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

Test Booklet No. : 02781

Series A

TEST BOOKLET

Paper—I

(MECHANICAL ENGINEERING)

Time Allowed : 2 Hours **Full Marks : 100**

Read the following instructions carefully before you begin to answer the questions :

1. The name of the Subject, Roll Number as mentioned in the Admission Certificate, Test Booklet No. and Series are to be written legibly and correctly in the space provided on the Answer-Sheet with Black/Blue ballpoint pen.
2. **Answer-Sheet without marking Series as mentioned above in the space provided for in the Answer-Sheet shall not be evaluated.**
3. All questions carry equal marks.

   The Answer-Sheet should be submitted to the Invigilator.

   Directions for giving the answers : Directions for answering questions have already been issued to the respective candidates in the 'Instructions for marking in the OMR Answer-Sheet' along with the Admit Card and Specimen Copy of the OMR Answer-Sheet.

   Example :

   Suppose the following question is asked :

   The capital of Bangladesh is
   (A) Chennai
   (B) London
   (C) Dhaka
   (D) Dhubri

   You will have four alternatives in the Answer-Sheet for your response corresponding to each question of the Test Booklet as below :

   Ⓐ Ⓑ Ⓒ Ⓓ

   In the above illustration, if your chosen response is alternative (C), i.e., Dhaka, then the same should be marked on the Answer-Sheet by blackening the relevant circle with a Black/Blue ballpoint pen only as below :

   Ⓐ Ⓑ ● Ⓓ

   The example shown above is the only correct method of answering.
4. Use of eraser, blade, chemical whitener fluid to rectify any response is prohibited.
5. Please ensure that the Test Booklet has the required number of pages (16) and 100 questions immediately after opening the Booklet. In case of any discrepancy, please report the same to the Invigilator.
6. No candidate shall be admitted to the Examination Hall/Room 20 minutes after the commencement of the examination.
7. No candidate shall leave the Examination Hall/Room without prior permission of the Supervisor/Invigilator. No candidate shall be permitted to hand over his/her Answer-Sheet and leave the Examination Hall/Room before expiry of the full time allotted for each paper.
8. No Mobile Phone, Electronic Communication Device, etc., are allowed to be carried inside the Examination Hall/Room by the candidates. Any Mobile Phone, Electronic Communication Device, etc., found in possession of the candidate inside the Examination Hall/Room, even if on off mode, shall be liable for confiscation.
9. No candidate shall have in his/her possession inside the Examination Hall/Room any book, notebook or loose paper, except his/her Admission Certificate and other connected papers permitted by the Commission.
10. Complete silence must be observed in the Examination Hall/Room. No candidate shall copy from the paper of any other candidate, or permit his/her own paper to be copied, or give, or attempt to give, or obtain, or attempt to obtain irregular assistance of any kind.
11. This Test Booklet can be carried with you after answering the questions in the prescribed Answer-Sheet.
12. Noncompliance with any of the above instructions will render a candidate liable to penalty as may be deemed fit.
13. No rough work is to be done on the OMR Answer-Sheet. You can do the rough work on the space provided in the Test Booklet.

N.B. : There will be negative marking @ 0·25 per 1 (one) mark against each wrong answer.

SEAL

[No. of Questions : 100]

1. The enthalpies before and after a throttled flow are h_1 and h_2 respectively. The correct relation between the two enthalpies is

(A) $h_1 > h_2$

(B) $h_1 < h_2$

(C) $h_1 = h_2$

(D) $h_1 = 0{\cdot}5h_2$

2. Which of the following is an intensive property?

(A) Specific volume

(B) Energy

(C) Volume

(D) Mass

3. The mechanical efficiency of an engine in terms of indicated power (IP) and brake power (BP) is expressed as

(A) $\frac{IP}{BP}$

(B) $\frac{BP}{IP}$

(C) $\frac{IP - BP}{IP}$

(D) $\frac{BP}{IP - BP}$

4. A heat exchange process in which the product of pressure and volume remains constant is known as

(A) isentropic process

(B) throttling process

(C) adiabatic process

(D) hyperbolic process

5. The COP of a cyclic heat pump (COP_{HP}) is 5. The ratio of the COP of a refrigerator (COP_R) to that of COP_{HP} will be

