

Fig. 2.

3) If θ is the angle, in degrees, between the longest diagonal of the cube and any one of the edges of the cube, then, $\cos \theta =$ [GATE XE 2021]

a) $\frac{1}{2}$
b) $\frac{1}{\sqrt{3}}$

c) $\frac{1}{\sqrt{2}}$
d) $\frac{\sqrt{3}}{2}$

4) If $\left(x - \frac{1}{2}\right)^2 - \left(x - \frac{3}{2}\right)^2 = x + 2$, then the value of x is: [GATE XE 2021]

a) 2
b) 4

c) 6
d) 8

5) **Pen : Write :: Knife :** _____

Which one of the following options maintains a similar logical relation in the above? [GATE XE 2021]

- a) Vegetables
- b) Sharp

- c) Cut
- d) Blunt

- 6) Listening to music during exercise improves exercise performance and reduces discomfort. Scientists researched whether listening to music while studying can help students learn better and the results were inconclusive. Students who needed external stimulation for studying fared worse while students who did not need any external stimulation benefited from music.

Which one of the following statements is the **CORRECT** inference of the above passage? [GATE XE 2021]

- a) Listening to music has no effect on learning and a positive effect on physical exercise.
- b) Listening to music has a clear positive effect both on physical exercise and on learning.
- c) Listening to music has a clear positive effect on physical exercise. Music has a positive effect on learning only in some students.
- d) Listening to music has a clear positive effect on learning in all students. Music has a positive effect only in some students who exercise.

- 7) A jigsaw puzzle has 2 pieces. One of the pieces is shown above. Which one of the given options for the missing piece when assembled will form a rectangle? The piece can be moved, rotated or flipped to assemble with the above piece.

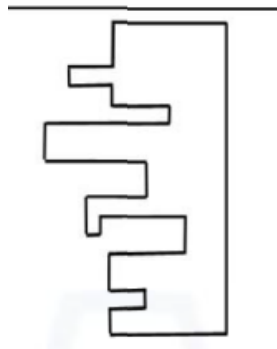


Fig. 7.

[GATE XE 2021]

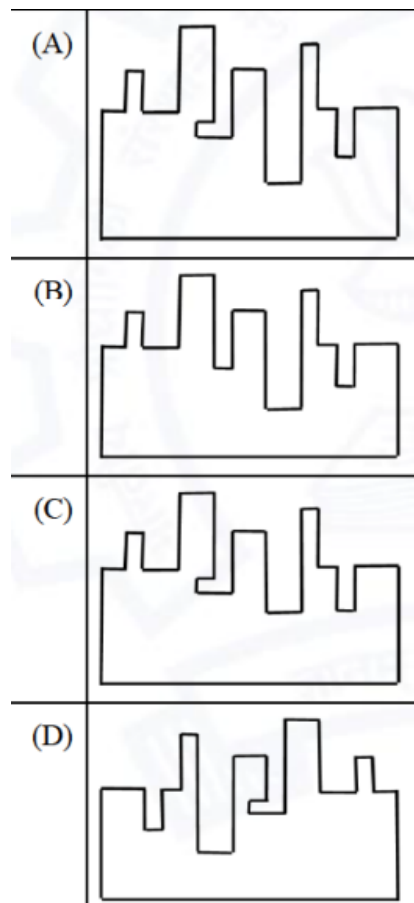


Fig. 7.

- 8) The number of students in three classes is in the ratio 3 : 13 : 6. If 18 students are added to each class, the ratio changes to 15 : 35 : 21.
The total number of students in all the three classes in the beginning was: [GATE XE 2021]
- a) 22 c) 88
b) 66 d) 110
- 9) The number of units of a product sold in three different years and the respective net profits are presented in the figure above. The cost/unit in Year 3 was |1, which was half the cost/unit in Year 2. The cost/unit in Year 3 was one-third of the cost/unit in Year 1. Taxes were paid on the selling price at 10%, 13% and 15% respectively for the three years. Net profit is calculated as the difference between the selling price and the sum of cost and taxes paid in that year.
The ratio of the selling price in Year 2 to the selling price in Year 3 is _____.

- a) α c) 3α
b) 2α d) 4α

13) Given that $i = \sqrt{-1}$. The value of

$$\lim_{z \rightarrow e^{\pi i/3}} \frac{z^3 + 1}{z^4 + z^2 + 1} \quad (2)$$

is

[GATE XE 2021]

- a) $\frac{3}{4} + i \frac{\sqrt{3}}{4}$ c) $-\frac{3}{4} + i \frac{\sqrt{3}}{4}$
b) $\frac{3}{4} - i \frac{\sqrt{3}}{4}$ d) $-\frac{3}{4} - i \frac{\sqrt{3}}{4}$

14) Let $f(x)$ be a non-negative continuous function of real variable x . If the area under the curve $y = f(x)$ from $x = 0$ to $x = a$ is $\frac{a^2}{2} + \frac{a}{2} \sin a + \frac{\pi}{2} \cos a - \frac{\pi}{2}$, then the value of $f\left(\frac{\pi}{2}\right)$ is _____ (round off to one decimal place).

[GATE XE 2021]

15) If the numerical approximation of the value of the integral $\int_0^4 2^{\alpha x} dx$ using the Trapezoidal rule with two subintervals is 9, then the value of the real constant α is _____ (round off to one decimal place).

[GATE XE 2021]

16) Let the transformation $y(x) = e^x v(x)$ reduce the ordinary differential equation

$$x \frac{d^2 y}{dx^2} + 2(1-x) \frac{dy}{dx} + (x-2)y = 0; \quad x > 0 \quad (3)$$

to

$$\alpha x \frac{d^2 v}{dx^2} + 2\beta \frac{dv}{dx} + 3\gamma v = 0, \quad (4)$$

where α, β, γ are real constants. Then, the arithmetic mean of α, β, γ is _____ (round off to three decimal places).

[GATE XE 2021]

17) A person, who speaks the truth 3 out of 4 times, throws a fair dice with six faces and informs that the outcome is 5. The probability that the outcome is really 5 is _____ (round off to three decimal places).

[GATE XE 2021]

18) Let $f(x, y) = x^4 + y^4 - 2x^2 + 4xy - 2y^2 + \alpha$ be a real valued function. Then, which one of the following statements is TRUE for all α ?

[GATE XE 2021]

- a) $(0, 0)$ is not a stationary point of f c) f has a local minima at $(0, 0)$
b) f has a local maxima at $(0, 0)$ d) f has a saddle point at $(0, 0)$

19) Let $u(x, y) = (x^2 - y^2)v(x, y)$ be such that both $u(x, y)$ and $v(x, y)$ satisfy the Laplace equation in a domain Ω of the xy -plane. Then, which one of the following is TRUE in Ω ?

[GATE XE 2021]

$$\begin{aligned} \text{a)} \quad & x \frac{\partial v}{\partial x} - y \frac{\partial v}{\partial y} = 0 \\ \text{b)} \quad & x \frac{\partial v}{\partial x} + y \frac{\partial v}{\partial y} = 0 \end{aligned}$$

c) $x \frac{\partial v}{\partial y} - y \frac{\partial v}{\partial x} = 0$
d) $x \frac{\partial v}{\partial y} + y \frac{\partial v}{\partial x} = 0$

$$\text{b) } x \frac{\partial v}{\partial x} + y \frac{\partial v}{\partial y} = 0$$

d) $x \frac{\partial v}{\partial y} + y \frac{\partial v}{\partial x} = 0$

- 20) Let I denote the identity matrix of order 7, and A be a 7×7 real matrix having characteristic polynomial $C_A(\lambda) = \lambda^2(\lambda - 1)^\alpha(\lambda + 2)^\beta$, where α and β are positive integers. If A is diagonalizable and $\text{rank}(A) = \text{rank}(A + 2I)$, then $\text{rank}(A - I)$ is _____ (in integer).

[GATE XE 2021]

- 21) Let C_1 be the line segment from $(0, 1)$ to $(\frac{4}{5}, \frac{3}{5})$, and let C_2 be the arc of the circle $x^2 + y^2 = 1$ from $(0, 1)$ to $(\frac{4}{5}, \frac{3}{5})$. If

$$\alpha = \int_{C_1} \left(\frac{2x}{y} \hat{i} + \frac{1-x^2}{y^2} \hat{j} \right) \cdot d\mathbf{r} \quad \text{and} \quad \beta = \int_{C_2} \left(\frac{2x}{y} \hat{i} + \frac{1-x^2}{y^2} \hat{j} \right) \cdot d\mathbf{r}, \quad (5)$$

where $\mathbf{r} = x\hat{i} + y\hat{j}$, then the value of $\alpha^2 + \beta^2$ is _____ (round off to two decimal places).

[GATE XE 2021]

- 22) The general relationship between shear stress, τ , and the velocity gradient $\left(\frac{du}{dy}\right)$ for a fluid is given by $\tau = k\left(\frac{du}{dy}\right)^n$, where k is a constant with appropriate units. The fluid is Newtonian if

[GATE XE 2021]

- a) $n > 1$
b) $n < 1$
- c) $n = 1$
d) $n = 0$

- b) $n < 1$

- d) $n = 0$

- 23) Which one of the following options is TRUE?

[GATE XE 2021]

- Pathlines and streaklines are the same in an unsteady flow, and streamlines are tangential to the local fluid velocity at a point.
- Streamlines are perpendicular to the local fluid velocity at a point, and streamlines and streaklines are the same in a steady flow.
- Pathlines and streaklines are the same in an unsteady flow, and streamlines and streaklines are the same in a steady flow.
- Streamlines are tangential to the local fluid velocity at a point, and streamlines and streaklines are the same in a steady flow.

- 24) If $P_{\text{in}} = 1.2 \text{ Pa}$ and $P_{\text{out}} = 1.0 \text{ Pa}$ are the average pressures at inlet and outlet respectively for a fully-developed flow inside a channel having a height of 50 cm, then the absolute value of average shear stress (in Pa) acting on the walls of the channel of length 5 m is

[GATE XE 2021]

- a) 0.005 c) 0.01
b) 0.02 d) 0.05

- b) 0.02

- d) 0.05

- 25) Consider the fully-developed flow of a Newtonian fluid (density ρ ; viscosity μ) through a smooth pipe of diameter D and length L . The average velocity of the flow is V . If the length of the pipe is doubled, keeping V, D, ρ, μ constant, the friction factor

[GATE XE 2021]

- a) increases by two times
b) remains the same
c) decreases by two times
d) increases by four times

26) The absolute value of pressure difference between the inside and outside of a spherical soap bubble of radius, R , and surface tension, γ , is:

[GATE XE 2021]

- a) $\frac{2\gamma}{R}$
b) $\frac{\gamma}{R}$
c) $\frac{\gamma}{2R}$
d) $\frac{4\gamma}{R}$

27) Which one of the following statements is TRUE about the continuity equation $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$ (where u, v, w are the velocity components along the x, y , and z coordinates respectively):

[GATE XE 2021]

- a) The equation is valid only for steady incompressible flows.
b) The equation is valid for both steady and unsteady incompressible flows.
c) The equation is valid only for steady compressible flows.
d) The equation is valid only for unsteady compressible flows.

28) The head loss (K_L) associated with the flow entry of water to an internal passage depends on the shape of the entry. The following figure shows three different types of flow entry into a pipe. Which one of the following relationships correctly represents the head loss associated with the three different flow entries?

