IES MASTER

Institute for Engineers (IES/GATE/PSUs)

ESE-2016

Detailed Exam Solutions (Objective Paper-I) Mechanical Engineering

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Explanation of Mechanical Engg. Objective Paper-I (ESE - 2016)

SET - A

1. In a differential manometer, a head of 0.5 m of fluid A in limb 1 is found to balance a head of 0.3 m of fluid B in limb 2. The atmospheric pressure is 760 mm of mercury. The ratio of specific gravities of A to B is

(a) 0.25 (b) 0.6

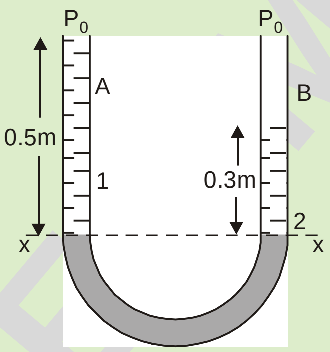
(c) 2 (d) 4

Ans. **(b)**

Sol. The differential manometer,

$$P_0 + h_1\rho_A g = P_0 + h_2\rho_B g$$

where P_0 is atmosphere pressure.



$$\therefore \quad h_1\rho_A = h_2\rho_B$$

$$\frac{\rho_A}{\rho_B} = \frac{h_2}{h_1} = \frac{0.3}{0.5} = 0.6$$

2. Consider the following processes :

1. Extension of a spring
2. Plastic deformation of a material
3. Magnetization of a material exhibiting hysteresis

Which of the above process are irreversible?

(a) 1 and 2 only (b) 1 and 3 only

(c) 1 and 3 only (d) 1, 2 and 3

Ans. **(c)**

Sol. A proces is reversible if both the system and surroundings are restored to initial condition. Thus, plastic deformation of a material and magnetization of a material exhibiting hysteresis are irreversible processes. The spring after extension will get back to its original position after removal of load, hence it can be considered as reversible.

3. Which of the following statements are correct for a throttling process?

1. It is an adiabatic steady flow process
2. The enthalpy before and after throttling is same
3. In the processes, due to fall in pressure, the fluid velocity at outlet is always more than inlet velocity

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(a)**

Sol. Throttling process involves the passage of a higher pressure fluid through a narrow constriction. This process is adiabatic, and there is no work interaction. Hence,

$$Q = 0 \;\; \& \;\; W = 0$$

$\Delta PE = 0$ (Inlet and outlet are at the same level)

$\Delta KE = 0$ (KE does not change significantly)

$\therefore$ Applying the SFEE, $h_1 = h_2$

Thus, enthalpy remain constant

Further, the velocity of flow is kept low and any difference between the kinetic energy upstream and downstream is negligible. The effect of the decrease in pressure is an increase in volume.

4. A Reversed Carnot Engine removes 50 kW from a heat sink. The temperature of the heat sink is 250 K and the temperature of the heat reservoir is 300 K. The power required of the engine is

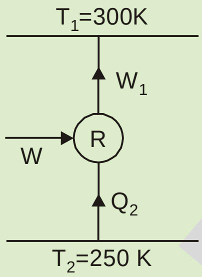
(a) 10 kW (b) 20 kW

(c) 30 kW (d) 50 kW

Ans. (a)

Sol. $Q_2 = 50$ kW

$$(COP)_R = \frac{Q_2}{W}$$



Since the engine is a reversed Carnot engine,

hence, $(COP)_R = \frac{T_2}{T_1 - T_2} = \frac{Q_2}{W}$

$\therefore$ $W = Q_2 \times \left(\frac{T_1 - T_2}{T_2}\right)$

$$= 50 \times \left(\frac{300 - 250}{250}\right) = 10 \text{kW}$$

5. A heat engine receives heat at the rate of 2500 kJ/min and gives an output of 12.4 kW. Its thermal efficiency is, nearly

(a) 18% (b) 23%

(c) 26% (d) 30%

Ans. (d)

Sol. Heat received

$$Q = 2500 \text{ kJ/min}$$

$$= \frac{2500}{60} \text{kW} = 41.67 \text{ kW}$$

and, work output W = 12.4 kW

$\therefore$ Thermal efficiency

$$\eta = \frac{W}{Q} = \frac{12.4}{41.67}$$

$$= 0.2975 \text{ or } 30\%$$

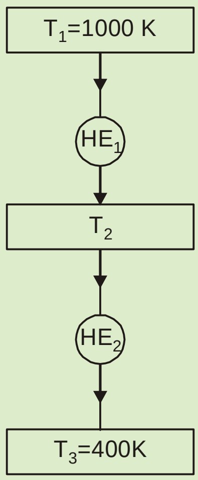
6. One reversible heat engine operates between 1000 K and T_2 K and another reversible heat engine operates between T_2K and 400 K. If both the engines have the same heat input and output, then the temperature T_2 must be equal to

(a) 582.7 K (b) 632.5 K

(c) 682.8 K (d) 732.5 K

Ans. (b)

Sol. Since both the engines have same heat input and output, so efficiency of both engines will be equal. Further, since both the engines are reversible, hence



$$\left(1 - \frac{T_2}{1000}\right) = \left(1 - \frac{400}{T_2}\right)$$

$\therefore$ $T_2 = \sqrt{400 \times 1000} = 632.5 \text{ K}$

7. Consider the following statements for isothermal process :

1. Change in internal energy is zero
2. Heat transfer is zero

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. **(d)**

Sol. $$dU = C_v dT + \left[T\left(\frac{\partial p}{\partial T}\right)_v - p\right]dV$$

For an ideal gas, $\left[T\left(\frac{\partial p}{\partial T}\right)_v - p\right] = T \times \frac{p}{T} - p = 0$

Thus, for an ideal gas, $dU = C_v dT$

For an isothermal process, dU = 0, for ideal gas

However, for isothermal process for a real gas

$$dU = \left[T\left(\frac{\partial p}{\partial T}\right)_v - p\right]dV \neq 0$$

Further, heat transfer is zero in a adiabatic process and not in isothermal process.

8. A system of 100 kg mass undergoes a process in which its specific entropy increases from 0.3 kJ/kg K to 0.4 kJ/kg K. At the same time, the entropy of the surroundings decreases from 80 kJ/K to 75 kJ/K. The process is :

(a) Reversible and isothermal

(b) Irreversible

(c) Reversible only

(d) Isothermal only

Ans. **(b)**

Sol. $(\Delta S)_{sys} = 100 \times (0.4 - 0.3) = 100 \times 0.1$

$= 10$ kJ/K

$(\Delta S)_{surr} = (75 - 80) = -5$ kJ/kg

$\therefore\ (\Delta S)_{univ} = (\Delta S)_{sys} + (\Delta S)_{surr} = 10 - 5 = 5$ kJ/K

Since, the change in entropy of the universe is positive, i.e. the entropy of the universe increases, hence the process is irreversible. The entropy change of universe is zero only for a reversible process.

9. Which one of the following statements is correct during adiabatic charging of an ideal gas into an empty cylinder from a supply main?

(a) The specific enthalpy of the gas in the supply main is equal to the specific enthalpy of the gas in the cylinder

(b) The specific enthalpy of the gas in the supply main is equal to the specific internal energy of the gas in the cylinder

(c) The specific internal energy of the gas in the supply main is equal to the specific enthalpy of the gas in the cylinder

(d) The specific internal energy of the gas in the supply main is equal to the specific internal energy of the gas in the cylinder

Ans. **(b)**

Sol. For charging the tank,

$$m_p h_p = m_2 u_2 - m_1 u_1$$

If the tank is initially empty, then $m_1 = 0$

$\therefore\quad m_p h_p = m_2 u_2$

Since $m_p = m_2$, hence, $h_p = u_2$

10. Consider the following systems :

1. An electric heater
2. A gas turbine
3. A reciprocating compressor

The steady flow energy equation can be applied to which of the above systems?

(a) 1 and 2 only (b) 1 and 3 only

(c) 1, 2 and 3 (d) 2 and 3 only

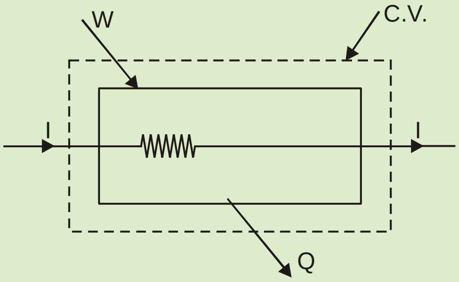
Ans. **(a)**

Sol. The reciprocating compressor can be considered as steady flow system provided the control volume includes the receiver which reduces the fluctuation of flow.

SFEE can be applied to gas turbine and electric heater.

For electric heater, at steady state

$$W = Q$$



11. Consider the following statements pertaining to Clapeyron equation :

1. It is useful in estimating properties like enthalpy from other measurable properties.
2. At a change of phase, it can be used to find the latent heat at a given pressure.
3. It is derived from the relationship

$$\left(\frac{\partial p}{\partial v}\right)_T = \left(\frac{\partial s}{\partial T}\right)_v$$

Which of the above statements are correct?

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

Ans. **(c)**

Sol. Clausius-Clapeyron equation is a relationship between the saturation pressure, temperature, enthalpy of evaporation and the specific volume of the two phases involved.

It can be derived from the use of following

Maxwell equation: $\left(\frac{\partial p}{\partial T}\right)_v = \left(\frac{\partial S}{\partial V}\right)_T$

$$\frac{dp}{dT} = \frac{s_g - s_f}{v_g - v_f} = \frac{h_{fg}}{T \cdot v_{fg}}$$

Thus, it can be used to find latent heat during change of phase. Also, enthalpy can be found out from other properties.

12. Consider the following conditions for the reversibility of a cycle :

1. The P and T of the working substance must not differ appreciably, from those of the surroundings at any state in the process.
2. All the processes, taking place in the cycle, must be extremely slow.
3. The working parts of the engine must be friction-free.

Which of the following conditions are correct?

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

Ans. **(a)**

Sol. A reversible process must be quasi-static and frictionless.

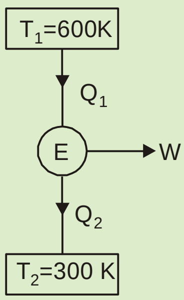
Further, a heat engine cycle in which there is a temperature difference (i) between the source and the working fluid during heat supply, and (ii) between the working fluid and the sink during heat rejection, exhibits external thermal irreversibility. Thus, P and T of the working substance must not differ, appreciably from those of the surroundings at any state in the process.

13. A Carnot engine operates between 300 K and 600 K. If the entropy change during heat addition is 1 kJ/K, the work produced by the engine is :

(a) 100 kJ (b) 200 kJ
(c) 300 kJ (d) 400 kJ

Ans. **(c)**

Sol. Since Carnot engine is a reversible engine, hence,



$$\frac{Q_1}{T_1} - \frac{Q_2}{T_2} = 0$$

$\therefore$ But, $\frac{Q_1}{T_1} = 1\,\text{kJ/K}$

$\therefore$ $Q_1 = 1 \times T_1 = 1 \times 600 = 600$ kJ

Further, $Q_2 = T_2 \times \frac{Q_1}{T_1} = 300 \times 1 = 300$ kJ

$\therefore$ Work produced $W = Q_1 - Q_2$

$= 600 - 300 = 300$ kJ

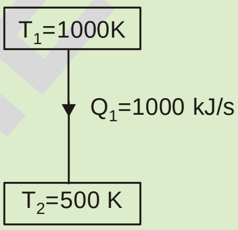
14. 1000 kJ/s of heat is transferred from a constant temperature heat reservoir maintained at 1000 K to a system at a constant temperature of 500 K. The temperature of the surroundings is 300 K. The net loss of available energy as a result of this heat transfer is :

(a) 450 kJ/s (b) 400 kJ/s

(c) 350 kJ/s (d) 300 kJ/s

Ans. (d)

Sol. $\dot{S}_{gen} = \frac{Q}{T_2} - \frac{Q}{T_1}$



According to guoy stodola's theorem, loss of available energy

$$= T_0 \dot{S}_{gen} = T_0\left(\frac{Q}{T_2} - \frac{Q}{T_1}\right)$$

$$= 300 \times \left(\frac{1000}{500} - \frac{1000}{1000}\right)$$

$= 300$ kJ/s

15. The effects of heat transfer from a high temperature body to a low temperature body are :

1. The energy is conserved
2. The entropy is not conserved
3. The availability is not conserved

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

Ans. (d)

Sol. The energy is conserved as per the first law of thermodynamics. Heat transfer is an irreversible process, hence entropy will be generated. Availability will decrease due to heat transfer from a high temperature body to a low temperature body.

