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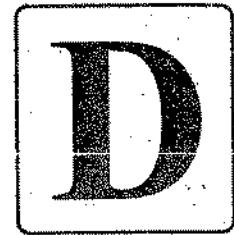
T.B.C. : B-HUF-P-OEA

Test Booklet Series

Serial No.

0026184

TEST BOOKLET
MECHANICAL ENGINEERING
Paper-I



Time Allowed : Two Hours

Maximum Marks : 200

INSTRUCTIONS

1. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS TEST BOOKLET **DOES NOT** HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET.
2. PLEASE NOTE THAT IT IS THE CANDIDATE'S RESPONSIBILITY TO ENCODE AND FILL IN THE ROLL NUMBER AND TEST BOOKLET SERIES CODE A, B, C OR D CAREFULLY AND WITHOUT ANY OMISSION OR DISCREPANCY AT THE APPROPRIATE PLACES IN THE OMR ANSWER SHEET. ANY OMISSION/DISCREPANCY WILL RENDER THE ANSWER SHEET LIABLE FOR REJECTION.
3. You have to enter your Roll Number on the Test Booklet in the Box provided alongside. **DO NOT** write *anything else* on the Test Booklet.
4. This Test Booklet contains 120 items (questions). Each item comprises four responses (answers). You will select the response which you want to mark on the Answer Sheet. In case you feel that there is more than one correct response, mark the response which you consider the best. In any case, choose **ONLY ONE** response for each item.
5. You have to mark all your responses **ONLY** on the separate Answer Sheet provided. See directions in the Answer Sheet.
6. All items carry equal marks.
7. Before you proceed to mark in the Answer Sheet the response to various items in the Test Booklet, you have to fill in some particulars in the Answer Sheet as per instructions sent to you with your Admission Certificate.
8. After you have completed filling in all your responses on the Answer Sheet and the examination has concluded, you should hand over to the Invigilator **only the Answer Sheet**. You are permitted to take away with you the Test Booklet.
9. Sheets for rough work are appended in the Test Booklet at the end.
10. **Penalty for wrong answers :**
THERE WILL BE PENALTY FOR WRONG ANSWERS MARKED BY A CANDIDATE.
 - (i) There are four alternatives for the answer to every question. For each question for which a wrong answer has been given by the candidate, **one-third** of the marks assigned to that question will be deducted as penalty.
 - (ii) If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that question.
 - (iii) If a question is left blank, i.e. no answer is given by the candidate, there will be no penalty for that question.

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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

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 processes are irreversible ?
 - (a) 1 and 2 only ✓
 - (b) 1 and 3 only
 - (c) 2 and 3 only
 - (d) 1, 2 and 3

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 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

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

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%

6. 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

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

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 ✓

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

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

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

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 ✓

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

Handwritten notes for Q13:
 $\frac{Q_1}{Q_2} = \frac{T_1}{T_2}$
 $1 = \frac{Q_1}{Q_2} \Rightarrow Q_1 = Q_2$
 $Q_1 = 1 \text{ kJ/K} \times 600 = 600 \text{ kJ}$
 $Q_2 = 600 \text{ kJ}$
 $W = Q_1 - Q_2 = 600 - 300 = 300 \text{ kJ}$

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

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

Handwritten notes for Q14:
 $Q_1 = 1000 \text{ kJ/s}$
 $T_1 = 1000 \text{ K}$
 $T_2 = 500 \text{ K}$
 $T_3 = 300 \text{ K}$
 $Q_2 = Q_1 \times \frac{T_2}{T_1} = 1000 \times \frac{500}{1000} = 500 \text{ kJ/s}$
 $Q_3 = Q_1 - Q_2 = 1000 - 500 = 500 \text{ kJ/s}$
 $W_{max} = Q_2 - Q_3 = 500 - 300 = 200 \text{ kJ/s}$
 $Q_1 - W_{max} = 1000 - 200 = 800 \text{ kJ/s}$
 $Q_3 = 500 \text{ kJ/s}$
 $Q_1 - Q_3 = 1000 - 500 = 500 \text{ kJ/s}$

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

Handwritten notes for Q17:
 $\frac{Q_1}{Q_2} = \frac{T_1}{T_2}$
 $1 = \frac{Q_1}{Q_2} \Rightarrow Q_1 = Q_2$
 $Q_1 = 1 \text{ kJ/kg} \times 900 = 900 \text{ kJ/kg}$
 $Q_2 = 900 \text{ kJ/kg}$
 $W = Q_1 - Q_2 = 900 - 621 = 279 \text{ kJ/kg}$

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

Handwritten notes for Q15:
 $Q_1 = 1000 \text{ kJ/s}$
 $T_1 = 1000 \text{ K}$
 $T_2 = 500 \text{ K}$
 $T_3 = 300 \text{ K}$
 $Q_2 = 500 \text{ kJ/s}$
 $Q_3 = 500 \text{ kJ/s}$
 $W_{max} = 200 \text{ kJ/s}$
 $Q_1 - W_{max} = 800 \text{ kJ/s}$
 $Q_3 = 500 \text{ kJ/s}$
 $Q_1 - Q_3 = 300 \text{ kJ/s}$

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

Handwritten notes for Q18:
 Statement 1: False (critical temperature is high)
 Statement 2: True (isothermal compression)
 Statement 3: True (water vapour in atmosphere is treated as ideal gas)

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

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

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

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

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

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.

