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T.B.C. : VBY-S-MCH

Test Booklet Series

Serial No.

0077957

TEST BOOKLET

**A**

**MECHANICAL ENGINEERING**

Time Allowed : Three Hours

Maximum Marks : 300

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INSTRUCTIONS

1. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS TEST BOOKLET *DOES NOT* HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS, ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET.
2. Please note that it is the candidate's responsibility to encode and fill in the Roll Number and Test Booklet Series 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. 

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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 a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that question.
  - (iii) If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

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1. Water is discharged from a tank maintained at a constant head of 5 m above the exit of a straight pipe 100 m long and 15 cm in diameter. If the friction coefficient for the pipe is 0.01, the rate of flow will be nearly
- (a)  $0.04 \text{ m}^3 / \text{s}$   
 (b)  $0.05 \text{ m}^3 / \text{s}$   
 (c)  $0.06 \text{ m}^3 / \text{s}$   
 (d)  $0.07 \text{ m}^3 / \text{s}$
2. A plate weighing 150 N and measuring  $0.8 \text{ m} \times 0.8 \text{ m}$  just slides down an inclined plane over an oil film of 1.2 mm thickness for an inclination of  $30^\circ$  and velocity of 0.2 m/s. Then the viscosity of the oil used is
- (a)  $0.3 \text{ N s/m}^2$   
 (b)  $0.4 \text{ N s/m}^2$   
 (c)  $0.5 \text{ N s/m}^2$   
 (d)  $0.7 \text{ N s/m}^2$
3. A spherical balloon of 1.5 m diameter is completely immersed in water and chained to the bottom. If the chain has a tension of 10 kN, the weight of the balloon will be nearly
- (a) 9.11 kN  
 (b) 8.22 kN  
 (c) 6.44 kN  
 (d) 7.33 kN
4. A nozzle at the end of an 80 mm hosepipe produces a jet 40 mm in diameter. When it is discharging the water 1200 Lpm, the force on the joint at the base of the nozzle will be
- (a) 180 N  
 (b) 200 N  
 (c) 220 N  
 (d) 240 N
5. A vertical water pipe, 1.5 m long, tapers from 75 mm diameter at the bottom to 150 mm diameter at the top and the rate of flow is 50 L/s upwards. If the pressure at the bottom end is  $150 \text{ kN/m}^2$ , the pressure at the top will be nearly
- (a)  $195.2 \text{ kN/m}^2$   
 (b)  $191.4 \text{ kN/m}^2$   
 (c)  $187.6 \text{ kN/m}^2$   
 (d)  $183.8 \text{ kN/m}^2$
6. The stream function for a flow field is  $\psi = 3x^2y + (2+t)y^2$ . The velocity at a point P for position vector  $r = i + 2j - 3k$  at time  $t = 2$  will be
- (a)  $19i - 12j$   
 (b)  $21i - 12j$   
 (c)  $19i + 22j$   
 (d)  $21i + 22j$

7. In a laminar flow through pipe, the point of maximum instability exists at a distance of  $y$  from the wall which is

- (a)  $\frac{3}{2}$  of pipe radius  $R$
- (b)  $\frac{2}{3}$  of pipe radius  $R$
- (c)  $\frac{1}{2}$  of pipe radius  $R$
- (d)  $\frac{1}{3}$  of pipe radius  $R$

8.  $Q = \frac{\partial u'}{\partial x} = -\frac{\partial v'}{\partial y}$  for a turbulent flow signifies

- (a) conservation of bulk momentum transport
- (b) increase in  $u'$  in  $x$ -direction followed by increase in  $v'$  in negative  $y$ -direction
- (c) turbulence is anisotropic
- (d) turbulence is isotropic

9. A flow field satisfying  $\nabla \cdot \vec{V} = 0$  as the continuity equation represents always

- (a) a steady compressible flow
- (b) an incompressible flow
- (c) an unsteady and incompressible flow
- (d) an unsteady and compressible flow

10. An oil of viscosity 8 poise flows between two parallel fixed plates, which are kept at a distance of 30 mm apart. If the drop of pressure for a length of 1 m is  $0.3 \times 10^4 \text{ N/m}^2$  and width of the plates is 500 mm, the rate of oil flow between the plates will be

- (a)  $4.2 \times 10^{-3} \text{ m}^3/\text{s}$
- (b)  $5.4 \times 10^{-3} \text{ m}^3/\text{s}$
- (c)  $6.6 \times 10^{-3} \text{ m}^3/\text{s}$
- (d)  $7.8 \times 10^{-3} \text{ m}^3/\text{s}$

11. In case of transmission of hydraulic power by a pipeline to a turbine in a hydroelectric power station, the maximum power transmission efficiency through the pipeline is

- (a) 76%
- (b) 67%
- (c) 54%
- (d) 42%

12. A pipe, having a length 200 m and 200 mm diameter with friction factor 0.015, is to be replaced by a 400 mm diameter pipe of friction factor 0.012 to convey the same quantity of flow. The equivalent length of the new pipe for the same head loss will be

- (a) 8300 m
- (b) 8240 m
- (c) 8110 m
- (d) 8000 m

13. Certain quantities cannot be located on the graph by a point but are given by the area under the curve corresponding to the process. These quantities in concepts of thermodynamics are called as

- (a) cyclic functions
- (b) point functions
- (c) path functions
- (d) real functions

14. When 25 kg of water at 95 °C is mixed with 35 kg of water at 35 °C, the pressure being taken as constant at surrounding temperature of 15 °C, and  $C_p$  of water is 4.2 kJ/kg K, the decrease in available energy due to mixing will be nearly

- (a) 270.5 kJ
- (b) 277.6 kJ
- (c) 281.8 kJ
- (d) 288.7 kJ

15. A frictionless piston cylinder device contains 5 kg of steam at 400 kPa and 200 °C. The heat is now transferred to the steam until the temperature reaches 250 °C. If the piston is not attached to a shaft, its mass is constant, and by taking the values of specific volume  $v_1$  as 0.53434 m<sup>3</sup>/kg and  $v_2$  as 0.59520 m<sup>3</sup>/kg, the work done by the steam during this process is

- (a) 121.7 kJ
- (b) 137.5 kJ
- (c) 153.3 kJ
- (d) 189.1 kJ

16. A diesel engine has a compression ratio of 14 and cutoff takes place at 6% of the stroke. The air standard efficiency will be

- (a) 74.5%
- (b) 60.5%
- (c) 52.5%
- (d) 44.5%

17. A gas mixture consists of 3 kg of O<sub>2</sub>, 5 kg of N<sub>2</sub> and 12 kg of CH<sub>4</sub>. The mass fraction and mole fraction of O<sub>2</sub> are