(A) 1

(B) 1·25

(C) 0·8

(D) 1·5

6. A condenser of a refrigerator rejects heat at a rate of 120 kW, while its compressor consumes a power of 30 kW. The coefficient of performance is

(A) $\frac{1}{4}$

(B) 4

(C) $\frac{1}{3}$

(D) 3

7. The thermal conductance or the heat conducted through a solid of area A, thickness L, and thermal conductivity K is

(A) $\frac{L}{KA}$

(B) $\frac{KA}{L}$

(C) $\frac{KL}{A}$

(D) $\frac{LA}{K}$

8. A cylinder contains 5 m^3 of an ideal gas at a pressure of 1 bar. This gas is compressed in a reversible isothermal process till its pressure increases to 5 bar. The work in kJ required for this process is

(A) 804·7

(B) 953·2

(C) 981·7

(D) 1012·2

9. The COP of a Carnot heat pump operating between 6 °C and 37 °C is

(A) 5

(B) 10

(C) 15

(D) 20

10. For dry saturated steam, dryness fraction is

(A) 0

(B) 0·80

(C) 0·50

(D) 1·0

11. The thermal diffusivity of a material of density ρ, specific heat C_P, and thermal conductivity K is

(A) $\frac{K}{\rho C_P}$

(B) $\frac{\rho C_P}{K}$

(C) $\frac{\rho}{KC_P}$

(D) $\frac{\rho K}{C_P}$

12. The maximum theoretical work obtainable, when a system interacts to equilibrium with a reference environment, is called

(A) entropy

(B) enthalpy

(C) exergy

(D) rothalpy

13. A vacuum gauge reads 50 kPa where the atmospheric pressure is 105 kPa. The absolute pressure will be

(A) 155 kPa

(B) 55 kPa

(C) 2·1 kPa

(D) 50 kPa

14. At the critical radius of insulation

(A) heat flow is minimum

(B) there is no heat loss

(C) heat transfer is maximum

(D) there is no effect of heat loss

15. In a Rankine cycle, the heat addition process is

(A) isothermal

(B) isobaric

(C) isochoric

(D) isentropic

16. In a four-stroke engine, the angle of crankshaft rotation for a complete cycle is

(A) 360°

(B) 180°

(C) 720°

(D) 540°

17. At the triple point of a pure substance, the number of degrees of freedom is

(A) 0

(B) 1

(C) 2

(D) 3

18. Given the temperature of mercury is 10 °C where its density equals 13570 kg/m^3. The atmospheric pressure at a location where the barometric reading is 740 mm of Hg and the gravitational acceleration is $g = 9{\cdot}81$ m/s^2 will be

(A) 90·5 kPa

(B) 95·5 kPa

(C) 98·5 kPa

(D) 100 kPa

19. Steam enters an adiabatic turbine at 8 MPa and 500 °C at a rate of 18 kg/s, and exits at 0·2 MPa and 300 °C. The rate of entropy generation in the turbine is

(A) 0 kW/K

(B) 14·2 kW/K

(C) 21 kW/K

(D) 38 kW/K

20. The air in a house is at 20 °C and 50% relative humidity. Now the air is cooled at constant pressure. The temperature at which the moisture in the air will start condensing is

(A) 8·4 °C

(B) 11 °C

(C) 18·8 °C

(D) 9·3 °C

21. At 20 °C and 1 atm, the specific gravity of a substance is 19·3. The density of the substance is

(A) 19300 kg/m^3

(B) 19300 kg/litre

(C) 19300 g/cm^3

(D) 19300 kg/cm^3

22. For a fluid at rest, the shear stress is

(A) one

(B) infinite

(C) zero

(D) between zero and one (both zero and one excluded)

23. A floating body is said to be stable if

(A) metacentre lies below the centre of gravity

(B) centre of gravity is above the centroid of displaced volume

(C) centre of gravity coincides with centre of buoyancy

(D) metacentre lies above the centre of gravity

24. In a U-tube manometer, one end is open to the atmosphere and the other end is attached to a pressurized gas of gauge pressure 40 kPa. The height of the fluid column on the atmospheric side is 60 cm, and that on the gas side is 30 cm. The manometric fluid is (take $g = 9{\cdot}8\ m/s^2$)

(A) liquid ammonia

(B) water

(C) mercury

(D) oil

25. What is the centre of buoyancy's position for a wooden block of width 3·5 m and depth 1 m when it floats horizontally in the water? The density of the wooden block is 850 kg/m^3, and its length is 7·0 m.

