

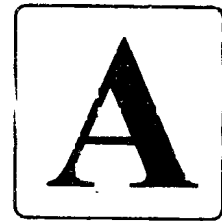
**DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO**

T.B.C. : B-GTD-O-NDA

Test Booklet Series

Seri

TEST BOOKLET  
MECHANICAL ENGINEERING



Paper—I

**Time Allowed : Two Hours**

**Maximum Marks : 200**

**INSTRUCTIONS**

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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 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.
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9. Sheets for rough work are appended in the Test Booklet at the end.
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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 (0.33)** 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 **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. A body of mass 20 kg falls freely in vacuum. It has fallen through a vertical distance of 50 m. The gravitational acceleration may be assumed as  $10 \text{ m/s}^2$ . What is the thermodynamic work done by the body?
  - (a) 1000 Nm
  - (b) 10 kJ
  - (c) 0
  - (d) 1 kNm
  
2. When a system is taken from state 'x' to state 'y', 30 kJ of heat flows into the system and the system does 10 kJ of work. When the system is returned from 'y' to 'x' along another path, work done on the system is 8 kJ. What is the amount of heat liberated or absorbed?
  - (a) 12 kJ of heat liberated
  - (b) 28 kJ of heat liberated
  - (c) 12 kJ of heat absorbed
  - (d) 28 kJ of heat absorbed
  
3. A closed gaseous system undergoes a reversible constant pressure process at 2 bar in which 100 kJ of heat is rejected and the volume changes from  $0.2 \text{ m}^3$  to  $0.1 \text{ m}^3$ . The change in the internal energy of the system is
  - (a) -100 kJ
  - (b) -80 kJ
  - (c) -60 kJ
  - (d) -40 kJ
  
4. A Carnot engine receives 100 kJ of heat at 600 K. Heat is rejected at 300 K. The displacement volume is  $0.2 \text{ m}^3$ . The mean effective pressure is
  - (a) 2 bar
  - (b) 2.5 bar
  - (c) 3 bar
  - (d) 3.5 bar

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

Process	Heat transfer (kJ)	Work transfer (kJ)
1	300	300
2	00	250
3	-100	-100
4	00	-250

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

- (a) 33% and 0.66
  - (b) 66% and 0.36
  - (c) 36% and 0.66
  - (d) 33% and 0.36
6. The performance of reciprocating compressors with provision of cooling cylinder is compared with
    - (a) Mechanical efficiency
    - (b) Isothermal efficiency
    - (c) Adiabatic efficiency
    - (d) Isentropic efficiency
  
  7. A body of mass 2 kg and  $C_p = 1.00 \text{ kJ/kg K}$  is available at 600 K. If the atmosphere is 300 K and  $\ln 2 = 0.693$ , the maximum work obtainable from the body till it comes to equilibrium with the atmosphere is
    - (a) 150 kJ
    - (b) 142 kJ
    - (c) 184.2 kJ
    - (d) 190.5 kJ

8. A liquid of heat capacity 5 J/K in an insulated container is heated electrically from 300 K to 600 K. If  $\ln 2 = 0.693$ , entropy generation of the universe would be
- 6.93 J/K
  - 3.465 J/K
  - 34.65 J/K
  - 10.65 J/K
9. Which of the following relationships represents the change of entropy of a perfect gas?
- $C_p \frac{dT}{T} + \frac{R}{V} dV$
  - $C_p \frac{dT}{T} - \frac{R}{P} dP$
  - $C_v \frac{dP}{P} + C_p \frac{dV}{V}$
  - $C_p \frac{dP}{P} - C_v \frac{dV}{V}$
- 1, 2 and 4 only
  - 1, 2 and 3 only
  - 2, 3 and 4 only
  - 1, 2, 3 and 4
10. Consider the following statements regarding availability:
- It is generally conserved
  - It can either be negative or positive
  - It is the maximum theoretical work obtainable
  - It can be destroyed in irreversibility
- Which of the above statements are correct?
- 3 and 4
  - 1 and 2
  - 1 and 3
  - 2 and 4
11. During a thermodynamic process, 100 kJ of heat is transferred from a reservoir at 800 K to a sink at 400 K. The ambient temperature is 300 K. The loss of available energy is
- 27.5 kJ
  - 32.5 kJ
  - 37.5 kJ
  - 62.5 kJ
12. A refrigerator that operates on a Carnot cycle is required to transfer 2000 kJ/min to the atmosphere at 27°C, where the low temperature reservoir is at 0°C. What is the power required?
- 200 W
  - 32.93 kW
  - 200 kW
  - 3.33 kW
13. Consider the following statements:
- Carnot, Ericsson and Stirling cycles are ideal power cycles that are completely reversible
  - Ericsson cycle is not a practical engine cycle
  - Stirling cycle is the only practical power cycle among the above
  - All these cycles have the same thermal efficiency
- Which of the above statements are correct?
- 1, 2, 3 and 4
  - 1, 2 and 4 only
  - 2, 3 and 4 only
  - 1, 2 and 3 only

