Q.1 – Q.20 Carry One Mark Each.

1. Match the items in columns I and II.

Column I	Column II
(P) Gauss-Seidel method	(1) Interpolation
(Q) Forward Newton-Gauss method	(2) Non-linear differential equations
(R) Runge-Kutta method	(3) Numerical integration
(S) Trapezoidal Rule	(4) Linear algebraic equations

    (A) P - 1   Q - 4   R - 3   S - 2
    (B) P - 1   Q - 4   R - 2   S - 3
    (C) P - 1   Q - 3   R - 2   S - 4
    (D) P - 4   Q - 1   R - 2   S - 3

2. The solution of the differential equation

$$\frac{dy}{dx} + 2xy = e^{-x^2} \text{ with } y(0) = 1 \text{ is:}$$

    (A) $(1 + x)e^{+x^2}$

    (B) $(1 + x)e^{-x^2}$

    (C) $(1 - x)e^{+x^2}$

    (D) $(1 - x)e^{-x^2}$

3. Let x denote a real number. Find out the INCORRECT statement.

    (A) $S = \{x : x > 3\}$ represents the set of all real numbers greater than 3

    (B) $S = \{x : x^2 < 0\}$ represents the empty set

    (C) $S = \{x : x \in A \text{ and } x \in B\}$ represents the union of set A and set B

    (D) $S = \{x : a < x < b\}$ represents the set of all real numbers between a and b, where a and b are real numbers.

4. A box contains 20 defective items and 80 non-defective items. If two items are selected at random without replacement, what will be the probability that both items are defective.?

    (A) $\frac{1}{5}$

(B) $\dfrac{1}{25}$

(C) $\dfrac{20}{99}$

(D) $\dfrac{19}{495}$

5. For a circular shaft of diameter d subjected to torque T, the maximum value of the shear stress is:

(A) $\dfrac{64T}{\pi d^3}$

(B) $\dfrac{32T}{\pi d^3}$

(C) $\dfrac{16T}{\pi d^3}$

(D) $\dfrac{8T}{\pi d^3}$

6. For a four-bar linkage in toggle position, the value of mechanical advantage is:
   (A) 0.0
   (B) 0.5
   (C) 1.0
   (D) ∞

7. The differential equation governing the vibrating system is:
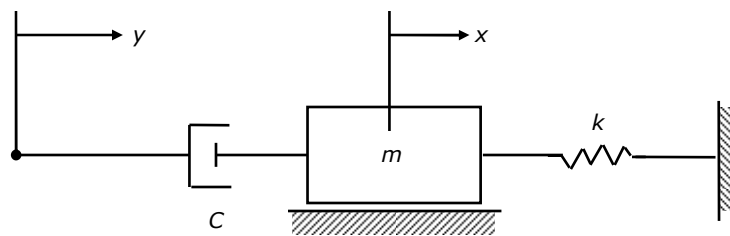
(A) $m\ddot{x} + c\dot{x} + k\left(x - y\right) = 0$

(B) $m\left(\ddot{x} - \ddot{y}\right) + c\left(\dot{x} - \dot{y}\right) + kx = 0$

(C) $m\ddot{x} + c(\dot{x} - \dot{y}) + kx = 0$

(D) $m(\ddot{x} - \ddot{y}) + c(\dot{x} - \dot{y}) + k(x - y) = 0$

8. A pin-ended column of length L, modulus of elasticity E and second moment of the cross-sectional area I is loaded centrically by a compressive load P. the critical buckling load (P_{cr}) is given by

(A) $P_{cr} = \dfrac{EI}{\pi^2 L^2}$

(B) $P_{cr} = \dfrac{\pi^2 EI}{3L^2}$

(C) $P_{cr} = \dfrac{\pi EI}{L^2}$

(D) $P_{cr} = \dfrac{\pi^2 EI}{L^2}$

9. The number of inversions for a slider crank mechanism is:
   (A) 6
   (B) 5
   (C) 4
   (D) 3

10. For a Newtonian fluid
   (A) shear stress is proportional to shear strain
   (B) rate of shear stress is proportional to shear strain
   (C) shear stress is proportional to rate of shear strain
   (D) rate of shear stress is proportional to rate of shear strain