16. Which of the folloiwng statements pertaining to entropy are correct?

1. The entropy of a system reaches its minimum value when it is in a state of equilibrium with its surroundings
2. Entropy is conserved in all reversible processes
3. Entropy of a substance is least in solid phase
4. Entropy of a solid soloution is not zero at absolute zero temperature

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

(c) 3 and 4 only (d) 1, 2, 3 and 4

Ans. (b)

Sol. The entropy attains its maximum value when the system reaches a stable equilibrium state from a non-equilibrium state. This is the state of maximum disorder.

Entropy change of the universe in all reversible processes is zero.

The third law of thermodynamics states that the entropy of a perfect crystal is zero at the absolute zero temperature as it represents the maximum degree of order. However, a substance not having a perfect crystalline structure and possessing a degree of randomness such as a solid solution or a glassy solid has a finite value of entropy at absolute zero.

Since the disorder of molecules is more in gaseous or liquid phase than the solid phase, hence the solid phase will have least entropy.

17. The maximum work developed by a closed cycle used in a gas turbine plant when it is working between 900 K and 289 K and using air as working substance is :

(a) 11 kJ/kg (b) 13 kJ/kg

(c) 17 kJ/kg (d) 21 kJ/kg

Ans. (*)

Sol. The maximum work developed by a closed cycle used in gas trubine plant is given by

$$W_{max} = c_p\left(\sqrt{T_{max}} - \sqrt{T_{min}}\right)^2$$

for per kg of air.

So, here T_{max} = 900 K

T_{min} = 289 K

$$\text{so,} \quad W_{max} = c_p\left(\sqrt{900} - \sqrt{289}\right)^2$$

$$= 1.005\{30-17\}^2$$

$$= 169.845 \approx 170 \text{ kg/kg}$$

18. Consider the following statements :

1. Gases have a very low critical temperature
2. Gases can be liquefied by isothermal compression
3. In engineering problems, water vapour in atmosphere is treated as an ideal or perfect gas

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

Ans. (b)

Sol. Water vapour in atmosphere exists as a superheated gas. It can be assumed as ideal gas and atmospheric air can be treated as a mixture of two ideal gases, dry air and water vapour.

There are three methods for liquefaction of gases:

(i) isothermal compression (ii) performance of the external work by the gas itself (iii) use of Joule -Kelvin effect.

It is not appropriate to state that all gases have very low critical temperature. The critical temperature of air is –140.5°C, while that of ammonia and CO_2 are 132.4°C and 31°C respectively.

19. The property of a thermodynamic system is :

(a) A pth function

(b) A point function

(c) A quantity which does not change in reversible process

(d) A quantity which changes when system undergoes a cycle

Ans. (b)

Sol. The propety of a thermodynamic system is a point function, since for a given state, there is a definite value for each property. The change in a thermodynamic property of a system in a change of state is independent of the path the system follows during the change of state and depends only on the initial and final states of the system.

20. Consider the following statements :

1. There is no change in temperature when a liquid is being evaporated into vapour.
2. Vapour is a mixed phase of liquid and gas in the zone between saturated liquid line and saturated vapour line.

3. The saturated dry vapour curve is steeper as copared to saturated liquid curve on a T-s diagram.
4. The enthalpy of vapourization decreases with increase in pressure.

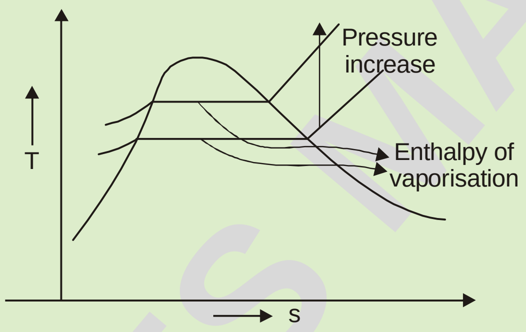
Which of the above statements are correct?

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

Ans. **(c)**

Sol. During phase change, temperature remains constant.

Enthalpy of vapourisation decreases with increase in pressure



21. An ideal heat engine, operating on a reversible cycle, produces 9 kW. The engine operates between 27°C and 927°C. What is the fuel consumption given that the calorific value of the fuel is 40000 kJ/kg?

(a) 0.8 kg/hr (b) 1.02 kg/hr
(c) 1.08 kg/hr (d) 1.28 kg/hr

Ans. **(c)**

Sol. Efficiency of the ideal reversible cycle

$$\eta = 1-\frac{T_2}{T_1} = 1-\frac{(27+273)}{(927+273)}$$

$$= 1-\frac{300}{1200} = 0.75 \text{ or } 75\%$$

$$\therefore \quad \eta = \frac{W}{Q} \Rightarrow Q = \frac{W}{\eta} = \frac{9}{0.75} = 12 \text{ kW}$$

$$Q = m_f \times CV$$

$$\therefore \quad m_f = \frac{Q}{CV} = \frac{12 \text{ kW}}{40000 \text{ kJ/kg}}$$

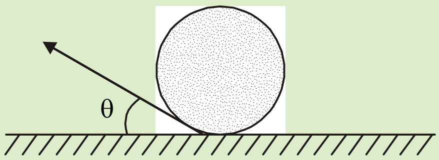
$$= \frac{12\times3600}{40000} = 1.08 \text{ kJ/hr}$$

22. If angle of contact of a drop of liquid is acute, then

(a) Cohesion is equal to adhesion
(b) Cohesion is more than adhesion
(c) Adhesion is more than cohesion
(d) Both adhesion and cohesion have noc onnection with angle of contact

Ans. **(b)**

Sol. The angle of contact of drop of liquid acute as shown in figure,



Hence the shop of droplet remain spherical which is possible only when the cohesion i.e. intermolecular force is more than adhesion i.e. force between liquid molecule and molecule of plate.

23. The Carnot cycle is impracticable because :

(a) Isothermal process is very fast; and isentropic process is very slow
(b) Isothermal process is very slowp; and isentropic process is very fast
(c) Isothermal process and isentropic process are both very slow
(d) Isothermal process and isentropic process are both very fast

Ans. **(b)**

Sol. The Carnot cycle cannot be performed in practice because of the following reasons :

1. It is impossible to perform a frictionless process.
2. It is impossible to transfer the heat without temperature potential.
3. Isothermal process can be achieved only if the piston moves very slowly to allow heat transfer so that the temperature remains constant. Adiabatic process can be achieved only if the piston moves as fast as possible so that the heat transfer is negligible due to very short time available. The isothermal and adiabatic processes take place during the same stroke therefore the piston has to move very slowly for part of the stroke and it has to move very fast during remaining stroke. This variation of motion of the piston during the same stroke is not possible.

24. An ideal Otto-cycle works between minimum and maximum temperature of 300 K and 1800 K. What is the compression ratio of the cycle for maximum work output when $\gamma = 1.5$ for this ideal gas?

(a) 5 (b) 6
(c) 7 (d) 8

Ans. **(b)**

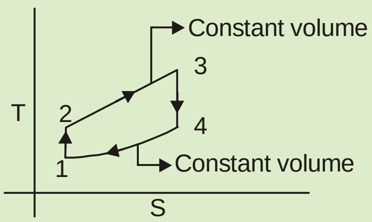
Sol. For maximum specific work output for Otto cycle, the compression ratio

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

T_{max} = 1800 K, T_{min} = 300 K, γ = 1.5

$$r = \left(\frac{1800}{300}\right)^{\frac{1}{2(1.5-1)}}$$

r = 6



25. Consider the following statements :

1. The air standard efficiency of an Otto cycle is a function of the properties of the working substance (gas)
2. For the same compression ratio and same input, the thermal efficiency of an Otto cycle is more than that of a Diesel cycle
3. The thermal efficiency of a Diesel cycle increases with decrease of cut-off ratio

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

Ans. **(d)**

Sol. $\eta_{Otto} = 1 - \frac{1}{r^{\gamma-1}}$

i.e. $\eta_{Otto} = f(r_1\gamma)$

Here r is not property of working substance.

Lower cut-off ratio leads to better efficiency.

26. Consider the following statements :

1. Both Otto and Diesel cycles are special cases of dual combustion cycle
2. Combustion process in IC engines is neither fully constant volume nor fully constant pressure process
3. Combustion process in ideal cycle is replaced by heat addition from internal source in closed cycle
4. Exhaust process is replaced by heat rejection in ideal cycle

Which of the above statements are correct?

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

Ans. **(d)**

Sol. Since, some time interval is required for the chemical reactions during combustion process, the combustion cannot take place at constant volume. Similarly, due to rapid uncontrolled combustion in diesel engines, combustion does not occur at constant pressure.

27. A four-cylinder four-stroke SI engine develops an output of 44 kW. If the pumping work is 5% of the indicated work and mechanical loss is an additional 7%, then the power consumed in pumping work is :

(a) 50 kW (b) 25 kW

(c) 5.0 kW (d) 2.5 kW

Ans. (d)

Sol. bp = ip – 0.05ip – 0.07ip

= ip – 0.12ip = 0.88ip

$$\therefore \quad ip = \frac{bp}{0.88} = \frac{44}{0.88} = 50 \text{ kW}$$

$\therefore$ Pumping work = 50 × 0.05 = 2.5 kW

28. In a two-stroke Petrol engine, fuel loss is maximum after :

(a) Opening the exhaust port

(b) Closing the exhaust port

(c) Opening the inlet port

(d) Closing the inlet port

Ans. (a)

Sol. With engines working on Otto cycle, a part of fresh mixture is lost as it escapes through the exhaust port during scavenging. This increase the fuel comsumption and reduces the thermal efficiency.

If the fuel is supplied to the cylinder after the exhaust ports are closed, there will be no loss of fuel.

29. In an Otto cycle, air is compressed from 2.2 *l* to 2.26 *l* from an initial pressure of 1.2 kg/cm^2. The net output/cycle is 440 kJ. What is the mean effective pressure of the cycle?

(a) 227 kPa (b) 207 kPa

(c) 192 kPa (d) 185 kPa

Ans. (a)

Sol. Mean effective pressure

$$= \frac{\text{Net work output}}{\text{Swept volume}}$$

$$= \frac{440}{(2.2-0.26)\times 10^{-3}}$$

= 226.8 kPa

≃ 227 kPa

30. A single cylinder, four-stroke cycle oil 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 load on the brake is 200 N and the spring balance reads 30 N. If the engine runs at 600 rpm, what will be the nearest magnitude of the brake power of the engine?

(a) 3.3 kW (b) 5.2 kW

(c) 7.3 kW (d) 7.2 kW

Ans. (a)

Sol.

$$r = \frac{600+26}{2} = 313 \text{ mm}$$

$$bp = \frac{2\pi N\,(W-S)r}{60\times 1000}$$

$$= \frac{2\pi\times 600\times(170)\times 313}{60\times 1000}$$

= 3.343 kW

31. In a furnace the heat loss through the 150 mm thick refractory wall lining is estimated to be 50 W/m^2. If the average thermal conductivity of the refractory material is 0.05 W/mK, the temperature drop across the wall will be :

(a) 140°C (b) 150°C

(c) 160°C (d) 170°C

Ans. (b)

Sol. Data given :

$$\frac{Q}{A} = 50 \text{ W/m}^2$$

K = 0.05 W/mK

t = 150 mm = 0.15 m

$$Q = \frac{kA\Delta\theta}{t}$$

or, $$\frac{Q}{A} = \frac{k\Delta\theta}{t}$$

or, $$50 = \frac{0.05\times\Delta\theta}{0.15}$$

or, $$\Delta\theta = 150°$$

32. Uniform flow occurs when :

(a) At every point the velocity vector is identical in magnitude and direction at any given instance

(b) The follow is steady

(c) Discharge through a pipe is constant

(d) Conditions do not change with at any time

Ans. **(a)**

Sol. In uniform flow, the flow velocity is same in magnitude and direction at different location at given instant of time i.e.

$$\left(\frac{\partial V}{\partial S}\right)_t = 0$$

33. A plane wall is 20 cm thick with an area of 1 m^2 and has a thermal conductivity of 0.5 W/m. K. A temperature difference of 100°C is imposed across it. The heat flow is at :

(a) 150 W (b) 180 W

(c) 220 W (d) 250 W

Ans. **(d)**

Sol.

$$K = 0.5 \text{ W/m}$$

$$A = 1 \text{ m}^2$$

$$t = 20 \text{ cm} = 20 \times 10^{-2} \text{ m} = 0.2$$

$$\Delta\theta = 100°C$$

So, $$Q = \frac{kA\Delta\theta}{t}$$

$$= \frac{0.5\times1\times100}{0.2} = 250 \text{ W}$$

34. Hot gases enter a heat exchanger at 200°C and leave at 150°C. The cold air enters at 40°C and leaves at 140°C. The capacity ratio of the heat exchanger will be :

(a) 0.40 (b) 0.45

(c) 0.50 (d) 0.52

Ans. **(c)**

Sol. By Newtons law of cooling heat loss by hot fluid = Heat gain by cold fluid.

