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ESE - 2016

MECHANICAL ENGINEERING PAPER - 1 (OBJECTIVE)

QUESTIONS WITH DETAILED SOLUTIONS

SET - D

NAME OF THE SUBJECT	NO. OF QUESTIONS
THERMAL ENGINEERING	78
FLUID MECHANICS	29
HEAT TRANSFER	13

ALL QUERIES RELATED TO ESE - 2016 KEY ARE TO BE SENT TO THE FOLLOWING EMAIL ADDRESS

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01. In a differential manometer, a head of 0.5 m of fluid A is 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

01. Ans: (b)

Sol: Given $h_a = 0.5$ m , $h_b = 0.3$ m

$$\rho_a g h_a = \rho_b g h_b$$

$$\gamma_a\, 0.5 = \gamma_b\, 0.3$$

$$\frac{\gamma_a}{\gamma_b} = \frac{3}{5} \Rightarrow 0.6$$

02. 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 processes are irreversible?

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

02. Ans: (c)

Sol: Extension of a spring = Reversible

Plastic deformation = Irreversible

Magnetization of a material exhibiting hysteresis = Irreversible

03. 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 process, 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

03. Ans: (a)

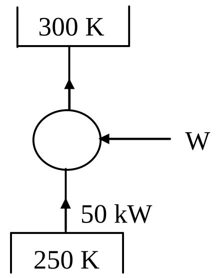
Sol: For throttling process, enthalpy before and after throttling are same, It is considered as steady flow process, we generally neglect changes in kinetic energy.

04. 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 hear reservoir is 300 K. The power required of the engine is

(a) 10 kW (b) 20 kW
(c) 30 kW (d) 50 kW

04. Ans: (a)

Sol:



Given $Q_{ab} = 50$ kW

$T_L = 250$ K

$T_H = 300$ K

$$COP = \frac{T_{L;}}{T_H - T_L}$$

$$COP = \frac{250}{300-250} = \frac{250}{50} = 5$$

$$5 = \frac{50}{W_{I/P}} \Rightarrow W_{I/P} = 10\text{kW}$$

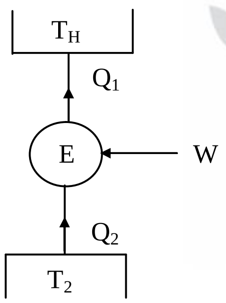
05. A heat engine receives heat at the rate of 2500 kJ/min and gives an output of 12.4 kW. Its thermal efficiency is, nearly:

(a) 18% (b) 23%

(c) 26% (d) 30%

05. Ans: (d)

Sol:



Given $Q_{abs} = 2500$ kJ/min = 41.666 kW

$W_{O/P} = 12.4$ kW

$$\eta_{th} = \frac{W_{O/P}}{Q_{abs}} = \frac{12.4}{41.66} = 0.2976 \approx 30\ \%$$

06. One reversible heat engine operates between 1000 K and T_2 K and another reversible heat engine operates between T_2 K 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

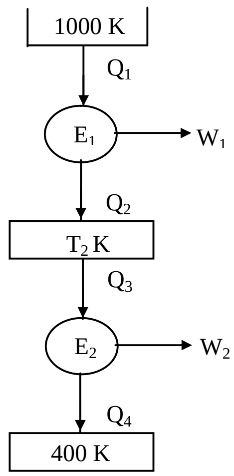
(c) 682.8 K (d) 732.5 K

06. Ans: (b)

Sol: Given $Q_1 = Q_3$

$W_1 = W_2$

To find $T_2 = ?$



$$\eta_{E_1} = 1 - \frac{T_2}{1000} = \frac{W_1}{Q_1}$$

$$\eta_{E_2} = 1 - \frac{400}{T_2} = \frac{W_2}{Q_3} \Rightarrow \frac{W_1}{Q_1}$$

$$\Rightarrow \eta_{E_1} = \eta_{E_2}$$

$$1 - \frac{T_2}{1000} = 1 - \frac{400}{T_2}$$

$$\Rightarrow T_2 = \sqrt{400 \times 1000} = 632.45 \text{ K}$$

07. 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

07. Ans: (a)

Sol: For an Isothermal process, Temperature remains constant, since nothing is mentioned regarding the nature of fluid undergoing the process, we assume it as ideal gas

for ideal gas u = f (T) alone.

$$\left.\begin{aligned}\Delta u &= 0\\ \delta Q &= \delta W\end{aligned}\right\}\text{for isothermal process}$$

08. A system of 100 kg mass undergoes a process in which its specific entropy increases from 0.3 kJ/kgK to 0.4 kJ/kgK. 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

08. Ans: (b)

Sol: Given m = 100 kg

$(s_1)_{sys} = 0.3$ kJ/kg K

$(s_2)_{sys} = 0.4$ kJ/kg K

$(s_1)_{surr} = 80$ kJ/K

$(s_2)_{surr} = 75$ kJ/K

$(s_1)_{system} = 100 \times 0.3 = 30$ kJ/K

$(s_2)_{system} = 100 \times 0.4 = 40$ kJ/K

$(ds)_{univ} = (ds)_{system} + (ds)_{surr}$

$= (S_2 - S_1)_{system} + (S_1 - S_2)_{surrounding}$

$= (40 - 30) + (75 - 80)$

$= 10 - 5 = 5$ kg/K

$(ds)_{univ} > 0$

$\therefore$ Process is Irreversible.

09. Which 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

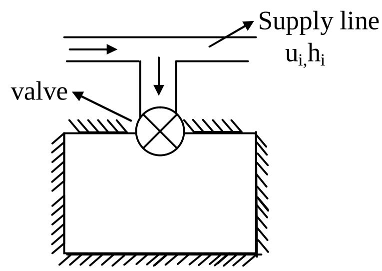
(b) The specific enthalpy of the gas in the supply main is equal to the specific internal energy of the gas in the cylinder

(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

09. Ans: (b)

Sol:



$$\left(\frac{du}{dt}\right)_{C.V} = \dot{m}_i h_i \;;\; \left(\frac{dm}{dt}\right)_{C.V} = \dot{m}_i$$

$U_2 - U_1 = (m_2 - m_1)\, h_i$

$m_2u_2 = m_2h_i$

$u_2 = h_i$

[$\because$ initially tank is empty $\Rightarrow m_1 = 0$]

$\Rightarrow$ Sp. Enthalpy of gas in supply line is equal to specific internal energy of gas in the cylinder.

