of 80:1 and develops a net output of 80kJ/kg of air. The thermal efficiency of the cycle is

(A) 12% (B) 16% (C) 20% (D) 18%

Key: (B)

Exp: Calorific value (C.V) = 40,000 kJ/kg

$$\frac{m_a}{m_f} = 80:1$$

Work output (W) = 80 kJ/kg of air

$$\text{Heat supplied } (Q) = \frac{m_f}{m_a} \times \text{C.V}$$

$$= \frac{1}{80} \times 40,000$$

$$= 500 \text{ kJ/kg of air}$$

$$\eta_{thermal} = \frac{W}{Q} = \frac{80}{500}$$

$$= 16\%$$

62. Consider the following statements regarding cycles:

(1) Stirling cycle consists of two isothermal and two adiabatic processes

(2) In vapour compression cycle, the refrigerant is in the form of dry saturated vapour before entering compressor.

(3) Diesel cycle consists of one constant pressure; one constant volume and two isentropic processes

Which of the above statements are correct?

(A) 1, 2 and 3 (B) 1 and 2 only (C) 1 and 3 only (D) 2 and 3only

Key: (D)

Exp: 1. In a stirling cycle we have 2-Isothermal and 2-constant volume process.

2. In vapour compression cycle, the refrigerant generally should be dry saturated at the beginning of compression

3. Diesel cycle consists of 2-isentropic processes (expansion and compression),1-Constant Pressure (Heat addition) & 1-constant volume (Heat Rejection).

63. The efficiency of the vapour power Rankine cycle can be increased by

(1) Increasing the temperature of the working fluid at which heat is added

(2) Increasing the pressure of the working fluid at which heat is added

(3) Decreasing the temperature of the working fluid at which heat is rejected

Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (D)

Exp: Rankine cycle efficiency can be improved by

1. Increasing the heat input temperature & pressure
2. Reducing the condenser pressure and temperature at which heat rejection takes place.

64. An ideal refrigerating machine works between the temperature limits of $45^{O}C$ and $-8^{O}C$. The power required per ton of refrigeration is

(A) 1.0 kW (B) 1.2 kW (C) 0.8 kW (D) 0.7 kW

Key: (D)

Exp: R.E = 1TR = 3.5 kW

$T_1 = 45^o C$

$T_2 = -8^o C$

$$\frac{T_2}{T_1 - T_2} = \frac{R.E}{W} \Rightarrow \frac{265}{45-(-8)} = \frac{3.5}{W}$$

$W = 0.7$ kW

65. Consider the following data referring to a refrigerator working on Vapour-compression refrigeration cycle:

(1) Enthalpy at entry to compressor = 180 kJ/kg

(2) Enthalpy at exit to compressor = 210 kJ/kg

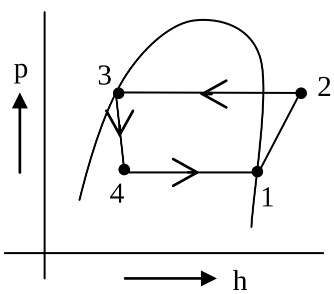
(3) Enthalpy at exit to condenser = 60kJ/kg

What is the COP of the refrigerator?

(A) 2 (B) 3 (C) 4 (D) 5

Key: (C)

Exp:



$h_1 = 180$ kJ/kg

$h_2 = 210$ kJ/kg

$h_4 = h_{f_3} = 60$ kJ/kg

$$C.O.P = \frac{h_1 - h_4}{h_2 - h_1} = \frac{180-60}{210-180} = \frac{120}{30} = 4$$

66. Consider the following statements about two-stage reciprocating compressors:

(1) For the same pressure ratio the volumetric efficiency of a two-stage compressor is more than that of single stage compressor.

(2) A two-stage compressor requires minimum work when inter-cooling is perfect.

(3) The intercooler pressure p_2 is the average of inlet pressure p_1 and delivery pressure p_3.

Which of the above statements are correct?

(A) 1 and 3 only (B) 1 and 2 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (B)

Exp: For a multi-stage compression we observe

(i) Improved overall volumetric efficiency

(ii) A reduction in work required per stroke and therefore the total driving power.

(iii) Multi-cylinder give more uniform torque and better mechanical balance thus needing smaller fly wheel.

By decreasing delivery pressure the volumetric efficiency of a reciprocating air compressor can be increased. For perfect intercooling $P_2 = \sqrt{P_3 P_1}$, and work done will be minimum.

67. A single cylinder, 4-stroke cycle engine is fitted with a rope brake. The diameter of the brake wheel is 600 mm and the rope diameter is 26 mm. The dead weight on the brake is 200 N and the spring balance reads 30 N. If the engine runs at 450 rpm what will be the brake power of the engine?