(A) 0·85 m

(B) 1·00 m

(C) 1·65 m

(D) 2·05 m

26. The diameter of a pipe in section 1 is 9 cm. If the velocity of water flowing through the line at section 1 is 4·8 m/s and section 2 is 9 m/s, the area of section 2 is

(A) 67·86 m^2

(B) 33·93 m^2

(C) 38·66 m^2

(D) 16·96 m^2

27. The pressure gradient in a pure Couette flow

(A) is infinite

(B) is zero

(C) is one

(D) drives the flow

28. The forces that are accounted for in the dimensionless Froude number are

(A) inertia and viscous forces

(B) inertia and pressure forces

(C) inertia and gravity forces

(D) inertia and surface tension force

29. At the throat of a venturi meter

(A) velocity reaches a minimum value

(B) pressure is maximum

(C) pressure and velocity values are equal

(D) velocity reaches the maximum value

30. Which of the following is ***not*** an assumption made in the derivation of Bernoulli's equation?

(A) Flow is viscous

(B) Flow is along a streamline

(C) Steady flow

(D) Fluid is incompressible

31. The head loss due to friction using Darcy formula when water flows through a pipe of 100 mm in diameter and 50 m long with velocity 2 m/s (assume $f = 0{\cdot}005$ and $g = 10\ m/s^2$) is

(A) 2·9

(B) 1

(C) 2

(D) 3·2

32. For same heat rejection and same maximum pressure and temperature, the efficiency of the given cycles can be arranged as

(A) $\eta_{Otto} > \eta_{Dual} > \eta_{Diesel}$

(B) $\eta_{Otto} < \eta_{Diesel} < \eta_{Dual}$

(C) $\eta_{Otto} < \eta_{Dual} < \eta_{Diesel}$

(D) $\eta_{Otto} > \eta_{Diesel} > \eta_{Dual}$

33. The diameter of a stream tube in an incompressible flow field

(A) increases as the flow accelerates

(B) decreases as the flow decelerates or diverges

(C) decreases as the flow accelerates or converges

(D) remains constant

34. For an isolated system, which of the following statements is correct?

(A) Both mass and energy can cross the boundary.

(B) Neither mass nor energy can cross the boundary.

(C) Energy in the form of heat or work can cross the boundary.

(D) Only mass can cross the boundary.

35. The dimension of the coefficient of viscosity having the dimensions of mass, length and time as M, L and T respectively is

(A) $M^{-1}L^{-1}T^{-1}$

(B) $M^{-1}L^{1}T^{-1}$

(C) $M^{1}L^{-1}T^{-1}$

(D) $M^{1}L^{-1}T^{-2}$

36. For a two-dimensional irrotational flow, the velocity potential is given by $\phi = \ln(x^2 + y^2)$. The velocity at a point (1, 1) will be