10. Consider the following system:
 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

10. Ans: (c)

Sol: Gas turbines and reciprocating compressors are treated as steady flow devices. Even electric heater without the input of electric current is useless, so we have to assume as steady flow device to solve the problem.

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

11. Ans: (c)

Sol: Clapeyron equation

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

During Phase Change

$$\frac{dP}{dT} = \frac{s_g - s_f}{v_g - v_f} = \frac{h_{fg}}{T(v_g - v_f)} = \frac{L.H}{T(v_g - v_f)}$$

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 above conditions are correct?

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

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

12. Ans: (a)

Sol: For reversibility dP = 0 , dT = 0

All processes should be quasi-static which Implies extremely slow, friction should not be present.

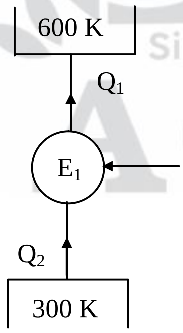
13. A Carnot engine operates between 300 K and 600 K. If the entropy change during heat addition is 1 kJ/K, the work produced by the engine is:

(a) 100 kJ (b) 200 kJ

(c) 300 kJ (d) 400 kJ

13. Ans: (c)

Sol:



Given,

$(\Delta S)_{\text{Heat addition}} = 1$ kJ/K

$$\Rightarrow \frac{Q_1}{600} = 1$$

$Q_1 = 600$ kJ

$$\eta_E = \frac{W}{Q_1} \Rightarrow 1 - \frac{T_2}{T_1}$$

$$\Rightarrow 1 - \frac{300}{600} = 0.5$$

$$0.5 = \frac{W}{600}$$

$\Rightarrow W = 300$ kJ

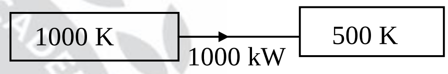
14. 1000 kJ/s of heat is transferred from a constant temperature heat reservoir maintained at 1000 K to a system at a constant temperature of 500 K. The temperature of the surroundings is 300 K. The net loss of available energy as a result of this heat transfer is:

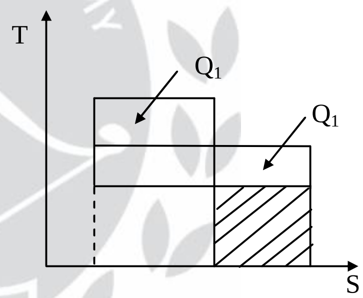
(a) 450 kJ/s (b) 400 kJ/s

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

14. Ans: (d)

Sol:





Given $Q_1 = 1000$ kW

$T_1 = 1000$ K

$T_2 = 500$ K

$T_0 = 300$ K

Net loss of available energy = Increase in unavailable energy

$$= Q_1 T_0 \left[\frac{T_1 - T_2}{T_1 T_2}\right]$$

$$= 1000 \times 300 \left[\frac{1000 - 500}{1000 \times 500}\right]$$

= 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 statement are correct?

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

15. Ans: (d)

Sol: Heat transfer from a high temperature body to a low temperature body results in increase of unavailable energy, Entropy change takes place and it increases. But energy is conserved.

16. Which of the following 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 solution is not zero at absolute zero temperature

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

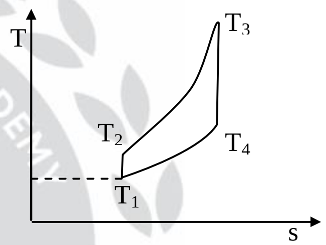
16. Ans: (c)

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

17. Ans: (*)

Sol:



Given, $T_3 = 900$ K; $T_1 = 289$ K

$$(W_{net})_{maximum} = c_p\left(\sqrt{T_3} - \sqrt{T_1}\right)^2$$

$$= 1.005\left(\sqrt{900} - \sqrt{289}\right)^2$$

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

(There is an error in options)

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 vapor 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

18. Ans: (d)

Sol: Water vapour is treated as ideal gas in temperature ranges $-10^{o}C$ to $-50^{o}C$. Gases generally have low critical temperatures.

19. The property of a thermodynamic system is:

(a) A path 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

19. Ans: (b)

Sol: For a thermodynamic system, property is a point function and change in the property is zero if the system undergoes a cycle.

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 compared to saturated liquid curve on a T-s diagram
4. The enthalpy of vaporization 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

20. Ans: (c)

Sol: Phase change is an isothermal and isobaric process, enthalpy of vaporization decreases with increase is pressure. Saturated liquid curve is more steeper than saturated vapour curve.

21. 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

21. Ans: (b)

Sol: Reciprocating compressors are generally evaluated on isothermal efficiency because for a isothermal compression work is least.

22. 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

22. Ans: (c)

Sol: $P_m = \sqrt{P_i P_c} = \sqrt{2\times 8} = \sqrt{16} = 4\text{bar}$

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 Statements (I) and Statements (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 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

23. **Statement (I) :** Clausius inequality is valid for all cycles, reversible or irreversible including refrigeration cycles.

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

23. Ans: (c)

Sol: Clausius statement can be proved for both refrigerator and engine heat.

$$\oint \frac{\delta Q}{T} \le 0$$

24. **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 thermometric substance.

24. Ans: (b)

25. **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

25. Ans: (c)

Sol: Throttling is a highly irreversible process. First law is Quantitative law, while second law is qualitative law.

26. **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.

26. Ans: (c)

27. **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.

27. Ans: (d)

Sol: Knocking happens at the end of combustion in S.I. engine and last portion of charge is responsible for knocking.

