

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

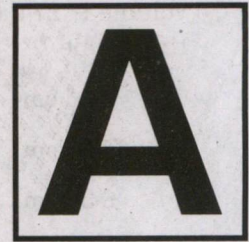
T.B.C. : MNGY-D-MCH

Test Booklet Series

Serial

1016049

TEST BOOKLET



Paper - II

(MECHANICAL ENGINEERING)

Time Allowed : Three Hours

Maximum Marks : 300

INSTRUCTIONS

1. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS TEST BOOKLET **DOES NOT** HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS, ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET.
2. Please note that it is the candidate's responsibility to encode and fill in the Roll Number and Test Booklet Series Code A, B, C or D carefully and without any omission or discrepancy at the appropriate places in the OMR Answer Sheet. Any omission/discrepancy will render the Answer Sheet liable for rejection.
3. You have to enter your Roll Number on the Test Booklet in the Box provided alongside.
DO NOT write *anything else* on the Test Booklet.
4. This Test Booklet contains 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 all your responses **ONLY** on the separate Answer Sheet provided. See directions in the Answer Sheet.
6. All items carry equal marks.
7. Before you proceed to mark in the Answer Sheet the response to various items in the Test Booklet, you have to fill in some particulars in the Answer Sheet as per instructions sent to you with your Admission Certificate.
8. After you have completed filling in all your responses on the Answer Sheet and the examination has concluded, you should hand over to the Invigilator **only the Answer Sheet**. You are permitted to take away with you the Test Booklet.
9. Sheets for rough work are appended in the Test Booklet at the end.
10. **Penalty for wrong answers :**
THERE WILL BE PENALTY FOR WRONG ANSWERS MARKED BY A CANDIDATE.
 - (i) There are four alternatives for the answer to every question. For each question for which a wrong answer has been given by the candidate, **one-third** of the marks assigned to that question will be deducted as penalty.
 - (ii) If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that question.
 - (iii) If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

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1. The cubic capacity of a four-stroke over-square spark-ignition engine is 245 cc. The over-square ratio is 1.1. The clearance volume is 27.2 cc. What is the stroke length of the engine ?
 - (a) 4.36 cm
 - (b) 5.36 cm
 - (c) 6.36 cm
 - (d) 7.36 cm
2. A 42.5 kW engine has a mechanical efficiency of 85%. If the frictional power is assumed to be constant with load, what is the mechanical efficiency at 60% of the load ?
 - (a) 44.2%
 - (b) 40.0%
 - (c) 66.3%
 - (d) 77.3%
3. A single-cylinder engine running at 1800 rpm develops a torque of 8 N-m. The indicated power of the engine is 1.8 kW. What is the loss due to friction power as the percentage of brake power ?
 - (a) 9.36%
 - (b) 19.36%
 - (c) 29.36%
 - (d) 39.36%
4. A gasoline engine working on Otto cycle consumes 8 litres of gasoline per hour and develops 25 kW. The specific gravity of gasoline is 0.75 and its calorific value is 44000 kJ/kg. What is the indicated thermal efficiency of the engine ?
 - (a) 14.1%
 - (b) 24.1%
 - (c) 34.1%
 - (d) 44.1%

Directions for the following **two (02)** items :

Read the following information and answer the **two** items that follow :

The bore and stroke of a water-cooled, vertical, single-cylinder, and four-stroke diesel engine are 80 mm and 110 mm respectively and the torque is 23.5 Nm.

5. What is the brake mean effective pressure of the engine ?
 - (a) 1.01 bar
 - (b) 2.01 bar
 - (c) 3.26 bar
 - (d) 5.34 bar
6. What is the mean effective pressure if its rating is 4 kW at 1500 rpm ?
 - (a) 3.26 bar
 - (b) 4.26 bar
 - (c) 5.78 bar
 - (d) 6.46 bar
7. A refrigerator operating on reversed Carnot cycle extracts 500 kJ/min heat from a refrigerated space being maintained at -16°C and rejects heat to the atmosphere at 27°C . What is the work input required to run the refrigerator ?
 - (a) 42.46 kJ/min
 - (b) 55.24 kJ/min
 - (c) 66.36 kJ/min
 - (d) 83.66 kJ/min

Directions for the following **two (02)** items :

Read the following information and answer the **two** items that follow :

A four-cylinder diesel engine of 4-stroke type has stroke to bore-stroke ratio as 1.2 and the cylinder diameter is 12 cm. Based on the indicator card, the area of 30 cm² and length as half of stroke is given. The indicator spring constant is given as 20×10^3 kN/m² and engine is running at 2000 rpm.

8. What is the mean effective pressure of the engine ?
- (a) 2.33×10^5 N/m²
(b) 4.33×10^5 N/m²
(c) 6.33×10^5 N/m²
(d) 8.33×10^5 N/m²
9. What is the indicated power for one cylinder ?
- (a) 22.6 kW
(b) 38.4 kW
(c) 41.2 kW
(d) 54.5 kW
10. A double-acting reciprocating pump has indicator diagram with area 40 cm² and length 8 cm. The bore diameter and stroke of the pump are 15 cm and 20 cm respectively. The pump motor runs at 100 rpm and the indicator spring constant is given as 1.5×10^8 Pa/m. What is the power required to drive a double acting reciprocating pump ?
- (a) 33.45 kW
(b) 44.36 kW
(c) 66.35 kW
(d) 88.36 kW

Directions for the following **two (02)** items :

Read the following information and answer the **two** items that follow :

For the atmospheric air at room temperature of 30°C and relative humidity of 60%, the saturation pressure at 30°C is given as 0.0425 bar.

11. What is the partial pressure of air ?
- (a) 0.4255 bar
(b) 0.6755 bar
(c) 0.7895 bar
(d) 0.9875 bar

12. What is the humidity ratio ?
- (a) 0.1606 kg/kg of dry air
(b) 0.01606 kg/kg of dry air
(c) 0.2606 kg/kg of dry air
(d) 0.02606 kg/kg of dry air

Directions for the following **two (02)** items :

Read the following information and answer the **two** items that follow :

A Pelton turbine is driven by two jets, generating 4.0 MW at 375 rev/min. The effective head at the nozzles is 200 m of water and the nozzle velocity coefficient, $K_N = 0.98$. The axes of the jets are tangent to a circle 1.5 m in diameter. The relative velocity of the flow across the buckets is decreased by 15 percent and the water is deflected through an angle of 150° neglecting bearing and windage losses.