(A) $\hat{i} + \hat{j}$

(B) $\frac{1}{2}\hat{i} + \frac{1}{2}\hat{j}$

(C) $2\hat{i} + 2\hat{j}$

(D) $2\hat{i} - 2\hat{j}$

37. The unit of force in SI system is

(A) dyne

(B) erg

(C) newton

(D) watt

38. The dimensional formula of force in MLT system is

(A) MLT^{-1}

(B) $ML^{-1}T^{-2}$

(C) MLT^{-2}

(D) $ML^{-2}T^{-2}$

39. The polar moment of inertia of a solid shaft of diameter D is

(A) $\frac{\pi}{32}D^4$

(B) $\frac{\pi}{32}D^3$

(C) $\frac{\pi}{16}D^3$

(D) $\frac{\pi}{16}D^4$

40. According to Grubler's criterion, the overall mobility of a planar mechanism with constrained motion is

(A) 2

(B) 1

(C) 3

(D) 4

41. The moment of inertia of a rectangle of width b and depth h about a horizontal axis through its centroid is

(A) $\frac{bh^3}{12}$

(B) $\frac{hb^3}{16}$

(C) $\frac{bh^3}{32}$

(D) $\frac{hb^2}{32}$

42. Which one of the following trusses is perfect? (n = number of members, j = number of joints)

(A) $n = 8,\ j = 8$

(B) $n = 13,\ j = 8$

(C) $n = 12,\ j = 8$

(D) $n = 15,\ j = 8$

43. The module of a gear having N number of teeth and pitch circle radius R is

(A) $\frac{2R}{N}$

(B) $\frac{N}{2R}$

(C) $\frac{R}{N}$

(D) $\frac{N}{R}$

44. The coefficient of friction between a shaft and bearing is 0·03, and the power transmitted by the shaft at 160 rad/s is 300 W. The torque will be

(A) 2 N-m

(B) 1·875 N-m

(C) 0·05625 N-m

(D) 62·5 N-m

45. The Porter governor is a modified form of

(A) Proell governor

(B) Hartnell governor

(C) Hartung governor

(D) Watt governor

46. In a four-bar linkage, the Grashof's law will be satisfied if

(A) no link makes a complete revolution relative to another

(B) all links make a complete revolution relative to another

(C) one of the links will rotate continuously relative to other links

(D) the largest link will make a half revolution relative to other three links

47. Tooth interference in an external involute spur gear pair can be reduced by

(A) decreasing centre distances between gear pair

(B) decreasing modules

(C) decreasing pressure angle

(D) increasing number of gear teeth

48. The mechanism used in a shaping machine is

(A) a closed 4-bar chain having 4 revolute pairs

(B) a closed 6-bar chain having 6 revolute pairs

(C) a closed 4-bar chain having 2 revolute and 2 sliding pairs

(D) an inversion of the single slider-crank chain

49. In a Watt governor, 15 cm height corresponds to angular speed of

(A) 9·2 rad/s

(B) 8·1 rad/s

(C) 6·5 rad/s

(D) 7·0 rad/s

50. The hollow shaft will transmit greater ____ than the solid shaft of the same weight.

(A) bending moment

(B) shear stress

(C) torque

(D) sectional modulus

51. The ratio of coil diameter to the wire diameter in a helical spring is known as

(A) spring stiffness

(B) spring rate

(C) spring index

(D) Wahl factor

52. Life of a bearing is expressed in

(A) hours of operation

(B) millions of revolution

(C) Both (A) and (B)

(D) years of operation only

53. In a reverted gear train having four gears

(A) first and second gears are coaxial

(B) fourth and first gears are coaxial

(C) first and third gears are coaxial

(D) second and last gears are coaxial

54. When all the three principal stresses are of same sign, then the Cauchy's stress quadric is

(A) a hyperboloid of one sheet

(B) a hyperboloid of two sheets

(C) a paraboloid

(D) an ellipsoid

55. The product of force and the time of applied force is called

(A) momentum

(B) impulse

(C) work

(D) power

56. In virtual displacement, the magnitude of displacement is

(A) infinitesimal

(B) zero

(C) infinite

(D) unity

57. According to principle of virtual work, an ideal system is in equilibrium for each virtual displacement when the work produced by the active forces is

(A) unity

(B) zero

(C) infinite

(D) infinitesimal

58. The speed of an engine varies from 210 rad/s to 190 rad/s. During a cycle, the change in kinetic energy is found to be 400 N-m. The inertia of the flywheel in kg-m^2 is

(A) 0·10

(B) 0·20

(C) 0·30

(D) 0·40

59. The equivalent torque on a shaft due to combined effect of bending moment M and torque T will be

(A) $\sqrt{M^2 + T^2 + 1}$

(B) $\sqrt{M^2 + T^2 - 1}$

(C) $\sqrt{M^2 + T^2}$

(D) $\sqrt{M^2 - T^2}$

60. The radius of gyration for a circular area of diameter D is

(A) $\frac{D}{2}$

(B) $\frac{D}{4}$

(C) $\frac{D^2}{2}$

(D) $\frac{D^2}{4}$

61. If N_1 and N_2 are the maximum and minimum speeds (r.p.m.) during a cycle, then the coefficient of fluctuation of speed is given by

