# GATE 2026 XE Question Paper

| **Time Allowed :**3 Hour | **Maximum Marks :**100 | **Total Questions :**65 |
|---|---|---|

## General Instructions

**Read the following instructions very carefully and strictly follow them:**

1. This question paper is divided into three sections:
   - **General Aptitude (GA):** 10 questions (5 questions × 1 mark + 5 questions × 2 marks) for a total of 15 marks.
   - **Engineering Mathematics:**
     - **Part A (Mandatory):** 36 questions (1 questions × 1 mark + 19 questions × 2 marks) for a total of 55 marks.
     - **Part B (Section 1):** Candidates can choose either Part B1 (Surveying and Mapping) or Part B2 (Section 2). Each part contains 16 questions (8 questions × 1 mark + 11 questions × 2 marks) for a total of 30 marks.
2. The total number of questions is **65**, carrying a maximum of **100 marks**.
3. The duration of the exam is **3 hours**.
4. Marking scheme:
   - For 1-mark MCQs, $\frac{1}{3}$ mark will be deducted for every incorrect response.
   - For 2-mark MCQs, $\frac{2}{3}$ mark will be deducted for every incorrect response.
   - No negative marking for numerical answer type (NAT) questions.
   - No marks will be awarded for unanswered questions.
5. Ensure you attempt questions only from the optional section (Part B1 or Part B2) you have selected.
6. Follow the instructions provided during the exam for submitting your answers.

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## General Aptitude

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**1. Consider an art gallery whose walls are shown in fig. A black dot represents a junction of two walkways. A guard may be placed at a junction to watch over the walls that joint at the junction. The min no of guards needed to watch all the walkways.**

(A) 4
(B) 2
(C) 3
(D) 5

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**2. In a population, patients who have high cholesterol also have high BP. Some patients with high BP also have diabetes. There are no patients who have both high cholesterol and diabetes. Furthermore:**
**1. The total no. of patients with at least one of these condition is 75**
**2. The no. of patients with high cholesterol is 10**
**3. The no. of patients with high BP is 45**
**4. The no. of patients with only high BP & no other condition is 20**
**Then the no. of patients who have both diabetes & high BP is:**

(A) 15
(B) 20
(C) 10
(D) 0

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**3. A coin with heads facing up is shown as H & a coin with tails facing up shown as T. Six coins are placed in the starting arrangement, as shown in fig below. A step is defined as interchanging a pair of adjacent coins without flipping them. The min no of steps needed to go from the starting arrangement to the final as shown in fig. is _____**
**Start: H H H T T T Final: T T T H H H**

(A) 3
(B) 6
(C) 12
(D) 9

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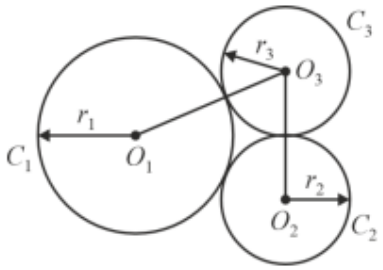
**4. Consider $C_1, C_2$ & $C_3$ with $O_1, O_2, O_3$ and radii $r_1, r_2, r_3$ respectively touch each other as shown in the following fig. Given $r_1 = 2$ cm, $r_2 = 1$ cm & angle $\angle O_1O_3O_2 = 90^\circ, r_3 =$ _____ cm.**




(A) $\frac{1}{2}(3+\sqrt{12})$
(B) $\frac{1}{2}(-3+2\sqrt{17})$
(C) $\frac{1}{2}(-3+\sqrt{17})$
(D) $\frac{1}{2}(-2+\sqrt{17})$

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**5. Four people, P, Q, R & S of different ages, make the following observations.**
**P : I am younger than S**
**Q : I am neither the youngest nor the oldest.**
**R : P is older than me.**
**Based on the observations, the youngest person is:**

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

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**6. Suresh said, "I did it yesterday."**
**Which one of the following options is the correct form of this sentence in indirect speech?**

(A) Suresh said that I did it yesterday.
(B) Suresh says he did it that day before.
(C) Suresh says I did it yesterday.
(D) Suresh said that he had done it the day before.

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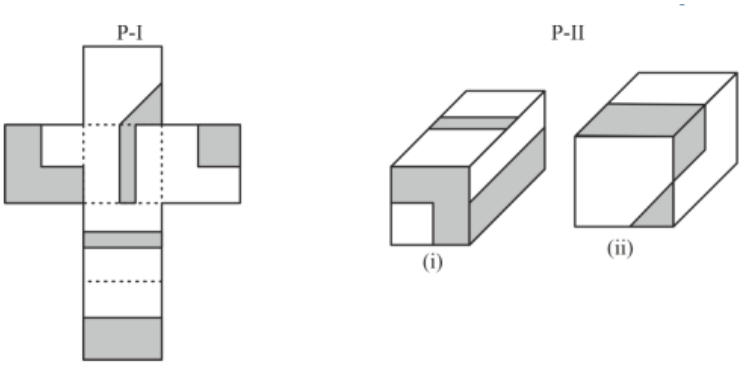
**7. A paper shown in P-I is folded along dashed lines to construct a cube. The shaded region shown in P-I appears on the outer surface of the cube. Referring to the cubes shown in P-II, which one of the following options is correct?**




(A) Neither (i) nor (ii)
(B) Only (ii)
(C) Only (i)
(D) Both (i) & (ii)

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**8. Tile indicated by the question mark:**


(A) 

(B) 

(C) 

(D) 

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**9. Choose the option with the correct pair of words to fill the blank.**
**Exacerbate : Mitigate :: _____ : _____**

(A) Emancipate ; Exonerate
(B) Aggravate ; precipitate
(C) Aggravate ; Alleviate
(D) Alleviate ; precipitate

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**10. $2^{nd}$ June is Thursday in a certain year. Which day of the week is the $3^{rd}$ July in that year?**

