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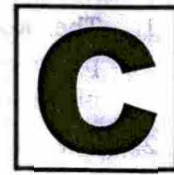
T.B.C. : SKP-D-MCH

Test Booklet Series

Serial No.

TEST BOOKLET

MECHANICAL ENGINEERING



Time Allowed : Three Hours

Maximum Marks : 300

I N S T R U C T I O N S

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 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 150 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.
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 (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. Consider the following statements with reference to combustion and performance in a four-stroke petrol engine :

1. The auto-ignition temperature of petrol as a fuel is higher than that of diesel oil as a fuel.
2. The highest compression ratio of petrol engines is constrained by the possibility of detonation.
3. A petrol engine is basically less suitable for supercharging than a diesel engine.

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

2. In a flooded evaporator refrigerator, an accumulator at the suction side of the compressor is provided to

- (a) collect the vapours
- (b) detect any liquids in the vapour
- (c) retain the refrigeration effect as originally working
- (d) collect the liquid refrigerant and preclude its reversion to the compressor

3. A four-stroke single-cylinder SI engine of 6 cm diameter and 10 cm stroke running at 4000 r.p.m. develops power at a mean effective pressure of 10 bar. The power developed by the engine is

- (a) 9.42 kW
- (b) 5.54 kW
- (c) 4.92 kW
- (d) 2.94 kW

4. Which of the following actions will help to reduce the black smoke emission of a diesel engine?

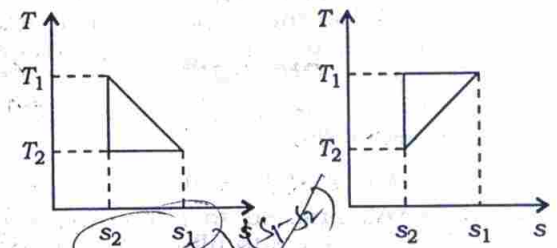
1. Run at lower load, i.e., derating
2. Have regular maintenance of the diesel engine, particularly of injection system
3. Use diesel oil of higher cetane number

Select the correct answer using the code given below.

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

5. What is the ratio of the efficiencies $\left(\frac{\eta_I}{\eta_{II}}\right)$

for the two cycles as shown in the T-s diagrams?



- (a) $\frac{T_1 + T_2}{2T_1}$
- (b) $\frac{T_1 + T_2}{2T_2}$
- (c) $\frac{2T_2}{T_1 + T_2}$
- (d) $\frac{2T_1}{T_1 + T_2}$

$\frac{2T_1 T_2}{60} = P$

$T = \frac{25 \times 10^5 \times \pi \times 10}{36 \times 2\pi}$

$\frac{\pi}{4} \times 6^2 \times 10 \times 10^5 \times \frac{1}{10^4}$
 $\frac{100 \times \pi \times 10^2}{25 \times 36} \times \pi$

$L = 10$
 $D = 6$

$\frac{4.4}{26.4} \times 2$
 $\frac{4.4}{105} \times 60$
 $BP = 105$
 $W_1 = \frac{4.4}{105} \times 10 \times 60$
 $= \frac{4.4 \times 600}{105}$

6. A four-stroke engine having a brake power of 105 kW is supplied with fuel at the rate of 4.4 kg/min for 10 minutes. The brake specific fuel consumption of the engine is
- (a) 0.18 kg/kW-hr
 - (b) 0.25 kg/kW-hr
 - (c) 0.36 kg/kW-hr
 - (d) 0.42 kg/kW-hr

8. In IC engine
1. the ideal air capacity of a two-stroke engine is the mass of air required to concurrently fill the total cylinder volume at inlet temperature and exhaust pressure
 2. with increase in air-fuel ratio beyond the value for maximum power, there is a fall in power developed and this fall is more with higher values of air-fuel ratio
 3. the volumetric efficiency of the engine depends on the design of intake and exhaust manifold

7. Consider the following statements :

1. Recycling exhaust gases by partial mixing with the intake gases increases the emission of oxides of nitrogen from the engine.
2. The effect of increase in altitude of operation on the carburetor is to enrich the entire port-throttle operation.
3. When the carburetor throttle is suddenly opened, the air-fuel mixture may lean out temporarily resulting in engine stall.
4. Use of multi-venturi system makes it possible to obtain a high velocity airstream when the fuel is introduced at the main venturi throat.

Which of the above are correct?

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

9. Consider the following statements :

1. Heat pumps and air conditioners have the same mechanical components.
2. The same system can be used as heat pump in winter and as air conditioner in summer.
3. The capacity and efficiency of a heat pump fall significantly at high temperatures.

Which of the above statements are correct?

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

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

SKP-D-MCH/47C

$\eta = \frac{T_1 - T_2}{T_1}$

$\frac{T_1 - T_2}{T_1} \times \frac{1}{2} (s_1 + s_2)$

$\frac{T_1 - T_2}{2T_1 + T_1 - T_2}$

$\frac{T_1 - T_2}{T_1 + T_2}$

$\eta_2 = \frac{T_1 - T_2}{2T_1}$

$\frac{\frac{1}{2} (T_1 - T_2) (s_1 + s_2)}{T_1 (s_1 + s_2)}$

[P.T.O.]

$\frac{2T_1}{T_1 + T_2}$

10. The following are the results of a Morse test conducted on a four-cylinder, four-stroke petrol engine at a common constant speed in all cases :

The brake power of the engine when all the cylinders are firing is 80 kW. The brake power of the engine when each cylinder is cut off in turn is 55 kW, 55.5 kW, 54.5 kW and 55 kW, respectively.

The mechanical efficiency of the engine when all the cylinders are firing will be

- (a) 90%
- (b) 85%
- (c) 80%
- (d) 75%

11. An ideal refrigerator working on a reversed Rankine cycle has a capacity of 3 tons. The COP of the unit is found to be 6. The capacity of the motor required to run the unit is (take 1 T = 210 kJ/min)

- (a) 1.85 kW
- (b) 1.75 kW
- (c) 1.65 kW
- (d) 1.50 kW

12. A flywheel weighs $\frac{9810}{\pi}$ kgf and has a radius of gyration of 100 cm. It is given a spin of 100 r.p.m. about its horizontal axis. The whole assembly is rotating about a vertical axis at 6 rad/s. The gyroscopic couple experienced will be

- (a) 2000 kgf-m
- (b) 1962 kgf-m
- (c) 200 kgf-m
- (d) 196 kgf-m

13. A cold storage has capacity for food preservation at a temperature of -3°C when the outside temperature is 27°C . The minimum power required to operate with a cooling load of 90 kW is

- (a) 20 kW
- (b) 15 kW
- (c) 10 kW
- (d) 5 kW

14. In a vapour absorption refrigerator, the temperatures of evaporator and ambient air are 10°C and 30°C , respectively. For obtaining COP of 2 for this system, the temperature of the generator is to be nearly