11. In a two-dimensional velocity field with velocities u and v along the x and y directions respectively, the convective acceleration along the x-direction is given by

(A) $u\dfrac{\partial u}{\partial x} + v\dfrac{\partial u}{\partial y}$

(B) $u\dfrac{\partial u}{\partial x} + v\dfrac{\partial v}{\partial y}$

(C) $u\dfrac{\partial v}{\partial x} + v\dfrac{\partial u}{\partial y}$

(D) $v\dfrac{\partial u}{\partial x} + u\dfrac{\partial u}{\partial y}$

12. Dew point temperature is the temperature at which condensation begins when the air is cooled at constant.

(A) volume

(B) entropy

(C) pressure

(D) enthalpy

13. In a composite slab, the temperature at the interface (T_{inter}) between two materials is equal to the average of the temperatures at the two ends. Assuming steady one-dimensional heat conduction, which of the following statements is true about the respective thermal conductivities?
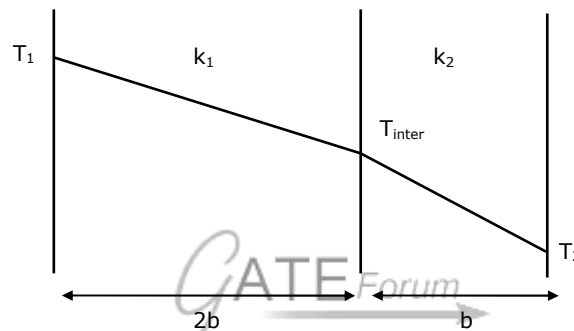
(A) $2k_1 = k_2$

(B) $k_1 = k_2$

(C) $2k_1 = 3k_2$

(D) $k_1 = 2k_2$

14. In a Pelton wheel, the bucket peripheral speed is 10 m/s, the water jet velocity is 25 m/s and volumetric flow rate of the jet is 0.1 m^3/s. If the jet deflection angle is 120° and the flow is ideal, the owe developed is:

(A) 7.5 kW

(B) 15.0 kW

(C) 22.5 kW

(D) 37.5 kW

15. An expendable pattern is used in

(A) slush casting

(B) squeeze casting

(C) centrifugal casting

(D) investment casting

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16. The main purpose of spheroidising treatment is to improve

    (A) hardenability of low carbon steels

    (B) machinability of low carbon steels

    (C) hardenability of high carbon steels

    (D) machinability of high carbon steels

17. NC contouring is an example of

    (A) continuous path positioning

    (B) point-to-point positioning

    (C) absolute positioning

    (D) incremental positioning

18. A ring gage is used to measure

    (A) outside diameter but not roundness

    (B) roundness but not outside diameter

    (C) both outside diameter and roundness

    (D) only external threads

19. The number of customers arriving at a railway reservation counter is Poisson distributed with an arrival rate of eight customers per hour. The reservation clerk at this counter takes six minutes per customer on an average with an exponentially distributed service time. The average number of the customers in the queue will be

    (A) 3

    (B) 3.2

    (C) 4

    (D) 4.2

20. In an MRP system, component demand is:

    (A) forecasted

    (B) established by the master production schedule

    (C) calculated by the MRP system from the master production schedule

    (D) ignored

Q.21 to Q.75 Carry Two Marks Each.

21. Eigen values of a matrix

$S \equiv \begin{bmatrix} 3 & 2 \\ 2 & 3 \end{bmatrix}$ are 5 and 1. What are the eigen values of the matrix $S^2 = SS$?