13. What is the Jet speed ratio ?
- (a) 0.2798
(b) 0.4798
(c) 0.6798
(d) 0.8798
14. What is the runner efficiency of the Pelton turbine ?
- (a) 62.55%
(b) 76.46%
(c) 86.66%
(d) 92.46%
15. The following data refers to an axial flow compressor :
- $\beta_1 = 60^\circ$, turning angle = 30° , degree of reaction 50%, speed 36000 rpm, mean diameter = 140 mm, inlet pressure = 2 bar and inlet temperature = 57°C. What is the blade mean speed ?
- (a) 140.36 m/s
(b) 263.89 m/s
(c) 313.85 m/s
(d) 413.85 m/s

16. During a trial on single acting single stage compression the following observations are made:

Dimensions of cylinder : 10 cm bore and 8 cm stroke,

Speed of rotation : 500 rpm,

Barometer reading : 76 cm Hg,

Atmospheric temperature : 27°C,

Delivery air temperature = 130°C,

Free air delivery = 15 m³/hr,

Spring balance of dynamometer type (electric motor) reading : 10 kg,

Radius of arm of spring balance : 30 cm.

Take mechanical efficiency = 0.90.

What is the volumetric efficiency of the compressor ?

- (a) 38.49%
- (b) 52.56%
- (c) 63.84%
- (d) 79.62%

Directions for the following two (02) items :

Read the following information and answer the two items that follow :

A jet aeroplane flies at a speed of 900 km/h. The density of air at this altitude is 0.15 kg/m³ and drag on plane is 6800 kW. Consider jet plane to have 2 jets and engine working on turbo-prop system with propulsive efficiency of 56%.

17. What is the absolute velocity of jet ?

- (a) 115.4 m/s
- (b) 250.4 m/s
- (c) 392.86 m/s
- (d) 480.46 m/s

18. What is the volume flow rate ?

- (a) 86.6 m³/s
- (b) 102.6 m³/s
- (c) 115.4 m³/s
- (d) 131.8 m³/s

19. A single stage impulse turbine has equal blade angles and nozzle angle of 30°. What is the maximum possible blade efficiency, if the blade velocity coefficient is 0.85 ?

- (a) 33.46%
- (b) 45.63%
- (c) 55.46%
- (d) 69.37%

20. Consider the following statements :

1. Impulse turbine stage has pressure drop occurring in moving blades only.
2. Reaction turbine stage has pressure drop occurring in both fixed as well as moving blades.
3. Reaction turbines have complete admission of steam or steam being admitted all around the rotor through fixed blade ring.

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

21. Which type of steam turbine is also known as Curtis turbine ?

- (a) Pressure compounded impulse turbine
- (b) Velocity compounded impulse turbine
- (c) Pressure-velocity compounded impulse turbine
- (d) Cross-flow compound turbine

22. A reaction turbine has mean blade speed of 180 m/s, blade speed to steam velocity ratio of 0.8, outlet angles of fixed and moving blades as 30° and 35° , specific volume at outlet of fixed blade as 0.5 m^3 and at moving blade outlet as 0.6 m^3 . Areas at exit of fixed blade and moving blades are same. Consider the efficiency of blades as 90% when considered as nozzles and $K^2 = 0.88$, where K is blade velocity coefficient. What is the axial velocity component at the inlet ?

- (a) 92.5 m/s
- (b) 98.5 m/s
- (c) 101.2 m/s
- (d) 112.5 m/s

Directions for the following two (02) items :

Read the following information and answer the two items that follow :

In a surface condenser operating with steam turbine, the vacuum near inlet of air pump is 69 cm of Hg when barometer reading is 76 cm of Hg. Temperature at inlet of vacuum pump is 30°C . Air leakage occurs at the rate of 60 kg/hr. Take 1 cm of Hg = 1333.22 Pa)

23. What is the absolute pressure at inlet to air pump ?

- (a) 4.33 kPa
- (b) 5.33 kPa
- (c) 6.33 kPa
- (d) 9.33 kPa

24. What is the partial pressure of air if saturation pressure at 30°C is taken as 4.246 kPa ?

- (a) 3.08 kPa
- (b) 4.08 kPa
- (c) 5.08 kPa
- (d) 6.08 kPa

Directions for the following two (02) items :

Read the following information and answer the two items that follow :

A simple Rankine cycle works between the boiler pressure of 3 MPa and condenser pressure of 4 kPa. The steam is dry saturated before the throttling in the turbine. From the steam tables at 3 MPa (30 bar) and saturated vapour condition, take enthalpy of steam entering into turbine as 2802.3 kJ/kg and enthalpy of steam leaving the turbine as 1862.04 kJ/kg. Consider pump work as 3 kJ/kg.

25. What is the work ratio ?

- (a) 0.677
- (b) 0.799
- (c) 0.845
- (d) 0.997

26. What is the specific steam consumption ?

- (a) 2.83 kg/kWh
- (b) 3.83 kg/kWh
- (c) 4.83 kg/kWh
- (d) 5.83 kg/kWh

27. In a power plant, the efficiencies of the electric generator, turbine (mechanical), boiler, cycle and the overall plant are 0.97, 0.95, 0.92, 0.42 and 0.33 respectively. What percentage of the total electricity generated is consumed in running the auxiliaries ?

- (a) 3.56%
- (b) 4.67%
- (c) 5.67%
- (d) 7.32%

Directions for the following **three (03)** items :

Read the following information and answer the **three** items that follow :

A forced draught fan supplies air at 10 m/s against a draught of 20 mm of water across the fuel bed. 2500 kg/h of coal is consumed and 16 kg of air is supplied per kg of coal burned to run the fan. The temperature of the flue gas and the ambient air may be taken as 600 K and 300 K respectively. Take density of air as 1.176 kg/m³.

28. What is the total pressure head to be produced by the fan ?

- (a) 176.50 N/m²
- (b) 255.00 N/m²
- (c) 310.05 N/m²
- (d) 412.00 N/m²

29. What is the volume of air to be handled ?

- (a) 2.46 m³/s
- (b) 4.79 m³/s
- (c) 8.29 m³/s
- (d) 9.45 m³/s

30. What is the power required to run the forced draught fan ?

- (a) 2.41 kW
- (b) 3.47 kW
- (c) 4.36 kW
- (d) 5.33 kW

31. In an impulse steam turbine, steam is accelerated through a nozzle from rest. It enters the nozzle at 9.8 bar dry and saturated. The height of the blade is 10 cm and the nozzle angle is 15°. Mean blade velocity is 144 m/s. The blade velocity ratio is 0.48 and blade velocity coefficient is 0.97. What is the isentropic heat drop ?

