

Q. 1 – Q. 25 carry one mark each.

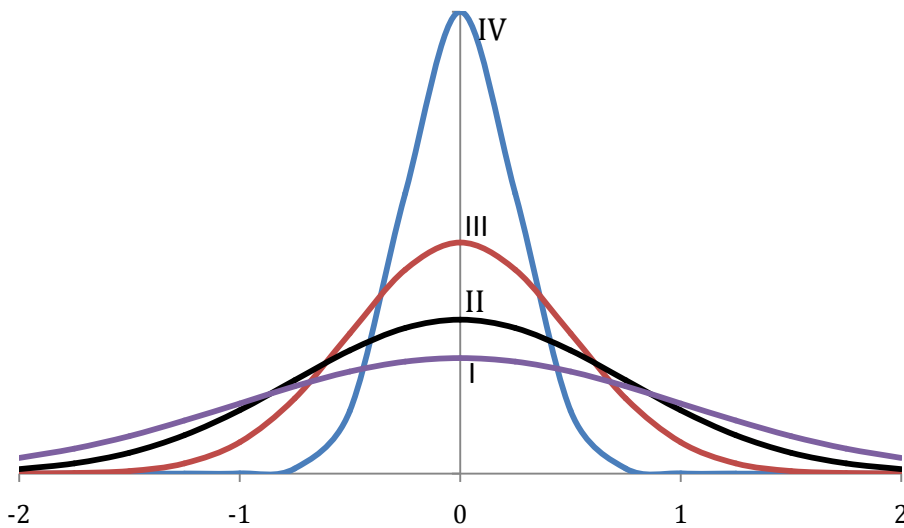
Q.1

If any two columns of a determinant $P = \begin{vmatrix} 4 & 7 & 8 \\ 3 & 1 & 5 \\ 9 & 6 & 2 \end{vmatrix}$ are interchanged, which one of the following statements regarding the value of the determinant is **CORRECT**?

- (A) Absolute value remains unchanged but sign will change.
 (B) Both absolute value and sign will change.
 (C) Absolute value will change but sign will not change.
 (D) Both absolute value and sign will remain unchanged.

Q.2

Among the four normal distributions with probability density functions as shown below, which one has the lowest variance?



- (A) I (B) II (C) III (D) IV

Q.3

Simpson's $\frac{1}{3}$ rule is used to integrate the function $f(x) = \frac{3}{5}x^2 + \frac{9}{5}$ between $x = 0$ and $x = 1$ using the least number of equal sub-intervals. The value of the integral is _____

Q.4

The value of $\lim_{x \rightarrow 0} \frac{1 - \cos(x^2)}{2x^4}$ is

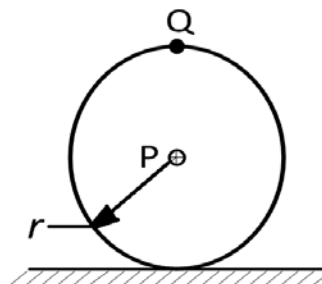
- (A) 0 (B) $\frac{1}{2}$ (C) $\frac{1}{4}$ (D) undefined

Q.5

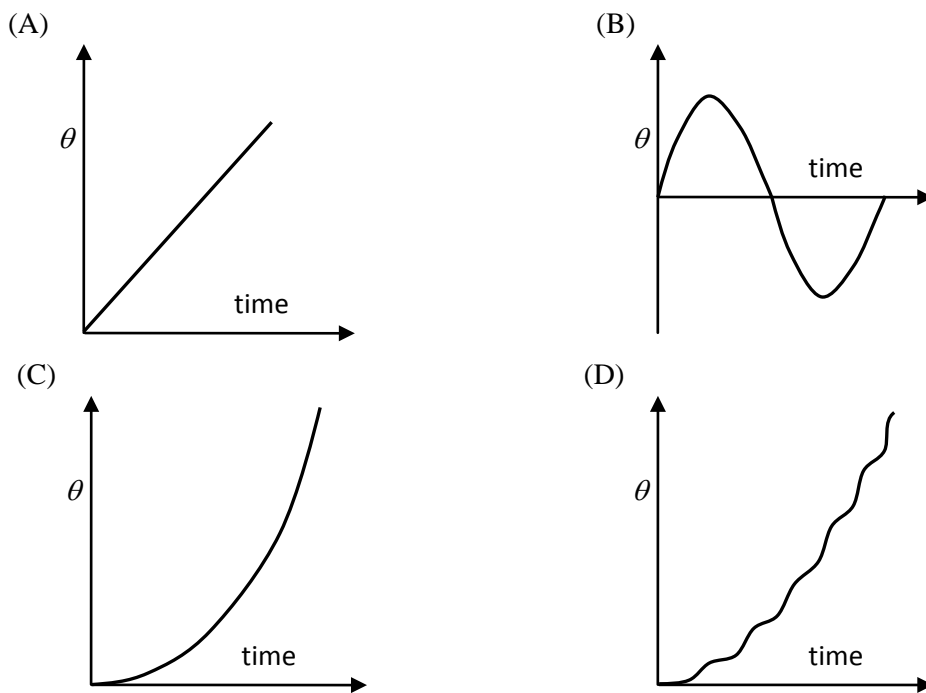
Given two complex numbers $z_1 = 5 + (5\sqrt{3})i$ and $z_2 = \frac{2}{\sqrt{3}} + 2i$, the argument of $\frac{z_1}{z_2}$ in degrees is

- (A) 0 (B) 30 (C) 60 (D) 90

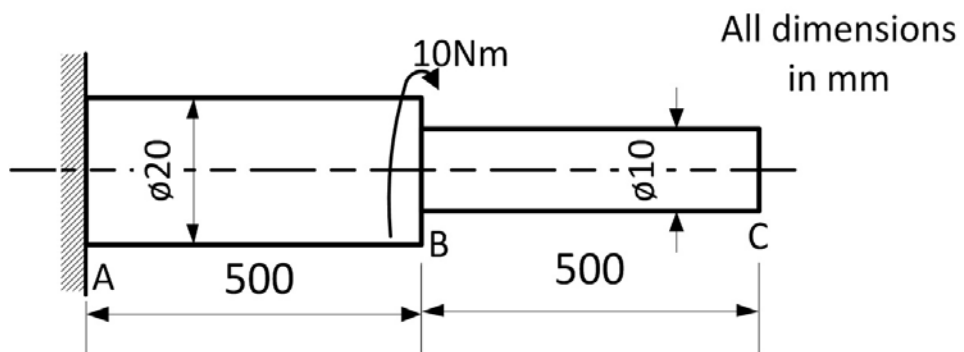
- Q.6 Consider fully developed flow in a circular pipe with negligible entrance length effects. Assuming the mass flow rate, density and friction factor to be constant, if the length of the pipe is doubled and the diameter is halved, the head loss due to friction will increase by a factor of
 (A) 4 (B) 16 (C) 32 (D) 64
- Q.7 The Blasius equation related to boundary layer theory is a
 (A) third-order linear partial differential equation
 (B) third-order nonlinear partial differential equation
 (C) second-order nonlinear ordinary differential equation
 (D) third-order nonlinear ordinary differential equation
- Q.8 For flow of viscous fluid over a flat plate, if the fluid temperature is the same as the plate temperature, the thermal boundary layer is
 (A) thinner than the velocity boundary layer
 (B) thicker than the velocity boundary layer
 (C) of the same thickness as the velocity boundary layer
 (D) not formed at all
- Q.9 For an ideal gas with constant values of specific heats, for calculation of the specific enthalpy,
 (A) it is sufficient to know only the temperature
 (B) both temperature and pressure are required to be known
 (C) both temperature and volume are required to be known
 (D) both temperature and mass are required to be known
- Q.10 A Carnot engine (CE-1) works between two temperature reservoirs A and B, where $T_A = 900$ K and $T_B = 500$ K. A second Carnot engine (CE-2) works between temperature reservoirs B and C, where $T_C = 300$ K. In each cycle of CE-1 and CE-2, all the heat rejected by CE-1 to reservoir B is used by CE-2. For one cycle of operation, if the net Q absorbed by CE-1 from reservoir A is 150 MJ, the net heat rejected to reservoir C by CE-2 (in MJ) is _____
- Q.11 Air enters a diesel engine with a density of 1.0 kg/m^3 . The compression ratio is 21. At steady state, the air intake is $30 \times 10^{-3} \text{ kg/s}$ and the net work output is 15 kW. The mean effective pressure (in kPa) is _____
- Q.12 A stream of moist air (mass flow rate = 10.1 kg/s) with humidity ratio of $0.01 \frac{\text{kg}}{\text{kg dry air}}$ mixes with a second stream of superheated water vapour flowing at 0.1 kg/s . Assuming proper and uniform mixing with no condensation, the humidity ratio of the final stream (in $\frac{\text{kg}}{\text{kg dry air}}$) is _____
- Q.13 A wheel of radius r rolls without slipping on a horizontal surface shown below. If the velocity of point P is 10 m/s in the horizontal direction, the magnitude of velocity of point Q (in m/s) is _____



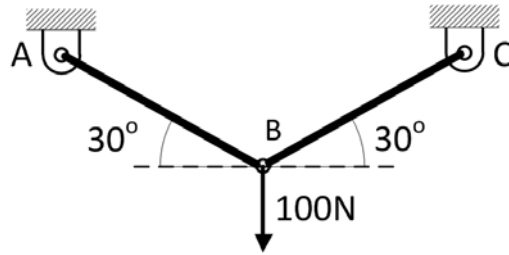
Q.14 Consider a slider crank mechanism with nonzero masses and inertia. A constant torque τ is applied on the crank as shown in the figure. Which of the following plots best resembles variation of crank angle, θ versus time