14. The vapour pressure of a liquid at any arbitrary temperature can be estimated approximately with the help of
- Gibbs equation
  - Joule-Kelvin equation
  - Clausius-Clapeyron equation
  - Gibbs-Duhem equation
15. In order to determine the quality of wet steam by a separating and throttling calorimeter, the steam should be first separated and then throttled such that the final state is
- Saturated vapour only
  - Superheated vapour only
  - At a pressure higher than the original pressure
  - A mixture of saturated liquid and vapour
16. The work done in a steady flow process is equal to  $-\int v dp$ . In the Rankine cycle, the turbine work is much greater than the pump work because
- The specific volume of water is much higher than that of steam
  - The specific volume of steam is much higher than that of water
  - The pressure drop in the turbine is much higher than that in the pump
  - There is less irreversibility in the turbine than in the pump
17. The maximum net specific work obtainable in an ideal Brayton cycle for  $T_{\text{max}} = 900 \text{ K}$  and  $T_{\text{min}} = 400 \text{ K}$  is given by
- 100 Cp
  - 500 Cp
  - 700 Cp
  - 800 Cp
18. The tendency of detonation is high in engines of larger cylinder diameter because of
- Higher intake pressure in larger cylinder
  - Higher fuel/air ratio in larger cylinder
  - Flame having to travel longer distance in larger cylinder
  - Sparks are advanced more in larger cylinder
19. Consider the following statements:
- The only practical way of improving efficiency of Otto cycle is to increase the compressor ratio of an internal combustion engine
  - Ericsson cycle needs heat transfer in all the processes
  - Ericsson and Stirling cycles employ regenerative heat exchangers for reversible heat transfer
  - Atkinson cycle has a greater specific work than a comparable Otto cycle engine
- Which of the above statements are correct?
- 1, 2, 3 and 4
  - 1, 2 and 4 only
  - 2, 3 and 4 only
  - 1, 2 and 3 only

20. For a multistage reciprocating compressor; which of the following statements are correct?
1. It decreases volumetric efficiency
  2. The work of compression is reduced
  3. The high pressure cylinder is smaller in size
- (a) 1 and 2 only  
(b) 2 and 3 only  
(c) 1 and 3 only  
(d) 1, 2 and 3
21. An open cycle pressure gas turbine uses a fuel of calorific value 40,000 kJ/kg with air-fuel ratio of 80:1 and develops a net output of 80 kJ/kg of air. The thermal efficiency of the cycle is
- (a) 12%  
(b) 16%  
(c) 20%  
(d) 18%
22. Consider the following statements regarding cycles:
1. Stirling cycle consists of two isothermal and two adiabatic processes.
  2. In vapour compression cycle, the refrigerant is in the form of dry saturated vapour before entering compressor.
  3. Diesel cycle consists of one constant pressure; one constant volume and two isentropic processes
- Which of the above statements are correct?
- (a) 1, 2 and 3  
(b) 1 and 2 only  
(c) 1 and 3 only  
(d) 2 and 3 only
23. The efficiency of the vapour power Rankine cycle can be increased by
1. Increasing the temperature of the working fluid at which heat is added
  2. Increasing the pressure of the working fluid at which heat is added
  3. Decreasing the temperature of the working fluid at which heat is rejected
- Which of the above statements are correct?
- (a) 1 and 2 only  
(b) 1 and 3 only  
(c) 2 and 3 only  
(d) 1, 2 and 3
24. An ideal refrigerating machine works between the temperature limits of 45°C and -8°C. The power required per ton of refrigeration is
- (a) 1.0 kW  
(b) 1.2 kW  
(c) 0.8 kW  
(d) 0.7 kW
25. Consider the following data referring to a refrigerator working on Vapour-compression refrigeration cycle:
1. Enthalpy at entry to compressor = 180 kJ/kg
  2. Enthalpy at exit from compressor = 210 kJ/kg
  3. Enthalpy at exit of condenser = 60 kJ/kg
- What is the COP of the refrigerator?
- (a) 2  
(b) 3  
(c) 4  
(d) 5