(A) 1.5kW (B) 2.5kW (C) 3.5kW (D) 4.5kW

Key: (B)

Exp: D = 600 mm = 0.6m, d = 26 mm = 0.026m, W = 200N, S = 30N, N = 450rpm

$$B.P = \frac{(W-S)\pi(D+d)\times N}{60\times 1000}$$

$$= \frac{(200-300)\times\pi(0.6+0.026)\times 450}{60000}$$

$$= 2.5\text{ kW}$$

68. Consider the following statements:

(1) Fuels of higher octane number can be employed at higher compression ratio

(2) In CI engines, brakes specific fuel consumption decreases with increasing load

Which of the above statements is/are correct?

(A) Both 1 and 2 (B) 1 only

(C) 2 only (D) Neither 1 nor 2

Key: (A)

Exp: 1. High octane number fuels require high compression ratio.

2. As the load increases specific fuel consumption decrease in Diesel engines

69. A spark ignition engine has a compression ratio of 8 and the volume before compression is 0.9 m^3/kg. Net heat interaction per cycle is 1575 kJ/kg. What is the mean effective pressure?

(A) 20kPa (B) 20bar (C) 2000 Pa (D) 2 bar

Key: (B)

Exp: Compression ratio $\left(\frac{r_1}{r_2}\right) = 8$

Initial volume $(V_1) = 0.9\, m^3/kg$

Net heat interaction per cycle = Net work done per cycle = 1575 kJ/kg

$$\text{Mean effective pressure} = \frac{\text{Work done}}{\text{Swept volume}}$$

$$= \frac{1575}{V_1 - V_2}$$

$$= \frac{1575}{V_1\left(1 - \frac{V_2}{V_1}\right)}$$

$$= \frac{1575}{0.9\left[1 - \frac{1}{8}\right]}$$

$$= \frac{1575 \times 8}{0.9 \times 7}$$

$$= 2000\text{ kPa}$$

$$= 20\text{ bar}$$

70. In case of a vapour compression refrigerator, if the condenser temperature of the refrigerant is closer to the critical temperature, then there will be

(1) Excessive power consumption

(2) High compression

(3) Large volume flow

Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (D)

Exp: As the condenser temperature is closer to the critical temperature, the power required for compression will be more and there should be large volume of refrigerant flow.

71. Which of the following factors can control detonation in spark ignition engines?

(1) Increasing engine rpm

(2) Advancing spark timing

(3) Making fuel-air ratio very rich

(A) 1, 2 and 3 (B) 1and 2 only (C) 2 and 3 only (D) 1 and 3 only

Key: (D)

Exp: The detonation can be controlled or even stopped by the following methods:

1. Increasing engine r.p.m
2. Retarding spark.
3. Reducing pressure in the inlet manifold by throttling.
4. Making the ratio too lean or too rich, preferably latter.
5. **Water injection**. Water injection increases the delay period as well as reduces the flame temperature.
6. Use of high octane fuel can eliminate detonation. High octane fuels are obtained by adding additives known as dopes (such as tetra-ethyl of lead, benzol, xylene etc.), to petrol.

72. Consider the following statements:

(1) Free expansion of a gas

(2) Slow heating of oil from a constant temperature source

(3) Evaporation of water at its saturation temperature by a source at the same temperature

(4) Isentropic compression of an ideal gas

Which of these processes are irreversible?

(A) 1 and 2 (B) 2 and 3 (C) 3 and 4 (D) 1 and 4

Key: (A)

Exp:
1. During free expansion of a gas entropy change occurs and the process is irreversible.
2. Heating of oil from a constant temperature source is irreversible.

73. Consider the following statements regarding supercharging of CI engines:

(1) Supercharging results in quieter and smoother operation of a CI engine

(2) Supercharging of a CI engine requires increase in valve overlap

(3) The limit of supercharging for a CI engine is reached by thermal and mechanical loading

Which of the above statements are correct?

(A) 1, 2 and 3 (B) 1 and 2 only (C) 1 and 3 only (D) 2 and 3 only

Key: (A)

Exp: Increase in pressure and temperature of the intake air reduces significantly delay and hence the rate of pressure rise resulting in a better, quieter and smoother combustion. This improvement in combustion allows a poor quality fuel to be used in a diesel engine and it is also not sensitive to the type of fuel used. The increase in intake temperature reduces volumetric and thermal efficiency but increase in density due pressure compensates for this and intercooling is not necessary except for highly supercharged engines.

If an unsupercharged engine is supercharged engine it will increase the reliability and durability of the engine due to smoother combustion and lower exhaust temperatures. The degree of supercharging is limited by thermal and mechanical load on the engine and strongly depends on the type of supercharger used and design of the engine.