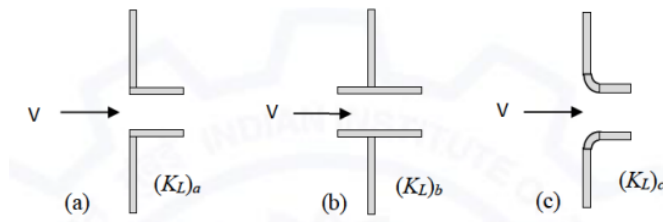


Fig. 28.

[GATE XE 2021]

- a) $(K_L)_a > (K_L)_b > (K_L)_c$
b) $(K_L)_b > (K_L)_a > (K_L)_c$
c) $(K_L)_b \leq (K_L)_a = (K_L)_c$
d) $(K_L)_b < (K_L)_a < (K_L)_c$

29) The form and friction drags together contribute to the total drag when flow of air occurs past any object. Two orientations of a finite flat plate are shown in the figure. In Orientation-1, the plate is placed perpendicular to the flow while in Orientation-2, the plate is placed parallel to the flow. If the velocity (V) of air in both orientations is the same, which one of the following options is TRUE?

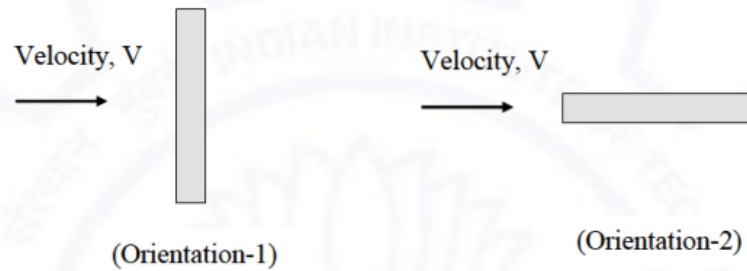


Fig. 29.

[GATE XE 2021]

- a) Orientation-1 has higher form drag and lower friction drag and Orientation-2 has lower form drag and higher friction drag
- b) Orientation-1 has lower form drag and lower friction drag and Orientation-2 has higher form drag and higher friction drag
- c) Orientation-1 has lower form drag and higher friction drag and Orientation-2 has higher form drag and lower friction drag
- d) Orientation-1 has higher form drag and higher friction drag and Orientation-2 has lower form drag and lower friction drag
- 30) A spherical ball is steadily supported against gravity by an upward air jet as shown in the figure. Take acceleration due to gravity to be $g = 10 \text{ m/s}^2$. The mass flow rate of air, reaching the ball, is 0.01 kg/s and the air reaches the ball at an upward velocity of 3 m/s . Neglecting the buoyancy force, and using the principle of integral momentum balance, the mass (in grams, up to one decimal place) of the ball is _____.

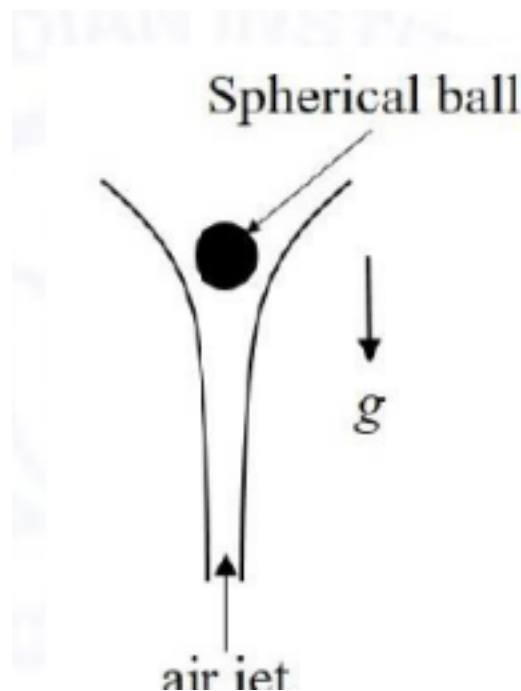


Fig. 30.

[GATE XE 2021]

- 31) The incompressible flow of air over a curved surface having possible flow separation is schematically shown in the figure. Two zones P and Q are indicated in the figure. Which one of the following

combinations is TRUE for zones P and Q ?

(a) Acceleration of flow, (b) Deceleration of flow, (c) Adverse pressure gradient, (d) Favourable pressure gradient, (e) No flow separation, (f) Possible flow separation.

[GATE XE 2021]

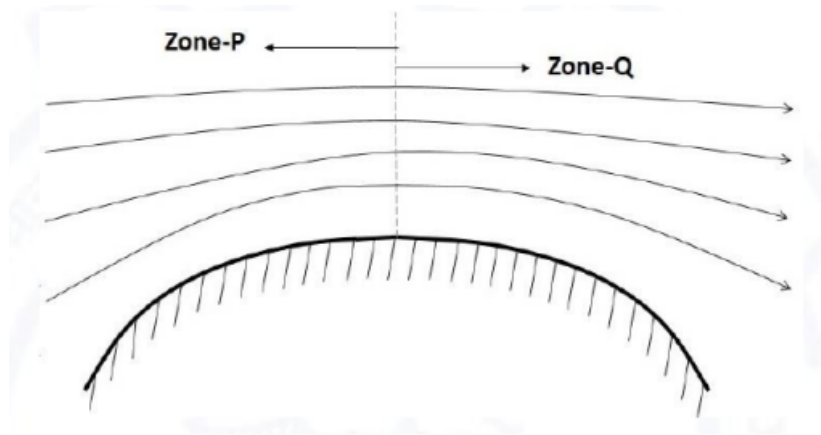


Fig. 31.

- | | |
|--|--|
| a) P : (a), (d), (e) and Q : (b), (c), (f) | c) P : (a), (c), (f) and Q : (a), (d), (e) |
| b) P : (a), (d), (f) and Q : (b), (d), (f) | d) P : (a), (c), (e) and Q : (a), (d), (f) |

- 32) A spherical metal ball (of density ρ_s and diameter D), attached to a string, is exposed to a crossflow (of velocity U_∞) of a viscous fluid (of viscosity μ and density ρ_f). Due to the crossflow, the string makes an angle of inclination, θ , with the top surface as shown in the figure. The acceleration due to gravity is denoted by g . For this flow, Reynolds number $Re = \frac{\rho_f U_\infty D}{\mu} \ll 1$ and buoyancy force in the fluid is negligible compared to viscous force. Assuming the string to be weightless and offering negligible drag, the expression for θ is

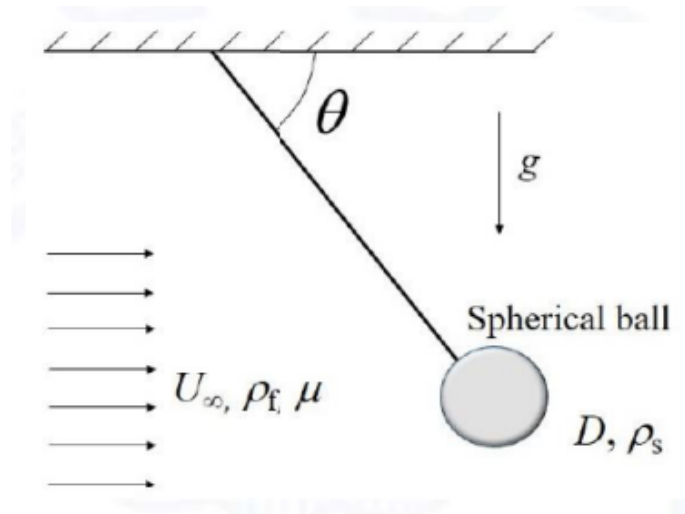


Fig. 32.

[GATE XE 2021]

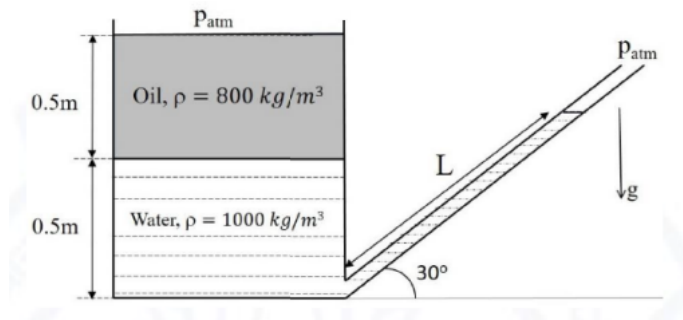


Fig. 36.

[GATE XE 2021]

- 37) A two-dimensional Eulerian velocity field is given (in m/s) by $\mathbf{V} = [(\sqrt{5})x]\mathbf{i} - [(\sqrt{12})y]\mathbf{j}$, where x and y are the coordinates (in meters) in a Cartesian coordinate system. The magnitude of the acceleration (in m/s^2 , up to one decimal place) of a fluid particle at $x = 1$ m and $y = -1$ m is _____.

[GATE XE 2021]

- 38) A large pump is to deliver oil at an average velocity (V) of 1.5 m/s. The pump has an impeller diameter (D) of 40 cm and the pressure rise across the pump is 400 kPa. To design this pump, a lab-scale model pump with an impeller diameter of 4 cm is to be used with water as the fluid. The viscosity (μ) of the oil is 100 times that of water, and the densities (ρ) of oil and water are identical. A complete geometric similarity is maintained between the model and prototype. If the pressure rise is a function only of V , D , ρ and μ , the pressure rise (in kPa, up to one decimal place) across the model pump is _____.

[GATE XE 2021]

- 39) Water (density = 10^3 kg/m^3) enters steadily into a horizontal pipe bend, which is part of a larger piping system, as shown in the figure. The volumetric flow rate of water is $0.1 \text{ m}^3/\text{s}$. The gage pressure at the inlet is 500 kPa, while the exit is open to atmosphere. The x -component of the force on the support is F_x . The absolute value of F_x (in kN, up to one decimal place) is _____.

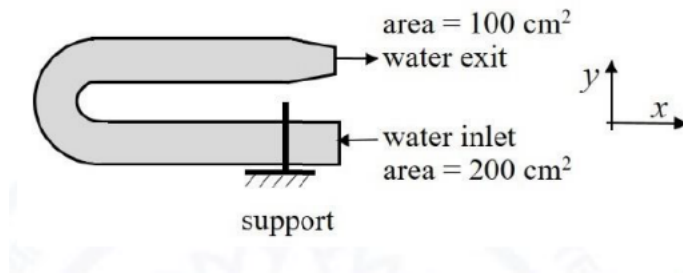


Fig. 39.

[GATE XE 2021]

- 40) Air (of density 0.5 kg/m^3) enters horizontally into a jet engine at a steady speed of 200 m/s through an inlet area of 1.0 m^2 . Upon entering the engine, the air passes through the combustion chamber and the exhaust gas exits the jet engine horizontally at a constant speed of 700 m/s. The fuel mass flow rate added in the combustion chamber is negligible compared to the air mass flow rate. Also neglect the pressure difference between the inlet air and the exhaust gas. The absolute value of the horizontal force (in kN, up to one decimal place) on the jet engine is _____.

[GATE XE 2021]

- 41) Water discharges from a cylindrical tank through an orifice, as shown in the figure. The flow is considered frictionless. Initially, the water level in the tank was $h_1 = 2$ m. The diameter of the tank

is $D = 1$ m, while the diameter of the jet is $d = 10$ cm, and the acceleration due to gravity is $g = 10 \text{ m/s}^2$. The time taken (in seconds, up to one decimal place) for the water level in the tank to come down to $h_2 = 1$ m is _____.

