Q. 1 – Q. 5 carry one mark each.

Q.1 "Going by the _________ that many hands make light work, the school _______ involved all the students in the task."

The words that best fill the blanks in the above sentence are

(A) principle, principal (B) principal, principle
(C) principle, principle (D) principal, principal

Q.2 "Her _______ should not be confused with miserliness; she is ever willing to assist those in need."

The word that best fills the blank in the above sentence is

(A) cleanliness (B) punctuality (C) frugality (D) greatness

Q.3 Seven machines take 7 minutes to make 7 identical toys. At the same rate, how many minutes would it take for 100 machines to make 100 toys?

(A) 1 (B) 7 (C) 100 (D) 700

Q.4 A rectangle becomes a square when its length and breadth are reduced by 10 m and 5 m, respectively. During this process, the rectangle loses 650 m^2 of area. What is the area of the original rectangle in square meters?

(A) 1125 (B) 2250 (C) 2924 (D) 4500

Q.5 A number consists of two digits. The sum of the digits is 9. If 45 is subtracted from the number, its digits are interchanged. What is the number?

(A) 63 (B) 72 (C) 81 (D) 90

Q. 6 – Q. 10 carry two marks each.

Q.6 For integers a, b and c, what would be the minimum and maximum values respectively of $a + b + c$ if $\log |a| + \log |b| + \log |c| = 0$?

(A) -3 and 3 (B) -1 and 1 (C) -1 and 3 (D) 1 and 3

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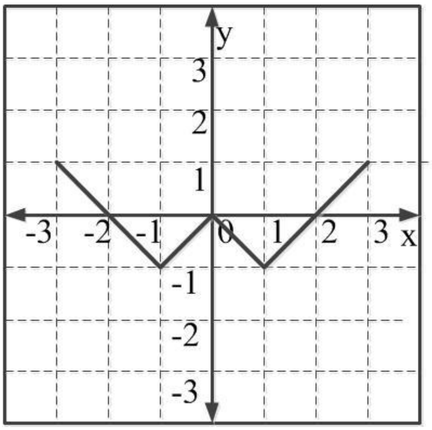
Q.7 Given that a and b are integers and $a + a^2 b^3$ is odd, which one of the following statements is correct?

(A) a and b are both odd
(B) a and b are both even
(C) a is even and b is odd
(D) a is odd and b is even

Q.8 From the time the front of a train enters a platform, it takes 25 seconds for the back of the train to leave the platform, while travelling at a constant speed of 54 km/h. At the same speed, it takes 14 seconds to pass a man running at 9 km/h in the same direction as the train. What is the length of the train and that of the platform in meters, respectively?

(A) 210 and 140
(B) 162.5 and 187.5
(C) 245 and 130
(D) 175 and 200

Q.9 Which of the following functions describe the graph shown in the below figure?



(A) $y = \big||x| + 1\big| - 2$
(B) $y = \big||x| - 1\big| - 1$
(C) $y = \big||x| + 1\big| - 1$
(D) $y = \big||x - 1| - 1\big|$

Q.10 Consider the following three statements:
(i) Some roses are red.
(ii) All red flowers fade quickly.
(iii) Some roses fade quickly.

Which of the following statements can be logically inferred from the above statements?

(A) If (i) is true and (ii) is false, then (iii) is false.
(B) If (i) is true and (ii) is false, then (iii) is true.
(C) If (i) and (ii) are true, then (iii) is true.
(D) If (i) and (ii) are false, then (iii) is false.

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XE-A: Q. 1 – Q. 7 carry one mark each & Q. 8 – Q. 11 carry two marks each.

Q.1 The largest interval in which the initial value problem

$$e^x \frac{d^2y}{dx^2} + \frac{1}{(x-5)}\frac{dy}{dx} + \left(\sqrt{x}\right) y = \ln(x), \quad y(1) = 0 \text{ and } \frac{dy}{dx}(1) = 1,$$

has a unique solution is

(A) $(-\infty, \infty)$ (B) $(-5, 5)$ (C) $(0, \infty)$ (D) $(0, 5)$

Q.2 The sum of the roots of the indicial equation at $x = 0$ of the differential equation

$$x^3 \frac{d^2y}{dx^2} + (x \sin x)\frac{dy}{dx} - (\tan x) y = 0, \quad x > 0,$$

is

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

Q.3 Let f be a three times continuously differentiable real valued function on $(0, 5)$ such that its third derivative $f'''(x) = \frac{1}{100}$ for all $x \in (0,5)$. If $P(x)$ is a polynomial of degree ≤ 2 such that $P(1) = f(1)$, $P(2) = f(2)$ and $P(3) = f(3)$ then $|f(4) - P(4)|$ equals ________________

Q.4 For real numbers α_1 and α_2, if the formula $\int_{-1}^{1} f(x)\,dx = \alpha_1 f\left(\frac{-1}{2}\right) + \alpha_2 f\left(\frac{1}{2}\right)$ is exact for all polynomials of degree ≤ 1 then $2\alpha_1 + 3\alpha_2$ equals ________________

Q.5 Raju has four fair coins and one fair dice. At first Raju tosses a coin. If the coin shows head then he rolls the dice and the number that dice shows is taken as his score. If the coin shows tail then he tosses three more coins and the total number of tails shown (including the first one) is taken as his score. If Raju tells that his score is 2 then the probability that he rolled the dice is (up to two decimal places) ________________

Q.6 Let f be a continuously differentiable real valued function defined by

$$f(x) = \begin{cases} bx + a & \text{if } x < 1, \\ 5x^2 & \text{if } x \ge 1. \end{cases}$$

Then the value of $a^2 b$ is ________________

Q.7 A rectangular box without top cover having a square base is to be made from a sheet of 108 square meters. Then the largest possible volume of the box in cubic meters is ________

Q.8 Let $A=\begin{pmatrix} 5 & -3 \\ 6 & -4 \end{pmatrix}$. Then the trace of A^{1000} equals

(A) $2^{1000}-1$ (B) $2^{1000}+1$ (C) 1 (D) 2^{1000}

Q.9 Let $\mathbb{C}$ denote the set of complex numbers and $i^2=-1$. Let γ be the simple positively oriented circle $|z|=1$ and $S=\{z\in\mathbb{C} \mid 0<|z|<2\}$. If $f:S\to\mathbb{C}$ is analytic in S and is given by

$$f(z)=\frac{1}{8z^2}+\frac{7}{2z}+\sum_{n=0}^{\infty}a_n z^n, \quad z\in S$$

then the value of the contour integral

$$\frac{1}{\pi i}\int_{\gamma}\left(\frac{e^z}{\cos z}+f(z)\right)dz$$

is

(A) 0 (B) $\frac{1}{8}$ (C) 7 (D) $\frac{7}{2}$

Q.10 Let $\mathbb{R}^3$ denote the three dimensional Euclidean space and $\mathbf{F}(x,y,z)=-y\,\hat{i}+x\,\hat{j}+z\,\hat{k}$ for all $(x,y,z)\in\mathbb{R}^3$. If C is the curve described by the parametric equation $\mathbf{r}(t)=\cos t\;\hat{i}+\sin t\;\hat{j}+2t^2\;\hat{k},\; 0\le t\le 1,$ then the value of the line integral $\int_C \mathbf{F}\cdot d\mathbf{r}$ is________

Q.11 Let $u(x,t)$ satisfy the initial and boundary value problem

$$\frac{\partial u}{\partial t}=2\,\frac{\partial^2 u}{\partial x^2}, \quad 0<x<\pi, \quad t>0,$$

$$u(0,t)=0=u(\pi,t), \quad t>0,$$

$$u(x,0)=\sin x+2\sin 4x, \quad 0<x<\pi.$$

Then the value of $u\left(\frac{\pi}{2},\ln(5)\right)$ is________

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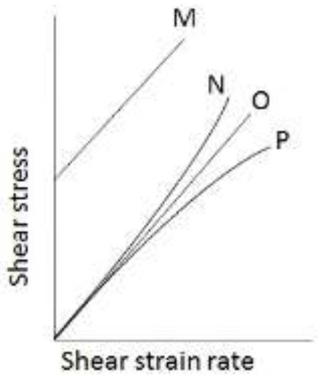
XE (B): Q. 1 – Q. 9 carry one mark each & Q. 10 – Q. 22 carry two marks each.

Q.1 Rheological diagram of different types of fluids is shown in figure. Column I represents the nature of the fluid and column II represents the curve showing the variation of shear stress against shear strain rate.

Column I		Column II
(i)	Newtonian	M
(ii)	Shear thinning	N
(iii)	Shear thickening	O
(iv)	Bingham plastic	P



The most appropriate match between columns I and II is,

(A) (i) – O; (ii) – N ; (iii) – P; (iv) – M
(B) (i) – O; (ii) – P ; (iii) – N; (iv) – M
(C) (i) – P; (ii) – O ; (iii) – M; (iv) – N
(D) (i) – P; (ii) – O ; (iii) – N; (iv) – M

Q.2 In a two-dimensional, incompressible and irrotational flow, stream function ($\psi = \psi(x, y)$) and velocity potential ($\phi = \phi(x, y)$) exist. The velocities in x and y directions are non-zero. The product of $\left.\frac{dy}{dx}\right|_{\phi=\text{constant}}$ and $\left.\frac{dy}{dx}\right|_{\psi=\text{constant}}$, is

(A) -1 (B) 0 (C) 1 (D) ∞

Q.3 The inviscid flow past a rotating circular cylinder can be generated by the superposition of

(A) uniform flow, source and vortex
(B) uniform flow, doublet
(C) uniform flow, sink and vortex
(D) uniform flow, doublet and vortex

Q.4 The velocity field and the surface normal vector are given by, $\vec{V} = u\hat{i} + v\hat{j} + w\hat{k}$ and $\vec{n} = n_1\hat{i} + n_2\hat{j} + n_3\hat{k}$, respectively. If Euler equations are to be solved, the boundary condition that must be satisfied at the wall is,

(A) $\vec{V} \cdot \vec{n} = 0$ (B) $\vec{V} = 0$ (C) $\nabla \cdot \vec{V} = 0$ (D) $\vec{V} \times \vec{n} = 0$

Q.5 The influence of Froude number is most significant in

(A) capillary flows
(B) creeping flows
(C) free surface flows
(D) compressible flows

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Q.6 If the stream function ($\psi(x,y)$) for a two-dimensional incompressible flow field is given as $2y\left(x^2-y^2\right)$, the corresponding velocity field is

(A) $\vec{V}=2\left(x^2-3y^2\right)\hat{i}+4xy\,\hat{j}$

(B) $\vec{V}=2\left(x^2-3y^2\right)\hat{i}-4xy\,\hat{j}$

(C) $\vec{V}=2\left(x^2y\right)\hat{i}-4xy\,\hat{j}$

(D) $\vec{V}=2\left(x^2y\right)\hat{i}+4xy\,\hat{j}$

Q.7 Water is flowing in two different tubes of diameters D and $2D$, with the same velocity. The ratio of laminar friction factors for the larger diameter tube to the smaller diameter tube is

(A) 0.5 (B) 1.0 (C) 2.0 (D) 4.0

Q.8 If the velocity field is $\vec{V}=xy^2\,\hat{i}+4xy\,\hat{j}$ m/s, vorticity of the fluid element in the field at (x=1, y=2) in s^{-1} is ____.

Q.9 A pitot-static tube is used to measure air velocity in a duct by neglecting losses. The density of air is 1.2 kg/m^3. If the difference between the total and static pressures is 1 kPa, the velocity of air at the measuring location, in m/s, is _______.