- (a) 90°C
- (b) 85°C
- (c) 80°C
- (d) 75°C

15. The following data refer to a vapour compression refrigerator :

- Enthalpy at compressor inlet = 1200 kJ/kg
- Enthalpy at compressor outlet = 1400 kJ/kg
- Enthalpy at condenser outlet = 200 kJ/kg

The COP of the refrigerator is

- (a) 7
- (b) 6
- (c) 5
- (d) 4

16. The compressor of an ammonia refrigerating machine has a volumetric efficiency of 85% and swept volume of $0.28\text{ m}^3/\text{min}$. Ammonia having a dry specific volume of $0.25\text{ m}^3/\text{kg}$ enters the compressor with a dryness fraction of 0.7. The mass flow rate of ammonia through the machine is

- (a) 1.28 kg/min
- (b) 1.36 kg/min
- (c) 1.42 kg/min
- (d) 1.54 kg/min

Handwritten calculations and notes:

- 10: $\frac{210 \times 3}{26} = 24.23$
- 11: $\frac{210 \times 3}{26} = 24.23$
- 12: $r = 1\text{m} \times \frac{20}{60} \times \frac{2\pi \times 100}{60} \times \frac{9810}{\pi} = 3270$
- 13: $\text{COP} = \frac{27 - (-3)}{27} = 1.11$
- 14: $\text{COP} = \frac{30 - 10}{T_g - 30} = 2 \Rightarrow T_g = 85^\circ\text{C}$
- 15: $\text{COP} = \frac{1400 - 200}{1400 - 1200} = 1.6$
- 16: $\dot{m} = \frac{0.28 \times 0.85}{0.25 \times 0.7} = 1.54\text{ kg/min}$

17. Air is drawn in a compressor at the rate of 0.8 kg/s at a pressure of 1 bar and temperature of 20 °C, and is delivered at a pressure of 10 bar and temperature of 90 °C. This air delivery is through an exit valve of area $2 \times 10^{-3} \text{ m}^2$. If R is 287 kJ/kg-K, the exit velocity of the air is

- (a) 41.7 m/s
- (b) 35.8 m/s
- (c) 29.7 m/s
- (d) 27.3 m/s

$$Q = m \cdot c_p \cdot \Delta T$$

18. Consider the following statements :

1. The operation of a refrigerator unit at more than one temperature can be accomplished by using different throttling valves and a separate compressor for each 'temperature range'.
2. The refrigerated space must be maintained above the ice point to prevent freezing.
3. In domestic refrigerators, the refrigerant is throttled to a higher pressure in the freezer followed by full expansion in the refrigerated space.

$$\begin{array}{r} 1.6 \times 85 \\ 1280 \\ \hline 1360 \end{array}$$

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

19. Which one of the following methods is more effective to improve the efficiency of the Rankine cycle used in thermal power plant?

- (a) Increasing the condenser temperature
- (b) Decreasing the condenser temperature
- (c) Decreasing the boiler temperature
- (d) Increasing the boiler temperature

20. Consider the following statements regarding vapour absorption systems in the field of refrigeration :

1. In ammonia-water absorption system, ammonia is the refrigerant.
2. In water-lithium bromide system, water is the refrigerant.
3. Ammonia-water absorption reaction is endothermic.
4. The amount of ammonia absorbed by water is inversely proportional to the temperature of ammonia.

Which of the above statements are correct?

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

21. In an air-handling unit, air enters the cooling coil at a temperature of 30 °C. The surface temperature of the coil is -10 °C. If the bypass factor of the coil is 0.45, then the temperature of the air at the exit will be

- (a) 6 °C
- (b) 8 °C
- (c) 10 °C
- (d) 12 °C

22. Consider the following statements :

1. The relative humidity of air does not change with temperature as long as specific humidity remains constant.
2. Dew-point temperature is the temperature at which condensation begins when air is cooled at constant volume.
3. Saturated air passing over a water surface does not cause change of air temperature.
4. For saturated air, dry-bulb, wet-bulb and dew-point temperatures are identical.

Which of the above statements are correct?

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

23. A cold storage has 23 cm brick wall on the outside and 8 cm plastic foam on the inside. The inside and outside temperatures are -2°C and 22°C , respectively. If the thermal conductivities of brick and foam are 0.98 W/m-K and 0.02 W/m-K , and the inside and outside heat transfer coefficients are $29\text{ W/m}^2\text{-K}$ and $12\text{ W/m}^2\text{-K}$, respectively, then the rate of heat removal for a (projected) wall area of 90 m^2 will nearly be

- (a) 503 W
- (b) 497 W
- (c) 490 W
- (d) 481 W

24. Consider the following statements :

1. The distinguishing features of a radial flow reaction turbine are—
(i) only a part of the total head of water is converted into velocity head before it reaches the runner and
(ii) the flow-through water completely fills all the passages in the runner.
2. Kaplan turbine is essentially a propeller working in reverse, and its blades are so mounted that all the blade angles can be adjusted simultaneously by means of suitable gearing even as the machine is in operation.
3. A draft tube is a pipe of gradually increasing cross-sectional area which must be airtight, and under all conditions of operation, its lower end must be submerged below the level of the discharged water in the tailrace.

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

25. The specific speed of a turbine is the speed of an imaginary turbine, identical with the given turbine, which

- (a) delivers unit discharge under unit speed
- (b) delivers unit discharge under unit head
- (c) develops unit discharge under unit speed
- (d) develops unit power under unit head

26. The mechanical efficiency of a centrifugal pump is the ratio of

- (a) manometric head to the energy supplied by the impeller per kN of water
- (b) energy supplied to the pump to the energy available at the impeller
- (c) actual work done by the pump to the energy supplied to the pump by the prime mover
- (d) energy available at the impeller to the energy supplied to the pump by the prime mover

27. Consider the following advantages of rotary pumps compared to reciprocating pumps :

1. Steady discharge which increases with decrease in head
2. Suitable for handling fluids with suspended solid particles
3. Less bulky than positive displacement pumps
4. Can be started with open delivery with least load

Which of the above advantages are correct?

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

28. According to aerofoil theory, the guide angle of Kaplan turbine blades is defined as the angle between

- (a) lift and resultant force
- (b) drag and resultant force
- (c) lift and tangential force
- (d) lift and drag

Handwritten note: $\frac{200}{300} \approx 0.67$

29. An ideal closed-cycle gas turbine plant is working between the temperatures 927 °C and 27 °C using air as working fluid. The pressure ratio for maximum output is

- (a) 11.3
- (b) 13.3
- (c) 15.3
- (d) 17.3

30. The critical speed of a turbine is

- (a) same as the runaway speed
- (b) the speed that will lead to mechanical failure of the shaft
- (c) the speed which equals the natural frequency of the rotor
- (d) the speed equal to the synchronous speed of the generator

31. Consider the following statements :

1. In spur gears, the contact occurs abruptly on a line parallel to the axis, and the disengagement too is abrupt.
2. In helical gears, both loading and unloading are gradual, and therefore, these happen more smoothly and less noisily.
3. When two gears mesh, any arbitrary shape of the tooth can be chosen for the profile of the teeth of any one of the two gears, and the profile for the other shall be obtained by applying the law of gearing.