So, $m_h \times C_{ph}(T_{h_1} - T_{h_2}) = m_c \times C_{pc}(T_{c_2} - T_{c_1})$

Here $T_{h_2} = 200°C$

$T_{h_1} = 150°C$

$T_{c_2} = 140°C$

$T_{c_1} = 40°C$

So, $m_h \times C_{ph}(200 - 150) = m_c \times C_{pc} \times (140 - 40)$

or, $C_h \times 50 = C_c \times 100$

or, $C_h = 2C_c$

So, here $C_{min} = C_c$

$C_{max} = C_h$

So, Capacity ratio = $\frac{C_{min}}{C_{max}} = \frac{C_c}{C_h} = \frac{C_c}{2C_c} = 0.5$

35. During very cold weather conditions, cricket players prefer to wear white woolen sweaters rather than coloured woolen sweaters. The reason is that white wool comparatively :

1. Absorbs less heat from body

2. Emits less heat to the atmosphere

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. **(b)**

Sol. As white colour reflect the solar radiation and absorb the infrared radiation. In winter season as body temperature is more than atmospheric temperature. Body radiate heat in infrared region which is not visible un is absorbed by sweater of white colour but it emit the same inless amount to the surrounding. Due which human body remain hot. Here, white colour absorb the infrared radiation from outside and keep the body hot.

36. A pipe of 10 cm diameter and 10 m length is used for condensing steam on its outer surface. The average heat transfer coefficient h_h (when the pipe is horizontal) is n times the average heat transfer coefficient h_v (when the pipe is vertical). The value of n is :

(a) 2.44 (b) 3.34

(c) 4.43 (d) 5.34

Ans. (a)

Sol. $\because \quad \frac{(h_m)_h}{(h_m)_v} = 0.77\left(\frac{L}{D_0}\right)^{1/4}$

In condensation

Here $(h_m)_h = n(h_m)_v$

and $L = 10$ m

$D_0 = 10$ cm $= 10 \times 10^{-2}$ m

So, $\frac{n(h_m)_v}{(h_m)_v} = 0.77\left(\frac{10}{10\times10^{-2}}\right)^{1/4}$

or, $n = 2.434 \simeq 2.44$

37. A cross-flow type air heater has an area of 50 m^2. The overall transfer coefficient is 100 Wm^2 K; and heat capacity of the stream, be it hot or cold, is 1000 W/K. What is the NTU?

(a) 500 (b) 50

(c) 5 (d) 0.5

Ans. (c)

Sol. $NTU = \frac{UA}{C_{min}}$

$U = 100\ W/m^2K$

$C = 1000\ W/K = C_{min}$

$A = 50\ m^2$

$NTU = \frac{UA}{C_{min}} = \frac{100\times 50}{1000} = 5$

38. The effectiveness of a counter-flow heat exchanger has been estimated as 0.25. Hot gases enter at 200°C and leave at 75°C. Cooling air enters at 40°C. The temperature of the air leaving the unit will be :

(a) 60°C (b) 70°C

(c) 80°C (d) 90°C

Ans. (c)

Sol. $\varepsilon = \frac{t_{c_2} - t_{c_1}}{t_{h_2} - t_{c_1}}$

or, $0.25 = \frac{t_{c_2} - 40}{200 - 40}$

or, $t_{c_2} = 160 \times 0.25 + 40 = 80$

39. Consider the following statements regarding C.I. engine :

1. C.I. engines are more bulky than S.I. engines
2. C.I. engines are more efficient than S.I. engines
3. Lighter flywheels are required in C.I. engines

Which of the above statements are correct?

(a) 1 and 3 only (b) 2 and 3 only

(c) 1 and 2 only (d) 1, 2 and 3

Ans. (c)

Sol. Because of higher compression ratios and higher pressure ratio involved, C.I. engine require stronger engine parts, and inherently heavier. The C.I. engines may be 2 to 3 times heavier than comparable S.I. engines.

The use of higher compression ratio in C.I. engines as compared to S.I. engine results in higher thermal efficiency for the C.I. engine.

Lighter or heavier flywheel requirements of engine depends on Stroke of the engine. In four stroke, flywheel is heavier than two stroke due to fluctuation of load and only one power stroke in 360 degree of rotation.

40. Thermal boundary layer is a region where :

(a) Heat dissipation is negligible

(b) Inertia and convection are of the same order of magnitude

(c) Convection and dissipation terms are of the same order of magnitude

(d) Convection and conduction terms are of the same order of magnitude

Ans. (c)

Sol. In thermal boundary layer heat dissipate it can not be zero.

Thermal boundary layer generate due to viscosity (momentum diffusivity) and molecular diffusivity of heat (α), so its is not inertia and convection.

In thermal boundary layer we finaly find convective heat transfer co-efficient (h′) either for laminar or turbulent which measure the amount of heat dissipate in the region. So, convection and dissipation are of the same order of magnitude.

Convection and conduction can not be of same order as finally convection take place with joint effect of momentum and conduction.

41. Solar radiation of 1000 W/m^2 is incident on a grey opaque surface with emissivity of 0.4 and emissive power of 400 W/m^2. The ratiosity of the surface will be :

(a) 940 W/m^3 (b) 850 W/m^2

(c) 760 W/m^2 (d) 670 W/m^2

Ans. (c)

Sol. Here $G = 1000$ W/m^2

$E_b = 400$ W/m^2 (Assume)

Radiosity, $J = E + \rho G$

ρ = Reflectivity

as surface is opaque.

So, $\tau = 0$ (Transmitivity)

So, $\rho = 1 - \alpha = 1 - \varepsilon = 1 - 0.4 = 0.6$

(by Krischoff's law)

So, $J = \varepsilon E_b + \rho G$

$= 0.4 \times 400 + 0.6 \times 100$

$= 760$ W/m^2

Note : In this question emissive power = 400 W/m^2 is considered for black surface.

Otherwise, for opaque surface emissive power = 400 W/m^2, surface turned out to be black.

42. A body 1 in the form of a sphere of 2 cm radius at temperature T_1 is located in body 2, which is a hollow cube of 5 cm side and is at temperature T_2 ($T_2 < T_1$). The shape factor F_{21} for radiation heat transfer becomes :

(a) 0.34 (b) 0.43

(c) 0.57 (d) 0.63

Ans. (a)

Sol. As sphere can not see itself

so, $F_{11} = 0$

by summationrule

$F_{11} + F_{12} = 1$

or, $F_{12} = 1$

By reciprocity theorem

$A_1F_{12} = A_2F_{21}$

or $F_{21} = \frac{A_1}{A_2} \times F_{12}$

$= \frac{4\tau r^2}{6\,a^2} \times 1$

$= \frac{4 \times 3.14 \times (2)^2}{6 \times (5)^2} = 0.334$

43. Consider the following statements in respect of vapour compression refrigeration units :

1. In actual units the refrigerant leaving the evaporator is superheated
2. Superheating of refrigerant at exit of evaporator increases the refrigerating effect
3. The superheating of refrigerant increases the work of the compressor

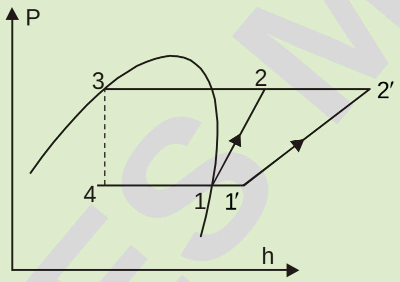
Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

Sol. 1. In actual vapour compression units, the refrigerant leaving the evaporator is superheated to avoid entry of liquid in compressor, the p-h diagram,



2. Refrigerating effect increases from $(h_1 - h_2)$ to $(h_1 - h_2)$
3. Compression work increases because as superheat increases, the slope of compression curve decreases on p-h diagram. Hence $(h_{2'} - h_1) > (h_2 - h_1)$

44. In a vapour compression refrigerator, the heat rejected in condenser is 1500 kJ/kg of refrigerant flow and the work done by compressor is 250 kJ/kg. The COP of the refrigerator is :

(a) 5 (b) 6

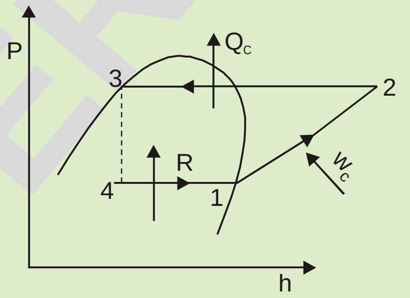
(c) 7 (d) 8

Ans. (a)

Sol. The p-h diagram of VCR

Heat rejected in condenser,

$$Q_c = 1500 \text{ kJ/kg}$$



Compressor work,

$$W_c = 250 \text{ kJ/kg}$$

where R is refrigeration effect,

$$\because \quad Q_c = W_c + R$$

$$1500 = 250 + R$$

$$\therefore \quad R = 1500 - 250 = 1250 \text{ kJ/kg}$$

$$\therefore \quad COP = \frac{R}{W} = \frac{1250}{250} = 5$$

45. A refrigeration plant is designed to work between –3°C and 27°C. The plant works on the Carnot cycle. If the same plant is used as a heat-pump system, then the COP of the heat pump becomes :

(a) 10 (b) 9

(c) 8 (d) 7

Ans. (a)

Sol. A refrigerant plant works on Carnot cycle between T_1 = 27°C = 300 K and T_2 = –3°C = 270 K.

The COP of the same plant when aperate as heat pump,

$$COP_{HP} = \frac{T_1}{T_1 - T_2} = \frac{300}{300 - 270}$$

$$= \frac{300}{30} = 10$$

46. A refrigeration plant working on Carnot cycle is designed to take the load of 4T of refrigeration. The cycle works between 2°C and 27°C. The power required to run the system is :

(a) 1.27 kW (b) 3.71 kW
(c) 5.71 kW (d) 7.27 kW

Ans. (a)

Sol. Refrigeration plant on Carnot cycle takes load i.e. Refrigeration effect, R = 4T=4 × 3.5 =14 kW

The working temperature,

$$T_1 = 27°C = 300K$$
$$T_2 = 2°C = 275K$$

$\therefore$ COP is defined as,

$$\frac{R}{W} = \frac{T_2}{T_1 - T_2}$$

$$\frac{14}{W} = \frac{275}{300-275} = \frac{275}{25} = 11$$

$\therefore$ Power required to run the compressor,

$$P = \frac{14}{11} = 1.27 kW$$

47. The choice of a refrigerant depends upon :

1. Refrigerating capacity
2. Type of compressor used (reciprocating, centrifugal or screw)
3. Service required (whether for air conditioning, cold storage or food freezing)

Which of the above statements is/are correct?

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

Ans. (d)

Sol. The choice of a refrigerant depends-

1. If a refrigerant has large latent heat of evaporation the size of condenser evaporator and compressor reduces because less mass flow rate.
2. If a specific volume a refrigerant is large at evaporator pressure, the size of compressor increases. Large specific volume refrigerant are compressed by centrifugal compressor and less specific by centrifugal compressor and less specific volume refrigeants by reciprocating compressor.
3. Off course evaporator temperature (high for air conditioner as compared to cold storage) also influence the refrigerant choice.