Q.10 A parallelepiped of (2 m × 2 m) square cross-section and 10 m in length, is partially floating in water upto a depth of 1.2 m, with its longest side being horizontal. The specific gravity of the block is

(A) 0.8 (B) 0.6 (C) 0.5 (D) 0.4

Q.11 The velocity field in a two-dimensional, unsteady flow is given by $\vec{V}(x,y,t)=2xy^2\,\hat{i}+3xyt\,\hat{j}$ m/s. The magnitude of acceleration of a fluid particle located at x = 1 m, y = 1 m at the time t = 1 s, in m/s^2, is

(A) 16.0 (B) 18.1 (C) 24.1 (D) 34.1

Q.12 In a two-dimensional, incompressible and irrotational flow, fluid velocity (v) in the y-direction is given by $v=2x-5y$. The velocity (u) in the x-direction is

(A) $u=2x-5y$ (B) $u=2x+5y$ (C) $u=5x+2y$ (D) $u=5x-2y$

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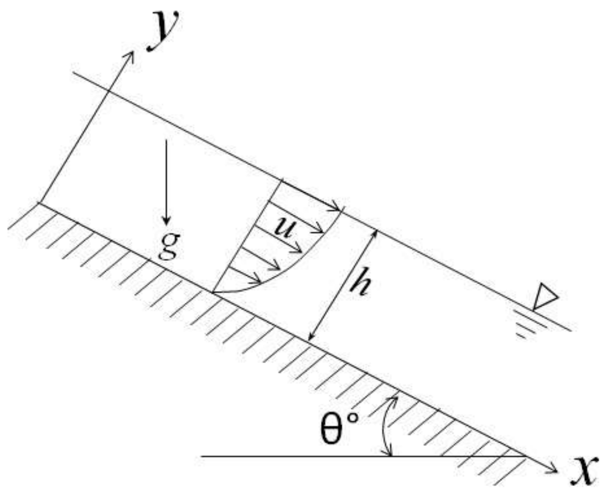
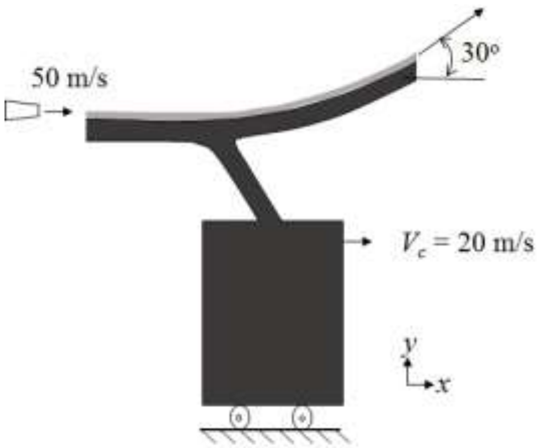
Q.13 A two-dimensional laminar viscous liquid film of constant thickness (h) steadily flows down an incline as shown in figure. Acceleration due to gravity is g. If the velocity profile in the liquid film is given as, $u = ky(2h - y)$; $v = 0$, the value of constant k is



(A) $\dfrac{\rho g \sin\theta}{2\mu}$ (B) $\dfrac{\rho g \cos\theta}{2\mu}$

(C) $\rho g \sin\theta$ (D) $\rho g \cos\theta$

Q.14 A water jet of 100 mm diameter issuing out of a nozzle at a speed of 50 m/s strikes a vane and flows along it as shown in figure. The vane is attached to a cart which is moving at a constant speed of 20 m/s on a frictionless track. The jet is deflected at an angle of 30°. Take the density of water as 1000 kg/m^3. Neglecting the friction between the vane and the fluid, the magnitude of the force exerted by water on the cart in the x-direction, in N, is ______.



Q.15 Capillary waves are generated in the sea. The speed of propagation (C) of these waves is known to be a function of density (ρ), wave length (λ), and surface tension (σ). Assume, ρ and λ to be constant. If the surface tension is doubled, in the functional form of the relevant non-dimensional group, the percentage increase in propagation speed (C) is _______ .

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Q.16 Consider a fully developed, two-dimensional and steady flow of a viscous fluid between two fixed parallel plates separated by a distance of 30 mm. The dynamic viscosity of the fluid is 0.01 kg/m-s and the pressure drop per unit length is 300 Pa/m. The fluid velocity at a distance of 10 mm from the bottom plate, in m/s, is ________.

Q.17 A 2.6 gram smooth table-tennis (ping-pong) ball has a diameter of 38 mm. Density (ρ) of air is 1.2 kg/m^3. Neglect the effect of gravity. Take coefficient of drag as 0.5. If the ball is struck with an initial velocity of 30 m/s, the initial deceleration, in m/s^2, is _________.

Q.18 On a flat plate, transition from laminar to turbulent boundary layer occurred at a critical Reynolds number (Re_{cr}). The empirical relations for the laminar and turbulent boundary layer thickness are given by $\frac{\delta_{lam}}{x} = 5.48\,Re_x^{-0.5}$ and $\frac{\delta_{turb}}{x} = 0.37\,Re_x^{-0.2}$, respectively. The ratio of laminar to turbulent boundary layer thickness, at the location of transition, is 0.3. The value of Re_{cr} is _______.

Q.19 In a capillary tube of radius R = 0.25 mm, a fully developed laminar velocity profile is defined as, $u = \frac{R^2}{4\mu}\left(-\frac{dp}{dx}\right)\left(1-\frac{r^2}{R^2}\right)$. In this expression, $-\frac{dp}{dx} = 1$ MPa/m, μ is the dynamic viscosity of the fluid, and r is the radial position from the centerline of the tube. If the flow rate through the tube is 1000 mm^3/s, the viscosity of the fluid, in Pa-s, is ______________.

Q.20 The skin friction coefficient for a turbulent pipe flow is defined as, $C_f = \frac{\tau_w}{1/2\,\rho V^2}$, where τ_w is the wall shear stress and V is the average flow velocity. The value of C_f is empirically given by the relation: $C_f = 0.065\left(2/Re\right)^{0.25}$, where Re is the Reynolds number. If the average flow velocity is 10 m/s, diameter of the pipe is 250 mm, kinematic viscosity of the fluid is 0.25×10^{-6} m^2/s, and density of the fluid is 700 kg/m^3, the skin friction drag induced by the flow over 1 m length of the pipe, in N, is ___________.

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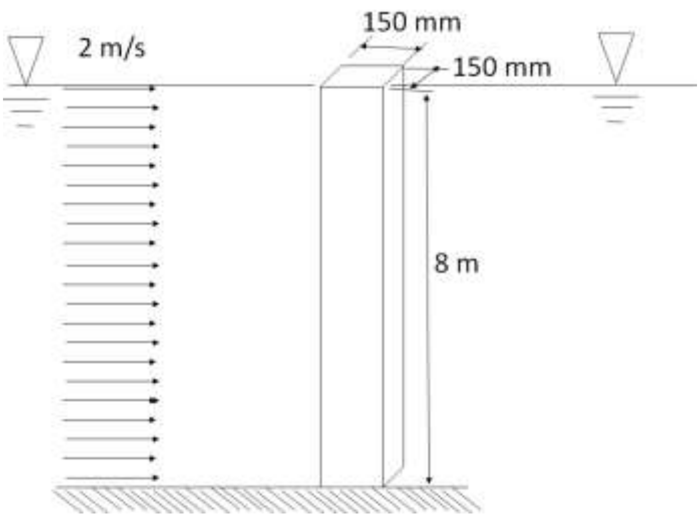
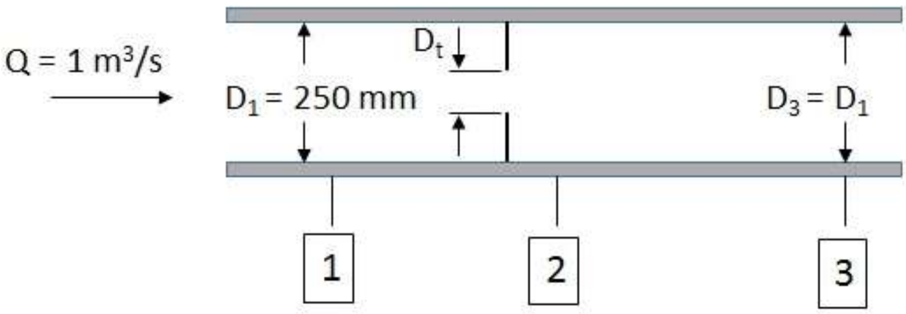
Q.21 A (150 mm × 150 mm) square pillar is located in a river with water flowing at a velocity of 2 m/s, as shown in figure. The height of the pillar in water is 8 m. Take density of water as 1000 kg/m^3 and kinematic viscosity as 1×10^{-6} m/s^2. The coefficient of drag of the pillar is 2.0. The drag force exerted by water on the pillar in N is _______.



Q.22 An orifice plate is used to measure flow rate of air (density = 1.23 kg/m^3) in a duct of 250 mm diameter as shown in figure. The volume flow rate is 1 m^3/s. Flow at sections 1 and 3 is uniform and section 2 is located at vena contracta. The diameter ratio, D_t/D_1, is 0.66. The flow area at vena contracta, $A_2 = 0.65A_t$, where A_t is area of the orifice. The pressure difference between locations 2 and 3 in N/m^2 is ____________.



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XE (C): Q. 1 – Q. 9 carry one mark each & Q. 10 – Q. 22 carry two marks each.

Q.1 The stress ratio for a completely reversed cyclic loading during a fatigue test is

(A) 0 (B) 1 (C) −1 (D) −1/2

Q.2 Minimum symmetry that a cubic crystal must possess is

(A) four 3-fold rotation axes.
(B) three 4-fold rotation axes.
(C) three orthogonal mirror planes.
(D) centre of symmetry.

Q.3 If a material is repelled in an external magnetic field then it is

(A) Ferromagnetic (B) Diamagnetic
(C) Paramagnetic (D) Antiferromagnetic

Q.4 An electron makes a transition from the valence band to the conduction band in an indirect band gap semiconductor. Which one of the following is true?

(A) Energy of the electron decreases.
(B) A photon is emitted in the process.
(C) A phonon is annihilated in the process.
(D) A photon is created in the process.

Q.5 Which one of the following is the characteristic of a screw dislocation?

(A) Dislocation line and Burgers vector are parallel.
(B) Direction of motion of dislocation is parallel to the Burgers vector.
(C) Atomic displacement due to the movement of the dislocation is in the direction of the motion of the dislocation line.
(D) It has a unique slip plane.

Q.6 The number of vibrational degrees of freedom for a non-linear triatomic molecule are

(A) 9 (B) 6 (C) 4 (D) 3

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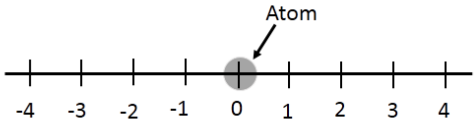
Q.7 An atom is restricted to move in one dimension by making unit jumps either to the left or right, as shown in the figure. Assuming that a jump to the left or right is equally probable, the probability of the atom returning back to the starting point after four jumps is



(A) 0.250 (B) 0.333 (C) 0.375 (D) 0.500

Q.8 For a two-dimensional solid, the variation of lattice specific heat as a function of temperature T (in K, at low temperatures) is given as: $C_p = bT^n$, where b is a constant. The value of n is ____________.

Q.9 If the cation (C) to anion (A) radius ratio, r_C/r_A is 0.6, then the coordination number (i.e., number of A ions surrounding a C ion) is likely to be ____________.

Q.10 Match the invariant reactions in Column I with the names in Column II (L is liquid phase, and α, β, γ are solid phases). All reactions proceed to the right on cooling.