Effects of supercharging on performance of the engine:

1. The 'power output' of a supercharged engine is higher than its naturally aspirated counterpart.

2. The 'mechanical efficiencies' of supercharged engines are slightly better than the naturally aspirated engines.

3. Inspite of better mixing and combustion due to reduced delay a mechanically supercharged Otto engine almost always have 'specific fuel consumption' higher than a naturally aspirated engine.

74. Consider the following statements with regard to IC engines:

(1) For best fuel economy of spark ignition engines, the fuel-air mixture should be lean

(2) With supercharging, the specific consumption in compression ignition engines increases

(3) With increase of load, knocking tendency in compression ignition engines decreases

Which of the above statements are correct?

(A) 1 and 2 only (B) 2 and 3 only

(C) 1 and 3 only (D) 1, 2 and 3

Key: (C)

Exp: Supercharging is the process of supplying air or fuel air mixture higher than that pressure of naturally aspirated engines.

Due to increase in load, knocking tendency in CI engine decreases. In SI engines to get best fuel economy the fuel-air mixture should be lean.

75. Consider the following statements pertaining to supercharging of engines:

(1) The power output for a given engine increase

(2) The loss of power due to altitude is compensated

(3) The increase is supercharging pressure decreases the tendency to denote in spark ignition engines

(4) The mechanical efficiency of supercharged engines is quite high compared to naturally aspirated engines

Which of the above statements are correct?

(A) 1 and 4 (B) 3 and 4 (C) 2 and 3 (D) 1 and 2

Key: (D)

Exp: Supercharging increases tendency for deterioration in SI engine.

η_m is only slightly improved.

76. Consider the following statements for a combustion process:

(i) The total mass of each chemical element in the reactants is preserved in the products

(ii) The presence of carbon monoxide in the products of combustion implies incomplete combustion

Which of the above statements is/are correct?

(A) 1 only (B) 2 only (C) Neither 1 nor 2 (D) Both 1 and 2

Key: (D)

77. There is a uniform distributed source of heat present in a plane wall whose one side (x = 0) is insulated and other side (x = L) is exposed to ambient temperature (T_∞), with heat transfer coefficient (h). Assuming constant thermal conductivity (k), steady state and one dimensional conduction, the temperature of the wall is maximum at x equal to

(A) 0 (B) L (C) L/2 (D) L/4

Key: (A)

Exp: At the beginning ΔT is maximum.

78. An insulating material with a thermal conductivity, k = 0.12 W/mK is used for a pipe carrying steam. The local coefficient of heat transfer (h) to the surrounding is $4 W/m^2K$. in order to provide effective insulation, the minimum outer diameter of the pipe should be

(A) 45mm (B) 60mm (C) 75mm (D) 90mm

Key: (B)

Exp: $r_c = \frac{k}{h_0} = \frac{0.12}{4} = 0.03 m = 30\ mm$

$$\therefore \quad \text{Minimum diameter} = 2 \times r_c = 2 \times 30 = 60\ mm$$

79. A plane wall is 20cm thick with an area perpendicular to heat flow of $1m^2$ and has a thermal conductivity of 0.5 W/mK A temperature difference of 100^OC is imposed across it. The rate of heat flow is

(A) 0.10kW (B) 0.15kW (C) 0.20kW (D) 0.25kW

Key: (D)

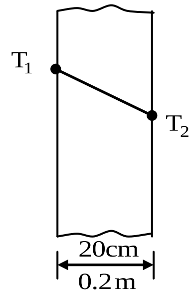
Exp: $A = 1m^2$

$k = 0.5\ W/mK$

$dx = 0.2\ m$

$T_1 - T_2 = 100^o C$

$$Q = kA\frac{T_1 - T_2}{dx}$$
$$= 0.5 \times 1 \times \frac{100}{0.2}$$
$$= 250W$$
$$= 0.25kW$$



80. The laminar flow is characterized by Reynolds number which is

(A) Equal to critical value
(B) Less than the critical value
(C) More than the critical value
(D) Zero critical value

Key: (B)

Exp: Reynold number is a dimensionless quantity which comprises viscosity, density velocity & geometry of flow which affect flow properly i.e.,

$$R_e = \frac{\rho VL}{\mu}$$

If it is lesser than critical value flow is laminar, if greater than critical value it may be transient or turbulent depending on Range of Reynold number.

Directions: -

Each of the next Twenty (20) items consists of two statements, one labelled as the 'Statement (I)'. and the other as 'Statement (II)'. Examine these two statements carefully and select the answers to these items using the codes given below:

Codes:

(A) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of statement (I)

(B) Both Statement (I) and Statement (III) are individually true but Statement (III) is Not the correct explanation of statement (I)

(C) Statement (I) is true but statement (II) is false

(D) Statement (I) is false but statement (II) is true

81. Statement (I): Temperature potential difference is a necessary condition for heat interaction between systems.

Statement (II): Heat transfer to a system inevitably increases the temperature of the system.