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

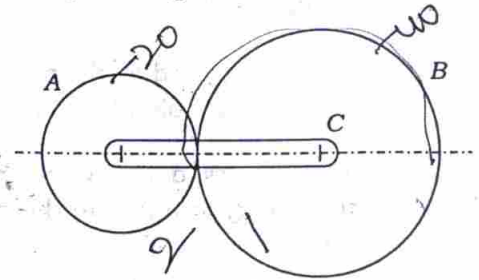
32. The interference between a given pinion tooth and a gear tooth can be avoided by using

1. smaller pressure angle
2. larger pressure angle
3. less number of teeth on the gear for a pinion with predefined number of teeth
4. more number of teeth on the gear for a pinion with predefined number of teeth

Which of the above are correct?

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

33. A gear train is as shown in the figure below, in which gears A and B have 20 and 40 teeth, respectively. If arm C is fixed and gear A rotates at 100 r.p.m., the speed of gear B will be



- (a) 90 r.p.m.
- (b) 75 r.p.m.
- (c) 50 r.p.m.
- (d) 20 r.p.m.

34. A single-cylinder reciprocating engine works with a stroke of 320 mm, mass of reciprocating parts as 45 kg and mass of revolving parts as 35 kg at crank radius. If 60% of the reciprocating parts and all the revolving parts are to be balanced, then the balancing mass required at a 300 mm radius is nearly

- (a) 33.1 kg
- (b) 36.3 kg
- (c) 39.5 kg
- (d) 42.7 kg

35. Consider the following statements :

1. Gyroscopic effects generate forces and couples which act on the vehicles, and these effects must be taken into account while designing their bearings.
2. Rolling motion of a ship usually occurs because of the difference in buoyancy on the two sides of the ship due to a wave.

Which of the above statements is/are correct?

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

36. When two shafts, one of which is hollow, are of the same length and transmit equal torques with equal maximum stress, then they should have equal

- (a) polar moments of inertia
- (b) polar moduli
- (c) diameters
- (d) angles of twist

37. A solid rod of circular cross-section made of brittle material, when subjected to torsion, fails along a plane at 45° to the axis of the rod. Consider the following statements as pertaining thereto :

1. Distortion energy is maximum on this 45° plane.
2. Shear stress is maximum on this 45° plane.
3. Normal stress is maximum on this 45° plane.

Which of the above is/are correct?

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

38. A riveted joint may fail by

1. tearing of the plate at an edge
2. tearing of the plate across a row of rivets
3. shearing of rivets

Which of the above are correct?

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

39. An offset provided in radial cam-translating-follower mechanism serves to

- (a) decrease the pressure angle during ascent of the follower
- (b) increase the pressure angle during ascent of the follower
- (c) avoid possible obstruction due to some machine parts
- (d) decrease the pressure angle during descent of the follower

40. In combined parallel and transverse fillet welded joint

- (a) the parallel portion will fail due to tension, whereas the transverse portion will fail due to shear
- (b) the transverse portion will fail due to tension, whereas the parallel portion will fail due to shear
- (c) both parallel and transverse portions will fail due to tension
- (d) both parallel and transverse portions will fail due to shear

41. In a journal bearing, the diameter of the journal is 0.15 m, its speed is 900 r.p.m. and the load on the bearing is 40 kN. Considering $\mu = 0.0072$, the heat generated will be nearly

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

42. Which one of the following governors is having a larger displacement of sleeve for a given fractional change of speed?

- (a) Stable governor
- (b) Sensitive governor
- (c) Isochronous governor
- (d) Hunting governor

43. Consider the following statements :

1. HSS tools wear very rapidly, whereas in cemented carbide tools, even though hardness is retained, crater wear can occur due to solid-state diffusion.
2. Cutting tools made of Super-HSS, also known as cobalt-based HSS, are made by adding 2% to 15% of cobalt which increases the cutting efficiency at heavier cuts by increasing the hot hardness and wear resistance.
3. Tool failure due to excessive stress can be minimized by providing small or negative rake angles on brittle tool materials, protecting tool tip by providing large side-cutting edge angles, and honing a narrow chamfer along the cutting edge.

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

44. The resilience of steel can be found by integrating stress-strain curve up to the

- (a) ultimate fracture point
- (b) upper yield point
- (c) lower yield point
- (d) elastic point

45. While turning a 60 mm diameter bar, it was observed that the tangential cutting force was 3000 N and the feed force was 1200 N. If the tool rake angle is 32° , then the coefficient of friction is nearly (may take $\sin 32^\circ = 0.53$, $\cos 32^\circ = 0.85$ and $\tan 32^\circ = 0.62$)

- (a) 1.37
- (b) 1.46
- (c) 1.57
- (d) 1.68

46. For spot welding of 1 mm thick sheet with a current flow time of 0.2 s, the heat generated is 1000 J. If the effective resistance is $200 \mu\Omega$, the current required is

- (a) 4000 A
- (b) 5000 A
- (c) 6000 A
- (d) 7000 A

47. The maximum possible draft in rolling, which is the difference between initial and final thicknesses of the sheet metal, depends on

- (a) rolling force
- (b) roll radius
- (c) roll width
- (d) yield shear stress of the material

48. For a strain gauge (gauge factor = 2.1 and resistance = 50Ω), subjected to a maximum strain of 0.001, the maximum change in resistance is

- (a) 0.084Ω
- (b) 0.105Ω
- (c) 0.135Ω
- (d) 0.156Ω

$$\frac{0.05}{0.001 \times 50} = 2.1$$

$$\frac{2.1 \times 0.001 \times 50}{0.001} = 50$$

49. Consider the following statements :

Dispatching authorizes the start of production operation by

1. releasing of material and components from stores to the first process
2. releasing of material from process to process
3. issuing of drawing and instruction sheets

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

50. Which one of the following forecasting models best predicts the turning point?

- (a) Simple exponential smoothing model
(b) Brown's quadratic smoothing model
(c) Double exponential smoothing model
(d) Moving average model (using 5 data points)

51. The material removal rate will be higher in ultrasonic machining process for materials with

- (a) higher ductility
(b) higher fracture strain
(c) higher toughness
(d) lower toughness

52. In queuing theory with multiple servers, the nature of the waiting situation can be studied and analyzed mathematically, if