Column I	Column II
(P) $L \rightleftarrows \alpha + \beta$	(1) Monotectic
(Q) $L + \alpha \rightleftarrows \beta$	(2) Peritectoid
(R) $\gamma \rightleftarrows \alpha + \beta$	(3) Peritectic
(S) $\alpha + \beta \rightleftarrows \gamma$	(4) Eutectoid
	(5) Eutectic

(A) P-5, Q-1, R-4, S-3 (B) P-5, Q-3, R-4, S-2
(C) P-5, Q-1, R-2, S-4 (D) P-2, Q-1, R-4, S-5

Q.11 Consider the following anodic (oxidation) reaction in an acidic solution:

$$Mg \longrightarrow Mg^{+2} + 2e^-$$

If 48250 Coulomb charge is produced during this anodic reaction then the amount of Mg (in g) dissolved into the solution is
(Given: Faraday Constant =96500 C/mole of electrons, Atomic weight of Mg = 24)

(A) 6 (B) 12 (C) 24 (D) 48

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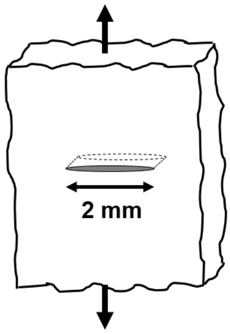
Q.12 An intrinsic semiconductor has conduction electron concentration, $n = 10^{12}$ cm^{-3}. The mobility of both electrons and holes are identical = 4×10^4 cm^2 V^{-1} s^{-1}. If a voltage of 100 V is applied on two parallel end faces of the cube (edge length 1 cm) through Ohmic contacts, the current through the cube would be (in mA)
(Given: charge of electron = 1.6×10^{-19} C)

(A) 640 (B) 1280 (C) 6400 (D) 12800

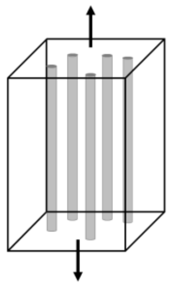
Q.13 An infinite plate with a through-thickness crack of length 2 mm is subjected to a tensile stress (as shown in the figure). Assuming the plate to be linear elastic, the fracture stress is ____________ MPa *(round off to the nearest whole number)*

(Given: Fracture toughness, $K_{IC} = 25\ MPa\sqrt{m}$)



Q.14 A unidirectionally aligned carbon fibre reinforced epoxy composite is loaded as shown in the figure. The volume fraction of the fibre is 0.6. The Young's modulus of the composite is ____________ GPa.

(Given: Young's Modulus of the fibre and the matrix are 200 GPa and 10 GPa, respectively)



Q.15 A sintered sample was weighed in air and water using an analytical balance. The mass of the sample in air is 2.67 g and its apparent mass in water is 1.67 g. The density of the sample is __________ g cm^{-3} *(give answer up to 2 decimal places)*

(Given: Density of water = 1.00 g cm^{-3})

Q.16 The atoms in a gas laser have two energy levels such that a transition from the higher to the lower level releases a photon of wavelength 500 nm. If 7×10^{20} atoms are pumped into the upper level with 4×10^{20} atoms in the lower level, the amount of energy released in a single pulse is ____________ Joules *(give answer up to 2 decimal places)*

(Given: Planck's constant, h = 6.6×10^{-34} J s; speed of light, c = 3×10^{8} m s^{-1})

Q.17 The speed of an electron is measured to be 300 m s^{-1} with an uncertainty of 0.01%. The fundamental accuracy with which the position of the electron can be determined simultaneously with the speed in the same experiment is _________ mm *(give answer up to 2 decimal places)*

(Given: Planck's constant, h = 6.6×10^{-34} J s; mass of electron = 9.1×10^{-31} kg)

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Q.18 When 3 identical non-interacting spin ½ particles are put in an infinite potential well, the ground state energy of the system is 18 meV. If instead, seven particles are put inside the potential well, the new ground state energy is ________ meV.

Q.19 If the value of the integral (I) is 4, the value of the constant b is ___________ *(give answer up to 2 decimal places).*

$$I = \int_{-\infty}^{\infty} e^{\frac{-x^2}{b}} dx$$

Q.20 X-ray diffraction pattern is obtained from FCC polycrystalline aluminium (lattice parameter = 0.405 nm) using Cr-Kα radiation of wavelength 0.229 nm. The maximum number of peaks that can be observed in the pattern is ____________.

Q.21 The planar atomic density in the (110) plane of a BCC iron crystal is ____________ nm^{-2} *(give answer up to 2 decimal places)*

(Given: lattice parameter of iron is 0.287 nm)

Q.22 Mild steel is carburized at 1300 K for 1 hour to obtain a certain case depth. Keeping the time as 1 hour, the case depth can be doubled by increasing the temperature to ______________K *(round off to the nearest whole number)*

(Given: Activation energy Q = 148 kJ mol^{-1}, Gas constant, R = 8.314 J mol^{-1} K^{-1})

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XE (D): Q. 1 – Q. 9 carry one mark each & Q. 10 – Q. 22 carry two marks each.

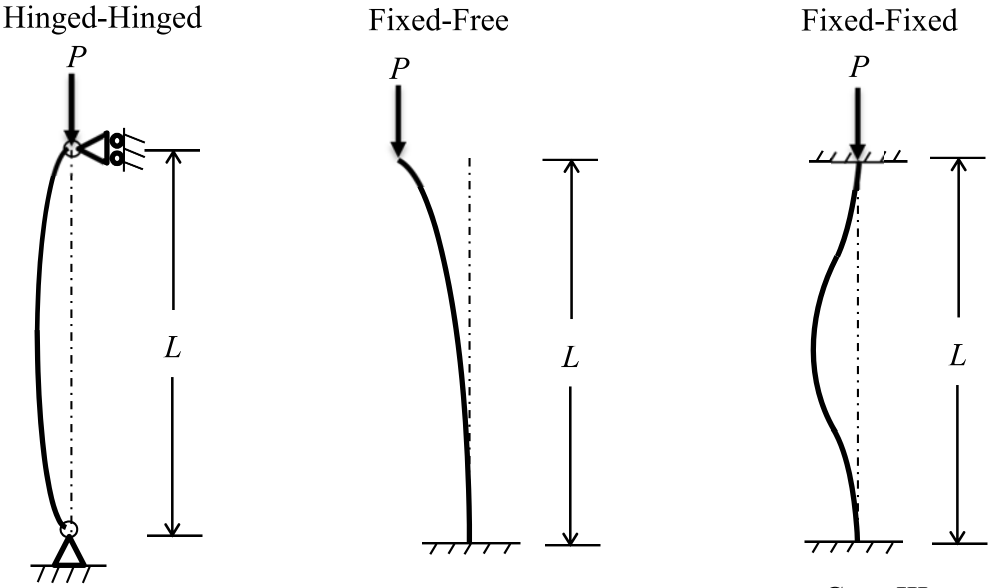
Q.1 A thin cylinder (thickness, t and diameter, d) with closed ends is subjected to an internal pressure, p. The ratio of hoop stress to longitudinal stress developed in the wall of the cylinder is

(A) 1:4 (B) 1:2 (C) 1:1 (D) 2:1

Q.2 A steel rod is fixed at one end and free at the other end. The coefficient of thermal expansion of the steel is α, and modulus of elasticity is E. If the temperature of the rod is increased by ΔT then the stress and strain developed in the rod are respectively

(A) zero, $\alpha\Delta T$
(B) $E\alpha\Delta T$, $\alpha\Delta T$
(C) $E\alpha\Delta T$, zero
(D) zero, zero

Q.3 The effective lengths of the columns with ideal boundary conditions shown in Case-I, Case-II, and Case-III are respectively



Case-I Case-II Case-III

(A) L, $4L$, $2L$
(B) L, $2L$, $L/4$
(C) L, L, L
(D) L, $2L$, $L/2$

Q.4 At a point in a stressed body, sum of the normal stresses acting on perpendicular faces of an arbitrarily oriented plane stress element is always

(A) dependent on the angle of orientation of the element
(B) constant and independent of angle of orientation of the element
(C) one half of the sum of the principal stresses
(D) zero

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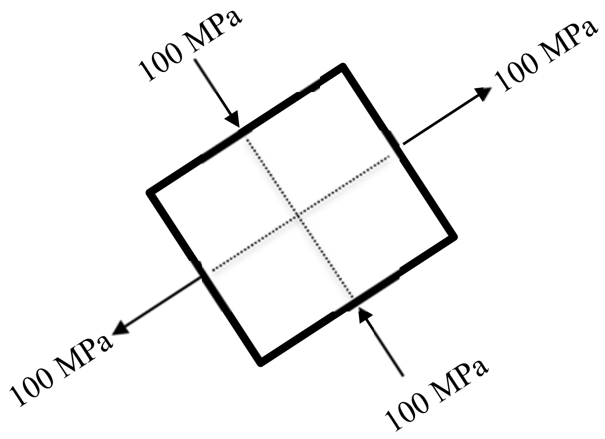
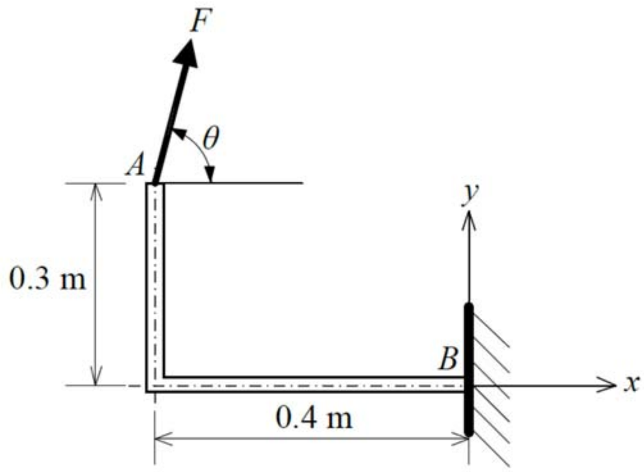
Q.5 The principal stresses on a plane stress element are shown in the figure. The maximum shear stress (in MPa) is



(A) 200 (B) 100 (C) 50 (D) 0

Q.6 A rigid and thin L-shaped bracket is fixed to the wall at point *B,* and a force *F* is applied at point *A* as shown**.** For a given force *F*, the point *B* experiences the maximum clockwise moment when the inclination θ (in degrees) with the *x*-axis is……….[*up to two decimal places*].



Q.7 A cantilever beam with length, $L = 1$ m, modulus of elasticity, $E = 210$ GPa, and area moment of inertia, $I = 1.2 \times 10^{-7}\text{m}^4$ carries a concentrated mass $m = 100$ kg at its free-end. By idealizing it as a single degree-of-freedom system and neglecting the mass of the cantilever beam, the natural frequency (in rad/s) of small transverse oscillations of the mass m is …….. [*up to two decimal places*]

Q.8 For a typical grade of steel, the value of modulus of elasticity (E) and Poisson's ratio (ν) are 208 GPa and 0.3 respectively. The value of shear modulus (G) of the steel (in GPa) is ……..