(A) Sunday
(B) Thursday
(C) Friday
(D) Saturday

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## Engineering Mathematics

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**1. In $W(x)$ – Wronskian of 2 linearly independent solution $y_1(x), y_2(x)$.**
$(x-1)\frac{d^2y}{dx^2} + 2\frac{dy}{dx} + xe^x y = 0, x > 1$
**Where $w(2) = 2$, the value of $w(5)$** _____

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

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**2. In Complex function**
$f(z) = f(x+iy) = x^3 - 4xy^2 + i(4x^2y - 2y^3)$
**P: $f$ is not analytic at (0, 0)**
**Q: $f$ does not satisfy the C-R equation along x-axis**

(A) P is true Q is false
(B) P is false Q is true
(C) P and Q both are correct Q is implies of P
(D) P and Q both are correct Q is not implies of P

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**3. Let X be a random variable having probability density function**

$$f_X(x) = \begin{cases} \frac{e}{2(e-1)}e^{-x}, & 0 < x < 1 \\ \frac{1}{2}, & 1 < x < 2 \\ 0, & \textbf{elsewhere} \end{cases}$$

**The value of expectation of X, E(X)** _____**. (Rounded off two decimal places)**

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**4. Let C is circle $(x-1)^2 + y^2 = 25$, is oriented counter clock wise. The value of line integral**

$\oint_C[(x^5 - 3y)dx + (-2x + e^{y^2})dy]$

(A) $10\pi$
(B) $15\pi$
(C) $20\pi$
(D) $25\pi$

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**5.** $\begin{bmatrix} L_{11} & 0 & 0 \\ L_{21} & L_{22} & 0 \\ L_{31} & L_{32} & -10 \end{bmatrix} \begin{bmatrix} 1 & u_{12} & u_{13} \\ 0 & 1 & u_{23} \\ 0 & 0 & 1 \end{bmatrix}$ **be the LU decomposition of matrix**
$A = \begin{bmatrix} 1 & 1 & 1 \\ 4 & 3 & -1 \\ 3 & 5 & \alpha \end{bmatrix}$**, the value of** $\alpha$ **is** _____**. (rounded off two decimal places)**

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**6. In the given partial differentiation equation**
$(y-1)\frac{\partial^2 u}{\partial x^2} - (x-3)^2\frac{\partial^2 u}{\partial y^2} + y^2\frac{\partial u}{\partial x} + x^2 y\frac{\partial u}{\partial y} + (x-y)u = 0$
**Which of the following statements is are correct.**

(A) In a region $(x+y) \in \mathbb{R}^2 : y < 1, x < 3$ is hyperbolic
(B) In a region $(x+y) \in \mathbb{R}^2 : y > 1, x > 3$ is hyperbolic
(C) In a region $(x+y) \in \mathbb{R}^2 : y < 1, x > 3$ is elliptical
(D) In a region $(x+y) \in \mathbb{R}^2 : y > 1, x < 3$ is elliptical

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**7. Match the following**

| List-I | List-II |
|---|---|
| P. the sum of series $\sum_{n=1}^{\infty} \frac{1}{(n+2)(n+1)}$ | 1. $\frac{3}{2}$ |
| Q. $\lim_{x\to 0} \frac{3}{x^2}\int_0^x \sin(t)\,dt$ is equal | 2. 1 |
| R. Let $\frac{a_0}{2} + \sum_{n=1}^{\infty}[a_n \cos(nx) + b_n \sin(nx)]$ be the Fourier series expansion of function $f(x) = \frac{1}{2}\sin x - \frac{1}{2}\cos x + \frac{1}{\sqrt{2}}\sin(2x), x \in [0,2\pi]$ then $\sum_{n=0}^{\infty}(a_n^2 + b_n^2) =$ — | 3. $\frac{1}{2}$ |

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

**8. Let L be the lamina of the $x^2 + 4y^2 \leq 64, 0 \leq y \leq 4$ with density $\rho(x, y) = |x|y$. The mass of L is _____**

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**9. In matrix**

$$A = \begin{bmatrix} 1 & \sqrt{2} & 0 \\ \sqrt{2} & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

(A) Determinant of $A = 3$
(B) Matrix $A - 2I$ is invertible. I denotes the identity matrix of order $3 \times 3$
(C) All the eigen value of A real number
(D) Eigen value of $A^{-1} = 1, 1/2, -1$

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**10. The value of $\frac{du}{dt} = u^2 + t^2, t \geq 0, u(0) = 1$, the step value $h = 0.2$ using the explicit Euler method, the value of $u(0.4) =$ ____. (Rounded off two decimal places)**

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## Fluid Mechanics

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**1. The basic dimensions, i.e. mass, length and time are represented by M, L and T respectively. The correct dimension of Dynamic viscosity is**

(A) $ML^{-1}T^{-1}$
(B) $M^0L^2T^{-1}$
(C) $MLT^{-2}$
(D) $M^0L^{-2}T^2$

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**2. Which of the following statements about streamlines, pathlines and streaklines is/are correct?**

(A) A streamline is a curve that is everywhere tangent to the instantaneous local velocity vector.
(B) Two streamlines can intersect at a point in a flow.
(C) A pathline is the locus of the fluid particles passing sequentially through a particular point.
(D) For steady flows, streamlines, pathlines and streaklines are the same.