- (a) 0.25 and 0.125
- (b) 0.15 and 0.092
- (c) 0.25 and 0.092
- (d) 0.15 and 0.125

18. An insulated pipe of 50 mm outside diameter with  $\epsilon = 0.8$  is laid in a room at 30 °C. If the surface temperature is 250 °C and the convective heat transfer coefficient is 10 W/m<sup>2</sup> K, the total heat loss per unit length of the pipe will be

- (a) 896.6 W/m
- (b) 818.8 W/m
- (c) 786.4 W/m
- (d) 742.2 W/m

19. A wire of 8 mm diameter at a temperature of  $60^\circ\text{C}$  is to be insulated by a material having  $k = 0.174 \text{ W/m K}$ . The heat transfer coefficient on the outside  $h_a = 8 \text{ W/m}^2 \text{ K}$  and ambient temperature  $T_a = 25^\circ\text{C}$ . The maximum thickness of insulation for maximum heat loss will be

- (a) 15.25 mm
- (b) 16.50 mm
- (c) 17.75 mm
- (d) 18.25 mm

20. In liquid metals, thermal boundary layer develops much faster than velocity boundary layer due to

- (a) lower value of Nusselt number
- (b) higher value of Prandtl number
- (c) lower value of Prandtl number
- (d) higher value of Nusselt number

21. The temperature of a body of area  $0.1 \text{ m}^2$  is  $900 \text{ K}$ . The wavelength for maximum monochromatic emissive power will be nearly

- (a)  $2.3 \mu\text{m}$
- (b)  $3.2 \mu\text{m}$
- (c)  $4.1 \mu\text{m}$
- (d)  $5.0 \mu\text{m}$

22. Consider the following statements :

For the laminar condensation on a vertical plate, the Nusselt theory says that

1. inertia force in the film is negligible compared to viscosity and weight
2. heat flow is mainly by conduction through the liquid film, convection in liquid film as well as in vapour is neglected
3. velocity of vapour is very high

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. In transition boiling, heat flux decreases due to which of the following?

1. Low value of film heat transfer coefficient at the surface during  $100^\circ\text{C}$  to  $120^\circ\text{C}$  surface temperature
2. Major portion of heater surface is covered by vapour film which has smaller thermal conductivity as compared to liquid
3. Nucleate boiling occurs very fast

Select the correct answer using the code given below.

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

- 24.** A hemispherical furnace of radius 1.0 m has a roof temperature of  $T_1 = 800$  K and emissivity  $\epsilon_1 = 0.8$ . The flat floor of the furnace has a temperature  $T_2 = 600$  K and emissivity  $\epsilon_2 = 0.5$ . The view factor  $F_{12}$  from surface 1 to 2 will be
- (a) 0.3                      (b) 0.4  
(c) 0.5                      (d) 0.6

**25.** Consider the following statements :

Combustion chamber is

1. the volume between TDC and BDC during the combustion process
2. the space enclosed between the upper part of the cylinder and the top of the piston during the combustion process
3. the space enclosed between TDC and the top of the piston during the combustion process

Which of the above statements is/are correct?

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

- 26.** A 4-stroke diesel engine has length of 20 cm and diameter of 16 cm. The engine is producing power of 25 kW when it is running at 2500 r.p.m. The mean effective pressure of the engine will be nearly

- (a) 5.32 bar              (b) 4.54 bar  
(c) 3.76 bar              (d) 2.98 bar

- 27.** A 4-stroke, 6-cylinder gas engine with a stroke volume of 1.75 litres develops 26.25 kW at 506 r.p.m. and the MEP is  $600 \text{ kN/m}^2$ . The number of misfires per minute per cylinder will be

- (a) 3                      (b) 4  
(c) 5                      (d) 6

- 28.** Which one of the following compressors will be used in vapour compression refrigerator for plants up to 100 tonnes capacity?

- (a) Reciprocating compressor  
(b) Rotary compressor  
(c) Centrifugal compressor  
(d) Double-acting compressor

- 29.** A cold storage is to be maintained at  $-5^\circ\text{C}$  while the surroundings are at  $35^\circ\text{C}$ . The heat leakage from the surroundings into the cold storage is estimated to be 29 kW. The actual COP of the refrigeration plant used is  $\frac{1}{3}$ rd that of an ideal plant working between the same temperatures. The power required to drive the plant will be

- (a) 13 kW  
(b) 14 kW  
(c) 15 kW  
(d) 16 kW

**30.** Consider the following statements :

An expansion device in a refrigeration system

1. reduces the pressure from the condenser to the evaporator
2. regulates the flow of the refrigerant to the evaporator depending on the load
3. is essentially a restriction offering resistance to 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. A reversed Carnot engine is used for heating a building. It supplies  $210 \times 10^3$  kJ/hr of heat to the building at  $20^\circ\text{C}$ . The outside air is at  $-5^\circ\text{C}$ . The heat taken from the outside will be nearly

(a)  $192 \times 10^3$  kJ/hr

(b)  $188 \times 10^3$  kJ/hr

(c)  $184 \times 10^3$  kJ/hr

(d)  $180 \times 10^3$  kJ/hr

32. In an Electrolux refrigerator, a thermo-siphon bubble pump is used to lift the

(a) weak aqua solution from the generator to the separator

(b) weak aqua solution from the separator to the absorber

(c) strong aqua solution from the generator to the separator

(d) strong aqua solution from the generator to the evaporator

33. The enthalpy of moist air with normal notations is given by

(a)  $h = (1.005 + 1.88W)t + 2500W$

(b)  $h = 1.88Wt + 2500W$

(c)  $h = 1.005Wt$

(d)  $h = (1.88 + 1.005W)t + 2500W$

34. If the relative humidity of atmospheric air is 100%, then the wet-bulb temperature will be

(a) more than dry-bulb temperature

(b) equal to dew-point temperature

(c) equal to dry-bulb temperature

(d) less than dry-bulb temperature

35. During an air-conditioning of a plant, the room sensible heat load is 40 kW and room latent heat load is 10 kW, ventilation air is 25% of supply air. At full load, the room sensible heat factor will be

(a) 0.9 (b) 0.8

(c) 0.7 (d) 0.6

36. A 2-stroke oil engine has bore of 20 cm, stroke 30 cm, speed 350 r.p.m., i.m.e.p.  $275 \text{ kN/m}^2$ , net brake load 610 N, diameter of brake drum 1 m, oil consumption 4.25 kg/hr, calorific value of fuel  $44 \times 10^3$  kJ/kg. The indicated thermal efficiency will be

(a) 29.1% (b) 31.3%

(c) 33.5% (d) 35.7%

37. The hydraulic efficiency of a turbine is the ratio of

(a) mechanical energy in the output shaft at coupling and hydrodynamic energy available from the fluid

(b) mechanical energy supplied by the rotor and hydrodynamic energy available from the fluid

(c) useful hydrodynamic energy in the fluid at final discharge and mechanical energy supplied to the rotor

(d) useful hydrodynamic energy in the fluid at final discharge and mechanical energy supplied to the shaft and coupling

38. Consider the following statements regarding compounding in steam turbines :

1. In impulse turbine, steam pressure remains constant between ends of the moving blades.
2. In reaction turbine, steam pressure drops from inlet to outlet of the blade.
3. In velocity compounding, partial expansion of steam takes place in the nozzle and further expansion takes place in the rotor blades.