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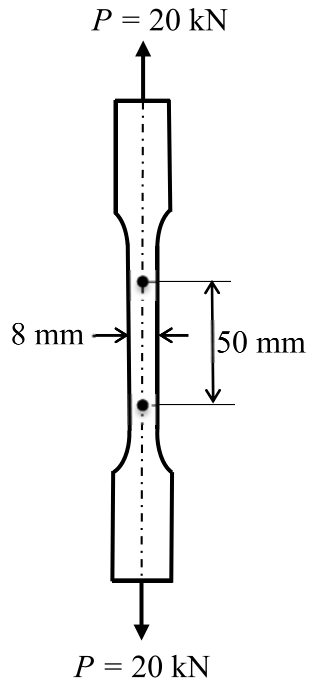
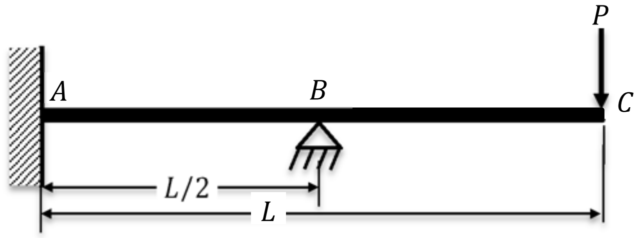
Q.9 A tensile test is performed on a metallic specimen of diameter 8 mm and gauge length 50 mm. When the tensile load P reaches a value of 20 kN, the distance between the gauge marks increases by 0.09 mm. If the sample remains within the elastic limit, the modulus of elasticity (in GPa) of the test metal is……….[*up to two decimal places*]



Q.10 A beam ABC is subjected to load P at its free end C as shown in the figure. The flexural rigidity of the beam is EI. The vertical support reaction at point B is



(A) $\frac{5P}{4}$ (B) $\frac{5P}{2}$ (C) $\frac{4P}{5}$ (D) $\frac{2P}{5}$

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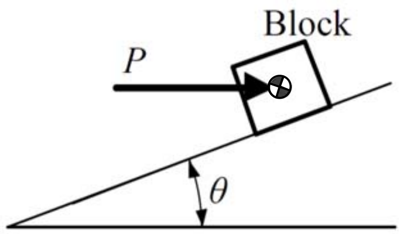
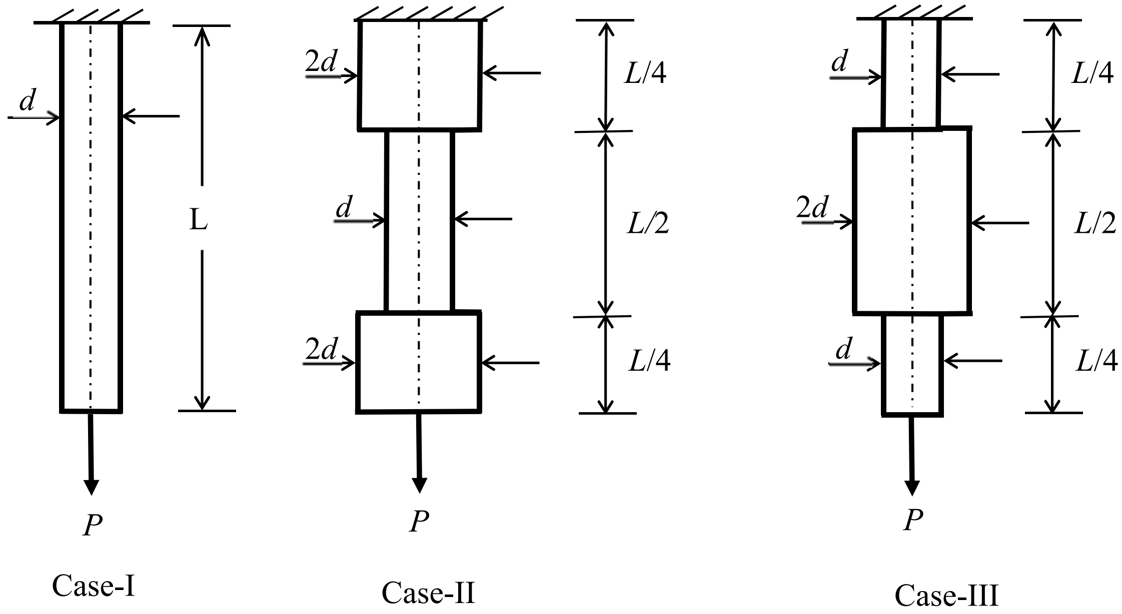
Q.11 A horizontal effort P is applied to raise a block of weight W on a rough surface inclined at an angle θ with the horizontal. If μ_s is the coefficient of static friction between the block and the surface, the minimum effort P required to impend the upward motion of the block along the surface is



(A) $W\left(\frac{\mu_s - tan\theta}{1+\mu_s tan\theta}\right)$ (B) $W\left(\frac{\mu_s + tan\theta}{1-\mu_s tan\theta}\right)$ (C) $W\left(\frac{\mu_s - tan\theta}{1-\mu_s tan\theta}\right)$ (D) $W\left(\frac{\mu_s + tan\theta}{1+\mu_s tan\theta}\right)$

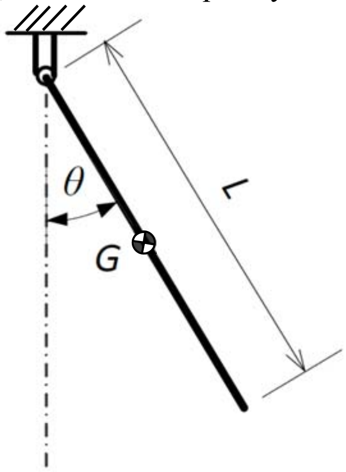
Q.12 Three round bars of same material, equal lengths, and different cross-sectional dimensions are shown in the figures as Case-I, Case-II and Case-III. All the bars are clamped at the upper end, and a concentrated load P is applied at the lower end of each bar. If the elastic strain energy stored in the bar shown in Case-I is U_1 then the elastic strain energy stored in Case-II and Case-III respectively is



(A) $\left(8/5\right)U_1, \left(5/8\right)U_1$ (B) $\left(5/16\right)U_1, \left(5/16\right)U_1$

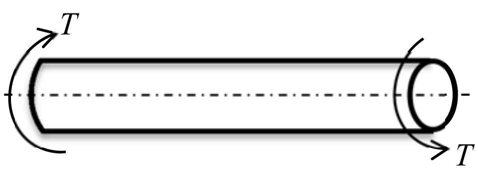
(C) $\left(5/8\right)U_1, \left(8/5\right)U_1$ (D) $\left(5/8\right)U_1, \left(5/8\right)U_1$

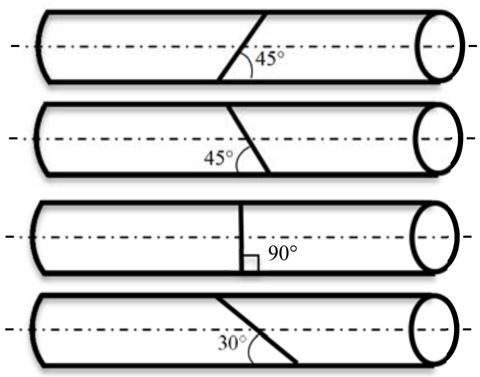
Q.13 A rigid uniform rod with mass m, length L and center of gravity G is freely suspended from a hinge as shown in the figure. The rod is given a small angular displacement θ in the counter-clockwise direction from the position in which it hangs vertically ($\theta = 0$). If g is the acceleration due to gravity, the natural frequency of oscillations (in rad/s) is



(A) $\sqrt{\frac{6g}{L}}$ (B) $\sqrt{\frac{2g}{L}}$ (C) $\sqrt{\frac{3g}{2L}}$ (D) $\sqrt{\frac{g}{L}}$

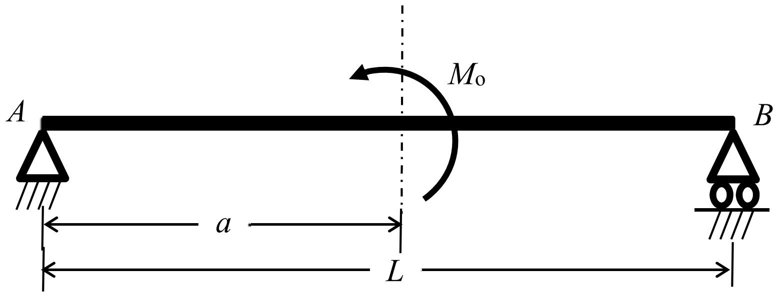
Q.14 A cylindrical member, made up of ductile material, is subjected to pure torsion as shown in the figure. The failure plane (from Option-I to Option-IV) for ductile material as per maximum shear stress theory is represented by

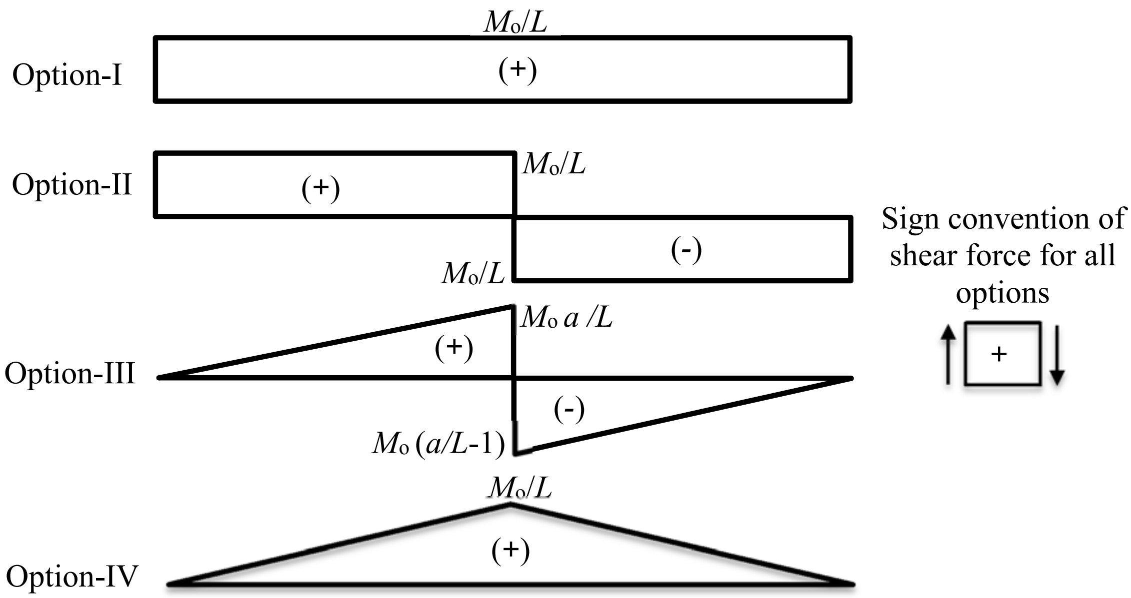




(A) Option I
(B) Option II
(C) Option III
(D) Option IV

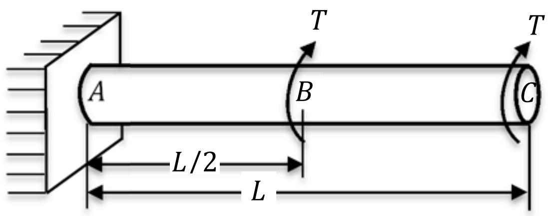
Q.15 A simply supported beam of span L is subjected to a couple M_o at a distance a from support A. Among the four options (Option-I to Option-IV) shown, the correct shear force diagram of the beam is





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

Q.16 A circular shaft ABC of diameter, d and length, L is fixed at end A. It is subjected to the torsional moments at point B and point C as shown in the figure. The ratio of angle of twists at point B to point C is