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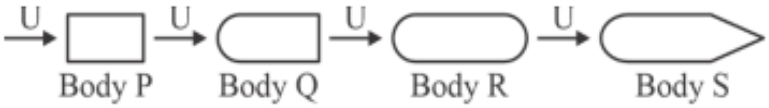
**3. Air flows with a free-stream velocity U over four different bodies having same frontal area facing to the flow direction as shown in the figure. Which one of the following bodies has the lowest pressure form drag force for Reynolds number $Re > 10^3$?**




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

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**4. Consider the following statements:**
**Assertion (A): Surface tension acts along the interface of two fluids.**
**Reason (R): The pressure of the fluid inside a bubble is higher than that of the fluid outside the bubble.**

(A) (A) is true but (R) is false
(B) Both (A) and (R) are true, however (R) is not the correct explanation of (A)
(C) Both (A) and (R) are true and (R) is the correct explanation of (A)
(D) (A) is false but (R) is true

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**5. Consider a steady and incompressible flow over a body with characteristic length L. The boundary layer thickness at a distance x from the leading edge is $\delta$. Which one of the following assumptions is correct for deriving the Prandtl boundary layer equations?**

(A) $\delta > L$
(B) $\delta \approx L$
(C) $\delta \ll L$
(D) $\delta \gg L$

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**6. For a laminar, incompressible and fully developed flow through a circular pipe, the ratio of maximum velocity to the average velocity is**

(A) 2
(B) 3
(C) 4
(D) 1.5

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**7. The velocity components in x and y directions of a 2-D incompressible flow field are $u(x, y) = 2x^2 + y^3$ and $v(x, y) = x^3 - 2xy + f(x, y)$, respectively. Here, $f(x, y)$ is a polynomial function and $g(x)$ is a polynomial function of x only. Which one of the following options for $f(x, y)$ is correct?**

(A) $f(x, y) = -2x + g(x)$
(B) $f(x, y) = -2x^2y + g(x)$
(C) $f(x, y) = -2xy + g(x)$
(D) $f(x, y) = -x^2y + g(x)$

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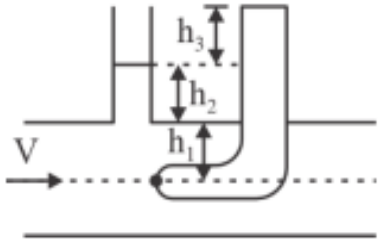
**8. A piezometer and a pitot tube are tapped into a horizontal water pipe, as shown in the figure, where $h_1 = 4$ cm, $h_2 = 6$ cm and $h_3 = 5$ cm. Consider the flow to be steady, laminar and incompressible. Assume the density of water $1000$ kg/m$^3$ and acceleration due to gravity $10$ m/sec$^2$. The water velocity V (in m/s) at the center of the pipe is _____ (Round upto one decimal place).**

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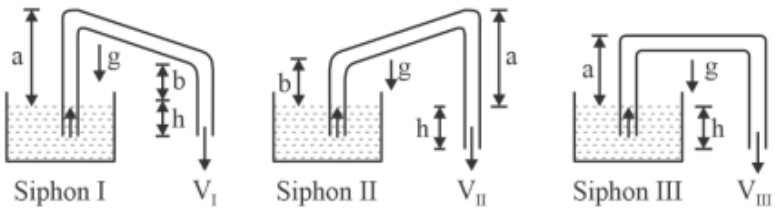
**9. Three different siphons steadily discharge water at velocities $V_I, V_{II}$ and $V_{III}$ as shown in the figure. The tubes of the siphons are of same diameter. If the frictional losses are neglected, which of the following is correct?**
**In figure g is acceleration due to gravity, a, b and h are different heights.**




(A) $V_I > V_{II} > V_{III}$
(B) $V_{II} > V_I > V_{III}$
(C) $V_{III} > V_{II} > V_I$
(D) $V_I = V_{II} = V_{III}$

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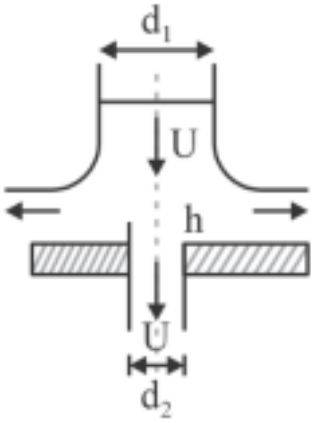
**10. A vertical jet of diagram $d_1$ strikes a horizontal plate with a velocity U, as**

**shown in figure. The plate has a hole of diameter $d_2$ ($< d_1$) concentric to the flow through which a portion of fluid passes with the same velocity U. The remaining fluid moves radially outward along the plate. If F is the force acting vertically upward to hold the horizontal plate at its initial place. Which of the following statements is/are true?**




(A) Radially outward flow has no effect on F
(B) F decreases as $d_2$ decreases keeping other parameters unchanged
(C) F increases as U increases keeping other parameters unchanged
(D) F remains constant as $d_1$ increases keeping other parameters unchanged

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**11. For a steady, laminar and incompressible flow over a flat plate, the local skin friction coefficient is given by $C_f = \frac{0.664}{\sqrt{Re_x}}$ where $Re_x$ is the local Reynolds number. The density and kinematic viscosity of the fluid are $1.2$ kg/m$^3$ and $1.5 \times 10^{-5}$ m$^2$/s respectively. If the free stream velocity is $3$ m/s, then local shear stress (in N/m$^2$) at $x = 0.05$ m is _____ (Round off to 3 decimal places)**

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**10. A ship is designed to sail at a speed of $8$ m/s. A designer makes a $1 : 10$ scaled model to test the ship in a water tunnel. The model and the ship satisfy the dynamic similarity. The speed (in m/s) of the model is _____ (Round off to 2 decimal places)**

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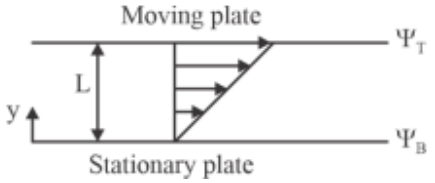
**13. An incompressible fluid flows between a pair of infinite plates separated by a distance L. The top plate is moving with a constant velocity U, whereas the bottom plate is stationary, as shown in figure. The difference of the stream functions ($\psi_T - \psi_B$) at the two plates for a laminar fully developed flow is equal to:**




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

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**14. Consider a steady, laminar, incompressible flow over a flat plate, as shown in figure with freestream velocity $U_\infty$ and kinematic viscosity $\nu_1$. The boundary layer thickness at a distance $x_1$ from the leading edge is $\delta_1$. If the kinematic viscosity of the fluid is increased by a factor of four ($\nu_2 = 4\nu_1$) the boundary layer thickness ($\delta_2$) at $x_1$ with same free stream velocity will be equal to:**