- (a) the complete details of the items in the waiting lines are known
(b) the arrival and waiting times are known and can be grouped to form an appropriate waiting line model
(c) all the variables and constants are known and they may form a linear equation
(d) the laws governing arrivals, service times and the order in which the arriving units are taken into service are all known

53. In any crash program for a project

- (a) both direct and indirect costs increase
(b) indirect costs increase and direct costs decrease
(c) direct costs increase and indirect costs decrease
(d) costs are of no criterion

54. Tool signature is

- (a) a numerical method of identification of the tool
- (b) the plan of the tool
- (c) the complete specification of the tool
- (d) associated with the tool manufacturer

55. With reference to a microprocessor, RISC stands for

- (a) Redefined Instruction Set Computer
- (b) Reduced Instruction Set Computer
- (c) Restructured Instruction Set Computer
- (d) Regional Instruction Set Computer

56. An OR logic control in pneumatic systems is possible with the help of

- (a) sequence valve
- (b) shuttle valve
- (c) dual pressure valve
- (d) delay valve

57. Which one of the following is **not** an Addressing Mode in 8085?

- (a) Immediate
- (b) Indirect
- (c) Register
- (d) Segment

58. Consider the following statements regarding Programming Logic Controller (PLC) :

1. It was developed to replace the microprocessor.
2. Wiring between devices and relay contacts are done in its program.
3. Its I/O interface section connects it to external field devices.
4. It requires extensive wiring in the application.

Which of the above statements are correct?

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

59. If B is the magnetic flux density at right angles to a plate, I is the current flow through the plate, t is the plate thickness and K_H is Hall coefficient, the resultant transverse potential difference V for Hall sensor is given by

- (a) $K_H \frac{Bt}{I}$
- (b) $K_H \frac{t}{BI}$
- (c) $K_H \frac{BI}{t}$
- (d) $K_H \frac{I}{Bt}$

60. The specific speed of a hydraulic turbine depends on

- (a) speed and power developed
- (b) speed and water head
- (c) discharge and power developed
- (d) speed, head and power developed

61. The degrees of freedom of a SCARA robot are

- (a) six (b) five
(c) four (d) three

62. Which one of the following devices produces incremental motion through equal pulses?

- (a) AC servomotor
(b) DC servomotor
(c) Stepper motor
(d) Series motor

63. A force of 400 N is required to open a process control valve. What is the area of diaphragm needed for a diaphragm actuator to open the valve with a control gauge pressure of 70 kPa?

- (a) 0.0095 m²
(b) 0.0086 m²
(c) 0.0057 m²
(d) 0.0048 m²

$$\frac{F}{A} = \frac{400}{7000} = A$$

$$A = \frac{400}{7000} = 0.057$$

$$7000 \text{ N/m}^2 = 0.5$$

$$\frac{0.57}{100} \times 95 = 0.0057$$

64. A force of 10 kN is required to move a workpiece. What is the needed working pressure, if the piston diameter is 100 mm?

- (a) 1.55 MPa
(b) 1.46 MPa
(c) 1.27 MPa
(d) 1.12 MPa

$$P = \frac{F}{A} = \frac{10000 \text{ N}}{\frac{\pi}{4} \times 100^2}$$

$$P = \frac{10000}{7850} = 1.27 \text{ MPa}$$

65. If a workpiece is moved by 50 mm in 10 s by a piston of diameter 100 mm, the hydraulic liquid flow rate is nearly

- (a) 3.00 × 10⁻⁵ m³/s
(b) 3.93 × 10⁻⁵ m³/s
(c) 4.74 × 10⁻⁵ m³/s
(d) 5.00 × 10⁻⁵ m³/s

$$Q = \frac{L \cdot A}{t} = \frac{50 \times \frac{\pi}{4} \times 100^2}{10}$$

$$Q = \frac{50 \times 7850}{10} = 39250 \text{ mm}^3/\text{s}$$

$$Q = 3.93 \times 10^{-5} \text{ m}^3/\text{s}$$

66. Which of the following are the basic building block elements for a mechanical system where forces and straight line displacements are involved without any rotation?

- Spring
- Dashpot
- Mass
- Moment of inertia

Select the correct answer using the code given below.

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

67. Consider the following statements regarding electromechanical devices :

- A potentiometer has an input of rotation and an output of a potential difference.
- An electric motor has an input of a potential difference and an output of rotation of a shaft.
- A generator has an input of rotation of a shaft and an output of a potential difference.

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

68. The indirect operation of solenoid valve in pneumatic circuit is designed to reduce

1. valve size towards lowering the cost
2. coil size and electrical power consumption
3. response time

Which of the above is/are relevant to the context?

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

69. Consider the following statements :

1. Robots take permissible actions only.
2. All actions that are obligatory for robots are actually performed by them subject to ties and conflicts among available actions.
3. All permissible actions can be proved by the robot to be permissible and it can be explained in ordinary English.

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

70. Consider the following statements relating to the term 'Robot Repeatability' :

1. It is a statistical term associated with accuracy in the action.
2. It is a measure of the ability of the robot to position the tool tip in the same place repeatedly.
3. It does not describe the error with respect to absolute coordinates.

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

71. Consider the following statements regarding homogeneous coordinate transformation matrix :

1. A homogeneous transformation matrix can be considered to consist of four sub-matrices.
2. The upper left 3×3 sub-matrix represents the position vector.
3. The upper right 3×1 sub-matrix represents the rotation matrix.
4. The lower left 1×3 sub-matrix represents perspective transformation.

Which of the above statements are correct?

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

Directions :

Each of the next **nineteen (19)** items consists of two statements, one labeled as Statement I and the other as Statement II. Examine these two statements carefully and select the correct answers to these items using the code given below.

Code :

- (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

72. Statement I :

A differential inverted U-tube manometer determines the difference in pressures between two points in a flow section to which it is connected.

Statement II :

The sensitivity of an inclined gauge depends on the angle of inclination.

73. Statement I :

In four-bar chain, whenever all four links are used, with each of them forming a turning pair, there will be continuous relative motion between the two links of different lengths.

Statement II :

For a four-bar mechanism, the sum of the shortest and longest link lengths is not greater than the sum of remaining two links.

74. Statement I :

When flow is unsteady, both normal and tangential components of acceleration will occur.

Statement II :

During unsteady flow, in addition to the change of velocity along the path, the velocity will also change with time.

75. Statement I :

There exists a positive pressure difference between the inlet and throat of a venturi meter.

Statement II :

The coefficient of discharge of a venturi meter accounts for the non-uniformity of flow at both inlet and throat.

76. Statement I :

The phase of a substance is characterized by its distinct molecular arrangement which is homogeneous throughout and is separated from the others by easily identifiable boundary surfaces.

Statement II :

Phase change is not characterized on molecular structure and/or behaviour of the different phases.

77. Statement I :

Non-viscous flow between two plates held parallel with a very small spacing between them is an example of irrotational flow.