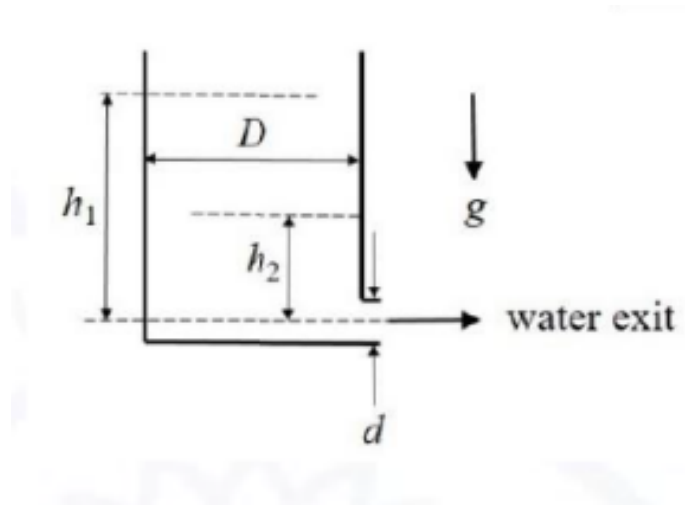


Fig. 41.

[GATE XE 2021]

- 42) Water discharges steadily from a large reservoir through a long pipeline, as shown in the figure. The Darcy friction factor in the pipe is 0.02. The pipe diameter is 20 cm and the discharge of water is $360 \text{ m}^3/\text{h}$. Water level in the reservoir is 10 m and acceleration due to gravity $g = 10 \text{ m/s}^2$. If minor losses are negligible, the length L (in meters, up to one decimal place) of the pipeline is _____.

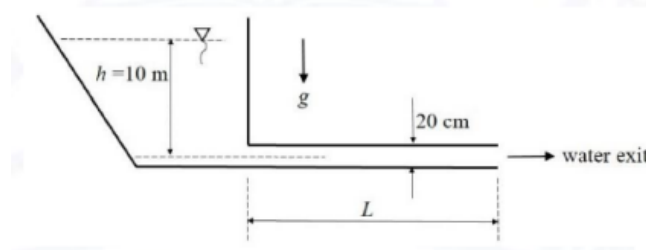


Fig. 42.

[GATE XE 2021]

- 43) Water is flowing with a flow rate Q in a horizontal circular pipe. Due to the low pressure created at the venturi section (Section-1 in the figure), water from a reservoir is drawn upward using a connecting pipe as shown in the figure. Take acceleration due to gravity $g = 10 \text{ m/s}^2$. The flow rate $Q = 0.1 \text{ m}^3/\text{s}$, $D_1 = 8$ cm, and $D_2 = 20$ cm. The maximum height (h , in meters, up to one decimal place) of the venturi from the reservoir just sufficient to raise the liquid up to Section-1 is _____.

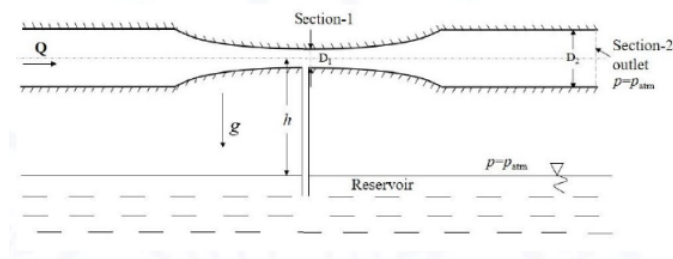


Fig. 43.

[GATE XE 2021]

- 44) Condition to be satisfied for α and β phases to be in equilibrium in a two-component (A and B) system at constant temperature and pressure is (Given: μ is the chemical potential)

[GATE XE 2021]

- a) entropy of the system should be maximum c) Gibbs energy of the system should be minimum and $\mu_A^\alpha = \mu_A^\beta$, $\mu_B^\alpha = \mu_B^\beta$
 b) Gibbs energy of the system should be minimum and $\mu_A^\alpha = \mu_B^\alpha$, $\mu_A^\beta = \mu_B^\beta$ d) Helmholtz energy should be minimum

- 45) Amino acids react to form peptides and proteins. This process is known as

[GATE XE 2021]

- a) addition polymerization c) condensation polymerization
 b) nucleophilic substitution d) hydration

- 46) The most favoured slip system in face centered cubic metal is

[GATE XE 2021]

- a) (111) [110] c) (111) [112]
 b) (110) [111] d) (111) [110]

- 47) The dielectric constant of a material at ultraviolet frequencies is mainly due to

[GATE XE 2021]

- a) dipolar polarizability c) electronic polarizability
 b) ionic polarizability d) interfacial polarizability

- 48) Match the different transformations/reactions in Column I with the most suitable information in Column II.

Column I

- (P) Eutectoid reaction
 (Q) Martensitic transformation
 (R) Precipitation reaction

Column II

- (1) involves no diffusion
 (2) one solid phase transforms into two solid phases
 (3) occurs in supersaturated solutions

[GATE XE 2021]

- a) P-2; Q-3; R-1 c) P-2; Q-1; R-3
 b) P-1; Q-2; R-3 d) P-3; Q-2; R-1

- 49) In scanning electron microscopy, the resolution of backscattered electron (BSE) image is poorer compared to that of secondary electron (SE) image, because

[GATE XE 2021]

- a) energy of BSE is lower
b) sampling volume of BSE is larger
c) yield of BSE is lower
d) sampling volume of SE is larger

50) Which of the following deposition conditions favour the formation of larger grains in thin film?
[GATE XE 2021]

- a) Low deposition rate and low substrate temperature
b) Low deposition rate and high substrate temperature
c) High deposition rate and low substrate temperature
d) High deposition rate and high substrate temperature

51) A metal has a melting point of 600°C . By rapid cooling, liquid metal can be made to solidify either at 500°C or 400°C or 300°C . Critical size of the solid nuclei is
[GATE XE 2021]

- a) same for solidification at 400°C and 500°C
b) smaller for solidification at 400°C as compared to solidification at 500°C
c) larger for solidification at 400°C as compared to solidification at 500°C
d) the smallest for solidification at 300°C

52) A magnet of mass 50 g has a magnetic moment of $4.2 \times 10^{-7} \text{ A m}^2$. The density of the magnet is 7.2 g cm^{-3} . The intensity of magnetization in A m^{-1} is _____ (round off to 3 decimal places).
[GATE XE 2021]

53) In the context of scanning electron microscopy, match the information in Column I with most appropriate information in Column II.

Column I

(P) Secondary electrons

(Q) Backscattered electrons

(R) Characteristic X-rays

(S) Diffracted backscattered electrons

Column II

(1) Crystallographic orientation of grains

(2) Failure analysis of fractured surfaces

(3) Chemical composition analysis

(4) Distinguishing chemically distinct phases

[GATE XE 2021]

- a) P-3; Q-2; R-1; S-4
b) P-2; Q-4; R-3; S-1
c) P-1; Q-3; R-2; S-4
d) P-4; Q-2; R-1; S-3

54) Match the heat treatment processes given in Column I with the most suitable outcomes in Column II.

Column I

(P) Quenching

(Q) Annealing

(R) Tempering

(S) Carburizing

Column II

(1) hardens the steel

(2) softens the cold worked steel

(3) toughens the steel

(4) hardens the surface of steel

[GATE XE 2021]

- a) P-3; Q-2; R-1; S-4
b) P-2; Q-4; R-3; S-1
c) P-1; Q-2; R-3; S-4
d) P-1; Q-3; R-4; S-2

55) A co-joined cross-ply laminate composite, as shown in figure, is distorted upon heating. What are the resultant shapes of edges XY and YZ?

the average length of diagonals of square indentation is 0.5 mm, the Vickers hardness in kg mm^{-2} is _____ (round off to nearest integer).

[GATE XE 2021]

- 62) The drift mobility of electron in an n-type Si crystal doped with 10^{16} cm^{-3} phosphorous atoms is $1350 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$. The electrical conductivity in $\Omega^{-1} \text{ m}^{-1}$ is _____ (round off to nearest integer).
(Given: Intrinsic charge concentration of Si = $1.45 \times 10^{10} \text{ cm}^{-3}$; Charge of an electron, $e = 1.6 \times 10^{-19} \text{ C}$)

[GATE XE 2021]

- 63) At 1000 K, the linear thermal expansion coefficients of graphite, parallel and perpendicular to the graphite layers, are $0.8 \times 10^{-6} \text{ K}^{-1}$ and $29 \times 10^{-6} \text{ K}^{-1}$, respectively. The percentage increase in the volume of graphite when heated from 900 K to 1100 K is _____ (round off to 2 decimal places).

[GATE XE 2021]

- 64) A certain ceramic has a theoretical density and sintered density of 6.76 g cm^{-3} and 6.60 g cm^{-3} , respectively. The green compact has 18 volume percent porosity. For a sintered cube of side 2 cm, the required side of the cubic green compact in cm is _____ (round off to 2 decimal places).

[GATE XE 2021]

- 65) When a metal (M) is immersed in de-aerated acid electrolyte, it polarizes anodically by 0.4 V. The M/M^{n+} exchange current density is 10^{-5} A m^{-2} and Tafel slope is 0.1 V/decade for the anodic reaction. Assume that corrosion is uniform and, anodic and cathodic reactions are under activation control. The rate of metal dissolution in A m^{-2} is _____ (round off to 1 decimal place).

[GATE XE 2021]

- 66) A force $F = 40 \text{ kN}$ is applied on the hook as shown. The equivalent force-couple system at B is

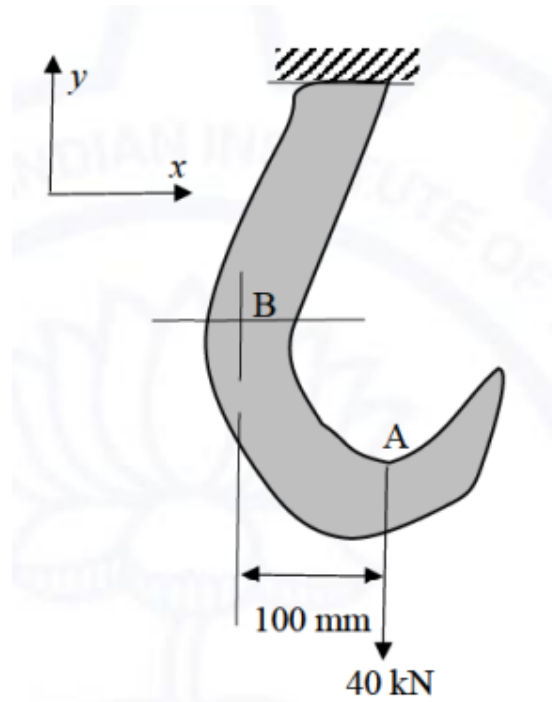


Fig. 66.

[GATE XE 2021]

- | | |
|--|--|
| a) 40 kN in +y direction and $M = 0$ | counter clockwise |
| b) 40 kN in -y direction and $M = 0$ | d) 40 kN in -y direction and $M = 4000 \text{ Nm}$ |
| c) 40 kN in +y direction and $M = 4000 \text{ Nm}$ | clockwise |

- 67) A rigid rod OA rotates clockwise at an angular velocity of 10 rad/s . A bead B ($OB = 1 \text{ m}$) translates outward on the rod at a speed of 5 m/s and acceleration 2.5 m/s^2 (both quantities with respect to the rod). The Coriolis component of acceleration is

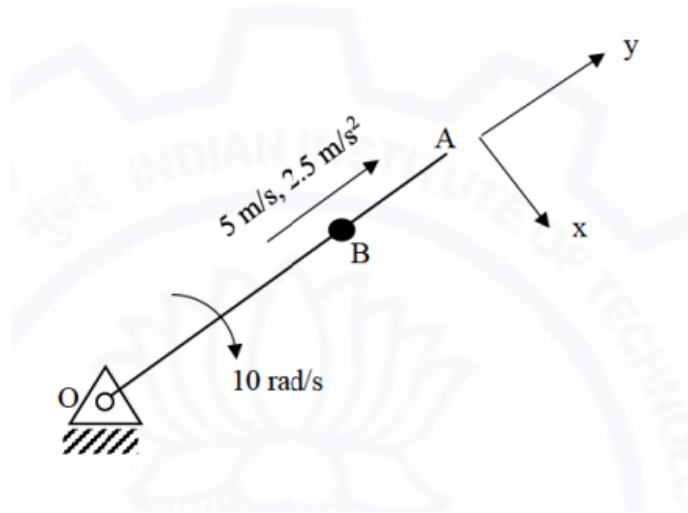


Fig. 67.