(A) 1.5 : 1 (B) 1 : 3 (C) 1 : 2 (D) 1 : 1.5

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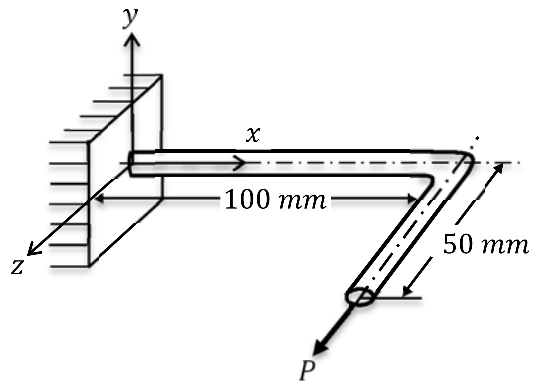
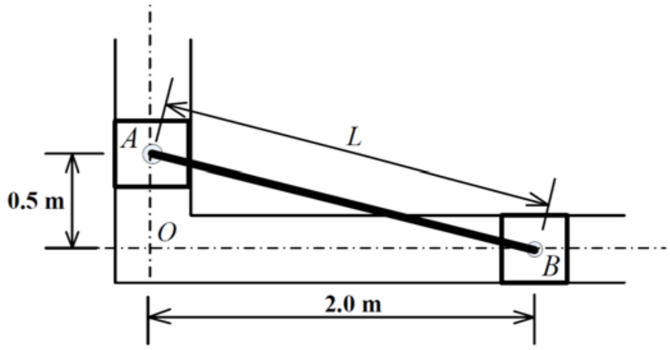
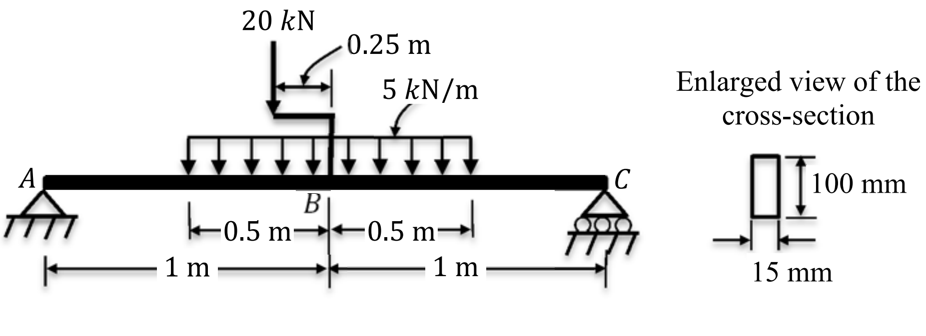
Q.17 A circular steel bar of diameter 10 mm is bent into the shape as shown in figure, and lies in *x*-*z* plane. A horizontal force *P* is applied along the positive *z*-direction as shown. The yield strength of the steel is 200 MPa. Neglecting the effect of transverse shear, the load *P* (in Newton) required to initiate yielding as per maximum shear stress theory of failure is…………[*up to two decimal places*]



Q.18 Two sliders *A* and *B*, connected by a rigid link of length *L*, slide in two mutually perpendicular and frictionless guide-ways. At a particular instance, the slider *A* is moving in the downward direction with a speed of 0.05 m/s. At this instance, the magnitude of the velocity of slider *B* (in m/s) is ……[*up to two decimal places*]



Q.19 A simply supported beam *ABC* is subjected to load as shown in the figure. The 20 kN load is applied at point *B* with the help of a welded bracket as shown. The beam has a rectangular cross-section of 15 mm width and 100 mm depth as shown. The maximum transverse shear stress developed in the beam (in MPa) is ……..[*up to one decimal place*]



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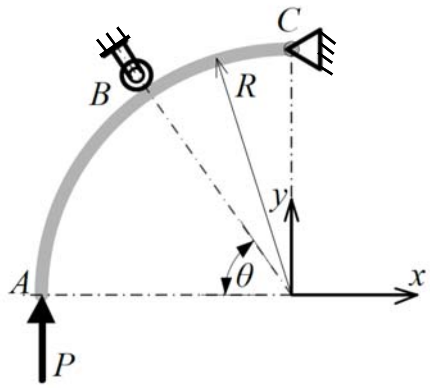
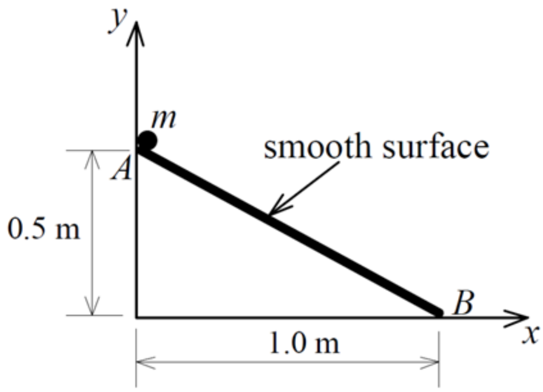
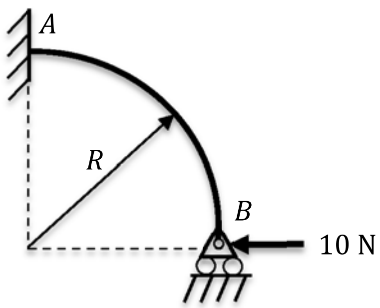
Q.20 A rigid rod *ABC*, in the form of a quarter-circular arc of radius *R*, is hinged at *C* and supported by a roller at *B***.** A vertical force *P* is applied at the end *A* of the bar. For the reactions at *B* and *C* to be equal in magnitude, the value of the angle θ (in degrees) is ………. [*up to two decimal places*].



Q.21 A marble of mass *m* slides along a frictionless linear slide *AB* kept in a vertical plane. The marble is released from point *A* with zero initial velocity, and it reaches point *B* under the action of gravity. Assuming the acceleration due to gravity to be 9.81 m/s^2, the speed (in m/s) of the marble when it just reaches point *B* is………[*up to two decimal places*].



Q.22 A horizontal force 10 N is applied at support *B* on the frame as shown in figure. Considering only bending deformation, the vertical reaction (in N) at support *B* is ………. [*up to one decimal place*]



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XE (E): Q. 1 – Q. 9 carry one mark each & Q. 10 – Q. 22 carry two marks each.

Notation used:
P : pressure, V : volume, T : temperature, s : specific entropy, h : specific enthalpy, C_p : molar heat capacity at constant pressure, C_v : molar heat capacity at constant volume, R : universal gas constant

Q.1 When a fixed mass of air-water vapour mixture is heated at constant pressure,

(A) both relative and specific humidity decrease.
(B) relative humidity decreases, but specific humidity remains unchanged.
(C) specific humidity decreases, but relative humidity remains unchanged.
(D) both relative and specific humidity increase.

Q.2 For a reversible isothermal expansion of one mole of an ideal gas from state 1 to state 2, the magnitude of work done is

(A) $RT\ln\left(\frac{P_1}{P_2}\right)$ (B) $P_2V_2 - P_1V_1$

(C) $R\ln\left(\frac{V_1}{V_2}\right)$ (D) 0

Q.3 The statement which is NOT a consequence of the first law of thermodynamics is

(A) Heat is a path function
(B) Energy is a property of a system
(C) Energy of an isolated system is not conserved
(D) A perpetual motion machine of the first kind is not possible

Q.4 For a refrigerator absorbing heat Q_L from a cold region and rejecting heat Q_H to a hot region, the coefficient of performance is written as

(A) $\frac{Q_L}{Q_H - Q_L}$ (B) $\frac{Q_H}{Q_H - Q_L}$

(C) $\frac{Q_H - Q_L}{Q_L}$ (D) $\frac{Q_L}{Q_H}$

Q.5 The value of the compressibility factor at the critical point evaluated using the van der Waals equation of state is

(A) $\frac{2}{7}$ (B) $\frac{5}{8}$ (C) $\frac{3}{8}$ (D) $\frac{1}{7}$

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Q.6 The vapour pressure of a liquid at 8 °C is 2.7 kPa. Its enthalpy of vaporization is constant and equal to 42700 kJ/kmol. Take R = 8.314 kJ/kmol.K. The temperature (in °C) at a vapour pressure of 13.5 kPa is

(A) 58.7 (B) 51.4 (C) 44.3 (D) 35.2

Q.7 One kmol of an ideal gas (C_p = 21 kJ/kmol.K) undergoes a constant pressure process from 300 K to 500 K. The molar entropy of the gas at 300 K is 150 kJ/kmol.K. The molar entropy (in kJ/kmol.K) at 500 K (up to 1 decimal place) is ________.

Q.8 A spring, having a spring constant of 350 kN/m, is initially compressed by 0.4 cm. The work required (in J) to compress it by another 0.6 cm (up to 1 decimal place) is ________.

Q.9 An ideal gas has a molar mass of 40 kg/kmol. Take R = 8.314 kJ/kmol.K. At a pressure of 2 bar and a temperature of 300 K, the volume (in m^3) of 1 kg of this gas (up to 2 decimal places) is ________.

Q.10 Consider the following statements for an ideal gas undergoing a reversible non-flow process:

P. If the process is adiabatic, the change in enthalpy of the gas is necessarily zero.
Q. If the process is adiabatic, the change in entropy of the gas is necessarily zero.
R. If the process is isothermal, the change in enthalpy of the gas is necessarily zero.
S. If the process is isothermal, the change in entropy of the gas is necessarily zero.

Which one of the following options is valid?

(A) Only P is correct
(B) Only S is correct
(C) Only Q and R are correct
(D) Only P and S are correct

Q.11 An ideal Otto cycle (O) and an ideal diesel cycle (D) have the same maximum temperature and reject equal amount of heat. Also, the working fluid enters at the same state before compression. One of the following statements always true about their efficiencies (η) is

(A) $\eta_O > \eta_D$
(B) $\eta_O = \eta_D$
(C) $\eta_O < \eta_D$
(D) $\eta_O = 1 - \eta_D$

Q.12 A reversible engine receives 75 kJ/s of energy from a reservoir at 750 K and does 12 kJ/s of work. The heat is rejected to two reservoirs at 650 K and 550 K. The rate of heat rejection (in kJ/s) to the reservoir at 650 K is

(A) 11 (B) 31 (C) 41 (D) 52

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Q.13 A gas obeys the following equation of state:

$$P(\bar{v}-b) = RT + \frac{aP^2}{T} \ ,$$

where $\bar{v}$ is molar volume, and a, b are constants with values $a = 10^{-5}$ J.K/Pa^2.kmol and $b = 8\times10^{-2}$ m^3/kmol. Take C_p = 30 kJ/kmol.K. At 10 bar and 500 K, the value of the Joule-Thomson coefficient (in K/Pa) is

(A) -2×10^{-6} (B) -4×10^{-6} (C) 2×10^{-6} (D) 4×10^{-6}

Q.14 In an ideal Rankine cycle, steam enters the turbine at 10 MPa and 500 °C (h = 3375.1 kJ/kg, s = 6.5995 kJ/kg.K). It is cooled in the condenser at a pressure of 10 kPa. At 10 kPa, h_f = 191.81 kJ/kg, s_f = 0.6492 kJ/kg.K, h_g = 2583.9 kJ/kg and s_g = 8.1488 kJ/kg.K. The heat rejected in the condenser (in kJ/kg) is

(A) 1898 (B) 3796 (C) 949 (D) 2847

Q.15 Methane has compressibility factor value of 0.9 at reduced pressure of 1.0 and reduced temperature of 1.5. For propane, the critical temperature and pressure are 369.8 K and 42.48 bar, respectively. Take R = 8.314 kJ/kmol.K. Applying the principle of corresponding states, the molar volume of propane (in m^3/kmol) at the same reduced pressure and temperature is

(A) 0.355 (B) 0.526 (C) 0.791 (D) 0.977

Q.16 A rigid insulated vessel is divided into two compartments by a partition. One compartment contains 12 kg of oxygen at 200 kPa and 280 K. The other compartment contains 26 kg of carbon dioxide at 400 kPa and 360 K. The specific heats at constant volume in kJ/kg.K for oxygen and carbon dioxide are 0.662 and 0.653, respectively. The partition is removed and the gases are allowed to mix. Considering both gases are ideal, the final temperature (in K) of the mixture (up to 1 decimal place) is ________.