Statement II :

Forced vortex implies irrotational flow.

78. Statement I :

The air-fuel ratio employed in a gas turbine is around 60 : 1.

Statement II :

A lean mixture of 60 : 1 in a gas turbine is mainly used for complete combustion.

79. Statement I :

The condenser in a steam power plant is always filled with a mixture of water, steam and air.

Statement II :

Slightly wet steam enters the condenser wherein the pressure is below the atmospheric conditions, causing some leakage of air through the glands and also the release of some air dissolved in the boiler feedwater.

80. Statement I :

In a pipeline, the nature of the fluid flow depends entirely on the velocity.

Statement II :

Reynolds number of the flow depends on the velocity, the diameter of the pipe and the kinematic viscosity of the fluid.

81. Statement I :

The air-standard efficiency of Brayton cycle depends only on the pressure ratio.

Statement II :

For the same compression ratio, the air-standard efficiency of Brayton cycle is equal to that of Otto cycle.

82. Statement I :

The energy of an isolated system is constant.

Statement II :

The entropy of an isolated system can increase but cannot decrease.

83. Statement I :

Rankine efficiency of a steam power plant increases in winter compared to summer.

Statement II :

The increase in Rankine efficiency is due to lower condenser temperature.

84. Statement I :

Direct condensers are more efficient than surface condensers.

Statement II :

In condenser, the momentum pressure drop opposes the frictional pressure drop.

85. Statement I :

Reheating between the high-pressure and low-pressure turbines increases the turbine work output.

Statement II :

The constant pressure lines on T-s diagram diverge away from the origin.

86. Statement I :

If a boat, built with sheet metal on wooden frame, has an average density which is greater than that of water, then the boat can float in water with its hollow face upward but will sink once it overturns.

Statement II :

Buoyant force always acts in the upward direction.

87. Statement I :

In air-blast injection, a separate compressor is used to create an air blast at a pressure of 6 MPa.

Statement II :

The solid injection system is heavier as it needs increasing the fuel pressure to 30 MPa.

88. Statement I :

In air-conditioning, the atmospheric air (mixture of dry air and water vapour) can be considered as mixture of two ideal gases.

Statement II :

In the temperature range used in air-conditioning, the partial pressure of the water vapour is very low and it follows the ideal gas relation with negligible error.

89. Statement I :

A dynamically balanced system of multiple rotors on a shaft can rotate smoothly at the critical speeds of the system.

Statement II :

Dynamic balancing eliminates all the unbalanced forces and couples from the system.

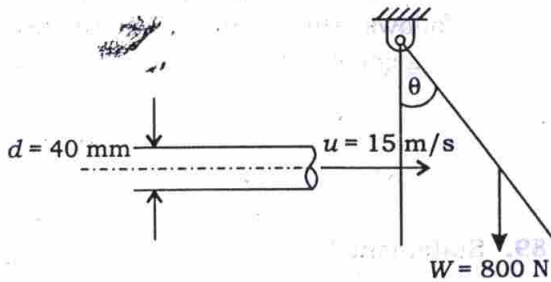
90. Statement I :

Referring to vapour compression refrigeration system, the coefficient of performance (COP) of a domestic refrigerator is less than that of a comfort air-conditioning plant.

Statement II :

In domestic refrigerator, the work required for pumping the same amount of heat is more than that in an air-conditioning plant because of greater difference between condenser and evaporator temperatures.

91. A 40 mm diameter water jet strikes a hinged vertical plate of 800 N weight normally at its surface at its centre of gravity as shown in the figure below :



The angle of deflection is nearly

- (a) $\sin^{-1} 0.353$
 (b) $\sin^{-1} 0.321$
 (c) $\tan^{-1} 0.353$
 (d) $\tan^{-1} 0.321$
92. Consider the following statements regarding a Ram Jet :
1. The engine has neither a compressor nor a turbine.
 2. It operates at much higher temperature than a gas turbine.
 3. It cannot operate statically. It needs to be put in flight by some means at sufficiently high speed before it produces any thrust and propels itself.

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. Air enters a turbojet engine at the rate of 40 kg/s with a velocity of 250 m/s relative to an aircraft which is moving at 300 km/hr. Exhaust of the engine has a velocity of 700 m/s relative to the moving aircraft. The thrust developed by the engine is

- (a) 24 kN
 (b) 18 kN
 (c) 12 kN
 (d) 9 kN

94. The clearance volume in reciprocating air compressor is provided

- (a) to reduce the work done per kg of air delivered
 (b) to increase the volumetric efficiency of the compressor
 (c) to accommodate the valves in the head of the compressor
 (d) to create turbulence in the air to be delivered

95. Consider the following statements regarding Reheat Rankine Steam Cycle :

1. The main purpose of reheat in Rankine cycle is to increase the efficiency of the cycle.
2. In practice, the reheat is generally limited to one point of expansion.
3. Due to reheat, the steam rate (specific steam consumption) is reduced.

Which of the above statements are correct?

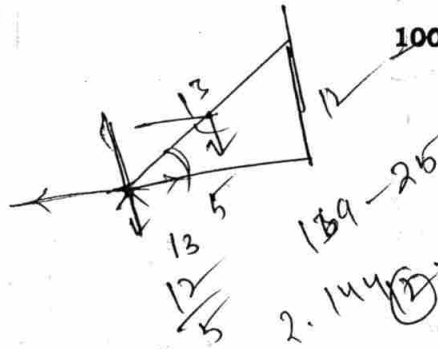
- (a) 1 and 2 only
 (b) 2 and 3 only
 (c) 1 and 3 only
 (d) 1, 2 and 3

96. In solar flat-plate collectors, the absorber plate is painted with selective paints. The selectivity is the ratio of

- (a) solar radiation-absorption to thermal infrared radiation-emission
- (b) solar radiation-emission to thermal infrared radiation-absorption
- (c) solar radiation-reflection to thermal infrared radiation-absorption
- (d) solar radiation-absorption to thermal infrared radiation-reflection

97. A 13 m long ladder is placed against a smooth vertical wall with its lower end 5 m from the wall. What should be the coefficient of friction between the ladder and the floor so that the ladder remains in equilibrium?

- (a) 0.29
- (b) 0.25
- (c) 0.21
- (d) 0.11

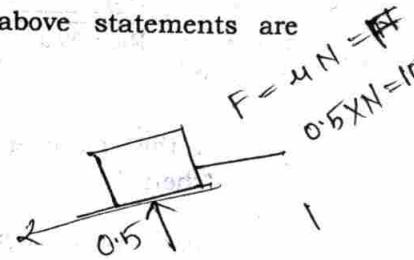


99. Consider the following statements regarding solid solution of metals :

1. The solubility of metallic solids is primarily limited by size factor.
2. A metal with high valence can dissolve large amount of metal of lower valence.
3. A metal with same lattice crystal structure can form a series of solid solutions.
4. The limit of solid solubility is indicated by a phase boundary called Liquidus.

