JEE Main 2020 Paper 2A (B.Arch) Sep 1 Shift 1 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) 2020, Session 2 (September), conducted by the National Testing Agency (NTA) in Computer Based Test (CBT) mode on 1 September 2020, Shift 1. The total duration is 3 hours.

(ii) The paper has 77 questions: Mathematics (25), 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 5 numerical value questions. 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. Let a function, $f : \mathrm{R} \to \mathrm{R}$ be defined by $f(x) = 1 + x|x|$ and let $\mathrm{sgn}(x) = \begin{cases} 1, & \text{if } x \geq 0 \\ -1, & \text{if } x < 0 \end{cases}$

Then : [4 marks]

(A) f is not invertible

(B) $f^{-1}(x) = \mathrm{sgn}(x-1)\sqrt{|x-1|}$

(C) $f^{-1}(x) = \sqrt{|x-1|}$

(D) $f^{-1}(x) = \mathrm{sgn}(x)\sqrt{|x-1|}$

Correct Answer: (B) $f^{-1}(x) = \mathrm{sgn}(x-1)\sqrt{|x-1|}$

Solution:

Concept:

- A function has an inverse on its codomain when it is both one-one and onto. Here we must check the whole real line, not only nonnegative inputs.
- The absolute value gives two branches: $x|x| = x^2$ for $x \geq 0$, while $x|x| = -x^2$ for $x < 0$.

Step 1: Write the two branches For a nonnegative input, $f(x) = 1 + x^2$, so its output is at least 1. For a negative input, $f(x) = 1 - x^2$, so its output is less than 1. On each of these intervals the function is strictly increasing. Moreover, all outputs from the negative branch are below all outputs from the nonnegative branch. Thus two different real inputs cannot have the same output.

Step 2: Solve for the input Put $y = f(x)$. If $y \geq 1$, use the nonnegative branch and retain the nonnegative square root. If $y < 1$, use the negative branch and retain the negative square root:

$$x = \begin{cases} \sqrt{y-1}, & y \geq 1, \\ -\sqrt{1-y}, & y < 1. \end{cases}$$

Each real y has exactly one such real input, proving that the function is onto as well as one-one.

Step 3: Combine the branches and check the choices The sign needed for the root changes when the output crosses 1, rather than when it crosses 0. Hence

$$f^{-1}(y) = \mathrm{sgn}(y-1)\sqrt{|y-1|}.$$

At $y = 1$, the root vanishes and this formula gives 0, as required. Option (A) contradicts bijectivity. Option (C) cannot return a negative input. Option (D), for example at $y = 1/2$, gives the wrong positive sign.

Step 4: Conclusion f is invertible and $f^{-1}(x) = \mathrm{sgn}(x-1)\sqrt{|x-1|}$. Hence, the correct option is (B).

Quick Tip to Solve: Locate the output where the original input is zero; that output, here 1, is where the sign of the inverse changes.

2. Let α be a common root of the equations, $x^2-x-12=0$ and $\lambda x^2+10x+3=0$ (where λ is an integer). If β is the other root of the second equation, then the ordered pair (λ, β) is equal to : [4 marks]

(A) $\left(-3, \frac{1}{3}\right)$
(B) $\left(-3, -\frac{1}{3}\right)$
(C) $\left(3, \frac{1}{3}\right)$
(D) $\left(3, -\frac{1}{3}\right)$

Correct Answer: (D) $\left(3, -\frac{1}{3}\right)$

Solution:

Concept:

- A common root must satisfy both quadratic equations. Factoring the first equation gives a short list of candidates which must each be checked.
- For $ax^2 + bx + c = 0$, the product of its roots is c/a. The condition that λ is an integer must be imposed before choosing the common root.

Step 1: Find the candidate common roots Factor the first equation:

$$x^2 - x - 12 = (x - 4)(x + 3) = 0.$$

Therefore the common root α is either 4 or -3. These are candidates only: satisfying the first equation does not automatically make either value a root of the second.

Step 2: Use the integer condition If $\alpha = 4$, substitution in the second equation gives

$$16\lambda + 40 + 3 = 0 \quad \Longrightarrow \quad \lambda = -\frac{43}{16}.$$

This is not an integer and is excluded by the question. If $\alpha = -3$, substitution instead gives

$$9\lambda - 30 + 3 = 0 \quad \Longrightarrow \quad \lambda = 3.$$

Thus the common root must be -3, and the second equation is $3x^2 + 10x + 3 = 0$.

Step 3: Determine and verify the other root Using the product of roots,

$$\alpha\beta = \frac{3}{\lambda} = 1, \qquad (-3)\beta = 1, \qquad \beta = -\frac{1}{3}.$$

Direct factorisation confirms the result:

$$3x^2 + 10x + 3 = (3x + 1)(x + 3).$$

Options (A) and (B) use $\lambda = -3$, which fails substitution for either permitted common root. Option (C) has the correct leading coefficient but the wrong sign for the second root; the sum must be $-10/3$.

Step 4: Conclusion The ordered pair is $(\lambda, \beta) = (3, -1/3)$. Hence, the correct option is (D).

Quick Tip to Solve: Test every possible common root against the extra parameter restriction before applying the sum or product of roots.

3. If $z = -1 + i\sqrt{2}$, then which one of the following is not true ? [4 marks]

(A) $\mathrm{Re}(z^4) + \mathrm{Re}(z^3) = -2$

(B) $\mathrm{Im}(z^4) + \mathrm{Im}(z^3) = 5\sqrt{2}$

(C) $\mathrm{Im}(z^4) - \mathrm{Re}(z^3) = 4\sqrt{2} - 5$

(D) $\mathrm{Re}(z^4) - \mathrm{Im}(z^3) = \sqrt{2} - 7$

Correct Answer: (D) $\mathrm{Re}(z^4) - \mathrm{Im}(z^3) = \sqrt{2} - 7$

Solution:

Concept:

- For $a + ib$, the real part is a and the imaginary part is the real coefficient b, not ib. Use $i^2 = -1$ when multiplying.
- The question asks for the statement that is not true. Compute the powers once, then check all four statements without changing any signs.

Step 1: Compute the required powers First square $z = -1 + i\sqrt{2}$:

$$z^2 = 1 - 2i\sqrt{2} - 2 = -1 - 2i\sqrt{2}.$$

Multiplying this by z gives

$$z^3 = (-1 - 2i\sqrt{2})(-1 + i\sqrt{2}) = 5 + i\sqrt{2}.$$

It is convenient to square z^2 for the fourth power:

$$z^4 = (-1 - 2i\sqrt{2})^2 = 1 + 4i\sqrt{2} - 8 = -7 + 4i\sqrt{2}.$$

Thus the four real coefficients we need are 5, $\sqrt{2}$, -7, and $4\sqrt{2}$.

Step 2: Check the first three statements From these powers,

$$\mathrm{Re}(z^4) + \mathrm{Re}(z^3) = -7 + 5 = -2,$$

so (A) is true. Likewise,

$$\mathrm{Im}(z^4) + \mathrm{Im}(z^3) = 4\sqrt{2} + \sqrt{2} = 5\sqrt{2},$$

making (B) true. Finally,

$$\mathrm{Im}(z^4) - \mathrm{Re}(z^3) = 4\sqrt{2} - 5,$$

which is exactly statement (C).

Step 3: Test the remaining difference For the left side of statement (D), subtract the imaginary coefficient of z^3 from the real part of z^4:

$$\mathrm{Re}(z^4) - \mathrm{Im}(z^3) = -7 - \sqrt{2}.$$

The option instead states $\sqrt{2} - 7$. These numbers differ by $2\sqrt{2}$, which is nonzero. Hence (D) is the unique false statement; the plus sign before the radical in that option is decisive.

Step 4: Conclusion The false statement is (D), because the actual difference is $-7 - \sqrt{2}$. Hence, the

correct option is (D).