- (a) 28.4 kJ/kg
- (b) 38.4 kJ/kg
- (c) 48.9 kJ/kg
- (d) 58.9 kJ/kg

32. The principal characteristic of an ash collector is the degree of collection (η) which is given in terms of quantity by

- (a) $(G_1 - G_2)/G_1$
- (b) $(G_1 + G_2)/G_1$
- (c) $G_1/(G_1 - G_2)$
- (d) $G_1/(G_1 + G_2)$

where G_1 = Quantity of ash entering an ash collector per unit time (kg/s)

G_2 = Quantity of uncollected ash passing through the collector per unit time (kg/s)

Directions for the following **four (04)** items :

Read the following information and answer the **four** items that follow :

In a condenser test, the following observations were made :

Vacuum = 720 mm of mercury;

Barometer = 765 mm of mercury;

Mean temperature of condensation = 34°C;

Hot well temperature = 29°C;

Inlet temperature of cooling water = 15°C;

Outlet temperature of cooling water = 25°C;

Absolute pressure of steam at 34°C is 0.0533 bar.

Take 760 mm of Hg = 1.013 bar.

33. What is the vacuum corrected to standard barometer of 760 mm ?

- (a) 348 mm of Hg
- (b) 424 mm of Hg
- (c) 715 mm of Hg
- (d) 804 mm of Hg

34. What is the under cooling efficiency ?

- (a) 45.36
- (b) 53.31
- (c) 84.36
- (d) 99.31

35. What is the under cooling of condenser ?

- (a) 2°C
- (b) 3°C
- (c) 4°C
- (d) 5°C

36. What is the condenser pressure ?

- (a) 0.03 bar
- (b) 0.04 bar
- (c) 0.05 bar
- (d) 0.06 bar

37. Consider the following statements related to Pyranometer :

1. Pyranometer is used to measure global (direct and diffuse) solar radiation on a surface.
2. This instrument cannot be used to measure the diffuse radiation by blocking out the direct radiation with a shadow band.

Which of the above statements is/are correct ?

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

38. Most of the reflection occurs from clouds, with a small proportion from the Earth's surface. This reflectance is called

- (a) Scattering
- (b) Greenhouse effect
- (c) Albedo
- (d) Climate change

39. What is the amount of solar heat that comes through a south-facing window (single pane) for January (70% sunshine) ? (Consider vertical window, dimensions of 1.2 m × 2.5 m, single pane, transmission = 90%, area = 3 m² and insolation for January is 6 kWh/m² per clear day)

- (a) 300 kWh
- (b) 351 kWh
- (c) 400 kWh
- (d) 451 kWh

40. The temperature difference between absorber plate and outdoor air is -10°C , and then the flat-plate collector efficiency is higher for
- one pane
 - two panes
 - three panes
 - more than three panes
41. The Hottel-Whillier-Bliss equation, expresses the useful heat collected, Q , per unit area, in terms of two operating variables, the incident solar radiation normal to the collector plate, G_c , and the temperature difference between the mean temperature of the heat-removal fluid in the collector, T_m , transmittance-absorptance product ($\tau\alpha$) and the surrounding air temperature, T_a , as follows :
- $F[(\tau\alpha)G_c + U(T_m - T_a)]$
 - $F[(\tau\alpha)G_c - U(T_m + T_a)]$
 - $F[(\tau\alpha)G_c - U(T_m - T_a)]$
 - $F[(\tau\alpha)G_c + U(T_a - T_m)]$
42. What is the heat stored in 5 m^3 of water, if specific heat is $4.19\text{ kJ}/(\text{kg } ^{\circ}\text{C})$, temperature final = 26°C , temperature initial = 18°C ?
- $67.6 \times 10^3\text{ kJ}$
 - $147.6 \times 10^3\text{ kJ}$
 - $167.6 \times 10^3\text{ kJ}$
 - $47.6 \times 10^3\text{ kJ}$
43. Thermal comfort depends on environmental and physiological factors. Which one of the following is representing the physiological factor ?
- Air temperature (dry bulb)
 - Relative humidity
 - Radiation
 - Amount of clothing (insulation)
44. What is the approximate value of the energy output for a 0.5-kW PV system for Amarillo, Texas, for the month of January if the system is as follows : BP solar, crystalline silicon, 225-W module, $1.65\text{ m} \times 1\text{ m}$, area = 1.65 m^2 ; array of two modules tilted at latitude ? (Consider the Amarillo data; January average day = $4.9\text{ kWh}/\text{m}^2/\text{day}$. $E_s = 70\%$, $E_c = 17\%$)
- 60 kWh
 - 50 kWh
 - 40 kWh
 - 30 kWh
45. What is the annual energy production (AEP) for a 3-MW wind turbine in a class 4 wind regime ? (Take class 4 in a good wind regime, Capacity Factor = 40%)
- 8512 MWh/yr
 - 9512 MWh/yr
 - 10512 MWh/yr
 - 11512 MWh/yr

46. Waves are created by the progressive transfer of energy from the wind as it blows over the surface of the water. Once created, waves can travel large distances without much reduction in energy. The energy in a wave is
- directly proportional to the height
 - directly proportional to the height squared
 - indirectly proportional to the height
 - indirectly proportional to the height squared
47. A fuel cell converts chemical energy of a fuel into electricity
- indirectly, with conversion from fuel \rightarrow heat \rightarrow electricity
 - directly, with no intermediate combustion cycle
 - directly, with conversion from fuel \rightarrow heat \rightarrow work \rightarrow electricity
 - indirectly, with conversion from fuel \rightarrow work \rightarrow electricity
48. The efficiency of conversion from chemical energy to electricity by a fuel cell may
- theoretically be 100%
 - practically be 50%
 - theoretically be 50%
 - practically be 75%
49. A spherical water drop of 1 mm in diameter splits up in air into 64 smaller drops of equal size. The surface tension coefficient of water in air = 0.073 N/m. What is the work required in splitting up the drop ?
- 0.12×10^{-3} J
 - 0.36×10^{-3} J
 - 0.69×10^{-6} J
 - 0.89×10^{-3} J
50. What is the intensity of pressure in the ocean at a depth of 1500 m, assuming salt water is incompressible with a specific weight of 10050 N/m³ ?
- 15.08 MN/m² gauge
 - 25.08 MN/m² gauge
 - 32.06 MN/m² gauge
 - 42.06 MN/m² gauge
51. Oil of specific gravity 0.800 acts on a vertical triangular area whose apex is in the oil surface. The triangle is isosceles 3 m high and 4 m wide. A vertical rectangular area 2 m high is attached to the 4 m base of the triangle and is acted upon by water. What is the magnitude of the resultant hydrostatic force on the entire area ? (Consider acceleration due to gravity as 9.81 m/s²)
- 184 kN
 - 361 kN
 - 421 kN
 - 520 kN

