JEE Main 2021 Paper 2A (B.Arch) Sep 2 Single sitting Question Paper with Solutions PDF

Question Paper with Solutions

Conducted by the National Testing Agency (NTA)

Time Allowed: 3 Hours **Maximum Marks: 400**

General Instructions

(i) This paper is Paper 2A (B.Arch.) of JEE (Main) 2021, Session 4 (Aug-Sep), conducted by the National Testing Agency (NTA) in Computer Based Test (CBT) mode on 2 September 2021, Shift 2. The total duration is 3 hours.

(ii) The paper has 82 questions: Mathematics (30), Aptitude Test (50), Drawing Test (2), in that order. Maximum marks: 400.

(iii) Mathematics has two sections. Section A has 20 multiple choice questions (MCQs) with four options, of which only one is correct. Section B has 10 numerical value questions; attempt any 5 of them. The answer to each numerical value question is a number.

(iv) Marking scheme (multiple choice questions): $+4$ for a correct answer, -1 for an incorrect answer and 0 for an unanswered question.

(v) Marking scheme (numerical value questions): $+4$ for a correct answer, no negative marking and 0 for an unanswered question.

(vi) The Drawing Test questions are answered on the drawing sheet; marks for each are indicated against it.

(vii) Calculators, log tables, slide rules and electronic gadgets are not allowed.

Mathematics – Section A: Multiple Choice Questions (80 marks)

1. The domain of the function, $f(x) = \sqrt{\frac{\log_{0.6}|x-2|}{|x|}}$ is : [4 marks]

(A) $[1, 2) \cup [3, \infty)$

(B) $[1, 2) \cup (2, 3]$

(C) $(0, 1) \cup (2, 3]$

(D) $(-\infty, 0) \cup [1, 2)$

Correct Answer: (B) $[1, 2) \cup (2, 3]$

Solution:

Concept:

- A real square root requires a nonnegative radicand. A real logarithm requires a strictly positive argument.
- For a base between zero and one, the logarithm is decreasing: $\log_{0.6} t \geq 0$ precisely when $0 < t \leq 1$.

Step 1: Apply the separate domain restrictions The denominator $|x|$ must be nonzero, so $x \neq 0$. The logarithm requires $|x-2| > 0$, so $x \neq 2$. For every remaining value the denominator is strictly positive; therefore it does not reverse the inequality or change the sign of the numerator.

Step 2: Solve the radicand inequality We need $\log_{0.6}|x-2| \geq 0$. Since the base is less than one, this becomes $0 < |x-2| \leq 1$. The upper bound gives $1 \leq x \leq 3$, and the strict lower bound removes $x = 2$. The earlier exclusion of zero removes no further points. Both endpoints 1 and 3 are allowed because the logarithm is zero there. Options with negative values, values above 3, or values between 0 and 1 include a negative radicand and fail.

Step 3: Conclusion The domain is $\boxed{[1, 2) \cup (2, 3]}$. Hence, the correct option is (B).

Quick Tip to Solve: For a logarithmic radical with base below one, first turn nonnegativity into an upper bound on the logarithm argument.

2. Let α and β be the roots of the quadratic equation $x^2 + \sqrt{3}x + 1 = 0$. Then $\alpha^{2022} + \beta^{2022}$ is equal to : [4 marks]

(A) 2

(B) -2

(C) 0

(D) $-\sqrt{3}$

Correct Answer: (B) -2

Solution:

Concept:

- The quadratic formula gives the two conjugate roots. A unit-modulus complex number can be written as $\cos\theta + i\sin\theta$.

- De Moivre's formula gives $(\cos\theta + i\sin\theta)^n = \cos n\theta + i\sin n\theta$. Conjugate powers sum to $2\cos n\theta$.

Step 1: Express the roots in polar form The discriminant is $3 - 4 = -1$, so $\alpha, \beta = (-\sqrt{3} \pm i)/2$. Their moduli are one, and their arguments can be taken as $\pm 5\pi/6$. Thus they are $e^{\pm 5\pi i/6}$; interchanging their names does not affect the requested symmetric sum.

Step 2: Reduce the exponent and evaluate Each root has twelfth power one. Since $2022 = 12 \cdot 168 + 6$, the required powers equal their sixth powers. In particular, $6(5\pi/6) = 5\pi$, and both conjugate roots raised to the sixth power are -1. Hence $\alpha^{2022} + \beta^{2022} = 2\cos(1685\pi) = -2$. The value 2 would require an even multiple of π; zero and $-\sqrt{3}$ correspond to different angles and do not satisfy this exponent.

Step 3: Conclusion $\boxed{\alpha^{2022} + \beta^{2022} = -2}$. Hence, the correct option is (B).

Quick Tip to Solve: When conjugate quadratic roots lie on the unit circle, reduce the exponent using their angular period before computing powers.

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3. If $A = \begin{pmatrix} 0 & 0 & 2 \\ 1 & 0 & 0 \\ 0 & -1 & 0 \end{pmatrix}$**, then :** [4 marks]

(A) $A^6 = 2A^3$

(B) $2A^6 = A^3$

(C) $A^{12} = 4A^6$

(D) $A^{12} = 2A^6$

Correct Answer: (C) $A^{12} = 4A^6$

Solution:

Concept:

- Matrix powers are found by matrix multiplication, not by raising individual entries to powers.
- For a matrix that cycles the coordinate directions with weights, one full cycle multiplies every coordinate by the product of those weights.

Step 1: Compute one complete cycle For a column vector $(x, y, z)^T$, the matrix sends it to $(2z, x, -y)^T$. Applying the same map twice gives $(-2y, 2z, -x)^T$, and applying it a third time gives $(-2x, -2y, -2z)^T$. Since this holds for every vector, $A^3 = -2I$, where I is the three-dimensional identity matrix.

Step 2: Compare all four proposed relations Now $A^6 = (-2I)^2 = 4I$ and $A^{12} = (4I)^2 = 16I$. In the first relation, $2A^3 = -4I$, which differs from A^6. In the second, $2A^6 = 8I$, which differs from $A^3 = -2I$. In the fourth, $2A^6 = 8I$, which differs from $A^{12} = 16I$. However, $4A^6 = 4(4I) = 16I = A^{12}$, so exactly the third relation holds.

Step 3: Conclusion $\boxed{A^{12} = 4A^6}$. Hence, the correct option is (C).

Quick Tip to Solve: For a weighted cyclic matrix, find the first power that becomes a scalar multiple of the identity; all higher powers then simplify immediately.

4. The sum of all values of λ, for which the system of equations

$$x + y + z = 1$$

$$x + 2y + 4z = \lambda$$

$$x + 4y + 10z = \lambda^2$$

has infinitely many solutions, is : [4 marks]

(A) 2

(B) -2

(C) 3

(D) -3

Correct Answer: (C) 3

Solution:

Concept:

- Infinitely many solutions occur when the coefficient rank equals the augmented rank and is smaller than the number of unknowns.
- A linear dependence among coefficient rows must also hold among the right-hand-side entries for consistency.

Step 1: Identify the dependence among equations Let the coefficient rows be $R_1 = (1, 1, 1)$, $R_2 = (1, 2, 4)$, and $R_3 = (1, 4, 10)$. Directly, $R_3 = 3R_2 - 2R_1$. The first two rows are not proportional, so their rank is two. The third equation can add no coefficient rank; it must therefore have the corresponding dependent right-hand side.

Step 2: Impose consistency and count the freedom Consistency requires $\lambda^2 = 3\lambda - 2$, giving $\lambda^2 - 3\lambda + 2 = (\lambda - 1)(\lambda - 2) = 0$. Thus $\lambda = 1$ or 2. For either value, subtracting the first equation from the second gives $y + 3z = \lambda - 1$. Choosing any real $z = t$, we obtain $y = \lambda - 1 - 3t$ and $x = 2 - \lambda + 2t$. Hence both parameter values genuinely give infinitely many solutions, with no additional restriction. Their sum is 3, excluding the other listed sums.

Step 3: Conclusion The required sum is $1 + 2 = \boxed{3}$. Hence, the correct option is (C).

Quick Tip to Solve: For a singular three-equation system, find the row dependence first and apply the same dependence to the constants.

5. Let $f(x) = \max\{x^2, x^3\}$ for all $x \in \mathbf{R}$. Then which of the following is NOT true ? [4 marks]

(A) f is continuous for all x.

(B) f is not differentiable exactly at one point in $\mathbf{R}$.

(C) f is not differentiable exactly at two points in $\mathbf{R}$.

(D) $f'\left(-\frac{1}{2}\right) + f'\left(\frac{1}{8}\right) + f'\left(\frac{3}{2}\right) = 6$

Correct Answer: (C) f is not differentiable exactly at two points in $\mathbf{R}$.

Solution:

Concept:

- To determine which polynomial is the maximum, compare their difference: $x^2 - x^3 = x^2(1-x)$.
- A piecewise function is differentiable at a switch only when it is continuous there and its left and right derivatives agree.

Step 1: Find the active branches and continuity Since $x^2 \geq 0$, the difference is nonnegative for $x \leq 1$, and negative for $x > 1$. Therefore $f(x) = x^2$ for $x \leq 1$, while $f(x) = x^3$ for $x > 1$. The equality at zero does not cause a branch change: the quadratic is active on both sides of zero. At 1 both formulae give 1, so the function is continuous everywhere.

Step 2: Check differentiability and the derivative sum For $x < 1$, $f'(x) = 2x$, and for $x > 1$, $f'(x) = 3x^2$. At 1 the one-sided derivatives are 2 and 3, so the function is not differentiable exactly there. Thus the statement claiming two such points is false, while the statement claiming exactly one is true. Also

$$f'(-1/2) + f'(1/8) + f'(3/2) = -1 + \frac{1}{4} + \frac{27}{4} = 6.$$

Hence the derivative-sum statement is true as well.

Step 3: Conclusion The assertion that f is not differentiable at exactly two real points is NOT true. The supplied key selects the statement claiming exactly one point, but the printed function is differentiable at zero and fails differentiability only at 1; thus that statement is true and cannot answer NOT true. The direct derivative check above proves the printed false statement is the one claiming two points. Hence, the correct option is (C).

Quick Tip to Solve: An equality of the two candidate formulae need not create a corner: check whether the active maximum actually changes across that point.

6. The sum of the series

$\frac{1}{6}+\frac{5}{6^2}+\frac{19}{6^3}+\ldots+\frac{3^{10}-2^{10}}{3^{10}.2^{10}}$ **is :** [4 marks]

(A) $\frac{511}{2^{10}}$

(B) $1+\frac{2^9-3^{10}}{6^{10}}$

(C) $\frac{(255)\cdot 3^{10}+2^9}{6^{10}}$

(D) $\frac{(511)\cdot 3^{10}+2^9}{6^{10}}$

Correct Answer: (D) $\frac{(511)\cdot 3^{10}+2^9}{6^{10}}$

Solution:

Concept:

- The numerator pattern is 3^n-2^n: for $n=1,2,3$ it gives 1, 5, and 19.
- Splitting each term yields $(3^n-2^n)/6^n=2^{-n}-3^{-n}$. A finite geometric sum is $\sum_{n=1}^{N} r^n = r(1-r^N)/(1-r)$.

Step 1: Separate the two finite sums The final term has index 10, so there are ten terms, not eleven. Write

$$S=\sum_{n=1}^{10}\left(\frac{1}{2^n}-\frac{1}{3^n}\right).$$

The first series has ratio $1/2$ and first term $1/2$; the second has ratio $1/3$ and first term $1/3$. Keeping the same upper index in both is essential.

Step 2: Evaluate and match the printed expression The two sums are $1-2^{-10}$ and $\frac{1}{2}(1-3^{-10})$. Therefore

$$S=\frac{1}{2}-\frac{1}{2^{10}}+\frac{1}{2\cdot 3^{10}}=\frac{511}{2^{10}}+\frac{1}{2\cdot 3^{10}}.$$

With denominator $6^{10}=2^{10}3^{10}$, this is

$$S=\frac{511\cdot 3^{10}+2^9}{6^{10}}.$$

The first option omits the positive tail correction. The expression with coefficient 255 has the wrong binary-series subtotal, and the option beginning with 1 has the wrong constant contribution.

Step 3: Conclusion $\boxed{S=\frac{511\cdot 3^{10}+2^9}{6^{10}}}$. Hence, the correct option is (D).

Quick Tip to Solve: When a numerator is a difference of powers and the denominator is their product, split each term before summing.

7. $\lim_{x\to 0} \frac{1}{x^2}\left(e^{x^2} - \cos\frac{x}{2}\right)$ **is equal to :** [4 marks]

(A) $\frac{3}{2}$

(B) $\frac{5}{8}$

(C) $\frac{9}{8}$

(D) $\frac{9}{4}$

Correct Answer: (C) $\frac{9}{8}$

Solution:

Concept:

- The numerator vanishes at zero, so separate it into two differences whose standard limits are known. In particular, $\lim_{u\to 0}(e^u - 1)/u = 1$.
- The identity $1 - \cos t = 2\sin^2(t/2)$, together with $\lim_{t\to 0} \sin t/t = 1$, evaluates the trigonometric contribution without an approximation.

Step 1: Separate the exponential and cosine terms Add and subtract 1 in the numerator. For every nonzero x, the expression becomes

$$\frac{e^{x^2} - \cos(x/2)}{x^2} = \frac{e^{x^2} - 1}{x^2} + \frac{1 - \cos(x/2)}{x^2}.$$

Both terms have finite limits, so their limits can be added. The substitution $u = x^2$ sends u to zero through positive values; the standard exponential limit remains applicable and gives 1 for the first term.

Step 2: Evaluate the trigonometric contribution Apply the half-angle identity with $t = x/2$:

$$\frac{1 - \cos(x/2)}{x^2} = \frac{2\sin^2(x/4)}{x^2} = \frac{1}{8}\left(\frac{\sin(x/4)}{x/4}\right)^2.$$

The bracket tends to 1 from either side, so this term tends to $1/8$. Consequently the required sum is $1 + 1/8 = 9/8$. Option (B) omits part of the exponential contribution, while (A) and (D) have the wrong coefficient for the cosine term; none equals this exact limit.

Step 3: Conclusion The limit is $\boxed{9/8}$. Hence, the correct option is (C).

Quick Tip to Solve: For a difference of two functions approaching 1, add and subtract 1 first; remember that replacing x by x/2 scales a quadratic cosine term by 1/4.

8. If $\int \sqrt{\frac{\cos(x-\theta)}{\cos(x+\theta)}}dx = \alpha \sin^{-1}\left(\frac{\sin x}{\cos\theta}\right) + \beta \log_e \left|\cos x + \sqrt{\cos^2 x - \sin^2\theta}\right| + C$,
where C is a constant of integration and $\frac{\pi}{6} < \theta < \frac{\pi}{4}$**, then** $\alpha \sin\theta + \beta\cos\theta$ **is equal to :** [4 marks]

(A) 0

(B) 1

(C) $\cos 2\theta$

(D) $\sin 2\theta$

Correct Answer: (A) 0

Solution:

Concept:

- Use $\cos(x-\theta) = \cos x\cos\theta + \sin x\sin\theta$ and $\cos(x-\theta)\cos(x+\theta) = \cos^2 x - \sin^2\theta$.
- An indefinite integral is compared on a common real interval where its displayed branches are differentiable. Near $x = 0$, both cosine factors and the square root are positive because $\pi/6 < \theta < \pi/4$.

Step 1: Rewrite the square-root quotient Put $R = \sqrt{\cos^2 x - \sin^2\theta}$. On the interval around zero described above, multiplication of numerator and denominator inside the root gives

$$\sqrt{\frac{\cos(x-\theta)}{\cos(x+\theta)}} = \frac{\cos\theta\cos x + \sin\theta\sin x}{R}.$$

Thus the integral separates into a cosine-numerator integral and a sine-numerator integral. The positivity condition justifies the sign when replacing a square root of a square by its numerator.

Step 2: Integrate and identify both coefficients For the first term set $u = \sin x$, so $R = \sqrt{\cos^2\theta - u^2}$. For the second set $v = \cos x$, with $dv = -\sin x\,dx$. The standard antiderivatives give

$$\int \frac{\cos x}{R}\,dx = \sin^{-1}\left(\frac{\sin x}{\cos\theta}\right),$$
$$\int \frac{\sin x}{R}\,dx = -\log\left|\cos x + R\right|.$$

Here $\cos\theta > 0$, so no absolute-value adjustment of that constant is needed. Comparing with the stated form yields $\alpha = \cos\theta$ and $\beta = -\sin\theta$. Hence their requested weighted sum cancels exactly. It is not 1; also $\cos 2\theta$ and $\sin 2\theta$ are positive in the specified open interval, so options (B), (C), and (D) cannot give this zero.

Step 3: Conclusion $\alpha\sin\theta + \beta\cos\theta = \cos\theta\sin\theta - \sin\theta\cos\theta = \boxed{0}$. Hence, the correct option is (A).

Quick Tip to Solve: After rationalising this cosine quotient, split its numerator into cosine and sine terms; the logarithmic coefficient carries a minus sign from differentiating cosine.

9. If $\mathrm{I} = \int_0^1 \tan^{-1}(\sqrt{x}+1)\mathrm{d}x$, $\mathrm{J} = \int_0^1 \frac{\sqrt{x}\,\mathrm{d}x}{x+2\sqrt{x}+2}$, **then the value of** $2\mathrm{I}+\mathrm{J}$ **is equal to :** [4 marks]

(A) $2\tan^{-1}\left(\frac{1}{2}\right)$

(B) $2\tan^{-1}(2) - \frac{\pi}{2}$

(C) $2\tan^{-1}(2)$

(D) $\tan^{-1}(2)$

Correct Answer: (C) $2\tan^{-1}(2)$

Solution:

Concept:

- Integration by parts gives $\int u\,dv = uv - \int v\,du$; choose the inverse tangent as u because its derivative produces the rational denominator appearing in J.
- The chain rule gives $d[\tan^{-1}(1+\sqrt{x})]/dx = 1/[2\sqrt{x}\{1+(1+\sqrt{x})^2\}]$ for $x > 0$. The resulting integrals are convergent at zero.

Step 1: Integrate I by parts Choose $u = \tan^{-1}(1+\sqrt{x})$ and $dv = dx$, so $v = x$. Then

$$I = \left[x\tan^{-1}(1+\sqrt{x})\right]_0^1 - \frac{1}{2}\int_0^1 \frac{x}{\sqrt{x}\{1+(1+\sqrt{x})^2\}}\,dx.$$

Although the derivative of u is unbounded at zero, one may perform this calculation on $[\varepsilon, 1]$ and let ε decrease to zero. The boundary product at zero tends to zero because the inverse tangent is bounded.

Step 2: Recognise J and cancel the remainder Simplify $x/\sqrt{x} = \sqrt{x}$ for positive x and expand the denominator:

$$1+(1+\sqrt{x})^2 = x + 2\sqrt{x} + 2.$$

The remaining definite integral is precisely J, with the same bounds and numerator. Its integrand tends to zero at the lower endpoint, so the limiting integration-by-parts calculation is legitimate. Therefore

$$I = \tan^{-1}(2) - \frac{1}{2}J, \qquad 2I + J = 2\tan^{-1}(2).$$

Option (A) uses the reciprocal argument and has a different value. Option (B) subtracts an extra $\pi/2$ that no boundary term supplies. Option (D) omits the factor 2 in the requested combination.

Step 3: Conclusion The required value is $\boxed{2\tan^{-1}(2)}$. Hence, the correct option is (C).

Quick Tip to Solve: When two integrals share a denominator generated by differentiating an inverse trigonometric function, integrate that function by parts before trying to evaluate either integral separately.

10. Let $y = y(x)$ be the solution of the differential equation $x\frac{dy}{dx} = (2x+3)e^x + xy, x > 0$.
If $y(e) = (2e+3)e^e$, then $\frac{d^2y}{dx^2} - \frac{dy}{dx}$ at $x = 1$ is equal to : [4 marks]

(A) $3e$

(B) e

(C) 0

(D) $2e$

Correct Answer: (D) $2e$

Solution:

Concept:

- Divide a differential equation only by a nonzero quantity. Since $x > 0$, the given equation is equivalent to $y' - y = e^x(2 + 3/x)$.
- To obtain a requested combination of derivatives, differentiate the corresponding first-derivative identity directly. This can avoid finding the integration constant or the entire solution.

Step 1: Isolate the useful derivative combination Dividing the given equation by x yields

$$y' = \left(2 + \frac{3}{x}\right)e^x + y, \qquad y' - y = \left(2 + \frac{3}{x}\right)e^x.$$

The right-hand side is differentiable throughout $x > 0$, so the solution is twice differentiable there. In particular it is legitimate to differentiate at $x = 1$. The initial value at $x = e$ selects a unique solution, but the combination requested below is already fixed for every solution of this equation.

Step 2: Differentiate and substitute x equal to 1 Use the product rule and $d(3/x)/dx = -3/x^2$:

$$\begin{aligned} y'' - y' &= e^x\left(2 + \frac{3}{x}\right) + e^x\left(-\frac{3}{x^2}\right) \\ &= e^x\left(2 + \frac{3}{x} - \frac{3}{x^2}\right). \end{aligned}$$

At x equal to 1 the two terms involving 3 cancel, leaving $e(2 + 3 - 3) = 2e$. There is no need to substitute the initial condition at a different point. Option (A) retains an uncancelled 3, option (B) loses the coefficient 2, and option (C) incorrectly discards the derivative of the exponential term. Only (D) agrees with the differentiated identity.

Step 3: Conclusion At $x = 1$, $\frac{d^2y}{dx^2} - \frac{dy}{dx} = \boxed{2e}$. Hence, the correct option is (D).

Quick Tip to Solve: Before solving a differential equation fully, check whether the required expression follows simply by differentiating the given equation once.

11. Let f be a non-zero polynomial function such that $f(3x) = f'(x)f''(x)$.
Then the value of $f(6)$ is : [4 marks]

(A) 648

(B) 324

(C) 136

(D) 108

Correct Answer: (B) 324

Solution:

Concept:

- For a nonzero polynomial of degree n at least 2, the product of its first two derivatives has degree $(n-1)+(n-2) = 2n-3$. Equal polynomials have equal degrees and corresponding coefficients.
- A nonzero constant or linear polynomial cannot satisfy this identity because its second derivative is zero while $f(3x)$ is not the zero polynomial.

Step 1: Determine the degree and leading coefficient Let the degree be n. The constant and linear cases are excluded by the second derivative, so comparison of degrees gives

$$n = 2n - 3, \qquad n = 3.$$

Write $f(x) = ax^3 + bx^2 + cx + d$, with $a \neq 0$. The coefficient of x^3 in $f(3x)$ is $27a$; that in $f'(x)f''(x)$ is $(3a)(6a) = 18a^2$. Therefore $27a = 18a^2$, giving $a = 3/2$, since division by a is allowed.

Step 2: Compare the remaining coefficients Expand the derivative product in descending powers:

$$\begin{aligned} f'(x)f''(x) &= (3ax^2 + 2bx + c)(6ax + 2b) \\ &= 18a^2x^3 + 18abx^2 + (4b^2 + 6ac)x + 2bc. \end{aligned}$$

Meanwhile $f(3x) = 27ax^3 + 9bx^2 + 3cx + d$. With $a = 3/2$, the quadratic comparison gives $9b = 27b$, so $b = 0$. The linear comparison becomes $3c = 9c$, so $c = 0$; finally $d = 2bc = 0$. Thus $f(x) = 3x^3/2$, which indeed satisfies the full identity. Evaluate $f(6) = (3/2)216 = 324$. The other offered numbers, 648, 136 and 108, do not equal this value of the uniquely determined nonzero polynomial.

Step 3: Conclusion $f(6) = \boxed{324}$. Hence, the correct option is (B).

Quick Tip to Solve: Use degree comparison before expanding a polynomial functional equation; after fixing its leading coefficient, compare every lower coefficient rather than assuming a pure monomial.