(A) $2\delta_1$
(B) $4\delta_1$
(C) $\frac{\delta_1}{2}$
(D) $\delta_1$

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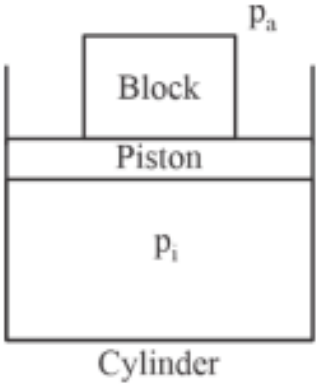
**15. A gas is pressurized in a vertical frictionless piston-cylinder device, as shown in figure. The piston has a mass of 4 kg and cross-sectional area of $40$ cm$^2$. A metallic block of 13 kg is placed on the piston. The atmospheric pressure ($P_a$) = 1 bar. Assume acceleration due to gravity, $g = 10$ m/s$^2$. The pressure inside the cylinder $P_i$ (in bar) is _____. (Round off to 3 decimal places)**



**16. Air flows through a pipe of diameter D with an average velocity of 3 m/s. The Darcy's friction factor of the pipe is 0.02. Assume acceleration due to gravity 10 m/s$^2$. If the head loss per metre is 0.05, the diameter (in m) of the pipe is _____. (Round off to 2 decimal places)**

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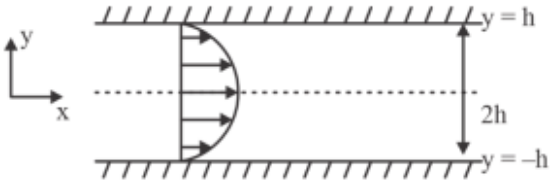
**17. A steady, laminar, incompressible flow between a pair of infinite parallel plates is driven by a constant pressure gradient $\left(-\frac{dp}{dx}\right)$. The plates are separated by a distance $2h$ as shown in the figure. The fully developed velocity profile of the fluid is $u(y) = -\frac{dp}{dx}\frac{h^2}{2\mu}\left(1 - \frac{y^2}{h^2}\right)$ where $\mu$ is dynamic viscosity. The value of $y$, for which the local flow velocity is equal to the average flow velocity are:**




(A) $\pm\frac{h}{\sqrt{2}}$
(B) $\pm\frac{h}{\sqrt{3}}$
(C) $\pm\frac{h}{2}$
(D) $\pm\frac{h}{\sqrt{5}}$

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**18. $\vec{V} = (a-x)\hat{i}+(b+y)\hat{j}+(c+z)\hat{k}$ where $a, b, c$ are constants and $\hat{i}, \hat{j}, \hat{k}$ are unit vectors in $x, y$ and $z$ directions respectively which of the following statements is/are correct?**

(A) The flow is steady for any value of $a, b, c$
(B) At a point (2, 3, 6) the velocity components is higher than the velocity component in y and z directions at $a = 2, b = 6$ and $c = 2$.
(C) The acceleration of the flow along the x-direction is not constant for any value of $a, b, c$.
(D) The point (2, 3, 6) is a stagnation point for $a = 2, b = -3, c = -6$.

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**19. A two-dimensional source flow with stream function $\left\{\psi_1 = m\tan^{-1}\left(\frac{y}{x}\right)\right\}$ is placed at the origin in a uniform flow with stream function $\{\psi_2 = Uy\}$. Here the strength of the source is $m$ and the free stream velocity is $U$. The velocity components $u$ and $v$ of the combined flow in $x$ and $y$ directions respectively are:**

(A) $u = \frac{mx}{x^2+y^2}, v = U + \frac{my}{x^2+y^2}$
(B) $u = U + \frac{mx}{x^2+y^2}, v = \frac{my}{x^2+y^2}$
(C) $u = U + \frac{mx}{x^2+y^2}, v = -\frac{my}{x^2+y^2}$
(D) $u = \frac{mx}{x^2+y^2}, v = U - \frac{my}{x^2+y^2}$

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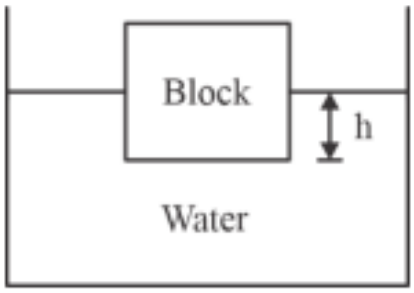
**20. A rectangular block of density = 600 kg/m$^3$ with base area 0.06 m$^2$ and height 15 cm is partially submerged in water ($\rho = 1000$ kg/m$^3$), as shown in figure. Assume acceleration due to gravity 10 m/s$^2$. The submerged depth $h$ (in m) of the block in the water is _____. (Round off to 2 decimal places)**

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**21. The axial velocity profile of a laminar, incompressible and fully developed flow flow in circular pipe of radius $R$ is given by $V_z = -\frac{1}{4\mu}\frac{dP}{dz}(r^2 - R^2)$, where $\mu, p, z$ are dynamic viscosity, pressure axial coordinate and radial coordinate respectively. If the magnitude of shear stress at the pipe wall is given by $|\tau_w| = \frac{R}{K}\frac{dP}{dz}$. Then the value of $K$ is _____. (Answer in integer)**

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**22. Consider two different cases of water flowing through a smooth pipe of 50 cm diameter. The mass flow rates for the two cases are: (i) 0.25 kg/s and (ii) 0.8 kg/s. Assume density of water 1000 kg/m$^3$ and dynamic viscosity $10^{-3}$ Pa-s respectively. Which one of the following options is correct?**

(A) The flow is laminar for (i) and turbulent for (ii)
(B) The flow is laminar for both (i) and (ii)
(C) The flow is turbulent for both (i) and (ii)
(D) The flow is turbulent for (i) and laminar for (ii)