52. A jet propelled boat with an absolute velocity of 8.7 m/s is moving upstream in a river. The stream is flowing with a velocity of 2.3 m/s. A jet of water is ejected astern at a relative velocity of 18 m/s. If the flow in jet is $1.4 \text{ m}^3/\text{s}$, what is the efficiency of the propulsion device ?
- (a) 38.5%
 (b) 48.5%
 (c) 58.5%
 (d) 68.5%
53. Air flows through a duct, and the Pitot-static tube measuring the velocity is attached to a differential manometer containing water. The deflection of the manometer is 100 mm, assuming the density of air is constant and equals to 1.22 kg/m^3 , and that the coefficient of the tube is 0.98. What is the air velocity ? (Consider acceleration due to gravity as 9.81 m/s^2)
- (a) 19.3 m/s
 (b) 29.3 m/s
 (c) 39.3 m/s
 (d) 49.3 m/s
54. Water flows in a circular pipe. At one section, the diameter is 0.3 m, the static pressure is 260 kPa gauge, the velocity is 3 m/s and the elevation is 10 m above ground level. The elevation at a section downstream is 0 m, and the pipe diameter is 0.15 m. Frictional effects may be neglected. Assume density of water to be 999 kg/m^3 . What is the gauge pressure at the downstream section ? (Consider acceleration due to gravity as 9.81 m/s^2)
- (a) 180.25 kPa gauge
 (b) 290.57 kPa gauge
 (c) 320.25 kPa gauge
 (d) 380.57 kPa gauge
55. Water at 20°C is flowing between a two-dimensional channel in which the top and bottom walls are 1.5 mm apart. If the average velocity is 2 m/s, what is the maximum velocity ?
- (a) 1 m/s
 (b) 1.5 m/s
 (c) 2 m/s
 (d) 3 m/s
56. Air moves over a 10 m long flat plate. The transition from laminar to turbulent flow takes place between Reynolds numbers of 2.5×10^6 and 3.6×10^6 . The free stream velocity is 30 m/s and $\nu = 1.5 \times 10^{-5} \text{ m}^2/\text{s}$. What is the maximum distance from the front edge of the plate along which one expects laminar flow in the boundary layer ?
- (a) 0.9 m
 (b) 1.2 m
 (c) 1.5 m
 (d) 1.8 m
- Directions for the following two (02) items :*
- Read the following information and answer the two items that follow :*
- Air ($\rho = 1.23 \text{ kg/m}^3$ and $\nu = 1.5 \times 10^{-5} \text{ m}^2/\text{s}$) is flowing over a flat plate. The free stream speed is 15 m/s at a distance of 1 m from the leading edge.
57. What is the boundary layer thickness for completely laminar flow ?
- (a) 5.48 mm
 (b) 7.21 mm
 (c) 2.83 mm
 (d) 8.35 mm

58. What is the wall shear stress for completely laminar flow ?
- 0.101 N/m²
 - 1.201 N/m²
 - 2.301 N/m²
 - 3.401 N/m²
59. A hollow cylinder of 0.6 m diameter, open at the top, contains some liquid and spins about its vertical axis, producing a forced vortex motion. What is the height of the vessel so that the liquid just reaches the top of the vessel and begins to uncover the base at 100 rpm ? (Consider acceleration due to gravity as 9.81 m/s²)
- 3.203 m
 - 2.303 m
 - 1.403 m
 - 0.503 m
60. The velocity of air at the outer edge of a tornado, where the pressure is 750 mm of Hg and diameter 30 meters, is 12 m/s. Consider the density of air to be constant and equal to 1.2 kg/m³ (specific gravity of mercury = 13.6). What is the velocity of air at a radius of 2 meters from its axis ?
- 60 m/s
 - 70 m/s
 - 80 m/s
 - 90 m/s
61. In the cylinder of an air motor, the compressed air has a specific internal energy of 420 kJ/kg at the beginning of the expansion and a specific internal energy of 200 kJ/kg after expansion. What is the heat flow to or from the cylinder when the work done by the air during the expansion is 100 kJ/kg ?
- 120 kJ/kg
 - + 200 kJ/kg
 - 80 kJ/kg
 - + 100 kJ/kg
62. In the turbine of a gas turbine unit the gases flow through the turbine at 17 kg/s and the power developed by the turbine is 14000 kW. The specific enthalpies of the gases at inlet and outlet are 1200 kJ/kg and 360 kJ/kg respectively, and the velocities of the gases at inlet and outlet 60 m/s and 150 m/s respectively. What is the rate at which heat is rejected from the turbine ?
- 89.5 kW
 - 96.2 kW
 - 121.5 kW
 - 119.3 kW
63. A certain perfect gas of mass 0.01 kg occupies a volume of 0.003 m³ at a pressure of 7 bar and a temperature of 131°C. The gas is allowed to expand until the pressure is 1 bar and the final volume is 0.02 m³. What is the molar mass of the gas ? (Take universal gas constant as 8314.5 J/K. kmol)
- 8 kg/kmol
 - 10 kg/kmol
 - 12 kg/kmol
 - 16 kg/kmol

64. What is the highest possible theoretical efficiency of a heat engine operating with a hot reservoir of furnace gases at 2000°C when the cooling water available is at 10°C ?
- (a) 47.37%
 (b) 57.37%
 (c) 77.54%
 (d) 87.54%
65. What is the compression ratio of the Otto cycle for a petrol engine with a cylinder bore of 50 mm, a stroke of 75 mm, and a clearance volume of 21.3 cm³ ?
- (a) 4.9
 (b) 5.9
 (c) 6.9
 (d) 7.9
66. The inner surface of a plane brick wall is at 40°C, the outer surface is at 20°C, the wall is 250 mm thick and the thermal conductivity of the brick is 0.52 W/m K. What is the rate of heat transfer per unit area of wall surface ?
- (a) 24.9 W/m²
 (b) 34.9 W/m²
 (c) 41.6 W/m²
 (d) 51.6 W/m²
67. What is the Reynolds number ?
- (a) 31340
 (b) 44680
 (c) 48450
 (d) 51230
68. What is the convective heat transfer coefficient at inlet ?
- (a) 1961 W/m² °C
 (b) 1961 W/m² K
 (c) 1348 W/m² °C
 (d) 1348 W/m² K
69. Consider the following statements regarding methods of compounding in steam engines :
1. Tandem type compounding of steam engines has the in-line cylinders having pistons mounted on the same piston rod which is further having crosshead and connecting rod providing power output at crankshaft.
 2. Woolf compound engine is a cross-type compounding having two cylinders having pistons at 270° phase difference i.e., at some position one cylinder may have piston at inner dead centre and other cylinder has piston at outer dead centre.
 3. Receiver compound engine is also a cross compound engine having two cylinders with out of phase pistons and receiver in between.

Directions for the following two (02) items :

Read the following information and answer the two items that follow :

Hot water at 98°C flows through a 2-in schedule 40 horizontal steel pipe, ID = 0.0525 m, OD = 0.06033 m [k = 54 W/m°C] and is exposed to atmospheric air at 20°C. The water velocity is 25 cm/s.