Which of the above statements are correct?

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



100. A box of weight 1000 N is placed on the ground. The coefficient of friction between the box and the ground is 0.5. When the box is pulled by a 100 N horizontal force, the frictional force developed between the box and the ground at impending motion is

- (a) 50 N
- (b) 75 N
- (c) 100 N
- (d) 500 N

98. A cube strikes a stationary ball exerting an average force of 50 N over a time of 10 ms. The ball has mass of 0.20 kg. Its speed after the impact will be

- (a) 3.5 m/s
- (b) 2.5 m/s
- (c) 1.5 m/s
- (d) 0.5 m/s

$$\frac{50}{0.20} \times 10^{-3}$$

$$\frac{500}{2} \times 10^{-2}$$

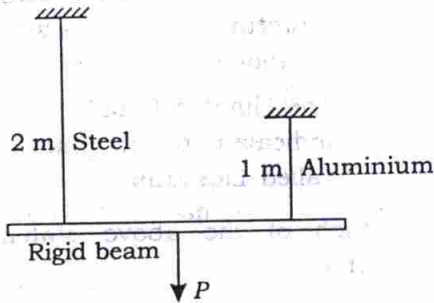
$$\frac{2500}{100}$$

101. A state of plane stress consists of a uniaxial tensile stress of magnitude 8 kPa, exerted on vertical surfaces and of unknown shearing stresses. If the largest stress is 10 kPa, then the magnitude of the unknown shear stress will be

- (a) 6.47 kPa
- (b) 5.47 kPa
- (c) 4.47 kPa
- (d) 3.47 kPa



102. A rigid beam of negligible weight is supported in a horizontal position by two rods of steel and aluminium, 2 m and 1 m long, having values of cross-sectional areas 100 mm^2 and 200 mm^2 , and Young's modulus of 200 GPa and 100 GPa, respectively. A load P is applied as shown in the figure below :



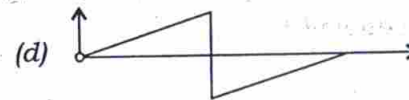
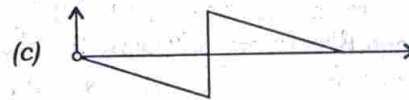
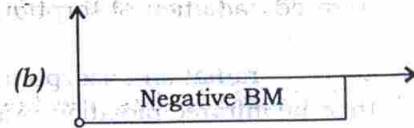
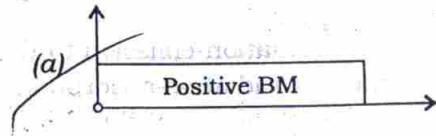
If the rigid beam is to remain horizontal, then

- (a) the force P must be applied at the centre of the beam
- (b) the force on the steel rod should be twice the force on the aluminium rod
- (c) the force on the aluminium rod should be twice the force on the steel rod
- (d) the forces on both the rods should be equal

103. A solid shaft is subjected to bending moment of 3.46 kN-m and a torsional moment of 11.5 kN-m. For this case, the equivalent bending moment and twisting moment are

- (a) 7.73 kN-m and 12.0 kN-m
- (b) 14.96 kN-m and 12.0 kN-m
- (c) 7.73 kN-m and 8.04 kN-m
- (d) 14.96 kN-m and 8.04 kN-m

104. Which one of the following is the correct bending moment diagram for a beam which is hinged at the ends and is subjected to a clockwise couple acting at the mid-span?



105. A steel specimen is heated to 780°C and is then cooled at the slowest possible rate in the furnace. The property imparted to the specimen by this process is

- (a) toughness
- (b) hardness
- (c) softness
- (d) tempering

$$\sqrt{M^2 + T^2}$$

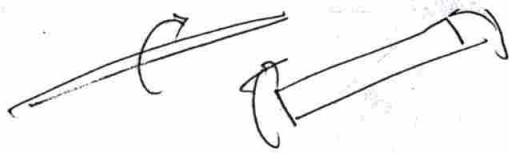
$$= \sqrt{3.46^2 + 11.5^2}$$

$$P \cdot 2 = \frac{P \cdot L}{A \cdot E}$$

$$A = 100$$

$$P = \frac{P \cdot L}{A \cdot E}$$

114
 124
 132



106. Consider the following statements :

1. In case of a thin spherical shell of diameter d and thickness t , subjected to internal pressure p , the principal stresses at any point equal $\frac{pd}{4t}$.
2. In case of thin cylinders, the hoop stress is determined assuming it to be uniform across the thickness of the cylinder.
3. In thick cylinders, the hoop stress is not uniform across the thickness but it varies from a maximum value at the inner circumference to a minimum value at the outer circumference.

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

107. Addition of magnesium to cast iron increases its

- (a) hardness
- (b) corrosion resistance
- (c) creep strength
- (d) ductility and strength in tension

108. Consider the following statements :

1. The quenching of steel results in an increase in wear resistance, strength and hardness.
2. By the process of case-hardening, hard wearing resistant surface is produced on mild steel. This is an effective method for low-carbon steels because they cannot be hardened by the process of quenching.
3. When a metal is mixed with small atoms of non-metallic element in such a manner that invading atoms occupy interstitial positions in the metal lattice, an interstitial alloy results.

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

109. Recrystallization temperature is one at which

- (a) crystals first start forming from molten metal when cooled
- (b) new spherical crystals first begin to form from the old deformed ones when that strained metal is heated
- (c) the allotropic form changes
- (d) crystals grow bigger in size

110. Fe-C alloy containing less than 0.83% carbon is called

- (a) high-speed steel
- (b) hypo-eutectoid steel
- (c) hyper-eutectoid steel
- (d) cast iron

111. Which of the following statements are correct?

1. Steel and cast iron are multi-phase alloys.
2. Ferrite is a single-phase interstitial solid solution of carbon in iron.
3. Wrought iron is a highly refined iron with a small amount of slag which gives resistance to progressive corrosion.
4. Stellite contains large amounts of metals like cobalt and tungsten resulting in high hardness.

Select the correct answer using the code given below.

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

112. Which one of the following statements is correct?

- (a) Microprocessor is more suitable for general purpose and microcontroller is more suitable for special purpose and custom-built application.
- (b) Microprocessor and microcontroller are suitable for general purpose application.
- (c) Microprocessor and microcontroller are suitable for special purpose application.
- (d) Microprocessor and microcontroller are suitable for special purpose and custom-built application.

113. The unique property of cast iron is its high

- (a) malleability
(b) ductility
(c) toughness
(d) damping characteristics

114. Which one of the following pairs of tests has been developed to evaluate the fracture resistance of engineering materials, subjected to dynamic loads or impacts?