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

39. In a lawn sprinkler, water leaves the jet with an absolute velocity of 2 m/s and the sprinkler arms are 0.1 m in length. The sprinkler rotates at a speed of 120 r.p.m. The utilization factor of this sprinkler will be nearly

- (a) 0.72
- (b) 0.64
- (c) 0.56
- (d) 0.49

40. Which one of the following statements is correct with respect to axial flow 50% reaction turbine?

- (a) The combined velocity diagram is symmetrical.
- (b) The outlet absolute velocity should not be axial for maximum utilization.
- (c) Angles of both stator and rotor are not identical.
- (d) For maximum utilization, the speed ratio  $\frac{U}{v_1} = \sin^2 \alpha$ .

41. In axial flow pumps and compressors, the combined velocity diagram with common base is used to determine change in

- (a) absolute velocity ( $V_2 - V_1$ )
- (b) relative velocity ( $V_{r2} - V_{r1}$ )
- (c) tangential velocity ( $U_2 - U_1$ )
- (d) whirl velocity ( $V_{u2} - V_{u1}$ )

42. In a steam turbine with steam flow rate of 1 kg/s, inlet velocity of steam of 100 m/s, exit velocity of steam of 150 m/s, enthalpy at inlet of 2900 kJ/kg, enthalpy at outlet of 1600 kJ/kg, the power available from the turbine will be nearly

- (a) 1575.5 kW
- (b) 1481.6 kW
- (c) 1387.7 kW
- (d) 1293.8 kW



43. In an isentropic flow through a nozzle, air flows at the rate of 600 kg/hr. At inlet to nozzle, the pressure is 2 MPa and the temperature is 127 °C. The exit pressure is of 0.5 MPa. If the initial velocity of air is 300 m/s, the exit velocity will be

- (a) 867 m/s      (b) 776 m/s  
(c) 685 m/s      (d) 594 m/s

44. In a steam turbine, the nozzle angle at the inlet is 18°. The relative velocity is reduced to the extent of 6% when steam flows over the moving blades. The output of the turbine is 120 kJ/kg flow of steam. If the blades are equiangular, the speed ratio and the absolute velocity of steam at inlet for maximum utilization are nearly

- (a) 0.42 and 230.2 m/s  
(b) 0.48 and 230.2 m/s  
(c) 0.42 and 515.1 m/s  
(d) 0.48 and 515.1 m/s

45. An air compressor compresses atmospheric air at 0.1 MPa and 27 °C by 10 times of air inlet pressure. During compression, the heat lost to the surrounding is estimated to be 5% of compression work. Air enters the compressor with a velocity of 40 m/s and leaves with 100 m/s. The inlet and exit cross-sectional areas are 100 cm<sup>2</sup> and 20 cm<sup>2</sup> respectively. The temperature of air at the exit from the compressor will be

- (a) 1498 K  
(b) 1574 K  
(c) 1654 K  
(d) 1726 K

46. A compressor delivers 4 m<sup>3</sup> of air having a mass of 5 kg. The specific weight and specific volume of air being delivered will be nearly

- (a) 12.3 N/m<sup>3</sup> and 0.8 m<sup>3</sup>/kg  
(b) 14.6 N/m<sup>3</sup> and 0.4 m<sup>3</sup>/kg  
(c) 12.3 N/m<sup>3</sup> and 0.4 m<sup>3</sup>/kg  
(d) 14.6 N/m<sup>3</sup> and 0.8 m<sup>3</sup>/kg

47. In centrifugal compressors, there exists a loss of energy due to the mismatch of direction of relative velocity of fluid at inlet with inlet blade angle. This loss is known as

- (a) frictional loss  
(b) incidence loss  
(c) clearance loss  
(d) leakage loss

48. A centrifugal compressor develops a pressure ratio of 5 and air consumption of 30 kg/s. The inlet temperature and pressure are 15 °C and 1 bar respectively. For an isentropic efficiency of 0.85, the power required by the compressor will be nearly

- (a) 5964 kW  
(b) 5778 kW  
(c) 5586 kW  
(d) 5397 kW

49. The efficiency of superheat Rankine cycle is higher than that of simple Rankine cycle because

- (a) the enthalpy of main steam is higher for superheat cycle
- (b) the mean temperature of heat addition is higher for superheat cycle
- (c) the temperature of steam in the condenser is high
- (d) the quality of steam in the condenser is low

50. In steam power cycle, the process of removing non-condensable gases is called

- (a) scavenging process
- (b) deaeration process
- (c) exhaust process
- (d) condensation process

51. The internal irreversibility of Rankine cycle is caused by

1. fluid friction
2. throttling
3. mixing

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

52. A 1 g sample of fuel is burned in a bomb calorimeter containing 1.2 kg of water at an initial temperature of 25 °C. After the reaction, the final temperature of the water is 33.2 °C. The heat capacity of the calorimeter is 837 J/°C. The specific heat of water is 4.18 J/°C. The heat released by the fuel will be nearly

- (a) 36 kJ/g
- (b) 42 kJ/g
- (c) 48 kJ/g
- (d) 54 kJ/g

53. A boiler is having a chimney of 35 m height. The draught produced in terms of water column is 20 mm. The temperature of flue gas inside the chimney is 365 °C and that of air outside the chimney is 32 °C. The mass of air used will be nearly

- (a) 10.3 kg/kg of fuel
- (b) 12.5 kg/kg of fuel
- (c) 14.7 kg/kg of fuel
- (d) 16.9 kg/kg of fuel

54. A 2 kg of steam occupying 0.3 m<sup>3</sup> at 15 bar is expanded according to the law  $pv^{1.3} = \text{constant}$  to a pressure of 1.5 bar. The work done during the expansion will be

- (a) 602.9 kJ
- (b) 606.7 kJ
- (c) 612.5 kJ
- (d) 618.3 kJ

55. Which of the following statements is/are correct regarding superheater in boilers?

1. It is a heat exchanger in which heat is transformed to the saturated steam to increase its temperature.
2. It raises the overall efficiency.
3. It reduces turbine internal efficiency.