12. A rod AB of length 4 units rests against a vertical wall with A on the horizontal floor. P is a point on AB such that $\mathrm{AP} : \mathrm{PB} = 2 : 1$. If the rod slides down along the wall in a vertical plane, then the point $\mathrm{P}(x, y)$ moves on the curve : [4 marks]

(A) $36x^2 + 9y^2 = 64$

(B) $36x^2 + 9y^2 = 16$

(C) $9x^2 + 36y^2 = 64$

(D) $9x^2 + 36y^2 = 16$

Correct Answer: (A) $36x^2 + 9y^2 = 64$

Solution:

Concept:

- Place the wall and floor on perpendicular coordinate axes, with their intersection as origin. If the rod endpoints are $A = (a, 0)$ and $B = (0, b)$, its fixed length gives $a^2 + b^2 = 16$.
- The internal section formula weights each endpoint by the opposite segment. For $AP : PB = 2 : 1$, $P = (A + 2B)/3$, not $(2A + B)/3$.

Step 1: Express the point coordinates using the endpoints Let a and b denote the horizontal and vertical intercepts of the rod. Pythagoras applied to the right triangle formed by the wall, floor and rod gives

$$a^2 + b^2 = AB^2 = 4^2 = 16.$$

Because P is two-thirds of the way from A towards B, its coordinates are

$$P = A + \frac{2}{3}(B - A) = \left(\frac{a}{3}, \frac{2b}{3}\right).$$

Consequently $a = 3x$ and $b = 3y/2$. The horizontal coordinate is closer to the wall than A's coordinate, as expected from the ratio.

Step 2: Eliminate the moving endpoint parameters Insert these two expressions into the fixed-length condition:

$$(3x)^2 + \left(\frac{3y}{2}\right)^2 = 16.$$

Multiply every term by 4 to remove the denominator:

$$36x^2 + 9y^2 = 64.$$

This is an ellipse, with horizontal semiaxis $4/3$ and vertical semiaxis $8/3$. In the physical sliding arrangement P traverses the relevant first-quadrant arc. Option (B) has a smaller right-hand side and hence the wrong scale. Options (C) and (D) interchange the relative horizontal and vertical semiaxes, corresponding to an incorrect application of the division ratio; (D) also has the wrong scale.

Step 3: Conclusion The point lies on $\boxed{36x^2 + 9y^2 = 64}$. Hence, the correct option is (A).

Quick Tip to Solve: For a sliding-rod locus, write the length condition for the intercepts first, then use the section formula; checking the limiting intercepts catches a reversed ratio.

13. Let $A(1,2)$ and $B(3,6)$ are two points on a circle of radius R, whose one of the diameters is along the line $2x - y + 4 = 0$. Then R^2 is equal to : [4 marks]

(A) 17

(B) $\frac{37}{3}$

(C) $\frac{31}{5}$

(D) $\frac{41}{5}$

Correct Answer: (D) $\frac{41}{5}$

Solution:

Concept:

- The centre of a circle lies on every diameter. Hence the given diameter line supplies one linear equation for its centre (h, k).
- Two points on the same circle are equidistant from the centre: $CA^2 = CB^2 = R^2$. Subtracting squared distances eliminates the quadratic terms.

Step 1: Place the centre on the diameter line Let the centre be $C(h, k)$. Since a diameter passes through the centre, substituting its coordinates in the stated line gives

$$2h - k + 4 = 0, \qquad k = 2h + 4.$$

The line is not merely a tangent or a chord; its designation as a diameter is what permits this substitution.

Step 2: Use equal distances to the two given points The points $A(1,2)$ and $B(3,6)$ both lie on the circle, so

$$(h-1)^2 + (k-2)^2 = (h-3)^2 + (k-6)^2.$$

Expanding and cancelling $h^2 + k^2$ gives

$$4h + 8k = 40, \qquad h + 2k = 10.$$

Substitute $k = 2h + 4$ to obtain

$$5h + 8 = 10, \qquad h = \frac{2}{5}, \quad k = \frac{24}{5}.$$

Step 3: Calculate the squared radius Use either endpoint; using A gives

$$R^2 = \left(\frac{2}{5} - 1\right)^2 + \left(\frac{24}{5} - 2\right)^2 = \frac{9}{25} + \frac{196}{25} = \frac{41}{5}.$$

As a check, the differences from B are $-13/5$ and $-6/5$, whose squared sum is again $205/25$. Thus 17, $37/3$, and $31/5$ do not equal the required squared distance.

Step 4: Conclusion The circle has $R^2 = \frac{41}{5}$. Hence, the correct option is (D).

Quick Tip to Solve: Find the centre by intersecting the diameter line with the perpendicular bisector of the chord; subtract squared distances before expanding everything.

14. A line perpendicular to the line $4x = 3y$ is a tangent to the parabola $y^2 = 3x + 1$ at a point P on it. If S is the focus of the parabola, then the equation of the line SP is : [4 marks]

(A) $24x + 5y = 10$

(B) $24x - y = 26$

(C) $24x + 7y = 10$

(D) $8x + y = 6$

Correct Answer: (C) $24x + 7y = 10$

Solution:

Concept:

- Perpendicular nonvertical lines have slopes whose product is -1. Differentiating the parabola gives the tangent slope at its point of contact.
- For $y^2 = 4a(x - h)$, the vertex is $(h, 0)$ and the focus is $(h + a, 0)$. Retain the horizontal translation when finding the focus.

Step 1: Find the required tangent slope The given line is $y = 4x/3$, so its slope is $4/3$. The tangent perpendicular to it therefore has slope $-3/4$. Differentiate the parabola implicitly:

$$2y\frac{dy}{dx} = 3, \qquad \frac{dy}{dx} = \frac{3}{2y}.$$

At the point of tangency P, equate this derivative to the required slope.

Step 2: Locate the point of contact and focus The slope equation gives

$$\frac{3}{2y_P} = -\frac{3}{4}, \qquad y_P = -2.$$

Substitution in $y^2 = 3x + 1$ gives $4 = 3x_P + 1$, hence $P = (1, -2)$. Rewrite the parabola as

$$y^2 = 3\left(x + \frac{1}{3}\right).$$

Thus $h = -1/3$, $a = 3/4$, and

$$S = \left(-\frac{1}{3} + \frac{3}{4}, 0\right) = \left(\frac{5}{12}, 0\right).$$

Step 3: Form the line through the focus and contact point The slope of SP is

$$m_{SP} = \frac{-2 - 0}{1 - 5/12} = -\frac{24}{7}.$$

Its equation is therefore

$$y = -\frac{24}{7}\left(x - \frac{5}{12}\right), \qquad 24x + 7y = 10.$$

Both P and S satisfy this equation. Options (A) and (D) do not pass through P; option (B) passes through P but fails at S, since $24(5/12) = 10$, not 26.

Step 4: Conclusion The equation of SP is $24x + 7y = 10$. Hence, the correct option is (C).

Quick Tip to Solve: After finding a tangent point by differentiation, translate the parabola to standard form before locating its focus; the vertex here is not the origin.

15. If a line $px + qy = 12$ is a tangent to the ellipse $4x^2 + 9y^2 = 16$, then pq can NOT be equal to : [4 marks]

(A) 29

(B) 26

(C) 23

(D) 21

Correct Answer: (A) 29

Solution:

Concept:

- The ellipse $x^2/a^2 + y^2/b^2 = 1$ admits the tangent $px + qy = c$ exactly when $c^2 = a^2p^2 + b^2q^2$. This follows by maximizing the linear expression on the ellipse.
- For real numbers, $u^2 + v^2 \geq 2|uv|$. Applying this inequality to the tangent coefficients bounds their product.

Step 1: Write the ellipse and tangency condition Divide the ellipse equation by 16 to obtain

$$\frac{x^2}{4} + \frac{y^2}{16/9} = 1.$$

The squared semiaxes are consequently $a^2 = 4$ and $b^2 = 16/9$. For the line $px + qy = 12$, the tangency condition becomes

$$4p^2 + \frac{16}{9}q^2 = 144, \qquad p^2 + \frac{4}{9}q^2 = 36.$$

A line satisfying this condition touches rather than cuts the ellipse.

Step 2: Bound the coefficient product Apply the sum-of-squares inequality to p and $2q/3$:

$$36 = p^2 + \left(\frac{2q}{3}\right)^2 \geq 2\left|p\frac{2q}{3}\right| = \frac{4}{3}|pq|.$$

Hence

$$|pq| \leq 27.$$

Equality is possible when $|p| = 2|q|/3$, so this bound is sharp. In particular the positive product 29 exceeds the maximum and cannot occur.

Step 3: Check that the remaining offered products can occur It remains to check that being below 27 really permits the other choices. Put $p = 6\cos t$ and $q = 9\sin t$; then the tangent condition holds identically and

$$pq = 54\sin t\cos t = 27\sin 2t.$$

For any of 26, 23, or 21, its ratio to 27 lies strictly between zero and one, so a real angle t exists. Each is therefore an attainable tangent-coefficient product, whereas 29 is not.

Step 4: Conclusion The value $pq = 29$ is impossible. Hence, the correct option is (A).

Quick Tip to Solve: Convert a tangent condition into a fixed sum of two squares; its product bound often settles a coefficient-product MCQ without solving for the coefficients separately.

16. If the angle between the line $\frac{x+1}{1} = \frac{y-1}{2} = \frac{z+2}{-1}$ and the plane $\mathrm{P} : 2x - y - \lambda z + 4 = 0$, $\lambda > 0$, is $\sin^{-1}\left(\frac{1}{9\sqrt{6}}\right)$, then the distance of the point $(-1, 1, -2)$ from the plane P is : [4 marks]

(A) $\frac{2}{3}$

(B) 1

(C) $\frac{3}{2}$

(D) $\frac{2}{9}$

Correct Answer: (A) $\frac{2}{3}$

Solution:

Concept:

- If a line has direction vector $\mathbf{d}$ and a plane has normal vector $\mathbf{n}$, the acute line-plane angle θ satisfies $\sin\theta = |\mathbf{d}\cdot\mathbf{n}|/(|\mathbf{d}||\mathbf{n}|)$.
- The perpendicular distance from (x_0, y_0, z_0) to $Ax + By + Cz + D = 0$ is $|Ax_0 + By_0 + Cz_0 + D|/\sqrt{A^2 + B^2 + C^2}$.

Step 1: Extract the vectors and determine the parameter The symmetric line has direction vector $\mathbf{d} = (1, 2, -1)$. The plane normal is $\mathbf{n} = (2, -1, -\lambda)$. Therefore

$$\mathbf{d}\cdot\mathbf{n} = 2 - 2 + \lambda = \lambda, \quad |\mathbf{d}| = \sqrt{6}, \quad |\mathbf{n}| = \sqrt{5 + \lambda^2}.$$

Since $\lambda > 0$, its absolute value can be removed in the angle formula.

Step 2: Solve the angle equation The specified angle has sine $1/(9\sqrt{6})$, so

$$\frac{\lambda}{\sqrt{6}\sqrt{5 + \lambda^2}} = \frac{1}{9\sqrt{6}}.$$

Cancel $\sqrt{6}$ and square the remaining positive quantities:

$$81\lambda^2 = 5 + \lambda^2, \qquad 80\lambda^2 = 5, \qquad \lambda = \frac{1}{4}.$$

The negative root is excluded by the explicit condition. Also $\sqrt{5 + \lambda^2} = \sqrt{81/16} = 9/4$.

Step 3: Apply the point-to-plane distance formula For the point $(-1, 1, -2)$, evaluate the plane expression before taking its absolute value:

$$2(-1) - 1 - \frac{1}{4}(-2) + 4 = \frac{3}{2}.$$

Hence the perpendicular distance is

$$d = \frac{3/2}{9/4} = \frac{2}{3}.$$

This is a distance, so the sign is positive. The other listed values 1, $3/2$, and $2/9$ do not include the required normalization by the plane-normal length correctly.

Step 4: Conclusion The perpendicular distance is $\frac{2}{3}$ unit. Hence, the correct option is (A).

Quick Tip to Solve: Use sine for the angle with a plane, cosine for the angle with its normal; normalize the plane expression only after evaluating its signed numerator.

17. Let the distinct numbers $\mathrm{a}, \mathrm{b}, \mathrm{c}$ be the $\mathrm{p}^{\text{th}}, \mathrm{q}^{\text{th}}$ and r^{th} terms of a geometric progression of positive terms. Then the angle between the vectors $\vec{\mathrm{u}} = \left(\log_{\mathrm{e}} \mathrm{a}^2\right)\hat{i} + \left(\log_{\mathrm{e}} \mathrm{b}^2\right)\hat{j} + \left(\log_{\mathrm{e}} \mathrm{c}^2\right)\hat{k}$ and $\vec{\mathrm{v}} = (\mathrm{q}-\mathrm{r})\hat{i} + (\mathrm{r}-\mathrm{p})\hat{j} + (\mathrm{p}-\mathrm{q})\hat{k}$ is : [4 marks]

(A) 0

(B) $\frac{\pi}{4}$

(C) $\frac{\pi}{3}$

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

Correct Answer: (D) $\frac{\pi}{2}$

Solution:

Concept:

- If a positive geometric progression has first term $A > 0$ and common ratio $r > 0$, its nth term is Ar^{n-1}. Taking logarithms makes the index dependence linear.
- Two nonzero vectors are perpendicular exactly when their scalar product is zero. Their angle then equals $\pi/2$.

Step 1: Express the three logarithms in terms of the indices Let the first term of the progression be $A > 0$ and let its common ratio be $t > 0$, using t to keep the ratio distinct from the index r. Then

$$a = At^{p-1}, \qquad b = At^{q-1}, \qquad c = At^{r-1}.$$

Put $L = \log_e A$ and $M = \log_e t$. Taking logarithms of the squared positive terms gives

$$\log_e a^2 = 2[L + (p-1)M],$$

with analogous expressions replacing p by q and r. Thus each component of the first vector is an affine function of its corresponding index.

Step 2: Calculate the scalar product and cancel the coefficients Using the three components of $\mathbf{v}$,

$$\begin{aligned}\frac{\mathbf{u}\cdot\mathbf{v}}{2} &= L[(q-r)+(r-p)+(p-q)] \\ &\quad + M[(p-1)(q-r)+(q-1)(r-p) \\ &\qquad + (r-1)(p-q)].\end{aligned}$$

The coefficient of L is zero. In the coefficient of M, the constant-index terms sum to zero, and the remaining expression is

$$p(q-r) + q(r-p) + r(p-q) = 0.$$

Every product cancels with its negative, hence the scalar product is zero.

Step 3: Check that the angle is defined The terms a, b, c are distinct, so their indices are distinct and the vector $(q-r, r-p, p-q)$ is nonzero. The logarithmic vector cannot be zero either, since that would require $a = b = c = 1$. Thus both vector lengths are positive and

$$\cos\theta = \frac{\mathbf{u}\cdot\mathbf{v}}{|\mathbf{u}||\mathbf{v}|} = 0.$$

The angles 0, $\pi/4$, and $\pi/3$ have nonzero cosine and are excluded.

Step 4: Conclusion The angle between the vectors is $\pi/2$. Hence, the correct option is (D).

Quick Tip to Solve: For indexed GP terms, take logarithms first: the resulting affine functions of the indices cancel against cyclic differences such as $(q-r, r-p, p-q)$.

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18. For $0 < x < \pi$, the sum of the solutions of the equation $4^{\left(\frac{1}{2}\sin x + \frac{1}{4}\sin^2 x + \frac{1}{8}\sin^3 x + \cdots\right)} = 2^{\frac{2}{3}}$ is : [4 marks]

(A) $\frac{\pi}{3}$

(B) $\frac{2\pi}{3}$

(C) π

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

Correct Answer: (C) π

Solution:

Concept:

- The infinite geometric series $a + ar + ar^2 + \cdots$ has sum $a/(1-r)$ when $|r| < 1$. Here the common ratio involves $\sin x$.
- Equal positive powers of the same base have equal exponents. Once $\sin x$ is fixed, both solutions in $(0, \pi)$ must be counted.

Step 1: Sum the exponent as a convergent geometric series Let $s = \sin x$. Since $0 < x < \pi$, we have $0 < s \leq 1$, and so $0 < s/2 \leq 1/2 < 1$. Thus the exponent converges throughout the stated interval. Its first term and ratio are both $s/2$, giving

$$S = \frac{s}{2} + \frac{s^2}{4} + \frac{s^3}{8} + \cdots = \frac{s/2}{1 - s/2} = \frac{s}{2 - s}.$$

The denominator is positive, so no excluded zero denominator is introduced.

Step 2: Compare powers after changing to base two The equation is $4^S = 2^{2/3}$. Since $4^S = 2^{2S}$ and the exponential function with base 2 is one-to-one,

$$2S = \frac{2}{3}, \qquad S = \frac{1}{3}.$$

Substitute the geometric-series sum:

$$\frac{s}{2 - s} = \frac{1}{3}, \qquad 3s = 2 - s, \qquad s = \frac{1}{2}.$$

This value respects the original convergence and interval restrictions.

Step 3: Find every root in the specified interval and add them The solutions of $\sin x = 1/2$ in $(0, \pi)$ lie in the first and second quadrants:

$$x_1 = \frac{\pi}{6}, \qquad x_2 = \frac{5\pi}{6}.$$

Therefore

$$x_1 + x_2 = \pi.$$

There are no further roots in this open interval. Options $\pi/3$, $2\pi/3$, and $\pi/2$ are not the sum; in particular the symmetry about $\pi/2$ makes the sum of the two distinct roots exactly π.

Step 4: Conclusion The sum of all the solutions is π. Hence, the correct option is (C).

Quick Tip to Solve: Check the geometric-series ratio before summing, then use the pair α and $\pi - \alpha$ for a positive sine value on $(0, \pi)$.

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19. The domain of the function

$f(x) = \tan^{-1}\left(\sqrt{x^2 + x - 2}\right) + \sec^{-1}\left(x^2 - 5x + 3\right)$ **is :** [4 marks]

(A) $(-\infty, -2] \cup [1, \infty)$

(B) $[1, 4] \cup \left[\frac{5+\sqrt{17}}{2}, \infty\right)$

(C) $\left(-\infty, \frac{5-\sqrt{17}}{2}\right] \cup [1, 4] \cup \left[\frac{5+\sqrt{17}}{2}, \infty\right)$

(D) $(-\infty, -2] \cup [1, 4] \cup \left[\frac{5+\sqrt{17}}{2}, \infty\right)$

Correct Answer: (D) $(-\infty, -2] \cup [1, 4] \cup \left[\frac{5+\sqrt{17}}{2}, \infty\right)$

Solution:

Concept:

- The square root is real only when its radicand is nonnegative. The inverse tangent accepts every real argument, so it imposes no additional restriction.
- The real inverse secant is defined for arguments in $(-\infty, -1] \cup [1, \infty)$. Both summands must be defined at the same input, so their domains are intersected.

Step 1: Impose the square-root condition Factor the radicand and use the sign of an upward-opening quadratic:

$$x^2 + x - 2 = (x + 2)(x - 1) \geq 0.$$

Thus the first summand requires $x \leq -2$ or $x \geq 1$. Equality is allowed because the square root can be zero and $\tan^{-1} 0$ exists.

Step 2: Impose the inverse-secant condition Put $g(x) = x^2 - 5x + 3$. Its admissible values satisfy either $g(x) \geq 1$ or $g(x) \leq -1$. These give

$$x^2 - 5x + 2 \geq 0 \quad \Longrightarrow \quad x \leq \frac{5 - \sqrt{17}}{2} \text{ or } x \geq \frac{5 + \sqrt{17}}{2},$$

$$x^2 - 5x + 4 \leq 0 \quad \Longrightarrow \quad 1 \leq x \leq 4.$$

The inverse-secant domain is the union of these three intervals.

Step 3: Intersect the conditions and compare the options Intersecting with $(-\infty, -2] \cup [1, \infty)$ cuts the left interval down to $(-\infty, -2]$, while retaining the middle and right intervals. Option (A) wrongly

includes the forbidden gap above 4. Option (B) omits all admissible negative inputs. Option (C) keeps inputs between -2 and $(5-\sqrt{17})/2$ where the radicand is negative.

Step 4: Conclusion The domain is $\boxed{(-\infty,-2]\cup[1,4]\cup[(5+\sqrt{17})/2,\infty)}$. Hence, the correct option is (D).

Quick Tip to Solve: For a sum of inverse functions, find each real domain separately and intersect them; the two inequalities for an inverse secant are combined by a union.

20. Which of the following is equivalent to $p \leftrightarrow q$? [4 marks]

(A) $(\sim p \wedge \sim q) \vee (p \vee q)$

(B) $(p \wedge q) \vee (\sim p \wedge \sim q)$

(C) $(p \vee q) \wedge (\sim p \vee \sim q)$

(D) $(p \wedge q) \vee (p \vee q)$

Correct Answer: (B) $(p \wedge q) \vee (\sim p \wedge \sim q)$

Solution:

Concept:

- The biconditional $p \leftrightarrow q$ means that p and q have the same truth value: either both are true or both are false.
- Conjunction $\wedge$ requires both statements to be true, disjunction $\vee$ requires at least one, and negation $\sim$ reverses a truth value.

Step 1: Translate the two cases of agreement If both propositions are true, the conjunction $p \wedge q$ is true. If both are false, the conjunction $\sim p \wedge \sim q$ is true. Taking the disjunction of these two mutually exclusive cases gives

$$(p \wedge q) \vee (\sim p \wedge \sim q).$$

This statement is false in both mixed cases, since neither conjunction can then have two true members.

Step 2: Check the truth values explicitly For the ordered pairs $(p,q) = (T,T),(T,F),(F,T),(F,F)$, the biconditional has truth values T,F,F,T. The expression in option (B) has exactly this sequence: its first conjunction selects (T,T), and its second selects (F,F). This checks both directions of the equivalence, rather than only checking the case when both statements are true.

Step 3: Exclude the remaining expressions Option (A) is always true: if both statements are false its first conjunction is true, and otherwise its second disjunction is true. It therefore fails in either mixed case. Option (C) requires at least one true statement and at least one false statement, so it is the exclusive-or and has the opposite truth values. By absorption, option (D) simplifies to $p \vee q$; it is true in mixed cases and false when both are false. None of these agrees with the biconditional.

Step 4: Conclusion $\boxed{p \leftrightarrow q \equiv (p \wedge q) \vee (\sim p \wedge \sim q)}$. Hence, the correct option is (B).

Quick Tip to Solve: Read a biconditional as agreement of truth values: combine the both-true conjunction with the both-false conjunction using a disjunction.

Mathematics – Section B: Numerical Value Questions (20 marks)

Attempt any 5 of the 10 questions in this section.

21. Three fair dice are thrown. The number of ways to obtain a total of 11 is _____. [4 marks]

Solution:

Concept:

- A result of three dice is an ordered triple (a, b, c) with $1 \le a, b, c \le 6$. Permuting distinct face values gives a different outcome.
- The number of nonnegative integer solutions of $u + v + w = N$ is $\binom{N+2}{2}$. Inclusion-exclusion removes solutions exceeding a face limit.

Step 1: Shift to nonnegative variables We need $a + b + c = 11$. Set $u = a - 1$, $v = b - 1$, $w = c - 1$. The conditions become

$$u + v + w = 8, \qquad 0 \le u, v, w \le 5.$$

If the upper bounds are initially ignored, the stars-and-bars count is

$$\binom{8+3-1}{3-1} = \binom{10}{2} = 45.$$

Every counted solution identifies which value appears on each die, so this is an ordered-outcome count.