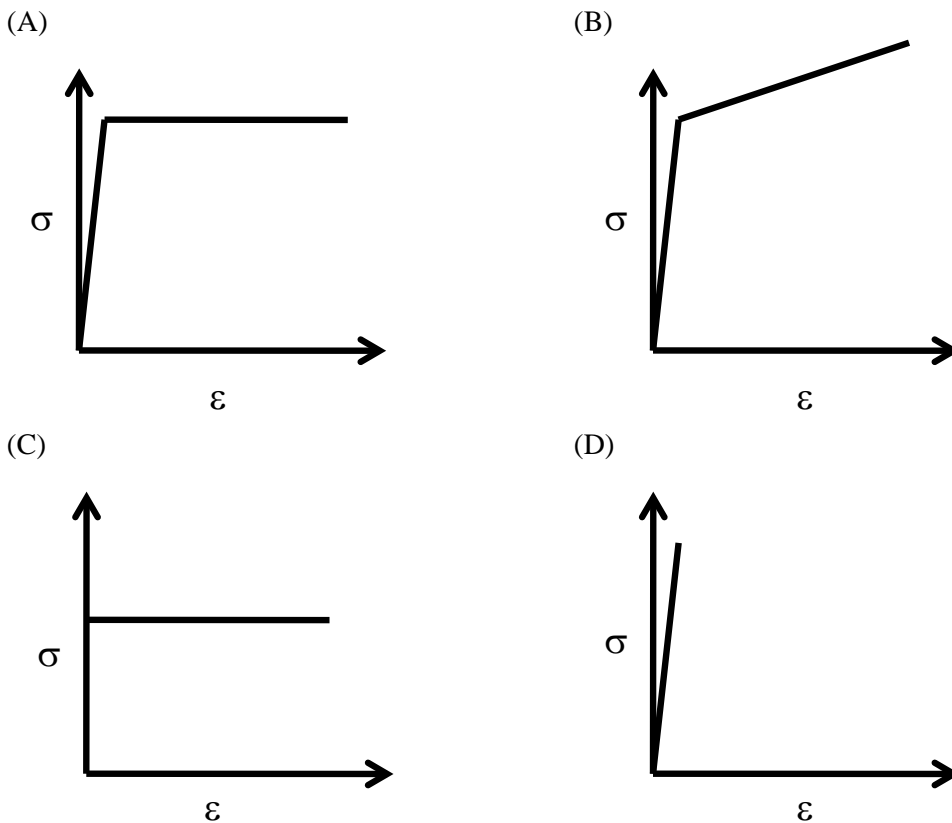
Q.15 Consider a stepped shaft subjected to a twisting moment applied at B as shown in the figure. Assume shear modulus, $G = 77 \text{ GPa}$. The angle of twist at C (in degrees) is _____



- Q.16 Two identical trusses support a load of 100 N as shown in the figure. The length of each truss is 1.0 m; cross-sectional area is 200 mm^2 ; Young's modulus $E = 200 \text{ GPa}$. The force in the truss AB (in N) is _____



- Q.17 Consider a steel (Young's modulus $E = 200 \text{ GPa}$) column hinged on both sides. Its height is 1.0 m and cross-section is $10 \text{ mm} \times 20 \text{ mm}$. The lowest Euler critical buckling load (in N) is _____
- Q.18 A swimmer can swim 10 km in 2 hours when swimming along the flow of a river. While swimming against the flow, she takes 5 hours for the same distance. Her speed in still water (in km/h) is _____
- Q.19 Which one of the following is the most conservative fatigue failure criterion?
- (A) Soderberg
(B) Modified Goodman
(C) ASME Elliptic
(D) Gerber
- Q.20 Which one of the following types of stress-strain relationship best describes the behaviour of brittle materials, such as ceramics and thermosetting plastics, ($\sigma = \text{stress}$ and $\epsilon = \text{strain}$)?



Q.21 Match the following products with preferred manufacturing processes:

Product		Process	
P	Rails	1	Blow molding
Q	Engine crankshaft	2	Extrusion
R	Aluminium channels	3	Forging
S	PET water bottles	4	Rolling

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

Q.22 Holes of diameter $25.0^{+0.040}_{+0.020}$ mm are assembled interchangeably with the pins of diameter $25.0^{+0.005}_{-0.008}$ mm. The minimum clearance in the assembly will be

- (A) 0.048 mm
 (B) 0.015 mm
 (C) 0.005 mm
 (D) 0.008 mm

Q.23 Under certain cutting conditions, doubling the cutting speed reduces the tool life to $\left(\frac{1}{16}\right)^{th}$ of the original. Taylor's tool life index (n) for this tool-workpiece combination will be _____

Q.24 In a linear arc welding process, the heat input per unit length is inversely proportional to

- (A) welding current
 (B) welding voltage
 (C) welding speed
 (D) duty cycle of the power source

Q.25 The function of interpolator in a CNC machine controller is to

- (A) control spindle speed
 (B) coordinate feed rates of axes
 (C) control tool rapid approach speed
 (D) perform Miscellaneous (M) functions (tool change, coolant control etc.)

Q. 26 – Q. 55 carry two marks each.

Q.26 Consider a spatial curve in three-dimensional space given in parametric form by

$$x(t) = \cos t, \quad y(t) = \sin t, \quad z(t) = \frac{2}{\pi}t, \quad 0 \leq t \leq \frac{\pi}{2}.$$

The length of the curve is _____

Q.27 Consider an ant crawling along the curve $(x - 2)^2 + y^2 = 4$, where x and y are in meters. The ant starts at the point $(4, 0)$ and moves counter-clockwise with a speed of 1.57 meters per second. The time taken by the ant to reach the point $(2, 2)$ is (in seconds) _____

Q.28 Find the solution of $\frac{d^2y}{dx^2} = y$ which passes through the origin and the point $(\ln 2, \frac{3}{4})$.

(A) $y = \frac{1}{2}e^x - e^{-x}$

(B) $y = \frac{1}{2}(e^x + e^{-x})$

(C) $y = \frac{1}{2}(e^x - e^{-x})$

(D) $y = \frac{1}{2}e^x + e^{-x}$

Q.29 The probability of obtaining at least two "SIX" in throwing a fair dice 4 times is

(A) $425/432$

(B) $19/144$

(C) $13/144$

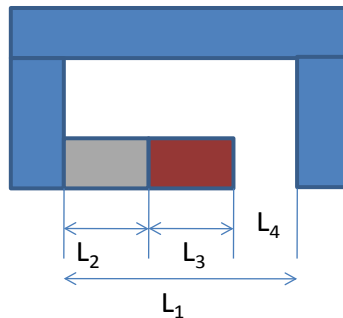
(D) $125/432$

Q.30 In the assembly shown below, the part dimensions are:

$L_1 = 22.0 \pm 0.01$ mm,

$L_2 = L_3 = 10.0 \pm 0.005$ mm.

Assuming the normal distribution of part dimensions, the dimension L_4 in mm for assembly condition would be:



(A) 2.0 ± 0.008

(B) 2.0 ± 0.012

(C) 2.0 ± 0.016

(D) 2.0 ± 0.020

Q.31 A DC welding power source has a linear voltage-current ($V-I$) characteristic with open circuit voltage of 80 V and a short circuit current of 300 A. For maximum arc power, the current (in Amperes) should be set as _____

Q.32 A triangular facet in a CAD model has vertices: P1(0,0,0); P2(1,1,0) and P3(1,1,1). The area of the facet is

(A) 0.500

(B) 0.707

(C) 1.414

(D) 1.732

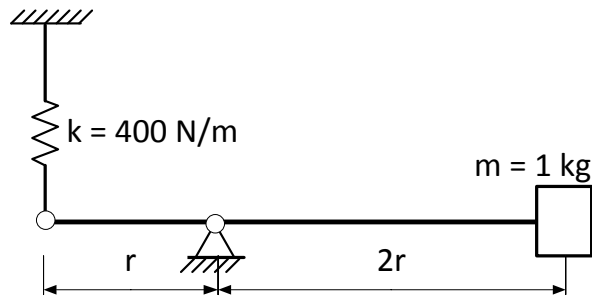
- Q.33 Following data refers to the activities of a project, where, node 1 refers to the start and node 5 refers to the end of the project.