[GATE XE 2021]

- | | |
|--|--|
| a) 2.5 m/s^2 in $+x$ direction | c) 100 m/s^2 in $-y$ direction |
| b) 100 m/s^2 in $+x$ direction | d) 25 m/s^2 in $+y$ direction |

- 68) A two force member in equilibrium is one in which

[GATE XE 2021]

- | | |
|---|--|
| a) Forces act at two points and forces are collinear | to carry moment at any point |
| b) Forces act at two points and member is always straight | d) Force acts at one point and moment acts at second point |
| c) Forces act at two points but the member is free | |

- 69) If the yield point shear stress obtained from the torsion test of a cylindrical specimen is τ_y , then what is the maximum value of principal strain at yielding? (μ is Poisson's ratio and E is Young's modulus)

[GATE XE 2021]

- | | |
|--------------------------------|--------------------------------|
| a) $\frac{\tau_y}{E}$ | c) $\frac{\tau_y}{2E}$ |
| b) $\frac{(1 + \mu)\tau_y}{E}$ | d) $\frac{(1 - \mu)\tau_y}{E}$ |

- 70) If the ratio of Young's modulus to bulk modulus of a material is $3/2$, then the ratio of shear modulus to the Young's modulus of the material is

[GATE XE 2021]

- | | |
|----------|----------|
| a) 1 | c) $1/3$ |
| b) $2/5$ | d) $3/5$ |

- 71) With respect to the plane of maximum shear stress, which of the following statements is **INCORRECT**?

[GATE XE 2021]

- a) The normal stress on this plane is zero. 45° to the principal planes.
 b) The maximum shear stress is equal to the largest of the one half the difference of principal stresses d) The magnitude of the maximum shear stress is equal to the largest of the radius of the Mohr's circles.
 c) The plane of maximum shear stress occurs at

- 72) A simply supported beam of length L is loaded by two symmetrically applied point loads P at $L/3$ from each support. Both the loads are then shifted to new points which are at a distance $L/4$ from each support. The bending moments at the mid-section of the beam in both the cases are same. The magnitude of P_1 in terms of P is

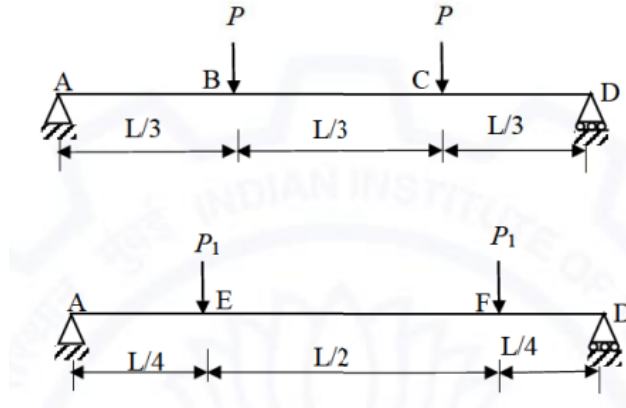


Fig. 72.

[GATE XE 2021]

- a) $P/4$ c) $4P/3$
 b) $8P/3$ d) $P/3$

- 73) A beam having rectangular cross section is subjected to transverse loading. The ratio of maximum shear stress developed in the beam to the average shear stress is

[GATE XE 2021]

- a) 1.50 c) 1.33
 b) 1.25 d) 1.66

- 74) During an earthquake, a structure vibrates and the vibration can be assumed to be in simple harmonic motion at 5 Hz. At a measurement point, the RMS value of acceleration is 10 m/s^2 . The approximate amplitude of motion (in mm) at this point (*rounded off to two decimal places*) is _____

[GATE XE 2021]

- 75) For the state of plane stress shown, the components of normal and shear stresses are given in terms of stress σ and unknown constants m and n . If the normal and shear components of stress on a 45° plane are 2σ and zero, the values of m and n would be:

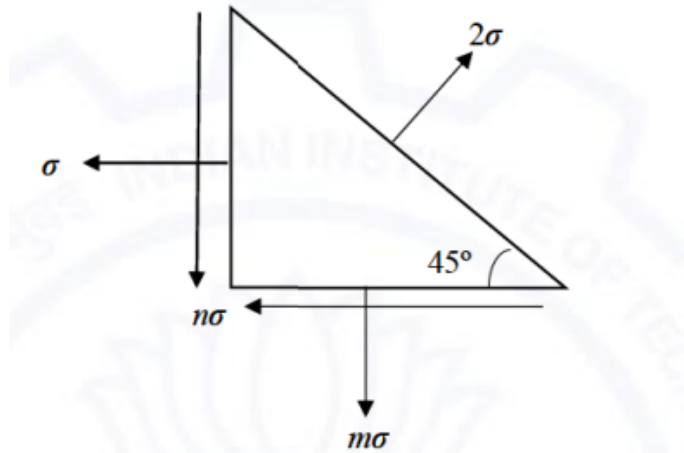


Fig. 75.

[GATE XE 2021]

- a) $m = 1, n = 2$ c) $m = 1, n = 1$
 b) $m = 2, n = 1$ d) $m = 2, n = 2$

76) For a state of plane strain, the normal strains are given by $\epsilon_{xx} = 1000 \times 10^{-6}$, $\epsilon_{yy} = 200 \times 10^{-6}$ and the maximum shear strain is $\gamma_{\max} = 1000 \times 10^{-6}$. The value of shear strain γ_{xy} for this strain state is [GATE XE 2021]

- a) 600×10^{-6} c) 1000×10^{-6}
 b) 183×10^{-6} d) 800×10^{-6}

77) A thin cylinder (closed at its ends) of radius r and thickness t ($r \gg t$) is subjected to internal pressure p . The maximum shear stress in the wall of the cylinder is

[GATE XE 2021]

- a) $\frac{pr}{t}$ c) $\frac{pr}{4t}$
 b) $\frac{pr}{2t}$ d) $\frac{3pr}{2t}$

78) The truss shown is subjected to a force P . All members of the truss have the same length L . The reaction at A and force in member AB are

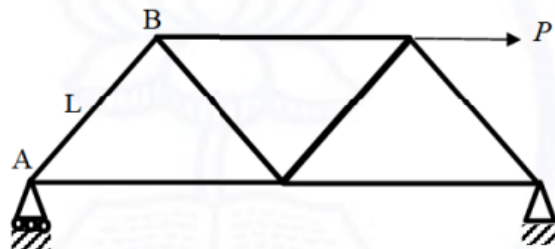


Fig. 78.

[GATE XE 2021]

- a) $\frac{P\sqrt{3}}{4}$ and $\frac{P}{2}$ c) $\frac{P\sqrt{3}}{4}$ and $\frac{P}{4}$
 b) $\frac{P\sqrt{3}}{8}$ and $\frac{P\sqrt{3}}{4}$ d) P and $\frac{P}{4}$

79) The figure shows a structure with supports. The correct free body diagram when the supports are removed is

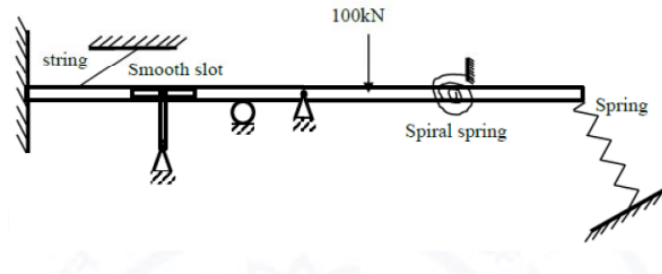


Fig. 79.

[GATE XE 2021]

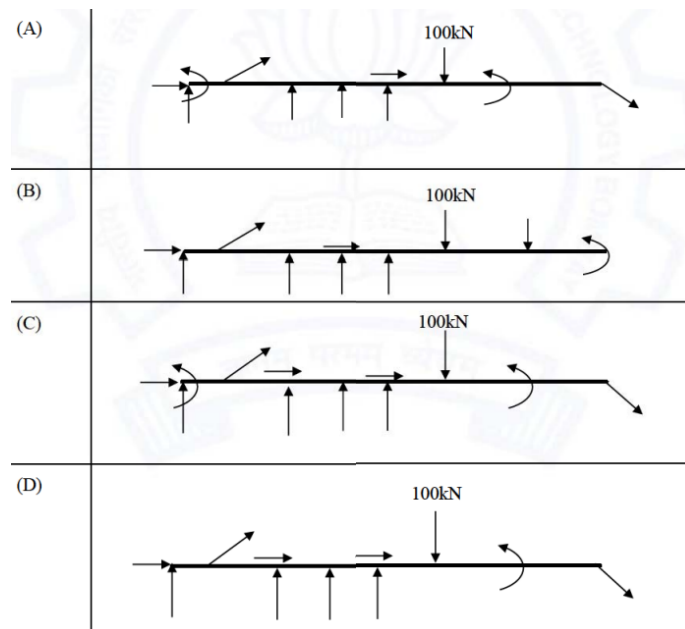


Fig. 79.

80) A hammer of mass 1 kg is used to break an almond shell. The velocity–time graph of the hammer during the impact duration is shown in the figure. The shape of force–time graph is also given, which can be approximated as a triangle. A force of 300 N is required for breaking the shell, while a force of 200 N will not be able to break it, but just introduce a crack. Which one of the following events will happen?

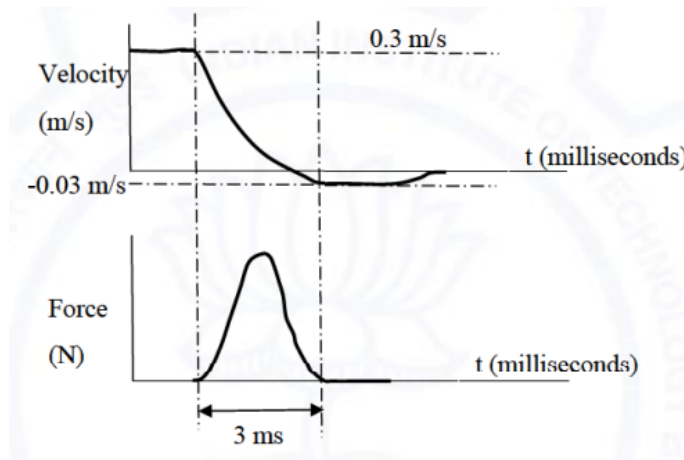


Fig. 80.

[GATE XE 2021]

- a) Shell will crack but not break
 b) Shell will break
 c) Shell will remain intact
 d) Cannot be determined from the given data

81) A rigid circular disc of radius 0.2 m and mass 10 kg rolls without slip on the ground at A. The coefficient of static friction between ground and disc is 0.7. A torque $T = 9 \text{ Nm}$ acts on the disc as shown. Given acceleration due to gravity $g = 10 \text{ m/s}^2$. The friction force acting on the disc (in N, integer) is _____.