Step 2: Remove values outside a die face range For solutions with $u \ge 6$, replace u by $u' + 6$. Then $u' + v + w = 2$, giving $\binom{4}{2} = 6$ invalid solutions. There are also 6 with $v \ge 6$ and 6 with $w \ge 6$. Two variables cannot both exceed 5, because their sum would already be at least 12, greater than 8. Thus no overlap correction is needed:

$$45 - 3 \times 6 = 27.$$

Step 3: Check by unordered patterns and permutations The sorted face triples with sum 11 are $(1, 4, 6)$, $(1, 5, 5)$, $(2, 3, 6)$, $(2, 4, 5)$, $(3, 3, 5)$, and $(3, 4, 4)$. Their permutation counts are respectively $6, 3, 6, 6, 3, 3$, again totaling 27. Fairness makes these ordered outcomes equally likely, but the question asks for a count rather than a probability, so no division by 6^3 is made.

Step 4: Conclusion The number of ways to obtain the total 11 is $\boxed{27}$. This is a dimensionless count.

Quick Tip to Solve: Subtract one from each die value before using stars and bars, and remember to remove shifted values of 6 or more.

22. If a plane, that contains the line $\vec{r} = (1,-1,1)+\lambda(2,3,-6), \lambda \in \mathbf{R}$, passes through the point $(2,0,2)$ and is at a distance d from the origin, then the value of $73\,d^2$ is _____. [4 marks]

Solution:

Concept:

- A plane containing a line has a normal perpendicular to the direction of that line. A second direction within the plane is obtained by joining a point on the line to the given point.
- For a plane $Ax + By + Cz + D = 0$, its perpendicular distance from the origin is $d = |D|/\sqrt{A^2+B^2+C^2}$. Multiplying all coefficients by a common nonzero factor leaves the plane and its distance unchanged.

Step 1: Find two directions in the plane At $\lambda = 0$, the given line passes through $P = (1,-1,1)$, with direction $\mathbf{u} = (2,3,-6)$. The other given point is $Q = (2,0,2)$, so

$$\overrightarrow{PQ} = (1,1,1) = \mathbf{v}.$$

These direction vectors are not parallel, so they determine the plane uniquely. A normal vector is their cross product:

$$\mathbf{n} = \mathbf{u} \times \mathbf{v} = (9,-8,-1).$$

For a check, $\mathbf{n}\cdot\mathbf{u} = 18 - 24 + 6 = 0$ and $\mathbf{n}\cdot\mathbf{v} = 9 - 8 - 1 = 0$.

Step 2: Write and verify the plane equation Using point P, the point-normal equation gives

$$9(x-1) - 8(y+1) - (z-1) = 0,$$

which simplifies to $9x - 8y - z - 16 = 0$. Substitution of Q yields $18 - 0 - 2 - 16 = 0$. The entire specified line also lies in this plane, since its base point lies in it and its direction is perpendicular to the normal.

Step 3: Calculate the requested distance expression The squared distance from the origin is

$$d^2 = \frac{(-16)^2}{9^2 + (-8)^2 + (-1)^2} = \frac{256}{146} = \frac{128}{73}.$$

Therefore $73d^2 = 128$. Squaring removes the sign ambiguity of the plane coefficients; the distance itself is positive, as required.

Step 4: Conclusion $\boxed{73d^2 = 128}$. With coordinates in the stated coordinate units, $d = 16/\sqrt{146}$ units.

Quick Tip to Solve: Use the line direction and the vector from its base point to the extra point to form a normal; square the distance formula directly when the target contains d^2.

23. Number of real roots of the equation

$\sqrt{x+2}-\sqrt{x-2}=\sqrt{4x-1}$ **is _____.** [4 marks]

Solution:

Concept:

- Every square root denotes its principal, nonnegative real value. Before solving a radical equation, intersect the domains of all radicands.
- Bounds can rule out an equation without squaring. For a positive difference of square roots, multiplying by the conjugate often gives a useful upper bound.

Step 1: Find the admissible real inputs The radicands require $x+2\geq 0$, $x-2\geq 0$, and $4x-1\geq 0$. Their intersection is simply

$$x\geq 2.$$

Any value below 2 is excluded before algebraic manipulation. In particular, potential roots produced by later squaring would still have to satisfy this restriction.

Step 2: Bound the left-hand side using its conjugate For $x\geq 2$, the sum of the two roots is positive, so rationalization is valid:

$$\sqrt{x+2}-\sqrt{x-2}=\frac{4}{\sqrt{x+2}+\sqrt{x-2}}.$$

The denominator is at least $\sqrt{4}+\sqrt{0}=2$. Thus the left side is positive and no greater than 2. At $x=2$ it is exactly 2; when x increases above 2, the denominator increases and the left side becomes smaller.

Step 3: Compare with the right-hand side Throughout the same domain,

$$\sqrt{4x-1}\geq\sqrt{7}>2.$$

Consequently, the left side is at most 2 and the right side is strictly greater than 2, so equality is impossible. This also checks the endpoint $x=2$: the two sides there are 2 and $\sqrt{7}$, respectively. The disjoint bounds cover every admissible real input and avoid introducing extraneous candidates through squaring.

Step 4: Conclusion The equation has no real solution. The requested number of real roots is $\boxed{0}$, a dimensionless count.

Quick Tip to Solve: After finding the radical domain, compare the largest possible difference of roots with the smallest possible value on the other side before squaring.

24. Between 1 and 31, n numbers have been inserted in such a way that the resulting sequence is an A.P. If the ratio of $(n-1)^{th}$ and 7^{th} inserted numbers is $9:5$, then n is equal to _____. [4 marks]

Solution:

Concept:

- If n arithmetic means are inserted between two endpoints, the complete progression has $n+2$ terms and $n+1$ equal gaps.

- The kth inserted number is the $(k+1)$th term of the complete progression. If the first endpoint is a and common difference is d, that inserted number is $a+kd$.

Step 1: Express the common difference correctly The endpoints are 1 and 31, and n numbers lie strictly between them. Hence there are $n+1$ increments from the first endpoint to the last:

$$31 = 1 + (n+1)d, \qquad d = \frac{30}{n+1}.$$

The common difference is positive. This step distinguishes the number of inserted numbers from the number of gaps.

Step 2: Translate the ratio of inserted numbers The $(n-1)$th inserted number is $1+(n-1)d$, whereas the seventh inserted number is $1+7d$. The given ratio becomes

$$\frac{1+(n-1)d}{1+7d} = \frac{9}{5}.$$

Cross-multiplying gives $5+5(n-1)d = 9+63d$, or

$$(5n-68)d = 4.$$

Substitute $d = 30/(n+1)$, whose denominator is positive:

$$30(5n-68) = 4(n+1).$$

Thus $150n - 2040 = 4n + 4$, so $146n = 2044$ and $n = 14$.

Step 3: Check the progression and the requested positions For $n = 14$, the common difference is $30/15 = 2$. The inserted numbers are $3, 5, 7, \ldots, 29$, followed by the endpoint 31. The $(n-1)$th inserted number is the thirteenth, namely $1 + 13 \times 2 = 27$; the seventh is $1 + 7 \times 2 = 15$. Their ratio is $27 : 15 = 9 : 5$, exactly as required. The value 14 is an integer large enough for the seventh inserted number to exist.

Step 4: Conclusion The number of inserted arithmetic means is $\boxed{n = 14}$. It is a dimensionless count.

Quick Tip to Solve: Index inserted means from $a+d$, not from a: the seventh inserted mean is $a+7d$, while the endpoints are separated by $n+1$ gaps.

25. The sum of absolute maximum and absolute minimum values of the function $f(x) = |4x^2+3x-10| + x^2 - 2x + 5, x \in [-3, 1]$ is _____. [4 marks]

Solution:

Concept:

- Absolute extrema on a closed interval are found by comparing endpoints, points where a formula changes, and stationary points inside each smooth piece.
- For a quadratic inside an absolute value, determine its sign first. On an interval where it is negative, reverse the sign of every term inside the modulus.

Step 1: Locate the change in the modulus Factor the expression inside the absolute value:

$$4x^2 + 3x - 10 = (x + 2)(4x - 5).$$

Its zeros are -2 and $5/4$. Only -2 lies in the prescribed interval. The product is nonnegative on $[-3, -2]$ and nonpositive on $[-2, 1]$. Thus the function must be analysed using two different quadratics; treating the modulus as a single signed expression throughout would lose an endpoint candidate.

Step 2: Find all candidates and compare their values On the first interval,

$$f(x) = 5x^2 + x - 5, \qquad f'(x) = 10x + 1 < 0.$$

It decreases from $f(-3) = 37$ to $f(-2) = 13$. On the second interval,

$$f(x) = -3x^2 - 5x + 15, \qquad f'(x) = -6x - 5.$$

The stationary point is $x = -5/6$, which belongs to this interval. Since this quadratic is concave down, its stationary value is a maximum:

$$f(-5/6) = \frac{205}{12}, \qquad f(1) = 7.$$

Comparing $37, 13, 205/12, 7$ gives the global maximum 37 and global minimum 7. The local maximum on the second piece is smaller than the left-endpoint value.

Step 3: Conclusion The required sum is $37 + 7 = \boxed{44}$. This is a dimensionless numerical value.

Quick Tip to Solve: For a modulus quadratic, split at its zeros before differentiating, and retain every original endpoint in the comparison.

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26. If the area (in sq. units) of the region bounded by the curve $y = |x - 2| + |2x - 3| + |3x - 4|$ and the line $y = 3$ is A, then 12 A is equal to _____. [4 marks]

Solution:

Concept:

- The sum of absolute values is continuous and piecewise linear. Its formula changes at the zeros of the expressions inside the moduli.
- Where the curve lies below the horizontal line, the enclosed area equals the integral of the line minus the curve. Straight pieces can also be evaluated as triangles and rectangles.

Step 1: Obtain the pieces and intersection points The breakpoints are $4/3, 3/2, 2$, in that order. Resolving each modulus gives

$$y = \begin{cases} 9 - 6x, & x \le 4/3, \\ 1, & 4/3 \le x \le 3/2, \\ 4x - 5, & 3/2 \le x \le 2, \\ 6x - 9, & x \ge 2. \end{cases}$$

For example, between $4/3$ and $3/2$, the first two expressions are negative and the third is positive, producing the constant value 1. The line $y = 3$ meets the left segment at $x = 1$ and the right segments at their common endpoint $x = 2$. The middle pieces have values no greater than 3, so the whole bounded region lies between these two intersections.

Step 2: Add the three enclosed areas From $x = 1$ to $4/3$, the vertical gap grows linearly from zero to 2. From $4/3$ to $3/2$, it remains 2. From $3/2$ to 2, it decreases linearly to zero. Therefore

$$\begin{aligned} A &= \tfrac{1}{2}(\tfrac{4}{3} - 1)(2) + (\tfrac{3}{2} - \tfrac{4}{3})(2) + \tfrac{1}{2}(2 - \tfrac{3}{2})(2) \\ &= \frac{1}{3} + \frac{1}{3} + \frac{1}{2} = \frac{7}{6}. \end{aligned}$$

These are, respectively, a triangle, a rectangle and another triangle. Using unsigned vertical gaps avoids cancellation and gives the actual geometric area.

Step 3: Conclusion The enclosed area is $7/6$ square units. Hence $12A = 12(7/6) = \boxed{14}$.

Quick Tip to Solve: Sort the modulus breakpoints first; a constant middle segment is easy to miss when adding the signed linear expressions.

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27. The coefficient of $\mathrm{a}^4\ \mathrm{b}^6\mathrm{c}^6$ in the expansion of $(\mathrm{ab} + \mathrm{bc} + \mathrm{ca})^8$ is _____. [4 marks]

Solution:

Concept:

- When expanding a power of a sum, choosing each term a specified number of times contributes a multinomial coefficient.
- If the multiplicities of ab, bc, ca are r, s, t, their product is $a^{r+t}b^{r+s}c^{s+t}$, and the coefficient is $8!/(r!s!t!)$ when $r + s + t = 8$.

Step 1: Match the powers of each variable Let ab be chosen r times, bc be chosen s times and ca be chosen t times from the eight factors. The required powers impose

$$r + t = 4, \qquad r + s = 6, \qquad s + t = 6.$$

Subtracting the last two equations gives $r = t$. The first equation then gives $r = t = 2$, and the second gives $s = 4$. These counts are all nonnegative integers and satisfy $r + s + t = 8$, so the requested term really occurs. The equations also determine the counts uniquely, so no additional multinomial contributions need to be added.

Step 2: Count all arrangements of those choices Choose which two of the eight factors supply ab, then which four of the remaining six supply bc. The final two necessarily supply ca:

$$\binom{8}{2}\binom{6}{4}\binom{2}{2} = 28 \times 15 \times 1 = 420.$$

Equivalently,

$$\frac{8!}{2!\,4!\,2!} = 420.$$

Every selected product is $(ab)^2(bc)^4(ca)^2 = a^4b^6c^6$. Since all three original summands have coefficient one and positive sign, each arrangement contributes one with the same sign. Division by the factorials removes the overcount from permuting identical choices of the same summand.

Step 3: Conclusion The coefficient of $a^4b^6c^6$ is $\boxed{420}$, a dimensionless integer.

Quick Tip to Solve: Match exponents before using factorials: a variable belongs to two of the three summands, so its exponent is a sum of two multiplicities.

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28. The number of ordered pairs (a, b), such that the function $f(x) = 4x^3 - (3\mathrm{a} + 2\,\mathrm{b})x^2 + 2\mathrm{ab}x$ is decreasing in $\left[\frac{3}{2}, \frac{5}{3}\right]$ and increasing in $\mathbf{R} - \left[\frac{3}{2}, \frac{5}{3}\right]$, is _____. [4 marks]

Solution:

Concept:

- A differentiable function that increases outside one interval and decreases inside it has a derivative with the corresponding positive-negative-positive sign pattern.
- A quadratic derivative with positive leading coefficient is negative between its two distinct real roots and positive outside them.

Step 1: Identify the required derivative roots Differentiate and factor the polynomial:

$$\begin{aligned} f'(x) &= 12x^2 - 2(3a + 2b)x + 2ab \\ &= 2(2x - a)(3x - b). \end{aligned}$$

The required sign changes occur at $3/2$ and $5/3$. Continuity of the derivative forces it to vanish at each boundary: if it were strictly positive or negative at a boundary, the same sign would persist on both sides nearby, contradicting the specified change of monotonicity. As the derivative is a quadratic with positive leading coefficient, these two boundary values are precisely its roots.

Step 2: Assign the roots to the two factors The roots of the factored derivative are $a/2$ and $b/3$. There are exactly two possible assignments:

$$\begin{aligned} \frac{a}{2} = \frac{3}{2}, \quad \frac{b}{3} = \frac{5}{3} &\implies (a, b) = (3, 5), \\ \frac{a}{2} = \frac{5}{3}, \quad \frac{b}{3} = \frac{3}{2} &\implies (a, b) = (10/3, 9/2). \end{aligned}$$

Both yield the same derivative $12(x - 3/2)(x - 5/3)$, which is positive before $3/2$, negative between the two roots and positive after $5/3$. The zero derivative at the endpoints is consistent with the stated monotonicity on the closed interval. No integrality condition on a or b is given, so the second pair must also be included.

Step 3: Conclusion There are exactly $\boxed{2}$ ordered pairs. The count is dimensionless.

Quick Tip to Solve: After factoring the derivative, match its unordered root set with the interval endpoints; assigning the roots in both orders can give different parameter pairs.

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29. Three numbers are randomly picked from the set $\{0,1,2,3,4,5,6,7,8,9\}$ one after another without replacement. If p be the probability that the smallest of these three numbers is less than 4 , then $18p$ is equal to _____. [4 marks]

Solution:

Concept:

- The event that the smallest selected number is below 4 means that at least one selected number belongs to $\{0,1,2,3\}$.
- Its complement is that all three selected numbers belong to $\{4,5,6,7,8,9\}$. For sampling without replacement, count selections with combinations or use successive conditional probabilities.

Step 1: Count the complementary selections There are ten available numbers, and all three-element subsets are equally likely because every subset has the same $3!$ possible picking orders. The total number of subsets is

$$\binom{10}{3} = 120.$$

For the smallest number to be at least 4, all three picks must lie among the six numbers from 4 through 9. The number of such subsets is

$$\binom{6}{3} = 20.$$

This complementary event includes a smallest number equal to 4; that case must be excluded from the requested event because the question uses the strict inequality less than 4.

Step 2: Find the desired probability and scale it The complement has probability $20/120 = 1/6$. Thus

$$p = 1 - \frac{1}{6} = \frac{5}{6}.$$

The same complementary probability follows from ordered sampling:

$$\frac{6}{10} \cdot \frac{5}{9} \cdot \frac{4}{8} = \frac{1}{6}.$$

The decreasing numerators and denominators reflect removal of each picked number, so independence is not being assumed. Finally, multiply the desired probability by the factor requested in the question:

$$18p = 18 \cdot \frac{5}{6} = 15.$$

The answer is consistent with a probability below one and with most triples containing at least one of the four smaller numbers.

Step 3: Conclusion The required value is $18p = \boxed{15}$. Both the probability and this numerical value are dimensionless.

Quick Tip to Solve: For a condition on the smallest selected value, count the complement where every selected value lies above the threshold.

30. If the mean of the numbers $3, 4, a, b, 10$ is 6 and their standard deviation is $\sqrt{6.8}$, then $a^3 + b^3$ is equal to _____. [4 marks]

Solution:

Concept:

- For n observations with mean $\bar{x}$, the variance is $\sigma^2 = (\sum x_i^2)/n - \bar{x}^2$. The standard deviation must be squared before using this identity.
- The identities $a^2 + b^2 = (a+b)^2 - 2ab$ and $a^3 + b^3 = (a+b)^3 - 3ab(a+b)$ determine the required cube sum without separately solving for the two observations.

Step 1: Use the mean and variance to find the symmetric sums The mean condition gives a total of $5 \times 6 = 30$. Hence

$$a + b = 30 - (3 + 4 + 10) = 13.$$

Since the standard deviation is $\sqrt{6.8}$, the variance is 6.8. Substituting the five observations into the variance formula gives

$$6.8 = \frac{3^2 + 4^2 + a^2 + b^2 + 10^2}{5} - 6^2.$$

Therefore their total sum of squares is $5(6.8 + 36) = 214$, and

$$a^2 + b^2 = 214 - (9 + 16 + 100) = 89.$$

These are population-style descriptive statistics for the given five numbers, so the denominator is 5, rather than the sample-variance denominator 4.

Step 2: Compute the cube sum without finding the individual numbers The square identity now gives

$$ab = \frac{(a+b)^2 - (a^2 + b^2)}{2} = \frac{169 - 89}{2} = 40.$$

Consequently,

$$\begin{aligned} a^3 + b^3 &= (a+b)^3 - 3ab(a+b) \\ &= 13^3 - 3(40)(13) \\ &= 2197 - 1560 = 637. \end{aligned}$$

As a check, a and b are roots of $t^2 - 13t + 40 = (t-5)(t-8)$, so the two possible orders are $(5, 8)$ and $(8, 5)$. Either order has the same mean, variance and cube sum; indeed $125 + 512 = 637$.

Step 3: Conclusion The value of $a^3 + b^3$ is $\boxed{637}$, a dimensionless number.

Quick Tip to Solve: Use the mean for $a + b$, the variance for $a^2 + b^2$, and then a symmetric identity; there is no need to choose an order for a, b.

31. Match List - I with List - II :

List - I	List - II
(A) Jaisalmer	(I) Pink city
(B) Jodhpur	(II) Golden city
(C) Jaipur	(III) Lake city
(D) Udaipur	(IV) Blue city

[4 marks]

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

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

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

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

Correct Answer: (B) -(II), (B)-(IV), (C)-(I), (D)-(III)

Solution:

Concept:

- A city nickname commonly refers to a distinctive feature of its built environment, landscape or traditional building material.
- For a matching question, establish each city and its own identifying feature first; then compare the entire ordered code with the choices.

Step 1: Identify the golden and blue cities Jaisalmer is the Golden City. Its yellow sandstone buildings and the great sandstone fort acquire a golden appearance in sunlight, giving the city its familiar name. Therefore Jaisalmer, entry (A), matches (II). Jodhpur is the Blue City, associated with its blue-painted houses, particularly in the older settlement near Mehrangarh Fort. Thus entry (B) matches (IV). These are separate identities: interchanging the two would confuse sandstone colour with painted house colour.

Step 2: Identify the pink and lake cities Jaipur is the Pink City, known for the characteristic pink appearance of its historic urban facades. Thus entry (C) matches (I). Udaipur is the Lake City, associated with its lakes and the palaces and urban landscape around them. Thus entry (D) matches (III). The complete matching is therefore (A)-(II), (B)-(IV), (C)-(I), (D)-(III). Only the second listed option gives this sequence. The first choice reverses the golden and blue identities, the third assigns the lake identity to Jaisalmer, and the fourth interchanges the Jaipur and Udaipur matches.

Step 3: Conclusion Jaisalmer is the Golden City, Jodhpur the Blue City, Jaipur the Pink City and Udaipur the Lake City. Hence, the correct option is (B).

Quick Tip to Solve: Use the four feature cues together: Jaisalmer–golden sandstone, Jodhpur–blue houses, Jaipur–pink facades and Udaipur–lakes.

32. Match List - I with List - II :

List - I	List - II
(A) Jod Gumbaz	(I) Mahabalipuram
(B) Cave temples	(II) Madhurai
(C) Rangnatha temple	(III) Bijapur
(D) Minakshi temple	(IV) Srirangam

[4 marks]

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

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

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

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

Correct Answer: (B) -(III), (B)-(I), (C)-(IV), (D)-(II)

Solution:

Concept:

- Monument-location matching requires the town or city associated with each named monument, rather than merely the state or architectural tradition.
- Confirm all four pairs independently before selecting the code: one correct pair alone does not establish the whole option.

Step 1: Locate the first two monuments Jod Gumbaz is associated with Bijapur, also known as Vijayapura, in Karnataka. Hence entry (A) matches (III). The cave temples in this list refer to the celebrated rock-cut monuments of Mahabalipuram in Tamil Nadu, so entry (B) matches (I). Mahabalipuram is associated with Pallava rock-cut architecture; it should not be interchanged with Madurai merely because both are well-known temple destinations in Tamil Nadu.

Step 2: Complete the temple pairs and check the code The Ranganatha temple named in the question is at Srirangam, near Tiruchirappalli, giving (C)-(IV). The Minakshi, or Meenakshi, temple is at Madurai, giving (D)-(II). Combining these results gives (A)-(III), (B)-(I), (C)-(IV), (D)-(II), which is the second listed option. The first option incorrectly sends the cave temples to Madurai and Minakshi temple to Mahabalipuram. The third exchanges the locations of Jod Gumbaz and Ranganatha temple. The fourth assigns Jod Gumbaz to Mahabalipuram and the cave temples to Srirangam, so it also fails the monument-location check.

Step 3: Conclusion Jod Gumbaz is at Bijapur, the cave temples at Mahabalipuram, Ranganatha temple at Srirangam and Minakshi temple at Madurai. Hence, the correct option is (B).

Quick Tip to Solve: Pair the two famous Tamil Nadu temples first: Ranganatha–Srirangam and Meenakshi–Madurai; then confirm the two remaining sites.

33. Which is the largest monestry in India ? [4 marks]

(A) Tawang

(B) Leh

(C) Dharamshala

(D) Labrang

Correct Answer: (A) Tawang

Solution:

Concept:

- A monastery is a religious establishment housing a monastic community; its size and identity belong to a particular complex, not to every institution in its surrounding town.
- Tawang Monastery in Arunachal Pradesh is recognised as the largest monastery in India; location provides a useful check when comparing monastery names.

Step 1: Identify the monastery asked for The question asks for the largest monastery in India. Tawang Monastery, situated at Tawang in Arunachal Pradesh, is the recognised answer. It is a major Tibetan Buddhist monastic complex of the Gelug tradition. The name Tawang therefore identifies the specific establishment that satisfies both parts of the question: it is a monastery and it lies within India. The geographical condition matters because a large monastery elsewhere cannot qualify.