28. **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.

28. Ans: (c)

Sol: Generally in India we use octane number between 80–95. While cetane number is between 50–70. But higher the octane number and higher the cetane number for respective engines is beneficial.

We feel answer should be ‘c’

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

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

29. Ans: (a)

Sol: In the inlet manifold the pressure is 0.3 atm where as in engine cylinders it is 1.03 atm as a result there is a backward flow of exhaust gases into inlet manifold, which reduces contact between fuel and air particles, hence to overcome the problem of dilution mixture is richened.

30. **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 heat capacities.

30. Ans: (a)

Sol: Specific heat of liquid is more than specific heat of gas at constant pressure, hence heat carrying capacity is lower for gases.

31. **Statement (I) :** Effective temperature is an index which correlates an index which correlates 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.

31. Ans: (c)

Sol: Mean radiant temperature has strong influence on thermo physiological comfort, while effective temperature is a index which correlates air temperature, air humidity and air movement.

32. **Statement (I) :** Commercial 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.

32. Ans: (b)

Sol: Commercial airplanes save fuel by flying a higher altitudes during long trips so as to minimize the drag forces.

33. **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.

33. Ans: (a)

Sol: In a venturimeter, the divergent section angle of divergence is less than 7^o.

The diverging angle is never kept above 7^o in order to avoid flow separation.

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

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

34. Ans: (b)

Sol: Fanno flow refers to adiabatic flow through a constant area duct where the effect of friction is considered.

Rayleigh flow refers to frictionless, non adiabatic flow through a constant area duct where effect of heat addition or rejection is considered.

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

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

35. Ans: (c)

Sol: A choked flow is a limiting condition where the mass flow will not increase with a further decrease in downstream pressure. At the throat Mach number is one.

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

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

36. Ans: (c)

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

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

37. Ans: (a)

38. **Statement (I) :** In a boundary layer formed by uniform flow past a flat plate, the pressure gradient 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.

38. Ans: (b)

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

Statement (II): Gas engines do not require cooling.

39. Ans: (c)

Sol: Anti freeze has the same purpose as the coolant.

40. **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 $\vec{V}, \nabla.(\nabla \times \vec{V}) = 0$

40. Ans: (d)

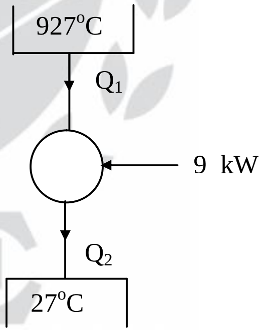
Sol: For incompressible flows $\nabla.V=0$. So, statement 1 is wrong.

41. 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

41. Ans: (c)

Sol:



Give $T_H = 927 + 273 = 1200$ K

$T_L = 27 + 273 = 300$ K

$$\eta_E = 1 - \frac{T_L}{T_H} \Rightarrow 1 - \frac{300}{1200}$$

$= 75\ \%$

$$0.75 = \frac{W}{Q_1} \Rightarrow \frac{9}{Q_1}$$

$\Rightarrow Q_1 = 12$ kW

$Q_1 = \dot{m} \times CV = \dot{m} \times 40{,}000 = 12$

$$\dot{m} = \frac{3}{10000}\text{kg/sec} = 1.08 \text{ kg/hr.}$$

42. 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 no connection with angle of contact

42. Ans: (c)

Sol: Given, $\theta^o < 90°$

Wetting of the surface takes place and adhesion is greater than cohesion.

43. The Carnot cycle is impracticable because:
    (a) Isothermal process is very fast; and isentropic process is very slow
    (b) Isothermal process is very slow; 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.

43. Ans: (b)

Sol: Isothermal process is very slow, while isentropic process is very fast this is what renders impracticality to Carnot cycle.

44. An ideal Otto-cycle between minimum and maximum temperatures of 300 K and 1800 K. What is the compression ratio of the cycle for maximum work output when γ=1.5 for this ideal gas?
    (a) 5 (b) 6 (c) 7 (d) 8

44. Ans: (b)

Sol: $T_2 = T_4 = \sqrt{T_1T_3}$

$$= \sqrt{300 \times 1800} = 735\text{K}$$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = \left(\frac{V_1}{V_2}\right)^{0.5}$$

$$\left(\frac{735}{300}\right)^2 = \frac{V_1}{V_2} = r_k = 6$$

45. 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

45. Ans: (d)

46. 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 only (b) 3 and 4 only

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

46. Ans: (d)

47. 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

47. Ans: (d)

Sol: Given, B.P = 44 kW

Pumping work = 5% of I.P.

Mechanical loss = 7% of I.P.

Total losses = 12% of I.P.

$$\eta_{mech} = 93\% = \frac{B.P}{I.P} \Rightarrow 0.93 = \frac{44}{I.P}$$

$$\Rightarrow I.P = \frac{44}{0.93}$$

$$\text{Pumping work} = \frac{44}{0.93} \times \frac{5}{100} = 2.36\text{kW}$$

$$= 2.5 \text{ kW}$$

48. 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

48. Ans: (b)

Sol: First the exhaust port opens, then transfer port opens, the incoming charge is deflected upwards then transfer port is closed later exhaust port is closed. At this point losses are maximum i.e., at the end of closing of exhaust port.

49. In an Otto cycle, air is compressed from 2.2*l* to 0.26*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

49. Ans: (a)

Sol: $V_1 = 2.2\ \ell$; $V_2 = 0.26\ \ell$

$P_1 = 1.2$ kg/cm^2 ;

$W_{out} = 440$ kJ

MEP = ?