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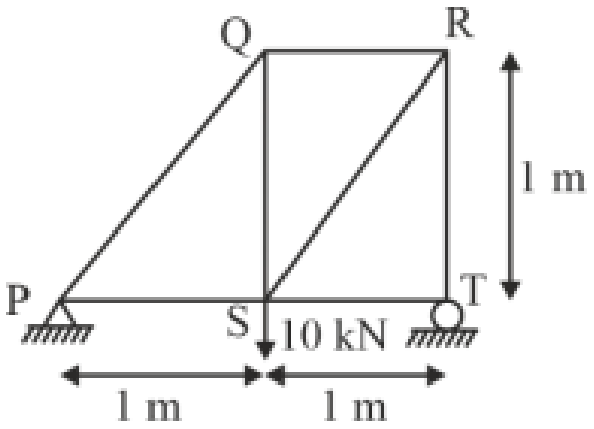
## Solid Mechanics

**1. Identify zero force member in the truss as shown in figure.**




(A) SQ
(B) SP
(C) ST
(D) SR

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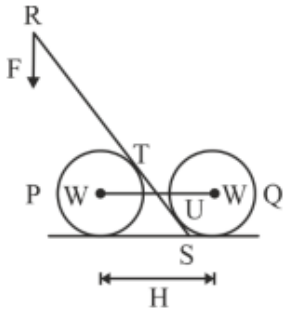
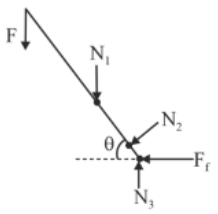
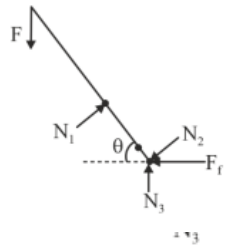
**2. Two smooth drums each weighing W and radius r connected by stiff rope of length h as shown in figure. Force F is applied using a massless lever (RS) of length, $l$. The friction between drum and lever is negligible. The system is in equilibrium. Which one of the following represent correct FBD of lever RS?**



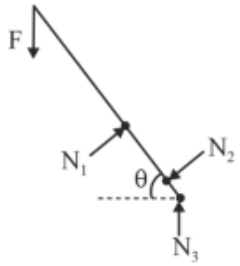

(A)



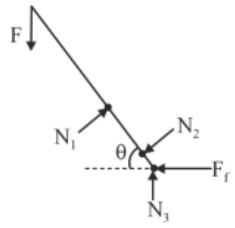
(B)




(C)




(D)

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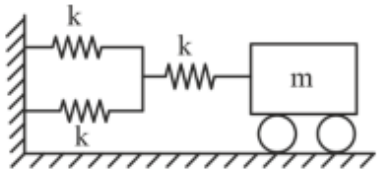
**3. A 2D state of stress at a point in a body is given by $\sigma_{xx} = -40$ MPa, $\sigma_{yy} = 100$ MPa and $\tau_{xy} = 50$ MPa. The radius of Mohr's circle for the given state of stress is _____ MPa (Round off to two decimal places).**

---

**4. Sum of principal stresses of 2D stress state $\begin{bmatrix} 11 & 4 \\ 4 & 5 \end{bmatrix}$ is _____ (in integer)**

---

**5. A rigid block of mass m connected to three springs as shown in figure. The natural frequency of the system is**




(A) $\sqrt{\frac{3k}{m}}$

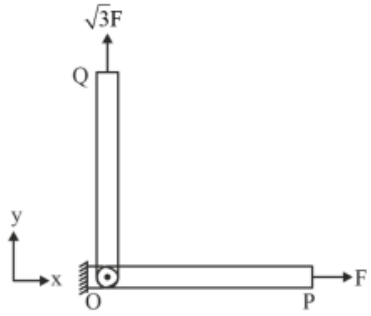
(B) $\sqrt{\frac{2k}{3m}}$

(C) $\sqrt{\frac{3k}{2m}}$

(D) $\sqrt{\frac{3k}{4m}}$

---

**6. Two axial members OP and OQ are pin jointed at O as shown in figure. A force F acts at point P along positive x direction and force $\sqrt{3}F$ acts at point Q along positive y direction. The resultant force makes an angle $\theta$ (Anti clockwise from positive x axis). The Value of $\theta$ is _____.**




(A) 30°
(B) 60°
(C) 45°
(D) 75°

---

**7. Which among following options is/are correct unit(s) of stress?**

(A) $Nm^2$
(B) $N/m^2$
(C) $Pa$
(D) $N$-$m$

---

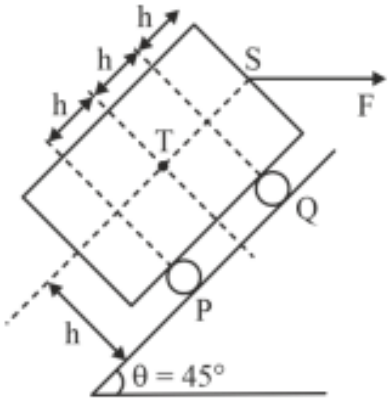
**8. A car is moving on horizontal surface in a straight line with a constant velocity of 3 m/s. A ball is thrown vertically upward at t = 0 from top of moving car with velocity of 20 m/s. (g =10 m/s$^2$). At what value(s) of time in second(s), the ball is at a height of 15 m from top of moving car?**

(A) 3
(B) 2
(C) 4
(D) 1

---

**9. A cart of weight 5 KN, stands on an inclined smooth surface at an angle of 45° as shown in fig. The cart is maintained in equilibrium by a horizontal force acting**