Step 2: Eliminate the other listed places Leh is a major town of Ladakh and a centre from which several important monasteries are visited, but the choice Leh does not name the largest Indian monastery. Dharamshala is strongly associated with Tibetan Buddhism and the Tibetan community in Himachal Pradesh; that association alone does not make it the answer to a question about the largest monastery. Labrang Monastery is in the Tibetan cultural region of Gansu in China, so it fails the explicit condition that the monastery be in India. Among the listed alternatives, Tawang is thus the institution that meets the requested identification, rather than simply a place with Buddhist associations.

Step 3: Conclusion Tawang Monastery in Arunachal Pradesh is the largest monastery in India. Hence, the correct option is (A).

Quick Tip to Solve: For monastery questions, check the country and the specific institution first: Tawang is in Arunachal Pradesh, whereas Labrang is in China.

34. Where is 'Junagadh fort' choose the correct option amongst the following ? [4 marks]

(A) Udaipur

(B) Jodhpur

(C) Bikaner

(D) Jaisalmer

Correct Answer: (C) Bikaner

Solution:

Concept:

- A fort must be matched to the city containing it; similar names of cities and monuments can otherwise lead to a geographical mix-up.
- Junagarh Fort, rendered Junagadh in the question, is the major historic fort at Bikaner in Rajasthan.

Step 1: Identify the fort-city pair The name in the question refers to Junagarh Fort at Bikaner. This is one of the principal monuments of Bikaner and is associated with the rulers of that state. Therefore the city required by the question is Bikaner. The spelling Junagadh in the statement should not prompt a change to a different option: the available city choices and the named Rajasthan fort identify the established Junagarh–Bikaner pair.

Step 2: Compare the remaining Rajasthan cities Udaipur is associated with the City Palace and its lake setting, rather than Junagarh Fort. Jodhpur is associated with Mehrangarh Fort, so choosing Jodhpur would substitute a different famous fort for the one actually named. Jaisalmer is associated with Jaisalmer Fort, the golden sandstone fort rising above its old city. All four options are well-known Rajasthan destinations, but being a fortified historic city is not sufficient: the precise monument-city correspondence is decisive. Bikaner is the only listed city that contains Junagarh Fort, so the third option is selected without confusing the fort with the better-known hilltop landmarks of the other cities.

Step 3: Conclusion Junagarh Fort is in Bikaner, Rajasthan. Hence, the correct option is (C).

Quick Tip to Solve: Keep the fort pairs distinct: Junagarh–Bikaner, Mehrangarh–Jodhpur and Jaisalmer Fort–Jaisalmer.

35. 'Kyoto protocol' summit was held in which country ? [4 marks]

(A) Japan

(B) Korea

(C) Malyasia

(D) China

Correct Answer: (A) Japan

Solution:

Concept:

- The Kyoto Protocol is an international climate agreement associated with the United Nations Framework Convention on Climate Change.
- A question about the summit venue asks for the host country of the named city, not for every country participating in the agreement.

Step 1: Locate Kyoto and identify the event Kyoto is a city in Japan. The Kyoto Protocol was adopted at the climate conference held there in 1997, commonly identified as the third Conference of the Parties to the climate convention. Thus the geographical clue in the name of the protocol leads directly to Japan. The question is asking where that meeting was held; it does not ask which countries later ratified the protocol or what commitments individual countries accepted.

Step 2: Check the country choices Japan is the country containing Kyoto and is therefore the correct host-country choice. Korea and China are different East Asian countries, but neither contains Kyoto. Malaysia, written Malyasia in the options, is in Southeast Asia and is also not the location of Kyoto. The fact that these countries may be connected with international environmental discussions does not answer the venue question. Matching the named city to its country is the necessary and sufficient test here: Kyoto belongs to Japan. This also distinguishes the Kyoto meeting from climate conferences named after other host cities, whose agreements must not be substituted for the one specified.

Step 3: Conclusion The Kyoto Protocol summit was held in Kyoto, Japan. Hence, the correct option is (A).

Quick Tip to Solve: Use the agreement name as a location cue: Kyoto is a Japanese city; distinguish the host country from the agreement's participating countries.

36. What was Delhi's old name ? [4 marks]

(A) Old Delhi

(B) Shahjahanpur

(C) Shahpur Jat

(D) Shahajahanabad

Correct Answer: (D) Shahajahanabad

Solution:

Concept:

- Delhi developed through several historic urban settlements. A name associated with one historic city should be distinguished from a modern neighbourhood or a descriptive label.
- Shahjahanabad was the Mughal city founded by Shah Jahan and corresponds to the historic walled city now commonly called Old Delhi.

Step 1: Identify the intended historic city The historical name required by the options is Shahjahanabad, written Shahajahanabad in the fourth choice. It was the city established by the Mughal emperor Shah Jahan and became the walled city now commonly called Old Delhi. The reference to an old name in this question therefore points to the formal historic city name rather than simply repeating the modern description Old Delhi. This connection between the emperor and the city name gives the direct identification.

Step 2: Distinguish the other names Old Delhi is the familiar descriptive name used today for the historic walled-city area; it is not the earlier formal name sought in this matching of names. Shahjahanpur is a different city and must not be selected merely because its name also recalls Shah Jahan. Shahpur Jat is a locality in Delhi, rather than the name of the Mughal walled city. Delhi has had other historic settlements and names across its long history, but among these four alternatives the recognised name of its Mughal old city is unambiguously Shahjahanabad. Hence the fourth choice fits the historical relationship while the other three refer to a present description, a separate city, and a locality respectively.

Step 3: Conclusion The historic walled city of Old Delhi was called Shahjahanabad, given as Shahajahanabad in the options. Hence, the correct option is (D).

Quick Tip to Solve: Associate Shahjahanabad with Shah Jahan and the walled city of Old Delhi; do not confuse it with Shahjahanpur or the locality Shahpur Jat.

37. Match List - I with List - II :

List - I : Name of the cities/towns where traditional Ghats are situated.

List - II : Name of the river on which traditional Ghats are constructed.

List - I	List - II
(A) Maheshwar, MP	(I) Ganga
(B) Kolhapur, Maharashtra	(II) Shipra
(C) Ujjain, MP	(III) Narmada
(D) Varanasi, UP	(IV) Panchganga

[4 marks]

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

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

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

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

Correct Answer: (D) -(III), (B)-(IV), (C)-(II), (D)-(I)

Solution:

Concept:

- Traditional ghats are flights of steps connecting a settlement to the bank of its river. A city–river match is determined by the actual riverside location, not by the order of the two lists.
- For a matching question, first establish each geographical association independently, then translate the river names into their Roman-numbered codes.

Step 1: Match the Madhya Pradesh towns Maheshwar stands on the Narmada, so entry (A) must match (III). Ujjain is associated with the Shipra, so entry (C) must match (II). These two separate associations already distinguish the correct sequence from one that places Maheshwar on the Ganga or Ujjain on the Narmada.

Step 2: Complete and check the sequence Kolhapur is associated with the Panchganga, giving (B)–(IV). Varanasi is famous for its ghats on the Ganga, giving (D)–(I). Thus, in List I order, the river-code sequence is (III), (IV), (II), (I). The first option places all four towns with the wrong rivers; the second does not place Maheshwar with the Narmada or Kolhapur with the Panchganga; the third also misplaces Maheshwar and Ujjain. The fourth option is the one containing the required sequence.

Step 3: Conclusion The matches are Maheshwar–Narmada, Kolhapur–Panchganga, Ujjain–Shipra and Varanasi–Ganga; in List I order the river codes are (III), (IV), (II), (I). Hence, the correct option is (D).

Quick Tip to Solve: Anchor the list with Varanasi–Ganga and Maheshwar–Narmada, then verify the remaining two entries rather than selecting a partially matching sequence.

38. 'Rani Ki Vav' is an example of : [4 marks]

(A) Haveli

(B) Stepwell

(C) Temple

(D) Fort

Correct Answer: (B) Stepwell

Solution:

Concept:

- A building type is identified by its main spatial organisation and purpose. A stepwell provides access to water through a descending series of steps and landings.
- Rani Ki Vav at Patan in Gujarat belongs to the Indian stepwell tradition. The architectural term vav denotes a well, rather than a residence or a military enclosure.

Step 1: Identify the monument type Rani Ki Vav is organised as a descent below ground towards a well. Its stepped passages, successive levels and richly sculpted architectural treatment are features of a monumental stepwell. The sculptural decoration does not change the underlying function of the structure: the descent and water source determine its classification.

Step 2: Eliminate the other building categories A haveli is a substantial traditional residence, generally organised around domestic spaces and courtyards; that is not the primary layout of this monument. A temple is primarily a place of worship organised around sacred spaces, whereas the monument named here is classified as a stepwell even though it has religious sculptures. A fort is a defensive enclosure with protective walls and controlled entrances. None of those three categories describes its central stepped access to water. Therefore the second listed category is the appropriate architectural identification.

Step 3: Conclusion Rani Ki Vav is a stepwell at Patan, Gujarat. Hence, the correct option is (B).

Quick Tip to Solve: For monument-type questions, distinguish the structure's main purpose from its decorative motifs: religious carving alone does not make a stepwell a temple.

39. 'Al–Khazneh' the treasury is located in : [4 marks]

(A) Jordan

(B) Turkey

(C) UAE

(D) Saudi-Arabia

Correct Answer: (A) Jordan

Solution:

Concept:

- Al–Khazneh, popularly called the Treasury, is a rock-cut monument at Petra. Identifying the archaeological site first gives a reliable route to identifying its country.

- Petra is in Jordan. Its rock-cut facades are associated with Nabataean architecture, so the monument should be located through this site rather than through the English name Treasury.

Step 1: Locate the named monument Al–Khazneh is the celebrated facade carved into the rock at Petra. The name Treasury is a conventional name for this monument; it does not mean that every building called a treasury belongs to the same country. The relevant geographical association is Al–Khazneh with Petra, and Petra with Jordan.

Step 2: Compare all four country choices Jordan contains Petra and therefore satisfies the monument–site–country chain. Turkey has many important ancient monuments, but Petra is not located there. The United Arab Emirates is likewise not the country containing Petra, so its prominent modern architecture does not support that option. Saudi Arabia also has notable archaeological and rock-cut sites, but those should not be confused with Petra. The question names this particular monument, and its location identifies the first choice uniquely. No change in the monument's familiar English title changes that geographical match.

Step 3: Conclusion Al–Khazneh, the Treasury at Petra, is located in Jordan. Hence, the correct option is (A).

Quick Tip to Solve: Remember a three-part association for world monuments: Al–Khazneh–Petra–Jordan. It prevents confusion between similar rock-cut sites in neighbouring countries.

40. Proposed 'Central Vista' project is located in which city ? [4 marks]

(A) New Delhi

(B) Lucknow

(C) Mumbai

(D) Varanasi

Correct Answer: (A) New Delhi

Solution:

Concept:

- A major civic project should be located by the governmental precinct it serves. Central Vista denotes the central administrative and ceremonial axis in India's national capital.
- The Central Vista project concerns the government precinct in New Delhi. The word proposed in this question describes the project at the time of the paper; the geographical identity remains New Delhi.

Step 1: Identify the governmental precinct The Central Vista is associated with the national governmental centre in New Delhi, including the monumental ceremonial axis and adjoining central government buildings. The redevelopment project takes its name from this established precinct. Consequently, the required response is the city containing this national administrative setting, not a city chosen merely because it has government offices.

Step 2: Check the other cities against the name Lucknow is the capital of Uttar Pradesh, but the national Central Vista project named in the question is not located there. Mumbai is a major

metropolitan and financial centre, but it is not the site of this national government precinct. Varanasi is an important historic and religious city, yet it is also not the location of the named project. These three cities do not satisfy the specific project–precinct association. New Delhi does, which makes the first alternative the only correct geographical identification.

Step 3: Conclusion The Central Vista project is located in New Delhi. Hence, the correct option is (A).

Quick Tip to Solve: Associate Central Vista with the national government's ceremonial and administrative precinct in New Delhi; do not confuse it with a state-capital project.

41. Originally there were five 'Jantar Mantars' (Architectural Observatories) constructed by 'Raja Jai Singh'. Which out of those got destroyed in the 19^{th} century ? [4 marks]

(A) Jantar Mantar at Ujjain.

(B) Jantar Mantar at Mathura.

(C) Jantar Mantar at Varanasi.

(D) Jantar Mantar at Delhi.

Correct Answer: (B) Jantar Mantar at Mathura.

Solution:

Concept:

- Jai Singh II established five major masonry astronomical observatories, commonly called Jantar Mantars: Delhi, Jaipur, Ujjain, Varanasi and Mathura.
- The question asks for the observatory that was destroyed, so the five-city list must be combined with the survival history of the sites. Mathura is the lost member of this group.

Step 1: Recall the complete observatory group The five observatories were distributed across Delhi, Jaipur, Ujjain, Varanasi and Mathura. They used large architectural instruments for observing celestial positions and measuring astronomical quantities. Listing the five sites helps separate this specific historical group from other observatories and avoids choosing a city only because its name is less familiar.

Step 2: Identify the lost observatory and reject the survivors The Mathura observatory was destroyed in the nineteenth century, which is the event described in the question. The Ujjain observatory is a surviving member of the group, so option (A) does not answer the destruction question. Varanasi also retains its historic observatory, excluding option (C). Delhi's Jantar Mantar survives as well, excluding option (D). Jaipur is the fifth member, although it is not among the four choices here. Thus the historical distinction required is survival versus destruction, and among the listed sites the destroyed observatory is Mathura.

Step 3: Conclusion The Jantar Mantar at Mathura was destroyed in the nineteenth century. Hence, the correct option is (B).

Quick Tip to Solve: Recall the five sites together, then attach the exception: Mathura is the destroyed Jantar Mantar; the other four are the surviving historic observatories.

42. The local term 'Barsati' in a building mean. [4 marks]

(A) Mumty

(B) Balcony

(C) Canopy

(D) Parapet

Correct Answer: (A) Mumty

Solution:

Concept:

- Barsati is a local term associated with a small covered room or shelter at terrace level. It should be distinguished from the open edges, projections and protective elements of a building.
- Among the given alternatives, mumty is the enclosed rooftop structure that best corresponds to the intended terrace-level built space. A balcony, canopy and parapet describe different architectural elements.

Step 1: Interpret the terrace-level term A barsati is understood in ordinary building terminology as a small rooftop room or covered terrace accommodation. The essential clue is an enclosed or covered built space at roof level. In the terminology used by this question, that points to mumty, a rooftop enclosure, commonly associated with the staircase head. Although local usage can distinguish the precise functions of rooftop rooms, the first option is the intended match among these four choices.

Step 2: Distinguish the remaining elements A balcony is a projecting platform accessible from an upper floor, usually open along its outer side; it is not the small rooftop enclosure described by the term. A canopy is an overhead cover, often over an entrance or passage, and does not by itself constitute a room. A parapet is the low protective wall along the edge of a roof, terrace or balcony, rather than the enclosed rooftop space. Comparing the physical forms therefore eliminates the other three alternatives and leaves the rooftop enclosure in the first choice.

Step 3: Conclusion In the terminology intended by the given alternatives, Barsati corresponds to Mumty. Hence, the correct option is (A).

Quick Tip to Solve: Separate rooftop terms by form: mumty is an enclosure, parapet is an edge wall, canopy is an overhead cover, and balcony is a projecting platform.

43. Lingraj temple is situated in : [4 marks]

(A) Cuttack

(B) Puri

(C) Bhubaneshwar

(D) Konark

Correct Answer: (C) Bhubaneshwar

Solution:

Concept:

- Lingaraj Temple is a major Hindu temple of Bhubaneswar in Odisha, associated with the Kalinga tradition of temple architecture.
- For a monument-location question, identify the particular monument first; several well-known temple towns in the same state are not interchangeable.

Step 1: Identify the monument The name Lingaraj identifies the temple dedicated to Shiva in Bhubaneswar. It is one of the principal historic temples of the city, whose concentration of temples makes it an important centre in the architectural history of Odisha. The requested fact is the city in which this specific temple stands, rather than the state or its architectural style.

Step 2: Compare the listed cities Bhubaneshwar in option (C) is a spelling of Bhubaneswar and gives the required location. Puri is associated especially with the Jagannath Temple, while Konark is associated with the Sun Temple. Those monuments are different from the Lingaraj Temple. Cuttack is another important city of Odisha, but it is not the location of the temple named here. Thus the regional similarity of the choices does not change the monument-city pairing.

Step 3: Conclusion Lingaraj Temple is situated in Bhubaneswar. Hence, the correct option is (C).

Quick Tip to Solve: Keep the Odisha monument-city pairs together: Lingaraj–Bhubaneswar, Jagannath–Puri and Sun Temple–Konark.

44. Porcelain is a product made up of : [4 marks]

(A) Steel

(B) Stone

(C) Clay

(D) Timber

Correct Answer: (C) Clay

Solution:

Concept:

- Porcelain is a ceramic material produced by shaping a suitable clay-based mixture and firing it at a high temperature.
- Kaolin, a fine white clay, is a characteristic raw material of porcelain; feldspar and quartz may be included in the ceramic body.

Step 1: Identify the material family The essential distinction is between a ceramic product and a metallic, stone or wood product. Porcelain belongs to the ceramic family. Its raw mixture is formed into the required shape and fired in a kiln, producing a hard, dense and usually white body. The firing process changes the clay-based body into the finished ceramic; it is not simply a piece of natural stone cut to shape.

Step 2: Select the matching raw material Clay in option (C) is the appropriate raw-material category. Steel is an iron-based alloy and would describe a metallic product. Stone is naturally occurring rock, whereas porcelain is manufactured through ceramic processing. Timber is wood and cannot be the body of a fired porcelain product. Although a porcelain mixture can contain several mineral ingredients, the question asks for the broad material from the given choices, for which clay is the correct classification.

Step 3: Conclusion Porcelain is a clay-based ceramic product. Hence, the correct option is (C).

Quick Tip to Solve: When porcelain, earthenware or pottery appears in a material question, first place it in the clay-and-ceramics family.

45. Bhagalpur is known for : [4 marks]

(A) Cotton

(B) Silk

(C) Tea

(D) Rice

Correct Answer: (B) Silk

Solution:

Concept:

- Bhagalpur in Bihar is traditionally associated with silk textiles and the silk-weaving industry.
- A town-product question asks for its characteristic association, rather than every crop or commodity that may be traded there.

Step 1: Recall the characteristic industry Bhagalpur is well known for its silk production and weaving, including fabrics associated with tussar silk. Its reputation as a silk centre connects the place name directly with a textile material. The question is therefore testing the familiar city-industry pairing Bhagalpur–silk, not asking which agricultural product might be grown somewhere in the surrounding region.

Step 2: Eliminate the other product categories Silk is option (B). Cotton is also a textile fibre, but it is not the distinctive association intended by the name Bhagalpur. Tea is a beverage crop and rice is a food grain; neither identifies the celebrated silk-weaving tradition of this city. Recognising that both cotton and silk are fibres helps isolate the potentially tempting distractor, after which the specific regional craft association decides the answer.

Step 3: Conclusion Bhagalpur is known for silk. Hence, the correct option is (B).

Quick Tip to Solve: Associate Bhagalpur with silk weaving; do not replace a city's characteristic craft with a general agricultural product.

46. Which one of the following terms is used to describe trade between two or more countries ?

[4 marks]

(A) Internal trade

(B) External trade

(C) International trade

(D) Local trade

Correct Answer: (C) International trade

Solution:

Concept:

- International trade is the exchange of goods and services across national boundaries between two or more countries.
- Internal or domestic trade occurs within one country; local trade describes exchange over a smaller local area.

Step 1: Identify the geographical scale The decisive words are "between two or more countries". They specify that a national boundary separates the trading parties. The direct term for trade at this scale is international trade: international means involving different nations. Nothing in the question restricts the transaction to one city, one region or the domestic market of a single country.

Step 2: Compare the terms carefully Internal trade and local trade do not express exchange between different countries, so options (A) and (D) do not fit. Option (C), international trade, states the definition in the question explicitly and is the intended keyed choice. External trade in option (B) is also commonly used for foreign trade, viewed from the standpoint of one country, so it overlaps in meaning. This terminological overlap should be recognised; the most direct match to the wording about two or more countries remains international trade.

Step 3: Conclusion The official keyed answer is international trade, option (C). External trade, option (B), also describes trade across national boundaries, so the printed alternatives overlap and the question has no uniquely defensible choice. Internal trade and local trade do not match the international scope.

Quick Tip to Solve: For trade between nations, look for "international"; internal and local trade remain within domestic boundaries.

47. Who has designed the 'India Habitat Center' building situated at New Delhi ? [4 marks]

(A) B.V. Doshi

(B) Joseph Allein Stein

(C) Charles Correa

(D) I.M. Pei

Correct Answer: (B) Joseph Allein Stein

Solution:

Concept:

- The India Habitat Centre in New Delhi was designed by the architect Joseph Allen Stein.
- Architect-building questions require a specific attribution; several prominent architects may have worked in the same country or period.

Step 1: Match the building with its architect The India Habitat Centre is associated with Joseph Allen Stein, whose work in New Delhi includes institutional complexes organised around landscaped courts and connected spaces. The spelling "Joseph Allein Stein" in the listed option identifies the same architect. The attribution therefore selects that name rather than a general association with modern Indian architecture.

Step 2: Check the remaining names Option (B) names Stein. B. V. Doshi and Charles Correa are both major architects with important contributions to modern architecture in India, but neither is the designer of the India Habitat Centre. I. M. Pei was a prominent international architect, yet his name is not the attribution for this New Delhi complex. The building's name and location must be treated as one specific identification, so fame or nationality alone cannot decide among the options.

Step 3: Conclusion Joseph Allen Stein designed the India Habitat Centre in New Delhi. Hence, the correct option is (B).

Quick Tip to Solve: Remember the exact pairing India Habitat Centre–Joseph Allen Stein, and recognise minor spelling variants in the option.

48. Mirror the words along X-Y axis and choose the correct option amongst the following. [4 marks]



(A) SUCCESS

(B) SUCCESS

(C) SUCCESS

(D) SSECCUS

Correct Answer: (C) SUCCESS

Solution:

Concept:

- Reflection in the horizontal line X-Y interchanges top and bottom. A point and its image lie on the same perpendicular to the mirror line, at equal distances on opposite sides.
- This reflection preserves the horizontal positions of the letters. Thus the letter order in SUCCESS remains S, U, C, C, E, S, S from left to right; individual letters must be turned upside down without reversing the order.

Step 1: Identify the mirror line and preserve horizontal order The dotted X-Y line lies horizontally below SUCCESS. Therefore reflect the word downward across this line rather than across a vertical line at either end. The leftmost S must remain the leftmost character, and the U must remain second. Each letter keeps its width and its horizontal position; only its height relative to the dotted line changes sign. Reading the letters backwards would represent the wrong transformation.

Step 2: Check the distinctive letters under reflection The U has its curved base below its two upright strokes. Its reflected image consequently has that curved part above the strokes, appearing as an inverted U. The capital C and E in the supplied typeface have horizontal symmetry, so their top and bottom interchange without changing their overall appearance. The S characters do change: their upper and lower bends exchange positions. This provides a second check beyond merely turning U upside down.

Step 3: Compare all four graphical options Option (C) preserves the complete left-to-right sequence and reflects both the U and all three S characters vertically. Option (A) inverts the U but leaves the S shapes in their original orientation, so it is incomplete. Option (B) reflects the S characters but retains an upright U, so it fails the top-to-bottom reversal test. Option (D) changes the left-to-right arrangement, including the location of the inverted U, and therefore does not describe a reflection about the horizontal X-Y line. Only the third graphical option satisfies both the order and the orientation tests.

Step 4: Conclusion The mirror image is the third displayed word, obtained by reversing top and bottom while retaining every letter's horizontal position. Hence, the correct option is (C).