Key: (C)

Exp: Heat transfer can increase or decrease the temperature of the system.

82. Statement (I): In an isolated system, the heat transfer ∂Q and the work transfer ∂W are always zero.

Statement (II): In an isolated system; the entropy always remains constants.

Key: (A)

Exp: Both statements are true. There will be no entropy change in an Isolated system, hence there will be no energy interactions.

83. Statement (I): $\oint \frac{\delta Q}{T} = 0$, the cycle is reversible

Statement (II): $\oint \frac{\delta Q}{T} > 0$, the cycle is irreversible and possible

Key: (B)

Exp: Both statements are individually true.

84 Statement (I): The three phase (triple state/point) of a single component system possesses a single set of properties.

Statement (II): For a single component system, the Gibbs phase rule, $F = C + 2 - P$ (where F is number of independent intensive properties, C is number of components in the system and P is number of phases), reduces to F = 3 – P.

Key: (B)

Exp: Both statements are individually true. Statement-I is explaining about Triple point and Statement-II is explain about Gibb's phase rule for a single component system.

85. Statement (I): The Clapeyron equation enables us to determine the enthalpy change associated with phase change.

Statement (II): Using usual notations, the Clapeyron equation is given by

$$\left(\frac{dT}{dP}\right)_{sat} = \frac{h_{fg}}{Tv_{fg}}$$

Key: (C)

Exp: Statement-I is true. Statement-II is false because $\left(\frac{dp}{dT}\right)_v = \frac{h_{f_g}}{T\vartheta_{f_g}}$ but it is given as

$$\left(\frac{dT}{dP}\right)_{sat} = \frac{h_{f_g}}{T\vartheta_{fg}}$$

86. Statement (I): Mixture of liquid air and air cannot be considered as pure substance.

Statement (II): Proportions of oxygen and nitrogen differ in liquid and gaseous states in equilibrium.

Key: (A)

Exp: Statement I & Statement II are complimentary to each other.

87. Statement (I): A good CI engine fuel, like diesel oil, is a bad SI engine fuel and a good SI engine fuel, like petrol, is a bad CI engine fuel.

Statement (II): A good CI engine fuel requires high self-ignition temperature and good SI engine fuel requires low self-ignition temperature.

Key: (A)

88. Statement (I): The specific fuel consumption of a CI engine is lower than that of an SI engine.

Statement (II): For the same power, a CI engine is bigger in size than an SI engine.

Key: (B)

89. Statement (I): The cut off ratio of a Diesel engine cycle should be greater than one; but should be as low as possible.

Statement (II): Lower cut off ratio does improve the thermal efficiency but lowers the specific work output. Hence, the value of cut off ratio must be optimized.

Key: (A)

90. Statement (I): In CI engine, increase of load decreases the knocking tendency.

Statement (II): increase of load increases the temperature of mixture and thereby increase in delay angle.

Key: (D)

Exp: In CI engines, increase in load decrease the delay period and the knocking tendency increases. It also increases the operating temperature.

91. Statement (I): Liquid-cooled engines are able to vary the size of their passage ways through the engine block, so that coolant flow may be tailored to the needs of each area. Locations with either high peak temperature (narrow islands around the combustion chamber) or high heat flow (around exhaust ports) may require generous cooling. This reduces the occurrence of hot spots.

Statement (II): Air-cooled engines may also vary their cooling capacity by using more closely spaced cooling fins in that area, but this can make their manufacture difficult an expensive.

Key: (D)

Exp: Engines cannot vary their passage ways. So statement I is the false and by providing closely spaced cooling fins cooling capacity increases but is a costly affair.

92. Statement (I): A counter flow heat exchanger is more effective than a parallel flow heat exchanger.

Statement (II): For same temperature limits of hot and cold fluids, the overall heat transfer coefficient of counter flow heat exchanger is more than parallel flow heat exchanger.

Key: (A)

Exp: As the overall heat transfer coefficient is more in Counter flow heat exchange number of transfer units will be more so there will be more heat transfer rate.

93. Statement (I): The COP of an air conditioning plant is higher than the COP of a household refrigerator.

Statement (II): for the same condenser temperature, the suction pressure of the evaporator is higher in air conditioning plant than in household refrigerator.

Key: (C)

Exp: For the same condenser temperature, the suction pressure of the evaporator will be less in air conditioning plant than in housed hold refrigerator.

94. Statement (I): The main difference between vapour compression refrigeration compression refrigeration cycle and Bell-Coleman gas refrigeration cycle is that in gas cycle, an expander is used in place of a throttle valve.