48. The COP of an ideal refrigerator of capacity 2.5 T is 5. The power of the motor required to run the plant is :

(a) 1.15 kW (b) 1.35 kW
(c) 1.55 kW (d) 1.75 kW

Ans. (d)

Sol. The COP of a refrigerator,

$$COP = \frac{\text{Refrigeration effect}}{\text{Compression work}} = \frac{R}{W}$$

$$5.0 = \frac{2.5 \times 3.5}{W}$$

$$W = \frac{2.5 \times 3.5}{5} = 1.75 \text{ kW}$$

49. The objective of supercharging an engine is :

1. To reduce space occupied by the engine
2. To increase the power output of an engine when greater power is required

Which of the above statements are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. (c)

Sol. The main objective of supercharging is to increase the power output but at the same time supercharger are used where weight and space are important like racing car, automotive engine, marine engine. So, supercharging is used to reduce space occupied by engine.

50. To reversible refrigerators are arranged in series and their COPs are 5 and 6 respectively. The COP of composite refrigeration system would be :

(a) 1.5 (b) 2.5
(c) 3.5 (d) 4.5

Ans. (b)

Sol. The COP of refrigerator R_1

$$COP_1 = \frac{T}{T_1 - T_2} = 5$$

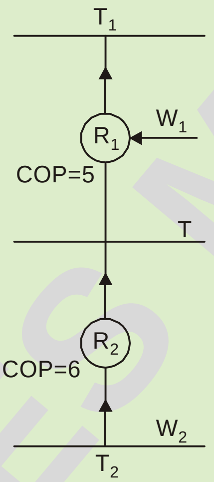
$\therefore$ $6T = 5T_1$ ...(i)

The COP of refrigerator, R_2,

$$COP = \frac{T_2}{T_1 - T_2} = 6 \quad \text{...(ii)}$$

$\therefore$ $7T_2 = 6T$

$\therefore$ Overall COP,



$$= \frac{T_2}{T_1 - T_2} = \frac{\frac{6T}{7}}{\frac{6T}{5} - \frac{6T}{7}} = \frac{\frac{6}{7}}{\frac{6\times 2}{35}}$$

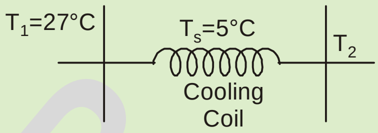
$$= \frac{6}{7} \times \frac{35}{6\times 2} = 2.5$$

51. In an air-conditioning plant, air enters the cooling coil at 27°C. The coil surface temperature is –5°C. If the bypass factor of the unit is 0.4, the air will leave the coil at :

(a) 5.6°C (b) 7.8°C
(c) 9.2°C (d) 11.2°C

Ans. (b)

Sol. The cooling coil and various temperature,



Bypass factor,

$$BPF = \frac{(T_2 - T_s)}{T_1 - T_s}$$

$$0.4 = \frac{T_2 - (5)}{27 - (-5)} = \frac{T_2 + 5}{32}$$

$T_2 + 5 = 0.4 \times 32 = 12.8$

$T_2 = 12.8 - 5 = 7.8$°C

52. The wet bulb and dry bulb temperatures of an air sample will be equal when :

1. Air is fully saturated
2. Dew point temperature is reached
3. Partial pressure of vapour equals the total pressure
4. Humidity ratio is 100%

Which of the above statements are correct?

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

Ans. (a)

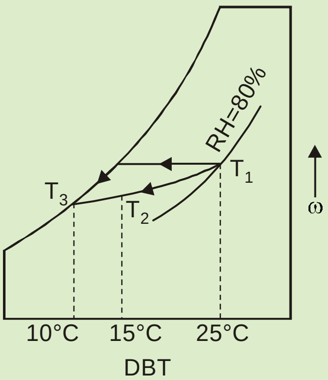
Sol.
- The WBT and DBT and Dew point temperature all are equal at saturation curve i.e. RH = 100% of psychrometric chart
- It is impossible that vapour pressure is equal to total pressure in air-vapour mixture
- Humidity ratio of 100% has no meaning in psychrometry

53. Air at 25°C DBT and 80% RH is passed over a cooling coil whose surface temperature is 10°C which is below DPT of the air. If the air temperature coming out of the cooling coil is 15°C, then the bypass factor of the cooling coil is :

(a) 0.56 (b) 0.67
(c) 0.76 (d) 0.87

Ans. (b)

Sol. Since the coil temperature is lower than DPT, so condensation is there,



$$\text{BPF} = \frac{T_1 - T_2}{T_1 - T_3}$$

$$= \frac{25-15}{25-10} = \frac{10}{15} = \frac{2}{3}$$

$$= 0.67$$

54. Consider the following statements for the appropriate context :

1. The Relative Humidity of air remains constant during sensible heating or cooling
2. The Dew Point Temperature of air remains constant during sensible heating or cooling
3. The total enthalpy of air remains constant during adiabatic cooling
4. It is necessary to cool the air below its Dew Point Temperature for dehumidifying

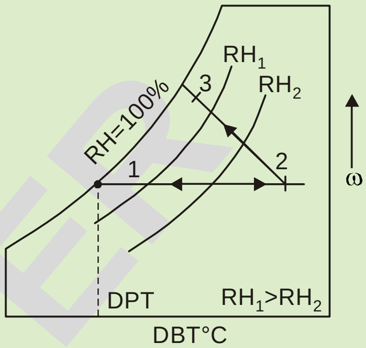
Which of the above statements are correct?

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

(c) 3 and 4 only (d) 2, 3 and 4

Ans. (d)

Sol. 1. The Relative humidity (RH) reduces during sensible heating $(1 \rightarrow 2)$ and increases during sensible cooling $(2 \rightarrow 1)$.



2. Dew point temperature (DPT) remains constant during both heating and cooling sensibly.
3. The enthalpy remains constant during adiabatic cooling (2–3).
4. In dehumidifying process, moisture in air vapour mixture needs to be condensed for removal. So dehumidification requires cooling of mixture below DPT for condensation.

55. The discharge through an orifice fitted in a tank can be increased by :

(a) Fitting a short length of pipe to the outside

(b) Sharpening the edge of orifice

(c) Fitting a long length of pipe to the outside

(d) Fitting a long length of pipe to the inside

Ans. (a)

Sol. By fitting long pipe discharge will be more but less in comparison of short length pipe due to more friction loss in long pipe.

When pipe is fitted outside in that case co-efficient of discharge is around 0.82 and when it fitted inside then same is of 0.75. So, pipe of short length fitted outside give more discharge.

56. The latent heat load in an auditorium is 25% of sensible heat load. The value of sensible heat factor is

(a) 0.3 (b) 0.5

(c) 0.8 (d) 1.0

Ans. (c)

Sol. Latent heat load, = 25% of sensible heat.

LHL = 25% SHL = 0.25 SHL

Sensible heat factor

$$SHF = \frac{SHL}{SHL + LHL} = \frac{SHL}{SHL + 0.25\ SHL}$$

$$= \frac{1}{1.25} = 0.8$$

57. In a solar collector, the function of the transparent cover is to :

(a) Transmit solar radiation only

(b) Protect the collector from dust

(c) Decrease the heat loss from collector beneath to atmosphere

(d) Absorb all types of radiation and protect the collector from dust

Ans. (c)

Sol. The purpose of transparent cover is to transmit the shorter wavelength solar radiation but block longer wavelength reradiation from the absorber plate and to reduce the heat loss by convection from top of the absorber plate.

58. The most suitable refrigeration system utilizing solar energy is :

(a) Ammonia-Water vapour absorption refrigeration system

(b) Lithium Bromide-Water vapour absorption refrigeration system

(c) Desiccant refrigeration system

(d) Thermoelectric refrigeration system

Ans. (a)

Sol. Ammonia-water absorption is more suitable for refrigeration than lithium bromide (LiBr) water absorption using solar energy. In LiBr, water is refrigerant and LiBr is absorbent so water freezes as temperature decreases to 0°C.

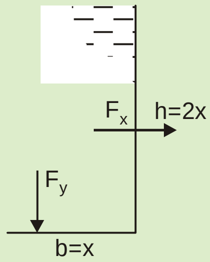
59. A house-top water tank is made of flat plates and is full to the brim. its height is twice that of any side. The ratio of total thrust force on the bottom of the tank to that on any side will be :

(a) 4 (b) 2

(c) 1 (d) 0.5

Ans. (c)

Sol. The thrust on wall,



$$F_x = \rho g \bar{h} A$$

$$= \rho g \frac{2x}{2} \times 2x \cdot x$$

$$= 2\rho g x^3 \qquad \text{...(i)}$$

Bottom force

$$F_y = \rho g \bar{h} A = \rho g \cdot 2x \times x \times x$$

$$= 2\rho g x^3 \qquad \text{...(ii)}$$

$$\therefore \quad F_x/F_y = 2\rho g x^3 / 2\rho g x^3 = 1\text{-}$$

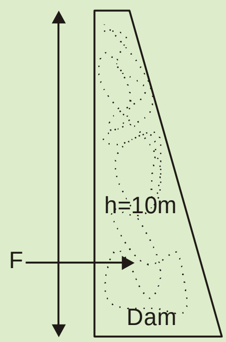
60. The water level in a dam is 10 m. The total force acting on vertical wall per metre length is:

(a) 49.05 kN (b) 490.5 kN

(c) 981 kN (d) 490.5 kN

Ans. (b)

Sol.



The force on vertical wall,

$$F = \rho g \bar{h} A$$

$$= 1000 \times 9.81 \times \frac{10}{2} \times 10 \times 1$$

$$= 490.5 \text{ kN}$$

61. A vacuum gauge fixed on a steam condenser reads 80 kPa vacuum. The barometer indicates 1.013 bar. The absolute pressure in terms of mercury head is, nearly

(a) 160 mm of Hg (b) 190 mm of Hg

(c) 380 mm of Hg (d) 760 mm of Hg

Ans. (a)

Sol. Absolute pressure = Atmospheric pressure + Gauge pressure

$\therefore \quad P_a = P_o + P_g$

Since the condenser pressure is vacuum.

$\therefore \quad P_g = -80$ kPa

$\therefore \quad P_a = 101.3 - 80 = 21.3$ kPa

$\rho_m g h_m = 21.3 \times 10^3$

$13.6 \times 10^3 \times 9.81 . h_m = 21.3 \times 10^3$

$\therefore$ Mercury head, $h_m = \dfrac{21.3}{136 \times 4.81} = 0.15965\,\text{m}$

$= 159.65$ mm

$\simeq 160$ mm

62. The Orsat apparatus gives

1. Volumetric analysis of dry products of combustion

2. Gravimetric analysis of dry products of combustion

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. (a)

Sol. Orsat apparatus is used for volumetric analysis of dry gas only.

Gravimetric analysis is basically mass analysis.

63. A 25 cm long prismatic homogeneous solid floats in water with its axis vertical and 10 cm projecting abovbe water surface. If the same solid floats in some oil with its axis vertical and 5 cm projecting above the liquid surface, then the specific gravity of the oil is

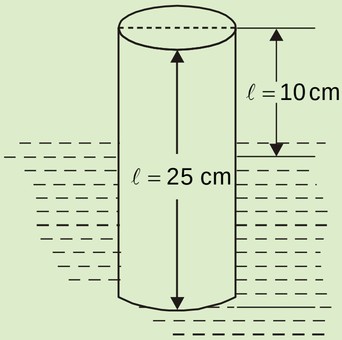
(a) 0.55 (b) 0.65

(c) 0.75 (d) 0.85

Ans. (c)

Sol. Let the cross-section area of bar is A.

In water,



Buoyancy force = weight of water displaced

$$F_{B_W} = \rho V g.$$

$$= \rho_\omega \cdot A(L - \ell) g$$

$$= \rho_B \cdot A(25 - 10) \cdot g = 15\,\rho_B A g \quad \text{...(i)}$$

Now the bar is in oil, the buoyancy force,

$$F_{B_0} = \rho_0 A(25 - 5) g = 20\,\rho_0 A g \quad \text{...(ii)}$$

Since buoyancy force is equal to weight of bar in both cases, so

$$F_{B_\omega} = F_{B_o}$$

$$15 \rho_\omega A g = 20 \rho_o A g$$

$$\rho_o = \frac{15}{20} \rho_\omega$$

$$\frac{\rho_o}{\rho_\omega} = \frac{15}{20} = 0.75$$

64. Consider the following statements :

1. Increases stability

2. Decreases stability
3. Increases comfort for passengers in a ship
4. Decreases comfort for passengers in a ship

Which of the above statements are correct?