Quick Tip to Solve: For a horizontal mirror line, first keep the letter order fixed, then check an asymmetric letter such as U or S. Do not reverse the word as you would for a vertical mirror.

49. Match List - I with List - II :

List - I
(A) Dubai
(B) London
(C) New York
(D) Kuala Lumpur

List - II is shown in the figure. Choose correct answer. [4 marks]

(I) 

(II) 

(III) 

(IV) 

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

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

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

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

Correct Answer: (C) -(III), (B)-(II), (C)-(IV), (D)-(I)

Solution:

Concept:

- Identify a skyline from its distinctive landmarks, rather than from the generic rectangular towers shared by many cities.
- A matching answer is correct only when all four city-to-image assignments agree with the numbered figures.

Step 1: Identify the paired towers and the London landmarks Image (I) shows two matching tall towers with pointed tops and a connecting skybridge. These are the Petronas Twin Towers, identifying Kuala Lumpur, so (D) matches (I). Image (II) includes the clock tower associated with Big Ben and the rounded, tapering Gherkin building. This combination identifies London, so (B) matches (II). The paired-tower silhouette in (I) is quite different from the single dominant spire in the Dubai skyline.

Step 2: Identify Dubai and New York Image (III) has the exceptionally tall, narrow, stepped spire of the Burj Khalifa rising above the surrounding towers. It therefore represents Dubai, giving (A)-(III).

Image (IV) includes the Statue of Liberty in front of a group of skyscrapers. The raised torch and the statue silhouette identify New York, giving (C)-(IV). Use these visible features together; a general resemblance between high-rise buildings is not a reliable city identifier.

Step 3: Check the complete matching sequence The required sequence is (A)-(III), (B)-(II), (C)-(IV), (D)-(I). This is the third answer choice. The first choice incorrectly puts Dubai with the Petronas skyline; the second puts Dubai with New York; the fourth puts Dubai with London. Each therefore fails before the remaining assignments even need to be checked.

Step 4: Conclusion The matching is Dubai-(III), London-(II), New York-(IV), Kuala Lumpur-(I). Hence, the correct option is (C).

Quick Tip to Solve: First locate one unmistakable landmark: the Petronas twin towers fix Kuala Lumpur, and the Statue of Liberty fixes New York.

50. Match List - I with List - II :

List - I
(A) Empire state building
(B) Opera House
(C) Hagia Sophia
(D) Guggenheim Museum

List - II is shown in the figure. Choose correct answer from the options given below : [4 marks]

(I)



(II)



(III)



(IV)



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

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

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

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

Correct Answer: (A) -(III), (B)-(IV), (C)-(I), (D)-(II)

Solution:

Concept:

- Architectural landmarks can be identified by their massing, roof profile and characteristic structural elements.
- Match each named building to the Roman-numbered photograph, then compare the complete sequence with the answer choices.

Step 1: Identify the Empire State Building and Opera House Photograph (III) shows a tall stepped skyscraper whose upper storeys narrow toward a central mast. This is the Empire State Building, so (A)-(III). Photograph (IV) shows the distinctive group of white sail-like roof shells beside water. These shells identify the Sydney Opera House, so (B)-(IV). The building in (III) is a vertical tower, whereas the Opera House spreads into several low sculptural roof forms.

Step 2: Identify Hagia Sophia and the Guggenheim Museum Photograph (I) shows a large central dome with surrounding smaller domes and slender minarets. This is Hagia Sophia, so (C)-(I). Photograph (II) shows the irregular curved metallic volumes of the Guggenheim Museum in Bilbao, giving (D)-(II). The curved metal surfaces distinguish that museum from the stone dome composition of Hagia Sophia; they are not interchangeable simply because both buildings have rounded forms.

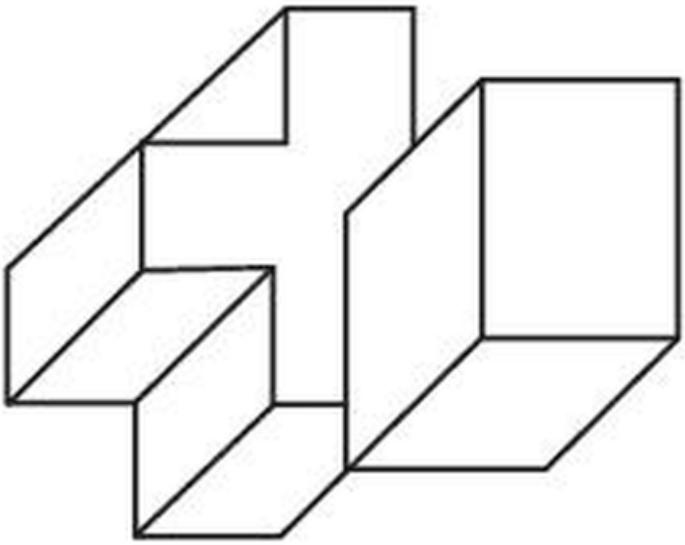
Step 3: Select the option containing all four matches Putting the identifications in List-I order gives (A)-(III), (B)-(IV), (C)-(I), (D)-(II), exactly the first option. The second option wrongly assigns the Empire State Building to the Opera House photograph. The third assigns it to Hagia Sophia, and the fourth assigns it to the Guggenheim photograph. These mismatches eliminate the other choices independently of their remaining pairs.

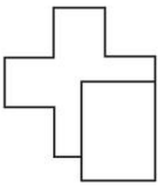
Step 4: Conclusion The matching is Empire State Building-(III), Opera House-(IV), Hagia Sophia-(I), Guggenheim Museum-(II). Hence, the correct option is (A).

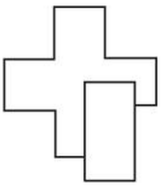
Quick Tip to Solve: Use the roof silhouette first: sail-like shells identify the Opera House, while the dome and minarets identify Hagia Sophia.

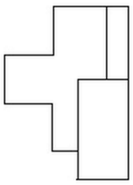
51. The 3D figure shows the view of an object. Identify the correct top view, amongst the answer figure's.

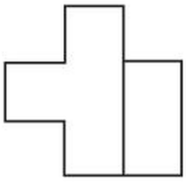
[4 marks]

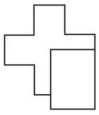


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A top view is obtained by looking vertically downward: height is suppressed, but the horizontal footprint and visible changes of level remain.
- Parallel receding edges in the pictorial view become parallel edges in the plan; do not copy the slant of the perspective drawing.

Step 1: Separate the footprint from the vertical faces The object has a cross-like portion on the left and a rectangular portion projecting toward the front on the right. Follow the upper and lower boundaries of these portions rather than the apparent lengths of the slanting edges. The right rectangular portion occupies the lower-right part of the plan and meets the cross-like portion along an internal boundary. Looking from above removes the visible heights of the upright faces; it does not remove the horizontal

extent of the right-hand portion.

Step 2: Compare the junction in the answer figures In option (A), the projecting rectangle shares the right outer edge of the cross-like outline and begins at the inner horizontal step. Its upper-left corner and the short internal boundary reproduce the junction seen in the object. Option (B) places the right rectangle farther inward, leaving an extra narrow arm beyond its right edge. This does not match the flush outer alignment of the object. Trace the two rightmost edges in the pictorial view to check this distinction.

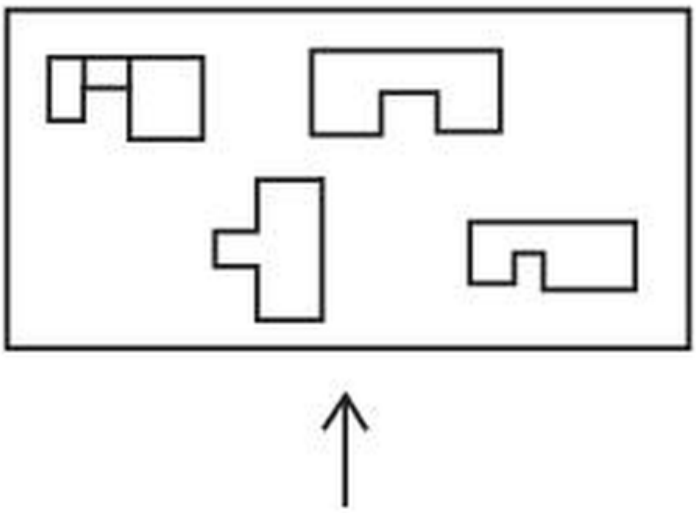
Step 3: Eliminate changes to the outline Option (C) lengthens the right-hand outline upward and introduces an extra long dividing strip. Option (D) suppresses the required lower step and makes the right-hand region terminate level with the central lower edge. Neither preserves the visible combination of the cross-like portion with the forward rectangular projection. Option (A) retains both the outside silhouette and the internal boundary at their proper relative positions.

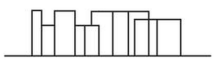
Step 4: Conclusion The top view preserves the cross-like left portion and the forward rectangle at the lower right as shown in option (A). Hence, the correct option is (A).

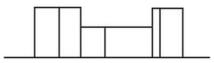
Quick Tip to Solve: For this object, compare where the right rectangle begins and whether its right edge is flush with the cross-like portion; the junction is more useful than the overall resemblance.

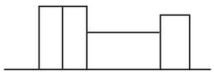
52. The problem figure shows the top view of an object. Identify the correct elevation looking in the direction of arrow, amongst the answer figure's.

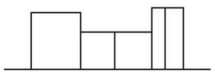
[4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- For the elevation along the upward arrow, horizontal positions across the plan are retained, while front-to-back distances collapse onto the viewing plane.
- Compare the projected edges and overlaps of the separate plan shapes. A rear edge is visible only where it is not covered by a nearer part.

Step 1: Fix the viewing direction The arrow lies below the plan and points upward. Therefore the lower shapes are nearer the viewer, while the two shapes near the upper boundary lie behind them. Keep the left-to-right order unchanged: the detailed shape is at the left, the small projecting shape lies in the middle, and the two notched shapes overlap in horizontal position at the right. Reversing the view would reverse which boundaries are visible, so the arrow must be used before comparing the alternatives.

Step 2: Project and compare the vertical divisions Imagine drawing vertical projection lines from the corners of all four plan shapes onto a horizontal baseline. The left group has several closely spaced edges; the middle projecting shape contributes another short group of boundaries. At the right, the nearer notched shape and the rear notched shape overlap, so their visible vertical divisions do not reduce to one plain rectangle. Option (A) is the alternative that retains this richer succession of edges, including the central divisions and overlapping right-hand group.

Step 3: Reject the simplified or reversed alternatives Options (B) and (C) replace much of the middle group by a long uninterrupted low strip, losing the separate projected boundaries of the small central shape and the overlap at the right. Option (D) also simplifies the left group and places the taller divided group at the other side. These do not preserve the detailed horizontal alignment indicated by the plan. Option (A) is therefore the matching conventional elevation among the supplied answer figures; the task is a comparison of the given drawings rather than a calculation of dimensions.

Step 4: Conclusion The elevation looking in the direction of the arrow is the figure that retains the projected left, central and overlapping right-hand divisions. Hence, the correct option is (A).

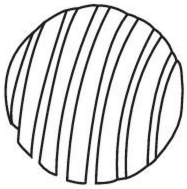
Quick Tip to Solve: Project the small central shape first: alternatives that erase its separate vertical divisions can be rejected before comparing the larger groups.

53. A tennis ball is cut according to the pattern of the grooves of a screw. Which of the following is the correct output : [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- The groove of a screw is a helix: it advances along the screw axis while winding around that axis.
- A sphere cut along a screw-like pattern must show winding cuts on a curved surface, rather than a set of independent straight parallel slices.

Step 1: Translate the screw pattern into a spatial cut A screw groove does not lie in a single flat plane. As it goes around the axis it also moves lengthwise, producing a continuous winding path. Apply that property to the tennis ball: the cut must turn around the ball while advancing from one end toward the other. The pieces and exposed cut boundaries should consequently suggest a twisted or spiral separation. A pattern made merely by slicing the ball between parallel planes has a different geometry.

Step 2: Inspect the surfaces in the four outputs Option (A) shows separate straight vertical strips with flat parallel gaps. Option (B) likewise shows a group of straight parallel slots or bands. Neither carries the winding movement of a screw thread. Option (D) tilts the parallel bands across the sphere, but sloping a family of straight cuts does not make them helical. Their common direction remains the defining feature of planar slicing.

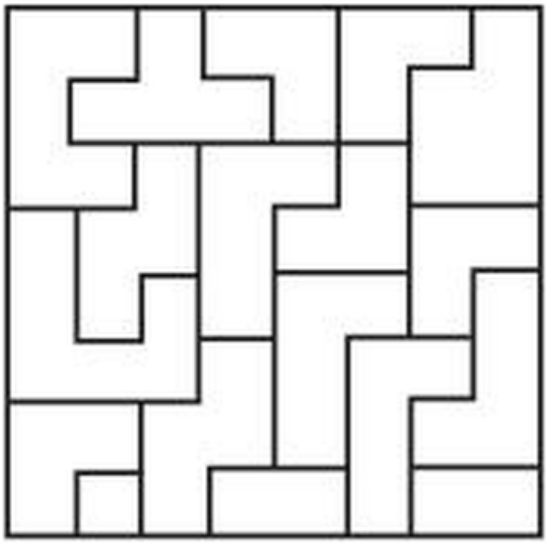
Step 3: Identify the winding separation Option (C) shows curved, twisting boundaries and the exposed shaded surfaces between the separated portions. The winding portions change their apparent width and direction as they pass around the curved ball, which is consistent with a screw-like cut. It is the only alternative that displays this spatial twisting rather than just a change in the direction of parallel lines. Thus it represents the effect described in the question.

Step 4: Conclusion The screw-groove pattern produces the twisting, winding separation illustrated in option (C). Hence, the correct option is (C).

Quick Tip to Solve: Do not confuse diagonal parallel slices with a helix: a screw pattern must wind around an axis while advancing along it.

54. One of the following answer figure is hidden in the problem figure in same size and direction select correct one.

[4 marks]

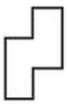


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- An embedded figure must preserve its sequence of turns, relative lengths and orientation. Translation is allowed, but the question does not permit rotation or reflection.
- Additional lines in the larger drawing may cross the required outline; trace the outline continuously instead of treating every small compartment as a separate candidate.

Step 1: Describe the distinctive boundary Option (B) is a stepped outline with an upper-right vertical portion and a lower-left portion joined through a central step. Trace its perimeter clockwise and keep the long vertical direction fixed. The two ends are offset horizontally, so it is neither a simple L shape nor a symmetric cross. Its sequence of two outward steps and two inward steps gives a useful signature that can be followed through the busy problem figure.

Step 2: Locate the same outline in the problem figure Look in the lower central part of the large square, just to the left of its centre line. The top of the required shape is the short horizontal segment below the central tall compartment. From its right end, follow the vertical line downward to the long horizontal boundary above the bottom row. Turn left along that boundary, then downward along the short vertical step to the bottom border. Follow the border leftward, turn upward along the long vertical segment, then right along the upper edge of the lower-left compartment and upward to the starting level. This is the same upright, offset boundary as option (B). Additional lines meet or cross this outline, but do not change its required perimeter.

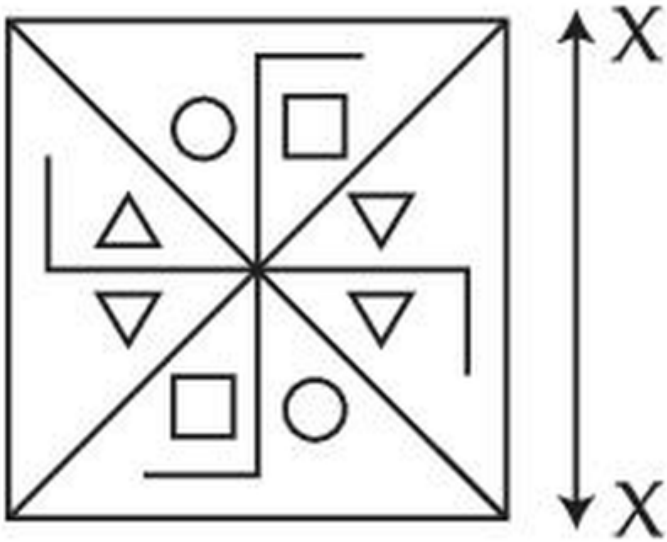
Step 3: Compare the other candidate shapes Option (A) requires a horizontal bar with a central downward opening and matching arms, whereas the traced outline has two offset ends. Option (C) requires a single corner cut from a compact rectangular outline; it lacks the second offset step. Option (D) is a symmetric plus-shaped outline with four projecting arms. The large drawing contains many suggestive fragments, but those fragments do not supply the complete boundary of these alternatives in the required size and orientation. The continuous stepped boundary matches option (B).

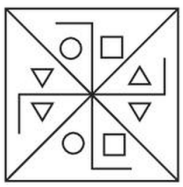
Step 4: Conclusion The upright stepped outline of option (B) is embedded in the lower central portion of the problem figure without rotation or reflection. Hence, the correct option is (B).

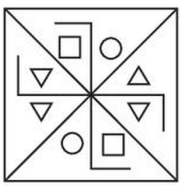
Quick Tip to Solve: Trace the lower central stepped boundary without turning at crossing lines; compare its complete clockwise sequence of turns with option (B).

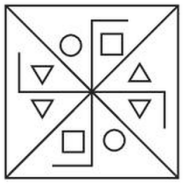
55. Which of the answer figure is correct mirror image of the problem figure with respect to X-X ?

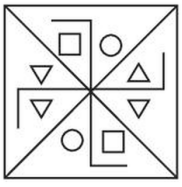
[4 marks]

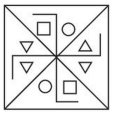


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A mirror or projection preserves the relationships implied by its viewing direction; track asymmetric landmarks rather than the outside outline alone.
- Compare the position, orientation and connection of each feature independently; a candidate is correct only if all required details agree.

Step 1: Apply the mirror rule The line X–X is vertical, so reflection reverses left and right while leaving heights unchanged. Every symbol must move to the equally distant position on the opposite side of the centre line. The square outline and its diagonals remain a square divided into the same sectors; their symmetry alone cannot identify the answer. Use the small circles, squares, triangles and bent lines as landmarks instead.

Step 2: Track the upper and lower symbols In the upper half, the circle originally left of the centre must appear on the right, and the small square originally on the right must move left. The upright triangle on the left must move to the right without becoming upside down. In the lower half, the small square must move from the left to the right, while the circle moves from the right to the left. The downward triangles keep pointing down because a vertical mirror does not reverse up and down.

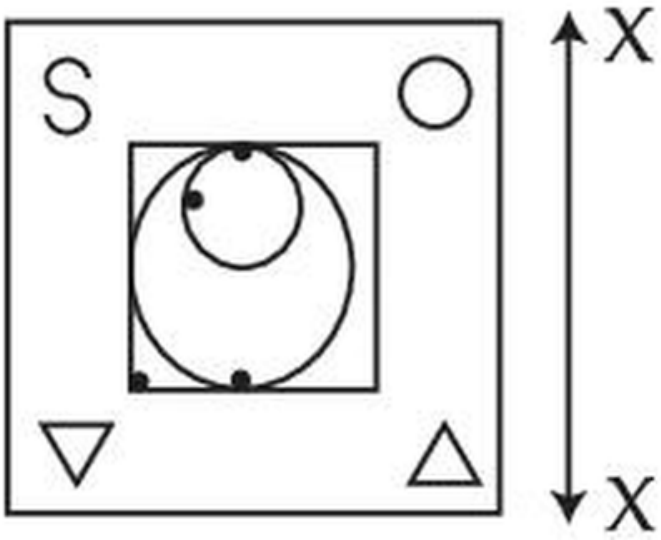
Step 3: Compare all the choices Option D satisfies these symbol positions and also reverses the bent line segments correctly: the upper elbow extends left from the vertical segment and the lower elbow extends right. Option A leaves the upper circle and square in their original left-right positions. Option B substitutes an open V-like mark for the complete upper-left downward triangle. Option C retains several original symbol positions and has an incorrect triangle arrangement. Thus similarity of the outside frame is insufficient; D alone preserves all reflected details.

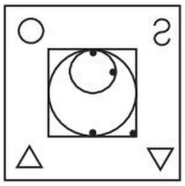
Step 4: Conclusion The required answer figure is option (D). Hence, the correct option is (D).

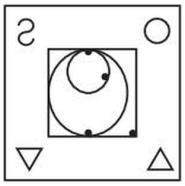
Quick Tip to Solve: Use one circle, one square and the upright triangle as three independent landmarks; then check the elbows to avoid selecting a near-match.

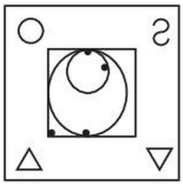
56. Which one of the answer figure is correct mirror image of problem figure with respect to X-X ?

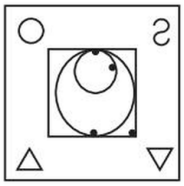
[4 marks]

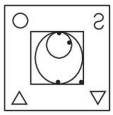


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A mirror or projection preserves the relationships implied by its viewing direction; track asymmetric landmarks rather than the outside outline alone.
- Compare the position, orientation and connection of each feature independently; a candidate is correct only if all required details agree.

Step 1: Reverse horizontal positions A vertical mirror exchanges left and right but preserves vertical positions, lengths and incidence. The open circle at the upper right of the original must therefore be at the upper left of the image. The letter S at the upper left must appear at the upper right with its handedness reversed. At the bottom, the downward triangle on the left must move right, while the upright triangle on the right must move left.

Step 2: Check the internal curves and dots The inner square remains at the same height. Its bottom-

left corner dot must move to the bottom-right corner. The dot on the left side of the smaller inner loop must move to that loop's right side. Check the clearance between the large loop and the inner square as well. In the source, the large loop touches the square's left side, but there is a visible gap between its rightmost arc and the square's right side. Reflection reverses these contacts: the image must touch the right side and leave a gap at the left. The top and bottom contact dots stay at their original heights.

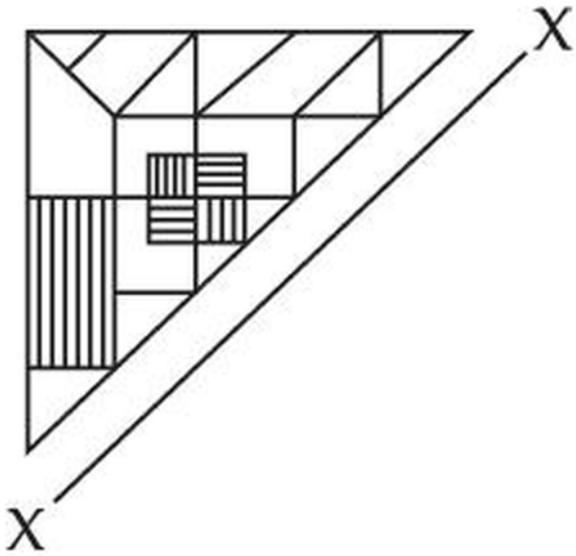
Step 3: Eliminate the near-matches Option D gives every required reversal: the upper circle is left, the reversed letter is right, the lower upright triangle is left and the inverted triangle is right. The inner corner dot and small-loop dot are on the right. Crucially, the large loop touches the right side of the square and leaves clearance on the left. A has a large loop touching both side boundaries, losing the required left-hand gap. B fails the outer circle and letter positions. C leaves the corner dot on the left and gives the wrong small-loop-dot location. Thus D alone preserves the complete reflected arrangement.

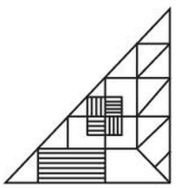
Step 4: Conclusion The reflected large loop must touch the right side of the inner square and leave a gap at the left, in addition to reversing all outer symbols and dots. Hence, the correct option is (D).