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

1. For the same pressure ratio the volumetric efficiency of a two-stage compressor is more than that of single stage compressor.
2. A two-stage compressor requires minimum work when inter-cooling is perfect.
3. The intercooler pressure  $p_2$  is the average of inlet pressure  $p_1$  and delivery pressure  $p_3$ .

Which of the above statements are correct?

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

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

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

28. Consider the following statements

1. Fuels of higher octane number can be employed at higher compression ratio
2. In CI engines, brake specific fuel consumption decreases with increasing load

Which of the above statements is/are correct?

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

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

- (a) 20 kPa
- (b) 20 bar
- (c) 2000 Pa
- (d) 2 bar

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

1. Excessive power consumption
2. High compression
3. Large volume flow

Which of the above statements are correct?

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

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

1. Increasing engine rpm
2. Advancing spark timing
3. Making fuel-air ratio very rich

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

32. Consider the following statements:

1. Free expansion of a gas
2. Slow heating of oil from a constant temperature source
3. Evaporation of water at its saturation temperature by a source at the same temperature
4. Isentropic compression of an ideal gas

Which of these processes are irreversible?

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

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

1. Supercharging results in quieter and smoother operation of a CI engine
2. Supercharging of a CI engine requires increase in valve overlap
3. The limit of supercharging for a CI engine is reached by thermal and mechanical loading

Which of the above statements are correct?

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

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

1. For best fuel economy of spark ignition engines, the fuel-air mixture should be lean
2. With supercharging, the specific consumption in compression ignition engines increases
3. With increase of load, knocking tendency in compression ignition engines decreases

Which of the above statements are correct?

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

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

1. The power output for a given engine increases
2. The loss of power due to altitude is compensated
3. The increase in supercharging pressure decreases the tendency to detonate in spark ignition engines
4. The mechanical efficiency of supercharged engines is quite high compared to naturally aspirated engines

Which of the above statements are correct?

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

36. Consider the following statements for a combustion process:

1. The total mass of each chemical element in the reactants is preserved in the products
2. The presence of carbon monoxide in the products of combustion implies incomplete combustion

Which of the above statements is/are correct?

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

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

- (a) 0
- (b)  $L$
- (c)  $L/2$
- (d)  $L/4$

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

- (a) 45 mm
- (b) 60 mm
- (c) 75 mm
- (d) 90 mm

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

- (a) 0.10 kW
- (b) 0.15 kW
- (c) 0.20 kW
- (d) 0.25 kW

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

- (a) Equal to critical value
- (b) Less than the critical value
- (c) More than the critical value
- (d) Zero critical value

41. Consider the following statements:

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

1. Convective coefficient
2. Thermal conductivity
3. Sectional area
4. Circumference

Which of the above statements are correct?

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



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

- (a) Middle length of flow
- (b) Beginning of flow
- (c) End of flow
- (c) None of the above

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

- (a)  $\left(\frac{p_3}{p_1}\right)^{\frac{1}{4}}$
- (b)  $\left(\frac{p_3}{p_1}\right)^{\frac{1}{3}}$
- (c)  $\left(\frac{p_3}{p_1}\right)^{\frac{1}{2}}$
- (d)  $\left(\frac{p_3}{p_2}\right)^{\frac{1}{4}}$

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

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

1. Use of 5% lean mixture
2. Advancing the spark timing
3. Recirculating a fraction of exhaust gas
4. Using an oxidation catalyst in the exhaust manifold

Which of the above statements is/are correct?