Activity	Duration (days)
1-2	2
2-3	1
4-3	3
1-4	3
2-5	3
3-5	2
4-5	4

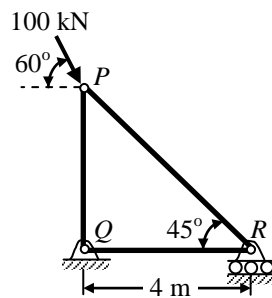
The critical path (CP) in the network is

- (A) 1-2-3-5
 (B) 1-4-3-5
 (C) 1-2-3-4-5
 (D) 1-4-5
- Q.34 For a canteen, the actual demand for disposable cups was 500 units in January and 600 units in February. The forecast for the month of January was 400 units. The forecast for the month of March considering smoothing coefficient as 0.75 is _____
- Q.35 An orthogonal turning operation is carried out under the following conditions: rake angle = 5° ; spindle rotational speed = 400 rpm; axial feed = 0.4 m/min and radial depth of cut = 5 mm. The chip thickness, t_c , is found to be 3 mm. The shear angle (in degrees) in this turning process is _____
- Q.36 The solidification time of a casting is proportional to $\left(\frac{V}{A}\right)^2$, where V is the volume of the casting and A is the total casting surface area losing heat. Two cubes of same material and size are cast using sand casting process. The top face of one of the cubes is completely insulated. The ratio of the solidification time for the cube with top face insulated to that of the other cube is
- (A) $\frac{25}{36}$ (B) $\frac{36}{25}$ (C) 1 (D) $\frac{6}{5}$
- Q.37 In a slab rolling operation, the maximum thickness reduction (Δh_{max}) is given by $\Delta h_{max} = \mu^2 R$, where R is the radius of the roll and μ is the coefficient of friction between the roll and the sheet. If $\mu = 0.1$, the maximum angle subtended by the deformation zone at the centre of the roll (bite angle in degrees) is _____

- Q.38 Considering massless rigid rod and small oscillations, the natural frequency (in rad/s) of vibration of the system shown in the figure is

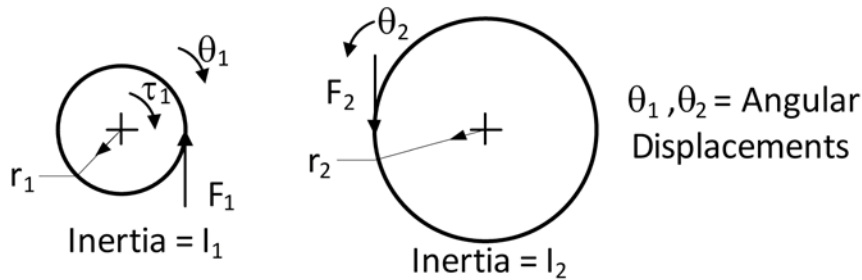


- (A) $\sqrt{\frac{400}{1}}$ (B) $\sqrt{\frac{400}{2}}$ (C) $\sqrt{\frac{400}{3}}$ (D) $\sqrt{\frac{400}{4}}$
- Q.39 For the truss shown in figure, the magnitude of the force in member PR and the support reaction at R are respectively



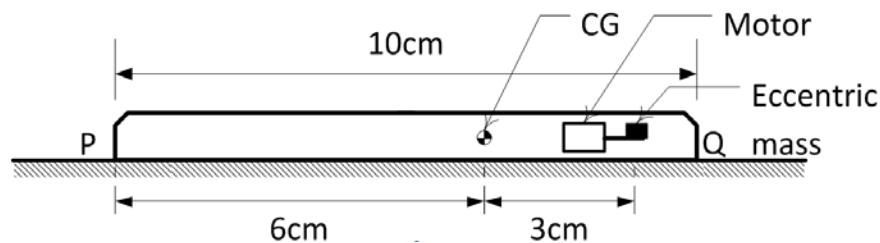
- (A) 122.47 kN and 50 kN (B) 70.71 kN and 100 kN
 (C) 70.71 kN and 50 kN (D) 81.65 kN and 100 kN
- Q.40 A ball of mass 0.1 kg, initially at rest, is dropped from height of 1 m. Ball hits the ground and bounces off the ground. Upon impact with the ground, the velocity reduces by 20%. The height (in m) to which the ball will rise is _____

- Q.41 A pinion with radius r_1 , and inertia I_1 is driving a gear with radius r_2 and inertia I_2 . Torque τ_1 is applied on pinion. The following are free body diagrams of pinion and gear showing important forces (F_1 and F_2) of interaction. Which of the following relations hold true?



- (A) $F_1 \neq F_2$; $\tau_1 = I_1 \ddot{\theta}_1$; $F_2 = I_2 \frac{r_1}{r_2} \ddot{\theta}_1$
 (B) $F_1 = F_2$; $\tau_1 = \left[I_1 + I_2 \left(\frac{r_1}{r_2} \right)^2 \right] \ddot{\theta}_1$; $F_2 = I_2 \frac{r_1}{r_2} \ddot{\theta}_1$
 (C) $F_1 = F_2$; $\tau_1 = I_1 \ddot{\theta}_1$; $F_2 = I_2 \frac{1}{r_2} \ddot{\theta}_2$
 (D) $F_1 \neq F_2$; $\tau_1 = \left[I_1 + I_2 \left(\frac{r_1}{r_2} \right)^2 \right] \ddot{\theta}_1$; $F_2 = I_2 \frac{1}{r_2} \ddot{\theta}_2$

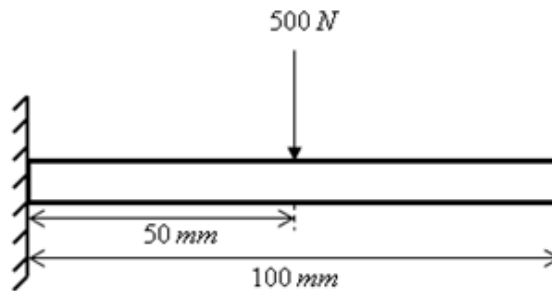
- Q.42 A mobile phone has a small motor with an eccentric mass used for vibrator mode. The location of the eccentric mass on motor with respect to center of gravity (CG) of the mobile and the rest of the dimensions of the mobile phone are shown. The mobile is kept on a flat horizontal surface.



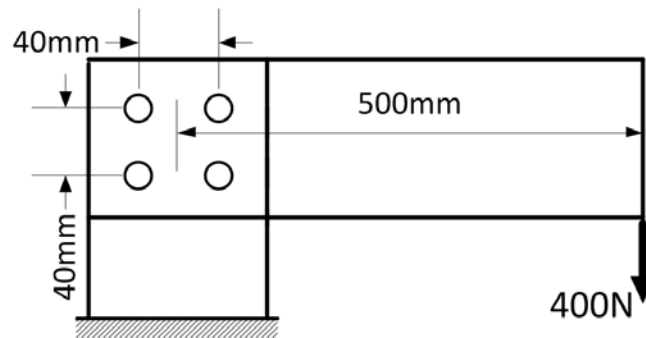
Given in addition that the eccentric mass = 2 grams, eccentricity = 2.19 mm, mass of the mobile = 90 grams, $g = 9.81 \text{ m/s}^2$. Uniform speed of the motor in RPM for which the mobile will get just lifted off the ground at the end Q is approximately

- (A) 3000 (B) 3500 (C) 4000 (D) 4500
- Q.43 A machine element is subjected to the following bi-axial state of stress: $\sigma_x = 80 \text{ MPa}$; $\sigma_y = 20 \text{ MPa}$; $\tau_{xy} = 40 \text{ MPa}$. If the shear strength of the material is 100 MPa, the factor of safety as per Tresca's maximum shear stress theory is
- (A) 1.0 (B) 2.0 (C) 2.5 (D) 3.3

- Q.44 A cantilever beam with flexural rigidity of 200 N.m^2 is loaded as shown in the figure. The deflection (in mm) at the tip of the beam is _____



- Q.45 A precision instrument package ($m = 1 \text{ kg}$) needs to be mounted on a surface vibrating at 60 Hz . It is desired that only 5% of the base surface vibration amplitude be transmitted to the instrument. Assume that the isolation is designed with its natural frequency significantly lesser than 60 Hz , so that the effect of damping may be ignored. The stiffness (in N/m) of the required mounting pad is _____
- Q.46 A horizontal plate has been joined to a vertical post using four rivets arranged as shown in the figure. The magnitude of the load on the worst loaded rivet (in N) is _____



- Q.47 For flow through a pipe of radius R , the velocity and temperature distribution are as follows:

$$u(r, x) = C_1, \text{ and } T(r, x) = C_2 \left[1 - \left(\frac{r}{R} \right)^3 \right], \text{ where } C_1 \text{ and } C_2 \text{ are constants.}$$

The bulk mean temperature is given by $T_m = \frac{2}{U_m R^2} \int_0^R u(r, x) T(r, x) r dr$, with U_m being the mean velocity of flow. The value of T_m is

- (A) $\frac{0.5C_2}{U_m}$ (B) $0.5C_2$ (C) $0.6C_2$ (D) $\frac{0.6C_2}{U_m}$

Q.48 Match the following pairs:

Equation		Physical Interpretation	
P	$\nabla \times \vec{V} = 0$	I	Incompressible continuity equation
Q	$\nabla \cdot \vec{V} = 0$	II	Steady flow
R	$\frac{D\vec{V}}{Dt} = 0$	III	Irrotational flow
S	$\frac{\partial \vec{V}}{\partial t} = 0$	IV	Zero acceleration of fluid particle

- (A) P-IV, Q-I, R-II, S-III
 (B) P-IV, Q-III, R-I, S-II
 (C) P-III, Q-I, R-IV, S-II
 (D) P-III, Q-I, R-II, S-IV

Q.49 The velocity field of an incompressible flow is given by

$\vec{V} = (a_1x + a_2y + a_3z)\mathbf{i} + (b_1x + b_2y + b_3z)\mathbf{j} + (c_1x + c_2y + c_3z)\mathbf{k}$, where $a_1 = 2$ and $c_3 = -4$. The value of b_2 is _____

Q.50 A 10 mm diameter electrical conductor is covered by an insulation of 2 mm thickness. The conductivity of the insulation is 0.08 W/m-K and the convection coefficient at the insulation surface is 10 W/m²-K. Addition of further insulation of the same material will

- (A) increase heat loss continuously
 (B) decrease heat loss continuously
 (C) increase heat loss to a maximum and then decrease heat loss
 (D) decrease heat loss to a minimum and then increase heat loss

Q.51 Temperature of nitrogen in a vessel of volume 2 m³ is 288 K. A U-tube manometer connected to the vessel shows a reading of 70 cm of mercury (level higher in the end open to atmosphere). The universal gas constant is 8314 J/kmol-K, atmospheric pressure is 1.01325 bar, acceleration due to gravity is 9.81 m/s² and density of mercury is 13600 kg/m³. The mass of nitrogen (in kg) in the vessel is _____