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

Ans. (b)

Sol. Increase in metacentric height increases stability of ship but at the same time, it reduces period of oscillation. A low period of oscillation causes sharp vibration to ship which are quite un comfortable to passengers on board.

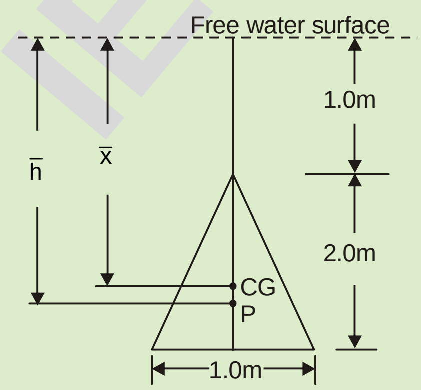
65. An isosceles triangular lamina of base 1 m and height 2 m is located in the water in vertical plane and its vertex is 1 m below the free surface of the water. The position of force acting on the lamina from the free water surface is :

(a) 2.42 m (b) 2.33 m
(c) 2.00 m (d) 1.33 m

Ans. (a)

Sol. The position of Lamina in water

The depth of centre of Gravity of lamina from free water surface,



$$\bar{x} = 1+\frac{2}{3}\times 2 = \frac{7}{3}\text{m}$$

The depth of centre of pressure,

$$\bar{h} = \bar{x}+\frac{I_G}{A\bar{x}}$$

Moment of area of lamina about centre of gravity,

$$I_G = \frac{1}{36}\cdot bh^3 = \frac{1}{36}\times 1\times 2^3 = \frac{2}{9}$$

$$\therefore \text{ Area, } A = \frac{1}{2}\cdot b\cdot h = \frac{1}{2}\times 1\times 2 = 1\text{m}^2$$

$$\therefore \bar{h} = \frac{7}{3}+\frac{2/9}{1\times 7/3} = \frac{7}{3}+\frac{2}{9}\times\frac{3}{7} = \frac{7}{3}+\frac{2}{21}$$

$$= \frac{51}{21} = 2.4286 \text{ m}$$

66. A solid body of specific gravity 0.5 is 10 m long 3 m wide and 2 m high. When it floats in water with its shortest edge vertical, its metacentric height is :

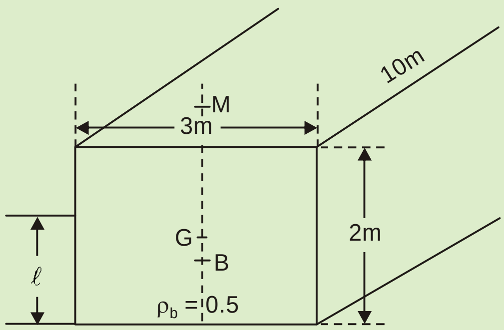
(a) 0.75 m (b) 0.45 m
(c) 0.25 m (d) 0.15 m

Ans. (c)

Sol. The solid body inside water in desired condition,

The metacentric height

$$GM = BM - BG \quad \text{...(i)}$$



V-Volume of displaced liquid,

The depth of body in water

$$\rho_\omega \ell A\cdot g = \rho_b h\cdot A\cdot g$$

$$1.0\times\ell\, Ag = 0.5\times 2\, Ag$$

$$\therefore \ell = 1.0\text{m}$$

Volume displaced,

$$V = A\cdot\ell = 3\times 10\times 1 = 30 \text{ m}^3$$

Moment of area of top surface,

$$I = \frac{1}{12}\times 10\times 3^3 = \frac{10\times 27}{12} = 22.5\ m^4$$

$$= \frac{22.5}{30} = 0.75\ m$$

$\therefore$ Metacentric radius, BM = I/V

$$BG = \frac{2}{2} - \frac{1}{2} = 0.5\ m$$

Metacentric height,

GM = BM – BG = 0.75 – 0.5 = 0.25 m

67. For a steady two-dimensional flow, the scalar components of the velocity field are $V_x = -2x$; $V_y = 2y$ and $V_z = 0$. The corresponding components of acceleration a_x and a_y, respectively are :

(a) 0 and 4y (b) 4x and 0

(c) 0 and 0 (d) 4x and 4y

Ans. (d)

Sol. The velocity field,

$V_x = -2x$; $V_y = 2y$ and $V_z = 0$

This x-component of acceleration,

$$a_x = V_x\cdot\frac{\partial V_x}{\partial x} + V_y\cdot\frac{\partial V_x}{\partial y} + 0$$

$$= -2x \times -2 + 0 = 4x$$

The y-component of acceleration,

$$a_y = V_x\cdot\frac{\partial V_y}{\partial x} + V_y\cdot\frac{\partial V_y}{\partial y} + 0$$

$$= 0 + 2y \times 2 = 4y$$

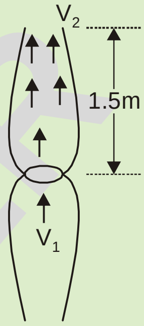
68. The velocity of flow from a tap of 12 mm diameter is 8 m/s. What is the diameter of the jet at 1.5 m from the tap when the flow is vertically upwards? Assuming that, the jet continues to be circular upto that level.

(a) 44 mm (b) 34 mm

(c) 24 mm (d) 14 mm

Ans. (d)

Sol.



The velocity of flow at 1.5 m above the tap,

$$\therefore\quad V_2^2 = V_1^2 - 2gh$$

$$= 8^2 - 2\times 9.81\times 1.5$$

$$= 64 - 3\times 9.81 = 34.57$$

$$V_2 = 5.88\ m/sec$$

From continuity equation

$$A_1V_1 = A_2V_2$$

$$\therefore\quad \frac{\pi}{4}\cdot 12^2\times 8 = \frac{\pi}{4}\times d_2^2\times 5.88$$

$$\therefore\quad d_2 = 12\times\sqrt{\frac{8}{5.88}} = 13.997\ mm$$

$$\simeq 14\ mm$$

69. Consider the following statements about thermal conductivity :

1. Thermal conductivity decreases with increasing molecular weight
2. Thermal conductivity of non-metallic liquids generally decreases with increasing temperature
3. Thermal conductivity of gases and liquids is generally smaller than that of solids

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

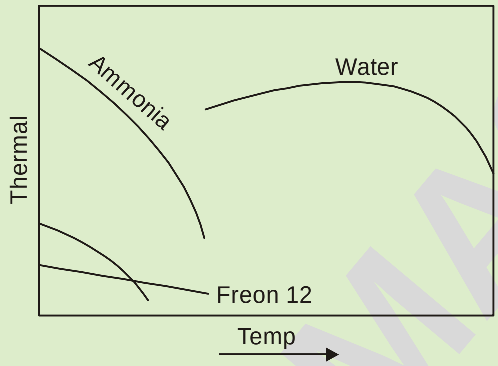
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

Sol. For non-metallic liquid study is done on saturated condition. The thermal conductivity of non-metallic liquids generally decreases with increasing temperature, the notable exceptions is being glycerine and water,

Thermal conductivity of non-metallic liquids decreases with increasing molecular weight.

Thats why these are not used in nuclear engineering.



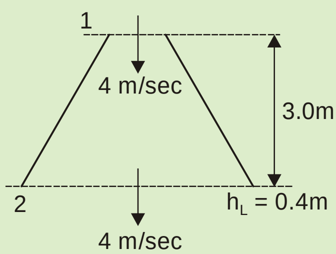
70. A conical diffuser 3 m long is placed vertically. The velocity at the top (entry) is 4 m/s and at the lower end is 2 m/s. The pressure head at the top is 2 m of the oil flowing through the diffuser. The head loss in the diffuser is 0.4 m of the oil. The pressure head at the exit is:

(a) 3.18 m of oil (b) 5.21 m of oil

(c) 7.18 m of oil (d) 9.21 m of oil

Ans. (b)

Sol.



Applying Bernoulli's theorem across the diffuser,

$$\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+z_1=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+z_2+h_2$$

$$2+\frac{4^2}{2g}+3=\frac{P_2}{\rho g}+\frac{2^2}{2g}+0+0.4$$

$$5-0.4+\frac{16-4}{2g}=\frac{P_2}{\rho g}$$

$$\therefore \quad \frac{P_2}{\rho g}=4.6+\frac{6}{g}=4.6+0.6162$$

$$= 5.2116 \text{ m of oil}$$

71. Bernoulli's equation $\frac{p}{\rho}+\frac{v^2}{2}+gZ=\text{Constant}$, is valid for :

1. Steady flow
2. Viscous flow
3. Incompressible flow
4. Flow along a streamline

Which of the above are correct?

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

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

Ans. (c)

Sol. The Bernoulli's equation

$$\frac{p}{\rho}+\frac{v^2}{2}+gz=\text{constant}$$

This equation is applicable under the following assumption

1. Steady incompressible flow
2. Fluid is ideal
3. Flow is irrotational and if rotational, it is applicable along a stream line.

If the flow is viscous, kinetic energy correction factor is introduced with loss factor as,

$$\frac{p_1}{\rho g}+\alpha_1\frac{v_1^2}{2g}+z_1=\frac{p_z}{\rho g}+\alpha_2\frac{v_2^2}{2g}+z_2+\text{losses}$$

72. Consider the following statements:

1. Absorptivity depends on wave length of incident radiation waves
2. Emissivity is dependent on wave length of incident radiation waves

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. (c)

Sol. Both emissivity and absorptivity depends on wavelength of incident radiation. The emissivity at a certain wavelength is called spectral emissivity likewise absorptivity. This applicable for real surface.

73. A steam turbine in which a part of the steam after expansion is used for process heating and the remaining steam is further expanded for power generationis/are:

1. Impulse turbine
2. Pass out turbine

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor

Ans. (b)

Sol. In pass out turbine a heat exchanger installed in place of condenser as-well-as in between condenser and turbine for process heating.

But in impulse turbine steam after expansion is used for in regenerator to increase the effective mean temperature of the cycle.

74. Two reservoirs connected by two pipe lines in parallel of the same diameter D and length. It is proposed to replace the two pipe lines by a single pipeline of the same length without affecting the total dishcarge and loss of head due to friction. The diameter of the equivalent pipe D_e in terms of the diameter of the existing pipe line, $\frac{D_e}{D}$, is:

(a) 4.0 (b) $(2)^{\frac{1}{5}}$

(c) $(4)^{\frac{1}{4}}$ (d) $(4)^{\frac{1}{5}}$

Ans. (d)

Sol. The head loss is same in both cases,

$$h_{f_1} = h_{f\,equivalent}$$

$$\frac{16fL}{2\pi^2 g}\frac{Q^2}{D^5} = \frac{16fL}{2\pi}\frac{(2Q)^2}{D_e^5}$$

$$\therefore \quad D_e^5 = 2^2 \cdot D^5$$

$$\frac{D_e}{D} = (4)^{1/5}$$

75. A fluid jet is discharging froma 100 m nozzle and the vena contracta formed has a diameter of 90 mm. If the coefficient of velocity is 0.98, then the coefficient of discharge for the nozzle is:

(a) 0.673 (b) 0.794

(c) 0.872 (d) 0.971

Ans. (b)

Sol. Coefficient of contraction,

$$C_c = \frac{\text{Area at vena contracta}}{\text{Area at nozzle exit}} = \frac{90^2}{100^2} = 0.81$$

Coefficient of discharge,

C_d = Velocity coefficient × Coeff. of contraction

$= C_v \cdot C_c$

$= 0.98 \times 0.81 = 0.7938$

$\simeq 0.794$

76. Consider fully developed laminar flow in a circular pipe of a fixed length:

1. The friction factor is inversely proportional to Reynolds number
2. The pressure drop in the pipe is proportional to the average velocity of the flow in the pipe

3. The friciton factor is higher for a rough pipe as compared to a smooth pipe
4. The pressure drop in the pipe is proportional to the square of average of flow in the pipe

Which of the abvoe statements are correct?