Select the correct answer using the code given below.

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

56. Water vapour at 90 kPa and 150 °C enters a subsonic diffuser with a velocity of 150 m/s and leaves the diffuser at 190 kPa with a velocity of 55 m/s, and during the process, 1.5 kJ/kg of heat is lost to the surrounding. For water vapour,  $C_p$  is 2.1 kJ/kg K. The final temperature of water vapour will be

- (a) 154 °C
- (b) 158 °C
- (c) 162 °C
- (d) 166 °C

57. A steam turbine is supplied with steam at a pressure of 20 bar gauge. After expansion in the steam turbine, the steam passes to condenser which is maintained at a vacuum of 250 mm of mercury by means of pumps. The inlet and exhaust steam pressures will be nearly

- (a) 2101 kPa and 68 kPa
- (b) 2430 kPa and 78 kPa
- (c) 2101 kPa and 78 kPa
- (d) 2430 kPa and 68 kPa

58. In a power plant, the efficiencies of the electric generator, turbine, boiler, thermodynamic cycle and the overall plant are 0.97, 0.95, 0.92, 0.42 and 0.33 respectively. The total electricity generated for running the auxiliaries will be nearly

- (a) 4.9%
- (b) 5.7%
- (c) 6.5%
- (d) 7.3%

59. A turbine in which steam expands both in nozzle as well as in blades is called as

- (a) impulse reaction turbine
- (b) reciprocating steam turbine
- (c) gas turbine
- (d) Curtis turbine

60. Consider the following statements regarding reaction turbine :

1. Blade shape is aerofoil type and its manufacturing is difficult.
2. It is suitable for small power.
3. Leakage losses are less compared to friction losses.

Which of the above statements is/are correct?

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

61. The solar heat pipe works on the principle of
- heating and condensation cycle
  - evaporation and condensation cycle
  - cooling and condensation cycle
  - heating and evaporation cycle
62. A good approximation of the measured solar spectrum is made by
- black-body energy distribution
  - Planck's energy distribution
  - inverse square law
  - solar constant
63. Which one of the following types of tracker uses liquid contained in canisters that can turn easily into vapour?
- Active tracker
  - Passive tracker
  - Single-axis tracker
  - Altitude-azimuth tracker
64. Which type of flat-plate collector is used to heat the swimming pools with plastic panel, utilizing solar energy?
- Pipe and fin type
  - Full water sandwich type
  - Thermal traps type
  - Corrugated plate with selective surface type
65. The edge loss  $U_e$  in a solar collector with respect to edge area  $A_e$ , collector area  $A_c$  and back loss coefficient  $U_b$  is
- $U_b \left( \frac{A_e}{A_c} \right)$
  - $U_b \left( \frac{A_c}{A_e} \right)$
  - $A_c \left( \frac{A_e}{U_b} \right)$
  - $U_b \left( \frac{A_e}{2A_c} \right)$
66. In solar porous type air heater, the pressure drop is usually
- higher than non-porous type
  - same as in non-porous type
  - lower than non-porous type
  - zero
67. In a drainback solar water heating system
- the water in the heat exchanger is recycled
  - the water is heated in collectors only during times when there is available heat
  - at the collector, the mixture of water and propylene-glycol is heated and returned to a solar storage tank
  - there is an expansion tank with enclosed air chamber to assist water draining
68. A PV cell is illuminated with irradiance ( $E$ ) of  $1000 \text{ W/m}^2$ . If the cell is  $100 \text{ mm} \times 100 \text{ mm}$  in size and produces  $3 \text{ A}$  at  $0.5 \text{ V}$  at the maximum power point, the conversion efficiency will be
- 15%
  - 19%
  - 23%
  - 27%

69. In a barrage of  $300000 \text{ m}^2$  area with a tide height of 3 m, barrage drain time of 10 hr, density of seawater as  $1025 \text{ kg/m}^3$  and gravitational acceleration as  $9.8 \text{ m/s}^2$ , the average power will be

- (a) 377 kW
- (b) 381 kW
- (c) 388 kW
- (d) 396 kW

70. The platinum nano-coating is made on the anode of the fuel cell to

- (a) create lighter and more efficient fuel cell membranes
- (b) make the fuel effective
- (c) create high thermal conductivity in the cell
- (d) make the fuel cell non-corrosive

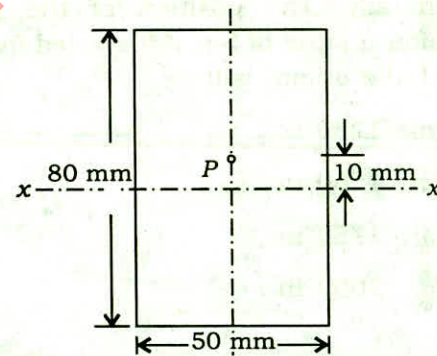
71. In a fuel cell, electric current is produced when

- (a) hydrogen and oxygen react with each other and electrons are freed
- (b) hydrogen reacts with water and electrons are freed
- (c) oxygen reacts with water and electrons are freed
- (d) electrons react with molecules of hydrogen and oxygen is freed

72. Which one of the following is suitable for fuel cell electric vehicle (FCEV)?

- (a) Direct methanol fuel cell (DMFC)
- (b) Alkaline fuel cell (AFC)
- (c) Proton exchange membrane fuel cell (PEMFC)
- (d) Solid oxide fuel cell (SOFC)

73. A pull of 100 kN acts on a bar as shown in the figure in such a way that it is parallel to the bar axis and is 10 mm away from  $xx$  :



The maximum bending stress produced in the bar at  $xx$  is nearly

- (a)  $20.5 \text{ N/mm}^2$
- (b)  $18.8 \text{ N/mm}^2$
- (c)  $16.3 \text{ N/mm}^2$
- (d)  $14.5 \text{ N/mm}^2$

74. The frequency of oscillation is the number of cycles per unit time described by the particle, given by the relation

(a)  $f = \frac{\omega}{2\pi}$

(b)  $\frac{1}{f} = \frac{\omega}{2\pi}$

(c)  $f' = \frac{2\pi r}{T}$

(d)  $f' = \frac{2\pi NT}{\omega}$

75. A particle of mass 1 kg moves in a straight line under the influence of a force which increases linearly with time at the rate of 60 N/s, it being 40 N initially. The position of the particle after a lapse of 5 s, if it started from rest at the origin, will be