$\Rightarrow V_S = V_1 - V_2 = 1.94\ \ell$

$$MEP = \frac{W_{out}}{V_s} = \frac{440}{1.94\times10^{-3}}$$

$= 226.8$ kPa ≈ 227 kPa

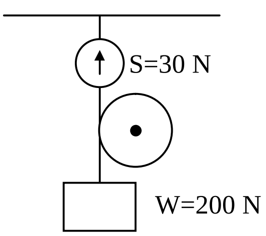
50. A single cylinder, four-stroke cycle oil engine is fitted with a rope brake. The diameter of the brake wheel is 600 mm and the rope diameter is 26 mm. The dead load on the brake is 200 N and the spring balance reads 30 N. If the engine runs at 600 rpm, what will be the nearest magnitude of the brake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

(a) 3.3 kW (b) 5.2 kW

(c) 7.3 kW (d) 9.2 kW

50. Ans: (a)

Sol:



$$T = (W - S)\left(\frac{D}{2} + d\right)$$

$$= (200 - 30)\left(\frac{600}{2} + 26\right)\times10^{-3}$$

$= 170\times0.326$ Nm

$$BP = \frac{2\pi NT}{60\times1000}$$

$$= \frac{\pi\times600\times170\times0.326}{30\times1000} = 3.48 \text{ kW}$$

51. In a furnace the heat loss through the 150 mm thick refactory wall lining is estimated to be 50 W/m^2. If the average thermal conductivity of the refactory 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

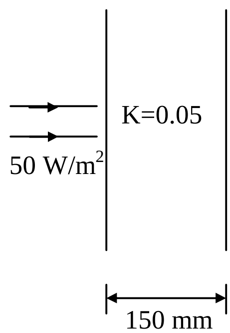
51. Ans: (b)

Sol: Given Q = 50 W/m^{2,}

k = 0.05 W/mK

k = 0.15 m

$T_1 - T_2$ =?



$$\dot{q} = -k\frac{dT}{dx}$$

$$50 = 0.05\left(\frac{dT}{0.15}\right)$$

$dT = 150^{o}$C

52. Uniform flow occurs when :

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

(b) The flow is steady

(c) Discharge through a pipe is constant

(d) Conditions do not change with at any time

52. Ans: (a)

Sol: Uniform flow is when flow properties at different points are same at a given instance.

53. 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

53. Ans: (d)

Sol: Given k = 0.5 W/mK , A = 1 m^2

$dT = 100^{o}C$, $dx = 1.2$ m

$$Q = kA\left(\frac{dT}{dx}\right) \Rightarrow 0.5\times1\times\frac{100}{0.2} = 250W$$

54. 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

54. Ans: (c)

Sol: Given, $T_{h_i} = 200^{o}C$, $T_{C_i} = 40^{o}C$,

$T_{h_e} = 150^{o}C$, $T_{C_e} = 140^{o}C$,

$(C)_{hot}(\Delta T)_{hot} = (C)_{cold}(\Delta T)_{cold}$

$C_h 50 = C_c 100$

$$\frac{C_c}{C_h} = 0.5$$

55. 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

55. Ans: (c)

56. 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

56. Ans: (a)

Sol: $\frac{h_{horizontal}}{h_{vertical}} = \frac{0.725}{0.943}\left(\frac{L}{D}\right)^{0.25}$

$L = 10\text{ m} \;, D = 0.1\text{ m}$

$$\frac{h_{horizontal}}{h_{vertical}} = \frac{0.725}{0.943}\left(\frac{10}{0.1}\right)^{0.25} = 2.44$$

57. A cross-flow type air heater has an area of 50 m^2. The overall transfer coefficient is 100 W/m^2K, 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

57. Ans: (c)

Sol: Given, $A = 50 m^2$,

$U = 100\text{ W/m}^2\text{K}$,

$C = 1000\text{ W/K}$,

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

58. 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

58. Ans: (c)

Sol: Given, $\varepsilon = 0.25$, $T_{h_i} = 200^\circ C$,

$T_{h_e} = 75^\circ C$, $T_{C_i} = 40^\circ C$, $T_{C_e} = ?$

$$0.25 = \frac{T_{C_e} - T_{C_i}}{T_{h_i} - T_{C_i}}$$

$$\Rightarrow T_{C_e} = 80^\circ C$$

59. 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 only

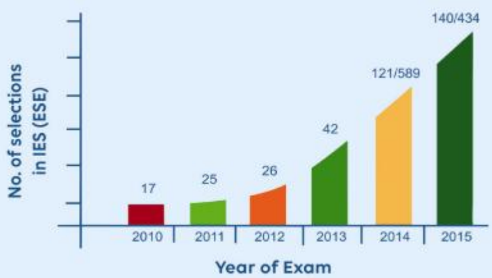
59. Ans: (c)

Sol: C.I engines are more bulky and efficient than SI engine but have heavier flywheels.

ESE 2015

RANKERS

CONTRIBUTION OF ACE IN THE SUCCESS OF ESE TOPPERS



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58. Ans: (c)

Sol: Given, ε = 0.25, $T_{h_i} = 200^oC$,

$T_{h_e} = 75^oC$, $T_{C_i} = 40^oC$, $T_{C_e} = ?$

$$0.25 = \frac{T_{C_e} - T_{C_i}}{T_{h_i} - T_{C_i}}$$

$$\Rightarrow T_{C_e} = 80^oC$$

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59. Ans: (c)

Sol: C.I engines are more bulky and efficient than SI engine but have heavier flywheels.