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

Ans. (d)

Sol.
- The friction factor, 'f' in fully developed laminar pipe,

$$f = \frac{64}{Re}$$

- The pressure drop in pipe having laminar flow,

$$\Delta p = \frac{32\mu V}{D^2} = \frac{128\mu QL}{\omega\pi D^4}$$

- In laminar flow, the friction factor is independent of roughness because boundary layer covers the roughness.

77. The thickness of the boundary layer for a fluid flowing over a flat plate at a point 20 cm from the leading edge is found to be 4 mm. The Reynolds number at the point (adopting 5 as the relevant constant) is:

(a) 48400 (b) 57600
(c) 62500 (d) 77600

Ans. (c)

Sol. The thickness of boundary layer over flat plate,

$$\frac{\delta}{x} = \frac{5}{\sqrt{Re_x}}$$

$$\frac{4\times10^{-3}}{20\times10^{-2}} = \frac{5}{\sqrt{Re_x}}$$

$$\sqrt{Re_x} = \frac{5\times20\times10^{-2}}{4\times10^{-3}} = 5\times5\times10$$

$$\therefore\ Re_x = 62500$$

78. What is the ratio of displacement thickness to boundary layer thickness for a linear distribution of velocity $\frac{u}{u_\infty} = \frac{y}{\delta}$ in the boundary layer on a flat plate, where δ is the boundary layer thickness and u_∞ is the free steam velocity?

(a) 0.5 (b) 0.67
(c) 0.75 (d) 0.8

Ans. (a)

Sol. Velocity distribution in boundary layer,

$$\frac{u}{U_\infty} = \frac{y}{\delta}$$

$\therefore$ Displacement boundary layer,

$$\delta^* = \int_0^\delta\left(1-\frac{u}{U_\infty}\right)dy = \int_0^\delta\left(1-\frac{y}{\delta}\right)dy$$

$$= \delta - \frac{\delta}{2} = \frac{\delta}{2}$$

$$\therefore\ \frac{\delta^*}{\delta} = \frac{1}{2} = 0.5$$

79. The oil with specific gravity 0.8, dynamic viscosity of 8 × 10^{-3} Ns/m^2 flows through a smooth pipe of 100 mm diameter and with Reynolds number 2100. The average velocity in the pipe is:

(a) 0.21 m/s (b) 0.42 m/s
(c) 0.168 m/s (d) 0.105 m/s

Ans. (a)

Sol.

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

$$\therefore\ V = \frac{\mu\times R_e}{\rho D}$$

$$= \frac{8\times10^{-3}\times2100}{800\times100\times10^{-3}}$$

$$= \frac{8\times2100}{800\times100} = 0.21 \text{ m/s}$$

80. In a psychrometric chart, relative humidity lines are:

(a) Curved

(b) Inclined and straight but non-uniformly spaced

(b) Horizontal and non-uniformly spaced

(d) Horizontal and uniformly spaced

Ans. (a)

Sol. In psychrometric chart, relative humidity (RH) lines are curved having positive slope from zero to infinite.

81. A solar collector receiving solar radiation at the rate of 0.6 kW/m^2 transforms it to the internal energy of afluid at an overall efficiency of 50%. the fluid heated to 350 K is used to run a heat engine which rejects heat at 313 K. If the heat engine is to deliver 2.5 kW power, the minimum area of the solar collector required would be, nearly:

(a) 8 m^2 (b) 17 m^2

(c) 39 m^2 (d) 79 m^2

Ans. (d)

Sol. $\eta_{max} = 1-\frac{T_2}{T_1} = 1-\frac{313}{350} = 0.106$

$\therefore \quad \eta_{max} = \frac{W}{Q}$

$Q_{min} = \frac{W}{\eta_{max}} = \frac{2.5}{0.106} = 23.6 \text{ kW}$

$\therefore \quad 0.6 \times 0.5 \times A_{min} = 23.6$

$\therefore \quad A_{min} = \frac{23.6}{0.6 \times 0.5} = 78.67 \simeq 79\text{m}^2$

82. A reversible heat engine, operating on Carnot cycle, between the temperature limits of 300 K and 1000 K produces 14 kW of power. If the calorific value of the fuel is 40,000 kJ/kg. The fuel consumption will be:

(a) 1.4 kg/hr (b) 1.8 kg/hr

(c) 2.0 kg/hr (d) 2.2 kg/hr

Ans. (b)

Sol. Since the heat engine is reversible,

so $\eta = 1-\frac{T_2}{T_1} = 1-\frac{300}{1000} = 0.7$

$\therefore \quad \eta = \frac{W}{Q} \Rightarrow Q = \frac{W}{\eta} = \frac{14}{0.7} = 20 \text{ kW}$

$\therefore \quad Q = \dot{m}_f \times CV$

$\therefore \quad \dot{m}_f = \frac{Q}{CV} = \frac{20 \text{ kW}}{40000 \text{ kJ/kg}}$

$= \frac{20 \times 3600}{40000} \text{kg/hr}$

$= 1.8$ kg/hr

83. Consider the following statements pertaining to the metacentric height of ocean-going vessels:

1. Increase in the metacentric height reduces the period roll
2. Some control of period of roll is possible if Cargo is placed further from the centre line of ship
3. In warships and racing yachts, metacentric height will be larger than other categories of ships
4. For ocean-going vessels, metacentric height is of the order of 30 cm to 120 cm

Which of the above statements are correct?

(a) 1, 2, 3 and 4 (b) 1, 2 and 3 only

(c) 1, 2 and 4 only (d) 3 and 4 only

Ans. (a)

Sol. The period of oscitation of ship,

$$T = 2\pi\sqrt{\frac{K_g^2}{g.\,GM}}$$

where K_g = radius of gyration about centre of gravity and GM is metacentric height.

Placing the cargo away from centre increases radius of gyration.

Warship and racing yachts have higher metacentric height to ensure improved stability.

Hence all statements are correct.

84. Consider the following statements pertaining to a convergent-divergent nozzle flow with Mach number 0.9 at the throat:

1. The flow is subsonic in both the converging and the diverging sections
2. The Mach number at the exit is less than one
3. In the diverging section, the flow is supersonic
4. There is a shock in the diverging section

Which of the above statements are correct?

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

Ans. (b)

Sol. For, gas nozzle,

$$\frac{dA}{A} = (M^2 - 1)\frac{dV}{V}$$

When M < 1, i.e., the inlet velocity is subsonic, as flow area A decreases, the pressure decreases and velocity increases, and when flow area A increase, pressure increases and velocity decreases.

85. For a two stage compressor, the ratio of diameters of L.P. cylinder to H.P. cylinder is equal to:

(a) Square of the ratio of final pressure to initial pressure
(b) The ratio of final pressure to initial pressure
(c) The square root of the ratio of final pressure to initial pressure
(d) Cube root of the ratio of final pressure to initial pressure

Ans. (a)

Sol. By considering the compression in compressor as isothermal compression. In this temperature in between stages will be constant.

i.e. $P_1V_1 = P_2V_2$

or, $$\frac{V_1}{V_2} = \frac{P_2}{P_1}$$

or, $$\frac{\pi D_1^2 \times L}{\pi D_2^2 \times L} = \frac{P_2}{P_1}$$

or, $$\frac{D_1}{D_2} = \left(\frac{P_2}{P_1}\right)^{1/2}$$

86. The condition for power transmission by flow through a pipeline to be maximum is that the loss of head of the flow due to friction throughout the piepline length is:

(a) One-third of the total head at inlet end
(b) One-fourth of the total head at inlet end
(c) Three-fourth of the total head at inlet end
(d) One-half of the total head at inlet end

Ans. (a)

Sol. Power transmitted through a pipe,

$$P = \rho g Q(H - h_f)$$

$$= \rho g \cdot \frac{\pi}{4} \cdot d^2 V\left(H - \frac{fLV^2}{2gd}\right)$$

For maximum power, $\frac{dP}{dV} = 0$

$$\therefore \quad h_f = \frac{H}{3}$$

87. The correct chronological order, in development of steam generators, is:

(a) Fire tube boiler, Monotube boiler and Water tube boiler
(b) Water tube boiler, Fire tube boiler and Monotube boiler
(c) Fire tube boiler, Water tube boiler and Monotube boiler
(d) Water tube boiler, Monotube boiler and Fire tube boiler

Ans. (c)

Sol. Fire tube boiler has been developed during industrial revolution. In due course of time developement occured and water tube boiler came in existance.

But it was bulky due to steam drum required for intermediate phase.

So, to avoid this supercritical or monotube boiler came in picture to meet the high quality steam requirement and lesser space installation time etc.

88. Supersaturated flow occurs in a steam nozzle due to delay in:

(a) Throttling (b) Condensation

(c) Evaoration (d) Entropy drop

Ans. (b)

Sol. Supersaturation phenomenon occurs in nozzle due to delay in condensation due to which mass flow rate coming from the nozzle is more than the designed value.

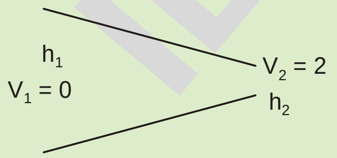
89. Under ideal conditions, the velocity of steam at the outlet of a nozzle for a heat drop of 450 kJ/kg from inlet reservoir condition upto the exit is:

(a) 649 m/s (b) 749 m/s

(c) 849 m/s (d) 949 m/s

Ans. (d)

Sol.



$h_2 - h_1 = 450$ kg/kg

by S.F.E.E.

$$h_1 + \frac{v_1^2}{2} = h_2 + \frac{v_2^2}{2}$$

{Here W = 0, Q = 0, potential energy term = 0}

or, $v_2 = \sqrt{2(h_1 - h_2)}$

$= \sqrt{2 \times 450 \times 1000} = 948.68$

$\simeq$ 949 m/sec

90. A shock wave which occurs in a supersonic flow represents a region in which:

(a) A zone of silence exists

(b) There is no change in pressure, temperature and density

(c) There is sudden change in pressure, temperature and density

(d) Analogy with a hydraulic jump is not possible

Ans. (c)

Sol. For shock wave Mach number is greater than one i.e., velocity of source is greater than velocity of sound. In this case the pressure and velocity at an arbitary point of the stream can be influenced only by disturbance acting at point that lie on or inside the zone of action (or Mach cone) so option (a) is wrong.

When shock occur then there is sudden change in pressure a temperature and density. As flow is changing from supersonic to subsonic, so velocity and pressure and temperature will change. Only stagnation enthalpy and temperature may remain constant. But static value definitely change.

91. A convergent-divergent nozzle is said to be choked when:

(a) Critical pressure is attained at the exit and Mach number at this section is sonic

(b) Velocity at the throat becomes supersonic

(c) Exit velocity becomes supersonic

(d) Mass flow rate thorugh the nozzle reaches a maximum value

Ans. (d)

Sol. A nozzle is said to be chocked when flow rate through it is maximum and at throat of nozzle M = 1.

92. In a gas turbine cycle, the turbine output is 600 kJ/kg, the compressor work is 400 kJ/kg, and the heat supplied is 1000 kJ/kg. the thermal efficiency of the cycle is:

(a) 20% (b) 30%

(c) 40% (d) 50%

Ans. (a)

Sol.

$$\eta = \frac{\text{Output}}{\text{Input}}$$

$$= \frac{600-400}{1000} \times 100$$

$$= 20\%$$

93. Which of the following units increase the work ratio in a gas turbine plant?

1. Regeneration
2. Reheating
3. Intercooling

(a) 1 and 2 only (b) 2 and 3 only

(c) 1 and 3 only (d) 1, 2 and only

Ans. (a)

Sol.

$$WR = \frac{W_{net}}{W_t} = \frac{W_t - W_c}{W_t}$$

$$= 1 - \frac{W_c}{W_t}$$

By intercooling W_c become isothermal so, W_c will be less comparative to general gas cycle, so, work ratio improve.

By reheating markedly increase the specific output (W_N) but efficiency decreased at the same time and hence, work ratio increased.

The specific output, i.e. W_N is unchanged by the addition of heat exchanger (regeneration) so, W_Q work ratio will remain unchanged. By regeneration only efficiency will increase provided pressure ratio should not be high.