Statement (II): In throttling of a perfect gas, temperature remains constant.

Key: (C)

Exp: During throttling, temperature does not remain constant

95. Statement (I): Humidity ratio of moist air is the ratio of the mass of water vapour to the mass of moist air in a given value of air-water vapour mixture.

Statement (II): For any given barometric pressure, humidity ratio is a function of the dew point temperature alone.

Key: (D)

Exp: Humidity ratio is the ratio of water vapour to the dry air.

96. Statement (I): With heat exchanger gas turbine cycle, the cycle efficiency reduces as the pressure ratio increases.

Statement (II): As the pressure ratio increases, the delivery temperature from the compressor increases and ultimately will exceed that of the exhaust gas from the turbine.

Key: (A)

97. Statement (I): The estimation of exact cooling load calculations of space to be conditioned is important to know because it involves both the initial cost and operating cost.

Statement (II): The outside heat gain to conditioned space is called external load and the heat gain from inside the conditioned space is called internal load.

Key: (B)

98. Statement (I): Entropy across the normal shock increases.

Statement (II): Stagnation temperature across the normal shock remains constant

Key: (B)

Exp: The entropy increases across the shock because the shockwave is very thin, the gradient of velocity and temperature in the shock are very high which leads to increase the entropy and stagnation pressure decreases.

Since, the flow across a shock is adiabatic the stagnation temperature does not change across a shock wave.

99. Statement (I): Axial flow air compressors need many stages to develop high pressure ratios.

Statement (II): The amount of turning of air flow in blade row is limited by the occurrence of separation, a phenomenon caused by adverse pressure gradient.

Key: **(A)**

Exp: Axial flow compressors need multistaging to achieve the high pressure ratio,

The low pressure ratio is due to,

(1) Radio blades

(2) Flow separation

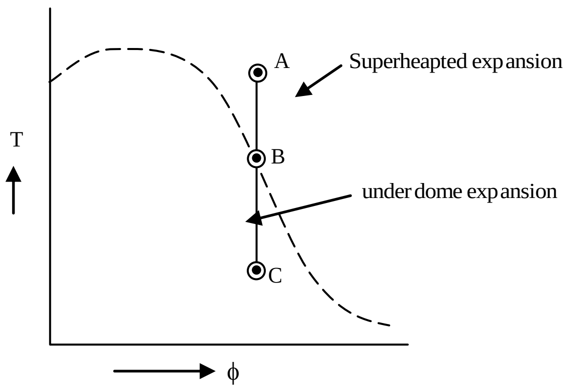
(3) eddy formation

100. Statement (I): The supersaturated expansion is nozzle is a process in which the steam expands beyond the saturated vapour line in superheated condition.

Statement (II): Steam cannot exist in superheated state when the expansion process in nozzle reaches the saturated vapour line.

Key: **(C)**

Exp: Statement II is false as can be seen in the following diagram



101. Consider the following statements:

An increase in pin fin effectiveness is caused by high value of

(1) Convective coefficient

(2) Thermal conductivity

(3) Sectional area

(4) Circumference

Which of the above statements are correct?

(A) 1 and 3 (B) 1 and 4

(C) 2 and 3 (D) 2 and 4

Key: **(D)**

Exp: $\varepsilon_{fin} = \sqrt{\frac{kP}{hA}}$

Hence fin effectiveness increases with high value of k α P

102. In a laminar developing flow through a pipe with constant wall temperature, the magnitude of the pipe wall inner surface convective heat transfer coefficient shall be maximum at the:

(A) Middle length of flow

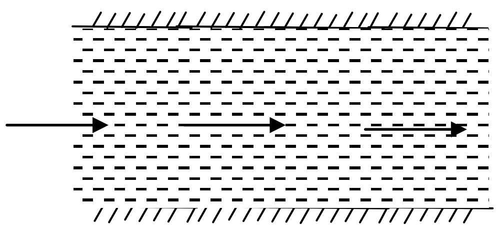
(B) Beginning of flow

(C) End of flow

(D) None of the above

Key: **(B)**

Exp: At the beginning temperature differential is maximum but as flow progresses ΔT reduces & hence convective heat transfer co-efficient is maximum.



103. For minimum compression work in a 2-stage reciprocating air compressor, which of the following expressions gives the ratio of low pressure cylinder to high pressure cylinder diameters?

(A) $\left(\frac{p_3}{p_1}\right)^{\frac{1}{4}}$ (B) $\left(\frac{p_3}{p_1}\right)^{\frac{1}{3}}$ (C) $\left(\frac{p_3}{p_1}\right)^{\frac{1}{2}}$ (D) $\left(\frac{p_3}{p_2}\right)^{\frac{1}{4}}$

Where p_1, p_2 and p_3 are suction, intermediate and delivery pressures respectively.