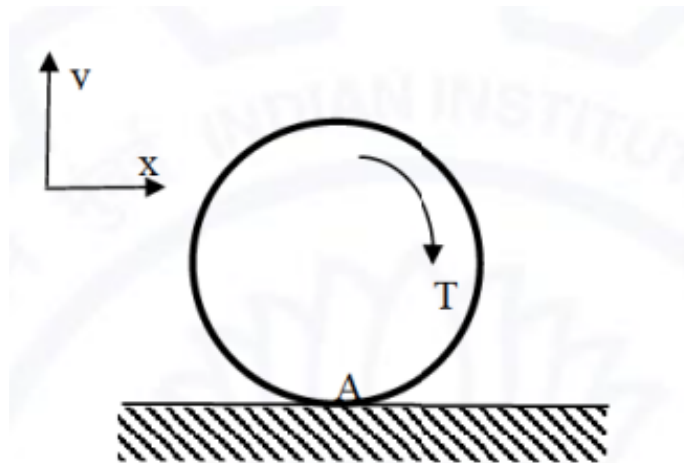


Fig. 81.

[GATE XE 2021]

82) A prismatic solid circular rod of diameter d is bent to introduce an offset $s = d$ as shown. The rod is further subjected to an axial load P . If the maximum longitudinal stress at a section A–B in the rod (with offset) is n times the longitudinal stress in the straight rod, the value of n (in integer) would be _____.

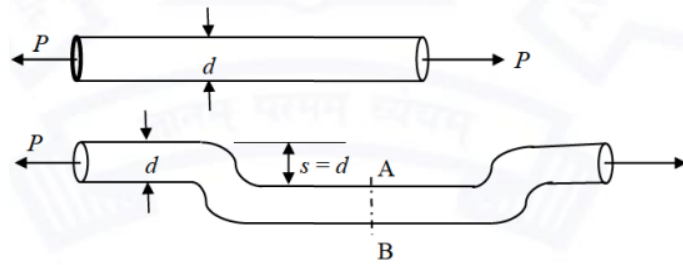


Fig. 82.

[GATE XE 2021]

- 83) A naturally curved steel beam AB having Young's modulus $E = 208 \text{ GPa}$, area moment of inertia $I = 26.7 \text{ cm}^4$ and radius $R = 2 \text{ m}$ is subjected to a vertical load $P = 1000 \text{ N}$ at B. The end A at $\theta = 90^\circ$ is rigidly fixed. The bending strain energy of the beam (in Nm, rounded off to two decimal places) is _____.

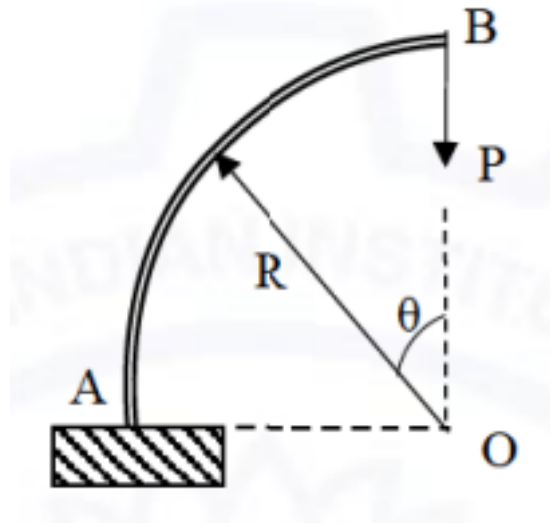


Fig. 83.

[GATE XE 2021]

- 84) At room temperature of 25°C , a gap of 1 mm exists between the ends of the rods 1 and 2 as shown. Given the cross-sectional area A of the rods is 1500 mm^2 , Young's modulus $E = 75 \text{ GPa}$ and the coefficient of thermal expansion $\alpha = 23 \times 10^{-6}/^\circ\text{C}$. When the temperature has reached 150°C , the magnitude of normal stress in each of the rods (in MPa, rounded off to two decimal places) is _____.

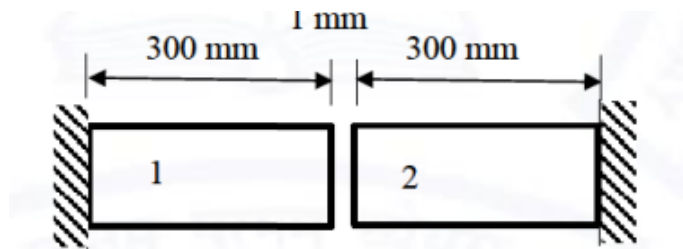


Fig. 84.

[GATE XE 2021]

- 85) A tube of inner radius 4 cm and outer radius 5 cm can carry a maximum torque T . This tube is now replaced by a solid circular shaft of the same material. The minimum radius of the solid circular shaft (in cm, rounded off to two decimal places) to carry the same amount of torque T is _____.

[GATE XE 2021]

- 86) In System A, a rectangular block of mass M is centrally supported on a spring of stiffness K as shown. In System B, the mass is hinged at one of its ends and is supported centrally by the spring. The ratio of natural frequency of System B to that of System A (rounded off to two decimal places) is _____.

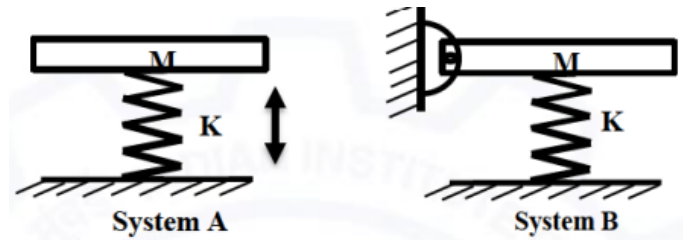


Fig. 86.

[GATE XE 2021]

- 87) A coronavirus droplet of mass 1 microgram ejects from the mouth of a patient with a velocity of 0.7 m/s and travels through air. The gravitational force experienced by it can be neglected due to the buoyancy effect. However, the droplet experiences air drag force proportional to its velocity and the drag coefficient is given as $1.0 \mu\text{N}\cdot\text{s/m}$. The distance travelled by the droplet before its velocity drops to 10% of its initial velocity (in m, rounded off to two decimal places) is _____.

[GATE XE 2021]

- 88) A refrigerator working on a reversed Carnot cycle has a Coefficient of Performance (COP) of 4. If it works as a heat pump and consumes work input of 1 kW, the heating effect will be:

[GATE XE 2021]

- | | |
|---------|---------|
| a) 1 kW | c) 5 kW |
| b) 4 kW | d) 6 kW |

- 89) The liquid phase of a pure substance is termed as, if its temperature is lower than the saturation temperature corresponding to its pressure P .

[GATE XE 2021]

- | | |
|------------------------|----------------------|
| a) super-heated liquid | c) metastable liquid |
| b) sub-cooled liquid | d) flashing liquid |

- 90) Two air streams of mass flow rates \dot{m}_1 and \dot{m}_2 enter a mixing chamber and exit after perfect mixing. The corresponding temperatures of the inlet streams are T_1 and T_2 , respectively. Heat loss rate from the mixing chamber to the surrounding is \dot{Q} . Assume that the process is steady, specific heat capacity is constant, and air behaves as an ideal gas. Identify the correct expression for the final exit temperature T_3 after mixing. The mass specific heat capacities of the gas at constant volume and constant pressure are c_v and c_p , respectively. Neglect the bulk kinetic and potential energies of the streams.

[GATE XE 2021]

$$\begin{aligned} \text{a) } T_3 &= \frac{\dot{m}_1 T_1 + \dot{m}_2 T_2}{\dot{m}_1 + \dot{m}_2} - \frac{\dot{Q}}{c_p(\dot{m}_1 + \dot{m}_2)} \\ \text{b) } T_3 &= \frac{\dot{m}_1 T_1 + \dot{m}_2 T_2}{\dot{m}_1 + \dot{m}_2} + \frac{\dot{Q}}{c_p(\dot{m}_1 + \dot{m}_2)} \end{aligned}$$

$$\begin{aligned} \text{c) } T_3 &= \frac{\dot{m}_1 T_1 + \dot{m}_2 T_2}{\dot{m}_1 + \dot{m}_2} - \frac{\dot{Q}}{c_v(\dot{m}_1 + \dot{m}_2)} \\ \text{d) } T_3 &= \frac{\dot{m}_1 T_1 + \dot{m}_2 T_2}{\dot{m}_1 + \dot{m}_2} + \frac{\dot{Q}}{c_v(\dot{m}_1 + \dot{m}_2)} \end{aligned}$$

91) If

- h is the mass specific enthalpy,
- s is the mass specific entropy,
- P is the pressure,
- T is the temperature,
- C_v is the mass specific heat at constant volume,
- C_p is the mass specific heat at constant pressure,
- β is the coefficient of thermal expansion,
- ν is the mass specific volume,
- κ is the isothermal compressibility,

then the partial derivative $\left(\frac{\partial h}{\partial s}\right)_P$ is:

[GATE XE 2021]

$$\begin{aligned} \text{a) } &\left(T - \frac{1}{\beta}\right)\left(\frac{C_p}{C_v}\right) \\ \text{b) } &\left(T - \frac{1}{\beta}\right) \end{aligned}$$

$$\begin{aligned} \text{c) } &T\left(1 - \frac{\nu\beta}{\kappa C_v}\right) \\ \text{d) } &T \end{aligned}$$

92) If

- ν is the mass specific volume,
- s is the mass specific entropy,
- P is the pressure,
- T is the temperature,

then using Maxwell relations, $\left(\frac{\partial s}{\partial P}\right)_T =$

[GATE XE 2021]

$$\begin{aligned} \text{a) } &\left(\frac{\partial \nu}{\partial T}\right)_P \\ \text{b) } &-\left(\frac{\partial \nu}{\partial T}\right)_P \end{aligned}$$

$$\begin{aligned} \text{c) } &\left(\frac{\partial \nu}{\partial T}\right)_s \\ \text{d) } &-\left(\frac{\partial \nu}{\partial T}\right)_s \end{aligned}$$

93) A closed system consists of a solution of liquid water and ethanol in equilibrium with its vapours. Using the Gibbs phase rule, the degree of freedom of the system is:

- a) 0
- b) 1
- c) 2
- d) 3

[GATE XE 2021]

94) For a real gas passing through an insulated throttling valve, the outlet temperature of the gas _____ with respect to the inlet temperature.

[GATE XE 2021]

- a) is always higher
- b) is always lower
- c) may be higher, lower or same
- d) is always same

95) Atmospheric air with Dry Bulb Temperature (DBT) of 24°C and Relative Humidity of 35%, entering in a circular duct (assume no pressure drop in the duct) is heated by an electrical resistance arrangement inside the duct. The DBT of air measured at the outlet of the duct is equal to 30°C . Considering the flow to be steady, which of the following statement(s) is (are) correct as regards to the outlet air, with respect to the inlet air?

[GATE XE 2021]

- a) There is no change in the Relative Humidity c) There is no change in the Specific Humidity
 b) There is no change in the Dew Point Temperature d) There is no change in the Specific Enthalpy

96) A cylinder of volume 1 m^3 contains a mixture of CO_2 (20% by mol) and O_2 (80% by mol) at 100 kPa and 300 K. This cylinder is connected to a 1 MPa pressure line carrying N_2 at 300 K. The cylinder is filled isothermally till the pressure of gas mixture inside it becomes 500 kPa, and then the filling is stopped. The amount of N_2 gas that has entered the cylinder is _____ (in mole, 2 decimal places).

The universal gas constant is $8.3145 \text{ J}/(\text{mol K})$.