(a) 1250 m

(b) 1500 m

(c) 1750 m

(d) 2000 m

76. Rails are laid such that there will be no stress in them at 24 °C. If the rails are 32 m long with an expansion allowance of 8 mm per rail, coefficient of linear expansion  $\alpha = 11 \times 10^{-6} / ^\circ\text{C}$  and  $E = 205 \text{ GPa}$ , the stress in the rails at 80 °C will be nearly

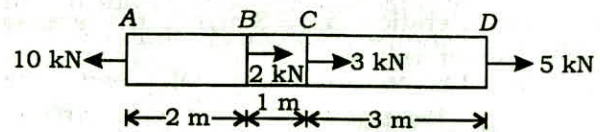
(a) 68 MPa

(b) 75 MPa

(c) 83 MPa

(d) 90 MPa

77. The loads acting on a 3 mm diameter bar at different points are as shown in the figure :



If  $E = 205 \text{ GPa}$ , the total elongation of the bar will be nearly

(a) 29.7 mm

(b) 25.6 mm

(c) 21.5 mm

(d) 17.4 mm

78. A hollow circular bar used as a beam has its outer diameter thrice the inside diameter. It is subjected to a maximum bending moment of 60 MN m. If the permissible bending stress is limited to 120 MPa, the inside diameter of the beam will be

(a) 49.2 mm

(b) 53.4 mm

(c) 57.6 mm

(d) 61.8 mm

79. In a beam of I-section, which of the following parts will take the maximum shear stress when subjected to traverse loading?

1. Flange

2. Web

Select the correct answer using the code given below.

(a) 1 only

(b) 2 only

(c) Both 1 and 2

(d) Neither 1 nor 2

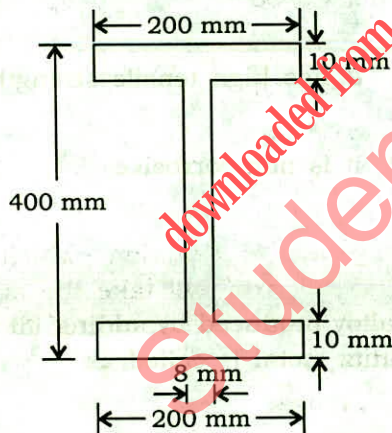
80. Which of the following statements is/are correct?

1. In uniformly distributed load, the nature of shear force is linear and bending moment is parabolic.
2. In uniformly varying load, the nature of shear force is linear and bending moment is parabolic.
3. Under no loading condition, the nature of shear force is linear and bending moment is constant.

Select the correct answer using the code given below.

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

81. The cross-section of the beam is as shown in the figure :



If the permissible stress is  $150 \text{ N/mm}^2$ , the bending moment  $M$  will be nearly

- (a)  $1.21 \times 10^8 \text{ N mm}$
- (b)  $1.42 \times 10^8 \text{ N mm}$
- (c)  $1.64 \times 10^8 \text{ N mm}$
- (d)  $1.88 \times 10^8 \text{ N mm}$

82. In a propeller shaft, sometimes apart from bending and twisting, end thrust will also develop stresses which would be

- (a) tensile in nature and uniform over the cross-section
- (b) compressive in nature and uniform over the cross-section
- (c) tensile in nature and non-uniform over the cross-section
- (d) compressive in nature and non-uniform over the cross-section

83. A spherical shell of 1.2 m internal diameter and 6 mm thickness is filled with water under pressure until volume is increased by  $400 \times 10^3 \text{ mm}^3$ . If  $E = 204 \text{ GPa}$ , Poisson's ratio  $\nu = 0.3$ , neglecting radial stresses, the hoop stress developed in the shell will be nearly

- (a) 43 MPa
- (b) 38 MPa
- (c) 33 MPa
- (d) 28 MPa

84. The inner diameter of a cylindrical tank for liquefied gas is 250 mm. The gas pressure is limited to 15 MPa. The tank is made of plain carbon steel with ultimate tensile strength of  $340 \text{ N/mm}^2$ , Poisson's ratio of 0.27 and the factor of safety of 5. The thickness of the cylinder wall will be

- (a) 60 mm
- (b) 50 mm
- (c) 40 mm
- (d) 30 mm

85. The structure of sodium chloride is considered as

- (a) a body-centered crystal
- (b) a simple cubic crystal
- (c) two interpenetrating FCC sublattices of  $\text{Cl}^-$  ions and  $\text{Na}^+$  ions
- (d) a cubic crystal with  $\text{Na}^+$  and  $\text{Cl}^-$  alternatively at the cubic corners

88. An atomic packing factor (APF) for the BCC unit cell of hard spheres atoms will be

- (a) 0.63
- (b) 0.68
- (c) 0.73
- (d) 0.78

86. Hardenability of steel is assessed by

- (a) Charpy impact test
- (b) Rockwell hardness test
- (c) Jominy end-quench test
- (d) open-hole test

89. The distinct characteristic of Invar is

- (a) it is magnetic
- (b) it has low coefficient of thermal expansion
- (c) it has high tensile strength
- (d) it is non-corrosive

87. A metal has lattice parameter of 2.9 Å, density of 7.87 g/cc, atomic weight of 55.85, and Avogadro's number is  $6.0238 \times 10^{23}$ . The number of atoms per unit cell will be nearly

- (a) 1
- (b) 2
- (c) 8
- (d) 16

90. An alloy produced by adding 1% of tin to Muntz metal is called as

- (a)  $\alpha$  brass
- (b) Admiralty brass
- (c) Naval brass
- (d) Leaded brass