(A) 1 and 25

(B) 6 and 4

(C) 5 and 1

(D) 2 and 10

22. Equation of the line normal to function

$f(x) = (x-8)^{\frac{2}{3}} + 1$ at $P(0,5)$ is:

(A) $y = 3x - 5$

(B) $y = 3x + 5$

(C) $3y = x + 15$

(D) $3y = x - 15$

23. Assuming $i = \sqrt{-1}$ and t is a real number, $\int_{0}^{\frac{\pi}{3}} e^{it} dt$ is:

(A) $\frac{\sqrt{3}}{2} + i\frac{1}{2}$

(B) $\frac{\sqrt{3}}{2} - i\frac{1}{2}$

(C) $\frac{1}{2} + i\frac{\sqrt{3}}{2}$

(D) $\frac{1}{2} + i\left(1 - \frac{\sqrt{3}}{2}\right)$

24. If $f(x) = \frac{2x^2 - 7x + 3}{5x^2 - 12x - 9}$, then $\lim_{x \to 3} f(x)$ will be

(A) $\frac{-1}{3}$

(B) $\frac{5}{18}$

(C) 0

(D) $\frac{2}{5}$

25. Match the items in columns I and II.

Price quoted by a supplier

Order quantity (units)	Unit price (Rs.)
< 500	10
≥ 500	9

Annual demand: 2500 units per year

Ordering cost: Rs.100 per order

Inventory holding rate: 25% of unit price.

The optimum order quantity (in units) is:

(A) 447

(B) 471

(C) 500

(D) ≥ 600

68.   A firm is required to procure three items (P, Q and R). The prices quoted for these items (in Rs.) by suppliers S1, S2 and S3 are given in table. The management policy requires that each item has to be supplied by only one supplier and one supplier supply only one item. The minimum total cost (in Rs.) of procurement to the firm is:

Item	Suppliers		
	S1	S2	S3
P	110	120	130
Q	115	140	140
R	125	145	165

(A) 350

(B) 360

(C) 385

(D) 395

69.   A stockist wishes to optimize the number of perishable items he needs to stock in any month in his store. The demand distribution for this perishable item is:

Demand (in units)	2	3	4	5
Probability	0.10	0.35	0.35	0.20

The stockist pays Rs.70 for each item and he sells each at Rs.90. if the stock is left unsold in any month, he can sell the item at Rs.50 each. There is no penalty for unfulfilled demand. To maximize the expected profit, the optimal stock level is:

(A) 5 units

(B) 4 units

(C) 3 units

(D) 2 units

70.   The table gives details of an assembly line.

Work station	I	II	III	IV	V	VI
Total task time at the workstation (in minutes)	7	9	7	10	9	6

What is the line efficiency of the assembly line?

(A) 70%

(B) 75%

(C) 80%

(D) 85%

Common Data Questions

Common Data for Questions 71, 72, 73:

In an orthogonal machining operation:

Uncut thickness = 0.5 mm   Cutting speed = 20 m/min

Width of cut = 5 mm   Chip thickness = 0.7 mm

Thrust force = 200 N   Cutting force = 1200 N

Rake angle = 15°

Assume Merchant's theory.

71.   The values of shear angle and shear strain, respectively, are

(A) 30.3° and 1.98

(B) 30.3° and 4.23

(C) 40.2° and 2.97

(D) 40.2° and 1.65

72.   The coefficient of friction at the tool-chip interface is:

(A) 0.23

(B) 0.46

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(C) 0.85

(D) 0.95

73.   The percentage of total energy dissipated due to friction at the tool-chip interface is:

(A) 30%

(B) 42%

(C) 58%

(D) 70%

Common Data for Questions 74, 75:

A planetary gear train has four gears and one carrier. Angular velocities of the gears are $\omega_1, \omega_2, \omega_3$ and ω_4 respectively. The carrier rotates with angular velocity ω_5.
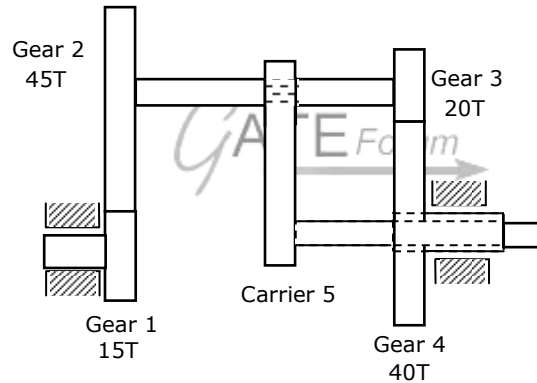
74.   What is the relation between the angular velocities of Gear 1 and Gear 4?