[GATE XE 2021]

97) The saturation pressure P_{sat} of a pure liquid is represented by an equation of the form $\ln P_{\text{sat}} = A - (B/T)$, where A and B are constants, and T is the absolute temperature. For this substance, which of the following expression for specific entropy difference between the saturated vapour and the saturated liquid phase (s_{fg}) is correct?

Note: Subscripts f and g refer to saturated liquid and saturated vapour phases, respectively, and v_{fg} is the specific volume difference between the saturated vapour and the saturated liquid phases.

[GATE XE 2021]

a) $s_{fg} = \frac{B P_{\text{sat}} v_{fg}}{T^2}$

c) $s_{fg} = v_{fg} \frac{dP_{\text{sat}}}{dT}$

b) $s_{fg} = \frac{B}{T^2}$

d) $s_{fg} = \frac{v_{fg}}{T}$

98) For a refrigeration cycle, the ratio of actual COP to the COP of a reversible refrigerator operating between the same temperature limits is 0.8. The condenser and evaporator temperatures are 51°C and -30°C , respectively. If the cooling capacity of the plant is 2.4 kW, then the power input to the refrigerator is:

(COP: Coefficient of Performance)

[GATE XE 2021]

- a) 1.00 kW
 b) 1.33 kW

- c) 1.25 kW
 d) 2.08 kW

99) Two identical pressure cookers, Cooker A and Cooker B, each having a total internal capacity of 6 litres are available. Cooker A is filled with 2 litres of liquid water at 110°C and Cooker B is filled with 4 litres of liquid water at 110°C . The remaining space in both the cookers is filled with saturated water vapour in equilibrium with the liquid water. If g represents the specific Gibbs free energy, and subscripts v and l represent the saturated vapour and the saturated liquid phases, respectively, which of the following expressions is correct?

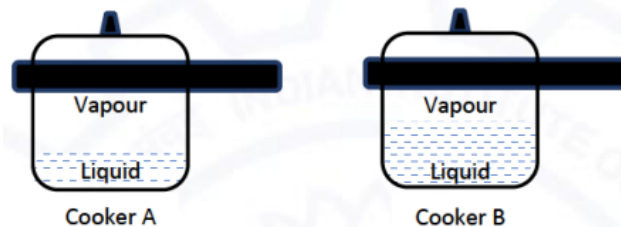


Fig. 99.

[GATE XE 2021]

- a) $g_{v,A} > g_{l,B}$ c) $g_{v,A} = g_{l,B}$
 b) $g_{v,A} < g_{l,B}$ d) $g_{l,B} = 2g_{l,A}$

100) Four different Entropy (S)–Temperature (T) diagrams, representing liquid to vapour phase transition process of a pure substance in a closed system under constant pressure are shown. The diagram, which correctly represents the process, is:

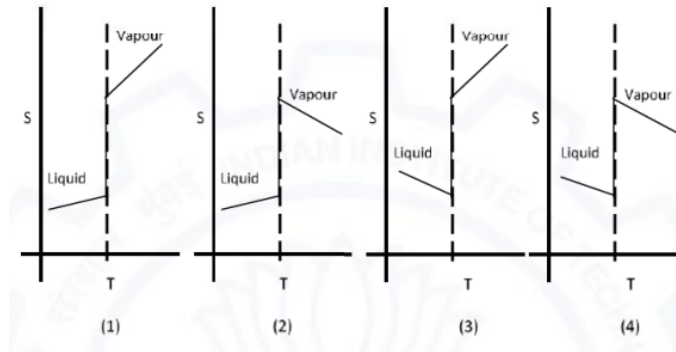


Fig. 100.

[GATE XE 2021]

- a) 1 b) 2 c) 3 d) 4

101) Air having a mass flow rate of 2 kg/s enters a diffuser at 100 kPa and 30°C, with a velocity of 200 m/s. Exit area of the diffuser is 400 cm² while the exit temperature of the air is 45°C. The rate of heat loss from the diffuser to the surrounding is 8 kJ/s. The pressure at the diffuser exit is _____ kPa (2 decimal places).

For air, the characteristic gas constant is 287 J/(kgK) and specific heat capacity at constant pressure is 1005 J/(kgK). Assume air to be an ideal gas and the flow in the diffuser is steady.

[GATE XE 2021]

102) For the Refrigerant R-134 (at 1 MPa and 50°C), the difference between the specific volume computed by assuming it to be an ideal gas and its actual specific volume is $V_{ideal} - V_{actual} = 4.529 \times 10^{-3}$ m³/kg. If the compressibility factor associated with this state is $Z = 0.84$, then $V_{igm} - V_{actual} =$ _____ $\times 10^{-3}$ m³/kg (3 decimal places).

Here V_{igm} is the specific volume calculated using the compressibility factor.

For Refrigerant R-134 (at 1 MPa and 50°C): The characteristic gas constant: 0.0815 kJ/(kgK). The critical pressure and temperature are, respectively, $P_c = 4.059$ MPa and $T_c = 374.2$ K.

[GATE XE 2021]

103) A mixture of air and water vapour enters a steady-flow adiabatic saturator at 50°C and 100 kPa. It leaves the saturator in a completely saturated state at temperature of 25°C and pressure of 100 kPa. Liquid water enters the saturator at 25°C. If air is considered to be an ideal gas, with constant specific heat capacity, the relative humidity of the air entering the saturator is _____% (1 decimal place).

Use the following data:

At 25°C: $h_f = 104.87$ kJ/kg, $h_g = 2547.17$ kJ/kg, $P_{sat} = 3.161$ kPa

At 50°C: $h_f = 209.31$ kJ/kg, $h_g = 2592.06$ kJ/kg, $P_{sat} = 12.335$ kPa

Specific heat capacity of air at constant pressure $C_p = 1.005$ kJ/(kgK)

[GATE XE 2021]

104) Air at a pressure of 1 MPa and 300 K is flowing in a pipe. An insulated evacuated rigid tank is connected to this pipe through an insulated valve. The volume of the tank is 1 m³. The valve is

opened and the tank is filled with air until the pressure in the tank is 1 MPa. Subsequently, the valve is closed. Consider air to be an ideal gas and neglect bulk kinetic and potential energy. The final temperature of air in the tank is _____ K (1 decimal place).

Specific heat capacity of air at constant pressure $C_p = 1.005 \text{ kJ/(kgK)}$ and characteristic gas constant for air $= 0.287 \text{ kJ/(kgK)}$.

[GATE XE 2021]

- 105) A cylinder of volume 0.1 m^3 is filled with 100 mol of propane (C_3H_8) at 2 MPa. If propane is assumed to obey the van der Waals equation of state, then its temperature is _____ K (1 decimal place).

The van der Waals constants for propane are: $a = 939.2 \text{ kPa(m}^3/\text{kmol)}^2$, $b = 0.0905 \text{ m}^3/\text{kmol}$. The universal gas constant is 8.3145 J/(mol K) .

[GATE XE 2021]

- 106) A frictionless piston cylinder device contains 1 kg of an ideal gas. The gas is compressed according to $pv^{1.2} = \text{constant}$ (where p is pressure and v is mass specific volume), from 100 kPa, 250 K, till it reaches a temperature of 500 K. The heat transfer from the piston cylinder device to its surroundings is _____ kJ (2 decimal places).

The characteristic gas constant is 287 J/(kgK) and the ratio of specific heat capacities is 1.4.

[GATE XE 2021]

- 107) A 0.8 m^3 insulated rigid tank contains 1.5 kg of an ideal gas at 100 kPa. Electric work is done on the system until the pressure in the tank rises to 135 kPa. The loss in availability (exergy) associated with the process is _____ kJ (2 decimal places).

For the ideal gas, the characteristic gas constant is 188.9 J/(kgK) and the specific heat capacity at constant volume is 680 J/(kgK) . The temperature of the dead state is 298 K.

[GATE XE 2021]

- 108) A rigid tank contains 1.0 kg of pure water consisting of liquid and vapour phases in equilibrium at 10 bar. If the liquid and vapour phase each occupies one half of the volume of the tank, then the net enthalpy of the contents of the tank is _____ kJ (1 decimal place).

For saturated liquid and vapour at 10 bar, the thermodynamic data table provides the following values: $v_f = 1.127 \times 10^{-3} \text{ m}^3/\text{kg}$, $v_g = 194.3 \times 10^{-3} \text{ m}^3/\text{kg}$, $h_f = 762.6 \text{ kJ/kg}$, $h_g = 2776.2 \text{ kJ/kg}$.

[GATE XE 2021]

- 109) An air-standard Diesel cycle with a compression ratio of 16 takes air at 1 bar and 300 K. If the maximum temperature in the cycle is 2100 K, then the thermal efficiency of the cycle is _____ % (1 decimal place).

The ratio of the specific heat capacities of air is 1.4.

[GATE XE 2021]

- 110) Linear low density polyethylene (LLDPE) is a copolymer of ethylene and a small fraction of _____.

[GATE XE 2021]

- a) butadiene
- b) isoprene

- c) butene
- d) hexadiene

- 111) Binary polymer blends of polypropylene and polyamide 6 are immiscible. From a thermodynamic viewpoint this is due to _____.

[GATE XE 2021]

- a) low enthalpy of mixing
- b) high entropy of mixing

- c) high enthalpy of mixing
- d) low entropy of mixing

- 112) Which one of the following is an elastomer?

[GATE XE 2021]

- a) Polyamide 6,6
b) Poly(ethylene terephthalate)
- c) Vulcanized polybutadiene
d) High density polyethylene

113) Compression moulded isotropic polypropylene film exhibits in X-ray diffraction analysis [GATE XE 2021]

- a) Spot pattern
b) Circular ring pattern
- c) Circular ring and spot pattern
d) Arc pattern

114) Which one of the following is an example of a biodegradable polymer? [GATE XE 2021]

- a) Polyethylene
b) Polyamide 6,6
- c) Polypropylene
d) Polylactic acid

115) Polymer crystals show a range of melting points in contrast to single melting point of crystals of small molecules, because [GATE XE 2021]

- a) there is an absence of intermolecular interactions
b) there is an absence of long range ordering
c) the polymer chains are not in thermodynamic equilibrium in a metastable state
d) the melting behavior of polymer crystal is independent of sample thermal history

116) When the rate of cooling is increased during the solidification process, the glass transition temperature of a polymer [GATE XE 2021]

- a) increases
b) decreases
- c) stays unaltered
d) shows a non-monotonic dependence

117) Equal and opposite forces of a constant magnitude F are applied at the two ends of a thin elastomeric rod, which is held at a temperature T_1 ($T_g < T_1 < T_m$), where T_g and T_m are the glass transition temperature and melting temperature respectively. If the temperature is increased to T_2 ($T_g < T_2 < T_m$ and $T_2 > T_1$), the rod will [GATE XE 2021]

- a) expand along the loading direction and the transverse direction
b) shrink along the loading direction
- c) remain dimensionally unaltered
d) expand only along the loading direction

118) The size of a coiled polymer chain in a dilute solution is R_G in a good solvent, R_I in an ideal solvent and R_P in a poor solvent. Select the correct ordering of sizes. [GATE XE 2021]

- (A) $R_G > R_I > R_P$
(B) $R_G < R_I < R_P$
- (C) $R_P > R_G > R_I$
(D) $R_P < R_G < R_I$

119) Match the Additive to its Function.

- | | |
|-----------------------------------|-------------------|
| P. Tritolyl phosphate | 1. Coupling Agent |
| Q. Stearic acid | 2. Lubricant |
| R. Silane | 3. Plasticizer |
| S. 4-Methyl-2,6-di-t-butyl phenol | 4. Blowing Agent |

[GATE XE 2021]

- a) P-3, Q-2, R-1, S-4
b) P-3, Q-1, R-4, S-2

- c) P-4, Q-1, R-3, S-2
d) P-1, Q-2, R-4, S-3

120) Match the polymer processing operation with respect to its typical range of shear rate.