Quick Tip to Solve: After checking the corner symbols, compare the asymmetric curves: a near-correct mirror option often preserves one unreversed internal detail.

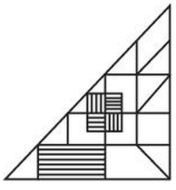
57. Which one of the answer figure is correct mirror image of problem figure with respect to X-X ?

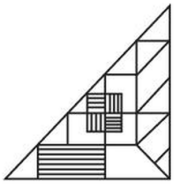
[4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A mirror or projection preserves the relationships implied by its viewing direction; track asymmetric landmarks rather than the outside outline alone.
- Compare the position, orientation and connection of each feature independently; a candidate is correct only if all required details agree.

Step 1: Locate the reflected triangle The mirror X–X slopes upwards to the right beside the sloping edge of the original triangular pattern. Reflect across this line rather than merely turning the page. The image lies on the opposite side of the mirror. Its lower horizontal side and right vertical side form the corresponding right angle. A reflection changes handedness, and a line perpendicular to the mirror joins each point to its image.

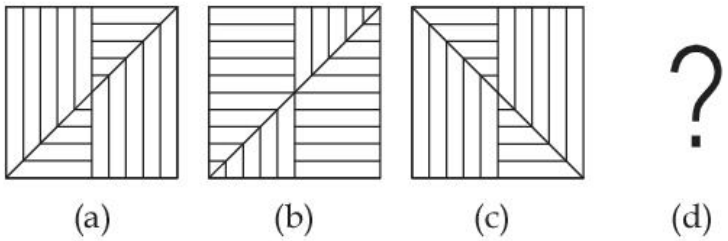
Step 2: Follow the striped blocks The large block of vertical stripes at the left of the original becomes a block of horizontal stripes along the lower edge of the image. This is because reflection in a diagonal line exchanges horizontal and vertical directions. The little four-part striped square must be checked independently. In the original its upper-left and lower-right cells have vertical stripes, while its upper-right and lower-left cells have horizontal stripes. Reflection in this sloping axis places horizontal stripes in the upper-left and lower-right image cells, and vertical stripes in the other two.

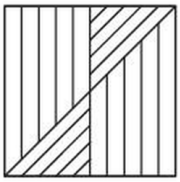
Step 3: Verify the remaining linework Option D has the lower horizontal band, the correct four-cell stripe pattern and the correctly reflected unshaded subdivision lines. A has the same general outer triangle but the small checkerboard of stripe directions is wrong. B leaves the large striped band vertical on the right instead of making it horizontal at the bottom. C also has incorrect internal stripe directions and subdivision details. Only D passes the position, orientation and connectivity tests together.

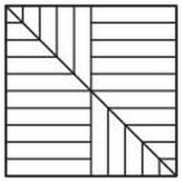
Step 4: Conclusion The required answer figure is option (D). Hence, the correct option is (D).

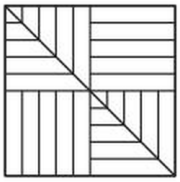
Quick Tip to Solve: For a diagonal mirror, track a striped rectangle first: vertical stripes become horizontal, and then the small checkerboard distinguishes close choices.

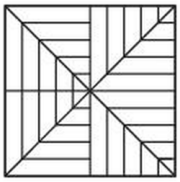
58. Which one of the answer figure will complete the sequence of the problem figure ? Choose correct one. [4 marks]

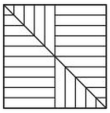


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A visual sequence or analogy must preserve all unchanged features while applying the same identified change consistently.
- Compare the position, orientation and connection of each feature independently; a candidate is correct only if all required details agree.

Step 1: Separate the two changing features Treat the long diagonal and the direction of the short parallel strokes as separate features. In figure a the diagonal rises from bottom left to top right. The upper-left and lower-right regions contain vertical strokes, while the upper-right and lower-left regions contain horizontal strokes. In figure b the long diagonal still rises in the same direction, but the horizontal and vertical stroke directions in the regions have exchanged.

Step 2: Continue the alternating operations Between b and c the stroke allocation stays the same: upper left and lower right are horizontal, while upper right and lower left are vertical. The long diagonal now falls from top left to bottom right. Thus the sequence alternates between exchanging the stroke directions and reversing the long diagonal. Apply the stroke-direction exchange next, keeping the falling diagonal of c. The required figure has vertical strokes in its upper-left and lower-right regions and horizontal strokes in the other two.

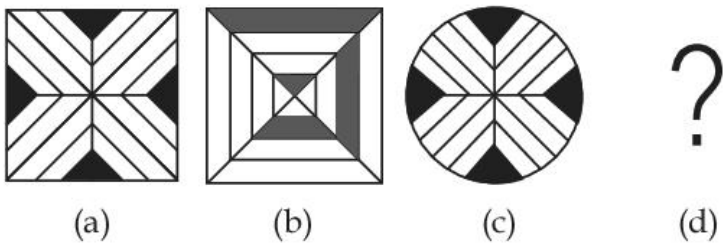
Step 3: Choose the matching continuation Option B has exactly this falling diagonal and the required allocation of horizontal and vertical strokes. A retains a rising diagonal and uses a different distribution of oblique lines. C keeps vertical strokes across both lower-left and upper-left regions instead of

completing the required exchange. D introduces several diagonals meeting at the centre, a structure absent from the three given figures. The answer follows the alternating changes without adding a new construction rule.

Step 4: Conclusion The required answer figure is option (B). Hence, the correct option is (B).

Quick Tip to Solve: Track the long diagonal separately from the short hatch lines; alternating changes become easier to see than when the whole square is treated as one shape.

59. Which one of the answer figure will complete the sequence of the problem figure ? Choose the correct one. [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A visual sequence or analogy must preserve all unchanged features while applying the same identified change consistently.
- Compare the position, orientation and connection of each feature independently; a candidate is correct only if all required details agree.

Step 1: Identify the paired relation Figures a and b are both square patterns, while figure c repeats the structure of a inside a circular boundary. In a and c the radial spokes, alternating black wedges at the four cardinal positions and narrow parallel bands have the same arrangement; the outside shape changes from square to circle. Therefore the missing figure must reproduce the internal organisation of b using circular bands, just as c reproduces a in a circle.

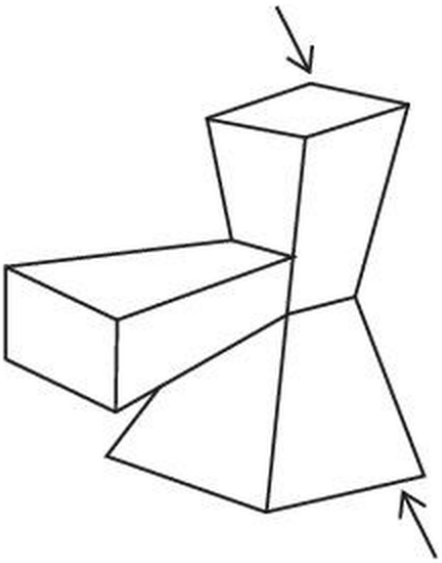
Step 2: Transfer the shaded positions Read the black areas in b by direction and by distance from the centre. The outer upper band is black. A black band occurs on the right at an intermediate distance, and a black band occurs below the centre nearer the middle. The central pattern includes the upper and lower dark triangular sectors separated by the diagonal spokes. Preserve these radial positions and directions when square bands become concentric circles; do not rotate the pattern or fill additional sectors.

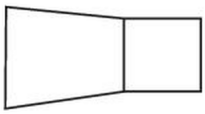
Step 3: Check all circular options Option C places the outer black band at the top, the intermediate one at the right and the inner one at the bottom, while preserving the central dark sectors and crossing diagonal lines. A places the intermediate black band on the left. B adds black shading on the inner left, changing the required arrangement. D alters both the central sectors and the extent of the dark rings. Consequently C alone performs the same square-to-circle transformation that relates a to c.

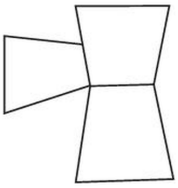
Step 4: Conclusion The required answer figure is option (C). Hence, the correct option is (C).

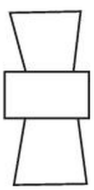
Quick Tip to Solve: For shape analogies, preserve direction and ring depth of each dark patch; the boundary may change, but the internal positional relationships must not.

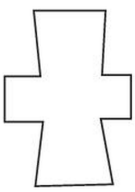
60. The 3D figure shows the view of an object. Find out the odd shape from the answer figures which is not related to 3D figure. [4 marks]

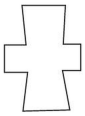


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A mirror or projection preserves the relationships implied by its viewing direction; track asymmetric landmarks rather than the outside outline alone.
- Compare the position, orientation and connection of each feature independently; a candidate is correct only if all required details agree.

Step 1: Inspect the solid components The object contains an upright member with a narrow middle and wider ends, together with a projecting arm. Its visible faces show a genuine waist: the upper portion tapers towards the junction, and the lower portion widens away from it. Orthographic views suppress depth, but they must preserve the visible changes in width when these changes lie in the plane of the view. Shared edges may overlap in a projection; new constant-width portions cannot be invented.

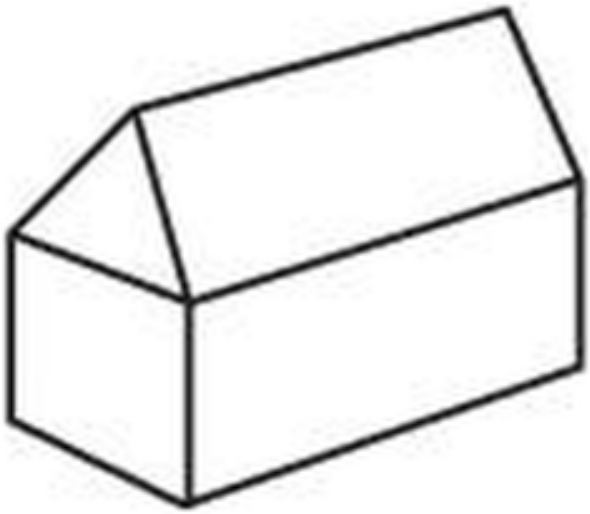
Step 2: Recognise the related projections Option A is a side projection: the long projecting face is seen as a tapering quadrilateral next to the end face. B is a view in which the projecting arm appears to one side of the upright tapered member, with the narrow central connection retained. C is the corresponding view in which the arm presents a broad rectangular face across the middle of the upright member. These drawings retain the characteristic proportions, waist and joining relationship of the same object from different directions.

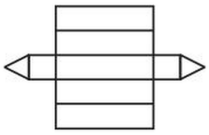
Step 3: Find the incompatible outline D gives a cross-like outline whose upper portion does not retain the inward taper towards the narrow junction shown by the solid. Compare the top width and the width just above the projecting arm: the given upper member narrows towards the arm, whereas D does not show this required narrowing. It also omits the face divisions that distinguish the arm from the upright member in the corresponding view. A preserves the long tapering side and end face; B preserves the side projection and waist; C preserves the broad face of the arm across the tapered upright. D is therefore the figure that is not a related view of the given object.

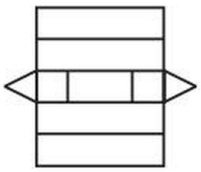
Step 4: Conclusion The required answer figure is option (D). Hence, the correct option is (D).

Quick Tip to Solve: Before matching a solid to its views, mark widths at the top, junction and bottom; a projection cannot arbitrarily turn a visible taper into parallel sides.

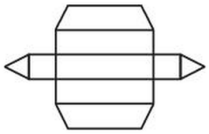
61. The 3D figure shows the view of an object. Identify the correct view when figure opened up amongst the answer figures. [4 marks]

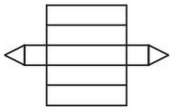


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A net is a planar development of every face of a solid. Folding must recover the same edges without gaps, overlapping faces or a change of face shape.
- The object has a house-shaped pentagonal end and a uniform length: it is a pentagonal prism. Its boundary consists of five rectangular lateral faces and two congruent pentagonal ends.

Step 1: Identify the cross-section Look at the near end of the solid. Its outline has a bottom, two upright sides and two sloping roof edges. These five edges identify a pentagon, although it can be viewed as a rectangle with a triangular roof. The long faces connect corresponding edges of the two identical ends.

Step 2: Check the folding pattern In option (A), five rectangular panels form one continuous strip. The two end pieces are attached on opposite sides of the strip; each contains the rectangular and triangular portions of the house-shaped end. Folding the strip closes the five-sided perimeter, and the

two matching end pieces close the opposite ends.

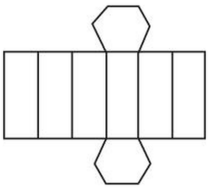
Step 3: Eliminate the other developments Option (B) subdivides the central lateral strip in the wrong direction and does not preserve the common longitudinal span of its panels. Option (C) has only four successive panels in the strip, leaving one of the five lateral faces missing. Option (D) changes the end panels of the strip into trapezoids, whereas all lateral faces of this straight prism are rectangles.

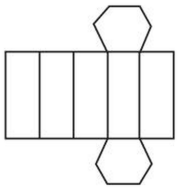
Step 4: Conclusion Option (A) supplies the complete rectangular strip and the matching house-shaped ends. Hence, the correct option is (A).

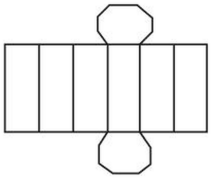
Quick Tip to Solve: Count the sides of the end cross-section first: a five-sided prism needs five lateral rectangles and two matching end faces.

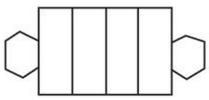
62. The 3D figure shows the view of an object. Identify the correct view when the figure opened up from amongst the answer figures. [4 marks]

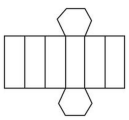


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A right prism has two congruent polygonal bases. Each side of either base corresponds to one rectangular lateral face.
- For an n-sided prism, the net needs n rectangular side panels and two n-sided bases. The bases must close opposite ends of the lateral strip.

Step 1: Count the sides of the end face The top face in the problem is a hexagon: trace its outline through its six straight sides. The visible vertical faces extend down from its sides, so the object is a hexagonal prism rather than an octagonal or rectangular prism. Its hidden side faces must also be included in the development.

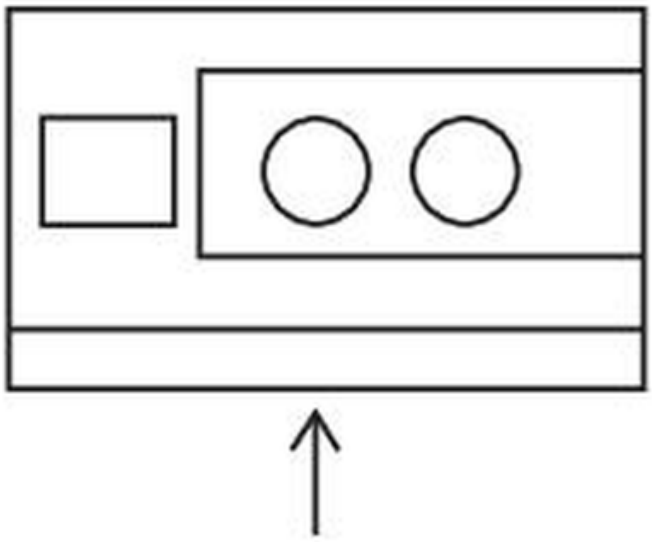
Step 2: Match the complete lateral strip Option (A) contains six adjacent rectangular panels of the same height. These can wrap around to make the six side walls. It also has two hexagons, one attached above and one below the strip, which close the two opposite open ends after folding. No base is being used as a lateral panel.

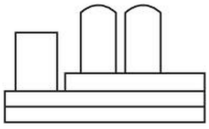
Step 3: Reject the incomplete or mismatched nets Option (B) provides only five rectangular side panels, so one side wall is absent. Option (C) uses eight-sided end faces even though its strip has only six panels and the given object has hexagonal ends. Option (D) has only four rectangular panels and places the hexagons on the strip ends instead of providing the complete six-face lateral band. These patterns cannot reproduce the given solid.

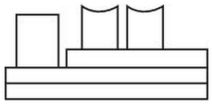
Step 4: Conclusion The six-panel strip with two hexagonal ends in option (A) is the required net. Hence, the correct option is (A).

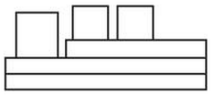
Quick Tip to Solve: For a prism net, match the number of side rectangles to the number of sides of either polygonal base before considering the fold.

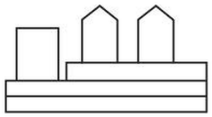
63. The problem figure shows the top view of an object. Identify the correct elevation amongst the answer figure looking in the direction of the arrow. [4 marks]

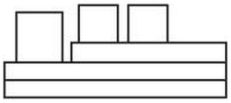


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- An elevation is the orthogonal projection on a vertical plane. Features at the same horizontal position in the plan retain that position in the elevation.
- A vertical circular cylinder appears as a circle in plan and as a rectangle in elevation. Its circular upper rim projects to a straight horizontal line, not an arc.

Step 1: Read the viewing direction and arrangement The arrow points upward on the page, so the requested elevation is seen from the lower edge of the plan. The separate square footprint is on the left. Two circular footprints stand side by side on the larger rectangular platform to the right. Preserve this left-to-right order when comparing the answer figures.

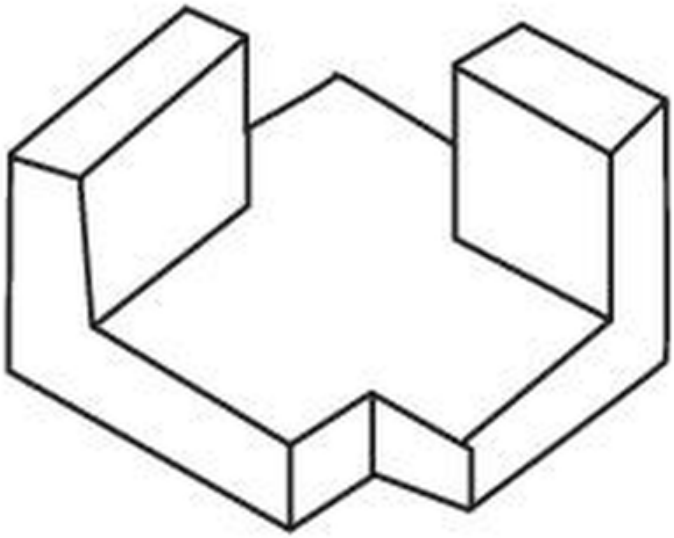
Step 2: Project the circular features Each circular footprint represents a vertical cylindrical feature. Looking horizontally at such a feature gives two vertical extreme generators and a straight top edge. Therefore the two features on the right must have rectangular silhouettes. Their plan circles do not become semicircular, hollow or pointed roof lines in the elevation.

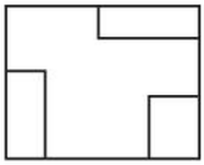
Step 3: Compare all four silhouettes Option (C) has the left rectangular feature, the raised support at the right, and two upright rectangular cylindrical projections in their correct order. Option (A) rounds their tops upward, and option (B) makes their tops concave; neither is the orthographic outline of the shown cylindrical features. Option (D) substitutes pointed pentagonal tops. Those changes are unsupported by the circular footprints in the supplied plan.

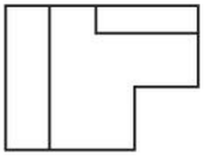
Step 4: Conclusion The arrangement with two flat-topped rectangular cylinder projections is option (C). Hence, the correct option is (C).

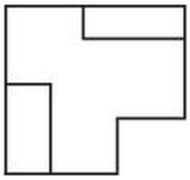
Quick Tip to Solve: Keep the horizontal order from the plan and remember that a vertical cylinder has a rectangular elevation, even though its plan is circular.

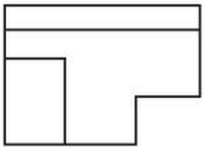
64. The 3D figure shows the view of an object. Identify the correct top view, from amongst the answer figure. [4 marks]

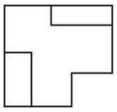


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A top view is obtained by projecting the object vertically downward onto a horizontal plane. Height disappears, while the footprint and the boundaries between different horizontal levels remain.
- In a pictorial view, parallel horizontal edge directions become the two perpendicular directions of the plan. Trace the outside perimeter before drawing the visible internal edges.

Step 1: Trace the footprint The base is not a complete rectangle: its front boundary steps inward, making a re-entrant corner. In plan this produces the lower-right rectangular notch shown in the relevant alternatives. The two upright blocks have finite footprints along different outer sides, and the remaining central area is the lower horizontal base.

Step 2: Locate both raised strips The left raised block occupies only the corresponding end portion of the left boundary; its footprint does not run the entire length of that side. The right raised block

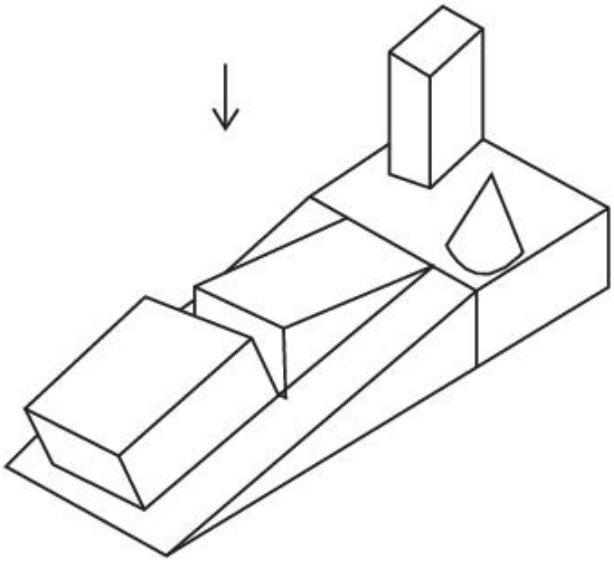
occupies the upper-right part of the plan. Their inner vertical faces appear as boundaries of these two rectangular strips when height is removed. Retain the notch and both strip endpoints together.

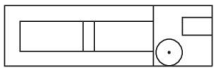
Step 3: Eliminate the alternatives Option (C) preserves the notched perimeter, the shorter strip at the lower left and the strip at the upper right. Option (A) fills in the notch, turning the perimeter into a full rectangle. Option (B) extends the left strip along the whole side, beyond the given raised block. Option (D) extends the upper strip across the whole top edge. Each of those alternatives changes a visible footprint or its extent.

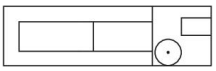
Step 4: Conclusion The perimeter and the two raised-strip footprints match option (C). Hence, the correct option is (C).

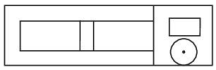
Quick Tip to Solve: Trace the notched outer boundary first, then mark where each raised block actually begins and ends; do not extend a wall across the whole base.

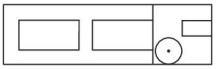
65. The 3D figure shows the view of an object. Identify the correct view in the direction of the arrow, from the answer figure's. [4 marks]

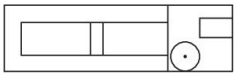


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An orthographic view in the downward arrow direction records horizontal footprints. Heights and apparent perspective lengths are suppressed.
- A cone gives a circular footprint with its apex projected at the centre; an upright rectangular prism

gives a rectangular footprint. Separate changes of slope can create additional visible edges.

Step 1: Project the objects at the far end The arrow is downward, so inspect the composite object from above. At the right end, the cone projects as a circle toward the lower side of the strip, while the tall rectangular column projects near the upper outer edge. The circle contains the apex point. Both their positions and their separation from the strip edges must be retained.