The properties of water at 98°C are

$$\rho = 960 \text{ kg/m}^3,$$

$$\mu = 2.82 \times 10^{-4} \text{ kg/m.s.},$$

$$k = 0.68 \text{ W/m.}^\circ\text{C},$$

$$\text{Pr} = 1.76,$$

$$\text{Nu} = 151.4$$

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

70. Water at the rate of 68 kg/min is heated from 35 to 75°C by oil having a specific heat of 1.9 kJ/kg °C. The fluids are used in a counter flow double-pipe heat exchanger, and the oil enters the exchanger at 110°C and leaves at 75°C. The overall heat-transfer coefficient is 320 W/m² °C. What is the total heat transfer? (Take specific heat of water as 4180 J/kg.K)

- (a) 78.3 kW
- (b) 189.5 kW
- (c) 241.3 kW
- (d) 280.6 kW

71. What is the specific volume of steam at 17672 kPa and 712 K considering it as a perfect gas? (Take critical pressure = 22.09 MPa, critical temperature = 647.3 K, $R_{\text{steam}} = 0.4615 \text{ kJ/kg.K}$)

- (a) 0.0186 m³/kg
- (b) 0.0986 m³/kg
- (c) 0.2146 m³/kg
- (d) 0.3146 m³/kg

72. Which type of gas power cycle has limitation of isochoric heat addition and rejection in piston cylinder arrangement?

- (a) Carnot cycle
- (b) Otto cycle
- (c) Diesel cycle
- (d) Dual cycle

73. Consider the following statements regarding slip and twinning in imperfection in solids:

1. In slip, orientations of the crystal above and below the slip plane will change drastically after deformation, but twinning results in an orientation difference across the twin plane.
2. Slip occurs in discrete multiples of atomic spacing, but in twinning, the atom movements are much less than an atomic distance.
3. Twins can be formed within a time as short as a few microseconds, while for slip there is a delay time of several milliseconds before a slip band is formed.

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

74. Which of the following materials are used for turbine blades in an aircraft engine?

- (a) Nickel-based super alloys
- (b) Magnesium-Zinc super alloys
- (c) Copper-Nickel super alloys
- (d) Copper-Tungsten super alloys

75. Which of the following steels are used for propeller hubs, welded steel propeller blades, engine bolts and nuts, coil springs and valve springs?

- (a) Chrome-Vanadium steels
- (b) Nickel-Chrome steels
- (c) Molybdenum-Nickel steels
- (d) Vanadium-Nickel steels

76. What is the interplanar spacing when an X-ray beam of wavelength 1.54 \AA is directed towards the crystal at an angle of 30° to the atomic plane ?
- (a) 1.54 \AA
 (b) 3.08 \AA
 (c) 4.62 \AA
 (d) 6.16 \AA
77. Which of the following is/are main ingredients of Portland cement ?
- (a) Sodium silicate only
 (b) Tri-calcium phosphate only
 (c) Bi-calcium phosphate only
 (d) Dicalcium silicate and Tri-calcium silicate
78. What is the fraction of Proeutectoid ferrite in 0.18 percent steel assuming that eutectoid reaction takes place at 0.8 percent carbon ?
- (a) 0.3
 (b) 0.5
 (c) 0.8
 (d) 0.9
79. Oxidation loss on the copper surface is 0.05 mm in 15 h. How much will be the loss in 225 h ?
- (a) 0.194 mm
 (b) 0.394 mm
 (c) 0.594 mm
 (d) 0.794 mm
80. What is the thermal shock resistance R of a steel body with
 $\alpha = 12 \times 10^{-6}/^\circ\text{C}$, $K = 80 \text{ W/mK}$,
 $\sigma_{ut} = 650 \text{ N/mm}^2$, $E_t = 200,000 \text{ N/mm}^2$?
 (where α is the coefficient of thermal expansion, K is thermal conductivity, σ_{ut} is the ultimate tensile strength of the material, E_t is the Young's modulus of the material in tension)
- (a) $10.549 \times 10^3 \text{ W/m}$
 (b) $21.667 \times 10^3 \text{ W/m}$
 (c) $32.856 \times 10^3 \text{ W/m}$
 (d) $41.256 \times 10^3 \text{ W/m}$
81. Which one of the following stainless steels is used in automobile exhaust components, valves and combustion chamber ?
- (a) Ferritic stainless steel
 (b) Martensitic stainless steel
 (c) Austenitic stainless steel
 (d) Invar steel
82. Consider the following statements regarding super alloys for high temperature applications :
- In iron-nickel super alloys, the composition is 15 percent Cr, 20 – 40 percent Ni, remainder is iron, and the two alloys, discalloy and incoloy are nickel-based alloys.
 - Vitalium is a vanadium-based super alloy.
 - Nickel-based alloys are best creep-resistant alloys.
- 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

83. Plain carbon steels in which carbon percentage is less than 0.8 wt% are called
- Hypoeutectoid steels
 - Eutectoid steels
 - Proeutectoid steels
 - Austenite steels
84. Which one of the following is a Gibbs phase rule ? (where P is the number of phase's presents, F is the number of degrees of freedom, C is the number of components and N is the number of non-compositional variables)
- $P + F = C + N$
 - $P - F = C + N$
 - $P + F = C - N$
 - $P + N = C + F$
85. A bicycle and rider of mass 120 kg are travelling at a speed of 15 km/h on a level road. The rider applies brake to the rear wheel that is 0.9 m in diameter. The pressure applied on the brake is 100 N and coefficient of friction between the brake and the cycle rim is 0.05. Assume that no other resistance is acting on the bicycle. How far does the bicycle travel before it comes to rest ?
- 85.36 m
 - 107.36 m
 - 208.33 m
 - 307.36 m
86. The reduction of speed from 360 rpm to 120 rpm is desired by the use of a chain drive. The driving sprocket has 18 teeth. What is the number of teeth on the driven sprocket ?
- 34
 - 44
 - 54
 - 64
87. Which one of the following types of cams has either a convex or a concave surface ?
- Conjugate cam
 - Spherical cam
 - Globoidal cam
 - Spiral cam
88. A spring-mass system consists of a spring of stiffness 350 N/m. The mass is 0.35 kg. The mass is displaced 20 mm beyond the equilibrium position and released. The damping coefficient is 14 N.s/m. What is the undamped natural frequency for the system ?
- 15.62 rad/s
 - 31.62 rad/s
 - 61.62 rad/s
 - 81.62 rad/s
89. Which one of the following methods/principles makes use of the fact that the maximum kinetic energy in a vibrating system is equal to the maximum potential energy in a free longitudinal vibrations system ?
- Equilibrium method
 - Rayleigh's method
 - Energy method
 - D'Alembert's principle
90. The distance between two parallel shafts connected by Oldham's coupling is 25 mm. The driving shaft revolves at 240 rpm. What is the maximum velocity of sliding ?
- 0.628 m/s
 - 0.725 m/s
 - 0.859 m/s
 - 0.926 m/s

Directions for the following **three (03)** items :

Read the following information and answer the **three** items that follow :

In a spring-controlled governor, the controlling force curve is a straight line. The balls are 450 mm apart when the controlling force is 1450 N and 250 mm when it is 750 N. The mass of each ball is 8 kg.