(A) $\frac{2(N_1 + N_2)}{N_1 - N_2}$

(B) $\frac{2(N_1 - N_2)}{N_1 + N_2}$

(C) $\frac{N_1 - N_2}{2(N_1 + N_2)}$

(D) $\frac{N_1 + N_2}{2(N_1 - N_2)}$

62. In a step-up transformer, the number of turns in the primary coil is N_1 and in the secondary coil is N_2. The relation between N_1 and N_2 is

(A) $N_1 < N_2$

(B) $N_1 > N_2$

(C) $N_1 = N_2$

(D) $N_1 - N_2 = 1$

63. Which of the following motors is typically found on low horsepower applications?

(A) Permanent magnet DC motor

(B) Shunt DC motor

(C) Compound DC motor

(D) Series DC motor

64. A 220 V DC motor having an armature resistance of 0·8 ohm draws an armature current of 25 A. What will be the value of back e.m.f. induced?

(A) 240 V

(B) 220 V

(C) 200 V

(D) 216 V

65. In a salient pole synchronous motor, the developed reluctance torque attains the maximum value when the load angle in electrical degrees is

(A) 0°

(B) 45°

(C) 60°

(D) 90°

66. Given a 250 : 5 current transformer used with an ammeter reading of 2·7 A, what is the line current (primary current) in the circuit?

(A) 250 A

(B) 135 A

(C) 84 A

(D) 36 A

67. The armature of DC generator is laminated to

(A) reduce the bulk

(B) provide the bulk

(C) insulate the core

(D) reduce eddy-current loss

68. In a synchronous motor, the back e.m.f. is E_b and applied voltage is V. The condition of normal excitation of the motor is

(A) $E_b < V$

(B) $E_b = V$

(C) $E_b = 0$

(D) $E_b > V$

69. The winding resistance and leakage reactance of a transformer are R and X respectively. The impedance is given by

(A) $\sqrt{R^2 + X^2}$

(B) $\sqrt{R^2 - 2X^2}$

(C) $R^2 + X^2$

(D) $R^2 - X^2$

70. The 14-point philosophy which forms the foundation of Total Quality Management (TQM) was developed by

(A) Shewhart

(B) Deming

(C) Ishikawa

(D) Juran

71. Performance rating is equal to

(A) observed performance + normal performance

(B) observed performance – normal performance

(C) observed performance × normal performance

(D) observed performance ÷ normal performance

72. Just-in-Time (JIT) is a concept of

(A) human resource management

(B) quality management

(C) inventory management

(D) financial management

73. In VED analysis of inventory management, the letter D stands for

(A) demand

(B) defective

(C) desirable

(D) delicate

74. Critical path in a network has

(A) shortest time duration

(B) second longest duration

(C) delayed activities that do not delay the project

(D) largest time duration

75. In work study, the symbol ∇ represents

(A) operation

(B) delay

(C) storage

(D) inspection

76. Simplex method is the method used for

(A) value analysis

(B) network analysis

(C) linear programming

(D) queuing theory

77. Fixed position layout is also known as

(A) analytical layout

(B) synthetic layout

(C) static product layout

(D) economical layout

78. An assembly line consists of 4 tasks with times of 5, 8, 4 and 7 min. The cycle time for the line is 9 min. If the proposed layout has 4 workstations, the efficiency of this layout is

(A) 100%

(B) 75%

(C) 67%

(D) 50%

79. The operating characteristic curve (OC curve) shows the probability of

(A) rejection for every possible true percentage of defectives

(B) acceptance for every possible true percentage of defectives

(C) making type–I errors for various percentages of defectives

(D) making type–II errors for various percentages of defectives

80. An item can be purchased for ₹100. The ordering cost is ₹200 and the inventory carrying cost is 10% of the item cost per annum. If the annual demand is 4000 units, the economic order quantity (in units) is

(A) 50

(B) 100

(C) 200

(D) 400

81. What is the type of stress developed, when the shaft is subjected to pure torsion?

(A) Shear

(B) Axial

(C) Bending

(D) Normal

82. A steel ball of mass 1 kg and specific heat 0·4 kJ/kg is at a temperature of 60 °C. It is dropped into 1 kg water at 20 °C. The final steady state temperature of water is

(A) 23·5 °C

(B) 300 °C

(C) 535 °C

(D) 640 °C

83. A thin-walled spherical shell is subjected to an internal pressure. If the radius of the shell is increased by 1% and the thickness is reduced by 1%, with the internal pressure remaining the same, the percentage change of hoop stress is