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

45. A counter flow shell and tube exchanger having an area of  $32.5 \text{ m}^2$ , is used to heat water with hot exhaust gases. The water ( $C_p = 4.16 \text{ kJ/kg K}$ ) flows at a rate of  $2 \text{ kg/sec}$  while the exhaust gases ( $C_p = 1.03 \text{ kJ/kg K}$ ) flow at a rate of  $5.15 \text{ kg/sec}$ . If the overall heat transfer surface coefficient is  $200 \text{ W/m}^2\text{K}$ , the NTU for the heat exchanger is

- (a) 1.2
- (b) 2.4
- (c) 3.6
- (d) 4.8

46. Consider the following statements with regard to heat transfer:
1. The temperature variations in lumped heat capacity analysis is exponential with time
  2. In situations involving simultaneous heat and mass transfer, the ratio of convective heat transfer to convective mass transfer varies with Lewis number,  $Le$ , as  $(Le)^{1/3}$ .
- Which of the above statements are correct?
- (a) Both 1 and 2
  - (b) Neither 1 nor 2
  - (c) 1 only
  - (d) 2 only
47. For a fluid with Prandtl number  $Pr > 1$ , momentum boundary layer thickness
- (a) Decreases rapidly compared to the thermal boundary layer thickness
  - (b) And thermal boundary layer thickness increase at the same rate
  - (c) Increases rapidly compared to the thermal boundary layer thickness
  - (d) And thermal boundary layer thickness decrease at the same rate
48. For the same type of shapes, the value of Radiation Shape Factor will be higher when surfaces are
- (a) More closer or ly
  - (b) Moved further apart
  - (c) Smaller and held closer
  - (d) Larger and held closer
49. In a pipe, laminar flow in fully developed region with constant heat flux from pipe wall, bulk mean temperature of fluid
- (a) and pipe wall temperature increase in flow direction
  - (b) and pipe wall temperature decrease in flow direction
  - (c) remains constant, but pipe wall temperature increases in flow direction
  - (d) increases but pipe wall temperature remains constant
50. Which of the following statements is correct for steam boiler ?
- (a) Boiler secondary heat transfer surface includes super-heater, economizer and air pre- heater.
  - (b) Boiler primary heat transfer surface includes evaporator section, super-heater section and reheat section.
  - (c) Boiler primary heat transfer surface includes evaporator section, economizer and super-heater section.
  - (d) Boiler secondary heat transfer surface includes evaporator section, economizer and air pre- heater
51. In a wall of constant thermal conductivity, the temperature profile for heat conduction in the presence of a heat source inside the wall is
- (a) Linear
  - (b) Logarithmic
  - (c) Parabolic
  - (d) Hyperbolic

52. Determine the heat transfer through a plane of length 4 m, height 3 m and thickness 0.2 m. The temperatures of inner and outer surfaces are  $150^{\circ}\text{C}$  and  $90^{\circ}\text{C}$  respectively. Thermal conductivity of the wall is  $0.5 \text{ W/mK}$ .
- (a) 1800 W  
 (b) 2000 W  
 (c) 2200 W  
 (d) 2400 W
53. In a Psychrometric chart, which of the following statement/s is/are correct?
- (a) It is used to determine properties of refrigerants  
 (b) It cannot determine WBT and DBT  
 (c) It is seldom used for air conditioning design  
 (d) It provides plots for moist air conditioning
54. In a Psychrometric chart, horizontal lines represent constant
- (a) Humidity ratio and vertical lines represent constant dry bulb temperature  
 (b) Humidity ratio and vertical lines represent constant wet bulb temperature  
 (c) Dry bulb temperature and vertical lines represent constant absolute humidity ratio  
 (d) Wet bulb temperature and vertical lines represent constant humidity ratio
55. Air is passed through a cooling coil at a temperature of  $-5^{\circ}\text{C}$ . If the temperature of air drops from  $25^{\circ}\text{C}$  to  $10^{\circ}\text{C}$ , the Bypass factor of the coil is
- (a) 0.2  
 (b) 0.5  
 (c) 0.7  
 (d) 1.0
56. The multistage compression of air as compared to single stage compression
- (a) Improves volumetric efficiency for the given pressure ratio  
 (b) Reduces work done per kg of air  
 (c) Gives more uniform torque  
 (d) All of the above
57. In sensible cooling of moist air, its physical properties vary as follows:
1. The wet bulb temperature decreases
  2. The dew point temperature remains constant
  3. The relative humidity increases
- Which of the above statements are correct?
- (a) 1, 2 and 3  
 (b) 1 and 2 only  
 (c) 1 and 3 only  
 (d) 2 and 3 only