- P. Injection moulding
Q. Extrusion
R. Blow moulding
S. Compression moulding

1. $10^5\text{--}10^6\text{ s}^{-1}$
2. $10^2\text{--}10^3\text{ s}^{-1}$
3. $10\text{--}10^2\text{ s}^{-1}$
4. $10^3\text{--}10^4\text{ s}^{-1}$

[GATE XE 2021]

- a) P-3, Q-4, R-2, S-1
b) P-1, Q-3, R-2, S-4

- c) P-2, Q-4, R-3, S-1
d) P-3, Q-2, R-1, S-4

121) Shear stress (σ) and shear viscosity (η) are plotted as functions of the shear rate $\dot{\gamma}$ for idealized “solid-like with yielding (1)” and “liquid-like (2)” materials. Associate the shear stress and viscosity plots with the appropriate material responses.

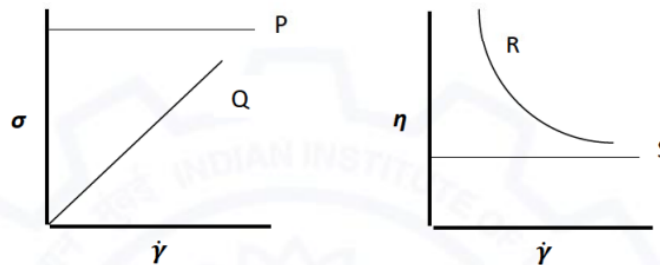


Fig. 121.

[GATE XE 2021]

- a) P-2, Q-1, R-2, S-1
b) P-1, Q-2, R-1, S-2

- c) P-1, Q-2, R-2, S-1
d) P-2, Q-1, R-1, S-2

122) The plateau modulus of polystyrene has a value of 0.2×10^6 Pa at 150°C . Given: density of polystyrene = 1.05 g/cm^3 , universal gas constant $R = 8.3\text{ J/(K mol)}$, and monomer molecular weight = 104 g/mol . The molecular weight between entanglements (rounded off to the nearest integer) of polystyrene chains is _____ g/mol.

[GATE XE 2021]

123) A unidirectional composite of epoxy and carbon fiber of 50% by volume is made. The elastic modulus of epoxy and carbon fiber are 3.5 GPa and 350 GPa, respectively. The ratio (rounded off to one decimal place) of the modulus of the composite to the matrix modulus is _____.

[GATE XE 2021]

124) A single screw extruder is operating at a rotational speed of 2 revolutions per second for the extrusion of a Newtonian polymer under open-discharge conditions (in absence of a die, $\Delta p = 0$). The extruder has a screw diameter $D = 5\text{ cm}$, a channel depth $H = 0.4\text{ cm}$, distance between flights $W = 1\text{ cm}$, and a helix angle $\phi = 20^\circ$. Assume $\pi = 3.14$. The volumetric flow rate (rounded off to 2 decimal places) is _____ cm^3/s .

[GATE XE 2021]

125) At 215°C , the viscosity of a polystyrene of molecular weight $250 \times 10^3\text{ g/mol}$ is $8.0 \times 10^3\text{ Pa}\cdot\text{s}$. The critical molecular weight of polystyrene is $M_c = 35 \times 10^3\text{ g/mol}$. For a similar polystyrene of molecular

weight 500×10^3 g/mol, the viscosity (rounded off to nearest integer) will be _____ $\times 10^3$ Pa.s.

[GATE XE 2021]

- 126) There are two different PTFE polymer specimens of the following density (ρ) and % crystallinity. For PTFE specimen-1: $\rho = 2.144$ g/cm³, crystallinity = 50%. For PTFE specimen-2: $\rho = 2.215$ g/cm³, crystallinity = 75%. Assuming the polymer is pure and defect free, the density (rounded off to 3 decimal places) of 100% amorphous PTFE specimen will be _____ g/cm³.

[GATE XE 2021]

- 127) The behavior of a polymer is described by a Maxwell model consisting of a spring element of modulus 10^6 Pa in series with a dashpot of viscosity 10^7 Pa.s. In the solid, 50 s after the sudden application of a fixed strain of 1%, the stress (rounded off to 2 decimal places) will be _____ $\times 10^7$ Pa.

[GATE XE 2021]

- 128) A particular free radical polymerization process yields a polymer with a number-averaged degree of polymerization, $\bar{X}_n = 100$. The monomer concentration is doubled and the initiator concentration is increased by four times. Assuming that all rate coefficients and other parameters remain unchanged, the value of \bar{X}_n (rounded off to the nearest integer) is _____.

[GATE XE 2021]

- 129) A polymer is synthesized from 2 moles of terephthalic acid (molecular weight of repeat unit $-\text{OCC}_6\text{H}_4\text{CO}-$ is 132 g/mol), 1 mol of ethylene glycol (repeat unit $-\text{OCH}_2\text{CH}_2\text{O}-$, 60 g/mol), and 1 mol of butylene glycol (repeat unit $-\text{O}(\text{CH}_2)_4\text{O}-$, 88 g/mol). The reaction is terminated at 99% conversion of the acid. The number-averaged molecular weight M_n (rounded off to the nearest integer) is _____ g/mol.

[GATE XE 2021]

- 130) A sample of natural rubber (cis-1,4-polyisoprene) is vulcanized such that one of every 240 chain carbon atoms is cross-linked. The formula unit of isoprene monomer is C_5H_8 (molecular weight = 68 g/mol). The average molecular weight (rounded off to the nearest integer) between cross-links is _____ g/mol.

[GATE XE 2021]

- 131) A sample of an oriented semi-crystalline polymer is subjected to uniaxial tensile stress σ in an X-ray diffractometer. The wavelength of X-ray radiation (Cu $K\alpha$) is $\lambda = 1.542$ Å. The position of the (002) peak, which was found initially at a Bragg angle of 37.50° at $\sigma = 0$ MPa, shifted to 37.45° at $\sigma = 160$ MPa. Assuming elastic deformation, the strain (rounded off to three decimal places) in the sample along the direction of applied stress is _____ $\times 10^{-3}$.

[GATE XE 2021]

- 132) In a typical bacterial growth curve, the first order kinetics for growth rate is observed in

[GATE XE 2021]

- | | |
|--------------|---------------------|
| a) Lag phase | c) Stationary phase |
| b) Log phase | d) Death phase |

- 133) Which one of the following microorganisms is NOT a causative agent for food borne diseases?

[GATE XE 2021]

- | | |
|-----------------------------------|--------------------------------|
| a) <i>Campylobacter jejuni</i> | c) Norovirus |
| b) <i>Clostridium perfringens</i> | d) <i>Borrelia burgdorferi</i> |

- 134) Which of the following is NOT a fermented food product?

[GATE XE 2021]

- a) Tofu
- b) Vinegar
- c) Sauerkraut
- d) Tempeh

135) The Protein Efficiency Ratio (PER) is defined as

[GATE XE 2021]

- a) Percentage of absorbed nitrogen retained in the body
- b) Weight gain in body mass (in gram) per gram protein intake
- c) Ratio of essential and non-essential amino acids in a protein
- d) Percent *in vitro* digestibility of a protein

136) Which one of the following enzymes sequentially releases maltose from starch?

[GATE XE 2021]

- a) alpha-amylase
- b) beta-amylase
- c) Glucoamylase
- d) Isoamylase

137) Which one of the following enzymes is involved in proteolysis of casein in cheese during aging?

[GATE XE 2021]

- a) Lipase
- b) Alliinase
- c) Cathepsin
- d) Rennin

138) Which one of the following compounds is present in soybean and acts as phytoestrogen?

[GATE XE 2021]

- a) Tangeretin
- b) Lutein
- c) Quercetin
- d) Genistein

139) Ultra high temperature (UHT) process of pasteurization of milk is achieved by Heating at

- a) 145°F for 30 minutes
- b) 161°F for 15 seconds
- c) 280°F for 2 seconds
- d) 400°F for 15 seconds

140) Bittering agent in grape fruit formed after juice extraction under acidic conditions is

- a) Quinine
- b) Theobromine
- c) Isohumulone
- d) Limonin

141) The conversion of pyruvate to lactic acid in homolactic fermentation is catalyzed by

[GATE XE 2021]

- a) Lactate dehydrogenase
- b) Pyruvate dehydrogenase
- c) Lactase
- d) Pyruvate decarboxylase

142) Which one of the following statements is INCORRECT with respect to Controlled Atmosphere Package (CAP) and Modified Atmosphere Package (MAP) of agro-produce?

[GATE XE 2021]

- a) CAP and MAP limit microbial as well as biochemical activities
- b) Gas composition inside a MAP during the storage is continuously monitored and regulated
- c) CAP implies a greater degree of precision than MAP in maintaining specific levels of the gas composition

- d) Modification of the atmosphere inside a MAP is achieved by natural interplay between respiration of products and permeation of gases through the packaging film

143) Match unit operation in Column I with its application in food processing in Column II.

Column I

- P. Hydrogenation
Q. Blanching
R. Leaching
S. Winterization

Column II

1. Removal of soft wax
2. Shortening of fat
3. Inactivation of enzyme
4. Separation of dye

[GATE XE 2021]

- a) P-2, Q-4, R-2, S-1
b) P-2, Q-3, R-4, S-1
c) P-4, Q-1, R-2, S-3
d) P-4, Q-2, R-1, S-3

144) Which of the followings are correct pair of GRAS chemical food preservative, affected organism and given food matrix?

[GATE XE 2021]

- a) Sodium lactate – Bacteria – Pre-cooked meats
b) Caprylic acid – Insects – Cheese wraps
c) Dehydroacetic acid – Molds – Squash
d) Sodium nitrite – Clostridia – Meat curing preparations

145) Choose the correct pair of pigment and their corresponding color in given plant product.

[GATE XE 2021]

- a) Carotene – Yellow-orange – Peppers
b) Betanin – Purple/red – Cactus pear
c) Lycopene – Red – Red beets
d) Flavanols – Orange – Cauliflower

146) Which of the following compounds act as anti-nutritional factors?

[GATE XE 2021]

- a) Isoflavones
b) Trypsin Inhibitor
c) Resveratrol
d) Tannins

147) Which of the followings is/are commonly used medium/media in the supercritical fluid extraction of spices and tea?

[GATE XE 2021]

- a) Water
b) Carbon dioxide
c) Dichloromethane
d) Carbon dioxide with Ethanol

148) Which of the following expressions represent the Reynolds number of a fluid flowing through a uniform circular cross section pipe?

[GATE XE 2021]

- a) $\frac{(\text{density of the fluid}) \times (\text{average velocity of the fluid}) \times (\text{internal diameter of the pipe})}{(\text{dynamic viscosity of the fluid})}$
b) $\frac{(\text{average velocity of the fluid}) \times (\text{internal diameter of the pipe})}{(\text{kinematic viscosity of the fluid})}$
c) $\frac{(\text{average velocity of the fluid}) \times (\text{density of the fluid}) \times (\text{internal diameter of the pipe})}{(\text{dynamic viscosity of the fluid})}$
d) $\frac{(\text{average velocity of the fluid}) \times (\text{internal diameter of the pipe})}{(\text{kinematic viscosity of the fluid})}$

149) Which of the following combinations of analytical equipment, property measured and food property are correct?