94. The pressure at a point in water column is 3.924 N/cm². What is the corresponding height of water?

(a) 8 m (b) 6 m

(c) 4 m (d) 2 m

Ans. (c)

Sol. Pressure in water column of height 'h'.

$$P = \rho gh$$

$$3.924 \times 10^4 = 10^3 \times 9.81h$$

$$\therefore \quad h = \frac{39.24}{9.81} = 4\text{m}$$

95. Consider the following statements:

1. Thermal efficiency of the simpel Steam or Ranking cycle can be improved by incresing the maximum system pressure and temperature
2. Increasing the superheat of the steam improves the specific work and decreases the moisture content of exhaust steam
3. Increasing maximum system pressure always increases the moisture content at the turbine exhaust
4. Lowering the minimum system pressure increases the specific work of the cycle

Which of the above statements are correct?

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

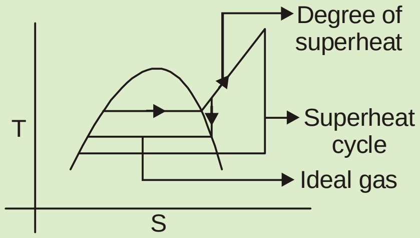
(c) 2, 3 and 4 (d) 1, 3 and 4

Ans. (b)

Sol. $\eta_R = f(T_m)$

So, by increasing temperature and pressure T_m of the cycle increases so, efficiency will increase.

By increasing superheat, following change will happen in cycle.



By increasing maximum pressure moisture content of turbine exhaust will be less, compare to ideal cycle.

By lowering the minimum system pressure the expansion ratio in turbine increases so, specific work output increases.

96. The gas turbine blades are subjected to :

(a) High centrifugal stress and thermal stress

(b) Tensile stress and compressive stress

(c) High creep and compressive stress

(d) Compressive stress and thermal stress

Ans. **(a)**

Sol. The turbine/centrifugal compressor

Subjected to centrifugal stress due to variation of velocity from root to tip and centrifugal motion.

$$(\sigma_{ct})_{max} = \frac{\rho_b}{2}u_t^2\left[-\left(\frac{r_r}{r_t}\right)^2\right]$$

where, σ_{ct} = centrifugal stress

u_t = tip peripheral velocity

$\frac{r_r}{r_t}$ = ratio of root radius and tip radius

= hub and tip ratio

Thermal stress exit is gas turbine due to high temperature.

Other stress can occurs but their effect is minimal in turbine in comparitive to these two.

97. Which one of the following methods can be adopted to obtain isothermal compression in an air compressor?

(a) Increasing the weight of the compressor

(b) Interstage heating

(c) Atmospheric cooling

(d) Providing appropriate dimensions to the cylinder

Ans. **(c)**

Sol. In reciprocating engine to achieve high pressure ratio the condition of minimum work is required which is possible in isothermal compression. To do isothermal compression intercooler is installed in between stages of compressor at outside of cylinder since intake is at atmospheric in general (except aircraft and all), so, temperature is at inlet is atmospheric. Since, process is isothermal so, intercooling will be isothermal atmospheric intercooling (the above is for ideal case not for real).

By providing appropiate dimension to cylinder we can increase volumetric efficiency not achieve the isothermal cooling.

98. Consider the following statements:

The compression process in a centrifugal compressor is comparable with:

1. Reversible and adiabatic

2. Irreversible and adiabatic

Which of the above statements is/are correct?

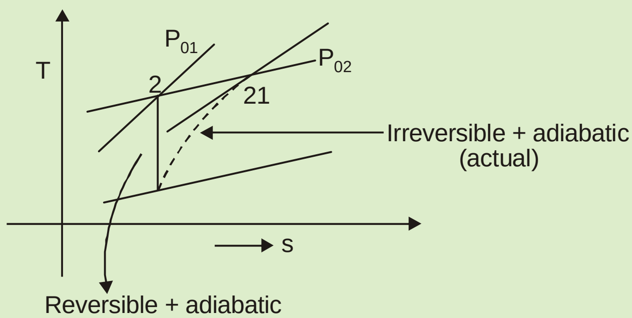
(a) Both 1 and 2 (b) Neither 1 nor 2

(c) 1 only (d) 2 only

Ans. **(c)**

Sol. Compression in centrifugal compressor is isentropic (reversible and adiabatic) for ideal case.

But practically, the actual process may deviate from ideal one due to internal irrevesibility (e.g. friction) but here process remain as adiabatic.



99. A portable compressor is taken from a place where the barometric pressure is 750 mm Hg and the average intake temperature is 27°C to a mountainous region where the barometric pressure is 560 mm Hg and temperature is 7°C. The reduction in mass output of the machine is:

(a) 80% (b) 60%

(c) 40% (d) 20%

Ans. (d)

Sol. The density of fluid in compressor is given by

$$\rho_1 = \frac{P_1}{RT_1} = \frac{750}{R(273+27)}$$

$$\rho_2 = \frac{P_2}{RT_2} = \frac{560}{R(273+7)}$$

$$\frac{\rho_2}{\rho_1} = \frac{560}{280} \times \frac{300}{750} = 0.80$$

$$\rho_2 = 0.80\,\rho_1$$

i.e. $m_2 = 0.80\, m_1$

(As volume of compressor remain same)

So, % reduction = $\frac{m_1 - m_2}{m_1} \times 100$

$= m_1 \left\{\frac{1-0.80}{2}\right\} \times 100$ = 20%

100. The ratio of static enthalpy rise in the rotor to the static enthalpy rise in the stage of an axial flow compressor is defined as:

(a) Power input factor

(b) Flow coefficient

(c) Temperature coefficient

(d) Degree of reaction

Ans. (d)

Sol. Degree of reaction = $\frac{(\Delta h)_{rotar}}{(\Delta h)_{stage}}$

101. The performance of a single stage reciprocating air compressor is evaluated by its:

(a) Isentropic efficiency

(b) Isothermal efficiency

(c) Adiabatic efficiency

(d) Volumetric efficiency

Ans. (d)

Sol. In single stage reciprocating compressor no intercooding and minimum work requirement are there. Only volumetric term is their to judge the performance

102. In a two stage reciprocating air-compressor with a suction pressure of 2 bar and delivery pressure of 8 bar, the ideal intercooler pressure will be:

(a) 10 bar (b) 6 bar

(c) 4 bar (d) 3 bar

Ans. (c)

Sol. P_1 = 2 bar, P_2 = 8 bar

P_x = ideal intercooler pressure

$= \sqrt{P_1 \times P_2} = \sqrt{2 \times 8}$

= 4 bar

Directions: Each of the next **Eighteen (18)** 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 (II) are individually true but Statement (II) 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

103. Statement (I) : Calusius inequality is valid for all cycles, reversible or irreversible including refrigeration cycles.

Statement (II) : Clausius statement is a negative statement which has no proof.

Ans. (c)

Sol. Clausius inequality states that

$$\oint \frac{dQ}{T} \le 0$$

It provides the criterion of the reversibility of a cycle.

If $\oint \frac{dQ}{T} = 0,$ the cycle is reversible,

$\oint \frac{dQ}{T} < 0,$ the cycle is irreversible and possible

$\oint \frac{dQ}{T} > 0,$ the cycle is impossible

Clausius theorem is $\oint_R \frac{dQ}{T} = 0$ and it can be proved.

104. Statement (I) : Thermometers using different thermometric property substance may give different readings except at two fixed points.

Statement (II) : Thermodynamic temperature scale is independent of any particular thermoemtric substance.

Ans. (b)

Sol. Thermodynamic or absolute temperature scale is independent of any working substance. The fact that the efficiency of a reversible heat engine cycle depends only on the temperature of the two reservoirs makes it possible to establish such a scale. If the temperature of a given system is mesured with thermometers using different thermoemetric properties, there is considerable difference among the readings.

105. Statement (I) : First law of thermodynamics analyses the problem quantitatively whereas second law of thermodynamics analyses the problem qualitatively.

Statement (II) : Throttling process is reversible process.

Ans. (c)

Sol. Throttling process is a irreversible process as the entropy of the fluid increases during the process. The first law of thermodynamics only gives a quantitative estimate of the heat and work interaction between the system and surroundings, however, it does not state about quality of energy. It is the second law of thermodynamics which deals with the low grade and high grade energy and concepts of availability.

106. Statement (I) : To prevent knocking in SI engines the end gas should have a low density.

Statement (II) : Pre-ignition is caused due to detonation

Ans. (b)

Sol. Due to less density of end gas, pressure and temperature of end gas not rise to achieve the ignition temperature, thus auto-ignition cannot take place hence detonation chance get reduce.

Detonation can lead to preignition and pre-ignition encourage detonation. If happens due to presence of overheated spark plugs, exhaust valve or causion deposite on the valve.

107. Statement (I) : Knocking in Petrol engine is the auto-ignition of the rich mixture entering the combustion chamber.

Statement (II) : Knocking is due to high compression ratio.

Ans. (c)

Sol. Knowcking in petrol engine is reduced by rich mixture because flame temperature can be kept low thus eliminating considerably tendency of knock. So, statement I is wrong.

Knocking increase by compression ratio because by high compression ratio density of end charge increase hence the temperature.

108. **Statement (I) :** Automotive Petrol engines require Petrol of Octane number between 85-95.

Statement (II) : Automotive Diesel engines require Diesel oil of Cetane number between 85-95.

Ans. **(b)**

Sol. In petrol engine octane no. used now a days in range of 85-95, so, statement I is correct.

While disel having cetone no. 40 is used as regular fuel and in premium fuel and in biodiesel it is 55. So, statement II is wrong.

109. **Statement (I) :** In Automotive Petrol engines during idling operation a rich mixture is required $(F/A \simeq 0.08)$

Statement (II) : Rich mixture is required because mixture is diluted by products of combustion.

Ans. **(a)**

Sol. An idiling operation engine operates at no load and with nearly closed throttle. Due to which exhaust gases remain in combution chamber. The mass of exhaust gas in the cylinder at the end of exhaust stroke remains fairly constant throughout the idiling range. The amount of fresh charge enter in cylinder is less compared to full throttling.

So, exhaust gas mixed with fresh charge admitted to cylinder. The presence of exhaust gas obstruct the contact of fuel and air in combution chamber, so finally combution is poor.

Therefore, there is requirement of more fuel is there, and rich fuel dilute the effect of exhaust gas or by product of combution.

So, statement II explain the statement I.

110. **Statement (I) :** Piston temperature profiles near full load are flattened in case of liquid cooled engines whereas for air cooled engines temperature profiles are steeper.

Statement (II) : The piston temperature profiles are different in nature for liquid cooled and air cooled engines because of the different values of ehat capacities.

Ans. **(d)**

Sol. The air cooling system for piston is likewise the fin cooling system in which cooling temperature profile is exponential curve not steeper curve. So, statement I is false. Also, liquid cooling system use convective type of cooling in which curve can not be flatten.

As different phenomenon is happening for cooling in two different process because of change in heat transportation media and hence heat capacities of cooling fluid.

111. **Statement (I) :** Effective temperature is an index which co-relates the combined effect of air temperature, air humidity and air movement upon human thermal comfort.

Statement (II) : Thermal comfort is not affected by mean radiant temperature.

Ans. **(c)**

Sol. Mean radiant temperature (mRT) is also a parameter in defining thermal comfort indice. mRT depends upon ceiling and floor temperature, sunlight through windown. So, it is an important parameter in thermal comfort.

112. **Statement (I) :** Commerical airplanes save fuel by flying at higher altitudes during long trips.

Statement (II) : At higher altitudes, the ambient temperature and the Carnot efficiency are low.

Ans. (b)

Sol. Both statement is correct. But statement II not explain the reason.

At higher altitude the rate of decrease of thrust is less than the rate of decrease of density with altidue because some loss due reduced density is compensated by lesser drag. Due to considerable reduction in drag (at an altitude of 800 m, normal hight of commercial planes the drag is reduced than 25% of sea level drag) most of the commercial plane flying at high altidue.

At high altidue temperature decreases so, the cycle maximum temperature So, the cycle maximum temperature rise will decrease leads to decrease in carnot efficiency.

113. **Statement (I) :** In a venturimeter, the divergent section is much longer as compared to the convergent section.

Statement (II) : Flow separation occurs only in the diverging section of the venturimeter.