Q.52 Air ($\rho = 1.2$ kg/m³ and kinematic viscosity, $\nu = 2 \times 10^{-5}$ m²/s) with a velocity of 2 m/s flows over the top surface of a flat plate of length 2.5 m. If the average value of friction coefficient is $C_f = \frac{1.328}{\sqrt{Re_x}}$, the total drag force (in N) per unit width of the plate is _____

Q.53 Water ($\rho = 1000$ kg/m³) flows through a venturimeter with inlet diameter 80 mm and throat diameter 40 mm. The inlet and throat gauge pressures are measured to be 400 kPa and 130 kPa respectively. Assuming the venturimeter to be horizontal and neglecting friction, the inlet velocity (in m/s) is _____

Q.54 A well insulated rigid container of volume 1 m^3 contains 1.0 kg of an ideal gas [$C_p = 1000 \text{ J}/(\text{kg}\cdot\text{K})$ and $C_v = 800 \text{ J}/(\text{kg}\cdot\text{K})$] at a pressure of 10^5 Pa . A stirrer is rotated at constant rpm in the container for 1000 rotations and the applied torque is $100 \text{ N}\cdot\text{m}$. The final temperature of the gas (in K) is

(A) 500.0

(B) 773.0

(C) 785.4

(D) 1285.4

Q.55 Steam enters a well insulated turbine and expands isentropically throughout. At an intermediate pressure, 20 percent of the mass is extracted for process heating and the remaining steam expands isentropically to 9 kPa .

Inlet to turbine: $P = 14 \text{ MPa}$, $T = 560^\circ\text{C}$, $h = 3486 \text{ kJ}/\text{kg}$, $s = 6.6 \text{ kJ}/(\text{kg}\cdot\text{K})$

Intermediate stage: $h = 2776 \text{ kJ}/\text{kg}$

Exit of turbine: $P = 9 \text{ kPa}$, $h_f = 174 \text{ kJ}/\text{kg}$, $h_g = 2574 \text{ kJ}/\text{kg}$, $s_f = 0.6 \text{ kJ}/(\text{kg}\cdot\text{K})$, $s_g = 8.1 \text{ kJ}/(\text{kg}\cdot\text{K})$

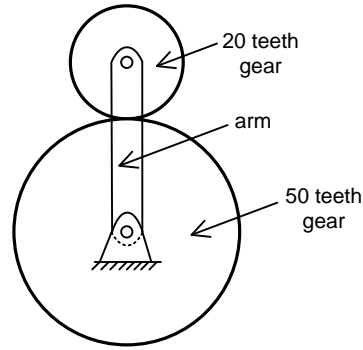
If the flow rate of steam entering the turbine is $100 \text{ kg}/\text{s}$, then the work output (in MW) is _____

END OF THE QUESTION PAPER

Q. 1 – Q. 25 carry one mark each.

- Q.1 At least one eigenvalue of a singular matrix is
(A) positive (B) zero (C) negative (D) imaginary
- Q.2 At $x = 0$, the function $f(x) = |x|$ has
(A) a minimum (B) a maximum
(C) a point of inflexion (D) neither a maximum nor minimum
- Q.3 Curl of vector $\mathbf{V}(x, y, z) = 2x^2 \mathbf{i} + 3z^2 \mathbf{j} + y^3 \mathbf{k}$ at $x = y = z = 1$ is
(A) $-3\mathbf{i}$ (B) $3\mathbf{i}$ (C) $3\mathbf{i} - 4\mathbf{j}$ (D) $3\mathbf{i} - 6\mathbf{k}$
- Q.4 The Laplace transform of e^{i5t} where $i = \sqrt{-1}$, is
(A) $\frac{s-5i}{s^2-25}$ (B) $\frac{s+5i}{s^2+25}$ (C) $\frac{s+5i}{s^2-25}$ (D) $\frac{s-5i}{s^2+25}$
- Q.5 Three vendors were asked to supply a very high precision component. The respective probabilities of their meeting the strict design specifications are 0.8, 0.7 and 0.5. Each vendor supplies one component. The probability that out of total three components supplied by the vendors, at least one will meet the design specification is _____
- Q.6 A small ball of mass 1 kg moving with a velocity of 12 m/s undergoes a direct central impact with a stationary ball of mass 2 kg. The impact is perfectly elastic. The speed (in m/s) of 2 kg mass ball after the impact will be _____
- Q.7 A rod is subjected to a uni-axial load within linear elastic limit. When the change in the stress is 200 MPa, the change in the strain is 0.001. If the Poisson's ratio of the rod is 0.3, the modulus of rigidity (in GPa) is _____
- Q.8 A gas is stored in a cylindrical tank of inner radius 7 m and wall thickness 50 mm. The gage pressure of the gas is 2 MPa. The maximum shear stress (in MPa) in the wall is
(A) 35 (B) 70 (C) 140 (D) 280

Q.9 The number of degrees of freedom of the planetary gear train shown in the figure is



- (A) 0 (B) 1 (C) 2 (D) 3

Q.10 In a spring-mass system, the mass is m and the spring constant is k . The critical damping coefficient of the system is 0.1 kg/s . In another spring-mass system, the mass is $2m$ and the spring constant is $8k$. The critical damping coefficient (in kg/s) of this system is _____

Q.11 The uniaxial yield stress of a material is 300 MPa . According to von Mises criterion, the shear yield stress (in MPa) of the material is _____

Q.12 If the fluid velocity for a potential flow is given by $\mathbf{V}(x, y) = u(x, y)\mathbf{i} + v(x, y)\mathbf{j}$ with usual notations, then the slope of the potential line at (x, y) is

- (A) $\frac{v}{u}$ (B) $-\frac{u}{v}$ (C) $\frac{v^2}{u^2}$ (D) $\frac{u}{v}$

Q.13 Which of the following statements regarding a Rankine cycle with reheating are **TRUE**?

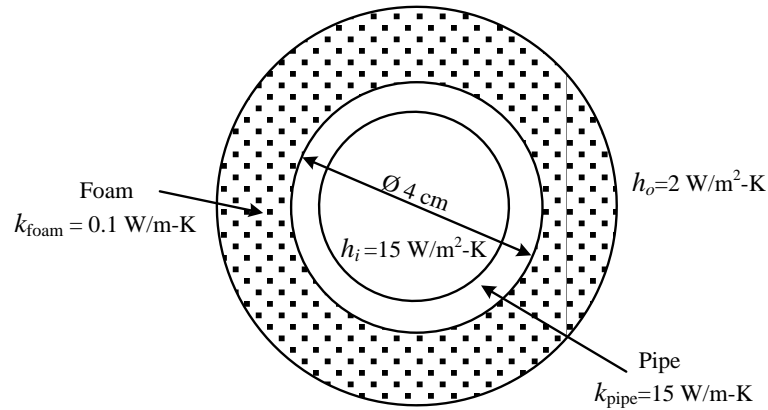
- (i) increase in average temperature of heat addition
- (ii) reduction in thermal efficiency
- (iii) drier steam at the turbine exit

- (A) only (i) and (ii) are correct
 (B) only (ii) and (iii) are correct
 (C) only (i) and (iii) are correct
 (D) (i), (ii) and (iii) are correct

Q.14 Within a boundary layer for a steady incompressible flow, the Bernoulli equation

- (A) holds because the flow is steady
 (B) holds because the flow is incompressible
 (C) holds because the flow is transitional
 (D) does not hold because the flow is frictional

- Q.15 If a foam insulation is added to a 4 cm outer diameter pipe as shown in the figure, the critical radius of insulation (in cm) is _____



- Q.16 In the laminar flow of air ($Pr = 0.7$) over a heated plate, if δ and δ_T denote, respectively, the hydrodynamic and thermal boundary layer thicknesses, then
- (A) $\delta = \delta_T$ (B) $\delta > \delta_T$
 (C) $\delta < \delta_T$ (D) $\delta = 0$ but $\delta_T \neq 0$
- Q.17 The COP of a Carnot heat pump operating between 6°C and 37°C is _____
- Q.18 The Van der Waals equation of state is $\left(p + \frac{a}{v^2}\right)(v - b) = RT$, where p is pressure, v is specific volume, T is temperature and R is characteristic gas constant. The SI unit of a is
- (A) J/kg-K (B) m^3/kg (C) $\text{m}^5/\text{kg-s}^2$ (D) Pa/kg
- Q.19 A rope-brake dynamometer attached to the crank shaft of an I.C. engine measures a brake power of 10 kW when the speed of rotation of the shaft is 400 rad/s. The shaft torque (in N-m) sensed by the dynamometer is _____
- Q.20 The atomic packing factor for a material with body centered cubic structure is _____
- Q.21 The primary mechanism of material removal in electrochemical machining (ECM) is
- (A) chemical corrosion
 (B) etching
 (C) ionic dissolution
 (D) spark erosion

- Q.22 Which one of the following statements is **TRUE**?
- (A) The 'GO' gage controls the upper limit of a hole
 (B) The 'NO GO' gage controls the lower limit of a shaft
 (C) The 'GO' gage controls the lower limit of a hole
 (D) The 'NO GO' gage controls the lower limit of a hole
- Q.23 During the development of a product, an entirely new process plan is made based on design logic, examination of geometry and tolerance information. This type of process planning is known as
- (A) retrieval
 (B) generative
 (C) variant
 (D) group technology based
- Q.24 Annual demand of a product is 50000 units and the ordering cost is Rs. 7000 per order. Considering the basic economic order quantity model, the economic order quantity is 10000 units. When the annual inventory cost is minimized, the annual inventory holding cost (in Rs.) is _____
- Q.25 Sales data of a product is given in the following table:

Month	January	February	March	April	May
Number of units sold	10	11	16	19	25

- Regarding forecast for the month of June, which one of the following statements is **TRUE**?
- (A) Moving average will forecast a higher value compared to regression.
 (B) Higher the value of order N , the greater will be the forecast value by moving average.
 (C) Exponential smoothing will forecast a higher value compared to regression.
 (D) Regression will forecast a higher value compared to moving average.