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.

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.

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.

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.

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.

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

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

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.

31. Statement (I) : Effective temperature is 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.

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.

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.

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.

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.

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.

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.

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.

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

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

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

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

$\eta = \frac{W}{Q_1} = \frac{9 \text{ kW}}{40000 \text{ kJ/kg} \times \dot{m}}$
 $\frac{1}{3} = \frac{9}{40000 \dot{m}}$
 $\dot{m} = \frac{9 \times 3}{40000} = \frac{27}{40000} \text{ kg/s}$
 $= \frac{27 \times 3600}{40000} \text{ kg/hr} = 2.43 \text{ kg/hr}$

44. An ideal Otto-cycle works between minimum and maximum temperatures 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 ✓

$\frac{1}{1-\gamma} = \frac{1}{1-1.5} = -2$
 $\ln \left(\frac{1800}{300} \right) = -2 \ln r$
 $\ln 6 = -2 \ln r$
 $\ln r = -\frac{\ln 6}{2}$
 $r = \frac{1}{\sqrt{6}} \approx 0.408$

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

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

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

$\eta_{Otto} = 1 - \frac{1}{r^{\gamma-1}}$
 $\eta_{Diesel} = 1 - \frac{1}{r^{\gamma}} \left(\frac{\rho^{\gamma} - 1}{\rho - 1} \right)$
 $\rho = \frac{V_2}{V_1}$

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

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

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

49. In an Otto cycle, air is compressed from 2.2 l to 0.26 l from an initial pressure of 1.2 kg/cm². 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

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

51. In a furnace the heat loss through the 150 mm thick refractory wall lining is estimated to be 50 W/m². 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

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

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

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

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

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

57. A cross-flow type air heater has an area of 50 m^2 . The overall transfer coefficient is $100 \text{ W/m}^2 \text{ K}$; 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

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

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

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

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

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

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

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

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

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

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 $4y$

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

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

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

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

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

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

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_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) $(4)^{\frac{1}{5}}$

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 is 0.98, then the coefficient of discharge for the nozzle is :

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

Handwritten notes for Q75:
 $\frac{90}{100}$
 0.9×0.98
 0.882

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

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 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

Handwritten notes for Q76:
 $\frac{1}{Re} \propto f$
 $\Delta P \propto V$
 $\Delta P \propto V^2$

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 stream velocity ?

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

79. The oil with specific gravity 0.8, dynamic viscosity of 8×10^{-3} Ns/m² 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

Handwritten notes for Q79:
 $Re = \frac{\rho V D}{\mu} = 2100$
 $V = \frac{2100 \times \mu}{\rho D}$

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

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

Handwritten notes: 600 , 400 , 1000

82. 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



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 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

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

Handwritten calculations: $1500 - 250 = 1250$, $1250 / 250 = 5$

85. 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

Handwritten calculations: $300 / (300 - 273) = 10.71$

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

Handwritten notes: 27°C , 2°C , 4 T , 140 , 17 , 15 , 15

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

Handwritten note: $1, 3$

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

Handwritten notes: 2.5 , 5 , 1.15 , 1.35 , 1.55 , 1.75

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

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

Handwritten notes: $5 \times 6 = 30$, $30/8 = 3.75$

91. 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

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

Handwritten notes: $2.5 \times 6 = 15$, $15/4 = 3.75$, $15/4 = 3.75$

93. 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

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

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

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

1. 78

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

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) Thermoelectric refrigeration 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

100. 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 N

981 m/s

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

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

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 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

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

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

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

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 ✓

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

- (a) Throttling ✓
- (b) Condensation
- (c) Evaporation
- (d) Entropy drop

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

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

111. 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 through the nozzle reaches a maximum value

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%

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
- 13.5

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

- (a) 8 m
 - (b) 6 m
 - (c) 4 m ✓
 - (d) 2 m
- 13.50

115. Consider the following statements :

- 1. Thermal efficiency of the simple Stear or Rankine cycle can be improved increasing the maximum system pressure and temperature
- 2. Increasing the superheat of the steam improves the specific work and decreases the moisture content 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 and 3
- (d) 3 and 4

- the 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

- a is ing 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

- eam l by tem 118. Consider the following statements :
- The compression process in a centrifugal compressor is comparable with :
1. Reversible and adiabatic
 2. Irreversible and adiabatic
- eam and t of Which of the above statements is/are correct?
- (a) Both 1 and 2
 - (b) Neither 1 nor 2
 - (c) 1 only
 - (d) 2 only ✓

119. 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%

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

$\frac{1}{100}$ $\frac{1}{m^2}$
 104 $\frac{3840}{117.6}$