91. What is the speed at which the governor runs when the balls are 300 mm apart ?
- (a) 65.1 rpm
(b) 185.5 rpm
(c) 265.1 rpm
(d) 320.5 rpm
92. What is the isochronous speed ?
- (a) 282.47 rpm
(b) 398.42 rpm
(c) 433.33 rpm
(d) 598.52 rpm
93. What is the initial tension to be increased to make the governor isochronous ?
- (a) 75 N
(b) 125 N
(c) 285 N
(d) 360 N

Directions for the following **two (02)** items :

Read the following information and answer the **two** items that follow :

The mass of a turbine rotor of a ship is 8000 kg and has a radius of gyration of 0.75 m. It rotates at 1800 rpm clockwise when viewed from the stern.

94. What is the gyroscopic couple if the ship travelling at 100 km/h steers to the left along a curve of 80 m radius ?
- (a) 125654 Nm
(b) 195785 Nm
(c) 225785 Nm
(d) 294531 Nm

95. What is the gyroscopic couple if the ship is pitching and the bow is descending with maximum velocity ? (Take the pitching is with simple harmonic motion with periodic time of 20 sec and the total angular movement between extreme positions is 10°)
- (a) 25654 Nm
(b) 32568 Nm
(c) 46510 Nm
(d) 52565 Nm
96. A petrol engine 100 mm in diameter and 120 mm stroke has a connecting rod 250 mm long. The piston has a mass of 1 kg and the speed is 1800 rpm. The gas pressure is 0.5 MPa at 30° from top dead centre during the explosion stroke. What is the force on piston due to gas pressure ?
- (a) 1927 N
(b) 2927 N
(c) 3927 N
(d) 4927 N
97. Contact stress for spur gears is proportional to :
- (a) Elastic coefficient (C_p)
(b) Face width (F)
(c) Pinion diameter (D_p)
(d) Geometry factor for bending stress (J)
98. The relationship between load, P, and life, L, for rolling contact bearings can be stated as $\frac{L_2}{L_1} = \left(\frac{P_1}{P_2}\right)^k$. What is the value of k for the roller bearing for this relation ?
- (a) 2.33
(b) 3.33
(c) 1.25
(d) 2.52

99. In static load analysis, the difference between a dynamic loading situation and a static one is

- (a) the presence or absence of accelerations
- (b) the presence or absence of velocities
- (c) the presence or absence of moments
- (d) the presence or absence of external forces

100. For dynamic loading, we need to modify the theoretical stress-concentration factor to obtain a fatigue stress-concentration factor based on

- (a) the factor of safety of the material to obtain a fatigue stress-concentration factor
- (b) the nominal stress to obtain a fatigue stress-concentration factor
- (c) the stress-concentration factor for nominal stress to obtain a fatigue stress-concentration factor
- (d) the notch sensitivity of the material to obtain a fatigue stress-concentration factor

101. For the failure of ductile materials under static loading, which of the failure theories is more accurate ?

- (a) The maximum normal-stress theory
- (b) The maximum normal-strain theory
- (c) The distortion-energy theory
- (d) The total strain-energy theory

102. Based on the maximum shear-stress theory, it can be predicted that the relation between the shear yield strength (S_{ys}) and tensile yield strength (S_y) of a ductile material is given by

- (a) $S_{ys} = 0.33 S_y$
- (b) $S_{ys} = 0.5 S_y$
- (c) $S_y = 0.5 S_{ys}$
- (d) $S_{ys} = 0.66 S_y$

103. Consider the following parameters involved in the rating of clutches and brakes :

- 1. Torque required to accelerate or decelerate the system
- 2. Time required to accomplish the speed change
- 3. The cycling rate is the number of on/off cycles per unit time

Which of the above parameters are applicable for the rating of clutches and brakes ?

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

104. An annular plate-type brake has the area of the friction surface of 20 in² and the frictional power absorbed about 2 hp. The wear rating is

- (a) 0.1 hp/in²
- (b) 0.2 hp/in²
- (c) 0.3 hp/in²
- (d) 0.4 hp/in²

105. A set of three bolts is to be used to provide a clamping force of 4000 N between two components of a machine. If the allowable stress is 800 N/mm², what is the required tensile stress area (A_t) for the bolt ?

- (a) 0.2 mm²
- (b) 0.5 mm²
- (c) 5 mm²
- (d) 20 mm²

106. What is the minimum leg size for the fillet weld of plate having thickness $\leq \frac{1}{2}$ inch ?
- $\frac{3}{16}$ inch
 - $\frac{5}{16}$ inch
 - $\frac{1}{4}$ inch
 - $\frac{1}{2}$ inch
107. The fatigue strength reduction factor is given by
- $\frac{\text{endurance limit of a notch-free specimen}}{\text{endurance limit of a notched specimen}}$
 - $\frac{\text{endurance limit of a notched specimen}}{\text{endurance limit of a notch-free specimen}}$
 - (endurance limit of a notch-free specimen) \times endurance limit of a notched specimen
 - (endurance limit of a notch-free specimen) $+$ endurance limit of a notched specimen
108. If the estimated actual endurance strength of the material is S_n , the ultimate tensile strength is S_u , the mean stress is σ_m and the alternating stress is σ_a , the equation for the Goodman line is
- $\frac{\sigma_a}{S_n} \times \frac{S_u}{\sigma_m} = 1$
 - $\frac{\sigma_a}{S_n} \times \frac{\sigma_m}{S_u} = 1$
 - $\frac{\sigma_a}{S_n} + \frac{\sigma_m}{S_u} = 1$
 - $\frac{\sigma_a}{S_n} + \frac{S_u}{\sigma_m} = 1$
109. According to the type of stress employed, which one of the following metal forming processes is classified under combined tension and compression type ?
- Extrusion
 - Rolling
 - Forging
 - Deep drawing
110. In rolled products, which one of the following is generally 5 mm or thicker and is 1.0 or 1.25 m in width and 2.5 m in length ?
- Foil
 - Slab
 - Plate
 - Billet
111. Which one of the following is mainly a surface crack detection technique which may be applied to all non-porous materials, but only cracks open to the surface can be detected ?
- Radiographic Testing
 - Liquid Colour Penetrant Testing
 - Eddy Current Testing
 - Ultrasonic Testing
112. Which one of the following NDT methods can be used for detection of internal voids or measuring the thickness of surface coatings ?
- Ultrasonic Testing
 - Liquid Colour Penetrant Testing
 - Eddy Current Testing
 - Acoustic Emissions

113. Consider the following statements for vibration monitoring of the wind turbines :

1. Position sensors are used for low frequencies.
2. Velocity sensors are used for medium-range frequencies.
3. Accelerometers are used for high frequencies.