Key: **(C)**

Exp: For minimum work

$$P_1 \times \frac{\pi}{4} d_1^2 = P_3 \times \frac{\pi}{4} d_3^2$$

$$\therefore \frac{d_1}{d_3} = \sqrt{\frac{P_3}{P_1}} = \left(\frac{P_3}{P_1}\right)^{\frac{1}{2}}$$

104. Oxides of nitrogen in Petrol engine exhaust can be reduced by the following methods:

(1) Use of 5% lean mixture

(2) Advancing the spark timing

(3) Recirculating a fraction of exhaust gas

(4) Using an oxidation catalyst in the exhaust manifold

Which of the above statements is/are correct?

(A) 1 and 2 (B) 2 only (C) 3 and 4 (D) 3 only

Key: (B)

Exp: By advancing spark timing only we can reduce Oxides of nitrogen in Petrol engine.

105. A counter flow shell and tube exchanger having an area of 35.5 m^2, is used to heat water with hot exhaust gases. The water (Cp = 4.16kJ/kg K) flows at a rate of 2kg/sec while the exhaust gases (Cp = 1.03kJ/kg K) flow at a rate of 5.15kg/sec. If the overall heat transfer surface coefficient is $200W/m^2K$, the NTU for the heat exchanger is

(A) 1.2 (B) 2.4 (C) 3.6 (D) 4.8

Key: (A)

Exp: $A = 32.5\,m^2$

$U = 200\,W/m^2K$

$m_c = 2\,kg/s$

$C_p = 4.16\,kJ/kgK$

$C_C = m_c c_{p_c}$

$C_c = 2 \times 4.16$

$= 8.32$

$m_h = 5.15\,kg/s$

$C_{p_h} = 1.03\,kJ/kg\,K$

$C_h = m_n C_{p_h}$

$C_h = 5.15 \times 1.03$

$= 5.3045$

$\therefore\; C_{min} = C_h = 5.3045 \times 1000 = 5304.5\,J/K$

$$NTU = \frac{UA}{C_{min}} = \frac{200 \times 32.5}{5.3045 \times 1000}$$

$= 1.2$

106. Consider the following statements with regard to heat transfer:

(1) The temperature variations in lumped heat capacity analysis is exponential with time

(2) In situations involving simultaneous heat and mass transfer, the ratio of convective heat transfer to convective mass transfer varies with Lewis number, Le, as $(Le)^{1/3}$

Which of the above statements are correct/

(A) Both `1 and 2 (B) Neither 1 nor 2

(C) 1 only (D) 2 only

Key: (A)

Exp: In lumped heat capacity analysis

$$\frac{T(t)-T_\infty}{T_i-T_\infty}=e^{-bt}$$

$$\text{where } b=\frac{hA}{\rho VC_p}$$

From the equation we can say that temperature variations in lumped system analysis are exponential with time.

In problems involving heat and mass transfer Lewis number is used.

107. For a Fluid with Prandtl number Pr > 1, momentum boundary layer thickness

(A) Decreases rapidly compared to the thermal boundary layer thickness

(B) And thermal boundary layer thickness increases at the same rate

(C) Increases rapidly compared to the thermal boundary layer thickness

(D) And thermal boundary layer thickness decrease at the same rate

Key: (C)

Exp: If $P_r>1,\ \delta_{th}<\delta$. This states that the momentum boundary layer thickness increases as compared to thermal boundary layer thickness.

108. For the same type of shapes, the value of Radiation shape factor will be higher when surfaces are

(A) More closer only

(B) Moved further apart

(C) Smaller and held closer

(D) Larger and held closer

Key: (D)

Exp: Radiation shape factor will be more when surfaces are larger and are held together.

109. In a pipe, laminar flow in fully developed region with constant heat flux from pipe wall, bulk mean temperature of fluid

(A) and pipe wall temperature increase in flow direction

(B) and pipe wall temperature decrease in flow direction

(C) remains constant, but pipe wall temperature increases in flow direction

(D) increases but pipe wall temperature remains constant

Key: (D)

Exp: During laminar flow in fully developed region in a pipe, bulk mean temperature of fluid increase but the pipe wall temperature remains constant.

110. Which of the following statements is correct for steam boiler?

(A) Boiler secondary heat transfer surface include super-heater, economizer and air pre-heater.

(B) Boiler primary heat transfer surface includes evaporator section, super heater section and reheat section.

(C) Boiler primary heat transfer surface includes evaporator section, economizer and super-heater section.

(D) Boiler secondary heat transfer surface includes evaporator section, economizer and air pre-heater

Key: (A)

Exp: Boiler primary heat transfer surface is evaporator section and secondary heat transfer surface includes Superheater, economics and air-preheater.