Quick Tip to Solve: List the real and imaginary coefficients in a small mental table before checking mixed expressions; this prevents a sign error in a subtraction.

4. For $\theta \in (0, \pi/2), \theta \in (\pi, 2\pi)$ and $\beta \in \mathrm{R}$, the value of the determinant

$$\begin{vmatrix} \cos 2\alpha & \cos(\alpha+\theta) & -\sin(\alpha+\theta) \\ \sin\alpha & \sin\theta & \cos\theta \\ \beta\cos\alpha & -\cos\theta & \sin\theta \end{vmatrix} :$$ [4 marks]

(A) is independent of α.

(B) is independent of β.

(C) is independent of θ.

(D) depends on all α, β and θ.

Correct Answer: (C) is independent of θ.

Solution:

Concept:

- Expand a third-order determinant along its first row, retaining the alternating cofactor signs $+, -, +$.
- Use $\sin^2\theta + \cos^2\theta = 1$, $\sin(u-v) = \sin u\cos v - \cos u\sin v$, and $\cos(u-v) = \cos u\cos v + \sin u\sin v$.

Step 1: Expand the determinant Denote the determinant by D. The first minor is $\sin^2\theta + \cos^2\theta = 1$. Keeping the minus sign already present in the top-right entry, expansion gives

$$\begin{aligned} D = {} & \cos 2\alpha - \cos(\alpha+\theta)(\sin\alpha\sin\theta - \beta\cos\alpha\cos\theta) \\ & + \sin(\alpha+\theta)(\sin\alpha\cos\theta + \beta\cos\alpha\sin\theta). \end{aligned}$$

This expression comes directly from the displayed matrix.

Step 2: Group terms by their first-column factors Collect the terms containing $\sin\alpha$, then those containing $\beta\cos\alpha$:

$$\begin{aligned} D = {} & \cos 2\alpha + \sin\alpha\big[\sin(\alpha+\theta)\cos\theta - \cos(\alpha+\theta)\sin\theta\big] \\ & + \beta\cos\alpha\big[\cos(\alpha+\theta)\cos\theta + \sin(\alpha+\theta)\sin\theta\big]. \end{aligned}$$

The brackets simplify to $\sin\alpha$ and $\cos\alpha$, respectively, by the angle-difference identities.

Step 3: Identify the remaining variables Therefore

$$D = \cos 2\alpha + \sin^2\alpha + \beta\cos^2\alpha = (1+\beta)\cos^2\alpha.$$

The final expression contains no θ. In general it does depend on α and β, so (A), (B), and (D) do not describe the determinant. The opening text repeats incompatible intervals for θ; no interval assumption is needed for this algebraic identity, which holds for all real angles.

Step 4: Conclusion The displayed determinant simplifies to $(1+\beta)\cos^2\alpha$ and is independent of θ.

Hence, the correct option is (C).

Quick Tip to Solve: When adjacent columns contain sine and cosine of the same angle, group the cofactor expansion into angle-difference identities before simplifying.

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5. Let $A = \begin{pmatrix} \alpha & 1 & 2 \\ 1 & 2 & 3 \\ 3 & 1 & 1 \end{pmatrix}, \alpha \in R$ **and** $B = [b_{ij}]_{3\times 3}$ **such that** $AB = rI, r \neq 0$ **in** R. **If** $b_{32} = -\frac{3}{2}r$ **and** $|\operatorname{adj} B| = r^5$**, then** $|\operatorname{adj}(AB)|$ **equals :** [4 marks]

(A) 4^{12}

(B) 2^{12}

(C) 2^6

(D) 4^8

Correct Answer: (B) 2^{12}

Solution:

Concept:

- From $AB = rI$ with $r \neq 0$, both matrices are invertible and $B = rA^{-1} = r\operatorname{adj}(A)/|A|$.
- For a matrix of order 3, $|\operatorname{adj} M| = |M|^2$. The entry $(A^{-1})_{ij}$ uses cofactor C_{ji}, so its indices are reversed.

Step 1: Find the determinant and required inverse entry Expanding A along its first row gives

$$|A| = \alpha(2-3) - (1-9) + 2(1-6) = -\alpha - 2.$$

To compute the entry in row 3, column 2 of the inverse, use cofactor C_{23}:

$$C_{23} = (-1)^{2+3}\begin{vmatrix} \alpha & 1 \\ 3 & 1 \end{vmatrix} = 3 - \alpha.$$

Consequently

$$b_{32} = r\frac{3-\alpha}{-\alpha-2}.$$

The denominator is nonzero because A is invertible.

Step 2: Apply the given entry condition Equate this entry to the given value and cancel the nonzero scalar r:

$$\frac{3-\alpha}{-\alpha-2} = -\frac{3}{2}.$$

Cross multiplication gives

$$2(3-\alpha) = 3(\alpha+2), \qquad \alpha = 0.$$

Hence $|A| = -2$. Taking determinants in $AB = rI$, where I has order 3, now yields

$$|A||B| = r^3 \quad \Longrightarrow \quad |B| = -\frac{r^3}{2}.$$

Step 3: Use the adjugate determinant relation The other condition becomes

$$|\operatorname{adj} B| = |B|^2 = \frac{r^6}{4} = r^5.$$

Dividing by r^5, allowed since $r \neq 0$, gives $r = 4$. Finally

$$|\operatorname{adj}(AB)| = |AB|^2 = (r^3)^2 = r^6 = 4^6 = 2^{12}.$$

Options (A) and (D) use incorrect powers of 4. Option (C) would miss the square in the adjugate determinant formula.

Step 4: Conclusion $|\operatorname{adj}(AB)| = 2^{12}$. Hence, the correct option is (B).

Quick Tip to Solve: For an inverse entry, reverse the cofactor indices first; for a third-order adjugate determinant, square the original determinant.

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6. Let a_1, a_2, a_3, a_4 and a_5 be in A.P. with the common difference greater than 2. If $\sum_{i=1}^{5} a_i = 30$ and $a_1 \cdot a_2 \cdot a_3 \cdot a_4 \cdot a_5 = 3840$, then $a_1 \cdot a_5$ is equal to : [4 marks]

(A) 82

(B) -128

(C) 128

(D) -82

Correct Answer: (B) -128

Solution:

Concept:

- Five consecutive terms of an A.P. can be written symmetrically as $m-2d, m-d, m, m+d, m+2d$. Their sum is $5m$.
- Pair terms equidistant from the middle: $(m-2d)(m+2d) = m^2-4d^2$ and $(m-d)(m+d) = m^2-d^2$. The condition $d > 2$ selects the admissible root.

Step 1: Determine the middle term Write the five given terms as $m-2d, m-d, m, m+d, m+2d$, where d is the common difference. Their sum is 30, so

$$5m = 30 \quad \Longrightarrow \quad m = 6.$$

Thus the first and last terms are $6-2d$ and $6+2d$, and the required product is $36-4d^2$. We do not need to determine each term separately.

Step 2: Convert the product condition to a quadratic Using the symmetric pairs in the product of all

five terms,

$$6(36 - d^2)(36 - 4d^2) = 3840.$$

Divide by 6 and put $t = d^2$:

$$(36 - t)(36 - 4t) = 640.$$

Expanding and simplifying gives

$$4t^2 - 180t + 656 = 0, \qquad t^2 - 45t + 164 = 0.$$

Factorisation yields

$$(t - 4)(t - 41) = 0,$$

so $d^2 = 4$ or $d^2 = 41$.

Step 3: Select the permissible difference and evaluate The given inequality $d > 2$ excludes both $d = 2$ and $d = -2$, hence excludes $d^2 = 4$. It also selects the positive root $d = \sqrt{41}$. Therefore

$$a_1 a_5 = (6 - 2\sqrt{41})(6 + 2\sqrt{41}) = 36 - 164 = -128.$$

As a check, the other symmetric product is $36 - 41 = -5$, and $6(-5)(-128) = 3840$. Thus the negative sign is essential: (C) has the wrong sign, while (A) and (D) do not satisfy the derived product.