(A) 0

(B) 1

(C) 1·08

(D) 2·02

84. A compression spring is made of music wire of 2 mm diameter having a shear strength and shear modulus of 800 MPa and 80 GPa respectively. The mean coil diameter is 20 mm, free length is 40 mm and the number of active coils is 10. If the mean diameter is reduced to 10 mm, the stiffness of the spring is approximately

(A) decreased by 8 times

(B) decreased by 2 times

(C) increased by 2 times

(D) increased by 8 times

85. If d is the diameter of rivet, then the margin (m) of a riveted joint is normally designed at

(A) $1{\cdot}5d$

(B) $2{\cdot}5d$

(C) $3{\cdot}5d$

(D) $4{\cdot}5d$

86. The inertia force in a system is directed at

(A) zero degrees to acceleration

(B) 45 degrees to acceleration

(C) 90 degrees to acceleration

(D) 180 degrees to acceleration

87. The mass moment of inertia of a flywheel of mass 2000 kg and radius of gyration 1·5 m is

(A) 4500 kg-m^2

(B) 2250 kg-m^2

(C) 3000 kg-m^2

(D) 1500 kg-m^2

88. In a plate clutch, the intensity of pressure is

(A) maximum at the outer radius of the friction surface

(B) minimum at the inner radius of the friction surface

(C) equal at the inner and outer radii of the friction surface

(D) minimum at the outer radius and maximum at the inner radius of the friction surface

89. The number of shoes in an internal expanding brake is

(A) 1

(B) 2

(C) 0

(D) 4

90. The SI unit of mass diffusion coefficient is

(A) kg/s

(B) m^2/s

(C) m/s

(D) m^3/s

91. In a psychrometric chart, the ordinate on the right-hand side of the chart represents

(A) dry-bulb temperature

(B) constant enthalpy lines

(C) wet-bulb temperature

(D) specific humidity

92. The condition of equilibrium of a body acted upon by three forces F_1, F_2 and F_3 having angle between the forces F_2 and F_3 as α, between F_1 and F_2 as β and between F_3 and F_1 as γ is given by

(A) $\frac{F_1}{\sin\beta} = \frac{F_2}{\sin\gamma} = \frac{F_3}{\sin\alpha}$

(B) $\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$

(C) $\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\gamma} = \frac{F_3}{\sin\beta}$

(D) $\frac{F_1}{\sin\gamma} = \frac{F_2}{\sin\alpha} = \frac{F_3}{\sin\beta}$

93. For a transformer under no-load condition, the loss which the primary input current has to supply is

(A) hysteresis loss

(B) eddy current loss

(C) copper loss in the secondary winding

(D) copper loss in the primary winding

94. If in a PERT network, the optimistic, most likely and pessimistic time estimates of an activity are given as t_o, t_l and t_p respectively, then the expected time of completion of the activity is given by

(A) $\frac{t_o + t_p + 4t_l}{6}$

(B) $\frac{t_o + 4t_p + t_l}{6}$

(C) $\frac{4t_o + t_p + t_l}{6}$

(D) $\frac{t_o + 2t_p + t_l}{6}$

95. The instrument/device which helps an equipment to maintain a desired humidity level in the air is

(A) hydrometer

(B) humidistat

(C) humidifier

(D) dehumidifier

96. In a bimetal thermostat, the alloy used having low coefficient of thermal expansion is

(A) Invar

(B) brass

(C) Inconel

(D) bronze

97. The emissivity of a black body is

(A) 0

(B) 0·5

(C) 0·75

(D) 1

98. The unit of Stefan-Boltzmann constant is

(A) watt/mK

(B) watt/m^2K^2

(C) watt/m^2K^4

(D) watt/mK^2

99. Usually fins are provided to increase the rate of heat transfer. But fins also act as insulation. Which one of the following non-dimensional numbers decides this factor?

(A) Eckert number

(B) Biot number

(C) Fourier number

(D) Peclet number

100. Price of a product is reduced and some additional offer is made in which of the following phases of product life cycle?

(A) Introduction phase

(B) Growth phase

(C) Maturity phase

(D) Declining phase

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