Q.17 Moist air having 60% relative humidity, enters a steady-flow air-conditioning unit at 102 kPa and 30 °C. The volume flow rate of the moist air entering the unit is 0.1 m^3/s. The moist air leaves the unit at 95 kPa and 15 °C with a relative humidity of 100%. Liquid condensate leaves the unit at 15 °C.

For water: at 15 °C, h_f = 62.982 kJ/kg, h_g = 2528.3 kJ/kg, P_{sat} = 1.7057 kPa.

at 30 °C, h_f = 125.74 kJ/kg, h_g = 2555.6 kJ/kg, P_{sat} = 4.2469 kPa.

For air, specific heat at constant pressure is 1.004 kJ/kg.K and the specific gas constant is 0.287 kJ/kg.K.

Neglecting heat leakage to the surrounding, the magnitude of heat extracted (in kW) from the air stream (up to 2 decimal places) is ___________.

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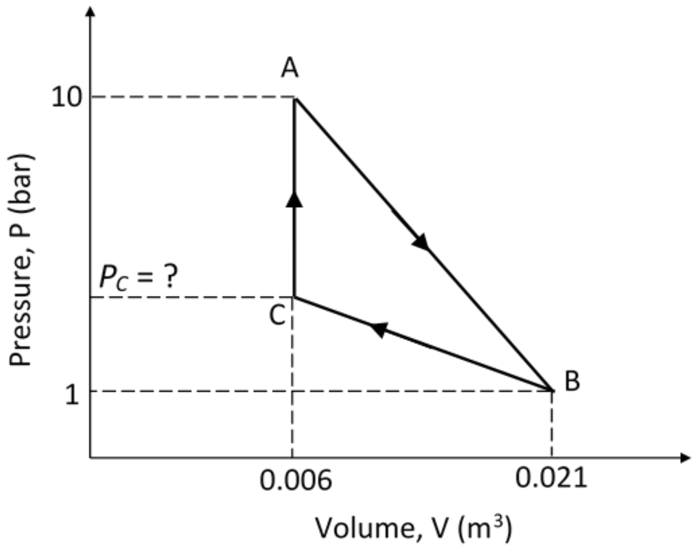
Q.18 Air at 150 kPa and 323 K is filled in a rigid vessel of 0.05 m^3 capacity. For air, assumed as an ideal gas, specific heat at constant volume is 0.7163 kJ/kg.K and the specific gas constant is 0.287 kJ/kg.K. Neglect kinetic and potential energy changes. If 30 kJ of heat is added, the final temperature (in K) of air (up to 1 decimal place) is __________.

Q.19 Superheated steam at 2 bar and 300 °C, with an enthalpy of 3072.1 kJ/kg, enters a horizontal adiabatic nozzle with negligible velocity and leaves at 0.2 bar as saturated vapour with an enthalpy of 2609.9 kJ/kg. Assuming steady flow and neglecting the potential energy changes, the exit velocity (in m/s) of the steam (up to 1 decimal place) is __________.

Q.20 A given mass of a simple compressible substance undergoes a reversible cycle, as shown in the P-V diagram. The magnitude of the net work done during the cycle is 3 kJ. The pressure (in bar) at point C (up to 1 decimal place) is ________.



Q.21 One kmol of an ideal gas at 300 K and 10 bar is reversibly heated in a constant volume process to 500 K. It is then reversibly and isothermally expanded to 2 bar. Take C_v = 20.8 kJ/kmol.K and R = 8.314 kJ/kmol.K. The total heat supplied (in kJ) to the gas (up to 1 decimal place) is ________.

Q.22 A rigid container is completely filled with a liquid having a constant isothermal compressibility of $1.09\times10^{-4}\ \text{bar}^{-1}$ and a constant coefficient of volume expansion of $1.12\times10^{-3}\ \text{K}^{-1}$. The liquid is initially at 300 K and 1 bar. Heat is supplied to the liquid to raise its temperature to 350 K. Assuming that no phase change occurs, the final pressure (in bar) of the liquid (up to 1 decimal place) is ________.

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XE (F): Q. 1 – Q. 9 carry one mark each & Q. 10 – Q. 22 carry two marks each.

Q.1 Which one of the following polymers occurs naturally?

(A) Bakelite (B) Teflon (C) Cellulose (D) Perspex

Q.2 The order of average molecular weights of a polymer is

(A) $M_z > M_w > M_v > M_n$
(B) $M_w > M_z > M_n > M_v$
(C) $M_n > M_w > M_v > M_z$
(D) $M_z > M_v > M_n > M_w$

Q.3 Rubbers are a class of polymer known for

(A) High intermolecular forces
(B) High T_g polymers
(C) Crystalline polymers
(D) Low intermolecular forces

Q.4 Nylon 6 is manufactured from

(A) Sebacic acid and hexamethylene diamine
(B) Caprolactam
(C) Adipic acid and hexamethylene diamine
(D) Caprolactone

Q.5 Storage modulus and tan δ of a polymer are experimentally measured by

(A) Differential scanning calorimetry
(B) Thermogravimetric analysis
(C) Thermomechanical analysis
(D) Dynamic mechanical thermal analysis

Q.6 A plastic bucket is manufactured by

(A) Compression moulding
(B) Injection moulding
(C) Extrusion
(D) Blow moulding

Q.7 The monomers, A and B with reactivity ratios r_A and r_B, form alternate copolymers when,

(A) $r_A = r_B = 0$ (B) $r_A = r_B = 1$ (C) $r_A > 1,\ r_B > 1$ (D) $r_A < 1,\ r_B < 1$

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Q.8 The degree of polymerization of a poly(methyl methacrylate) sample having number average molecular weight of 1,50,000 g/mol is___________.
(C = 12, H = 1, O = 16 g/mol).

Q.9 If the heat of fusion of 100 % crystalline polyethylene is 290 mJ/mg, a sample of polyethylene with heat of fusion of 141 mJ/mg will have_______ % crystallinity.

Q.10 Match the following:

P. Butyl rubber	1. Metallocene polymerization
Q. Cold SBR	2. Cationic polymerization
R. Poly(ethylene terephthalate)	3. Redox polymerization
S. Polypropylene	4. Condensation polymerization

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

Q.11 Match the following:

P. Polyaramid	1. Baby-feeding nipple
Q. Polytetrafluoroethylene	2. Optical glasses
R. Polycarbonate	3. Non-stick cookware
S. Poly(dimethyl siloxane)	4. Bullet-proof jacket

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

Q.12 Flexible PVC tubes are used for watering. If some organic solvents are passed through this tube, it becomes stiff. This is due to the fact that the organic solvents

(A) plasticize PVC and raise T_g.
(B) remove plasticizer and raise T_g.
(C) remove plasticizer and lower T_g.
(D) react with PVC and increase T_g

Q.13 Match the following:

P. Plastic egg container	1. Injection moulding
Q. Water tank	2. Extrusion
R. Chair	3. Rotational moulding
S. Cable	4. Thermoforming

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

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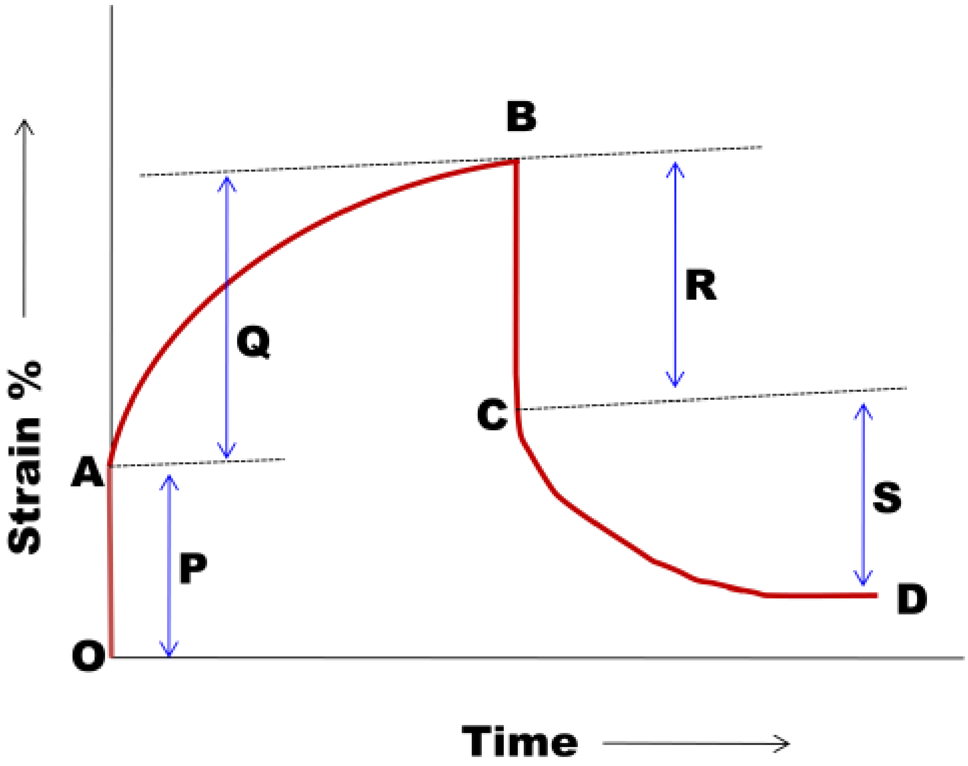
Q.14 Match the following:

P. Flame retardant	1. 4-Methyl-2,6-di-t-butyl phenol
Q. UV absorber	2. Azocarbonamide
R. Blowing agent	3. Phenyl salisylate
S. Antioxidant	4. Aluminium trihydrate

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

Q.15 A plot of strain (%) versus time of a polymer is given below. Based on this plot and the properties as mentioned below, find out the correct combination.



1 = Viscoelastic deformation; 2 = Elastic deformation
3 = Viscoelastic recovery; 4 = Elastic recovery

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

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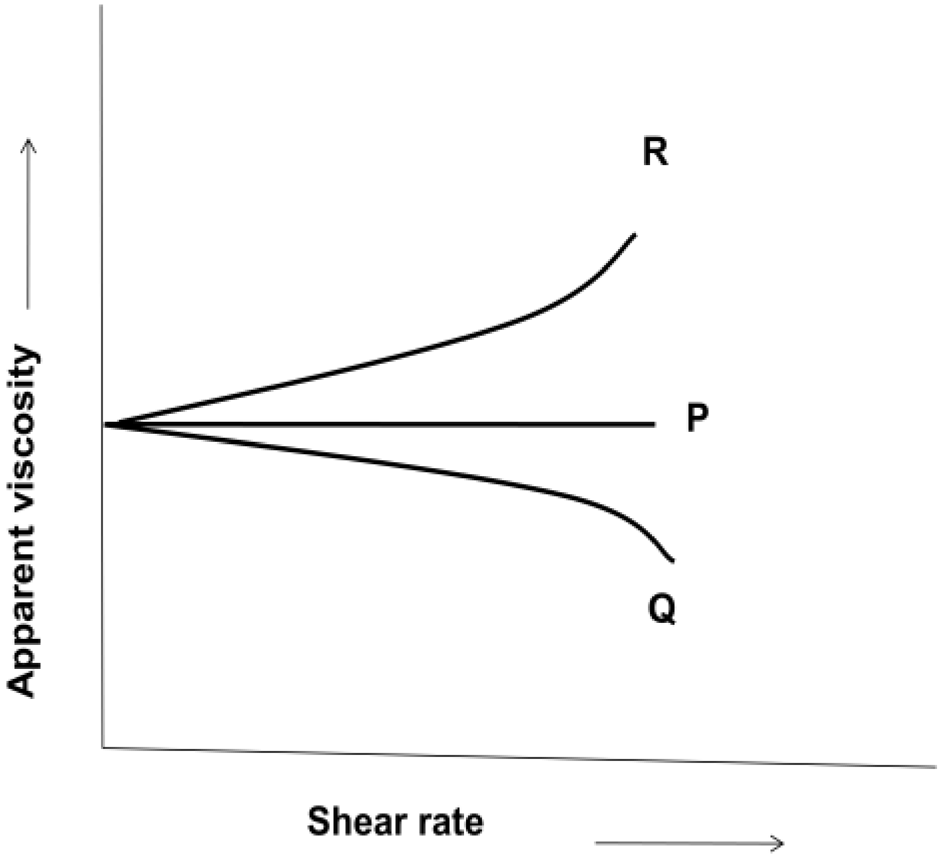
Q.16 The plot shows apparent viscosity versus shear rate of Newtonian, Dilatent and Pseudoplastic fluids. Based on this plot and the fluid behaviour as mentioned below, find out the correct combination.