Step 4: Conclusion The required product is $a_1 a_5 = -128$. Hence, the correct option is (B).

Quick Tip to Solve: For an odd number of A.P. terms with both a sum and a product, centre the terms on their mean and multiply symmetric pairs first.

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7. Let the functions f and g be defined as $f(x) = 2\cos|x - 2| + 3|x|\sin|x|$ and $g(x) = x^5 + x$. If S be the set of points where the function $(f \circ g)(x)$ is not differentiable, then S is equal to : [4 marks]

(A) $\{1\}$

(B) $\{0\}$

(C) $\{0, 1\}$

(D) ϕ (an empty set)

Correct Answer: (D) ϕ (an empty set)

Solution:

Concept:

- An absolute value inside an even trigonometric function can disappear: $\cos|u| = \cos u$. This identity holds for positive, negative and zero arguments.
- Because sine is odd, $|x|\sin|x| = x\sin x$ for every real x. A composition of differentiable functions is differentiable wherever both relevant derivatives exist.

Step 1: Remove the apparent corners For $x \geq 0$, the product is directly $x\sin x$. For $x < 0$, both factors

change sign, giving $(-x)\sin(-x) = x\sin x$. Hence the function has the single global expression

$$f(x) = 2\cos(x-2) + 3x\sin x.$$

This identity includes $x = 0$, so there is no need to assign different derivatives there. Similarly, the absolute value at $x = 2$ does not produce a corner because cosine is even.

Step 2: Apply the chain rule The simplified outer function has derivative

$$f\prime(x) = -2\sin(x-2) + 3\sin x + 3x\cos x,$$

defined for every real input. Also $g(x) = x^5 + x$ is a polynomial, with $g\prime(x) = 5x^4 + 1$. Therefore

$$(f \circ g)\prime(x) = [-2\sin(g(x)-2) + 3\sin g(x) + 3g(x)\cos g(x)]\,(5x^4+1)$$

exists at every real x. In particular neither zero nor one is exceptional; the first three options all incorrectly retain at least one apparent absolute-value corner.

Step 3: Conclusion There are no points of non-differentiability: $S = \varnothing$. Hence, the correct option is (D).

Quick Tip to Solve: Before taking one-sided derivatives, use evenness of cosine and oddness of sine to simplify absolute-value expressions.

8. Let f be a twice differentiable function on R such that $f(0) = 4$ and the function, $g(x) = \frac{1}{2}f^2(x) + 3x^3 - 5$ is monotonically increasing in R. Then $f(1)$ cannot be : [4 marks]

(A) $2\sqrt{3}$

(B) $3\sqrt{2}$

(C) 4

(D) $2\sqrt{2}$

Correct Answer: (D) $2\sqrt{2}$

Solution:

Concept:

- If g is monotonically increasing, then $g(1) \geq g(0)$. This necessary condition is enough to reject a proposed value.
- The square in $g(x) = \frac{1}{2}f(x)^2 + 3x^3 - 5$ must be retained when comparing endpoint values; $f(0) = 4$ fixes the starting value.

Step 1: Compare the endpoint values At the origin,

$$g(0) = \frac{1}{2}(4)^2 - 5 = 3.$$

At one,

$$g(1) = \frac{1}{2}f(1)^2 + 3 - 5 = \frac{1}{2}f(1)^2 - 2.$$

Monotonic increase on all real numbers implies increase on the interval from zero to one. Thus

$$\frac{1}{2}f(1)^2 - 2 \geq 3 \quad \Longrightarrow \quad f(1)^2 \geq 10.$$

If increasing is understood strictly, the corresponding inequality is strict, which does not change the option eliminated here.

Step 2: Test all four proposed values The squares of the proposed values $2\sqrt{3}, 3\sqrt{2}, 4, 2\sqrt{2}$ are respectively $12, 18, 16, 8$. The first three satisfy the necessary lower bound, whereas $8 < 10$. More explicitly, the first three produce endpoint values $g(1) = 4, 7, 6$, each above $g(0) = 3$. The last produces $g(1) = 2$, below the initial value. It is therefore incompatible with the stated monotonicity, independently of the behavior between the endpoints. Differentiating twice or constructing the unknown function is unnecessary for this exclusion.

Step 3: Conclusion The value $f(1) = 2\sqrt{2}$ would force $g(1) < g(0)$, so it cannot occur. Hence, the correct option is (D).

Quick Tip to Solve: When an unknown function occurs inside a monotone expression, compare the two specified inputs before attempting differential inequalities.

9. Let $f(x) = \left(2x^2 - 9x + 11\right) \cdot \mathrm{e}^x, -\infty < x < \infty$. Then f has : [4 marks]

(A) a local maxima at $x = \frac{1}{2}$ and a local minima at $x = 2$.

(B) a local minima at $x = \frac{1}{2}$ and a local maxima at $x = 2$.

(C) neither a local maxima nor a local minima at $x = \frac{1}{2}$.

(D) neither a local maxima nor a local minima at $x = 2$.

Correct Answer: (A) a local maxima at $x = \frac{1}{2}$ and a local minima at $x = 2$.

Solution:

Concept:

- For a product of a polynomial and e^x, use the product rule and factor out e^x. Since $e^x > 0$, the remaining polynomial decides the derivative sign.
- A derivative changing from positive to negative gives a local maximum; a change from negative to positive gives a local minimum.

Step 1: Find the stationary points For $f(x) = (2x^2 - 9x + 11)e^x$, differentiation gives

$$\begin{aligned} f\prime(x) &= e^x(4x - 9) + e^x(2x^2 - 9x + 11) \\ &= e^x(2x^2 - 5x + 2) \\ &= e^x(2x - 1)(x - 2). \end{aligned}$$

The exponential factor never vanishes, so the only stationary points are $x = \frac{1}{2}$ and $x = 2$. Both belong to the given domain, which is the whole real line.

Step 2: Check the sign on each interval For $x < \frac{1}{2}$, both linear factors are negative and $f\prime(x) > 0$.

For $\frac{1}{2} < x < 2$, the first is positive and the second negative, so $f\prime(x) < 0$. For $x > 2$, both are positive and $f\prime(x) > 0$. Thus the function increases, then decreases, then increases. It has a genuine local maximum at the first stationary point and a genuine local minimum at the second. Option (B) reverses these changes, while (C) and (D) wrongly deny an extremum at one of the simple derivative roots.

Step 3: Conclusion There is a local maximum at $x = \frac{1}{2}$ and a local minimum at $x = 2$. Hence, the correct option is (A).

Quick Tip to Solve: After factoring an exponential out of a derivative, ignore its positive value and make a sign chart for the polynomial factors.

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10. If for $x > 0$, $\int \frac{e^{\sqrt{x}} \sin\left(\frac{\pi}{4}+\sqrt{x}\right)}{\sqrt{x}} dx = e^{\sqrt{x}} \cdot f(x) + C$, where C is a constant of integration, then $f(x)$ is equal to : [4 marks]

(A) $\frac{3}{\sqrt{2}} \cos\sqrt{x}$

(B) $\frac{2\sqrt{2}}{3} \sin\sqrt{x}$

(C) $\sqrt{2} \sin\sqrt{x}$

(D) $\sqrt{2} \cos\sqrt{x}$

Correct Answer: (C) $\sqrt{2} \sin\sqrt{x}$

Solution:

Concept:

- With $t = \sqrt{x}$ and $x > 0$, $dx = 2t\,dt$, so $dx/\sqrt{x} = 2\,dt$.
- The angle-addition identity gives $\sin(\pi/4 + t) = (\sin t + \cos t)/\sqrt{2}$. The derivative of $e^t \sin t$ is $e^t(\sin t + \cos t)$.