**at S. The Value of F is _____ kN (in integer)**

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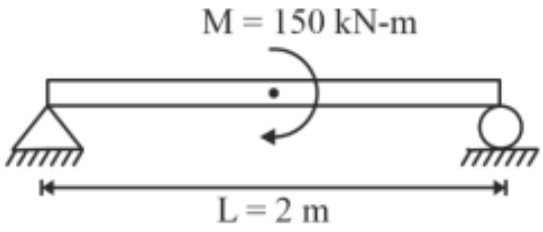
**10. The elastic strain energy U of given simply supported beam is given by following expression: $U = \frac{M^2 L}{48EI}$. The section modulus $EI = 25 \times 10^3$ N-m$^2$. The absolute value of slope of beam at distance $L/2$ from left end is _____ (rounded off to three decimal places). Given $M = 150$ kN-m and $L = 2$ m.**

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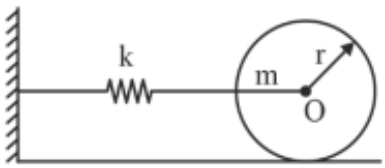
**11. A cylinder of mass m and radius r is rolling without slipping on a horizontal surface as shown in figure. Considering small oscillations which one is the correct natural frequency of system?**




(A) $\sqrt{\frac{k}{2m}}$

(B) $\sqrt{\frac{k}{m}}$

(C) $\sqrt{\frac{2k}{3m}}$

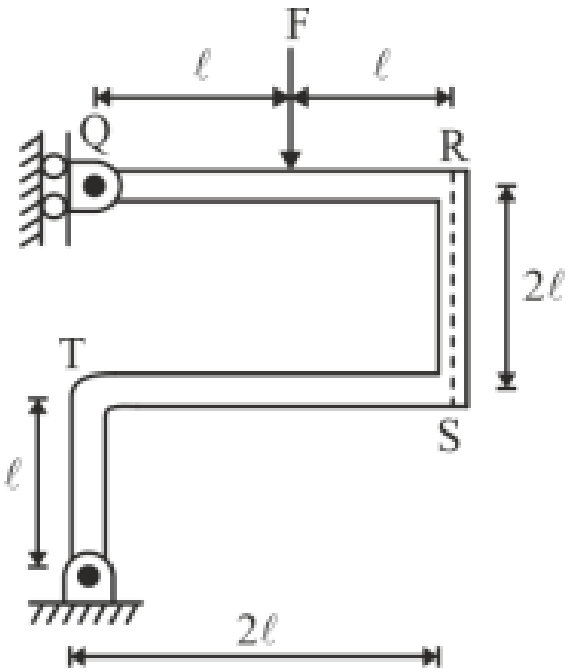
(D) $\sqrt{\frac{3k}{2m}}$

**12. Two prismatic rod of identical lengths are designed for some strain energy density when subjected to same axial load. One of rod is made of steel and another is made of aluminium. $E_s = 210$ GPa, $E_{Al} = 70$ GPa. If diameter of aluminium rod is 70 mm, then which of following options correspond to diameter of steel rod in mm?**

(A) 29.13
(B) 210
(C) 53.19
(D) 70

---

**13. Which one of following options is/are correct absolute value of bending moment at R in the frame as shown in figure?**



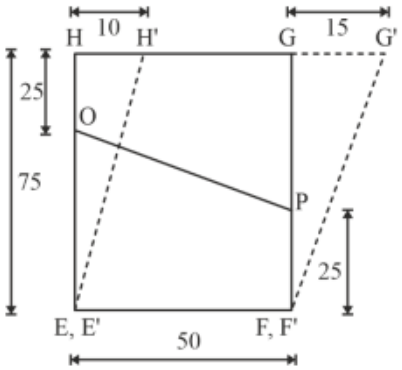

(A) 0
(B) $Fl$
(C) $3Fl$
(D) $2Fl$

---

**14. A thin-walled cylindrical container of diameter 2m and wall thickness of 2.5 cm is made of steel whose young modulus is 200 GPa and yield stress is 450 MPa. Using von-mises criteria, the maximum permissible pressure is _____ MPa. (Rounded off to two decimal places).**

---

**15. EFGH is the initial configuration and E'F'G'H' (dashed line) is the deformed configuration of an object as shown in figure. E' coincides with E and F' coincides with F. The average normal strain along line segment OP is _____ (Rounded off to three decimal places).**

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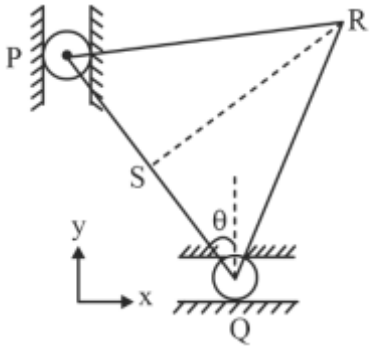
**16. One column with square cross section of side r and another column with rectangular cross-section of breadth p and width q ($q < p$) are made from same material. Both the columns have one fixed end and other end is free. They are subjected to axial loads along the centroidal axis. Consider area of cross-section of both columns to be same. The minimum critical euler buckling loads of columns with rectangular and square cross-section are $F_{rect}$ and $F_{sq}$ respectively. Then $\frac{F_{rect}}{F_{sq}}$ is _____.**

(A) $\frac{r}{q}$
(B) $\frac{q}{p}$
(C) $\frac{r^2}{pq}$
(D) $\frac{p}{q}$

---

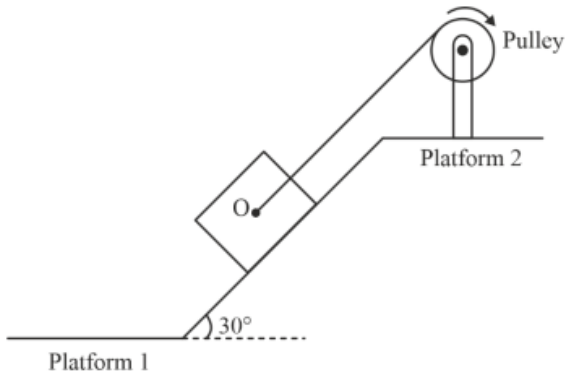
**17. The point Q of thin rigid equilateral triangular plate PQR is constrained to move in a horizontal channel. Point P of same plate is constrained to move in vertical channel as shown in figure. The length of PQ is 4 m. At the instant when $\theta = \frac{\pi}{3}$ rad and the velocity of point Q in positive x direction is 20 m/s. Which one of following options is the magnitude of the angular velocity vector of line SR on the plate in rad/s?**