1 = Dilatent fluid; 2 = Newtonian fluid, 3 = Pseudoplastic fluid

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

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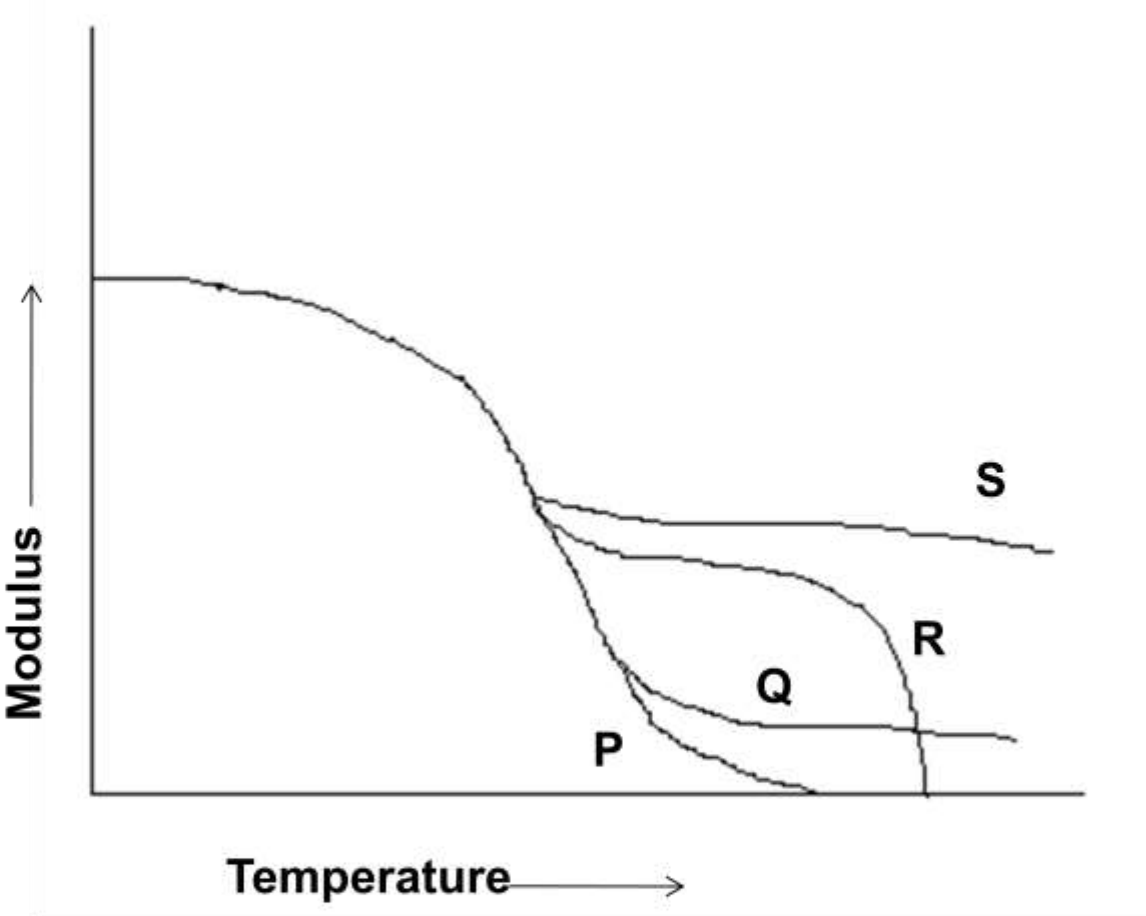
Q.17 Plot of the modulus versus temperature of different types of polymers is given below. Based on this plot and the nature of the polymers as mentioned below, find out the correct combination.



1 = An amorphous polymer of high molecular weight having entanglements
2 = An amorphous polymer of moderate molecular weight
3 = Highly crosslinked polymer
4 = Semi-crystalline polymer

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

Q.18 The T_g of homopolymers of A and B are +100 ^oC and -70 ^oC respectively. The T_g of a random copolymer of A and B having 40 wt% A and 60 wt% B is _________ ^oC.

Q.19 The number average molecular weight of a polymer prepared from $HO(CH_2)_{14}COOH$ is 24,000 g/mol. The conversion of the monomer required to reach the above molecular weight is__________%. (C = 12, H = 1, O = 16 g/mol).

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Q.20 Glass fibers in nylon provide reinforcement. The modulus of elasticity for each component of the composite is; E_{glass} = 10.5 x 10^6 psi; E_{nylon} = 0.4 x 10^6 psi. If the nylon contains 30 vol % E-glass, the fraction of the applied force is carried by the glass fiber is__________. (Assume that both glass fiber and nylon have equal strain).

Q.21 The solubility parameter of a polymer having cohesive energy density (E_{coh}) 43870 J/mol and molar volume (V) 136 cm^3/mol is _________ $(J/cm^3)^{1/2}$.

Q.22 The heat of polymerization of styrene is 20 Kcal/mol. Heat of 5 x10^5 Kcal will be released on polymerization of __________ Kg of styrene (C = 12 and H = 1 g/mol).

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XE (G): Q. 1 – Q. 9 carry one mark each & Q. 10 – Q. 22 carry two marks each.

Q.1 Which of the following is oil soluble pigment present in fruits and vegetables?

(A) Flavonoids (B) Carotenoids (C) Anthocyanins (D) Tannins

Q.2 Which of the following represent the group of saturated fatty acids?

(A) Lauric, Myristic, Arachidic
(B) Palmitic, Linoleic, Linolenic
(C) Capric, Stearic & Oleic
(D) Behenic, Caprylic, Arachidonic

Q.3 The anti-nutritional factor present in fava bean is

(A) Gossypol
(B) Curcine
(C) Vicine
(D) Cyanogen

Q.4 Irradiation carried out to reduce viable non-spore forming pathogenic bacteria using a dose between 3 to 10 kGy is called

(A) Radurization
(B) Thermoradiation
(C) Radappertization
(D) Radicidation

Q.5 Identify the correct statement related to the viscosity of Newtonian fluids from the following

(A) It is not influenced by temperature
(B) It increases with shearing rate
(C) It decreases with shearing rate
(D) It is not influenced by shearing rate

Q.6 Adult male Wistar rats were fed with a protein based diet. Total 150 g of protein was ingested per animal. If the average weight increased from 110 g to 350 g after the end of the experiment, the Protein efficiency ratio of the given protein would be _______. (up to two decimal points)

Q.7 The initial moisture content of a food on wet basis is 50.76%. Its moisture content (%) on dry basis is _______.(up to two decimal points)

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Q.8 The oxygen transmission rate through a 2.54 x 10^{-3} cm thick low density polyethylene film with air on one side and inert gas on the other side is 3.5 x 10^{-6} mL cm^{-2} s^{-1}. Oxygen partial pressure difference across the film is 0.21 atm. The permeability coefficient of the film to oxygen is _______ x 10^{-11} mL (STP) cm cm^{-2} s^{-1} (cm Hg)$^{-1}$.

Q.9 Ambient air at 30˚C dry bulb temperature and 80% relative humidity was heated to a dry bulb temperature of 80˚C in a heat exchanger by indirect heating. The amount of moisture gain (g kg^{-1} dry air) during the process would be _______.

Q.10 Match the commodity in **Group I** with the bioactive constituent in **Group II**

Group I	**Group II**
P. Ginger	1. Lutein
Q. Green tea	2. Gingerol
R. Spinach	3. Curcumin
S. Turmeric	4. Epigallocatechin gallate

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

Q.11 Match the process operation in **Group I** with the separated constituent in **Group II**

Group I	**Group II**
P. Extraction	1. Phospholipids
Q. Degumming	2. Free fatty acids
R. Neutralization	3. Pigments
S. Bleaching	4. Crude oil

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

Q.12 Match the spoilage symptom in **Group I** with the causative microorganism in **Group II**

Group I	**Group II**
P. Green rot of eggs	1. *Micrococcus* spp.
Q. Putrid swell in canned fish	2. *Serratia marcescens*
R. Red bread	3. *Pseudomonas fluorescens*
S. Yellow discoloration of meat	4. *Clostridium sporogenes*

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

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Q.13 Match the fermented product in **Group I** with the base material in **Group II**

Group I	**Group II**
P. Sake	1. Milk
Q. Chhurpi	2. Cabbage
R. Natto	3. Rice
S. Sauerkraut	4. Soybean

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

Q.14 Match the operation in **Group I** with the process in **Group II**

Group I	**Group II**
P. Cleaning	1. Quality separation
Q. Grading	2. Clarification
R. Size reduction	3. Screening
S. Filtration	4. Comminution

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

Q.15 Out of 7 principles of HACCP system, 4 are listed below. Arrange these principles in the order in which they are applied.

(P) Conduct a hazard analysis
(Q) Establish monitoring process
(R) Establish critical limit
(S) Establish record keeping and documentation process

(A) P, R, Q, S (B) Q, R, P, S (C) P, Q, R, S (D) R, S, P, Q

Q.16 Apple juice of 10% total solids (TS) is being concentrated in a single effect evaporator working with a surface condenser to 40% TS under a vacuum of 20 kPa. After some time the vacuum pump stops but the evaporation process continued. Choose the combination of possible implications from the following.

(P) Product quality is affected

(Q) Substantial increase in thermal energy requirement

(R) Decrease in the rate of evaporation

(A) P & Q (B) Q & R (C) R & P (D) P,Q & R

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Q.17 Identify an example of a classical diffusional mass transfer process without involving heat, among the following.

(A) Drying of food grains
(B) Carbonation of beverages
(C) Distillation of alcohol
(D) Concentration of fruit juice

Q.18 For an enzyme catalyzed reaction $S \rightarrow P$, the kinetic parameters are:
$[S] = 40\ \mu M$, $V_0 = 9.6\ \mu M\ s^{-1}$ and $V_{max} = 12.0\ \mu M\ s^{-1}$.
The K_m of the enzyme in µM will be _______.(up to one decimal points)

Q.19 A microbial sample taken at 10 AM contained 1×10^5 CFU/mL. The count reached to 1×10^{10} CFU/mL at 8 PM of the same day. The growth rate (h^{-1}) of the microorganism would be _______.(up to two decimal points)

Q.20 Black pepper is ground from an equivalent particle size of 6 mm to 0.12 mm using a 10 hp motor. Assuming Rittinger's equation and that 1 hp = 745.7 W, the power (hp) of motor required to fine grind black pepper to 0.08 mm would be _______.(up to two decimal points)

Q.21 Green pea (average diameter 0.8 cm) is frozen in a blast freezer operating at -40°C and with a surface heat transfer coefficient of 30 W m^{-2} K^{-1}. The thermal conductivity of pea is 2.5 W $m^{-1}K^{-1}$, and latent heat of crystallization is 2.74×10^2 kJ kg^{-1}. If the freezing point of pea is -1°C and the density is 1160 kg m^{-3}, the freezing time in minutes will be _______.(up to two decimal points)

Q.22 The rate of heat transfer from a metal plate is 1000 W m^{-2}. The surface temperature of the plate is 120°C and ambient temperature is 20°C. The convective heat transfer coefficient (W m^{-2} °C^{-1}) using the Newton's law of cooling will be _______.