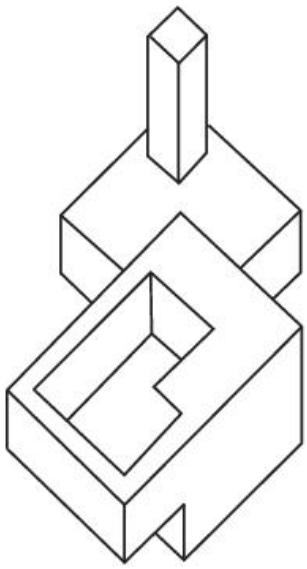
Step 2: Trace the central and left features The base becomes a long rectangle. The raised shapes on its left and middle create an inner longitudinal band. In the middle, the change between adjoining sloping and upright surfaces leaves two nearby transverse lines: a narrow intermediate band is visible in the correct plan. The left block remains within the longitudinal outline rather than becoming a detached square.

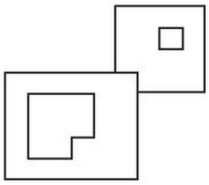
Step 3: Compare the differentiating details Option (A) retains the narrow central band, the circle near the lower side and the column footprint against the upper-right edge. Option (B) merges the nearby transverse lines into one and loses that band. Option (C) moves the column inward and changes the relative placement of the circle. Option (D) introduces a much wider separation between the left and middle shapes. These are geometric differences, not merely changes of drawing scale.

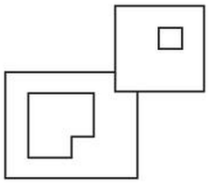
Step 4: Conclusion All the projected components and the narrow intermediate band match option (A). Hence, the correct option is (A).

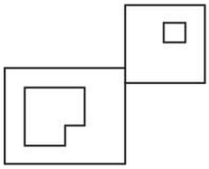
Quick Tip to Solve: For a composite top view, compare the smallest separating band as well as the obvious circle and rectangle; close parallel edges often decide the answer.

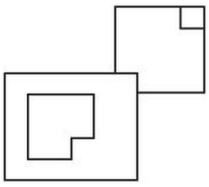
66. The 3D figure shows the view of an object. Identify the correct top view, amongst the answer figures. [4 marks]

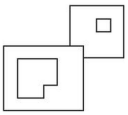


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A top view preserves horizontal outlines and the footprints of holes, recesses and vertical columns. Vertical height is removed by projection.
- Where one surface obscures another, retain only the visible boundary. A column standing on a platform appears as its small polygonal footprint inside that platform.

Step 1: Identify the two main footprints The near form projects as a large square outline with a stepped internal recess. Its recess is not a plain square: the inward step on one side remains visible from above. The rear platform supplies a second, offset square footprint, with the upright narrow column projecting as a small square within it.

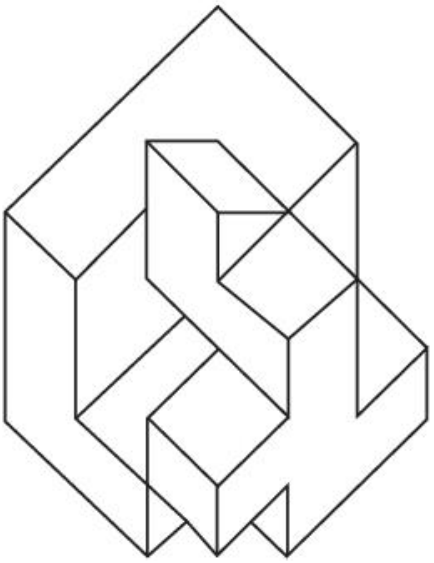
Step 2: Track the overlap and the column The front frame lies across the near corner of the rear platform. In the top projection, the front outline continues across that overlap while the hidden portion of the rear platform boundary is interrupted. The small column stands inward from the rear platform edges rather than at a corner. Preserve these overlap relationships instead of drawing every complete square through the other.

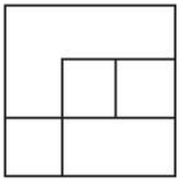
Step 3: Distinguish the four options Option (A) shows the front outline uninterrupted at the overlap, the proper stepped recess, and the column square inset within the rear platform. Option (B) reverses the visible overlap by continuing the rear square over the front corner. Option (C) makes the two large forms meet at a corner without their actual overlap. Option (D) puts the column footprint directly at the rear corner. Each distractor changes a specific visible feature of the given solid.

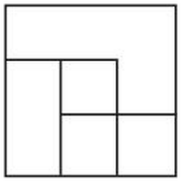
Step 4: Conclusion The offset footprints, stepped recess and inset column agree with option (A). Hence, the correct option is (A).

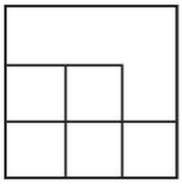
Quick Tip to Solve: After matching the large outlines, check which outline hides the other at their overlap and whether the small column is inset or touches an edge.

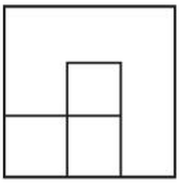
67. The 3D figure shows the view of an object. Identify the correct top view, amongst the answer figure's. [4 marks]

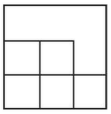


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- The top view is the vertical projection of the solid onto a horizontal plane. Height disappears, while the positions of horizontal edges in the two plan directions remain.
- Only actual visible changes of level or boundaries produce internal lines in the plan. An edge seen obliquely in the pictorial view must first be assigned its horizontal direction; its apparent slope on the page is not its plan direction.

Step 1: Trace the outer plan boundary Look straight down on the solid, using the two families of parallel oblique edges as the two perpendicular plan directions. The overall footprint is a square. The stepped vertical faces remain within that square, so the top view is neither the pictorial zigzag outline nor a silhouette taken from a side.

Step 2: Project the stepped horizontal boundaries Track the horizontal ledges from the near corner

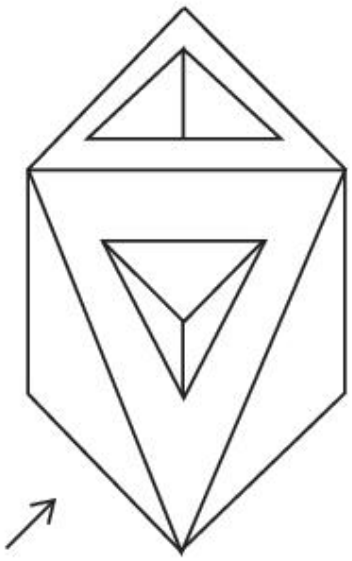
towards the far corner. Their plan gives a full horizontal division across the lower part, and a second horizontal division extending from the left edge to the second internal vertical. In the lower strip both internal vertical divisions are present. In the middle strip the central division separates two small regions, while the upper and right portions join around them. This is the arrangement in (C).

Step 3: Compare the proposed plans Option (A) continues the upper short horizontal division towards the right instead of the left and shifts the interior arrangement. Option (B) places the long wrapping region in the opposite orientation. Option (D) suppresses the right-hand internal subdivision in the lower strip. Keeping the original viewing orientation, rather than rotating an answer merely to make it resemble the solid, leaves (C).

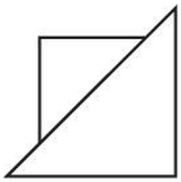
Step 4: Conclusion The correct top view is the square plan with the internal divisions shown in (C). Hence, the correct option is (C).

Quick Tip to Solve: For a top view, ignore vertical lengths and trace only the footprint and the positions where the horizontal levels change.

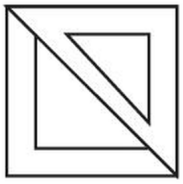
68. The 3D figure shows the view of an object. Identify the correct view looking in the direction of arrow, from answer figure's. [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- An orthographic view is obtained by looking parallel to the indicated arrow. Distances along the viewing direction collapse, while horizontal and vertical positions across the viewing plane remain.
- A visible edge is drawn only once when several edges coincide in projection. A line belonging to an inclined face need not remain visible on the face behind it.

Step 1: Fix the direction before tracing edges The arrow at the lower left directs the observer towards the solid from that side. Keep this direction fixed: do not interchange it with the lower-right viewing direction. The outer projected boundary is a square. The prominent inclined boundary projects from its upper-left corner to its lower-right corner.

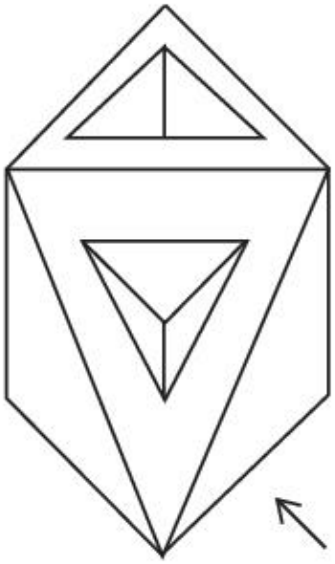
Step 2: Project the triangular opening The triangular recess on the face visible from this side is projected into the upper-right half of the square. It appears as a right triangle, with its horizontal upper edge and vertical right edge joined by a descending oblique edge. The internal meeting edges seen in the pictorial recess coincide or are screened in this direction; they do not create another triangle in the lower-left half.

Step 3: Reject the changed and extra lines Option (A) reverses the diagonal and puts the triangle on the other side. Option (B) loses the complete square boundary and therefore represents neither the required silhouette nor its visible recess. Option (D) adds a lower-left triangular set of lines that does not survive as visible edges in this view. Option (C) alone has the complete square, descending diagonal and single upper-right triangular opening.

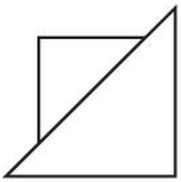
Step 4: Conclusion The required view is the square with a descending diagonal and an upper-right triangular opening. Hence, the correct option is (C).

Quick Tip to Solve: Anchor the diagonal to two named corners first; this immediately distinguishes left-side and right-side views of the same solid.

69. The 3D figure shows the view of an object. Identify the correct view looking in the direction of arrow, from given answer figures. [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- The arrow specifies the observer position and the direction of projection. A right-side view and a left-side view of the same object can place a recess on opposite sides of a diagonal.
- Projection preserves vertical alignment and removes depth. Edges that are behind an opaque face are omitted from a view drawn using visible outlines only.

Step 1: Read the lower-right arrow Here the observer looks from the lower-right side towards the object. Although the solid resembles that used in another directional-view problem, the arrow is different. The outline projects as a complete square, and the main diagonal rises from its lower-left corner to its upper-right corner.

Step 2: Locate the projected recess From this side the visible triangular opening lies above and to the left of the rising diagonal. Its top edge is horizontal, its left edge is vertical, and its third edge

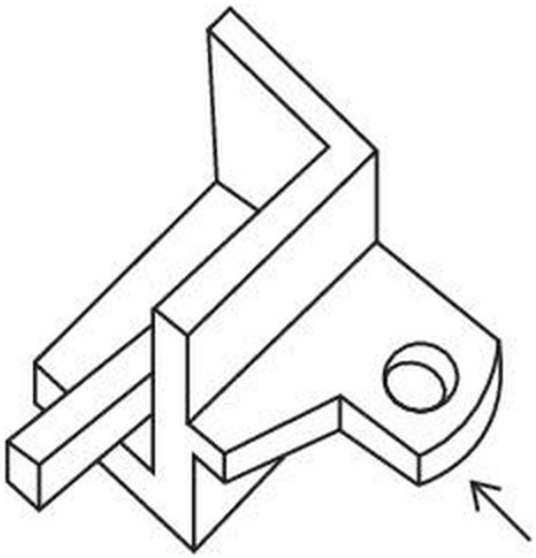
rises towards the right. The triangular subdivisions on the other inclined face do not all appear independently: depth collapses some edges and the intervening surface hides others.

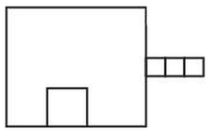
Step 3: Match silhouette and internal edges together Option (A) shows precisely the square outline, rising diagonal and single upper-left triangular opening. Option (B) retains only a triangular outline and omits portions of the outer square. Option (C) reverses the diagonal and moves the opening into the upper-right half, corresponding to the other side. Option (D) has that reversed diagonal and also adds an extra lower-left triangular outline. Thus neither reflection nor an extra hidden edge can be accepted.

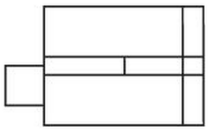
Step 4: Conclusion The correct directional view is the square with the rising diagonal and upper-left triangular opening. Hence, the correct option is (A).

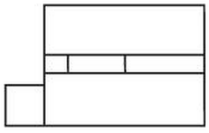
Quick Tip to Solve: When a solid repeats, check the arrow again: changing the observer side can reverse the main diagonal even though the solid is unchanged.

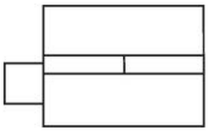
70. The 3D figure shows the view of an object. Identify the correct view looking in the direction of arrow amongst the answer figures. [4 marks]

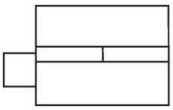


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- For a directional view, project the entire object parallel to the arrow, retaining heights and transverse positions while collapsing depth.
- A circular hole in a horizontal plate does not necessarily appear as a circle in an elevation. Its opening can be screened by the plate edge or a wall; do not add lines for invisible surfaces.

Step 1: Determine the overall elevation The lower-right arrow looks towards the broad side of the raised wall. The main wall projects as a rectangle. The transverse member projecting past its left edge produces a smaller rectangular projection outside that edge. The visible horizontal plate contributes a narrow horizontal band across the main rectangular region.

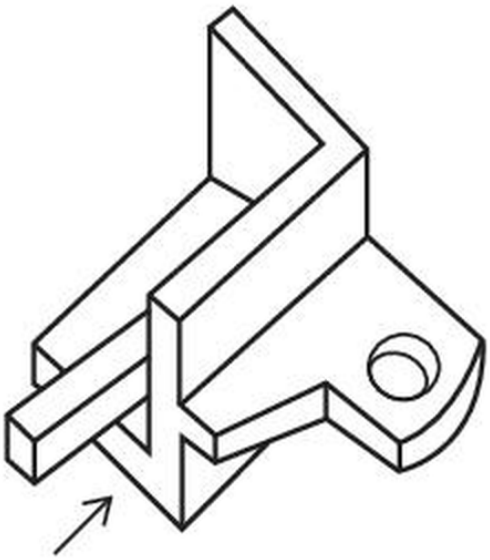
Step 2: Trace the divisions that remain visible Follow the front and rear edges of that plate into the projection. They give the two parallel horizontal lines delimiting the central band. The local change in the plate shape produces one short vertical division in that band. The circular hole is in a horizontal face: viewed along this horizontal arrow, its round top opening is not seen as a circle. Nor does it justify carrying a vertical line through the full wall height.

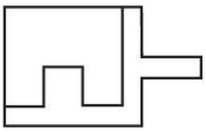
Step 3: Compare all four edge patterns Option (A) has a bottom notch and a projection on the wrong side, so its silhouette does not match this direction. Option (B) adds a full-height narrow strip on the right that is not a visible division of this elevation. Option (C) introduces an additional short vertical division near the left end of the band. Option (D) keeps the correct external projection and only the one required band division. It therefore matches both the silhouette and visible internal edges.

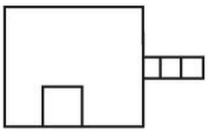
Step 4: Conclusion The view along the indicated arrow is the rectangular elevation with the left projection and central band shown in (D). Hence, the correct option is (D).

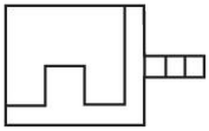
Quick Tip to Solve: Check the silhouette first, then the number of lines inside a narrow band; an extra projected edge can distinguish otherwise similar options.

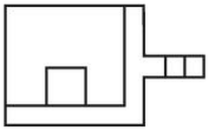
71. The 3D figure shows the view of an object. Identify the correct view looking in the direction of arrow, from answer figure's. [4 marks]

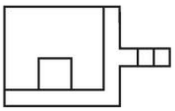


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- An elevation along an arrow is formed by collapsing all depths parallel to that arrow. The resulting outline and visible junctions must both agree with the three-dimensional object.
- Where a projecting member has faces at different depths, the outer profile may coincide while its visible face boundaries remain as short internal lines.

Step 1: Project the wall from the indicated side The lower-left arrow directs the view towards the other face of the stepped wall. The large upright portion appears rectangular. Its thin base and the return at the right are visible as a continuous lower and right border. The transverse member extends outside the right edge, so an option placing it elsewhere is inconsistent with the viewing direction.

Step 2: Retain the visible recess and member divisions The lower central recess has two upright sides and a horizontal top. The lower return of the solid is visible through this opening, so its horizontal upper edge continues straight across the base of the recess. It must not disappear between the two uprights. On the right, follow the projecting member: its exposed face has two short vertical subdivisions. Where that member joins the upright return, the visible outer outline turns onto the

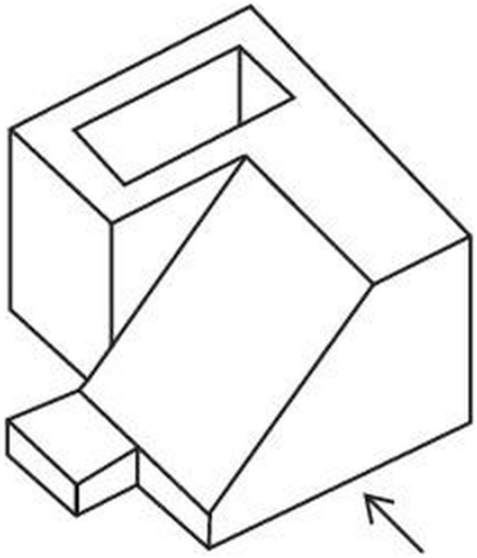
member and then returns to the wall below it; a separate vertical seam across that junction is not shown in this view.

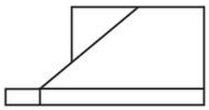
Step 3: Eliminate incomplete projections Option (A) has the lower-right return but omits the two short divisions on the projecting member. Option (B) has the subdivisions but loses that return. Both (C) and (D) have the lower-right return and the subdivided projection, so those features alone cannot distinguish them. In (C), the upper line of the bottom return stops at each side of the central recess, leaving no horizontal line across its base; it also continues the outer right upright vertically through the projecting-member junction. In (D), the lower horizontal line continues across the recess, and the outer right upright turns onto the projection instead of cutting vertically through its attachment. These line-continuity differences agree with the visible lower return and the connected projecting member in the solid, selecting (D).

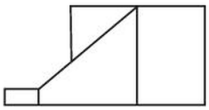
Step 4: Conclusion The view must retain the horizontal return edge across the lower recess and the open junction of the subdivided right-hand projection. These features are shown in (D). Hence, the correct option is (D).

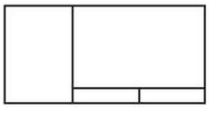
Quick Tip to Solve: For a recess, distinguish an internal visible boundary from an actual break in the outer silhouette before comparing answer figures.

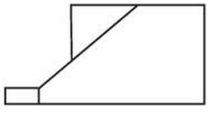
72. The 3D figure shows view of an object. Identify the correct view looking in the direction of arrow, from the answer figure's. [4 marks]

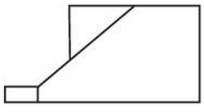


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- In a side elevation an inclined planar face projects as a straight sloping edge when its width lies along the viewing direction.
- An opening on an upper face is shown only if its boundary is visible in the chosen direction. The side outline of an opaque solid does not acquire every edge seen in its pictorial top view.

Step 1: Trace the external side silhouette Look along the lower-right arrow. The thin low projection extends to the left. Starting at its upper-right corner, the inclined face rises towards the top of the main block. Beyond the upper end of that incline the top outline is horizontal and the far side is vertical. The bottom is horizontal, giving the stepped profile drawn in (D).

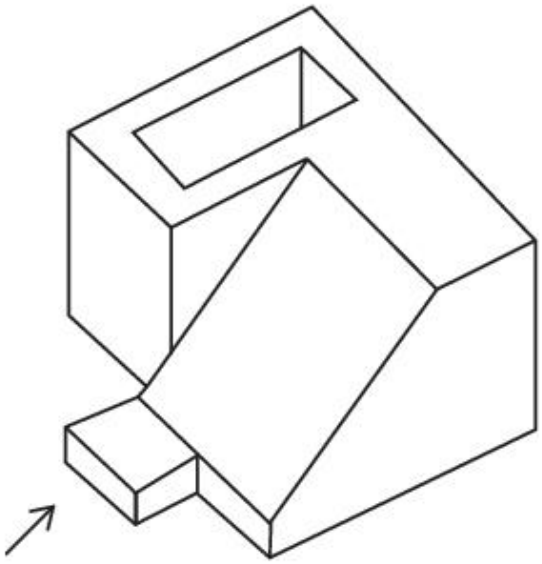
Step 2: Decide which internal edges survive The change from the inclined front to the higher rear block leaves a short upright segment above the lower part of the incline. The incline itself remains one uninterrupted straight line until it meets the top. The rectangular opening visible on the upper face is screened in this side projection; its depth edge must not be carried down through the entire elevation. Similarly, the thin base does not create a continuous horizontal seam across the face of the main block.

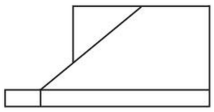
Step 3: Compare the candidate outlines Option (A) adds a full-width horizontal strip along the bottom of the main block. Option (B) adds a vertical division from the top of the incline to the base, which is not a visible side edge. Option (C) has a largely rectangular subdivision and does not reproduce the rising inclined profile. Option (D) shows the left low projection, the rising edge, the short upright segment behind it and the uninterrupted main side face. It is therefore the consistent projection.

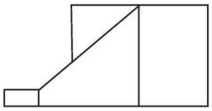
Step 4: Conclusion The side view along the arrow is the inclined profile shown in (D). Hence, the correct option is (D).

Quick Tip to Solve: Trace the outer profile as one continuous path, then add only visible edges; do not project every top-surface detail into a side view.

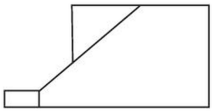
73. The 3D figure shows view of an object, looking in the direction of arrow, identify the correct elevation from the answer figures. [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- An elevation is an orthographic view: depth along the indicated line of sight is suppressed, while visible outlines and edges are retained.
- Compare the whole boundary and its internal divisions, rather than selecting an option from one locally similar line.

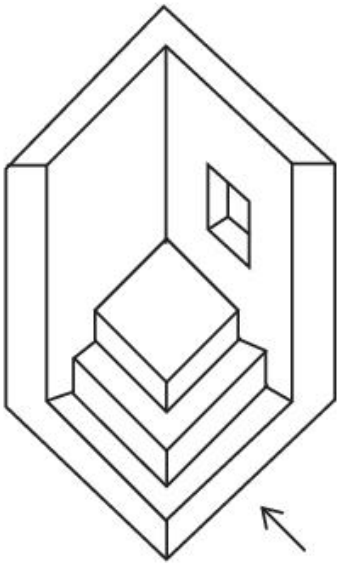
Step 1: Project in the indicated direction Follow the arrow towards the object and suppress distances along that viewing direction. The inclined surface is foreshortened in this elevation; it must not be reproduced as a diagonal simply because it looks diagonal in the pictorial view. The high rear portion gives a rectangular upper boundary, while the low projecting foot remains at the bottom.

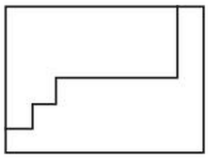
Step 2: Check the visible divisions The elevation has a full-height division towards the left and a low horizontal band on the right, with the projecting foot divided within that band. This arrangement is shown in (C). Options (A), (B) and (D) all retain a prominent diagonal ramp edge, so they depict a different viewing direction. Option (B) also adds a vertical division at the diagonal endpoint.

Step 3: Conclusion The required figure is the one shown in option (C). Hence, the correct option is (C).

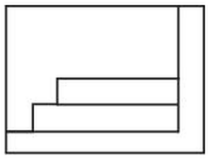
Quick Tip to Solve: Trace the viewing arrow first; never copy an isometric diagonal directly into an elevation.