- (a) Tension impacts and Bending impacts
(b) Tensile test and Brinell hardness test
(c) Vickers hardness test and Tensile test
(d) Scleroscope test and File test

115. The midpoint of a rigid link of a mechanism moves as a translation along a straight line, from rest, with a constant acceleration of 5 m/s^2 . The distance covered by the said midpoint in 5 s of motion is

- (a) 124.2 m
(b) 112.5 m
(c) 96.2 m
(d) 62.5 m

Handwritten calculations:
 25×5
 125
 9.81×5
 49.05

116. Consider the following statements :

1. A kinematic chain is the combination of kinematic pairs joined in such a way that the relative motion between them is completely constrained.
2. The degree of freedom of a kinematic pair is given by the number of independent coordinates required to completely specify the relative movement.

Which of the above statements is/are correct?

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

117. The equation of motion for a single degree of freedom system is

$$4\ddot{x} + 9\dot{x} + 16x = 0$$

The critical damping coefficient for the system is

- (a) $4\sqrt{2}$
- (b) 4
- (c) $16\sqrt{2}$
- (d) 16

118. The mass of a single-degree damped vibrating system is 7.5 kg and it makes 24 free oscillations in 14 s when disturbed from its equilibrium position. The amplitude of vibration reduces to 0.25 of its initial value after five oscillations. Then the logarithmic decrement will be

- (a) $\frac{2}{5} \log_e 4$
- (b) $\frac{1}{5} \log_e 6$
- (c) $\frac{1}{5} \log_e 4$
- (d) $\frac{2}{5} \log_e 6$

119. A 20 kg mass is suspended from a spring which deflects 15 mm under this load. The value of the critical damping coefficient to make the motion aperiodic will be

- (a) 1010 N/m/s
- (b) 1013 N/m/s
- (c) 1018 N/m/s
- (d) 1023 N/m/s

120. Consider the following statements :

1. The whirling (critical) speed of a shaft is that rotational speed at which the shaft so runs that the deflection of the shaft from the axis of rotation tends to become infinite.
2. Critical speed is equal to the frequency of transverse vibration of a shaft when the shaft carries a point load or a uniformly distributed load or a combination of both such loads.
3. The whirling of a shaft results from causes such as mass unbalance, hysteresis damping in the shaft, gyroscopic forces and fluid friction in the bearing.

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

121. A 150 mm diameter shaft rotates at 1500 r.p.m. within a 200 mm long journal bearing with 150.5 mm internal diameter. The uniform annular space between the shaft and the bearing is filled with oil of dynamic viscosity 0.8 poise. The shear stress on the shaft will be

- (a) 1.77 kN/m²
- (b) 2.77 kN/m²
- (c) 3.77 kN/m²
- (d) 4.77 kN/m²

122. Which one of the following substances has constant specific heat at all pressures and temperatures?

- (a) Mono-atomic gas
- (b) Di-atomic gas
- (c) Tri-atomic gas
- (d) Poly-atomic gas

123. The shear stress τ_0 for steady, fully developed flow inside a uniform horizontal pipe with coefficient of friction f , density ρ and velocity v , is given by

- (a) $\frac{f \rho v^2}{2}$
- (b) $\frac{f \rho^2 v}{2}$
- (c) $\frac{\rho^2 v}{2f}$
- (d) $\frac{\rho v^2}{2f}$

124. The total energy of each particle at various places in the case of a perfect incompressible fluid flowing in a continuous stream

- (a) keeps on increasing
- (b) keeps on decreasing
- (c) remains constant
- (d) may increase or decrease

125. The normal stresses within an isotropic Newtonian fluid are related to

- 1. pressure
- 2. viscosity of fluid
- 3. velocity gradient

Which of the above are correct?

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

126. Which one of the following regimes of boiling curve can be considered as reverse of condensation?

- (a) Free convection boiling regime
- (b) Nucleate boiling regime
- (c) Transition boiling regime
- (d) Film boiling regime

127. The service pump in a water supply system has to maintain a net static head lift of 5 m at the tank to which it delivers freely through a 4 km long pipe, wherein all minor losses can be neglected. The diameter of the pipe is 0.2 m and its friction factor $f = 0.01$. The pumped water is discharged at 2 m/s. The absolute pressure differential developed by the pump is nearly (taking atmospheric pressure as 10.3 m of water)

- (a) 4.5 bar
- (b) 5.5 bar
- (c) 45 bar
- (d) 55 bar

128. A wall surface of 200 mm thickness has an outside temperature of 50 °C and inside temperature of 25 °C with thermal conductivity of 0.51 W/m-K. The heat transfer through this wall will be

- (a) 63.75 W/m²
- (b) 65.75 W/m²
- (c) 70.25 W/m²
- (d) 73.25 W/m²

129. The necessary and sufficient condition for bodies in flotation to be in stable equilibrium is that the centre of gravity is located below the

- (a) metacentre
- (b) centre of buoyancy
- (c) epicentre
- (d) centroid

130. When the valve of an evacuated bottle is opened, the atmospheric air rushes into it. If the atmospheric pressure is 101.325 kPa and 0.6 m³ of air enters into the bottle, then the work done by the air will be

- (a) 80.8 kJ
- (b) 70.8 kJ
- (c) 60.8 kJ
- (d) 50.8 kJ

131. A thermodynamic cycle is composed of four processes. The heat added and the work done in each process are as follows :

Process	Heat transfer (J)	Work done (J)
1-2	0	50 (by the gas)
2-3	50 (from the gas)	0
3-4	0	20 (on the gas)
4-1	80 (to the gas)	0

The thermal efficiency of the cycle is

- (a) 20.3%
- (b) 37.5%
- (c) 40.3%
- (d) 62.5%

132. A steel tank placed in hot environment contains 5 kg of air at 4 atm at 30 °C. A portion of the air is released till the pressure becomes 2 atm. Later, the temperature of the air in the tank is found to be 150 °C. The quantity of air allowed to escape is

- (a) 4.72 kg
- (b) 4.12 kg
- (c) 3.71 kg
- (d) 3.21 kg

133. Consider the following statements :

1. Entropy is related to the first law of thermodynamics.
2. The internal energy of an ideal gas is a function of temperature and pressure.
3. The zeroth law of thermodynamics is the basis for measurement of temperature.

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

134. A heat reservoir is maintained at 927 °C. If the ambient temperature is 27 °C, the availability of heat from the reservoir is limited to

- (a) 57% (b) 66%
(c) 75% (d) 88%

135. The ordinate and abscissa of the diagram to depict the isobaric processes of an ideal gas as a hyperbola are, respectively

- (a) temperature and entropy
(b) internal energy and volume
(c) temperature and density
(d) enthalpy and entropy

136. Consider the following statements :

- The entropy of a pure crystalline substance at absolute zero temperature is zero.
- The efficiency of a reversible heat engine is independent of the nature of the working substance and depends only on the temperature of the reservoirs between which it operates.
- Carnot's theorem states that of all heat engines operating between a given constant temperature source and a given constant temperature sink, none has a higher efficiency than a reversible engine.