91. A sample of glass has a crack of half-length  $2 \mu\text{m}$ . The Young's modulus of glass is  $70 \text{ GN/m}^2$  and specific surface energy is  $1 \text{ J/m}^2$ . The fracture strength will be
- 885 MPa
  - 895 MPa
  - 915 MPa
  - 935 MPa
92. In the Pb-Sn system, the fraction of total  $\alpha$  phase is 3 times the fraction of  $\beta$  phase at eutectic temperature of  $182^\circ\text{C}$ , Pb with 19% Sn dissolved in it, Sn with 2.5% Pb dissolved in it, and liquid is in equilibrium. The alloy compositions of tin (Sn) and lead (Pb) are nearly
- 28.6% and 71.4%
  - 38.6% and 61.4%
  - 48.6% and 51.4%
  - 58.6% and 41.4%
93. A cylindrical specimen of steel having an original diameter of  $12.8 \text{ mm}$  is tensile tested to fracture and found to have engineering fracture strength  $\sigma_f$  of  $460 \text{ MPa}$ . If its cross-sectional diameter at fracture is  $10.7 \text{ mm}$ , the true stress at fracture will be
- 660 MPa
  - 645 MPa
  - 630 MPa
  - 615 MPa
94. An iron container  $10 \text{ cm} \times 10 \text{ cm}$  at its base is filled to a height of  $20 \text{ cm}$  with a corrosive liquid. A current is produced as a result of an electrolytic cell, and after four weeks, the container has decreased in weight by  $70 \text{ g}$ . If  $n = 2$ ,  $F = 96500 \text{ C}$  and  $M = 55.84 \text{ g/mole}$ , the current will be
- 0.05 A
  - 0.10 A
  - 0.20 A
  - 0.40 A
95. A copper piece originally  $305 \text{ mm}$  long is pulled in tension with a stress of  $276 \text{ MPa}$ . If the deformation is entirely elastic and the modulus of elasticity is  $110 \text{ GPa}$ , the resultant elongation will be nearly
- 0.43 mm
  - 0.54 mm
  - 0.65 mm
  - 0.77 mm
96. The indentation on a steel sample has been taken using  $10 \text{ mm}$  tungsten carbide ball at  $500 \text{ kgf}$  load. If the average diameter of the indentation is  $2.5 \text{ mm}$ , the BHN will be nearly
- 90
  - 100
  - 110
  - 120

97. Which of the following statements are correct with respect to inversion of mechanisms?

1. It is a method of obtaining different mechanisms by fixing different links of the same kinematic chain.
2. It is a method of obtaining different mechanisms by fixing the same links of different kinematic chains.
3. In the process of inversion, the relative motions of the links of the mechanisms produced remain unchanged.
4. In the process of inversion, the relative motions of the links of the mechanisms produced will change accordingly.

Select the correct answer using the code given below.

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

98. For the follower with stroke  $S$ , following the cycloidal motion, the radius of the rolling circle will be

- (a)  $S \times 2\pi$
- (b)  $\frac{S}{2\pi}$
- (c)  $\frac{2\pi}{S}$
- (d)  $S + 2\pi$

99. A vertical shaft of 100 mm diameter and 1 m length has its upper end fixed at the top. The other end carries a disc of 5000 N and the modulus of elasticity of the shaft material is  $2 \times 10^5 \text{ N/mm}^2$ . Neglecting the weight of the shaft, the frequency of the longitudinal vibrations will be nearly

- (a) 279.5 Hz
- (b) 266.5 Hz
- (c) 253.5 Hz
- (d) 241.5 Hz

100. The accurate method of finding the natural frequency of transverse vibrations of a system of several loads attached to some shaft is

- (a) Dunkerley method
- (b) energy method
- (c) Stodola method
- (d) Dunkerley and energy method

101. The speed at which the shaft runs, so that the deflection of the shaft from the axis of rotation becomes infinite, is known as

- (a) whipping speed
- (b) damping speed
- (c) resonant speed
- (d) gravitational speed

102. Which one of the following is **not** the correct statement with respect to the involute profile toothed gears in mesh?

- (a) Pressure angle remains constant from the start till the end of the engagement.
- (b) The base circle diameter and the pitch circle diameter of the two mating involutes are proportional.
- (c) When two involutes are in mesh, the angular velocity ratio is proportional to the size of the base circles.
- (d) The shape of the involute profile depends only on the dimensions of the base circle.

103. The centre distance  $C$  between two gears, in terms of base circle radii  $R_1$ ,  $R_2$  and the pressure angle  $\phi$  is

- (a)  $\frac{\cos \phi}{R_1 + R_2}$
- (b)  $\frac{R_1 + R_2}{\cos \phi}$
- (c)  $\left(\frac{R_1}{R_2}\right) \cdot \cos \phi$
- (d)  $\left(\frac{R_2}{R_1}\right) \cdot \cos \phi$

104. A three-cylinder single-acting engine has its cranks at  $120^\circ$ . The turning moment diagram for each cycle is a triangle for the power stroke with a maximum torque of  $60 \text{ N m}$  at  $60^\circ$  after the dead centre of the corresponding crank. There is no torque on the return stroke. The engine runs at  $400 \text{ r.p.m.}$  The power developed will be

- (a)  $1745 \text{ W}$
- (b)  $1885 \text{ W}$
- (c)  $1935 \text{ W}$
- (d)  $1995 \text{ W}$

105. A vertical single-cylinder opposed piston type engine has reciprocating parts of mass  $2000 \text{ kg}$  for the lower piston and  $2750 \text{ kg}$  for the upper piston. The lower piston has a stroke of  $60 \text{ cm}$  and the engine is in primary balance. If the ratio of the length of connecting rod to crank is  $4$  for the lower piston and  $8$  for the upper piston, and when the crankshaft speed is of  $135 \text{ r.p.m.}$ , the maximum secondary unbalanced force will be

- (a)  $48935.5 \text{ N}$
- (b)  $46946.5 \text{ N}$
- (c)  $44968.5 \text{ N}$
- (d)  $42989.5 \text{ N}$

**106.** The reciprocating mass is balanced when primary force is

1. balanced by the mass  $= c m r \omega^2 \cos \theta$
2. unbalanced by the mass  
 $= c m r \omega^2 \cos \theta$
3. balanced by the mass  
 $= (1 - c) c m r \omega^2 \cos \theta$
4. unbalanced by the mass  
 $= (1 - c) c m r \omega^2 \cos \theta$

Select the correct answer using the code given below.

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

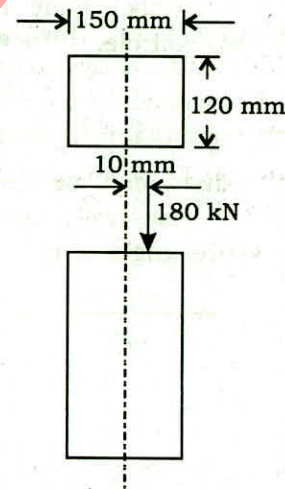
**107.** The active gyroscopic torque in gyroscope about a horizontal axis represents

- (a) the torque required to cause the axis of spin to precess in the vertical plane
- (b) the torque required to cause the axis of spin to precess in the horizontal plane
- (c) the force required to cause the axis of spin to precess in the horizontal plane
- (d) the force required to cause the axis of spin to precess in the vertical plane

**108.** The change in governor height for a Watt governor when speed varies from 100 r.p.m. to 101 r.p.m. will be nearly

- (a) 1.8 mm
- (b) 2.6 mm
- (c) 3.4 mm
- (d) 4.2 mm

**109.** A rectangular strut is 150 mm wide and 120 mm thick. It carries a load of 180 kN at an eccentricity of 10 mm in a plane bisecting the thickness as shown in the figure :



The maximum intensity of stress in the section will be

- (a) 14 MPa
- (b) 12 MPa
- (c) 10 MPa
- (d) 8 MPa

**110.** The theory of failure used in designing the ductile materials in a most accurate way is by

1. maximum principal stress theory
2. distortion energy theory
3. maximum strain theory

Select the correct answer using the code given below.