Step 1: Substitute the square root Write the integral as I. On the stated positive domain the substitution is valid and gives

$$I = 2\int e^t \sin(\pi/4 + t)\,dt$$
$$= \sqrt{2}\int e^t(\sin t + \cos t)\,dt.$$

The factor two comes from $dx = 2t\,dt$; it must not be lost when cancelling the denominator. The shift by $\pi/4$ creates equal sine and cosine coefficients.

Step 2: Recognise an exact derivative By the product rule,

$$\frac{d}{dt}(e^t \sin t) = e^t \sin t + e^t \cos t.$$

It follows immediately that

$$I = \sqrt{2}e^t \sin t + C = e^{\sqrt{x}}\left(\sqrt{2}\sin\sqrt{x}\right) + C.$$

Comparing the displayed factor multiplying $e^{\sqrt{x}}$ with the required form identifies $f(x)$. The two cosine choices differentiate to a cosine-minus-sine combination and cannot match the integrand. The smaller

sine coefficient in (B) also fails the derivative coefficient comparison; the coefficient must be $\sqrt{2}$.

Step 3: Conclusion We may take $f(x) = \sqrt{2}\sin\sqrt{x}$, with the arbitrary constant included in C. Hence, the correct option is (C).

Quick Tip to Solve: For an exponential times a shifted sine, expand the angle first and look for the product derivative of exponential times sine or cosine.

11. If $y(x) = \int_{\pi^2/16}^{x^2} \frac{\sin x \sin\sqrt{\theta}}{1+\cos^2\sqrt{\theta}} d\theta$, then $y'\left(\frac{\pi}{4}\right)$ is equal to : [4 marks]

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

(B) $\frac{\pi}{12}$

(C) $\frac{\pi}{6}$

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

Correct Answer: (C) $\frac{\pi}{6}$

Solution:

Concept:

- A factor independent of the integration variable can be taken outside the integral. Here $\sin x$ depends on the external variable, not on θ.
- For $H(x) = \int_a^{x^2} h(\theta)\, d\theta$, the fundamental theorem and chain rule give $H\prime(x) = 2x\, h(x^2)$. The product rule is still needed for an external factor.

Step 1: Separate the external factor Define

$$H(x) = \int_{\pi^2/16}^{x^2} \frac{\sin\sqrt{\theta}}{1+\cos^2\sqrt{\theta}}\, d\theta.$$

Then $y(x) = \sin x\, H(x)$, and therefore

$$y\prime(x) = \cos x\, H(x) + \sin x\, H\prime(x).$$

At $x = \pi/4$, the upper and lower integration limits are identical, so $H(\pi/4) = 0$. Consequently the first term vanishes at the requested point, although it is part of the derivative in general.

Step 2: Evaluate the moving-endpoint contribution Near the positive point $\pi/4$, we have $\sqrt{x^2} = x$. Thus

$$H\prime(x) = 2x\frac{\sin x}{1+\cos^2 x}.$$

Substituting $x = \pi/4$ into the product-rule expression yields

$$\begin{aligned} y\prime(\pi/4) &= \frac{\pi}{2}\frac{\sin^2(\pi/4)}{1+\cos^2(\pi/4)} \\ &= \frac{\pi}{2}\frac{1/2}{3/2} = \frac{\pi}{6}. \end{aligned}$$

The remaining options arise from dropping the external sine, the factor $2x$, or the squared cosine in the denominator; none equals this evaluated expression.

Step 3: Conclusion The required derivative is $y\prime(\pi/4) = \pi/6$. Hence, the correct option is (C).

Quick Tip to Solve: If the moving upper limit equals the lower limit at the evaluation point, the integral term in the product rule vanishes there.

12. The area (in sq. units) of the region $\{(x, y) \in \mathrm{R}^2 : 2|x| + |y| \leq 2$ and $x + y \geq 1\}$ is : [4 marks]

(A) $\frac{1}{3}$
(B) $\frac{2}{3}$
(C) $\frac{1}{2}$
(D) $\frac{4}{3}$

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

Solution:

Concept:

- The inequality $2|x| + |y| \leq 2$ describes a diamond with vertices $(1, 0), (0, 2), (-1, 0), (0, -2)$.
- The second inequality keeps the part above $y = 1 - x$. Intersections with the upper boundary give the limits for vertical strips.

Step 1: Find the retained boundary intersections On the upper-left edge the diamond has equation $y = 2 + 2x$. Intersecting with $y = 1 - x$ gives $x = -1/3$ and $y = 4/3$. On the upper-right edge, $y = 2 - 2x$, so its intersection with $y = 1 - x$ is $(1, 0)$. The other upper vertex $(0, 2)$ lies above the cutting line. The retained region is the triangle with these three vertices; no region below the horizontal axis satisfies both inequalities except the boundary point $(1, 0)$.

Step 2: Integrate the vertical widths For $-1/3 \leq x \leq 0$, the upper boundary is $2 + 2x$ and the lower boundary is $1 - x$. For $0 \leq x \leq 1$, the upper boundary is $2 - 2x$, with the same lower line. Therefore

$$\begin{aligned} A &= \int_{-1/3}^{0} (1 + 3x)\, dx + \int_{0}^{1} (1 - x)\, dx \\ &= \left[x + \frac{3}{2}x^2\right]_{-1/3}^{0} + \left[x - \frac{1}{2}x^2\right]_{0}^{1} \\ &= \frac{1}{6} + \frac{1}{2} = \frac{2}{3}. \end{aligned}$$

The value $1/2$ counts only the right-hand piece and misses the small left-hand triangle. Neither $1/3$ nor $4/3$ equals the full retained area.

Step 3: Conclusion The area of the specified region is $\frac{2}{3}$ square units. Hence, the correct option is (B).

Quick Tip to Solve: Split an absolute-value area calculation at the axes, where the straight-line formula for the boundary changes.

13. Let ABC be a triangle such that the vertex A has coordinates $(-3, 1)$. If the equation of the median through B be $2x + y - 3 = 0$ and the equation of the bisector of angle C be $7x - 4y - 1 = 0$, then the equation of the line BC is : [4 marks]

(A) $15x + y = 50$

(B) $4x - y = 7$

(C) $18x - y = 49$

(D) $7x - 3y = 6$

Correct Answer: (C) $18x - y = 49$

Solution:

Concept:

- A median joins a vertex to the midpoint of the opposite side. Thus the midpoint of AC lies on the given median through B.
- Reflection in the internal angle bisector at C maps the ray CA onto the ray CB. The reflected image of A therefore lies on the supporting line BC.

Step 1: Locate the vertex C Write $C = (h, k)$. The midpoint of AC is $((h-3)/2, (k+1)/2)$. Substituting it into the median gives

$$2\frac{h-3}{2} + \frac{k+1}{2} - 3 = 0 \quad \Longrightarrow \quad 2h + k = 11.$$

Also C lies on its angle bisector, so $7h - 4k = 1$. Substituting $k = 11 - 2h$ gives $15h = 45$. Hence $C = (3, 5)$.

Step 2: Reflect A in the angle bisector For reflection in $ax + by + c = 0$, the image of (x_0, y_0) is

$$\left(x_0 - \frac{2aD}{a^2+b^2},\ y_0 - \frac{2bD}{a^2+b^2}\right), \qquad D = ax_0 + by_0 + c.$$

Here $(a, b, c) = (7, -4, -1)$, $D = -26$, and $a^2 + b^2 = 65$. Therefore

$$A' = \left(-3 + \frac{364}{65},\ 1 - \frac{208}{65}\right) = \left(\frac{13}{5}, -\frac{11}{5}\right).$$

Step 3: Form the line through C and the reflected point The slope of CA' is

$$\frac{5 + 11/5}{3 - 13/5} = 18.$$

Thus BC has equation $y - 5 = 18(x - 3)$, or $18x - y = 49$. Options (A), (B) and (D) also pass through $C = (3, 5)$, so the reflected-ray condition is essential. Their slopes are $-15, 4, 7/3$, which differ from 18.

Step 4: Conclusion The required line is $\boxed{18x - y = 49}$. Hence, the correct option is (C).