(A) 20
(B) 5
(C) 25
(D) 10

---

**18. A motorized pulley of diameter 200 mm is used to transfer a block of mass 100 kg from platform 1 to platform 2 using a ramp kept at an inclination of $30^\circ$ as shown in figure. The coefficient of static friction between block and ramp is 0.2. ($g = 10$ m/s$^2$). Assume rope parallel to ramp surface. The minimum torque required by motor to transport the block uphill is _____ Nm (Round off to two decimal places).**

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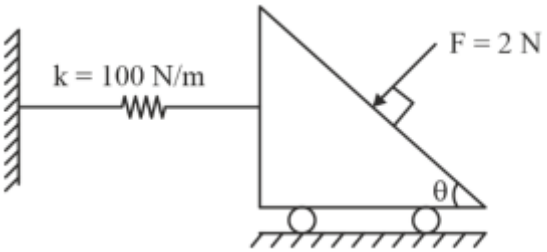
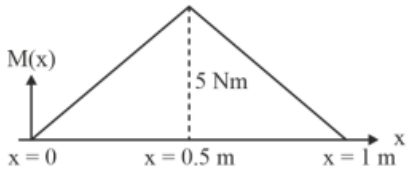
**19. In given figure, assume that the block is in static equilibrium and its mass is negligible. If the static deflection of spring ($\Delta$) is 0.01 m. which one of the following is the corresponding angle ($\theta$) in radians?**




(A) $\frac{\pi}{5}$
(B) $\frac{\pi}{6}$
(C) $\frac{\pi}{4}$
(D) $\frac{\pi}{3}$

---

**20. The bending moment diagrams for a simply supported beam is piecewise linear as shown in figure. The bending moment M(x) at x = 0.5 m is 5 N-m. The beam has a rectangular cross-section of area 1 $m^2$. The absolute value of maximum shear stress on the cross-section at x = 0.75 m is _____ $N/m^2$ (in integer)**

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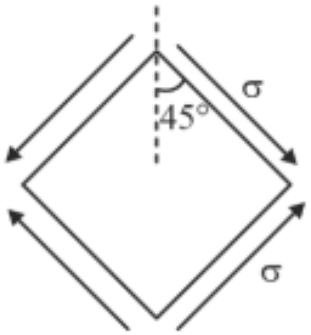
**21. A 2-D stress state of pure shear shown in figure. Which one of the following options is equivalent to the given stress state?**




(A) Horizontal and vertical normal stresses of magnitude $\sigma$
(B) Horizontal and vertical shear stresses of magnitude $\sigma$
(C) Horizontal and vertical normal stresses of magnitude $2\sigma$
(D) Diagonal shear stresses of magnitude $\sigma$

---

**22. A solid axial bar made of steel with young modulus 200 GPa and poison ratio 0.3, is subjected to uniaxial stress of 50 MPa. The absolute value of max. shear strain on the outer surface of bar is _____ $10^{-4}$ (Round off to two decimal places).**

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## Thermodynamics

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**1. A stream of moist air at 101 kPa & $25^{\circ}$C undergoes a constant pressure process such that its Dry Bulb temperature increases and specific humidity decreases. For this, which one of the following is/are always CORRECT?**

(A) Wet Bulb temperature increases
(B) Relative humidity decreases
(C) Dew point temperature decreases
(D) Adiabatic saturation temperatures increases

---

**2. For given $c_p$, $c_v$, R, which one of the following is CORRECT at all condition?**

(A) $c_p \geq c_v$
(B) $c_p = c_v$
(C) $c_p - c_v = R$
(D) $c_p > c_v$

---

**3. In a mixing chamber hot water enters at $80^{\circ}$C with mass flow rate of 0.5 kg/s. From another entry cold water, enters the chamber at $40^{\circ}$C. The desired temperature after mixing at the exit is $50^{\circ}$C. There is no water leakage & mixing happens at adiabatic condition. Assume $c_w = 4.2$ kJ/kgK. For steady state operation, mass flow rate (in kg/s) of cold water is**

(A) 1
(B) 1.5
(C) 2
(D) 5

---

**4. Which one of the following is correct?**

(A) U, S, H are path function
(B) Q & W are state (point) function
(C) T, P, v are intensive properties
(D) For an ideal gas h is a function of both temperature & pressure

**5. Which one of the following is/are example(s) of pure substance at $25^{\circ}$C, 101 kPa?**

(A) Mixture of liquid water and water vapour
(B) Gaseous oxygen
(C) Homogenous mixture of gaseous oxygen & water vapour
(D) Mixture of liquid water and gaseous oxygen

---

**6. A mixture of $CO_2$, $N_2$ & $O_2$ are introduce in a rigid & impermeable tank containing only liquid water ($H_2O$). Assuming components are non-reacting & undissociated. The system is kept isolated till an equilibrium is achieved, where only 2 phases are present. The degree of freedom of mixture as obtained from phase rule is:**

(A) 3
(B) 2
(C) 1
(D) 4

---

**7. Consider a mixture of ideal gas $N_2$ (28 kg/kmol) & $CO_2$ (44 kg/kmol) at $25^{\circ}$C & 101 kPa. If molar mass of mixture is 34 kg/kmol which one of the following is possible? & $CO_2$ by mass/volume, 37.5% $N_2$ & $CO_2$ by m/v.**

(A) 62.5% $N_2$ and 37.5% $CO_2$ by mass
(B) 37.5% $N_2$ and 62.5% $CO_2$ by mass
(C) 37.5% $N_2$ and 62.5% $CO_2$ by volume
(D) 62.5% $N_2$ and 37.5% $CO_2$ by volume