58. A desert cooler having a cooling efficiency of 70% reduces the temperature of atmospheric air from 37°C to 30°C. The wet bulb temperature of the air is

- (a) 24°C
- (b) 25°C
- (c) 26°C
- (d) 27°C

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

1. In adiabatic saturation process, air-vapour mixture undergoes a process of constant relative humidity
2. Wet bulb temperature of air whose relative humidity is 100 is equal to the dew point temperature
3. In winter air conditioning, the process is heating and humidification
4. For designing air conditioning ducts, equal friction method automatically reduces the air velocity in the duct in the direction of flow

Which of the above statements are correct?

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

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

- (a) Greater than 1
- (b) Equal to 1
- (c) Between  $\frac{1}{4}$  and  $\frac{3}{4}$
- (d) Less than 1

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

(a) 
$$V = \left[ \frac{2np_1v_1}{n-1} \right]^{\frac{1}{2}}$$

(b) 
$$V = \left[ \frac{2np_1v_1}{n+1} \right]^{\frac{1}{2}}$$

(c) 
$$V = [2np_1v_1]^{\frac{1}{2}}$$

(d) 
$$V = [np_1v_1]^{\frac{1}{2}}$$

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

62. Which of the following refrigeration systems is most suitable for solar cooling?

- (a) Ejector refrigeration system
- (b) Vapour absorption system
- (c) Desiccant refrigeration system
- (d) Vertex tube refrigeration system

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

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

64. Which of the following fluids exhibit a certain shear stress at zero shear strain rate followed by a straight line relationship between shear stress and shear strain rate?
- Newtonian fluids
  - Ideal Bingham plastic fluids
  - Pseudo-plastic fluids
  - Dilatent fluids
65. What is the specific gravity of a marble stone, which weighs 400 N in air, and 200 N in water? ( $g = 10\text{m/s}^2$ )
- 8
  - 6
  - 4
  - 2
66. What is the intensity of pressure in the following SI units, when specific gravity of mercury is 13.6 and the intensity of pressure is 400 KPa?
- 0.3 bar or 4.077 m of water or 0.299 m of Hg
  - 4 bar or 5.077 m of water or 0.399 m of Hg
  - 0.3 bar or 5.077 m of water or 0.599 m of Hg
  - 4 bar or 4.077 m of water or 0.299 m of Hg
67. Consider the following statements:
- If a small upward displacement is given to a floating body, it results in the reduction of the buoyant force acting on the body
  - A slight horizontal displacement does not change either the magnitude or the location of the buoyant force
- Which of the above statements is/are correct?
- Both 1 and 2
  - 1 only
  - 2 only
  - Neither 1 nor 2
68. State whether following flow field is physically possible?
- $u = 3xy^2 + 2x + y^2$  and  $v = x^2 - 2y - y^3$
- Possible for steady, incompressible flow
  - Possible for unsteady, incompressible flow
  - Possible for steady, compressible flow
  - Not possible
69. A steady incompressible flow field is given by  $u = 2x^2 + y^2$  and  $v = -4xy$ . The convective acceleration along x-direction at point (1, 2) is
- 6 units
  - 24 units
  - 8 units
  - 24 units
70. Consider the following remarks pertaining to the irrotational flow:
- The Laplace equation of stream function  $\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = 0$  must be satisfied for the flow to be potential.
  - The Laplace equation for the velocity potential  $\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = 0$  must be satisfied to fulfil the criterion of mass conservation i.e continuity equation.
- Which of the above statements is/are correct?
- 1 only
  - Both 1 and 2
  - 2 only
  - Neither 1 nor 2