Quick Tip to Solve: Use the median to locate C first; reflecting the known vertex across the angle bisector then supplies a second point of BC.

14. If the ellipse centered at the origin has a focus at $(0, 3)$ and the corresponding directrix is $y = 9$, then which one of the following is not true for this ellipse ? [4 marks]

(A) Length of its minor axis is $6\sqrt{2}$

(B) Length of its latus rectum is $4\sqrt{3}$

(C) Point $(\sqrt{6}, 2\sqrt{3})$ lies on it

(D) Point $(\sqrt{6}, -3\sqrt{2})$ lies on it

Correct Answer: (C) Point $(\sqrt{6}, 2\sqrt{3})$ lies on it

Solution:

Concept:

- For a vertical ellipse $x^2/b^2 + y^2/a^2 = 1$, the foci are $(0, \pm c)$, with $c = ae$, and the corresponding directrices are $y = \pm a/e$.
- The minor-axis length is $2b$, the latus-rectum length is $2b^2/a$, and $b^2 = a^2 - c^2$. A point lies on the ellipse exactly when its substitution gives 1.

Step 1: Determine the semiaxes The focus gives $ae = 3$, while the corresponding directrix gives $a/e = 9$. Multiplying these positive quantities eliminates the eccentricity:

$$a^2 = (ae)(a/e) = 3 \cdot 9 = 27, \qquad a = 3\sqrt{3}.$$

Now $c = 3$, so

$$b^2 = 27 - 9 = 18, \qquad b = 3\sqrt{2}.$$

The required ellipse is therefore $x^2/18 + y^2/27 = 1$. Its major axis is vertical, as indicated by the focus on the y-axis.

Step 2: Check the two length statements The minor axis has length $2b = 6\sqrt{2}$, agreeing with option (A). Its latus rectum has length

$$\frac{2b^2}{a} = \frac{36}{3\sqrt{3}} = 4\sqrt{3},$$

so option (B) is also true. These are full lengths: using a semiaxis or half a latus rectum would give a misleading comparison.

Step 3: Test the proposed points For the point in (C), substitution gives

$$\frac{(\sqrt{6})^2}{18} + \frac{(2\sqrt{3})^2}{27} = \frac{1}{3} + \frac{4}{9} = \frac{7}{9} \neq 1.$$

It does not lie on the ellipse. For the point in (D), the negative ordinate is squared, giving

$$\frac{6}{18} + \frac{(-3\sqrt{2})^2}{27} = \frac{1}{3} + \frac{2}{3} = 1.$$

Thus (D) is true, and (C) is the unique false statement.

Step 4: Conclusion The point $(\sqrt{6}, 2\sqrt{3})$ does not lie on the ellipse. Hence, the correct option is (C).

Quick Tip to Solve: When a focus and its corresponding directrix are supplied, multiply c=ae and a/e to obtain a squared immediately, then test point options by substitution.

15. If a hyperbola has length of its transverse axis $= \sqrt{2}$ and it has the same foci as that of the ellipse, $4x^2 + 3y^2 = 24$, then this hyperbola also passes through the point whose coordinates are : [4 marks]

(A) $\left(2\sqrt{3}, \frac{3}{\sqrt{2}}\right)$

(B) $\left(2\sqrt{3}, \frac{3}{2}\right)$

(C) $\left(\frac{1}{\sqrt{6}}, 1\right)$

(D) $\left(\frac{1}{\sqrt{6}}, \frac{\sqrt{2}}{3}\right)$

Correct Answer: (A) $\left(2\sqrt{3}, \frac{3}{\sqrt{2}}\right)$

Solution:

Concept:

- The larger denominator in an ellipse identifies its major axis. For a vertical ellipse, $c^2 = a_e^2 - b_e^2$, where c is the focal distance from the centre.
- A confocal hyperbola has the same centre, focal direction and focal distance. For $y^2/a_h^2 - x^2/b_h^2 = 1$, its transverse-axis length is $2a_h$, and $c^2 = a_h^2 + b_h^2$.

Step 1: Find the common foci Divide the ellipse equation by 24:

$$\frac{x^2}{6} + \frac{y^2}{8} = 1.$$

Since $8 > 6$, its major axis is the y-axis. Its squared focal distance is $c^2 = 8 - 6 = 2$, so its foci are $(0, \pm\sqrt{2})$. The hyperbola must also open along the y-axis; interchanging the x and y terms would describe a different pair of foci.

Step 2: Construct the hyperbola equation The full transverse axis is $\sqrt{2}$. Hence

$$2a_h = \sqrt{2}, \qquad a_h^2 = \frac{1}{2}, \qquad b_h^2 = c^2 - a_h^2 = 2 - \frac{1}{2} = \frac{3}{2}.$$

The hyperbola is therefore

$$\frac{y^2}{1/2} - \frac{x^2}{3/2} = 1, \quad \text{or} \quad 2y^2 - \frac{2}{3}x^2 = 1.$$

Step 3: Check all four coordinates For option (A), $x^2 = 12$ and $y^2 = 9/2$, giving $2y^2 - (2/3)x^2 = 9 - 8 = 1$. It lies on the hyperbola. For (B), the same expression is $9/2 - 8 = -7/2$. For (C), it is $2 - 1/9 = 17/9$. For (D), it is $4/9 - 1/9 = 1/3$. None of these last three equals 1, so no other proposed point satisfies the equation.

Step 4: Conclusion The hyperbola passes through $\boxed{(2\sqrt{3}, 3/\sqrt{2})}$. Hence, the correct option is (A).

Quick Tip to Solve: For confocal conics, calculate the common c squared first. Subtract a squared for the hyperbola; do not reuse the ellipse minor semiaxis.

16. Let P be the point of intersection of the plane, $4x - 6y + 14z = 57$ with the line joining the points $A(2, 3, 5)$ and $B(1, -1, 4)$. If $BP = \lambda AP$, then the value of λ is : [4 marks]

(A) $\frac{1}{9}$

(B) 9

(C) $\frac{1}{3}$

(D) 3

Correct Answer: (D) 3

Solution:

Concept:

- A point on the line through A and B can be written $P = A + t(B - A)$. The parameter t gives a signed position along the line, so values outside [0,1] describe external division.
- The distances are $AP = |t|\, AB$ and $BP = |t - 1|\, AB$. Use absolute values because the question concerns lengths rather than directed segments.

Step 1: Parametrise the joining line Here $B - A = (-1, -4, -1)$. Thus every point on the joining line has coordinates

$$(x, y, z) = (2 - t,\ 3 - 4t,\ 5 - t).$$

The parameter values $t = 0$ and $t = 1$ recover A and B respectively, which checks the direction and origin of this parametrisation.

Step 2: Impose the plane equation Substitute these coordinates into $4x - 6y + 14z = 57$:

$$4(2 - t) - 6(3 - 4t) + 14(5 - t) = 57.$$

Combining the constant terms gives $8-18+70 = 60$; combining the coefficients of t gives $-4+24-14 = 6$. Therefore

$$60 + 6t = 57, \qquad t = -\frac{1}{2}.$$

Consequently $P = (5/2, 5, 11/2)$. Direct substitution gives $10 - 30 + 77 = 57$, confirming that P lies in the plane.

Step 3: Compare the actual distances The negative parameter places P beyond A, away from B. Hence A lies between P and B. The lengths are

$$AP = \frac{1}{2}AB, \qquad BP = \frac{3}{2}AB, \qquad \lambda = \frac{BP}{AP} = 3.$$

This also follows from $BP = BA + AP$. Option (C) gives the reciprocal ratio, while options (A) and (B) give neither required distance ratio. The order BP/AP in the question must be retained.

Step 4: Conclusion We obtain $BP = 3AP$, so $\boxed{\lambda = 3}$. Hence, the correct option is (D).

Quick Tip to Solve: After solving for the line parameter, check whether the intersection is internal or external before taking a distance ratio.