(A) $\dfrac{\omega_1 - \omega_5}{\omega_4 - \omega_5} = 6$

(B) $\dfrac{\omega_4 - \omega_5}{\omega_1 - \omega_5} = 6$

(C) $\dfrac{\omega_1 - \omega_2}{\omega_4 - \omega_3} = -\left(\dfrac{2}{3}\right)$

(D) $\dfrac{\omega_2 - \omega_5}{\omega_4 - \omega_5} = \dfrac{8}{9}$

75.   For $\omega_1 = 60$ rpm clockwise (cw) when looked from the left, what is the angular velocity of the carrier and its direction so that Gear 4 rotates in counterclockwise (ccw) direction at twice the angular velocity of Gear 1 when looked from the left

(A) 130 rpm, cw

(B) 223 prm, ccw

(C) 256 rpm, cw

(D) 156 rpm, ccw

Linked Answer Questions: Q.76 to Q85 Carry Two Marks Each

Statement for Linked Answer Questions 76 & 77:

A simply supported beam of span length 6 m and 75 mm diameter carries a uniformly distributed load of 1.5 kN/m.

76.   What is the maximum value of bending moment?
   (A) 9 kNm
   (B) 13.5 kNm
   (C) 81 kNm
   (D) 125 kNm

77.   What is the maximum value of bending stress?
   (A) 162.98 MPa
   (B) 325.95 MPa
   (C) 625.95 MPa
   (D) 651.90 MPa

Statement for Linked Answer Questions 78 & 79:

A vibratory system consists of a mass 12.5 kg, a spring of stiffness 1000 N/m, and a dashpot with damping coefficient of 15 Ns/m.

78.   The value of critical damping of the system is:
   (A) 0.223 Ns/m
   (B) 17.88 Ns/m
   (C) 71.4 Ns/m
   (D) 223.6 Ns/m

79.   The value of logarithmic decrement is:
   (A) 1.35
   (B) 1.32
   (C) 0.68
   (D) 0.66

Statement for Linked Answer Questions 80 & 81:

A football was inflated to a gauge pressure of 1 bar when the ambient temperature was 15°C. When the game started next day, the air temperature at the stadium was 5°C. Assume that the volume of the football remains constant at 2500 cm^3.

80. The amount of heat lost by the air in the football and the gauge pressure of air in the football at the stadium respectively equal

(A) 30.6 J, 1.94 bar

(B) 21.8 J, 0.93 bar

(C) 61.1 J, 1.94 bar

(D) 43.7 J, 0.93 bar

81. Gauge pressure of air to which the ball must have been originally inflated so that it would equal 1 bar gauge at the stadium is:

(A) 2.23 bar

(B) 1.94 bar

(C) 1.07 bar

(D) 1.00 bar

Statement for Linked Answer Questions 82 & 83:

A smooth flat plate with a sharp leading edge is placed along a gas stream flowing at U = 10 m/s. The thickness of the boundary layer at section $r - s$ is 10 mm, the breadth of the plate is 1 m (into the paper) and the density of the gas $\rho = 1.0$ kg/m^3. Assume that the boundary layer is thin, two-dimensional, and follows a linear velocity distribution, $u = U\left(y/\delta\right)$, at the section $r - s$, where y is the height from plate.

82. The mass flow rate (in kg/s) across the section $q - r$ is:

(A) zero

(B) 0.05

(C) 0.10

(D) 0.15

83. The integrated drag force (in N) on the plate, between $p - s$, is:

(A) 0.67

(B) 0.33

(C) 0.17

(D) zero

Statement for Linked Answer Questions 84 & 85:

Consider a PERT network for a project involving six tasks (a to f).

Task	Predecessor	Expected task time (in days)	Variance of the task time (in days^2)
a	-	30	25
b	a	40	64
c	a	60	81
d	b	25	9
e	b, c	45	36
f	d, e	20	9

84.   The expected completion time of the project is:
   (A) 238 days
   (B) 224 days
   (C) 171 days
   (D) 155 days

85.   The standard deviation of the critical path of the project is:
   (A) $\sqrt{151}$ days
   (B) $\sqrt{155}$ days
   (C) $\sqrt{200}$ days
   (D) $\sqrt{238}$ days