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

**111.** When a load of 20 kN is gradually applied at a particular point in a beam, it produces a maximum bending stress of 20 MPa and a deflection of 10 mm. What will be the height from which a load of 5 kN should fall onto the beam at the same point if the maximum bending stress is 40 MPa?

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

**112.** The areas of fatigue failure in a part may be in the

1. region having slow growth of crack with a fine fibrous appearance.
2. region having faster growth of crack with a fine fibrous appearance.
3. region of sudden fracture with a coarse granular appearance.
4. region of gradual fracture with a coarse granular appearance.

Select the correct answer using the code given below.

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

**113.** The shock-absorbing capacity (resilience) of bolts can be increased by

- (a) increasing the shank diameter above the core diameter of threads
- (b) reducing the shank diameter to the core diameter of threads
- (c) decreasing the length of shank portion of the bolt
- (d) pre-heating of the shank portion of the bolt

**114.** The torque required to tighten the bolt comprises of the

- (a) torque required in overcoming thread friction only
- (b) torque required in inducing the pre-load only
- (c) torque required in overcoming circumferential hoop stress
- (d) torque required in overcoming thread friction and inducing the pre-load and also the torque required to overcome collar friction between the nut and the washer

**115.** A steel spindle transmits 4 kW at 800 r.p.m. The angular deflection should not exceed  $0.25^\circ/\text{m}$  length of the spindle. If the modulus of rigidity for the material of the spindle is 84 GPa, the diameter of the spindle will be

- (a) 46 mm
- (b) 42 mm
- (c) 38 mm
- (d) 34 mm

**116.** A taper roller bearing has a dynamic load capacity of 26 kN. The desired life for 90% of the bearings is 8000 hr and the speed is 300 r.p.m. The equivalent radial load that the bearing can carry will be nearly

- (a) 5854 N
- (b) 5645 N
- (c) 5436 N
- (d) 5227 N

**117.** Hollow shafts are stronger than solid shafts having same weight because

- (a) the stiffness of hollow shaft is less than that of solid shaft
- (b) the strength of hollow shaft is more than that of solid shaft
- (c) the natural frequency of hollow shaft is less than that of solid shaft
- (d) in hollow shafts, material is not spread at large radius

**118.** A propeller shaft is required to transmit 45 kW power at 500 r.p.m. It is a hollow shaft having inside diameter 0.6 times the outside diameter. It is made of plain carbon steel and the permissible shear stress is  $84 \text{ N/mm}^2$ . The inner and outer diameters of the shaft are nearly

- (a) 21.7 mm and 39.1 mm
- (b) 23.5 mm and 39.1 mm
- (c) 21.7 mm and 32.2 mm
- (d) 23.5 mm and 32.2 mm

**119.** A bicycle and rider travelling at 12 km/hr on a level road have a mass of 105 kg. A brake is applied to a rear wheel having 800 mm diameter. The pressure on the brake is 80 N and the coefficient of friction is 0.06. The number of turns of the wheel before coming to rest will be

- (a) 48.3 revolutions
- (b) 42.6 revolutions
- (c) 38.3 revolutions
- (d) 32.6 revolutions

**120.** To avoid self-engagement in cone clutch, its semi-cone angle is always kept

- (a) smaller than the angle of static friction
- (b) equal to the angle of static friction
- (c) greater than the angle of static friction
- (d) half of the angle of static friction

**121.** In case of arc welding of steel with a potential of 20 V and current of 200 A, the travel speed is 5 mm/s and the cross-sectional area of the joint is  $20 \text{ mm}^2$ . The heat required for melting steel may be taken as  $10 \text{ J/mm}^3$  and heat transfer efficiency as 0.85. The melting efficiency will be nearly

- (a) 18%
- (b) 29%
- (c) 36%
- (d) 42%

**122.** What is the force required for  $90^\circ$  bending of St50 steel of 2 mm thickness in a V-die, if the die opening is taken as 8 times the thickness and the length of the bent part is 1 m, ultimate tensile strength is 500 MPa and  $K = 1.33$ ?

- (a) 166.25 kN
- (b) 155.45 kN
- (c) 154.65 kN
- (d) 143.85 kN

**123.** A graph is drawn to a vertical magnification of 10000 and horizontal magnification of 100, and the areas above and below the datum line are as follows :

Above	$150 \text{ mm}^2$	$80 \text{ mm}^2$	$170 \text{ mm}^2$	$40 \text{ mm}^2$
Below	$80 \text{ mm}^2$	$60 \text{ mm}^2$	$150 \text{ mm}^2$	$120 \text{ mm}^2$

The average roughness  $R_a$  for sampling length of 0.8 mm will be

- (a)  $1.14 \mu\text{m}$
- (b)  $1.10 \mu\text{m}$
- (c)  $1.06 \mu\text{m}$
- (d)  $1.02 \mu\text{m}$

**124.** The radius of arc is measured by allowing a 20 mm diameter roller to oscillate to and fro on it and the time for 25 oscillations is noted at 56.25 s. The radius of arc will be

- (a) 865 mm
- (b) 850 mm
- (c) 835 mm
- (d) 820 mm

**125.** Which one of the following systems is consisting of processing stations, material handling and storage, computer control system and human labour?

- (a) Portable manufacturing system
- (b) Focused integrated system
- (c) Flexible manufacturing system
- (d) Automated integrated system

**126.** A project initially costs ₹ 5,000 and generates year-end cash inflows of ₹ 1,800, ₹ 1,600, ₹ 1,400, ₹ 1,200 and ₹ 1,000 respectively in five years of its life. If the rate of return is 10%, the net present value (NPV) will be

- (a) ₹ 500
- (b) ₹ 450
- (c) ₹ 400
- (d) ₹ 350

127. What is the mode for the following distribution?

Gross profit as percentage of sales	Number of companies
0-7	19
7-14	25
14-21	36
21-28	72
28-35	51
35-42	43
42-49	28

- (a) 19.55
- (b) 21.40
- (c) 23.25
- (d) 25.10

128. Consider the following data for quality acceptance process :

$$N = 10000$$

$$n = 89$$

$$c = 2$$

$$p = 0.01 \text{ (incoming lots of quality)}$$

$$P_a = 0.9397$$

The AOQ will be

- (a) 0.93%
- (b) 0.84%
- (c) 0.75%
- (d) 0.66%

129. An engine is to be designed to have a minimum reliability of 0.8 and minimum availability of 0.98 over a period of  $2 \times 10^3$  hr. The MTTR is nearly

- (a) 168 hr
- (b) 174 hr
- (c) 183 hr
- (d) 188 hr

130. Which one of the following relations with usual notations will hold good in a dynamic vibration absorber system under tuned conditions?