17. A six faced biased dice is so loaded that in any of its toss getting any of even scores is equally likely and the probability of getting an even score is three times the probability of getting an odd score. This dice is tossed repeatedly until a six is obtained. If X denotes the number of tosses required, then $\mathrm{P}(\mathrm{X} < 4)$ is : [4 marks]

(A) $\frac{19}{3^3}$

(B) $\frac{37}{4^3}$

(C) $\frac{61}{4^3}$

(D) $\frac{397}{(12)^3}$

Correct Answer: (B) $\frac{37}{4^3}$

Solution:

Concept:

- The even event is the union of the three equally likely even faces 2, 4 and 6. Its probability is three times the probability of the complementary odd event.
- For independent repeated tosses with success probability p, the probability that the first success occurs within n tosses is $1-(1-p)^n$. Here success means obtaining a six.

Step 1: Find the probability of a six Let E be the total probability of an even score and O the total probability of an odd score. The stated loading gives $E = 3O$, and the exhaustive parity events satisfy $E + O = 1$. Thus

$$O = \frac{1}{4}, \qquad E = \frac{3}{4}.$$

The three even faces are equally likely, so each has probability $E/3$. In particular,

$$p = P(6) = \frac{3/4}{3} = \frac{1}{4}.$$

There is no need to assume any separate distribution among the odd faces.

Step 2: Translate the strict inequality into tosses Since X is an integer counting tosses, $X < 4$ means that the first six occurs on toss 1, 2 or 3. Its complement is that none of the first three tosses is six. Each toss has non-six probability $1 - p = 3/4$, so independence gives

$$P(X \geq 4) = \left(\frac{3}{4}\right)^3 = \frac{27}{64}.$$

Therefore

$$P(X < 4) = 1 - \frac{27}{64} = \frac{37}{64}.$$

Step 3: Check the interpretation against a direct sum A direct check sums the first-success probabilities: $1/4 + 3/16 + 9/64 = 37/64$. This agrees with (B). Options (A), (C) and (D) differ from this sum. Using four trials would include the excluded event $X = 4$; using $p = 1/6$ would incorrectly treat the die as fair.

Step 4: Conclusion $\boxed{P(X < 4) = 37/4^3}$. Hence, the correct option is (B).

Quick Tip to Solve: For a first-success question, replace "within the first three tosses" by its complement: three consecutive failures.

18. If $2\sin x - \cos 2x = 1$, then : [4 marks]

(A) $\cos^4 x - \cos^2 x = 3 - \sqrt{5}$

(B) $2\left(\cos^4 x - \cos^2 x\right) = -1$

(C) $\sin^4 x - \sin^2 x = 2 - \sqrt{5}$

(D) $2\left(\sin^4 x - \sin^2 x\right) = 1$

Correct Answer: (C) $\sin^4 x - \sin^2 x = 2 - \sqrt{5}$

Solution:

Concept:

- Use $\cos 2x = 1 - 2\sin^2 x$ to express the given equation using only $s = \sin x$. Any quadratic root must also satisfy $-1 \le s \le 1$.
- The expressions $\sin^4 x - \sin^2 x$ and $\cos^4 x - \cos^2 x$ both equal $-\sin^2 x \cos^2 x$. Thus the same value checks the sine and cosine options.

Step 1: Solve the equation for sine Put $s = \sin x$. Then

$$2s - (1 - 2s^2) = 1 \quad \Longrightarrow \quad s^2 + s - 1 = 0.$$

The two algebraic roots are $(-1 \pm \sqrt{5})/2$. The negative root is less than -1 and cannot be a sine value. Hence

$$s = \frac{\sqrt{5} - 1}{2}, \qquad s^2 = 1 - s.$$

The positive root lies between 0 and 1, so it is admissible.

Step 2: Reduce the fourth-power expression Use the quadratic relation instead of repeatedly expanding radicals:

$$\begin{aligned} s^4 - s^2 &= (1 - s)^2 - (1 - s) \\ &= s^2 - s \\ &= 1 - 2s \\ &= 2 - \sqrt{5}. \end{aligned}$$

Thus the identity asserted in (C) follows directly from the admissible root. Its value is negative, as expected because $s^2(s^2 - 1) \le 0$.

Step 3: Eliminate the remaining statements Writing $c = \cos x$, we have $c^4 - c^2 = c^2(c^2 - 1) = -s^2c^2 = s^4 - s^2 = 2 - \sqrt{5}$. This differs from $3 - \sqrt{5}$, so (A) is false. Twice either fourth-power difference is $4 - 2\sqrt{5}$, approximately -0.472, which is neither -1 in (B) nor 1 in (D). These comparisons use both the exact value and the necessarily nonpositive sign.

Step 4: Conclusion $\boxed{\sin^4 x - \sin^2 x = 2 - \sqrt{5}}$. Hence, the correct option is (C).

Quick Tip to Solve: When sine satisfies a quadratic, reduce every higher power using that quadratic before substituting the radical root.

19. Let $\vec{a}, \vec{b}, \vec{c}$ be any three non-coplanar vectors. If the points $A(-2\vec{a}+3\vec{b}+5\vec{c})$, $B(\vec{a}+2\vec{b}+3\vec{c})$ and $C(7\vec{a}-\lambda\vec{c})$ are collinear, then λ is equal to : [4 marks]

(A) 1

(B) -1

(C) 2

(D) -2

Correct Answer: (A) 1

Solution:

Concept:

- Non-coplanar vectors $\vec{a}, \vec{b}, \vec{c}$ are linearly independent, so coefficients in their linear combinations can be compared.
- Three distinct points are collinear precisely when their displacement vectors satisfy $\overrightarrow{AC} = t\overrightarrow{AB}$ for a real scalar t.

Step 1: Form the displacement vectors Subtract the position vector of A from those of B and C. The subtraction must be done separately for each of the three independent directions. Thus

$$\overrightarrow{AB} = 3\vec{a} - \vec{b} - 2\vec{c},$$

$$\overrightarrow{AC} = 9\vec{a} - 3\vec{b} - (\lambda+5)\vec{c}.$$

In particular, the negative coefficient in the position vector of C gives $-\lambda - 5$, not $-\lambda + 5$, in the last displacement.

Step 2: Compare the independent coefficients Collinearity gives $\overrightarrow{AC} = t\overrightarrow{AB}$. Comparing the coefficient of $\vec{a}$ yields $9 = 3t$, hence $t = 3$. The coefficient of $\vec{b}$ confirms this value because $-3 = 3(-1)$. The remaining coefficient therefore satisfies

$$-(\lambda+5) = 3(-2) = -6,$$

$$\lambda + 5 = 6, \qquad \lambda = 1.$$

With this value every coefficient has the same multiplier, so collinearity is verified. The other proposed values give inconsistent coefficients in the $\vec{c}$ direction and cannot satisfy the vector equation.

Step 3: Conclusion The required value is $\boxed{\lambda = 1}$. Hence, the correct option is (A).

Quick Tip to Solve: Use the coefficient of a vector without the unknown to find the common ratio first, then substitute it into the remaining coefficient.

20. Which one of the following is a tautology ? [4 marks]

(A) $\sim (p \to q) \to q$

(B) $\sim (p \to q) \leftrightarrow \sim q$

(C) $\sim (p \to q) \leftrightarrow p$

(D) $\sim (p \to q) \to p$

Correct Answer: (D) $\sim (p \to q) \to p$

Solution:

Concept:

- A tautology is a proposition that is true for every assignment of truth values to its component propositions.
- The implication $p \to q$ is equivalent to $\sim p \vee q$. Consequently, $\sim (p \to q) \equiv p \wedge \sim q$.

Step 1: Simplify the antecedent Write $r = \sim (p \to q) = p \wedge \sim q$. Whenever r is true, p is necessarily true and q is false. Consider option (D):

$$r \to p \equiv \sim (p \wedge \sim q) \vee p.$$

By De Morgan's law and regrouping, this becomes

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

Since $\sim p \vee p$ is always true, the entire expression is always true, regardless of q. This proves that (D) is a tautology.