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

114. A data set is said to be incomplete if

- (a) it contains both failure data and replacement data
- (b) it does not contain both censored data and replacement data
- (c) it does not contain both failure and censored data
- (d) it contains both failure and censored data

115. Which one of the following is related to the process data such as the production rate, efficiency, resource consumption ?

- (a) Technical data
- (b) Operational data
- (c) Maintenance servicing data
- (d) Cost data

116. Consider the following common failure mechanisms found in gas turbine blades :

1. Mechanical damage
2. High temperature damage
3. Creep failures

Which of the above failure mechanisms are correct ?

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

117. Which one of the following is the excess of available time over the activity time when all jobs start as early as possible ?

- (a) Free float
- (b) Total float
- (c) Independent float
- (d) Interfering float

118. Which one of the following inventories are stocked in the manufacturing plant as a precaution, in case the semi-finished from one machine does not come to the next machine, and this stock is used to continue a production ?

- (a) Anticipation inventories
- (b) Fluctuation inventories
- (c) Decoupling inventories
- (d) Lot size inventories

119. Which one of the following consists of those surface irregularities on the part, which are of considerable wavelength of a periodic character ?

- (a) Lay
- (b) Waviness
- (c) Roughness
- (d) Flaws

120. Consider the following circumstances for a random-order FMS :

1. The part family is small.
2. There are substantial variations in part configurations.
3. The production schedule is subject to change from day-to-day.

Which of the above circumstances are correct ?

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

121. Which one of the following statements is correct related to PIC16F84 microcontroller ?
- It is a low-cost 32-bit microcontroller.
 - It has a built-in ADC, DAC or serial communication capability.
 - It supports 13 digital I/O lines and serves as a good learning platform.
 - It is low-cost and has difficulty of programming.

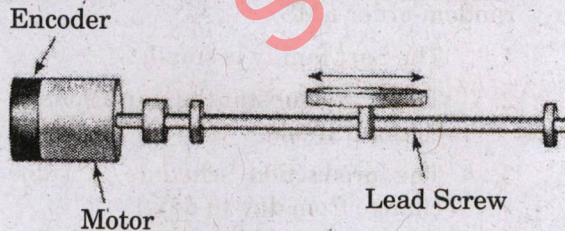
122. What is the smallest step size (resolution) of a 4-bit ADC, which has a maximum output voltage of 12 V ?

- 3.0 V
- 0.8 V
- 4.8 V
- 8.0 V

123. Which one of the following effects states that if a wave source and corresponding receiver are moving relative to each other, the frequency observed by the receiver will be greater than or smaller than the actual source frequency ?

- Doppler effect
- Piezoelectric effect
- Signal conditioning effect
- Variable capacitance effect

124. A DC motor equipped with an incremental optical encoder is used to drive a lead screw positioning table, as shown in figure. The screw has a lead of 2.54 mm/rev., the encoder disk has 1000 lines, and the encoder is operated in quadrature mode. What is the measurement resolution of this encoder ?



- 0.335 μm per count
- 0.435 μm per count
- 0.535 μm per count
- 0.635 μm per count

125. The hysteresis of the Schmitt trigger in typical circuit for a Hall-effect digital proximity switch is used to :

- increase the sensitivity of the sensor to noise and false triggering
- make constant sensitivity of the sensor to noise and false triggering
- reduce the sensitivity of the sensor to noise and false triggering
- increase the sensitivity of the sensor to noise and true triggering

126. In stepper motors, which one of the following features eliminates the need for brushes and a commutator ?

- It works without the need for a position sensor.
- There are no wires connected to the rotor.
- It does not generate large torque at low speed.
- It uses gears only.

127. Which of the following types of transducers are also known as externally powered transducers ?

- Self-generating transducers
- Passive transducers
- Active transducers
- Differential transducers

128. Consider the following statements :

- A multi-robot system whose dynamics are written is observable if and only if it is controllable.
- Duality principle can be invoked to show that a multi-robot system is controllable if and only if it is observable.

Which of the above statements is/are correct ?

- 1 only
- 2 only
- Both 1 and 2
- Neither 1 nor 2

129. Which of the following are used in material handling systems for moving raw materials or partly finished goods from one workstation to another within a manufacturing system facility ?

- (a) Stationary robots
- (b) Mobile robots
- (c) Automated guided vehicles
- (d) Robotic arms

130. Consider the following statements :

1. At the velocity level, the Manipulator Jacobian relates joint velocities to end effector velocities.
2. The Manipulator Jacobian is important in motion planning and for identifying singularities.

Which of the above statements is/are correct ?

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

131. A robotic arm made from steel has a length of 1.524 m, a breadth of 0.102 m, and a height of 0.1524 m. The payload is 444.82 kg. The density of steel, ρ , is 7.87 kg m^{-3} and its Young's modulus, E , is 206.85 GPa. What is the deflection of the robotic arm due to the payload and the robotic link mass ? (Consider moment of inertia of the arm, I , is $3 \times 10^{-5} \text{ m}^4$, $g = 9.81 \text{ m/s}^2$, and the robotic link mass is 1200 kg m^{-1})

- (a) 170 μm
- (b) 180 μm
- (c) 190 μm
- (d) 200 μm

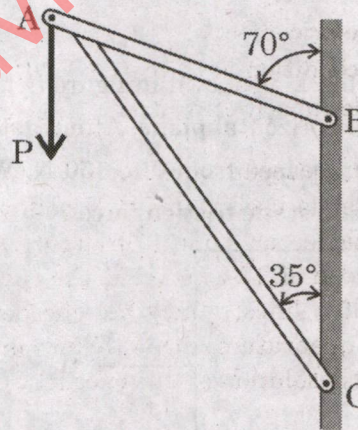
132. Consider the following statements :

1. Robots are normally controlled using microcomputers or microcontrollers.
2. The output from a robot needs to be transformed into usable forms using actuators.

Which of the above statements is/are correct ?

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

133. In the frame as shown in figure, an external force P is applied at joint A. Which one of the equations is correct by using law of sines ?