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

- (a) 3
- (b) 2.5
- (c) 4
- (d) 5

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

- (a) 3 m/s<sup>2</sup>
- (b) 6 m/s<sup>2</sup>
- (c) 9 m/s<sup>2</sup>
- (d) 15 m/s<sup>2</sup>

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

- (a) 9
- (b) -6
- (c) 117
- (d) 10.8

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

- (a)  $\frac{1}{4} \left( \frac{V_1^2}{2g} \right)$
- (b)  $\frac{3}{16} \left( \frac{V_1^2}{2g} \right)$
- (c)  $\frac{1}{64} \left( \frac{V_1^2}{2g} \right)$
- (d)  $\frac{9}{16} \left( \frac{V_1^2}{2g} \right)$

75. What is the ratio of momentum thickness to the boundary layer thickness  $\delta$  when the layer velocity profile is given by

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

- (a) 0.133
- (b) 0.333
- (c) 0.166
- (d) 0.136

where  $u$  is velocity at height  $y$  above surface and  $U_\infty$  is free stream velocity of flow.

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

- (a) More for lighter fluid
- (b) More for denser fluid
- (c) Less for denser fluid
- (d) Less for lighter fluid

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

- (a) Linearly with fluid density
- (b) Inversely with pressure drop
- (c) Directly as square of pipe radius
- (d) Inversely with fluid viscosity

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

- (a) 1.5 mm
- (b) 2.5 mm
- (c) 4.0 mm
- (d) 5.0 mm

79. Air is flowing over a flat plate with a free stream velocity of 24 m/s, and its kinematic viscosity is  $72 \times 10^{-6} \text{ m}^2/\text{s}$ . If at a particular point, the Reynolds number is 30000, its location from the leading edge is
- 0.05 m
  - 0.07 m
  - 0.08 m
  - 0.09 m
80. Consider the following statements pertaining to boundary layer on a flat plate:
- The thickness of laminar boundary layer at a distance  $x$  from the leading edge varies as  $x^{1/2}$
  - The thickness of turbulent boundary layer at a distance  $x$  from the leading edge varies as  $x^{4/5}$
  - Boundary layer is laminar when Reynolds number is less than  $5 \times 10^5$
- Which of the above statements are correct?
- 1, 2 and 3
  - 1 and 2 only
  - 1 and 3 only
  - 2 and 3 only
81. Which of the following parameters of fluid will increase as a result of friction while flowing adiabatically through a convergent divergent nozzle?
- Available heat drop
  - Entropy
  - Stagnation pressure
  - Stagnation temperature
82. In a shock wave, the flow passes from a
- Subsonic to a sonic state
  - Subsonic to a supersonic state
  - Supersonic to a sonic state
  - Supersonic to a subsonic state
83. A jet of water issues from a nozzle with a velocity of 20 m/s and it impinges normally on a flat plate moving away from it at 10 m/s. If the cross sectional area of the jet is  $0.01 \text{ m}^2$  and the density of water is taken as  $1000 \text{ kg/m}^3$ , then the force developed on the plate will be
- 100 N
  - 200 N
  - 1000 N
  - 2000 N
84. A two dimensional velocity field is given by
- $$V = (x^2 - y^2 + x) i - (2xy - y) j$$
- The convective acceleration at  $(x, y) = (1, 2)$  is
- 0
  - 14 units
  - 2 units
  - None of the above
85. Jet pumps are often used in process industry for their
- Large capacity
  - High efficiency
  - Capacity to transport gases, liquids and mixtures of both
  - None of the above

86. Mainly hydraulic turbines are used to drive the electrical alternators which require maintaining the peripheral speed constant even at part load conditions to avoid the change in frequency of electric power. The governing of the hydraulic turbine is done by
- Controlling the flow area
  - Controlling the velocity
  - Using the fly wheel
  - Combined control of flow area and velocity
87. In a hydraulic coupling
- The magnitudes of input and output torques are equal
  - The magnitude of input torque is greater than output torque
  - The magnitude of input torque is less than output torque
  - The magnitude of input torque is negligible as compared to output torque
88. Considering the flow of steam through a Convergent-Divergent nozzle under real conditions, where supersaturation occurs, the difference between the saturation temperature corresponding to the pressure and the supersaturated temperature is defined as degree of
- Under cooling
  - Superheat
  - Reaction
  - Saturation
89. For maximum discharge of hot gases through a chimney, the height of hot column producing draught is
- Twice the height of chimney
  - Equal to the height of chimney
  - Half the height of chimney
  - None of the above
90. Consider the following statements:
- In natural convection turbulent flow over heated vertical plate,  $h$  is independent of the characteristic length
  - In turbulent flow, non-dimensional heat transfer coefficient for natural convection over a heated vertical plate is given by
 