Step 2: Exclude the remaining propositions Each other option can be ruled out by one counterexample. For (A), set p true and q false. Then r is true, while its consequent q is false, so $r \to q$ is false. For (B), set both p and q false: r is false but $\sim q$ is true, making their biconditional false. For (C), set both p and q true: r is false but p is true, again making the biconditional false. Thus none of (A), (B), or (C) is true for every truth assignment.

Step 3: Conclusion $\boxed{\sim (p \to q) \to p}$ is always true. Hence, the correct option is (D).

Quick Tip to Solve: Replace the negated implication by $p \wedge \sim q$; it directly implies p, but it does not imply q.

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

21. If the sum of all possible 4 digit numbers formed using digits 1, 2, 3, 4 without repetition, is $1111k$, then k is equal to _____. [4 marks]

Solution:

Concept:

- The four distinct digits can be arranged without repetition in $4! = 24$ ways, and none begins with zero.
- By symmetry, any fixed digit occupies any specified place in $3! = 6$ arrangements. Place values are

$1000, 100, 10, 1$.

Step 1: Count the contribution at one place Fix a digit, for example 1, in the thousands place. The remaining three digits can be arranged in $3! = 6$ ways. Exactly the same count holds for each of 2, 3 and 4, and for each of the other three places. Therefore the sum of the digits appearing in any one fixed place over all the numbers is

$$3!(1 + 2 + 3 + 4) = 6 \times 10 = 60.$$

This counts occurrences in a fixed column rather than multiplying every digit by all 24 arrangements, which would overcount its contribution.

Step 2: Add the four place-value contributions The thousands column contributes 60×1000, the hundreds column contributes 60×100, the tens column contributes 60×10, and the units column contributes 60. Hence the total sum is

$$S = 60(1000 + 100 + 10 + 1) = 60 \times 1111 = 66660.$$

The question writes this same sum as $1111k$. Since $1111 \neq 0$, division gives $k = 60$. As an independent check, the average digit in each column is $(1 + 2 + 3 + 4)/4 = 2.5$, so the average four-digit number is $2.5 \times 1111 = 2777.5$. Multiplying by the 24 arrangements gives 66660, confirming the sum.

Step 3: Conclusion The requested numerical value is $\boxed{k = 60}$.

Quick Tip to Solve: For permutations of distinct nonzero digits, multiply their digit sum by $(n-1)!$ and the sum of the relevant place values.

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22. If $x = \operatorname{cosec}\theta - \sin\theta$ and $y = \operatorname{cosec}^5\theta - \sin^5\theta, 0 < \theta < \frac{\pi}{2}$, then $(x^2+4)\left(\frac{dy}{dx}\right)^2 - 25y^2$ is equal to _____. [4 marks]

Solution:

Concept:

- Put $u = \operatorname{cosec}\theta$ and $v = \sin\theta$. Then $uv = 1$, $x = u - v$, and $y = u^5 - v^5$.
- When $uv = 1$, the identity $u^5 - v^5 = (u-v)^5 + 5(u-v)^3 + 5(u-v)$ expresses y as a polynomial in x.

Step 1: Eliminate the parameter Expand $(u-v)^5$ and group the terms using $uv = 1$. The terms involving $u^3 - v^3$ reduce by $u^3 - v^3 = (u-v)^3 + 3(u-v)$. The resulting relation is

$$y = x^5 + 5x^3 + 5x.$$

It can also be checked by expanding its right-hand side with $x = u - v$: all intermediate mixed terms cancel. Since $0 < \theta < \pi/2$, the quantities are defined and x varies strictly monotonically with θ; therefore differentiating the polynomial relation gives the required derivative.

Step 2: Differentiate and simplify the invariant We obtain

$$\frac{dy}{dx} = 5(x^4 + 3x^2 + 1).$$

Let $t = x^2$, so $y = x(t^2 + 5t + 5)$. Substitution gives

$$(x^2 + 4)(y\prime)^2 - 25y^2 = 25\{(t + 4)(t^2 + 3t + 1)^2 - t(t^2 + 5t + 5)^2\}.$$

The two polynomials in braces expand as

$$(t + 4)(t^2 + 3t + 1)^2 = t^5 + 10t^4 + 35t^3 + 50t^2 + 25t + 4,$$
$$t(t^2 + 5t + 5)^2 = t^5 + 10t^4 + 35t^3 + 50t^2 + 25t.$$

Their difference is exactly 4, independent of the parameter.

Step 3: Conclusion The expression is $25 \times 4 = \boxed{100}$.

Quick Tip to Solve: Whenever reciprocal quantities occur in odd-power differences, express them in terms of their difference before differentiating.

23. Let the function $f : \mathrm{N} \to \mathrm{R}$ satisfy $f(x + y) = f(x) \cdot f(y)$ for all $x, y \in \mathrm{N}$ and $f(1) = 2$. If $\sum_{k=1}^{50} f(4 + k) = \lambda\left(2^{\beta} - 1\right)$, then $\lambda + \beta$ is equal to _____. [4 marks]

Solution:

Concept:

- The relation $f(x + y) = f(x)f(y)$, together with $f(1) = 2$, determines the values on positive integers by induction.
- A geometric progression with first term a, common ratio $r \neq 1$, and n terms has sum $a(r^n - 1)/(r - 1)$.

Step 1: Determine the function on the natural numbers Set $y = 1$ in the given relation. For every positive integer n,

$$f(n + 1) = f(n)f(1) = 2f(n).$$

Starting with $f(1) = 2$, this gives $f(2) = 4$, $f(3) = 8$, and by induction

$$f(n) = 2^n \quad (n \in \mathrm{N}).$$

Indeed, if $f(n) = 2^n$, then the recurrence gives $f(n + 1) = 2^{n+1}$, establishing the next case. No continuity or values at non-integer arguments are required.

Step 2: Sum the specified progression The argument $4 + k$ runs from 5 through 54 as k runs from 1 through 50. Thus there are exactly 50 terms, with first term $2^5 = 32$ and common ratio 2. Applying

the finite geometric-sum formula,

$$\sum_{k=1}^{50} f(4+k) = 2^5 + 2^6 + \cdots + 2^{54}$$
$$= 2^5 \frac{2^{50}-1}{2-1}$$
$$= 32(2^{50}-1).$$

Comparing this standard geometric-sum form with $\lambda(2^\beta - 1)$ identifies $\lambda = 32$ and $\beta = 50$. The exponent records the number of terms, rather than the last exponent 54. Therefore their sum is $32 + 50 = 82$.

Step 3: Conclusion In the stated geometric-sum form, $\lambda = 32$, $\beta = 50$, and $\boxed{\lambda + \beta = 82}$.

Quick Tip to Solve: Check the first exponent and the number of terms separately: the first gives the outside factor, and the count gives the exponent inside the brackets.

24. Let the circle, $(x - \mathrm{a})^2 + (y - \mathrm{b})^2 = 8$ and the parabola, $y^2 = 4x$ have a common tangent at the point $\mathrm{P}(1, 2)$. If C is the centre of the circle and S is the focus of the parabola, then the area (in sq. units) of $\triangle\mathrm{CPS}$ is equal to _____. [4 marks]

Solution:

Concept:

- The radius of a circle at a point of tangency is perpendicular to the tangent. Thus the circle centre lies on the normal at that point.
- For $y^2 = 4ax$, the focus is $(a, 0)$. Here $a = 1$, so $S = (1, 0)$, and the circle radius is $\sqrt{8} = 2\sqrt{2}$.

Step 1: Find the common normal direction Differentiate the parabola implicitly:

$$2y\frac{dy}{dx} = 4, \qquad \frac{dy}{dx} = \frac{2}{y}.$$

At $P = (1, 2)$, the tangent slope is 1, so the normal slope is -1. The common tangent is $y - 2 = x - 1$, or $y = x + 1$. Its perpendicular through P has equation $y - 2 = -(x - 1)$, or $y = 3 - x$. The circle centre C lies on this line because its radius CP is normal to the common tangent.