---

**8. For an otto cycle, $T_1 = 300$ K, $T_2 = 750$ K and $\gamma = 1.4$. the thermal efficiency of the otto cycle is _____% (Round off to two decimal places).**

---

**9. A house loses heat at the rate of 150 MJ/h. The outside temperature of the house is $-3^{\circ}$C. The minimum power required to maintain inside temperature at $25^{\circ}$C using heat pump is _____ kW. (Round off to two decimal places)**

---

**10. A rigid & impermeable tank has only moist air with specific humidity of 0.025 kg of water vapour/kg of dry air, at $30^{\circ}$C and 101 kPa. The air is heated to $90^{\circ}$C.**

**Assume moist air as ideal gas. The relative humidity of the heated air is _____%. (Round off to two decimal places)**
**Given:**
$(P_{sat})_{30^\circ C} = 4.25$ **kPa,** $(P_{sat})_{90^\circ C} = 70.18$ **kPa**

---

**11. For an ideal diesel cycle with cold air assumption compression ratio is 20 and cut-off ratio is 1.8. The temperature and pressure after compression are 1120 K, and 6.8 MPa respectively. For $\gamma = 1.4$, the temperature after expansion is _____ K. (Round off to two decimal places)**

---

**12. Consider a fluid with properties $v = 1.03$ m$^3$/kg, $c_p = 1$ kJ/kgK, $\beta = 4.39 \times 10^{-3}$ 1/K. The inversion temperature of the fluid is _____ K. (Round off to two decimal places)**

---

**13. A fluid undergoes a process from $(P_1, T_1, V_1)$ to $(P_2, T_2, V_2)$ with $\beta$ & $K_T$ remaining constant. Given $\beta = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P, K_T = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$ the ratio $(V_2/V_1)$ is:**

(A) $[\beta(T_2 - T_1) - K_T(P_2 - P_1)]$
(B) $[\beta(T_2 - T_1) \times K_T(P_2 - P_1)]$
(C) $[\beta(T_2 - T_1)/K_T(P_2 - P_1)]$
(D) $\exp[\beta(T_2 - T_1)]/\exp[K_T(P_2 - P_1)]$

---

**14. Consider a single component fluid at saturation conditions having properties $h_{fg} = 39.6 \times 10^3$ kJ/kmol, compressibility factor for vapor phase, $Z_g = \frac{P_{sat} v_g}{R_u T} = 0.95$. Assume $v_{fg} \approx v_g$, $R_u = 8.314$ kJ/kmol·K. Using Clapeyron equation, $-\frac{d(\ln P)}{d(1/T)}$ at saturation is _____ K. (Round off to two decimal places)**

---

**15. Consider real gas obeying $v = \frac{RT}{P} + C_1 - \frac{C_2}{Pv}$. The value of $\left(\frac{\partial s}{\partial v}\right)_P$ =?**

(A) $\frac{R^2 T}{P v^2}$
(B) $R/v$
(C) $\frac{C_1 \times C_2}{Tv}$
(D) $\frac{R}{v - C_1}$

---

**16. Consider an ideal Rankine cycle with fixed condition at turbine inlet. If pressure in the condenser is lowered, which one of the following is/are correct?**

(A) $W_p$ remains same
(B) Moisture at turbine exit decreases
(C) $Q$ rejected in condenser decreases
(D) $W_T$ increases

---

**17. A stream of moist air enters an adiabatic saturator at $45°$C & 101 kPa and leaves as a saturated mixture at $30°$C. Make-up water to the saturator is supplied at $30°$C. The amount of make-up water supplied is _____ g/kg dry air. (Round off to two decimal places)**

---

**18. A mixture of He (40% by mass) & $N_2$ (60% by mass) expands in turbine from 800 kPa to 100 kPa. Turbine inlet temperature is 1000 K. The temperature at turbine exit is _____ K. (Round off to two decimal places).**
**Given: isentropic expansion, K.E. & P.E. changes neglected,**
$\gamma_{He} = 1.67, \gamma_{N_2} = 1.4$, $c_{p,He} = 5.19$ **kJ/kg·K,** $c_{p,N_2} = 1.04$ **kJ/kg·K.**

---

**19. 2 kg of gas is compressed from 300 K to 600 K in process $Pv^{1.2} = C$. Assume gas as ideal gas with $R = 287$ J/kg·K, $\gamma = 1.4$. The heat rejected in the process is _____ kJ. (Round off to two decimal places)**

---

**20. An adiabatic, rigid & impermeable tank of volume 10 m$^3$ contains air at 800 kPa & $70°$C. The air is allowed to leak until pressure becomes 1/4 of original value. During process, air is maintained at $70°$C using an electric heater. Assume air as ideal gas with $R = 287$ J/kg·K, $\gamma = 1.4$. The total electrical energy supplied by heater is _____ MJ. (Round off to two decimal places)**

---

**21. m kg of liquid at temperature $T_1$ is mixed with m kg of same liquid at temperature $T_2$ in an isolated tank at constant pressure. $\Delta S$ is:**

(A) $mc_p \ln\left(\frac{T_1+T_2}{\sqrt{T_1T_2}}\right)$
(B) $2mc_p \ln\left(\frac{T_1+T_2}{2\sqrt{T_1T_2}}\right)$

(C) $mc_p \ln\left(\frac{T_1+T_2}{2\sqrt{T_1T_2}}\right)$

(D) $2mc_p \ln\left(\frac{T_1+T_2}{\sqrt{T_1T_2}}\right)$

---

**22. A rigid spherical solid ball at 1000°C is cooled slowly to 200°C in a surrounding air at 25°C. The density, specific heat and diameter of the ball are 8000 kg/m$^3$, 500 J/kg·K, 10 mm respectively, assuming cooling is quasi-equilibrium, $(\Delta S)_{gen}$ is _____ J/K. (Round off to two decimal places)**

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