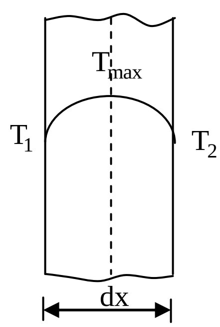
111. In a wall of constant thermal conductivity, the temperature profile for heat conduction in the presence of a heat source inside the wall is

(A) Linear (B) Logarithmic

(C) Parabolic (D) Hyperbolic

Key: (C)

Exp: The temperature profile for heat conduction in the presence of a heat source inside the wall with constant thermal conductivity is Parabolic.



112. Determine the heat transfer through a plane of length 4m, height 3 m and thickness 0.2m. The temperatures of inner and outer surfaces are $150^{O}C$ and $90^{O}C$ respectively. Thermal conductivity of the wall is 0.5 W/mK.

(A) 1800W (B) 2000W (C) 2200W (D) 2400W

Key: (A)

Exp: $T_1 = 150^oC$ $\quad dx = 0.2m$

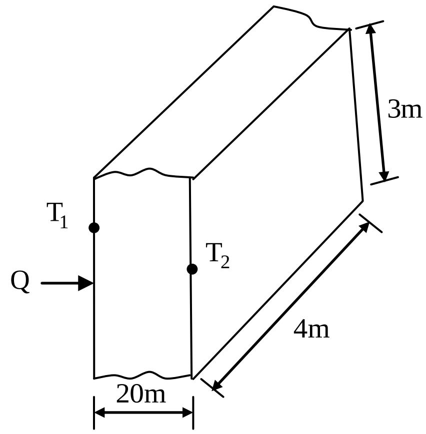
$T_2 = 90^oC$ $\quad A = 4 \times 3$

$k = 0.5\,\omega/mK$ $\quad = 12m^2$

$$Q = kA\frac{T_1 - T_2}{dx}$$

$$= 0.5 \times 12 \times \frac{150 - 90}{0.2}$$

$$= 1800W$$



113. In a Psychrometric chart, which of the following statements/is/are correct?

(A) It is used to determine properties of refrigerants

(B) It cannot determine WBT and DBT

(C) It is seldom used for air conditioning design

(D) It provides plot for moist air conditioning

Key: **(D)**

Exp: In Psychometric chart, we cannot determine properties in Refrigerants. Psychrometric chart shows DBT, WBT, DPT, Specific Humidity, Relative Humidity, Specific Enthalpy of air.

114. In a Psychrometric chart, horizontal lines represent constant

(A) Humidity ratio and vertical lines represent constant dry bulb temperature

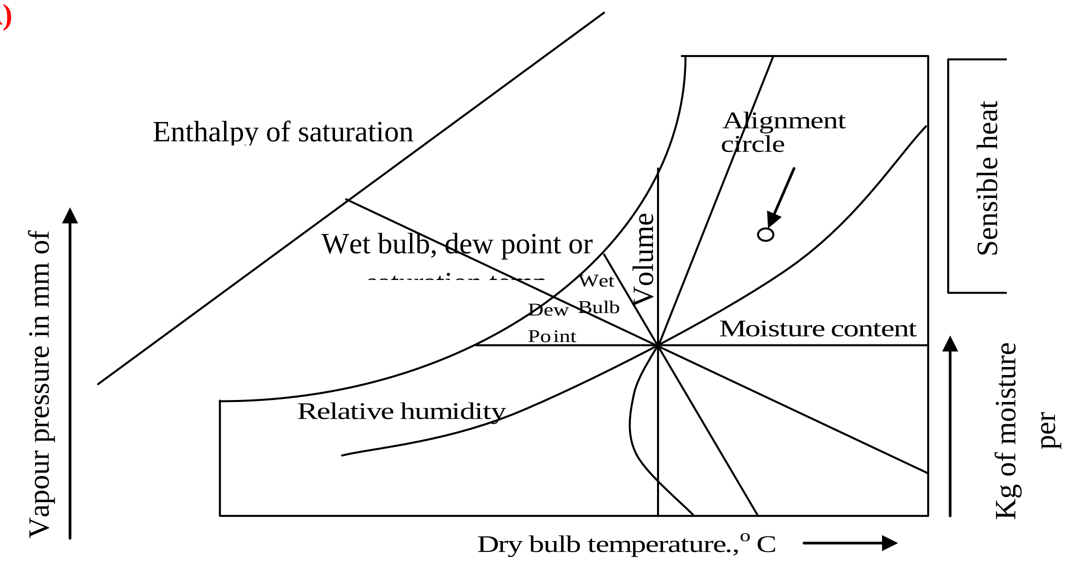
(B) Humidity ratio and vertical lines represent constant wet bulb temperature

(C) Dry bulb temperature and vertical lines represents constant absolute humidity ratio