[GATE XE 2021]

- a) Particle size analyzer – Particle size distribution – Span value c) Differential scanning calorimeter – Glass transition temperature – Degree of caking
 b) Texture profile analyzer – Morphology – Chewiness d) Capillary viscometer – Viscosity – Sensory

150) Choose the correct pair(s) of Governing Law and corresponding application(s).

[GATE XE 2021]

- a) Hagen–Poiseuille law – Pressure drop fer
 b) Rittinger’s law – Vapour pressure d) Raoult’s law – Size reduction
 c) Stefan–Boltzmann law – Radiation heat trans-

151) An orange juice sample is concentrated from 10% to 40% (by weight) total soluble solids in a single effect evaporator with a feed rate of 3600 kg/hr at 25°C. The evaporator operates at sufficient vacuum to allow the product moisture to evaporate at 55°C. The specific heat of both feed and concentrated juice is 4.0 kJ kg⁻¹ °C⁻¹. If enthalpy of water vapour at 55°C is 2600 kJ/kg, heat transfer rate through the heating surface area of the evaporator in kilowatt (in integer) will be _____.

[GATE XE 2021]

152) Dry air is fed into a tray dryer. The percentage relative humidity of the air leaving the dryer is 60% at 70°C and 101.35 kPa. If the saturated vapour pressure of water at 70°C is 31.2 kPa, the humidity of the air leaving the dryer in kg water per kg dry air (round off to 3 decimal places) will be _____.

(Given: Molecular weight of water and air are 18.02 g/mol and 28.97 g/mol, respectively.)

[GATE XE 2021]

153) In a cold storage plant, 5000 kg potato having a constant specific heat capacity of 3.65 kJ kg⁻¹ °C⁻¹ are cooled from 28°C to 2°C in 24 hours. The heat of respiration of potato per 24 hour is 3.12 kJ/kg during the storage. Assuming the efficiency of the storage plant to be 70%, the capacity of the plant in ton of refrigeration (round off to 2 decimal places) is _____.

(Given: 1 ton of refrigeration = 3.517 kilowatt)

[GATE XE 2021]

154) Western Boundary Current in the ocean is primarily due to

[GATE XE 2021]

- a) Ekman pumping c) River water forcing
 b) Rotation of the earth d) Ocean floor topography

155) The relevant non-dimensional number in deciding deepening of the thermocline driven by instability of ocean currents is

[GATE XE 2021]

- a) Rossby number c) Richardson number
 b) Reynolds number d) Ekman number

156) During July–August, the highest number of monsoon low pressure systems form over

[GATE XE 2021]

- a) Arabian Sea c) South India
 b) Bay of Bengal d) Himalayan foothills

157) CO₂ concentration in the Earth’s atmosphere is increasing because 50% of the annual anthropogenic emissions are retained in the atmosphere. If nations agree to reduce annual CO₂ emissions by one Giga

ton every year starting from 2021, then in which year will the CO_2 concentration in the atmosphere stop rising due to anthropogenic emissions?

Take the anthropogenic CO_2 emissions in 2020 as 40 Giga tons.

[GATE XE 2021]

- a) 2020
- b) 2050
- c) 2060
- d) 2100

158) The figure shows a schematic of Indian Ocean surface circulation. This pattern is representative of the circulation in which month of the year?

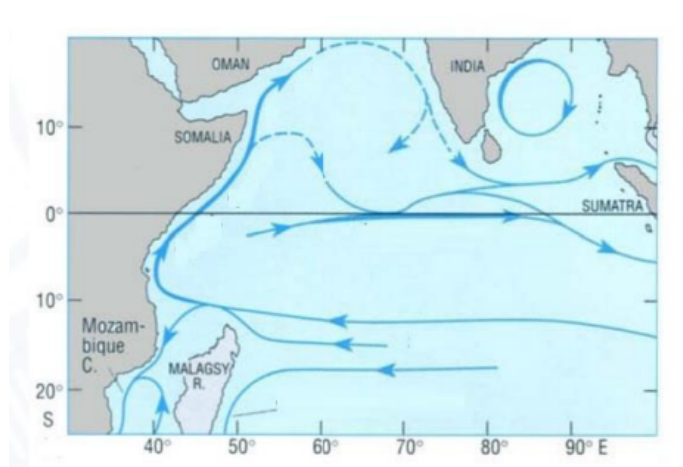


Fig. 158.

[GATE XE 2021]

- a) January
- b) July
- c) May
- d) November

159) Over the open ocean, if the air–sea temperature difference is zero, then which of the following statements is/are always true?

[GATE XE 2021]

- a) Sensible heat flux is zero
- b) Latent heat flux is zero
- c) Momentum flux is zero
- d) Net energy flux is zero

160) The psychrometric equation, which is useful in measuring humidity, is derived assuming the following process(es).

[GATE XE 2021]

- a) Isobaric process
- b) Isothermal process
- c) Adiabatic process
- d) Isentropic process

161) The water vapour mixing ratio of an air parcel increases from 10 g/kg to 20 g/kg at a constant pressure of 1010 hPa and temperature of 300 K. The change in virtual temperature is _____ K (to one decimal place).

[GATE XE 2021]

162) The Ekman layer thickness, if turbulent diffusivity is $0.01 \text{ m}^2/\text{s}$, is _____ m. Take Coriolis parameter to be 10^{-4} s^{-1} . (Round off to the nearest integer).

[GATE XE 2021]

- 163) The figure shows vertical variation of two chemicals P and Q measured in the Pacific Ocean. Identify the correct combination showing (P, Q) pair from the list below.

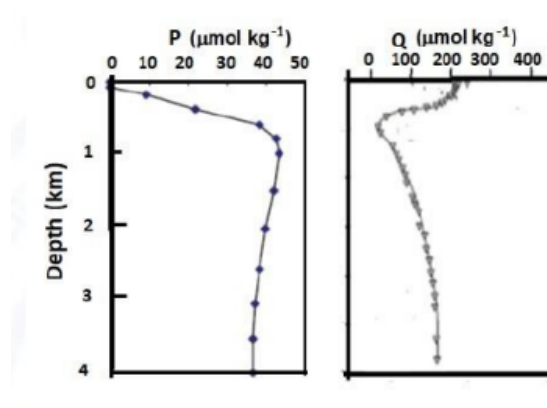


Fig. 163.

[GATE XE 2021]

- | | |
|--------------------|--------------------|
| a) Oxygen, Nitrate | c) Nitrate, Oxygen |
| b) Oxygen, Neon | d) Neon, Nitrate |

- 164) Consider tropical high-level clouds and low-level stratus clouds with bases at 12 km and 1 km above the surface of the Earth, respectively. Which of the following statement(s) is/are correct?

[GATE XE 2021]

- | | |
|---|--|
| a) High clouds are composed of ice crystals | climate |
| b) High clouds have a larger albedo than low clouds | d) Low clouds have a net warming effect on climate |
| c) High clouds have a net warming effect on | |

- 165) Which of the following statement(s) is/are correct in the context of Sverdrup transport?

[GATE XE 2021]

- | | |
|--|--|
| a) Sverdrup transport is always in the meridional direction | c) Sverdrup transport depends on the variation of the Coriolis parameter |
| b) Sverdrup transport is always orthogonal to the wind direction | d) Sverdrup transport is only due to ageostrophic currents |

- 166) Which of the following statement(s) is/are correct regarding the Hadley cell?

[GATE XE 2021]

- | | |
|--|--|
| a) The ascending branch is narrower than its descending branch | c) The lower level winds between the ascending and descending branches of the Hadley cell are north-westerly |
| b) Thunderstorms are more frequent in the subsiding region of the Hadley cell than in its ascending region | d) Latent heat is transported from the subsiding to the ascending region of the Hadley cell |

- 167) Which of the following statement(s) is/are true about the ocean circulation?

[GATE XE 2021]

- a) Large-scale ocean surface currents are driven by winds c) Upwelling currents bring warm nutrient-deficient water to the surface of the ocean
 b) Cold, dense and salty water forms in the North Atlantic Ocean d) Thermohaline circulation does not transport energy in the meridional direction

168) Coral reefs are found primarily in tropical and subtropical shallow seawaters. Which of the following statement(s) is/are correct?

[GATE XE 2021]

- a) Corals require plenty of sunlight for photosynthesis and sunlight is abundant in the tropical and subtropical latitudes c) Corals grow optimally in fresh low-salinity water
 b) Corals grow optimally in seawater unsaturated in carbonate, which is found only in the tropi- d) Corals grow optimally in water temperatures between 23°C and 29°C

169) In an incompressible fluid, the horizontal divergence is -0.01 s^{-1} . Then, the vertical velocity at 50 m above a flat surface is _____ m/s. (Round off to one decimal place)

[GATE XE 2021]

170) In an atmosphere, temperature T decreases linearly with height above the ground (z), i.e., $T(z) = T_0 - \gamma z$, where γ is a constant. Surface pressure is 900 hPa. If the atmosphere is at rest, then the value of z at which the pressure decreases to half of that at the surface is _____ m (round off to nearest integer).

Take acceleration due to gravity $g = 10 \text{ m/s}^2$, gas constant $R = 300 \text{ J/(kg K)}$, $T_0 = 300 \text{ K}$ and $\gamma = 1/30 \text{ K/m}$. Assume atmosphere behaves as an ideal gas.

[GATE XE 2021]

171) In a local Cartesian system, a zonal jet has a form $u(y) = u_0 \left(1 - \frac{y^2}{L^2}\right)$, for $-L < y < L$. Here, y is the meridional distance measured from the axis of the jet and is positive northward. The vertical component of vorticity of this flow at $y = L/2$ is _____ s^{-1} . (Round off to 3 decimal places)

Take $u_0 = 50 \text{ m/s}$ and $L = 5 \text{ km}$.

[GATE XE 2021]

172) An eastward flow with a speed of 10 m/s goes from station M to station N, which are separated by a distance of 1 km. The temperature at station N is always higher than that at station M by 10 K. The absolute change in temperature due to advection at the mid-point between the stations in 50 s is _____ K (round off to nearest integer).

[GATE XE 2021]

173) Suppose, because of the doubling of atmospheric CO_2 concentration, an ocean water column receives an additional net energy input of 4 W/m^2 . If the entire water column of depth 1 km heats up uniformly, the water temperature will increase by 1 K in _____ years (round off to nearest integer). Assume all the additional heat added is retained and not lost. Take density of seawater = 1000 kg/m^3 ; specific heat capacity of seawater = 4200 J/(kg K) .

[GATE XE 2021]

174) Consider a layer of atmosphere between 5 and 6 km height. The downwelling longwave radiation at 5 and 6 km is 240 and 230 W/m^2 , respectively. The upwelling longwave radiation at these heights is 260 and 240 W/m^2 , respectively. The longwave heating rate in this layer is _____ K/day. (Round off to one decimal place)

Take the average density of air in this layer to be 0.5 kg/m^3 ; specific heat capacity of air at constant pressure = 1000 J/(kg K) .

[GATE XE 2021]

- 175) A spherical asteroid, revolving around the Sun in a circular orbit, is in radiative balance. Suddenly, the asteroid enters the shadow of a planet and solar radiation is cut off. Assuming that the asteroid emits as a blackbody in the longwave regime, the time taken to reduce the average temperature of the asteroid by 0.5 K is _____ seconds (round off to nearest integer).

Ignore the temporal change in radiation emitted by the asteroid during this cooling period.

The physical properties of the asteroid are: diameter = 2 m, density = 3000 kg/m³, specific heat = 2000 J/(kg K), albedo = 0.8 in shortwave radiation. Take solar constant = 500 W/m², Stefan–Boltzmann constant = 5.67×10^{-8} W m⁻² K⁻⁴.

[GATE XE 2021]