Ans. (a)

Sol. In venturimeter divergent portion is much longer as compared to covergent section because in diverging section retardation of flow take place. If retardation of flow is allowed to take place rapidly in small length, then flowing fluid not remain in contact with boundary of diverging flow passage or in otherwords flow separates from the walls and eddies are formed. To avoid this divergent section of nozzle kept large.

114. **Statement (I) :** In Fanno flow, heat transfer is neglected and friction is considered.

Statement (II) : In Rayleight flow, heat transfer is considered and friction is neglected.

Ans. (b)

Sol. Statement I is condition for fanno line and statement II is condition for Rayleigh line but statement II not explaining the statement I

115. **Statement (I) :** In a choked flow in a convergent divergnet nozzle, flow in the diverging section is supersonic.

Statement (II) : In a choked flow in a convergnet divergent nozzle, the Mach number at the throat is larger than one.

Ans. (c)

Sol. In chocked flow, flow rate is maximum, and flow rate will be maximum only when Mach number at throat is equal to '1' i.e., Flow at throat is subsonic. So, statement II is wrong.

As flow is chocked in convergent divergent nozzle then flow at diffuser section might be supersonic or subsonic that depends on inlet condition of nozzle.

If at inlet M > 1, then flow is subsonic in divergent sections with formation of shock.

If at inlet M < 1, so, after throat flow will be supersonic and diverging section act as a diffuser.

$$\frac{dA}{A} = \frac{dp}{P\gamma}\left(\frac{1-M^2}{M^2}\right)$$

Here $dA = +ive$

$dp = -ive$

So, $M > 1$ for diverging section.

116. **Statement (I) :** Non-dimensional performance curves are applicable to any pump in the homologous series.

Statement (II) : Viscosity of water vaires with temperature causing cavitations on suction side.

Ans. (c)

Sol. Non-dimensional cures are defined for all homologous machines and defines general characteristic of machines.

It is vapour pressure not viscosity which causes cavitation in suction side i.e. low pressure region.

117. Statement (I) : In subsonic flow in a diverging channel, it is possibel that the flow may separate.

Statement (II) : In subsonic flow in a diverging channel, there is adverse pressure gradient in the channel.

Ans. (a)

Sol.
$$\frac{dA}{A} = \frac{dp}{P}\left(\frac{1-M^2}{m^2}\right)$$

Here for statement I

$dA = +ive$

$M < 1$, so, $1 - M^2 = +ive$

Means $dp = +ive$

i.e., pressure at outlet should be more, So, flow may seperate.

Statement II is supporting the above as $P_{outlet} > P_{inlet}$

So, adverse pressure gradient will be there.

118. Statement (I) : In a boundary layer formed by uniform flow past a flat plate, the pressure grdient in the x direction is zero.

Statement (II) : In a boundary layer formed by uniform flow past a flat plate, the pressure gradient in the y direction is negligible.

Ans. (b)

Sol. Since there is always a flow in the direction of pressure gradient. So the pressure gradient in x-direction under boundary layer is zero and the flow is due to momentum only or negligible while in y-direction, it is zero.

119. Statement (I) : Coolant and antifreeze refer to the same product

Statement (II) : Gas engines do not require cooling

Ans. (c)

Sol. Antifreeze is mixed with coolant to avoid freezing of coolant in cold climate application of engine.

All engines whether gas, or liquid or coal or steam requires cooling.

120. Statement (I) : Given a flow with velocity field $\vec{V}, \nabla \times \vec{V} = 0$, if the flow is incompressible.

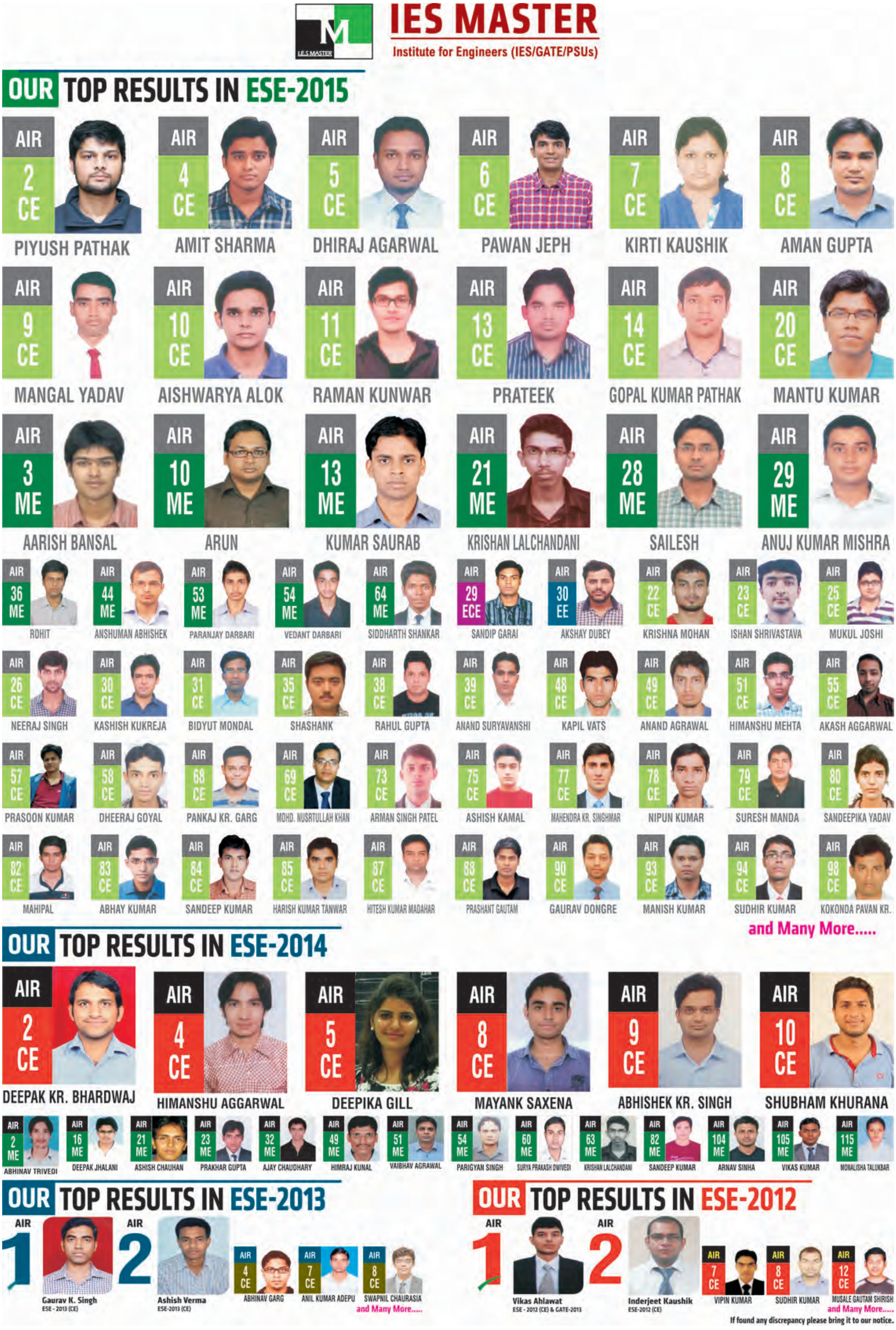
Statement (II) : Given a flow with velocity field $\vec{V}, \nabla \cdot (\nabla \times \vec{V}) = 0$.

Ans. (d)

Sol. In flow velocity field $\vec{v}$,

$\nabla \times \vec{v} = 0$

The condition ensures that the flow is irrotational not compressible.



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Institute for Engineers (IES/GATE/PSUs)
OUR TOP RESULTS IN ESE-2015
AIR 2 CE PIYUSH PATHAK
AIR 4 CE AMIT SHARMA
AIR 5 CE DHIRAJ AGARWAL
AIR 6 CE PAWAN JEPH
AIR 7 CE KIRTI KAUSHIK
AIR 8 CE AMAN GUPTA
AIR 9 CE MANGAL YADAV
AIR 10 CE AISHWARYA ALOK
AIR 11 CE RAMAN KUNWAR
AIR 13 CE PRATEEK
AIR 14 CE GOPAL KUMAR PATHAK
AIR 20 CE MANTU KUMAR
AIR 3 ME AARISH BANSAL
AIR 10 ME ARUN
AIR 13 ME KUMAR SAURAB
AIR 21 ME KRISHAN LALCHANDANI
AIR 28 ME SAILESH
AIR 29 ME ANUJ KUMAR MISHRA
AIR 36 ME ROHIT
AIR 44 ME ANSHUMAN ABHISHEK
AIR 53 ME PARANJAY DARBARI
AIR 54 ME VEDANT DARBARI
AIR 64 ME SIDDHARTH SHANKAR
AIR 29 ECE SANDIP GARAI
AIR 30 EE AKSHAY DUBEY
AIR 22 CE KRISHNA MOHAN
AIR 23 CE ISHAN SHRIVASTAVA
AIR 25 CE MUKUL JOSHI
AIR 26 CE NEERAJ SINGH
AIR 30 CE KASHISH KUKREJA
AIR 31 CE BIDYUT MONDAL
AIR 35 CE SHASHANK
AIR 38 CE RAHUL GUPTA
AIR 39 CE ANAND SURYAVANSHI
AIR 48 CE KAPIL VATS
AIR 49 CE ANAND AGRAWAL
AIR 51 CE HIMANSHU MEHTA
AIR 55 CE AKASH AGGARWAL
AIR 57 CE PRASOON KUMAR
AIR 58 CE DHEERAJ GOYAL
AIR 68 CE PANKAJ KR. GARG
AIR 69 CE MOHD. NUSRTULLAH KHAN
AIR 73 CE ARMAN SINGH PATEL
AIR 75 CE ASHISH KAMAL
AIR 77 CE MAHENDRA KR. SINGHMAR
AIR 78 CE NIPUN KUMAR
AIR 79 CE SURESH MANDA
AIR 80 CE SANDEEPIKA YADAV
AIR 82 CE MAHIPAL
AIR 83 CE ABHAY KUMAR
AIR 84 CE SANDEEP KUMAR
AIR 85 CE HARISH KUMAR TANWAR
AIR 87 CE HITESH KUMAR MADAHAR
AIR 88 CE PRASHANT GAUTAM
AIR 90 CE GAURAV DONGRE
AIR 93 CE MANISH KUMAR
AIR 94 CE SUDHIR KUMAR
AIR 98 CE KOKONDA PAVAN KR.
and Many More.....
OUR TOP RESULTS IN ESE-2014
AIR 2 CE DEEPAK KR. BHARDWAJ
AIR 4 CE HIMANSHU AGGARWAL
AIR 5 CE DEEPIKA GILL
AIR 8 CE MAYANK SAXENA
AIR 9 CE ABHISHEK KR. SINGH
AIR 10 CE SHUBHAM KHURANA
AIR 2 ME ABHINAV TRIVEDI
AIR 16 ME DEEPAK JHALANI
AIR 21 ME ASHISH CHAUHAN
AIR 23 ME PRAKHAR GUPTA
AIR 32 ME AJAY CHAUDHARY
AIR 49 ME HIMRAJ KUNAL
AIR 51 ME VAIBHAV AGRAWAL
AIR 54 ME PARIGYAN SINGH
AIR 60 ME SURYA PRAKASH DWIVEDI
AIR 63 ME KRISHAN LALCHANDANI
AIR 82 ME SANDEEP KUMAR
AIR 104 ME ARNAV SINHA
AIR 105 ME VIKAS KUMAR
AIR 115 ME MONALISHA TALUKBAR
OUR TOP RESULTS IN ESE-2013
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ESE - 2013 (CE)
AIR 2 Ashish Verma
ESE-2013 (CE)
AIR 4 CE ABHINAV GARG
AIR 7 CE ANIL KUMAR ADEPU
AIR 8 CE SWAPNIL CHAURASIA
and Many More.....
OUR TOP RESULTS IN ESE-2012
AIR 1 Vikas Ahlawat
ESE - 2012 (CE) & GATE-2013
AIR 2 Inderjeet Kaushik
ESE-2012 (CE)
AIR 7 CE VIPIN KUMAR
AIR 8 CE SUDHIR KUMAR
AIR 12 CE MUSALE GAUTAM SHIRISH
and Many More.....
If found any discrepancy please bring it to our notice..