60. 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

60. Ans: (d)

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

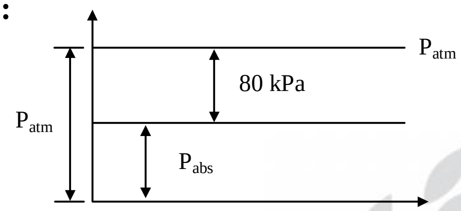
(b) 190 mm of Hg

(c) 380 mm of Hg

(d) 760 mm of Hg

61. Ans: (a)

Sol:



$P_{vacuum} = 80$ kPa

$P_{atm} = 1.013$ bar

$P_{abs} = 1.013\times10^5 - 80\times10^3$ Pa $= 21300$ Pa

$\rho_m g h_m = 21300$

$h_m = 0.159 \text{ m} \approx 160 \text{ mm}$

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

62. Ans: (a)

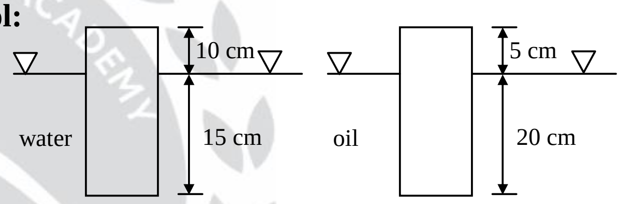
63. A 25 cm long prismatic homogeneous solid floats in water with its axis vertical and 10 cm projecting above water surface. If the same solid floats in some oil with its axis vertical and 5 cm projecting above the liquid surface, then the specific gravity of the oil is

(a) 0.55 (b) 0.65

(c) 0.75 (d) 0.85

63. Ans: (c)

Sol:



Let, ρ_s = density of solid

ρ_w = density of water

A = Area of c/s , ρ_o = density of oil

Case(i):

$$\rho_s\times gA\times0.25 = \rho_w\times gA\times0.15$$

$$\rho_s\frac{5}{3} = \rho_w \text{ -------(i)}$$

Case(ii):

$$\rho_g\times gA\times0.25 = \rho_o\times gA\times0.2$$

$$\rho_s\frac{5}{4} = \rho_o \text{ -------(ii)}$$

$$\Rightarrow \frac{4}{5}\rho_o\times\frac{5}{3} = \rho_w$$

$$\rho_o = \rho_w\times\frac{3}{4} = 750\,\text{kg/m}^3$$

64. Consider the following statements :

The increase in metacentric height

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

64. Ans: (b)

Sol: $T = 2\pi\sqrt{\dfrac{K_g^{\,2}}{g(GM)}}$

Where, K_g = least radius of gyration,

GM = metacentric height

If GM increases stability increases, but hampers comfort.

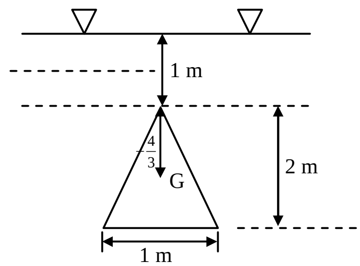
65. An isosceles triangular lamina of base 1 m and height 2m is located in the water in vertical plane and its vertex is 1m below the free surface of the water. The position of force acting on the lamina from the free water surface is :

(a) 2.42 m (b) 2.33 m

(c) 2.00 m (d) 1.33 m

65. Ans: (a)

Sol:



$\bar{h} = 1 + \dfrac{4}{3}$ m

$\bar{h}_{c_p} = \bar{h} + \dfrac{I_{Gx}}{A\bar{h}}$

$= \left(1+\dfrac{4}{3}\right) + \dfrac{(1)\times 2^3}{36\times\dfrac{1}{2}\times 2\times\left(1+\dfrac{4}{3}\right)}$

= 2.33 + 0.095 = 2.42 m

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

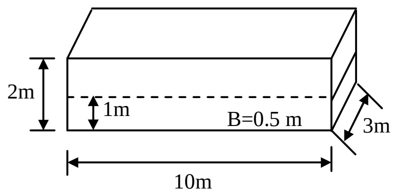
(a) 0.75m (b) 0.45 m

(c) 0.25 m (d) 0.15 m

66. Ans: (c)

Sol: $\rho_s = 500$ kg/m^3 , L = 10 m

b = 3 m , h = 2 m



$\rho_s g V_s = \rho_w g V_w'$

$500 \times 10 \times 3 \times 2 = 1000 \times 3 \times 10 \times x'$

$\Rightarrow x' = 1\text{m}$

$GM = \frac{I}{\forall} - BG$

I = least moment of inertia @ surface

$\forall$ = volume of body submerged in water

BG = distance between centroid to centre of buoyancy

$= \frac{10 \times 3^3}{12 \times 10 \times 3 \times 1} - 0.5$

$= \frac{3^2}{12} - 0.5$

GM = 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

67. Ans: (d)

Sol: u = –2x

v = 2y

To find a_x & a_y

$a_x = u\frac{\delta u}{\delta x} + v\frac{\delta v}{\delta x} \Rightarrow -2x(2) + 0 = 4x$

$a_y = u\frac{\delta u}{\delta x} + v\frac{\delta v}{\delta y} \Rightarrow 2y \times 2 + 0 = 4y$

68. The velocity of flow from a tap of 12mm 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 the level.

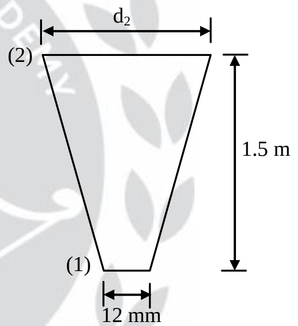
(a) 44 mm (b) 34 mm

(c) 24 mm (d) 14 mm

68. Ans: (d)

Sol: Given, d_1 = 12 mm , d_2 = ?

V_1= 8m , h_2 = 1.5 m



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

$$\frac{8^2}{2g} + 0 = \frac{V_2^2}{2g} + 1.5$$

V_2 = 5.83 m/s

Applying continuity

$A_1V_1 = A_2V_2$

$\Rightarrow d_1^2 \times V_1 = d_2^2 \times V_2$

$\Rightarrow d_2$ = 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 only

69. Ans: (c)

Sol: Thermal conductivity of gases and liquids increases with increase in temperature. Solids generally have higher thermal conductivity

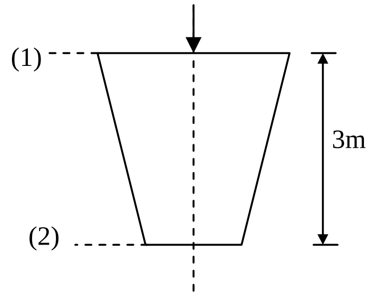
70. A conical diffuser 3m long is placed vertically. The velocity at the top (entry) is 4 m/s and at the lower end is 2 m/s. The pressure head at the top is 2m of the oil flowing through the diffuser. The head loss in the diffuser is 0.4 m of the oil. The pressure head at the exit is :