Q. 26 – Q. 55 carry two marks each.

- Q.26 The chance of a student passing an exam is 20%. The chance of a student passing the exam and getting above 90% marks in it is 5%. GIVEN that a student passes the examination, the probability that the student gets above 90% marks is
- (A) $\frac{1}{18}$ (B) $\frac{1}{4}$ (C) $\frac{2}{9}$ (D) $\frac{5}{18}$

- Q.27 The surface integral $\iint_S \frac{1}{\pi} (9x\mathbf{i} - 3y\mathbf{j}) \cdot \mathbf{n} \, dS$ over the sphere given by $x^2 + y^2 + z^2 = 9$ is _____

Q.28 Consider the following differential equation:

$$\frac{dy}{dt} = -5y; \quad \text{initial condition: } y = 2 \text{ at } t = 0.$$

The value of y at $t = 3$ is

- (A) $-5e^{-10}$ (B) $2e^{-10}$ (C) $2e^{-15}$ (D) $-15e^2$

Q.29 The values of function $f(x)$ at 5 discrete points are given below:

x	0	0.1	0.2	0.3	0.4
$f(x)$	0	10	40	90	160

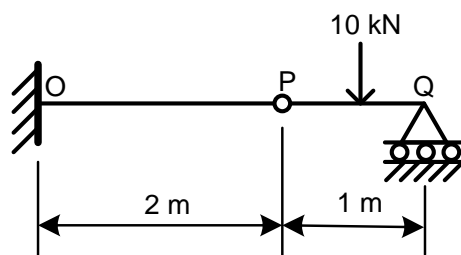
Using Trapezoidal rule with step size of 0.1, the value of $\int_0^{0.4} f(x) dx$ is _____

Q.30 The initial velocity of an object is 40 m/s. The acceleration a of the object is given by the following expression:

$$a = -0.1v,$$

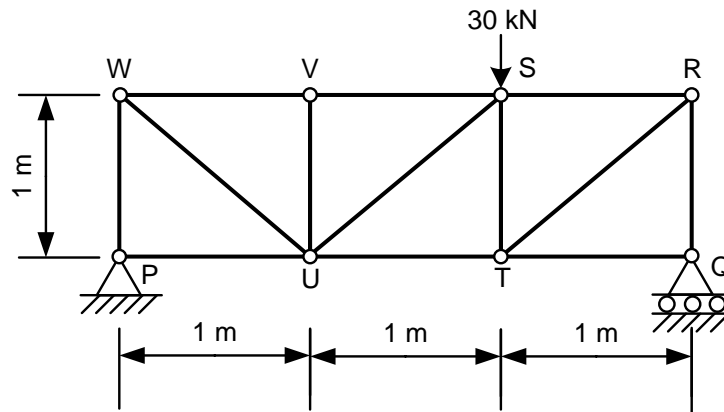
where v is the instantaneous velocity of the object. The velocity of the object after 3 seconds will be _____

Q.31 A cantilever beam OP is connected to another beam PQ with a pin joint as shown in the figure. A load of 10 kN is applied at the mid-point of PQ. The magnitude of bending moment (in kN-m) at fixed end O is



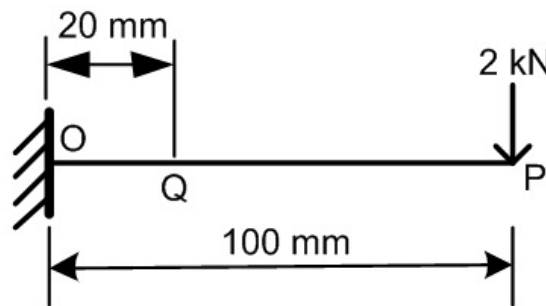
- (A) 2.5 (B) 5 (C) 10 (D) 25

Q.32 For the truss shown in the figure, the magnitude of the force (in kN) in the member SR is



- (A) 10 (B) 14.14 (C) 20 (D) 28.28

Q.33 A cantilever beam with square cross-section of 6 mm side is subjected to a load of 2 kN normal to the top surface as shown in the figure. The Young's modulus of elasticity of the material of the beam is 210 GPa. The magnitude of slope (in radian) at Q (20 mm from the fixed end) is _____



- Q.34 In a plane stress condition, the components of stress at a point are $\sigma_x = 20$ MPa, $\sigma_y = 80$ MPa and $\tau_{xy} = 40$ MPa. The maximum shear stress (in MPa) at the point is
- (A) 20 (B) 25 (C) 50 (D) 100
- Q.35 In a certain slider-crank mechanism, lengths of crank and connecting rod are equal. If the crank rotates with a uniform angular speed of 14 rad/s and the crank length is 300 mm, the maximum acceleration of the slider (in m/s^2) is _____
- Q.36 A single-degree-freedom spring-mass system is subjected to a sinusoidal force of 10 N amplitude and frequency ω along the axis of the spring. The stiffness of the spring is 150 N/m, damping factor is 0.2 and the undamped natural frequency is 10ω . At steady state, the amplitude of vibration (in m) is approximately
- (A) 0.05 (B) 0.07 (C) 0.70 (D) 0.90

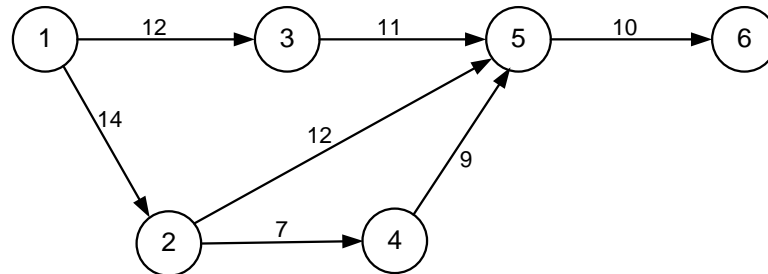
- Q.37 A hollow shaft of 1 m length is designed to transmit a power of 30 kW at 700 rpm. The maximum permissible angle of twist in the shaft is 1° . The inner diameter of the shaft is 0.7 times the outer diameter. The modulus of rigidity is 80 GPa. The outside diameter (in mm) of the shaft is _____
- Q.38 A hollow shaft ($d_o = 2d_i$ where d_o and d_i are the outer and inner diameters respectively) needs to transmit 20 kW power at 3000 RPM. If the maximum permissible shear stress is 30 MPa, d_o is
(A) 11.29 mm (B) 22.58 mm (C) 33.87 mm (D) 45.16 mm
- Q.39 The total emissive power of a surface is 500 W/m^2 at a temperature T_1 and 1200 W/m^2 at a temperature T_2 , where the temperatures are in Kelvin. Assuming the emissivity of the surface to be constant, the ratio of the temperatures $\frac{T_1}{T_2}$ is
(A) 0.308 (B) 0.416 (C) 0.803 (D) 0.874
- Q.40 The head loss for a laminar incompressible flow through a horizontal circular pipe is h_1 . Pipe length and fluid remaining the same, if the average flow velocity doubles and the pipe diameter reduces to half its previous value, the head loss is h_2 . The ratio h_2/h_1 is
(A) 1 (B) 4 (C) 8 (D) 16
- Q.41 For a fully developed laminar flow of water (dynamic viscosity 0.001 Pa-s) through a pipe of radius 5 cm, the axial pressure gradient is -10 Pa/m . The magnitude of axial velocity (in m/s) at a radial location of 0.2 cm is _____
- Q.42 A balanced counterflow heat exchanger has a surface area of 20 m^2 and overall heat transfer coefficient of $20 \text{ W/m}^2\text{-K}$. Air ($C_p=1000 \text{ J/kg-K}$) entering at 0.4 kg/s and 280 K is to be preheated by the air leaving the system at 0.4 kg/s and 300 K . The outlet temperature (in K) of the preheated air is
(A) 290 (B) 300 (C) 320 (D) 350
- Q.43 A cylindrical uranium fuel rod of radius 5 mm in a nuclear reactor is generating heat at the rate of $4 \times 10^7 \text{ W/m}^3$. The rod is cooled by a liquid (convective heat transfer coefficient $1000 \text{ W/m}^2\text{-K}$) at 25°C . At steady state, the surface temperature (in K) of the rod is
(A) 308 (B) 398 (C) 418 (D) 448
- Q.44 Work is done on an adiabatic system due to which its velocity changes from 10 m/s to 20 m/s, elevation increases by 20 m and temperature increases by 1 K. The mass of the system is 10 kg, $C_v = 100 \text{ J/(kg.K)}$ and gravitational acceleration is 10 m/s^2 . If there is no change in any other component of the energy of the system, the magnitude of total work done (in kJ) on the system is _____