(a)  $k_1 k_2 = m_1 m_2$

(b)  $k_1 m_2 = m_1 k_2$

(c)  $k_1 m_1 = k_2 m_2$

(d)  $k_1 + k_2 = m_1 + m_2$

131. In ultrasonic waves, the frequencies for non-destructive testing of materials are in the range of

(a) 0.5 MHz to 10 MHz

(b) 10 MHz to 20 MHz

(c) 20 MHz to 30 MHz

(d) 30 MHz to 40 MHz



**132.** The Curie point for most ferrous magnetic materials is about

- (a) 390 °C
- (b) 540 °C
- (c) 760 °C
- (d) 880 °C

**133.** Which of the following is one of the basic units of memory controller in micro-controller?

- (a) Microcode engine
- (b) Master program counter
- (c) Program status word
- (d) Slave program counter

**134.** Which one of the following ways will be adopted to store the program counter contents?

- (a) Last-in-First-out (LIFO)
- (b) First-in-First-out (FIFO)
- (c) Last-in-Last-out (LILO)
- (d) First-in-Last-out (FILO)

**135.** In ladder logic programming, an alternative in place of using same internal relay contact for every rung is to use

- (a) battery-backed relay
- (b) dummy relay
- (c) one-shot operation
- (d) master control relay

**136.** Consider the following statements :

1. The term 'attenuation' is used to describe the process of removing a certain band of frequencies from a signal and permitting others to be transmitted.
2. The Wheatstone bridge can be used to convert a voltage change to an electrical resistance change.

Which of the above statements is/are correct?

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

**137.** At time  $t$ , the excitation voltage to a resolver is 24 V. The shaft angle is  $90^\circ$ . The output signals from the resolver  $V_{S1}$  and  $V_{S2}$  will be

- (a) 12 V and 0 V
- (b) 24 V and 0 V
- (c) 12 V and 12 V
- (d) 24 V and 12 V

**138.** An actuator having a stem movement at full travel of 30 mm is mounted with a control valve having an equal percentage plug and with minimum flow rate of  $2 \text{ m}^3/\text{s}$  and maximum flow rate of  $24 \text{ m}^3/\text{s}$ . When the stem movement is 10 mm, the flow rate will be

- (a)  $3.4 \text{ m}^3/\text{s}$
- (b)  $3.8 \text{ m}^3/\text{s}$
- (c)  $4.2 \text{ m}^3/\text{s}$
- (d)  $4.6 \text{ m}^3/\text{s}$

139. In a rack and pinion system, rack is an element moving in translational direction and pinion is a rotary gear. Which one of the following statements is correct?

- (a) Translational acceleration is directly proportional to the moment of inertia of pinion.
- (b) Translational acceleration is inversely proportional to the moment of inertia of pinion.
- (c) Angular acceleration is inversely proportional to the torque on pinion shaft.
- (d) Translational velocity is directly proportional to the moment of inertia of pinion.

140. For the control signal to change at a rate proportional to the error signal, the robotic controller must employ

- (a) integral control
- (b) proportional-plus-integral control
- (c) proportional-plus-derivative control
- (d) proportional-plus-integral-plus-derivative control

141. What is the minimum number of degrees of freedom that a robot needs to have in order to locate its end effectors at an arbitrary point with an arbitrary orientation in space?

- (a) 3
- (b) 4
- (c) 5
- (d) 6

142. Using a robot with 1 degree of freedom and having 1 sliding joint with a full range of 1 m, if the robot's control memory has a 12-bit storage capacity, the control resolution for the axis of motion will be

- (a) 0.236 mm
- (b) 0.244 mm
- (c) 0.252 mm
- (d) 0.260 mm

143. Assume that the joint mechanisms at serial link manipulators are frictionless. The joint torque  $\tau$  required to bear an arbitrary end point force  $F$  is

- (a)  $J^{-1}F$
- (b)  $JF$
- (c)  $J^T F$
- (d)  $J^{-1}F^T$

144. Rotate the vector  $v = 5i + 3j + 8k$  by an angle of  $90^\circ$  about the  $x$ -axis. The rotated vector  $(Hv)$  would be

(a)  $\begin{bmatrix} 1 \\ 3 \\ -8 \\ 5 \end{bmatrix}$       (b)  $\begin{bmatrix} -8 \\ 5 \\ 1 \\ 3 \end{bmatrix}$

(c)  $\begin{bmatrix} 3 \\ -8 \\ 5 \\ 1 \end{bmatrix}$       (d)  $\begin{bmatrix} 5 \\ -8 \\ 3 \\ 1 \end{bmatrix}$

**Directions :**

Each of the **six (6)** items consists of two statements, one labelled as 'Statement (I)' and the other as 'Statement (II)'. You are to examine these two statements carefully and select the 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

**145. Statement (I) :**

The function of arithmetic logic unit (ALU) in microprocessor is to perform data manipulation.

Statement (II) :

The status register is where data for an input to the arithmetic and logic unit is temporarily stored.

**146. Statement (I) :**

To use a sensor, we generally need to add signal conditioning circuitry, such as circuits which amplify and convert from analog to digital, to get the sensor signal in the right form, take account of any non-linearities, and calibrate it.

Statement (II) :

A smart sensor is integrated with the required buffering and conditioning circuitry in a single element and provides functions beyond that of just a sensor.

**147. Statement (I) :**

The count-up overflow (OV) bit is 1 when the up-counter increments above the maximum positive value.

Statement (II) :

The count-down underflow (UN) bit is 1 when the counter decrements below the minimum negative value.

**148. Statement (I) :**

The multiplexer is essentially an electronic switching device which enables each of the inputs to be sampled in turn.

Statement (II) :

A multiplexer is a circuit that is able to have inputs of data from a number of sources and then, by selecting an input channel, gives an output from just one of them.

**149. Statement (I) :**

The term 'encoder' is used for a device that provides an analog output as a result of angular or linear displacement.

Statement (II) :

An increment encoder detects changes in angular or linear displacement from some datum position where as an absolute encoder gives the actual angular or linear position.

**150. Statement (I) :**

Process control valves are used to control the rate of fluid flow and are used where, perhaps, the rate of flow of a liquid into a tank has to be controlled.

Statement (II) :

A common form of pneumatic actuator used with process control valves is the diaphragm actuator.

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