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

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

70. Ans: (b)

Sol:



$E_1 = E_2 + h_L$

$$\left(Z+\frac{P_1}{\rho g}+\frac{V_1^2}{2g}\right)=\left(\frac{P_2}{\rho g}+\frac{V_2^2}{2g}\right)+h_L$$

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

$$\frac{P_2}{\rho g}=5-0.4+\frac{12}{20}=5.2 \text{ m of oil}$$

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

71. Ans: (c)

Sol: The assumptions of Bernoulli's equation are

i) Flow is along stream line

ii) Flow is non viscous

iii) Steady flow

iv) Incompressible flow

v) No energy interaction

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

72. Ans: (c)

Sol: Kirchhoff's law is a relationship between the monochromatic, directional remittance and the monochromatic, directional absorptance for a surface that is in thermodynamic equilibrium with its surroundings.

Exact form of kirchhoff's law

$$\varepsilon_\lambda(T, \theta, \phi) = \alpha_\lambda(T, \theta, \phi)$$

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 generation is/are :

1. Impulse turbine

2. Pass out turbine

(a) 1only (b) 2 only

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

73. Ans: (b)

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 discharge and loss of head due to friction. The diameter of the equivalent pipe D 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) $(4)^{\frac{1}{5}}$

74. Ans: (d)

Sol: $d_c = n^{\frac{2}{5}} d$

n = no. of similar parallel pipes

$$D_e = 2^{\frac{2}{5}} D$$

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

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

(a) 0.673 (b) 0.794
(c) 0.872 (d) 0.971

75. Ans: (b)

Sol: Given, $C_V = 0.98$, $d_1 = 100$ mm, $d_2 = 90$ mm,

$$C_c = \frac{d_2^2}{d_1^2} = \frac{90\times 90}{100\times 100}$$

$$C_d = C_V \cdot C_C = 0.98 \times 0.9 \times 0.9$$

$$= 0.7938 = 0.794$$

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 friction 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 a average of flow in the pipe

Which of the above statements are correct ?

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

76. Ans: (d)

Sol: For a laminar flow through circular pipe

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

$$h = \frac{\Delta P}{\rho g} \Rightarrow \frac{f\,LV^2}{2gD}$$

$$\Rightarrow \frac{LV^2 \times 64}{R_e \times 2g\,D} = \frac{32\times LV^2}{\frac{\rho VD \times gD}{\mu}}$$

$$\Rightarrow \frac{32\mu vL}{\rho g D^2}$$

$$\therefore \Delta P \propto V_{avg}$$

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

77. Ans: (c)

Sol: $$\delta = \frac{5x}{\sqrt{R_{ex}}} \Rightarrow R_{ex} = \left(\frac{5x}{\delta}\right)^2$$

$$= \left(\frac{5\times 20}{4}\times 10\right)^2 = (250)^2 = 62500$$

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

78. Ans: (a)

Sol: Displacement thickness

$$(\delta^*) = \int_o^\delta \left(1-\frac{y}{\delta}\right)dy = \left(y-\frac{y^2}{2\delta}\right)^\delta = \delta-\frac{\delta}{2}=\frac{\delta}{2}$$

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

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

79. Ans: (a)

Sol: Specific gravity (s) = 0.8
Density of oil (P_o) = $e_w \times s$ = 800 kg/m^2
Dynamic viscosity (μ) = 8×10^{-3} N-s/m^2
Diameter = 100 mm
Reynolds number (R_e) = 2100
Average velocity (v) =?

We know that

$$R_e=\frac{\rho VD}{\mu}\Rightarrow\frac{800\times V\times0.1}{8\times10^{-2}}=2100$$

$$\Rightarrow V=\frac{2100\times8\times10^{-3}}{80}$$

$$= 210 \times 10^{-3} = 0.21 \text{ m/s}$$

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

(a) Curved
(b) Inclined and straight but non uniformly spaced
(c) Horizontal and non-uniformly spaced
(d) Horizontal and uniformly spaced

80. Ans: (a)

81. 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 radiosity of the surface will be:

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

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

81. Ans: (c)

Sol: Given $G = 1000$ W/m^2,

$E = 400$ W/m^2,

$e = 0.4$,

$J = ?$

For opaque surface

$\alpha + \rho + \tau = 1 \qquad \tau = 0$

$\alpha + \rho = 1 \qquad \alpha = e$

$\rho = 0.6$

$J = \rho G + Ee$

$= 0.6 \times 1000 + 0.4 \times 400$

$= 600 + 160 = 760$ W/m^2

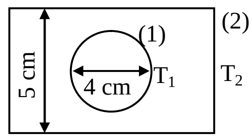
82. A body 1 in the form of a sphere of 2 cm radius at temperature T_2 is located in body 2, which is a hollow cube of 5 cm side and is at temperatures T_2 ($T_2 < T_1$). The shape factor F_{21} for radiation heat transfer becomes:

(a) 0.34 (b) 0.43

(c) 0.57 (d) 0.63

82. Ans: (a)

Sol:



By reciprocity

$A_1F_{12} = A_2F_{21}$

$4\pi r^2 F_{12} = 6\times5\times5\times F_{21}$ [$\because F_{12} = 1$]

$$\frac{4\pi\times2\times2}{6\times5\times5} = F_{21}$$

$\therefore F_{21} = 0.335 \approx 0.34$

83. 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 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

83. Ans: (b)

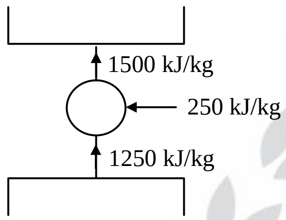
Sol: Generally in refrigeration system, compression is dry compression, so exit of evaporator is slightly superheated. This super heating increases work of compressor. If superheating is done inside the evaporator it increases Refrigerating effect but has no effect on Refrigeration effect if it is done outside. So, super heating increases Refrigerating effect is not always true.