- Q.45 One kg of air ($R = 287 \text{ J/kg-K}$) undergoes an irreversible process between equilibrium state 1 (20°C , 0.9 m^3) and equilibrium state 2 (20°C , 0.6 m^3). The change in entropy $s_2 - s_1$ (in J/kg-K) is _____
- Q.46 For the same values of peak pressure, peak temperature and heat rejection, the correct order of efficiencies for Otto, Dual and Diesel cycles is
- (A) $\eta_{Otto} > \eta_{Dual} > \eta_{Diesel}$
(B) $\eta_{Diesel} > \eta_{Dual} > \eta_{Otto}$
(C) $\eta_{Dual} > \eta_{Diesel} > \eta_{Otto}$
(D) $\eta_{Diesel} > \eta_{Otto} > \eta_{Dual}$
- Q.47 In a Rankine cycle, the enthalpies at turbine entry and outlet are 3159 kJ/kg and 2187 kJ/kg , respectively. If the specific pump work is 2 kJ/kg , the specific steam consumption (in kg/kW-h) of the cycle based on net output is _____
- Q.48 A cube and a sphere made of cast iron (each of volume 1000 cm^3) were cast under identical conditions. The time taken for solidifying the cube was 4 s . The solidification time (in s) for the sphere is _____
- Q.49 In a two-stage wire drawing operation, the fractional reduction (ratio of change in cross-sectional area to initial cross-sectional area) in the first stage is 0.4 . The fractional reduction in the second stage is 0.3 . The overall fractional reduction is
- (A) 0.24 (B) 0.58 (C) 0.60 (D) 1.00
- Q.50 The flow stress (in MPa) of a material is given by
- $$\sigma = 500 \varepsilon^{0.1},$$
- where ε is true strain. The Young's modulus of elasticity of the material is 200 GPa . A block of thickness 100 mm made of this material is compressed to 95 mm thickness and then the load is removed. The final dimension of the block (in mm) is _____
- Q.51 During a TIG welding process, the arc current and arc voltage were 50 A and 60 V , respectively, when the welding speed was 150 mm/min . In another process, the TIG welding is carried out at a welding speed of 120 mm/min at the same arc voltage and heat input to the material so that weld quality remains the same. The welding current (in A) for this process is
- (A) 40.00 (B) 44.72 (C) 55.90 (D) 62.25
- Q.52 A single point cutting tool with 0° rake angle is used in an orthogonal machining process. At a cutting speed of 180 m/min , the thrust force is 490 N . If the coefficient of friction between the tool and the chip is 0.7 , then the power consumption (in kW) for the machining operation is _____

Q.53 A resistance-capacitance relaxation circuit is used in an electrical discharge machining process. The discharge voltage is 100 V. At a spark cycle time of 25 μs , the average power input required is 1 kW. The capacitance (in μF) in the circuit is

- (A) 2.5 (B) 5.0 (C) 7.5 (D) 10.0

Q.54 A project consists of 7 activities. The network along with the time durations (in days) for various activities is shown in the figure.



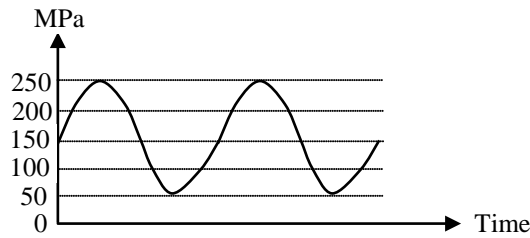
The minimum time (in days) for completion of the project is _____

Q.55 A manufacturer has the following data regarding a product:
Fixed cost per month = Rs. 50000
Variable cost per unit = Rs. 200
Selling price per unit = Rs. 300
Production capacity = 1500 units per month
If the production is carried out at 80% of the rated capacity, then the monthly profit (in Rs.) is _____

END OF THE QUESTION PAPER

Q. 1 – Q. 25 carry one mark each.

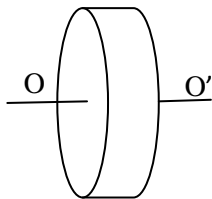
Q.1 For the given fluctuating fatigue load, the values of stress amplitude and stress ratio are respectively



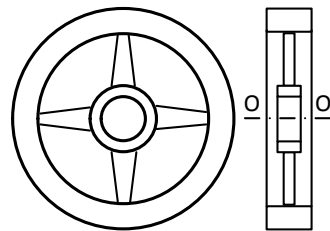
- (A) 100 MPa and 5
- (B) 250 MPa and 5
- (C) 100 MPa and 0.20
- (D) 250 MPa and 0.20

Q.2 For the same material and the mass, which of the following configurations of flywheel will have maximum mass moment of inertia about the axis of rotation OO' passing through the center of gravity.

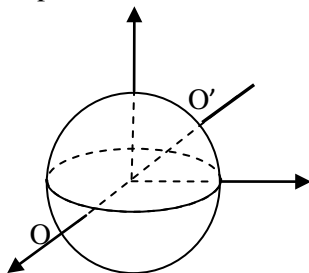
(A) Solid Cylinder



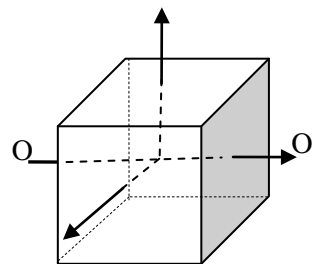
(B) Rimmed wheel



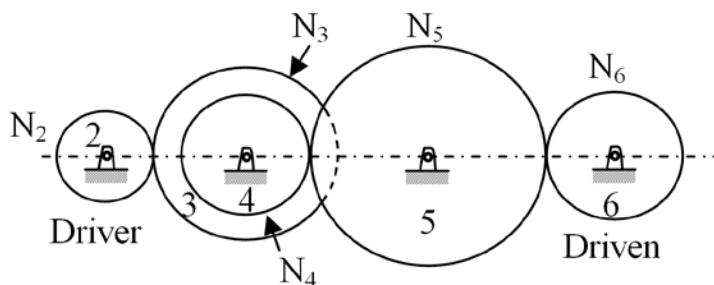
(C) Solid sphere



(D) Solid cube

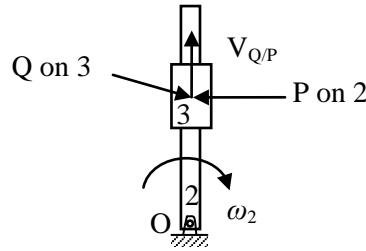


Q.3 A gear train is made up of five spur gears as shown in the figure. Gear 2 is driver and gear 6 is driven member. N_2, N_3, N_4, N_5 and N_6 represent number of teeth on gears 2, 3, 4, 5, and 6 respectively. The gear(s) which act(s) as idler(s) is/are



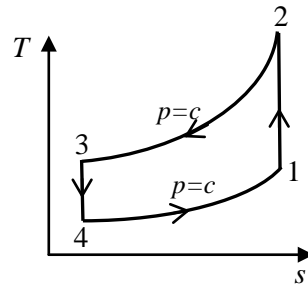
- (A) Only 3
- (B) Only 4
- (C) Only 5
- (D) Both 3 and 5

- Q.4 In the figure, link 2 rotates with constant angular velocity ω_2 . A slider link 3 moves outwards with a constant relative velocity $V_{Q/P}$, where Q is a point on slider 3 and P is a point on link 2. The magnitude and direction of Coriolis component of acceleration is given by



- (A) $2 \omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° in the direction of ω_2
 (B) $\omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° in the direction of ω_2
 (C) $2 \omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° opposite to the direction of ω_2
 (D) $\omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° opposite to the direction of ω_2
- Q.5 The strain hardening exponent n of stainless steel SS 304 with distinct yield and UTS values undergoing plastic deformation is
- (A) $n < 0$ (B) $n = 0$ (C) $0 < n < 1$ (D) $n = 1$
- Q.6 In a machining operation, if the generatrix and directrix both are straight lines, the surface obtained is
- (A) cylindrical (B) helical (C) plane (D) surface of revolution
- Q.7 In full mould (cavity-less) casting process, the pattern is made of
- (A) expanded polystyrene (B) wax
 (C) epoxy (D) plaster of Paris
- Q.8 In the notation $(a/b/c) : (d/e/f)$ for summarizing the characteristics of queueing situation, the letters 'b' and 'd' stand respectively for
- (A) service time distribution and queue discipline
 (B) number of servers and size of calling source
 (C) number of servers and queue discipline
 (D) service time distribution and maximum number allowed in system
- Q.9 Couette flow is characterized by
- (A) steady, incompressible, laminar flow through a straight circular pipe
 (B) fully developed turbulent flow through a straight circular pipe
 (C) steady, incompressible, laminar flow between two fixed parallel plates
 (D) steady, incompressible, laminar flow between one fixed plate and the other moving with a constant velocity

Q.10 The thermodynamic cycle shown in figure ($T-s$ diagram) indicates



- (A) reversed Carnot cycle
(B) reversed Brayton cycle
(C) vapor compression cycle
(D) vapor absorption cycle

Q.11 The ratio of momentum diffusivity (ν) to thermal diffusivity (α), is called

- (A) Prandtl number
(B) Nusselt number
(C) Biot number
(D) Lewis number

Q.12 Saturated vapor is condensed to saturated liquid in a condenser. The heat capacity ratio is

$C_r = \frac{C_{min}}{C_{max}}$. The effectiveness (ϵ) of the condenser is

- (A) $\frac{1 - \exp[-NTU(1+C_r)]}{1+C_r}$
(B) $\frac{1 - \exp[-NTU(1-C_r)]}{1-C_r \exp[-NTU(1-C_r)]}$
(C) $\frac{NTU}{1+NTU}$
(D) $1 - \exp(-NTU)$

Q.13 Using a unit step size, the value of integral $\int_1^2 x \ln x \, dx$ by trapezoidal rule is _____

Q.14 If $P(X) = 1/4$, $P(Y) = 1/3$, and $P(X \cap Y) = 1/12$, the value of $P(Y/X)$ is