(D) Wet bulb temperature and vertical lines represent constant humidity ratio

Key: **(A)**

Exp:



115. Air is passed through a cooling coil at a temperature of -5^{O}C. If the temperature of air drops from 25^{O}C to 10^{O}C, the Bypass factor of the coil is

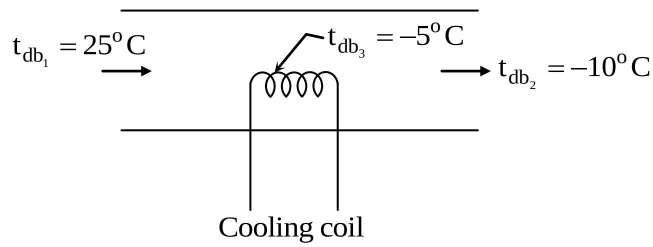
(A) 0.2 (B) 0.5 (C) 0.7 (D) 1.0

Key: (B)

Exp: Bypass factor $= \dfrac{t_{db_2} - t_{db_3}}{t_{db_1} - t_{db_3}}$

$$= \frac{10-(-5)}{25-(-5)}$$

$$= 0.5$$



116. The multistage compression of air as compared to single stage compression

(A) Improves volumetric efficiency for the given pressure ratio

(B) Reduces work done per kg of air

(C) Gives more uniform torque

(D) All of the above

Key: (D)

Exp: 1. The air can be cooled at pressure intermediate between intake and delivery pressures:

2. The power required to drive a multi-stage machine is less than would be required by single-stage machine delivering the same quantity of air at the same delivery pressure.

3. Multi-stage machines have better mechanical balance.

4. The pressure range (and hence also the temperature range) may be kept within desirable limits. This results in (i) reduced losses due to air leakage (ii) improved lubrication, due to lower temperatures and (iii) improved volumetric efficiency.

5. The cylinder, in a single-stage machine, must be robust enough to withstand the delivery pressure. The down pressure cylinders of a multi-stage machine may be lighter in construction since the maximum pressure therein is low.

117. In sensible cooling of moist air, its physical properties vary as follows:

(1) The wet bulb temperature decreases

(2) The dew point temperature remains constant

(3) The relative humidity increases

Which of the above statements are correct?

(A) 1, 2 and 3 (B) 1 and 2 only

(C) 1 and 3 only (D) 2 and 3 only

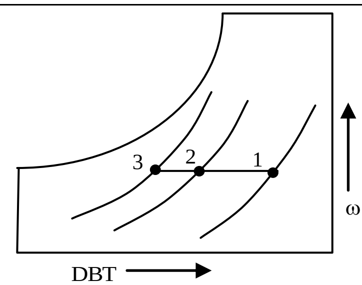
Key: (A)

Exp: During sensible cooling of moist air

1. Dry bulb temperature decreases

2. Specific humidity remains constant

3. Relative humidity increases
4. Wet bulb temperature decreases
5. Dew point temperature remains constant



118. A desert cooler having a cooling efficiency of 70% reduces the temperature of atmospheric air from 37^{O}C to 30^{O}C. The wet bulb temperature of the air is

(A) 24^{O}C (B) 25^{O}C (C) 26^{O}C (D) 27^{O}C

Key: (D)

Exp: Cooling efficiency $(\eta) = \dfrac{T_{e_{db}} - T_{l_{db}}}{T_{e_{db}} - T_{e_{wb}}}$

$Te_{db} = 37^{o}C$

$T_{l_{db}} = 30^{o}C$

$\eta = 70\% = 0.7$

$\Rightarrow 0.7 = \dfrac{37-30}{37 - T_{e_{wb}}}$

$T_{e_{wb}} = 27^{o}C$

119. Consider the following statements with regard to air-conditioning systems:

(1) In adiabatic saturation process, air-vapour mixture undergoes a process of constant relative humidity

(2) Wet bulb temperature of air whose relative humidity is 100 is equal to the dew point temperature

(3) In winter air conditioning, the process is heating and humidification

(3) For designing air conditioning ducts, equal friction method automatically reduces the air velocity in the duct in the direction of flow

Which of the above statements are correct?

(A) 1 and 2 (B) 1 and 4 (C) 2 and 3 (D) 3 and 4

Key: (C)

Exp: Equal friction method does not reduce the air velocity.

120. A fin will be more effective when Biot number is

(A) Greater than 1 (B) Equal to 1

(C) Between $\frac{1}{4}$ and $\frac{3}{4}$ (D) Less than 1

Key: (D)

Exp: $\varepsilon_{fin} = \sqrt{\frac{k\rho}{hA}}$

$\text{Biot number} = \frac{hx}{k}$

hence fin is more effective when Biot number is less than 1