84. 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

84. Ans: (a)

Sol:



$$\text{C.O.P} = \frac{\text{Desired effect}}{\text{Work Input}}$$

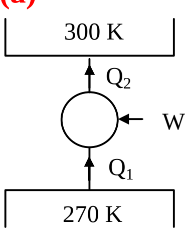
$$\text{C.O.P} = \frac{1250}{250} = 5$$

85. A refrigeration plant is designed to work between –3°C and 27°C. The plant work 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

85. Ans: (a)

Sol:



$$\text{C.O.P}_{\text{H.P}} = \frac{T_H}{T_H - T_L} = \frac{300}{300-270} = 10$$

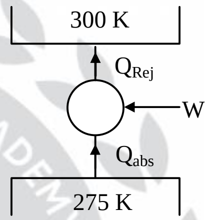
86. A refrigeration plant working on Carnot cycle is designed to take the load of 4 T of refrigeration. The cycle works between 2°C and 27°C. The power required to run the system is:

(a) 1.27 kW (b) 3.71 kW

(c) 5.71 kW (d) 7.27 kW

86. Ans: (a)

Sol:



$$Q_{abs} = 4T = 4\times3.5 \text{ kW}$$

$$\text{C.O.P} = \frac{T_L}{T_H - T_L} = \frac{Q_{abs}}{W_{IP}}$$

$$\frac{275}{300-275} = \frac{4\times3.5}{W_{IP}}$$

$$\Rightarrow W_{IP} = 1.27 \text{ kW}$$

87. 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

87. Ans: (d)

Sol: Refrigerant is chosen based on

(i) Refrigerating capacity
(ii) Type of compressor
(iii) Service required

88. 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) 1.5 kW (b) 1.35 kW
(c) 1.55 kW (d) 1.75 kW

88. Ans: (d)

Sol: C.O.P = 5

$Q_{abs} = 2.5T = 2.5\times3.5$ kW $(\because T = 3.5 \text{ KW})$

$$5 = \frac{Q_{abs}}{W_{IP}}$$

$$W_{I/P} = \frac{2.5\times3.5}{5} = 1.75\,\text{KW}$$

89. 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

89. Ans: (b)

Sol: Space in not the criteria for supercharging.

90. Two 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

90. Ans: (b)

Sol: $$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_1C_2}$$

$$= \frac{C_1 + C_2 + 1}{C_1C_2}$$

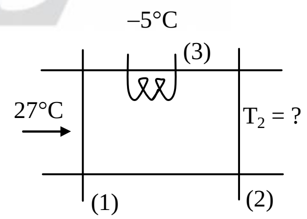
$$C = \frac{C_1C_2}{C_1 + C_2 + 1} = \frac{5\times6}{5+6+1} = \frac{30}{12} = \frac{10}{4} = 2.5$$

91. In 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

91. Ans: (b)

Sol:



$$\text{B.P.F} = \frac{T_3 - T_2}{T_3 - T_1} = 0.4$$

$$\frac{-5 - T_2}{-5 - 27} = 0.4 \Rightarrow T_2 = 7.8°\text{C}$$

92. 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

92. Ans: (a)

Sol: At ϕ = 100%

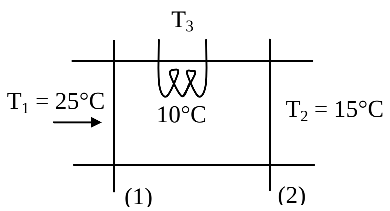
WBT = DBT = DPT

93. Air at 25°C 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

93. Ans: (*)

Sol:



$$\text{B.P.F} = \frac{T_3 - T_2}{T_3 - T_1} = \frac{10-15}{10-25} = \frac{1}{3} = 0.33$$

94. 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

94. Ans: (d)

95. 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

95. Ans: (a)

96. 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

96. Ans: (c)

Sol: $$S.H.F = \frac{S.H}{S.H + L.H} = \frac{SH}{SH + 0.25SH}$$

[∵ L.H = 0.25 S.H]

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

97. 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

97. Ans: (c)

98. 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) Thermo electric refrigeration system

98. Ans: (c)

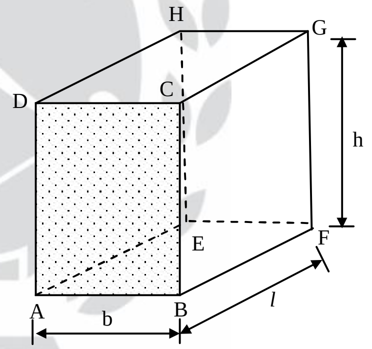
Sol: Desiccant refrigerant system is most suitable refrigeration system which uses solar system.

99. 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

99. Ans: (c)

Sol:



Given:

Height (h) = twice of any side

Let us take

h = 2b

∴ Total thrust force on bottom face ABFE of the tank

$F_1 = F_b = \gamma A \bar{x} = \gamma b \times l \times h$

$F_1 = \gamma \times b \times l \times 2b$

Hydro static thrust force on face BFGC

$$F_2 = \gamma A\ \bar{x}$$

$$= \gamma \times l \times h \times \frac{h}{2}$$

$$= \gamma \times \ell \times \frac{h^2}{2}$$

$$\therefore\ \frac{F_1}{F_2} = \frac{\gamma \times b \times \ell \times h}{\gamma \times \ell \times h \times \frac{h}{2}} = \frac{2b}{h} = 1$$

100. The water level in a dam is 10m. 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 N

100. Ans: (b)

Sol: Force acting on the wall by water

$$(F) = \gamma A.\ \bar{x}$$

$$= 9810 \times L \times h \times \frac{h}{2}$$

$$= 9810 \times L \times 10 \times \frac{10}{2}$$

$$F = 50 \times 9810 \times 2$$

Hydro static force per unit length on the dam wall

$$F = 490.5\ \text{kN}$$

101. A solar collector receiving solar radiation at the rate of 0.6 kW/m^2 transforms it to the internal energy of a fluid 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