- (a) $\frac{P}{\sin 55^\circ} = \frac{P_{AC}}{\sin 35^\circ} = \frac{P_{AB}}{\sin 110^\circ}$
- (b) $\frac{P}{\sin 110^\circ} = \frac{P_{AB}}{\sin 110^\circ} = \frac{P_{AC}}{\sin 55^\circ}$
- (c) $\frac{P}{\sin 35^\circ} = \frac{P_{AB}}{\sin 35^\circ} = \frac{P_{AC}}{\sin 110^\circ}$
- (d) $\frac{P_{AC}}{\sin 55^\circ} = \frac{P_{AB}}{\sin 35^\circ} = \frac{P}{\sin 55^\circ}$

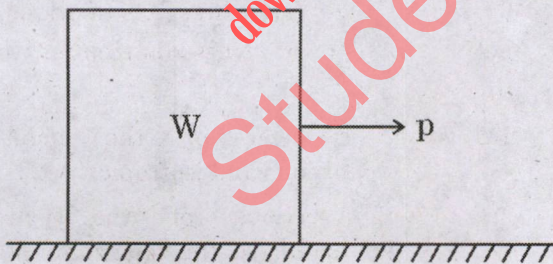
134. Consider the following properties for line loads distributed along a plane curve :

1. The magnitude of the resultant force is equal to the area under the load diagram.
2. The line of action of the resultant force passes through the centroid of the area under the load diagram.
3. The line of action of the resultant force is always vertically upward.

Which of the above properties are correct ?

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

135. The 50-kg block as shown in figure is initially at rest on a horizontal plane. After that P was gradually increased from 0 to 150 N. What is the maximum static friction force ?



$$\mu_s = 0.5$$

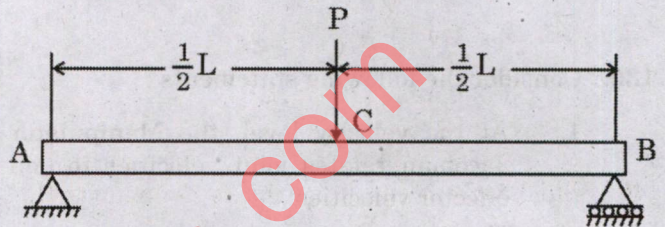
$$\mu_k = 0.2$$

- (a) 490.5 N
- (b) 245.25 N
- (c) 98.1 N
- (d) 25 N

136. What is the section modulus (Z) for a triangular section of base width b and height h ?

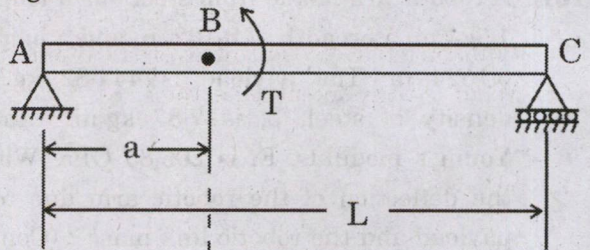
- (a) $bh^2/12$
- (b) $bh^2/24$
- (c) $bh^3/12$
- (d) $bh^3/24$

137. What is the maximum bending moment for the simply supported beam as shown in figure ?



- (a) $\frac{PL^4}{4}$
- (b) $\frac{PL^2}{4}$
- (c) $\frac{PL^2}{2}$
- (d) $\frac{PL}{4}$

138. What is the maximum shear force for the simply supported beam loaded by a couple of moment T applied at point B as shown in figure ?



- (a) $\frac{T}{L}$
- (b) $\frac{Ta}{4}$
- (c) $\frac{TL^2}{2}$
- (d) $\frac{TL}{4}$

139. A Surveyor's steel tape 30 m long has a cross-section of $15 \text{ mm} \times 0.75 \text{ mm}$. With this, line AB is measured as 150 m. If the force applied during measurement is 120 N more than the force applied at the time of calibration, what is the elongation? (Take modulus of elasticity for steel as 200 kN/mm^2)

- (a) 4.400 mm
- (b) 3.375 mm
- (c) 2.125 mm
- (d) 1.600 mm

140. Which one of the following is defined as the ratio of shearing stress to shearing strain within elastic limit?

- (a) Shear modulus
- (b) Poisson's ratio
- (c) Modulus of rigidity
- (d) Young's modulus

141. The extension of a bar uniformly tapering from a diameter of $(d + a)$ to $(d - a)$ in a length L is calculated by treating it as a bar of uniform cross-section of average diameter d . What is the percentage error?

- (a) $25 \frac{a^2}{d^2}$
- (b) $50 \frac{a^2}{d^2}$
- (c) $75 \frac{a^2}{d^2}$
- (d) $100 \frac{a^2}{d^2}$

142. What is the torque, if a shaft of 200 mm diameter can transmit safely and the shear stress is not to exceed 50 N/mm^2 ?

- (a) 78.54 N-m
- (b) 78.54 kN-m
- (c) 152.45 kN-m
- (d) 152.45 N-m

143. For the design of a thin cylindrical shell, if f_a is allowable tensile stress for the material of the shell, thickness t of the cylindrical shell of a diameter d and internal pressure p , then the criterion for the thickness is

- (a) $t \geq \frac{p}{2f_a}$
- (b) $t \geq \frac{d}{2f_a}$
- (c) $t \leq \frac{pd}{2f_a}$
- (d) $t \geq \frac{pd}{2f_a}$

144. Consider the following assumptions for Lamé's problem of stress distribution in the thick shells:

1. The material of the shell is heterogeneous and isotropic.
2. Plane sections of the cylinder, perpendicular to the longitudinal axis, remain plane under the pressure.
3. The material of the shell is homogeneous and isotropic.

Which of the above statements is/are correct?

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

Directions : Each of the next Six (06) items consists of two statements, one labelled as the '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 codes given below :

Codes :

- (a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
- (b) Both Statement (I) and Statement (II) are individually true, but Statement (II) is **not** the correct explanation of Statement (I).
- (c) Statement (I) is true, but Statement (II) is false.
- (d) Statement (I) is false, but Statement (II) is true.

145. Statement (I) :

Fluid motion produced due to change in density resulting from the temperature gradients is called free convection.

Statement (II) :

The movement of fluid in free convection is due to the fact that the fluid particles in the immediate vicinity of the hot object become warmer than the surrounding fluid resulting in a local change of density.

146. Statement (I) :

Heat is defined as the form of energy that is transferred between the system and surroundings due to the temperature difference between them.

Statement (II) :

The temperature difference is the driving force or potential for heat transfer.

147. Statement (I) :

The simple air standard cycle analysis cannot predict the variation of thermal efficiency with mixture strength since air is assumed to be the working medium.

Statement (II) :

Fuel air cycle analysis suggests that the thermal efficiency will deteriorate as the mixture supplied to an engine is enriched.

148. Statement (I) :

When three concurrent forces are in equilibrium then each force is inversely proportional to the sine of the angle between the remaining two forces.

Statement (II) :

The algebraic sum of moments of all forces about any point is equal to the moment of their resultant about that point.

149. Statement (I) :

When a material is subjected to a tensile strain, there is a simultaneous shortening of the cross-sectional dimensions perpendicular to the direction of the tensile strain.

Statement (II) :

The ratio of the shortening strain to the tensile strain is called Poisson's ratio.

150. Statement (I) :

Toughness is the ability of a material to absorb applied energy without failure.

Statement (II) :

The energy absorption value from such tests is often called impact energy or impact resistance.

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