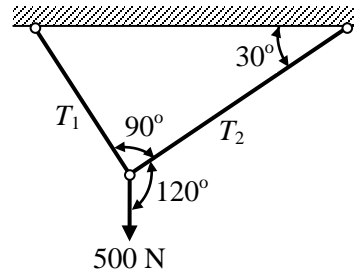
- (A) $\frac{1}{4}$
(B) $\frac{4}{25}$
(C) $\frac{1}{3}$
(D) $\frac{29}{50}$

Q.15 The lowest eigenvalue of the 2×2 matrix $\begin{bmatrix} 4 & 2 \\ 1 & 3 \end{bmatrix}$ is _____

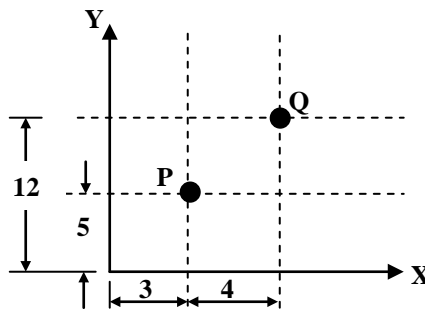
Q.16 The value of $\lim_{x \rightarrow 0} \left(\frac{-\sin x}{2 \sin x + x \cos x} \right)$ is _____

Q.17 A cylindrical tank with closed ends is filled with compressed air at a pressure of 500 kPa. The inner radius of the tank is 2 m, and it has wall thickness of 10 mm. The magnitude of maximum in-plane shear stress (in MPa) is _____

- Q.18 A weight of 500 N is supported by two metallic ropes as shown in the figure. The values of tensions T_1 and T_2 are respectively



- (A) 433 N and 250 N
(B) 250 N and 433 N
(C) 353.5 N and 250 N
(D) 250 N and 353.5 N
- Q.19 Which of the following statements are **TRUE** for damped vibrations?
- P. For a system having critical damping, the value of damping ratio is unity and system does not undergo a vibratory motion.
Q. Logarithmic decrement method is used to determine the amount of damping in a physical system.
R. In case of damping due to dry friction between moving surfaces resisting force of constant magnitude acts opposite to the relative motion.
S. For the case of viscous damping, drag force is directly proportional to the square of relative velocity.
- (A) P and Q only
(B) P and S only
(C) P, Q and R only
(D) Q and S only
- Q.20 A drill is positioned at point P and it has to proceed to point Q. The coordinates of point Q in the incremental system of defining position of a point in CNC part program will be



- (A) (3, 12)
(B) (5, 7)
(C) (7, 12)
(D) (4, 7)
- Q.21 Which two of the following joining processes are autogeneous?
- (i) Diffusion welding
(ii) Electroslag welding
(iii) Tungsten inert gas welding
(iv) Friction welding
- (A) (i) and (iv)
(B) (ii) and (iii)
(C) (ii) and (iv)
(D) (i) and (iii)
- Q.22 Three parallel pipes connected at the two ends have flow-rates Q_1 , Q_2 and Q_3 respectively, and the corresponding frictional head losses are h_{L1} , h_{L2} and h_{L3} respectively. The correct expressions for total flow rate (Q) and frictional head loss across the two ends (h_L) are
- (A) $Q = Q_1 + Q_2 + Q_3$; $h_L = h_{L1} + h_{L2} + h_{L3}$
(B) $Q = Q_1 + Q_2 + Q_3$; $h_L = h_{L1} = h_{L2} = h_{L3}$
(C) $Q = Q_1 = Q_2 = Q_3$; $h_L = h_{L1} + h_{L2} + h_{L3}$
(D) $Q = Q_1 = Q_2 = Q_3$; $h_L = h_{L1} = h_{L2} = h_{L3}$

- Q.23 A rigid container of volume 0.5 m^3 contains 1.0 kg of water at 120°C ($v_f = 0.00106 \text{ m}^3/\text{kg}$, $v_g = 0.8908 \text{ m}^3/\text{kg}$). The state of water is
- (A) compressed liquid
 (B) saturated liquid
 (C) a mixture of saturated liquid and saturated vapor
 (D) superheated vapor

- Q.24 Let ϕ be an arbitrary smooth real valued scalar function and \vec{V} be an arbitrary smooth vector valued function in a three-dimensional space. Which one of the following is an identity?

- (A) $\text{Curl}(\phi\vec{V}) = \nabla(\phi \text{Div}\vec{V})$ (B) $\text{Div}\vec{V} = 0$
 (C) $\text{Div Curl}\vec{V} = 0$ (D) $\text{Div}(\phi\vec{V}) = \phi \text{Div}\vec{V}$

- Q.25 An air-standard Diesel cycle consists of the following processes:

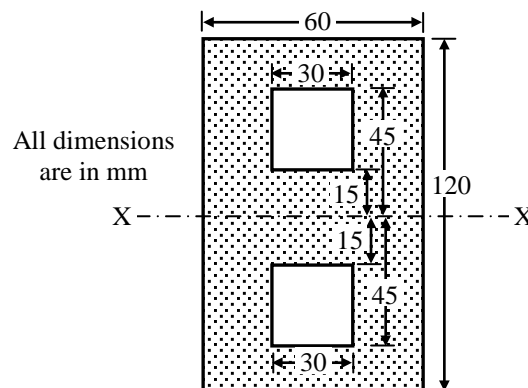
- 1-2: Air is compressed isentropically.
 2-3: Heat is added at constant pressure.
 3-4: Air expands isentropically to the original volume.
 4-1: Heat is rejected at constant volume.

If γ and T denote the specific heat ratio and temperature, respectively, the efficiency of the cycle is

- (A) $1 - \frac{T_4 - T_1}{T_3 - T_2}$ (B) $1 - \frac{T_4 - T_1}{\gamma(T_3 - T_2)}$
 (C) $1 - \frac{\gamma(T_4 - T_1)}{T_3 - T_2}$ (D) $1 - \frac{T_4 - T_1}{(\gamma - 1)(T_3 - T_2)}$

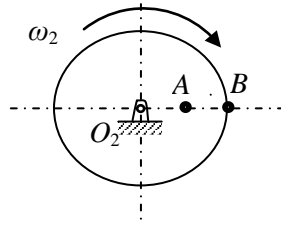
Q. 26 – Q. 55 carry two marks each.

- Q.26 The value of moment of inertia of the section shown in the figure about the axis-XX is

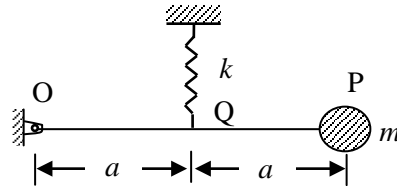


- (A) $8.5050 \times 10^6 \text{ mm}^4$ (B) $6.8850 \times 10^6 \text{ mm}^4$
 (C) $7.7625 \times 10^6 \text{ mm}^4$ (D) $8.5725 \times 10^6 \text{ mm}^4$

- Q.27 Figure shows a wheel rotating about O_2 . Two points A and B located along the radius of wheel have speeds of 80 m/s and 140 m/s respectively. The distance between the points A and B is 300 mm. The diameter of the wheel (in mm) is _____

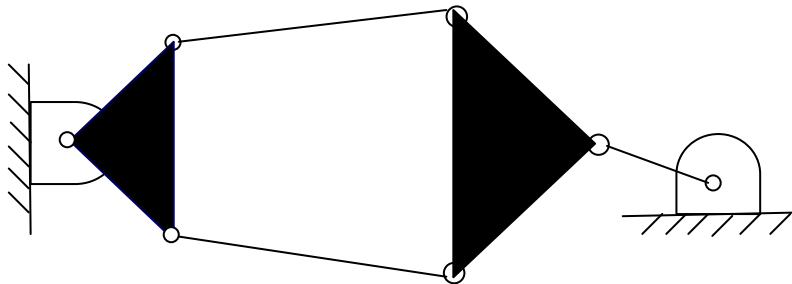


- Q.28 Figure shows a single degree of freedom system. The system consists of a massless rigid bar OP hinged at O and a mass m at end P . The natural frequency of vibration of the system is



- (A) $f_n = \frac{1}{2\pi} \sqrt{\frac{k}{4m}}$ (B) $f_n = \frac{1}{2\pi} \sqrt{\frac{k}{2m}}$
 (C) $f_n = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$ (D) $f_n = \frac{1}{2\pi} \sqrt{\frac{2k}{m}}$

- Q.29 The number of degrees of freedom of the linkage shown in the figure is

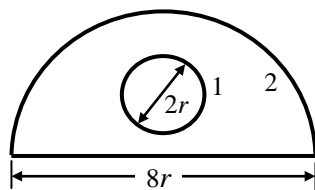


- (A) -3 (B) 0 (C) 1 (D) 2

- Q.30 For ball bearings, the fatigue life L measured in number of revolutions and the radial load F are related by $FL^{1/3} = K$, where K is a constant. It withstands a radial load of 2 kN for a life of 540 million revolutions. The load (in kN) for a life of one million revolutions is _____

- Q.31 In a rolling operation using rolls of diameter 500 mm, if a 25 mm thick plate cannot be reduced to less than 20 mm in one pass, the coefficient of friction between the roll and the plate is _____