$$Nu = c (Pr)^{\frac{1}{3}}$$
- Which of the above statements is/are correct?
- 1 only
  - Both 1 and 2
  - 2 only
  - Neither 1 nor 2
91. For accelerating an ideal gas isentropically from rest to supersonic speed, we require a convergent-divergent nozzle. To decelerate an ideal gas isentropically from supersonic speed to subsonic speed the diffuser should be
- Diverging
  - Converging
  - Convergent-divergent
  - Divergent-convergent



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

1. A single stage impulse turbine has a nozzle angle  $\alpha$ . The maximum blade efficiency of the turbine will be  $\cos^2 \alpha$
2. For a reaction steam turbine with identical stator and rotor blades, the blade velocity for maximum blade efficiency is equal to inlet steam velocity
3. Velocity compounded impulse steam turbine gives less speed and less efficiency

Which of the above statements are correct?

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

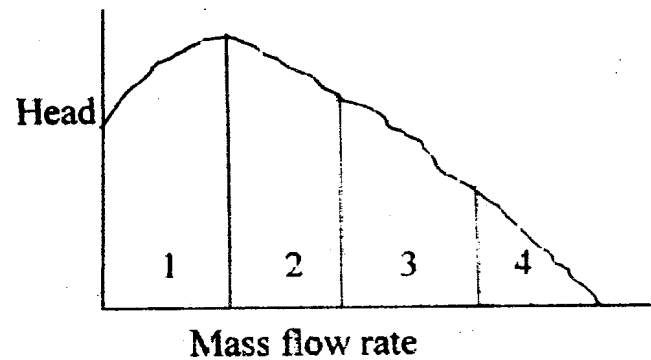
93. Surging is the phenomenon of

- (a) Steady, periodic and reversed flow
- (b) Unsteady, periodic and reversed flow
- (c) Unsteady, periodic and uniform flow
- (d) 1-dimensional steady and uniform flow

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

- (a) Work factor
- (b) Slip factor
- (c) Degree of reaction
- (d) Pressure coefficient

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



- (a) 4<sup>th</sup> zone
- (b) 2<sup>nd</sup> zone
- (c) 1<sup>st</sup> zone
- (d) 3<sup>rd</sup> zone

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

- (a) Increase in flow and increase in efficiency
- (b) Increase in flow and decrease in efficiency
- (c) Decrease in flow and decrease in efficiency
- (d) Decrease in flow and increase in efficiency

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

- (a) 1 for both
- (b) 1/2 for de Laval turbine and 1 for Parsons turbine
- (c) 1 for de Laval turbine and 1/2 for Parsons turbine
- (d) 1/2 for both

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

- (a) Air blower, axial flow fan, centrifugal compressor and reciprocating compressor
- (b) Axial flow fan, centrifugal compressor, air blower and reciprocating compressor
- (c) Air blower, centrifugal compressor, axial flow fan, and reciprocating compressor
- (d) Axial flow fan, air blower, centrifugal compressor and reciprocating compressor

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

- (a) Rotor with backward curved blades
- (b) Rotor with forward curved blades
- (c) Rotor with radial blades
- (d) All of the above

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

- (a) 0.70
- (b) 0.72
- (c) 0.75
- (d) 0.77

**Directions: —**

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

**Codes:**

- (a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
- (b) Both Statement (I) and Statement (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

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

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

102. Statement (I) : In an isolated system, the heat transfer  $\delta Q$  and the work transfer  $\delta W$  are always zero.

Statement (II) : In an isolated system, the entropy always remains constant.

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

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

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

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

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

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

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

106. Statement (I) : A mixture of liquid air and air cannot be considered as pure substance.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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



SPACE FOR ROUGH WORK