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

137. An engine works on the basis of Carnot cycle operating between temperatures of 800 K and 400 K. If the heat supplied is 100 kW, the output is

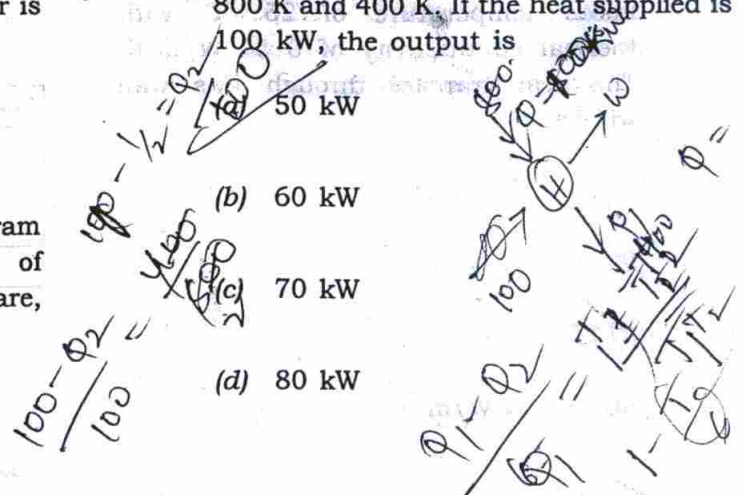
- (a) 50 kW
(b) 60 kW
(c) 70 kW
(d) 80 kW

138. The coefficient of performance of a heat pump working on reversed Carnot cycle is 6. If this machine works as a refrigerator with work input of 10 kW, the refrigerating effect will be

- (a) 35 kW
(b) 40 kW
(c) 45 kW
(d) 50 kW

139. Which of the following devices complies with the Clausius statement of the second law of thermodynamics?

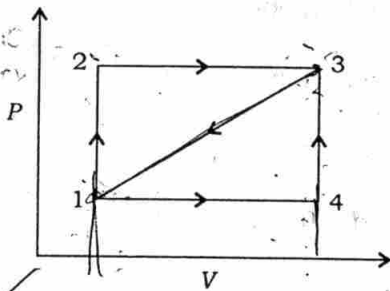
- (a) Closed-cycle gas turbine
(b) Internal combustion engine
(c) Steam power plant
(d) Domestic refrigerator



140. A reversible Carnot engine operates between 27°C and 1527°C , and produces 400 kW of net power. The change of entropy of the working fluid during the heat addition process is

- (a) ~~0.222~~ kW/K
- (b) 0.266 kW/K
- (c) 0.288 kW/K
- (d) 0.299 kW/K

141. A system absorbs 100 kJ as heat and does 60 kJ work along the path 1-2-3. The same system does 20 kJ work along the path 1-4-3. The heat absorbed during the path 1-4-3 is



- (a) -140 kJ
- (b) -80 kJ
- (c) 80 kJ
- (d) 60 kJ

Handwritten calculations:
 $0.5 T_2 = T_2 - T_3$
 $T_3 = 0.5 T_2$
 $= 0.2 T_1$

143. Consider the following statements for the air-standard efficiency of Diesel cycle :

1. For the same compression ratio, the efficiency decreases with increasing cutoff ratios.
2. For the same compression ratio and same heat input, Diesel cycle is more efficient than Otto cycle.
3. For constant maximum pressure and constant heat input, Diesel cycle is more efficient than Otto cycle.

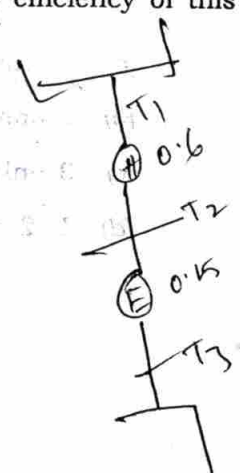
Which of the above statements are correct?

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

Handwritten notes:
 $T_3 = 0.4 T_1$
 $0.2 T_1$

142. Two reversible engines are connected in series between a heat source and a sink. The efficiencies of these engines are 60% and 50%, respectively. If these two engines are replaced by a single reversible engine, the efficiency of this engine will be

- (a) 60%
- (b) 70%
- (c) 80%
- (d) 90%



Handwritten calculation:
 $\frac{T_1 - T_2}{T_1} = 0.6$

Handwritten calculation:
 $\frac{T_2 - T_3}{T_2} = 0.5$

- (a) circumferential strain plus longitudinal strain
- (b) circumferential strain plus twice the longitudinal strain
- (c) twice the circumferential strain plus longitudinal strain
- (d) twice the circumferential strain plus twice the longitudinal strain

Handwritten calculation:
 $\frac{T_1 - T_3}{T_1} = \frac{0.8 T_1}{T_1}$

145. The refractory lining of a furnace has a thickness of 200 mm. The average thermal conductivity of the refractory material is 0.04 W/m-K. The heat loss is estimated to be 180 kJ/hr/m². The temperature difference across the lining will be

- (a) 280 °C
- (b) 250 °C
- (c) 240 °C
- (d) 220 °C

146. In forced convection, the surface heat transfer coefficient from a heated flat plate is a function of

- (a) Re and Gr
- (b) Pr and Gr
- (c) Re and Pr
- (d) Re, Gr and Pr

where Re is Reynolds number, Pr is Prandtl number and Gr is Grashof number.

147. It is desired to increase the heat dissipation rate from the surface of an electronic device of spherical shape of 5 mm radius exposed to convection with $h = 10 \text{ W/m}^2\text{-K}$ by encasing it in a spherical sheath of conductivity 0.04 W/m-K. For maximum heat flow, the critical diameter of the sheath shall be

- (a) 20 mm
- (b) 18 mm
- (c) 16 mm
- (d) 12 mm

148. If the intake air temperature of an IC engine increases, its efficiency will

- (a) remain same
- (b) decrease
- (c) increase
- (d) remain unpredictable

149. In a counterflow heat exchanger, hot gases enter the system at 200 °C and leave at 80 °C. The temperature of the outside air entering the unit is 35 °C. Its temperature at the exit is 90 °C. The heat exchanger has an effectiveness of

- (a) 0.35
- (b) 0.34
- (c) 0.33
- (d) 0.32

$$\frac{3 \cdot 45}{120}$$

150. If one cylinder of a diesel engine receives more fuel than the others, it is a serious condition for that cylinder and can be checked by

1. judging the seizure of the piston
2. checking incomplete combustion in that cylinder
3. checking cylinder exhaust temperature with a pyrometer

Which of the above is/are correct?

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