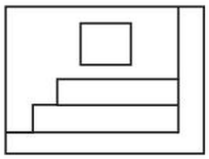
74. The 3D figure shows the view of an object. Identify the correct view looking in the direction of arrow, from the answer figure's. [4 marks]

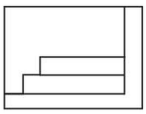


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- An elevation is an orthographic view: depth along the indicated line of sight is suppressed, while visible outlines and edges are retained.
- Compare the whole boundary and its internal divisions, rather than selecting an option from one locally similar line.

Step 1: Look past the near edge The arrow directs the sight towards the corner assembly from the lower right. In this view the wall on the right is seen edge-on, while the other wall provides the broad rectangular background. The small opening in the side wall does not appear as a square in the broad background.

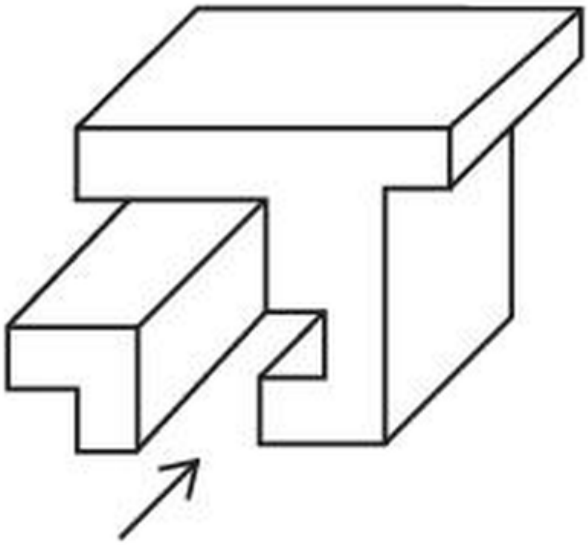
Step 2: Preserve the stepped platform and base The three rising levels appear as horizontal ledges joined by vertical risers. The outside wall edge and the continuous bottom base frame the view, giving (C). Option (A) omits the visible horizontal ledges. Option (B) extends the right-hand strip

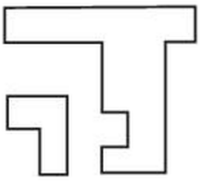
through the bottom base instead of retaining its continuous framing. Option (D) incorrectly shows the side-wall window on the broad wall.

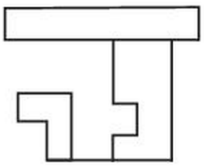
Step 3: Conclusion The required figure is the one shown in option (C). Hence, the correct option is (C).

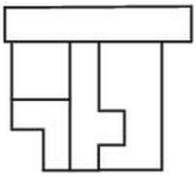
Quick Tip to Solve: Separate the background wall, its edge-on neighbour and the steps before comparing similar elevations.

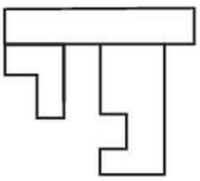
75. The 3D figures shows the view of an object. Identify the correct view looking in the direction of arrow, from the given answer figures. [4 marks]

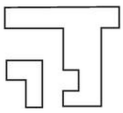


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An elevation is an orthographic view: depth along the indicated line of sight is suppressed, while visible outlines and edges are retained.
- Compare the whole boundary and its internal divisions, rather than selecting an option from one locally similar line.

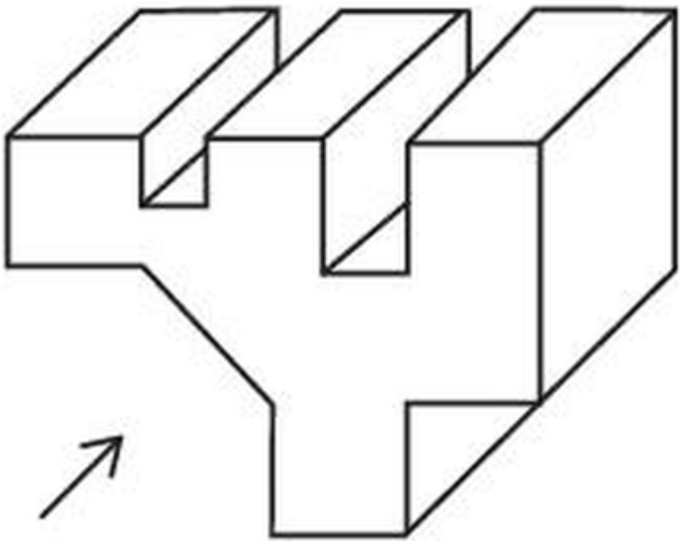
Step 1: Remove the depth edges Look along the arrow, so that the long receding edges disappear from the elevation. The broad top projects as a single horizontal cap, and the thick main support remains beneath it. The small projecting piece on the left has its own bent profile and is separated from the main support by an open gap.

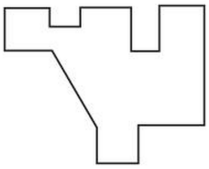
Step 2: Match both outlines Option (A) preserves the cap and the right-hand main support with its inward step, together with the separate bent left-hand piece. Options (B) and (C) fill or subdivide the open space with extra continuous edges. Option (D) attaches the small left-hand feature to the cap at a higher level. These differences are visible without judging pictorial depth lengths.

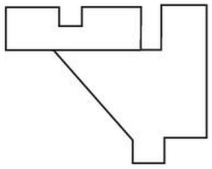
Step 3: Conclusion The required figure is the one shown in option (A). Hence, the correct option is (A).

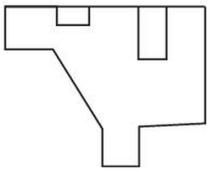
Quick Tip to Solve: In an elevation, retain true openings between components; receding surfaces must not become extra solid strips.

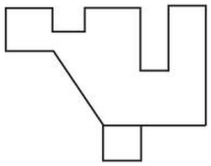
76. The 3D figure shows the view of an object. Identify the correct view looking in the direction of arrow, from the given answer figure's. [4 marks]

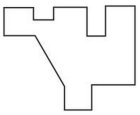


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An elevation is an orthographic view: depth along the indicated line of sight is suppressed, while visible outlines and edges are retained.
- Compare the whole boundary and its internal divisions, rather than selecting an option from one locally similar line.

Step 1: Trace the front silhouette The arrow looks along the receding direction of the extruded object. Its front outline therefore supplies the required view. Across the top are three raised portions with a shallow first notch and a deeper second notch. The lower left edge slopes down to the central projecting leg.

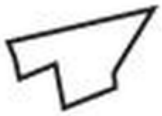
Step 2: Reject edges belonging to depth Option (A) follows this outline without adding lines across the continuous front face. In (B), an extra horizontal line traverses the front face below the top portions. In (C), a continuous top line closes the two open notches. In (D), a horizontal line separates the lower leg from the main body although no such front-face seam is shown. Thus only (A) represents the required elevation.

Step 3: Conclusion The required figure is the one shown in option (A). Hence, the correct option is (A).

Quick Tip to Solve: For an extrusion viewed along its length, start with its end outline and discard edges that merely recede.

77. One of the following answer figure is hidden in the problem figure in same size and direction. Select to correct one. [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- An embedded figure must be traced at the same size and in the same direction; rotation or reflection changes the answer.
- Compare the whole boundary and its internal divisions, rather than selecting an option from one locally similar line.

Step 1: Find a triangle with the same orientation The answer figures must occur without rotation, reflection or resizing. Inspect the triangular region just left of the centre of the problem, below the upper-left junction of several lines. Its upper side rises slightly towards the right; its right side descends almost vertically to the lower vertex, and the remaining side returns diagonally to the upper-left vertex.

Step 2: Compare the complete closed boundary This centre-left triangle has the same orientation

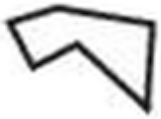
and proportions as (B). The other three options are concave outlines containing inward notches; none has the three-sided boundary of the traced region. A partial collection of similar sloping segments is insufficient: the entire answer outline must be followed continuously at its original size. The extra surrounding lines can be ignored when the triangle itself is traced.

Step 3: Conclusion The required figure is the one shown in option (B). Hence, the correct option is (B).

Quick Tip to Solve: Search for a distinctive corner first, then follow all sides until the boundary closes without turning the option.

78. One of the following answer figure is hidden in the problem figure in same size and direction. Select correct one. [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An embedded figure must be traced at the same size and in the same direction; rotation or reflection changes the answer.
- Compare the whole boundary and its internal divisions, rather than selecting an option from one locally similar line.

Step 1: Locate the central notched outline Inspect the central region of the problem figure, just above its lower crossing lines. Trace the outline with a short upper-left sloping side, an upper ridge, a right-hand descending side and a lower inward notch. The notch and the longer right-hand downward point keep their original orientation.

Step 2: Compare every corner in sequence Following the boundary in order reproduces (A): the left short side descends towards the notch, and the lower edge rises into the inward corner before descending towards the right-hand point. Option (B) is a narrow elongated outline, while (C) has an additional upper-left indentation and a different top boundary. Option (D) has a long left side and an arched inward turn that do not reproduce the traced central outline.

Step 3: Conclusion The required figure is the one shown in option (A). Hence, the correct option is (A).

Quick Tip to Solve: Use a concave corner as an anchor; matching the notch and its neighbouring sides is safer than matching only the outer slope.

79. One of the following answer figure is hidden in the problem figure in same size and direction. Select correct one. [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An embedded figure is recognised by following its complete boundary through the larger pattern. Extra lines crossing or continuing beyond that boundary do not remove the embedded shape.
- The required match must retain the direction of the candidate: a rotated or reflected resemblance is insufficient. Compare the inward notch, the long outer edges and the order of the corners.

Step 1: Trace the notched outline near the centre Look just to the right of the centre of the problem square. Start at the upper junction where the sloping diagonals meet the nearly vertical central line. Follow that central line down to the next junction, turn down-left along the short sloping edge, and then trace back upwards along the short edge beside the narrow central strip. Turn left along the small inward-notch edge, and finally follow the diagonal upwards to the starting junction. These segments form the arrow-like concave outline shown in option (A). Several other lines pass through this area, so select the required segments rather than treating every crossing as the end of the outline.

Step 2: Check the direction and reject the other outlines In this traced boundary the highest corner lies on the right, the long right edge descends from it, and the inward notch enters from the left. This is precisely the orientation of (A). Option (B) has a broad triangular outer outline and a lower-left inward cut; option (C) points towards the right with a long left side; option (D) has its long pointed extension directed down-left. Those different corner sequences do not match the outline traced in the central region without changing the figure. Therefore the match is determined by the whole boundary, rather than by one isolated diagonal.

Step 3: Conclusion The concave arrow-like figure in option (A) is embedded just to the right of the centre of the problem figure, in the same direction. Hence, the correct option is (A).

Quick Tip to Solve: Locate the candidate's inward notch first, then trace its boundary corner by corner while ignoring unrelated lines that cross it.

80. Monsoon first reach to which state of India ? [4 marks]

(A) Gujarat

(B) Maharashtra

(C) Kerala

(D) Karnataka

Correct Answer: (C) Kerala

Solution:

Concept:

- The southwest monsoon brings the principal rainy season to much of India. Its rain-bearing winds approach the subcontinent from the Indian Ocean.
- The Arabian Sea branch reaches the southwestern coast before advancing northward along the west coast. In the standard geographical description of monsoon onset over mainland India, Kerala is the first state.

Step 1: Locate the first mainland landfall Kerala lies on the southwestern coast of the Indian peninsula, facing the Arabian Sea. As the southwest monsoon advances towards mainland India, its onset is first associated with Kerala. The question asks for a state rather than an island territory or a date, so the relevant answer is this coastal state. The usual sequence of seasonal advance, rather than an isolated pre-monsoon shower, determines the answer.

Step 2: Compare the four states Karnataka lies to the north of Kerala on the west coast, Maharashtra is farther north, and Gujarat is farther north again. These states receive the advancing Arabian Sea branch after its onset over Kerala in the normal progression of the monsoon. Therefore Gujarat, Maharashtra and Karnataka do not identify the first mainland state reached. Kerala alone matches both the southwest location and the conventional onset description.

Step 3: Conclusion The southwest monsoon first reaches Kerala among the listed states. Hence, the correct option is (C).

Quick Tip to Solve: Follow the usual monsoon advance northward along the west coast: Kerala comes before Karnataka, Maharashtra and Gujarat.

Drawing Test (100 marks)

81(a). Draw a proportionate sketch of given reference image with black and white rendering techniques of your choice. Picture should fit in given space for this answer.

[50 marks]



Solution:

Concept:

- A proportionate reference sketch preserves the relative sizes, placement and movement of the visible forms. The dancer's raised arm, bent arm, small head and widely flaring skirt establish the reference silhouette.
- Black-and-white rendering expresses volume with a controlled range of light, middle and dark tones. Strong contrasts belong at important overlaps and deep folds, while lighter passages preserve the fabric's broad sweep.

Step 1: Fit the entire pose into the answer space Use a vertical composition with a light enclosing rectangle that leaves a small margin around the whole reference, including the raised hand, the outward veil and the base of the skirt. Mark the top of the raised hand and the bottom of the visible foot before drawing details. Place the head in the upper central region and the torso slightly to the right of the centre line. Measure the head height against the overall figure and compare the skirt's widest span with the full height. Lightly block the large flared skirt as a sweeping mass, making its silhouette broader than the torso. This prevents the common error of completing an oversized head and then finding that the skirt cannot fit.

Step 2: Establish the gesture and the major proportions Sketch the line of movement through the head, torso and supporting leg. The dancer's right arm rises towards the upper left of the reference and holds the flowing veil; the other arm bends outward on the right with its hand near the waist. Indicate these directions with simple lines before giving the arms thickness. Set the tilted shoulders and the waist, checking the triangular opening made by the bent arm. The face turns slightly downward, while the skirt sweeps from the waist into broad curved folds. Place the visible foot below the skirt as

in the reference and keep it subordinate to the overall pose. Compare the positions of the elbows, hands, waist and head rather than copying each part independently.

Step 3: Develop the fabric and the reference silhouette Draw the veil as a light, extended sheet behind the upper body, passing from the raised hand across and behind the head towards the right. Preserve its open, floating shape and the separation between it and the dancer's torso. Establish the main curved bands of the flaring skirt, including the broad light sweep across the left and the darker folded area beneath it. Use a few long directional lines to show the fabric's rotation before adding fine pleats. Keep the bodice fitted to the torso so its narrower form contrasts with the skirt's spread. Check the overall outline against the reference at this stage: the raised arm, veil, bent elbow and skirt must remain recognisable even without shading.

Step 4: Render the large tonal masses before the details Choose graphite pencil with hatching and controlled blending for a consistent black-and-white treatment. Reserve the paper's lightest tones for illuminated fabric and the prominent highlights. Lay middle tones over the bodice, the veil folds and selected skirt surfaces, following the direction of each form. Build the darkest tones gradually in the deep pleats beneath the flaring upper skirt, under overlapping fabric, around the hair and at the strongest contact shadows. Keep the veil lighter than the dense skirt shadows so it appears thin and airy. A soft shadow beneath the dancer anchors the figure to the ground, while a quiet background keeps attention on the pose.

Step 5: Refine the focal area and finish cleanly Refine the face, hands, jewellery and costume decoration only after the pose and large tonal divisions are secure. Suggest the facial features with restrained marks that preserve the downward turn of the head; avoid outlining every feature heavily. Use sharper edges at the face, hands and important fabric overlaps, and softer edges where the veil and background meet. Vary the density of hatching to turn the rounded arm and torso, and use curved strokes for the skirt folds. Finally compare the complete sketch with the supplied photograph: verify the relative widths, the height of the raised hand, the bend of the opposite arm, the spread of the skirt and the balance of light and dark. Erase construction lines and keep the margins clean.

Step 6: Conclusion The finished answer is a proportionate monochrome sketch of the supplied dancer, fitted fully within the allotted space. Its raised arm, floating veil, bent opposite arm and swirling skirt reproduce the reference pose, while graded pencil tones distinguish the illuminated fabric, deep folds and soft ground shadow.

Quick Tip to Solve: Secure the full silhouette and the widest skirt span before drawing the face; then organise the shading into light, middle and dark masses before adding costume detail.

OR

81(b). Create a wall magic for a metro station using triangles of any size and overall panel size of your choice. The theme of magic is 'Environment' use colours to make the mozaic attractive and meaningful. [50 marks]

Solution:

Concept:

- A mosaic creates a complete image from repeated small units. Here every visible unit should be triangular, while their combined colours and silhouettes communicate the environmental theme.
- A metro-station panel must read clearly from a distance: use a strong focal form, a limited colour palette and a clear balance between filled shapes and background.

Step 1: Plan the panel and its visual hierarchy Choose a horizontal rectangular panel, for example in a width-to-height proportion of three to one, suitable for a station wall. Mark a light border and place a large tree slightly left of centre as the focal image. Let its crown spread across the upper middle and let a river sweep along the bottom towards the right. A rising sun in the upper right balances the tree. Keep a quiet band of pale sky between these groups so the composition remains readable rather than becoming a uniform pattern.

Step 2: Construct every motif from triangles Divide the tree crown into interlocking triangles in several sizes, with a few smaller triangular leaf clusters extending outward. Build the trunk from narrow brown triangles and the river from long blue triangular facets. Make the sun from warm triangular wedges and suggest hills with large low triangular silhouettes. A few small triangular bird forms connect the open sky with the tree. The motifs must emerge from the triangular pieces themselves; do not add curved outlines or unrelated rectangular tiles that defeat the specified unit.

Step 3: Apply a coherent environmental colour scheme Use greens for vegetation, blues for clean water and sky, ochre and brown for earth, and yellow-orange for sunlight. Place the strongest dark green near the tree trunk and the strongest warm colour near the sun, then reduce contrast towards the background. Neighbouring triangles can vary slightly in tone to produce a mosaic effect without fragmenting the larger silhouette. Repeat selected greens and blues across the panel to unify it, and keep the river visibly separate from the surrounding land.

Step 4: Resolve the panel for a station setting Check that the tree, flowing water and sun can be recognised at a glance and express the connection between vegetation, water and life. Keep the triangular junctions neat, the border even and the colour fills clean. Avoid crowding the design with written slogans: the environmental message should come from the imagery. Review the whole panel from a distance before adding the smallest facets, ensuring that detail supports the overall composition.

Step 5: Conclusion The proposed panel is a horizontal triangular mosaic of a flourishing tree, clean river, hills, birds and sunlight. Its interlocking triangular units and restrained natural colours create an attractive, readable environmental composition for the metro-station wall.

Quick Tip to Solve: Establish the large tree-and-river silhouette first; subdivide it into triangles only after the environmental image reads clearly from a distance.

82(a). Consider yourself a fish in the aquarium that is in a room and a girl is standing near the aquarium and playing with the fish. Create the view of the room according the eye of fish. [50 marks]

Solution:

Concept:

- A viewpoint drawing must place the observer at the stated location. Here the observer is a fish inside the aquarium looking through its glass into the room, so the aquarium foreground and the girl outside establish the unusual viewpoint.
- Perspective, overlap, relative size and tonal contrast create depth. The room must share one consistent eye level instead of appearing as several unrelated frontal drawings.

Step 1: Establish the fish's eye level and framing Place the viewpoint inside the aquarium, looking outward through its front glass. Set a low eye level at the fish's chosen swimming height and lightly mark a vanishing point within the room. Use the lower aquarium rim, a narrow side edge and a few foreground aquatic plants to frame the view without enclosing it so heavily that the room disappears. Show the water surface or upper rim only where the chosen viewing direction permits it; do not draw the aquarium entirely from outside.

Step 2: Place the girl as the main subject Position the girl just beyond the front glass, close enough to dominate the middle distance. Turn her face and gaze towards the fish's viewpoint and show one hand near the glass in a gentle playful gesture. Her posture can lean slightly towards the tank, with the other arm relaxed. Keep her head, torso and hands proportionate, and make the gesture clear without inserting an impossible hand through the glass. Her closeness and eye contact communicate the action requested in the question.

Step 3: Build a coherent room around the action Draw the floor-wall junction and a side wall with receding lines directed towards the established vanishing point. Add a simple chair, a doorway or a window in the background, keeping their scale smaller than the girl and their perspective consistent. Let the girl overlap some background forms. Keep these objects subordinate so the view reads as an encounter between fish and girl, rather than as a catalogue of furniture. The viewer should understand both the interior location and the tank boundary.

Step 4: Render the glass, water and depth Use light broken reflections along the aquarium glass and subtle wavering contours where water changes the appearance of objects. Preserve the girl's recognisable proportions rather than applying arbitrary distortion. Give nearby plants and gravel firmer edges and darker accents, keep the girl clearly modelled with a consistent light direction, and simplify distant furnishings. Leave selected glass highlights white. Avoid opaque shading across the entire pane, since the fish must be able to see through it into the room.

Step 5: Conclusion The final composition is an outward view from within the aquarium: close aquatic foreground elements frame a girl leaning towards the glass and playing with the fish, while a consistently receding room provides the background. A low eye level, overlaps and restrained water reflections make the fish's viewpoint convincing.

Quick Tip to Solve: Fix the eye level inside the tank before drawing the girl or furniture, then use the glass edge and nearby aquatic plants to make the viewpoint unmistakable.

OR

82(b). Create picture with fish/fishes, a girl, boat, farmers, tractor, trees and plants. [50 marks]

Solution:

Concept:

- A composition should relate all the required elements in one believable setting. A riverside agricultural scene naturally connects fish, a boat and a girl with farmers, a tractor, trees and plants.
- Foreground, middle ground and background organise depth. Use scale, overlap and a consistent horizon to distinguish these zones while keeping every specified element recognisable.

Step 1: Organise the landscape and focal action Choose a horizontal picture frame and place the horizon above the centre to leave room for a river in the foreground. Let the river run diagonally towards the distance, with a cultivated bank on one side. Place a girl near the foreground bank beside a moored boat, looking towards visible fish near the surface. This forms the main group. Keep a clear space around her head and hands so her action is readable, rather than hiding her among vegetation or machinery.

Step 2: Connect the fish, girl and boat Draw the boat with a curved hull, a visible inner edge and a rope leading to the bank. Its long axis can recede obliquely to reinforce depth. Show several fish immediately below the clear foreground water surface with recognisable body shapes, tails and fins; use a few ripples and broken reflections rather than covering them with opaque shading. Place the girl on the bank, with balanced feet and a natural leaning or seated posture. Keep her safely separate from the boat's hull and the fish so each required form remains distinct.

Step 3: Integrate farming activity on the bank Place a tractor on a field path in the middle ground, at a smaller apparent scale than the foreground figures. Show its large rear wheel, smaller front wheel, bonnet and driver's position in one consistent perspective. Add farmers engaged in field work, such as one tending crop rows and another walking beside the tractor. Give their limbs clear gestures and align their feet with the ground plane. Furrows can lead towards a common distant region, linking the agricultural activity to the landscape instead of appearing as a separate inset.

Step 4: Balance vegetation, light and final detail Group trees along the bank and use smaller plants and grasses near the foreground to connect land and water. Vary tree height and spacing, leaving openings through which the farmers and tractor remain visible. Use the same light direction for people, boat, trees and machinery. Render the nearest forms with stronger line and contrast, reduce detail in distant fields, and keep the water lighter than the land. Review the scene to confirm that fish, girl, boat, farmers, tractor, trees and plants are all identifiable and belong to the same environment.

Step 5: Conclusion The proposed picture is a unified riverside farming scene: a girl and moored boat form the foreground group beside visible fish, farmers and a tractor occupy the middle-ground fields, and trees and plants connect the riverbank to the distant landscape. Consistent scale, perspective and lighting give the required elements a coherent setting.

Quick Tip to Solve: Reserve a clear silhouette for each required element in the first thumbnail; add crop rows, reflections and leaves only after all seven element groups are recognisable.