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Q. 1 – Q. 9 carry one mark each & Q. 10 – Q. 22 carry two marks each.

Q.1 The most abundant gas in the atmosphere among inert gases is

(A) Helium (B) Argon (C) Neon (D) Krypton

Q.2 The pair of variables that always exhibit monotonic decrease with height in the atmosphere is

(A) Pressure, Temperature
(B) Pressure, Ozone concentration
(C) Air Density, Pressure
(D) Temperature, Water Vapour

Q.3 Correct order of the maximum vertical extent of atmospheric circulation cells is

(A) Hadley > Ferrel > Polar
(B) Polar > Hadley > Ferrel
(C) Hadley > Polar > Ferrel
(D) Ferrel > Hadley > Polar

Q.4 Analysis of an atmospheric variable shows prominent modes at 5, 40 and 1460 days. These modes correspond respectively to

(A) Tidal, MJO and ENSO
(B) Synoptic, MJO and ENSO
(C) Synoptic, MJO and Decadal
(D) Tidal, Milankhovich and ENSO

Q.5 Atmospheric vertical profile of temperature is measured by radiosonde. Equivalent instruments for measuring ocean temperature profile among the following are:
(**P**) drifting buoy (**Q**) ARGO float (**R**) current mooring (**S**) XBT

(A) **Q, R, S** (B) **Q, S** (C) **R, S** (D) **P, R, S**

Q.6 When deep water sinks in the North Atlantic and moves away from where it formed, it gets

(A) richer in oxygen and nutrients
(B) less acidic and richer in metals
(C) richer in CO_2 and poorer in O_2
(D) richer in CO_2 and O_2

Q.7 The speed of sound in the ocean depends on

(A) temperature alone
(B) temperature and pressure
(C) temperature and salinity
(D) temperature, salinity and pressure

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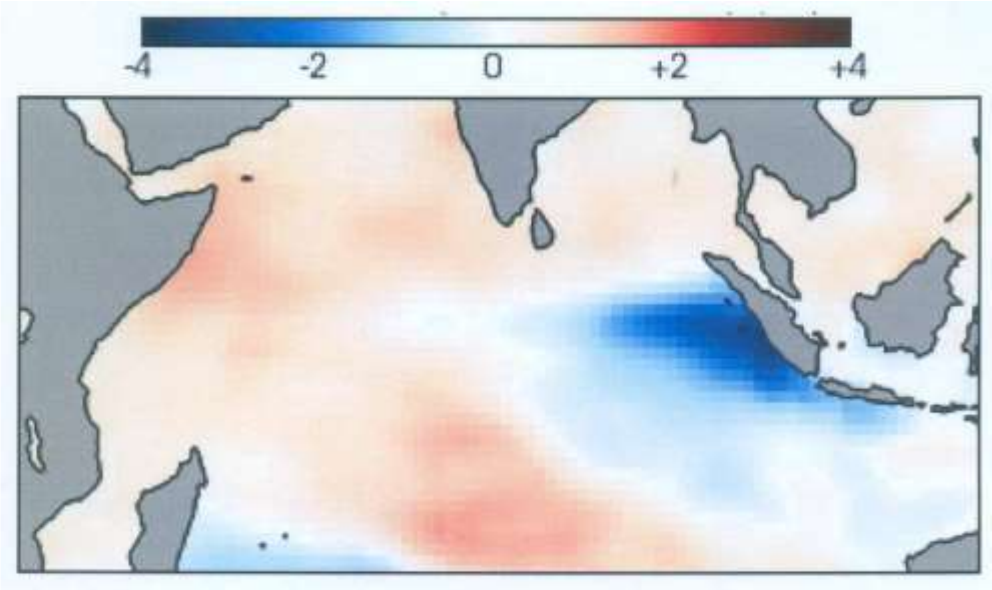
Q.8 In a numerical weather prediction model with a horizontal grid resolution of 50 km, convective cloud processes are parameterized, because

(A) Cloud physics is not known for modelling
(B) Models cannot handle phase change
(C) Cloud size is larger than the grid size
(D) Cloud size is much smaller than the grid size

Q.9 Figure below shows SST anomaly (in °C). It is associated with the phenomenon known as



(A) El Nino
(B) Indian Ocean dipole
(C) La Nina
(D) MJO

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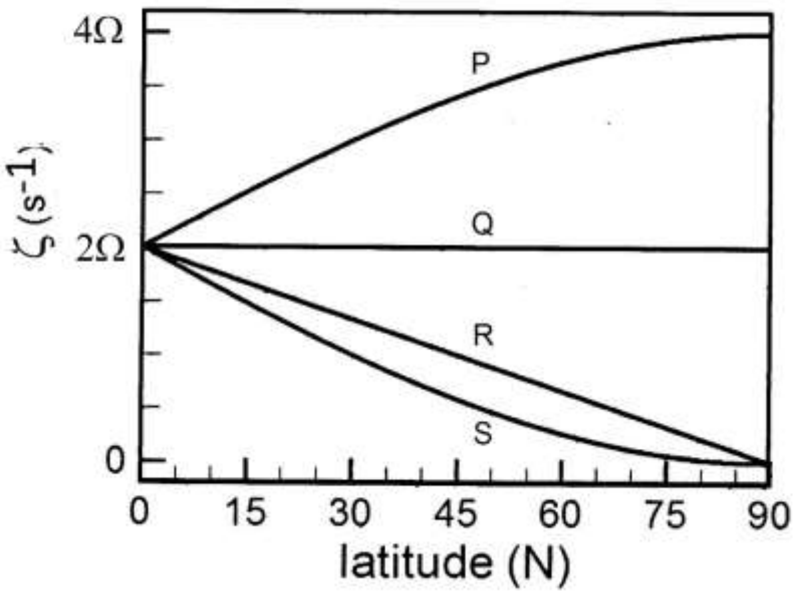
Q.10 For an inviscid and barotropic ocean of constant depth (D), a water parcel with initial vorticity 2Ω is displaced from the equator to the north pole. Latitudinal variation of the parcel vorticity (ζ) is well represented by the curve



(A) S (B) Q (C) P (D) R

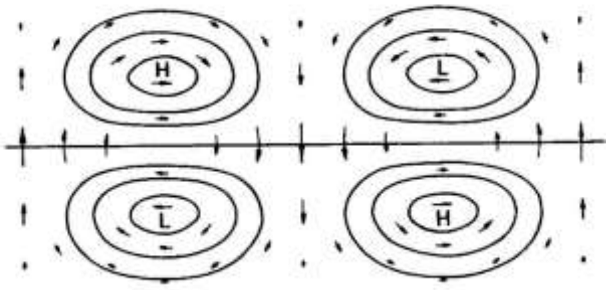
Q.11 A wave progresses up an estuary of decreasing water depth. If friction is neglected, then

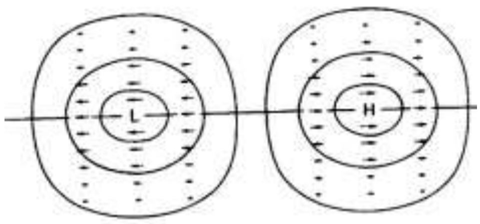
(A) wave amplitude decreases and wave length increases
(B) wave amplitude increases and wave length decreases
(C) wave amplitude decreases and wave length decreases
(D) wave amplitude increases and wave length increases

Q.12 In the Ekman flow limit, directions of ocean surface current and the geostrophic wind are

(A) the same
(B) surface current is 45^o to the left of the geostrophic wind
(C) surface current is 45^o to the right of the geostrophic wind
(D) exactly opposite to each other

Q.13





P **Q**

P and Q respectively describe flow fields corresponding to

(A) Mid latitude Rossby and Polar gravity waves

(B) Equatorial Rossby and Equatorial Kelvin waves

(C) Midlatitude gravity and Polar Rossby waves

(D) Equatorial Kelvin and Equatorial Rossby waves

Q.14 On the summer solstice day, the maximum incident shortwave radiation at the top of the atmosphere over the equator (up to one decimal place) is __________ W m^{-2}. (Take solar constant as 1368 W m^{-2}).

Q.15 In an isothermal atmosphere having a temperature of 15^{o}C, the height at which pressure decreases to 1/10 of its value at the surface is __________ km. (Give the answer to two decimal places.) Take g = 9.8 m s^{-2}, gas constant R = 287 J kg^{-1} K^{-1}

Q.16 At 30°N and 700 hPa pressure level, wind field is in gradient balance. If the gradient wind speed is 50 m s^{-1} and radius of curvature of the flow is 50 km, the corresponding geostrophic wind speed is __________ m s^{-1}. (Give the answer to one decimal place.) Take the angular velocity of the Earth as 7.3x10^{-5} s^{-1}

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Q.17 In a tropical cyclone over the Pacific Ocean, surface pressure at 500 km from the cyclone centre is 1000 hPa. Surface pressure at the centre is 900 hPa. Sea surface temperature and surface air temperature remain constant at 28°C and 27°C, respectively. Difference in potential temperature between 500 km and cyclone centre is __________ K. (Give the answer to two decimal places.) Take g = 9.8 m s^{-2}, C_p = 1005 J kg^{-1} K^{-1}, gas constant R = 287 J kg^{-1} K^{-1}

Q.18 A cloud forms by the lifting of moist air from the surface with the initial conditions T_o = 30°C, RH = 80% and P_o = 1005 hPa. If the vapour pressure of this parcel at 500 hPa is 6.5 hPa, the liquid water content of the parcel if no precipitation takes place is __________ gm kg^{-1}. (Give the answer to one decimal place.) Saturation vapour pressure of water at 30°C is 42.43 hPa.

Q.19 A numerical model of the atmosphere uses sigma (σ) coordinate system in vertical. At locations P and Q, surface pressures are 1005 hPa and 500 hPa, respectively. Absolute difference in the heights of $\sigma = 0.9$ level between these locations is __________ meters. (Give the answer to one decimal place.) Layer mean temperatures at P and Q are 300 K and 270 K, respectively. (Take g = 9.8 m s^{-2} gas constant R = 287 J kg^{-1} K^{-1})

Q.20 If difference in sea surface elevation is 1 m in 100 km at 30° N latitude, the corresponding geostrophic current is __________ m s^{-1}. (Give the answer to one decimal place.) Take g = 9.8 m s^{-2} and angular velocity of the Earth = 7.3x10^{-5} s^{-1}.

Q.21 If wind speed over ocean surface is 10 m s^{-1}, air-sea interface momentum flux is __________ N m^{-2}. (Give the answer to two decimal places.) Surface air temperature and pressure are 27°C and 1000 hPa, respectively. Take drag coefficient as 0.001 and gas constant R = 287 J kg^{-1} K^{-1}.

Q.22 Let L_x, L_y be length scales in x- and y-directions and corresponding mass transports are M_x and M_y. The ratio of M_x and M_y (to nearest integer) is __________ , if the ratio of L_x and L_y is 10 and vertical velocity is zero.

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