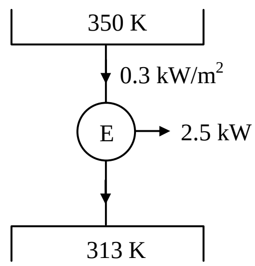
(c) 39 m^2 (d) 79 m^2

101. Ans: (d)

Sol: Given, $Q = 0.6\ \text{kW/m}^2$, $\eta = 0.5$

$T_H = 350$ K , $T_L = 313$ K

W = 2.5 kW



$$1 - \frac{313}{350} = \frac{2.5}{0.3A}$$

$$A = 78.82\ m^2 \approx 79 m^2$$

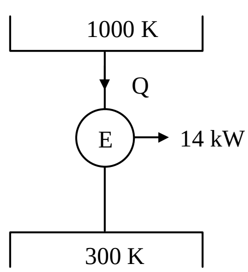
102. A reversible heat engine, operating on Carnot cycle, between the temperature limits of 300 K and 1000 K produces 14 kW of power. If the calorific value of the fuel is 40,000 kJ/kg. The fuel consumption will be:

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

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

102. Ans: (b)

Sol:



$$1-\frac{T_L}{T_H}=\frac{W}{Q}$$

$$1-\frac{300}{1000}=\frac{14}{Q}$$

$$\Rightarrow Q = 20\text{ kW}$$

$$\Rightarrow Q=\dot{m}C_V$$

$$\Rightarrow Q=\dot{m}C_V \Rightarrow \dot{m}\times 40{,}000 = 20$$

$$\therefore \quad \dot{m}=1.8\,\text{kg/hr}$$

103. 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 centric 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 4 only
(c) 1, 2 and 4 only (d) 3 and 4 only

103. Ans: (a)

104. 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

104. Ans: (b)

Sol: When flow velocity is less than sonic flow at throat subsonic flow prevails on converging as well as diverging section.

105. 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

105. Ans: (c)

Sol: $D_1^2 P_1 = D_2^2 P_2$

$$\frac{D_1^2}{D_2^2} = \frac{P_2}{P_1}$$

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

106. 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 pipeline 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

106. Ans: (a)

Sol: $h_L = \dfrac{H}{3}$ for maximum power transmission.

107. 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

107. Ans: (c)

Sol: Monotube is once through steam generator.

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

(a) Throttling (b) Condensation

(c) Evaporation (d) Entropy drop

108. Ans: (b)

Sol: Due to some time needed for condensation supersaturated flow occurs in a steam nozzle.

109. 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

109. Ans: (d)

Sol:

$$h_1 + Q + \cancelto{0}{\frac{V_1^2}{2}} = h_2 + \cancelto{0}{W} + \frac{V_2^2}{2}$$

$$\frac{V_2^2}{2} = 450\times10^3$$

$$V_2 = \sqrt{900\times10^3}$$

$$= 948.68 \text{ m/s} \approx 949 \text{ m/s}$$

110. 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

110. Ans: (c)

Sol: Shock waves occurs in a supersonic flow where there is change in Pressure, temperature and density.

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

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

(b) Velocity at the throat becomes supersonic

(c) Exit velocity becomes supersonic

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

111. Ans: (d)

Sol: When convergent divergent nozzle is choked mass flow rate reaches maximum and throat Mach number is one.

112. 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%

112. Ans: (a)

Sol: $W_T = 600$ kJ/kg

$W_C = 400$ kJ/kg

$Q_{supplied} = 1000$ kJ/kg

$$\eta = \frac{W_{net}}{Q_{sup\,plied}} = \frac{W_T - W_C}{Q_{sup\,plied}} = \frac{200}{1000} = 0.2\%$$

113. 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 3

113. Ans: (b)

Sol: Regeneration decreases work output of turbine reheating and intercooling improves work ratio.

114. The pressure at a point in water column 3.924 N/cm^2. What is the corresponding height of water?

(a) 8 m (b) 6 m

(c) 4 m (d) 2 m

114. Ans: (c)

Sol: Pressure (p) = 3.924 N/cm^2

We know that , P = ρgh

$$\Rightarrow h = \frac{p}{\rho g} = \frac{3.924 \times 10^4}{1000 \times 9.81}$$

$$= \frac{39.24}{9.81} = 4\,\text{m}$$

∴ Height of water column (h) = 4 m

115. Consider the following statements:

1. Thermal efficiency of the simple Steam or Rankine cycle can be improved increasing the maximum system pressure and temperature
2. Increasing the superheat of the steam improves the specific work a decreases the moisture content exhaust steam
3. Increasing maximum system pressure always increases the moisture content at the turbine exhaust
4. Lowering he 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

115. Ans: (*)

Sol: We feel all the four statements are correct, but according to UPSC the key could be ‘c’.

116. 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

116. Ans: (a)

117. 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

117. Ans: (a)

118. 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) Both1 and 2 (b) Neither 1 nor 2

(c) 1 only (d) 2 only

118. Ans: (c)

Sol: Generally comparison is done with ideal process.

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

(a) 80% (b) 60%

(c) 40% (d) 20%

119. Ans: (d)

Sol: Assume stroke volume is same

$P_1V_1 = m_1 RT_1$

$P_2 V_2 = m_2 RT_2$

$$m_1 = \frac{P_1V_1}{RT_1}$$

$$m_2 = \frac{P_2V_2}{RT_2}$$

$$\frac{m_1}{m_2} = \frac{P_1}{P_2} \times \frac{V_1}{V_2} \times \frac{T_2}{T_1}$$

$$= \frac{250}{560} \times \frac{280}{300} \times \frac{V_1}{V_2} = 1.25$$

$$\frac{m_2}{m_1} = \frac{1}{1.25} = 0.8$$

Reduction in mass is 20%

120. 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

120. Ans: (d)