- Q.32 Ratio of solidification time of a cylindrical casting (height = radius) to that of a cubic casting of side two times the height of cylindrical casting is _____
- Q.33 The annual requirement of rivets at a ship manufacturing company is 2000 kg. The rivets are supplied in units of 1 kg costing Rs. 25 each. If it costs Rs. 100 to place an order and the annual cost of carrying one unit is 9% of its purchase cost, the cycle length of the order (in days) will be _____
- Q.34 Orthogonal turning of a mild steel tube with a tool of rake angle 10° is carried out at a feed of 0.14 mm/rev. If the thickness of the chip produced is 0.28 mm, the values of shear angle and shear strain will be respectively
 (A) $28^\circ 20'$ and 2.19 (B) $22^\circ 20'$ and 3.53 (C) $24^\circ 30'$ and 4.19 (D) $37^\circ 20'$ and 5.19
- Q.35 In a CNC milling operation, the tool has to machine the circular arc from point (20, 20) to (10, 10) at sequence number 5 of the CNC part program. If the center of the arc is at (20, 10) and the machine has incremental mode of defining position coordinates, the correct tool path command is
 (A) N 05 G90 G01 X-10 Y-10 R10
 (B) N 05 G91 G03 X-10 Y-10 R10
 (C) N 05 G90 G03 X20 Y20 R10
 (D) N 05 G91 G02 X20 Y20 R10
- Q.36 A Prandtl tube (Pitot-static tube with $C=1$) is used to measure the velocity of water. The differential manometer reading is 10 mm of liquid column with a relative density of 10. Assuming $g = 9.8 \text{ m/s}^2$, the velocity of water (in m/s) is _____
- Q.37 Refrigerant vapor enters into the compressor of a standard vapor compression cycle at -10°C ($h = 402 \text{ kJ/kg}$) and leaves the compressor at 50°C ($h = 432 \text{ kJ/kg}$). It leaves the condenser at 30°C ($h = 237 \text{ kJ/kg}$). The COP of the cycle is _____
- Q.38 Steam enters a turbine at 30 bar, 300°C ($u = 2750 \text{ kJ/kg}$, $h = 2993 \text{ kJ/kg}$) and exits the turbine as saturated liquid at 15 kPa ($u = 225 \text{ kJ/kg}$, $h = 226 \text{ kJ/kg}$). Heat loss to the surrounding is 50 kJ/kg of steam flowing through the turbine. Neglecting changes in kinetic energy and potential energy, the work output of the turbine (in kJ/kg of steam) is _____
- Q.39 Air in a room is at 35°C and 60% relative humidity (RH). The pressure in the room is 0.1 MPa. The saturation pressure of water at 35°C is 5.63 kPa. The humidity ratio of the air (in gram/kg of dry air) is _____
- Q.40 A solid sphere 1 of radius ' r ' is placed inside a hollow, closed hemispherical surface 2 of radius ' $4r$ '. The shape factor F_{2-1} is



- (A) 1/12 (B) 1/2 (C) 2 (D) 12

Q.41 The value of $\int_C [(3x - 8y^2)dx + (4y - 6xy)dy]$, (where C is the boundary of the region bounded by $x = 0$, $y = 0$ and $x+y = 1$) is _____

Q.42 For a given matrix $P = \begin{bmatrix} 4 + 3i & -i \\ i & 4 - 3i \end{bmatrix}$, where $i = \sqrt{-1}$, the inverse of matrix P is

(A) $\frac{1}{24} \begin{bmatrix} 4 - 3i & i \\ -i & 4 + 3i \end{bmatrix}$

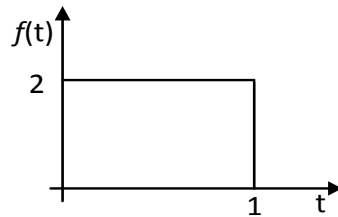
(B) $\frac{1}{25} \begin{bmatrix} i & 4 - 3i \\ 4 + 3i & -i \end{bmatrix}$

(C) $\frac{1}{24} \begin{bmatrix} 4 + 3i & -i \\ i & 4 - 3i \end{bmatrix}$

(D) $\frac{1}{25} \begin{bmatrix} 4 + 3i & -i \\ i & 4 - 3i \end{bmatrix}$

Q.43 Newton-Raphson method is used to find the roots of the equation, $x^3 + 2x^2 + 3x - 1 = 0$. If the initial guess is $x_0 = 1$, then the value of x after 2nd iteration is _____

Q.44 Laplace transform of the function $f(t)$ is given by $F(s) = L\{f(t)\} = \int_0^\infty f(t)e^{-st} dt$.
Laplace transform of the function shown below is given by



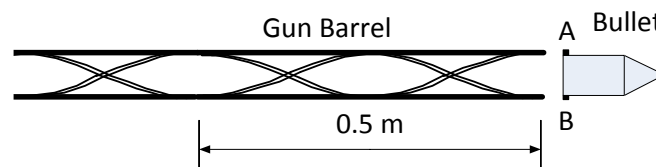
(A) $\frac{1-e^{-2s}}{s}$

(B) $\frac{1-e^{-s}}{2s}$

(C) $\frac{2-2e^{-s}}{s}$

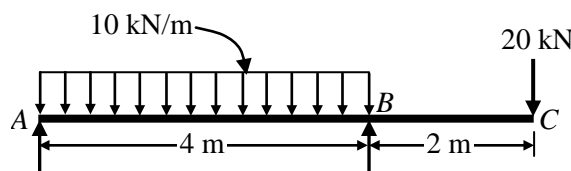
(D) $\frac{1-2e^{-s}}{s}$

Q.45 A bullet spins as the shot is fired from a gun. For this purpose, two helical slots as shown in the figure are cut in the barrel. Projections A and B on the bullet engage in each of the slots.



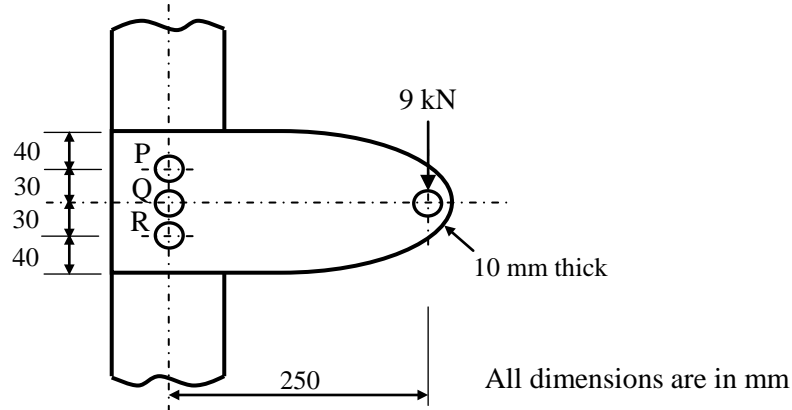
Helical slots are such that one turn of helix is completed over a distance of 0.5 m. If velocity of bullet when it exits the barrel is 20 m/s, its spinning speed in rad/s is _____

Q.46 For the overhanging beam shown in figure, the magnitude of maximum bending moment (in kN-m) is _____



Q.47 The torque (in N-m) exerted on the crank shaft of a two stroke engine can be described as $T = 10000 + 1000 \sin 2\theta - 1200 \cos 2\theta$, where θ is the crank angle as measured from inner dead center position. Assuming the resisting torque to be constant, the power (in kW) developed by the engine at 100 rpm is _____

Q.48 A cantilever bracket is bolted to a column using three M12×1.75 bolts P, Q and R. The value of maximum shear stress developed in the bolt P (in MPa) is _____



Q.49 A shaft of length 90 mm has a tapered portion of length 55 mm. The diameter of the taper is 80 mm at one end and 65 mm at the other. If the taper is made by tailstock set over method, the taper angle and the set over respectively are

- (A) $15^{\circ}32'$ and 12.16 mm (B) $18^{\circ}32'$ and 15.66 mm
 (C) $11^{\circ}22'$ and 10.26 mm (D) $10^{\circ}32'$ and 14.46 mm

Q.50 The dimensions of a cylindrical side riser (height = diameter) for a 25 cm × 15 cm × 5 cm steel casting are to be determined. For the tabulated shape factor values given below, the diameter of the riser (in cm) is _____

Shape factor	2	4	6	8	10	12
Riser volume/ Casting volume	1.0	0.70	0.55	0.50	0.40	0.35

Q.51 For the linear programming problem:

$$\text{Maximize } Z = 3X_1 + 2X_2$$

Subject to

$$-2X_1 + 3X_2 \leq 9$$

$$X_1 - 5X_2 \geq -20$$

$$X_1, X_2 \geq 0$$

The above problem has

- (A) unbounded solution (B) infeasible solution
 (C) alternative optimum solution (D) degenerate solution

Q.52 Which of the following statements are **TRUE**, when the cavitation parameter $\sigma = 0$?

- (i) the local pressure is reduced to vapor pressure
 (ii) cavitation starts
 (iii) boiling of liquid starts
 (iv) cavitation stops

- (A) (i), (ii) and (iv) (B) only (ii) and (iii)
 (C) only (i) and (iii) (D) (i), (ii) and (iii)

Q.53 One side of a wall is maintained at 400 K and the other at 300 K. The rate of heat transfer through the wall is 1000 W and the surrounding temperature is 25°C. Assuming no generation of heat within the wall, the irreversibility (in W) due to heat transfer through the wall is _____

Q.54 A brick wall ($k = 0.9 \frac{W}{m.K}$) of thickness 0.18 m separates the warm air in a room from the cold ambient air. On a particular winter day, the outside air temperature is $-5^{\circ}C$ and the room needs to be maintained at $27^{\circ}C$. The heat transfer coefficient associated with outside air is $20 \frac{W}{m^2.K}$. Neglecting the convective resistance of the air inside the room, the heat loss, in ($\frac{W}{m^2}$), is

(A) 88

(B) 110

(C) 128

(D) 160

Q.55 A mixture of ideal gases has the following composition by mass:

N ₂	O ₂	CO ₂
60%	30%	10%

If the universal gas constant is 8314 J/kmol-K, the characteristic gas constant of the mixture (in J/kg-K) is _____

END OF THE QUESTION PAPER