Step 2: Locate both possible centres A unit direction along the normal is $(1, -1)/\sqrt{2}$. Moving distance $2\sqrt{2}$ from P in either direction gives

$$C = (1, 2) \pm (2, -2).$$

Thus the possible centres are $C_1 = (3, 0)$ and $C_2 = (-1, 4)$. Both are legitimate: each is at distance $\sqrt{8}$ from P and has the same tangent line there. The answer must therefore be checked for both possibilities.

Step 3: Evaluate the triangle area The segment PS is vertical, with length 2. The perpendicular

distance from either possible centre to the line PS, which is $x = 1$, is

$$|3 - 1| = 2 \quad \text{or} \quad |-1 - 1| = 2.$$

Using PS as the base, the area is consequently

$$\frac{1}{2} \times 2 \times 2 = 2.$$

Although the circle centre need not be unique, the requested area is the same for both centres.

Step 4: Conclusion The area of $\triangle CPS$ is $\boxed{2 \text{ square units}}$.

Quick Tip to Solve: Find the normal first, then use a simple vertical or horizontal side as the triangle base; check both possible circle centres.

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25. If $y = y(x)$ is a solution of the differential equation, $x\frac{dy}{dx} = y(2 - 3xy), x > 0$ with $y(1) = 1$, then $y\left(\frac{1}{4}\right)$ is equal to _____. [4 marks]

Solution:

Concept:

- The equation can be written as $y\prime - \frac{2}{x}y = -3y^2$, a Bernoulli equation. Since $y(1) = 1$, use the reciprocal substitution $v = 1/y$ on the solution interval containing $x = 1$.
- A linear equation $v\prime + P(x)v = Q(x)$ is solved by multiplying by the integrating factor $e^{\int P(x)\,dx}$. Here $x > 0$, so $e^{2\log x} = x^2$.

Step 1: Transform the dependent variable Divide the given equation by x and then by y^2. The initial value is nonzero, so this operation is valid near the initial point. We obtain

$$\frac{y\prime}{y^2} = \frac{2}{xy} - 3.$$

Since $v = 1/y$, differentiation gives $v\prime = -y\prime/y^2$. Therefore the transformed equation is

$$v\prime + \frac{2}{x}v = 3.$$

Step 2: Integrate and apply the initial condition Multiply every term by x^2, so that the left side is a product derivative:

$$x^2v\prime + 2xv = 3x^2, \qquad \frac{d}{dx}(x^2v) = 3x^2.$$

Integration gives $x^2v = x^3 + C$, or

$$v = x + \frac{C}{x^2}, \qquad y = \frac{x^2}{x^3 + C}.$$

Now $v(1) = 1/y(1) = 1$, so $1 = 1 + C$ and $C = 0$. Hence $y = 1/x$ throughout the positive interval, and this expression is defined at the requested point.

Step 3: Evaluate and check the solution Substitute $x = 1/4$:

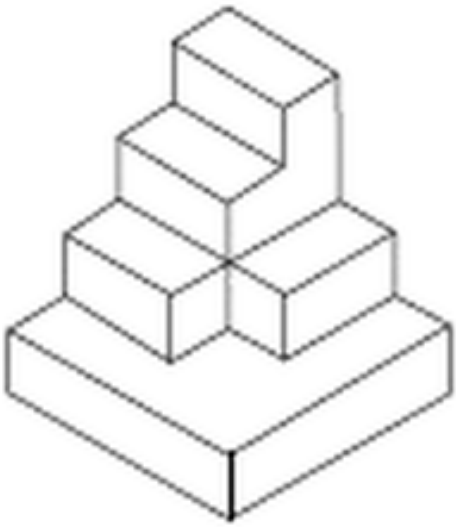
$$y\left(\frac{1}{4}\right) = \frac{1}{1/4} = 4.$$

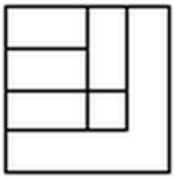
As a direct check, for $y = 1/x$ the left side of the original equation is $xy' = -1/x$. Its right side is $(1/x)(2-3) = -1/x$. Also $y(1) = 1$, confirming both the differential equation and the initial value.

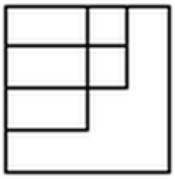
Step 4: Conclusion The required numerical value is $\boxed{4}$.

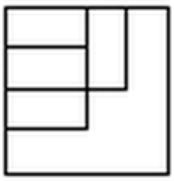
Quick Tip to Solve: When a first-order equation contains both y and y^2, try $v = 1/y$; apply the initial condition before substituting the target value of x.

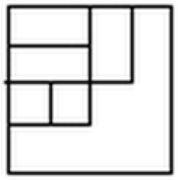
26. The 3 - D figure shows the view of an object. Identify the correct top view from amongst the answer figures. [4 marks]

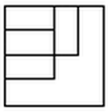


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A top view is the vertical projection of the object onto a horizontal plane. Heights disappear, but horizontal footprints and the visible boundaries between surfaces at different levels remain.
- Use the outside footprint first, then locate the highest block and follow each exposed tread. A vertical edge does not become a separate line in plan merely because it looks prominent in the three-dimensional view.

Step 1: Establish the footprint and orientation Look vertically down on the object without rotating it relative to the answer figures. Use the two perpendicular horizontal directions of the base as the plan directions. The outer boundary comes from the base, while the internal lines must come from

actual changes in the height of the exposed upper surfaces. Do not copy the sloping appearance of the isometric edges into the top view.

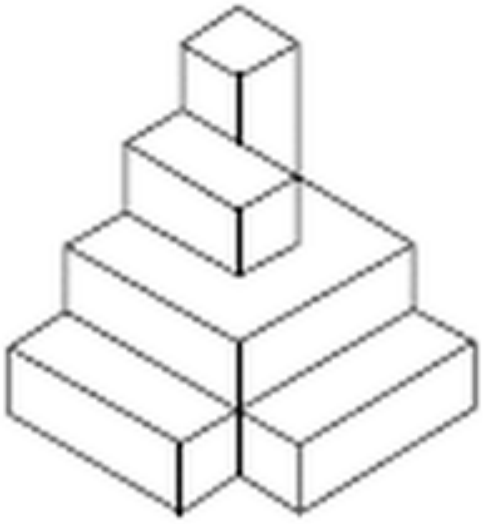
Step 2: Trace the visible upper surfaces The uppermost surface is a rectangular strip, rather than a single square. Descending towards the front-left gives three parallel step boundaries ending at the same inner vertical line. The lower projecting portion on the right produces a second, shorter return boundary, so the plan is not simply a set of equally extended stair lines. Follow each boundary only as far as the corresponding raised surface continues; a line cannot pass across an uninterrupted tread. This endpoint check distinguishes otherwise similar arrangements.

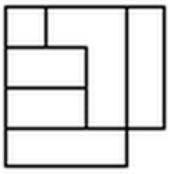
Step 3: Compare all four answer figures Option (C) preserves the long rear rectangular strip, the three parallel left-hand divisions, and the shorter return of the right-hand part. Option (A) extends the right return too far down and joins it to the lowest left division. Option (B) carries the upper left divisions across into the neighbouring strip. Option (D) introduces an extra little division in the lowest left tread that the solid does not have.

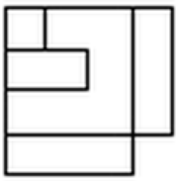
Step 4: Conclusion The vertical projection has exactly the footprint and internal step boundaries shown in option (C). Hence, the correct option is (C).

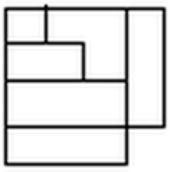
Quick Tip to Solve: Anchor the plan at the highest block, then trace the ends of the step boundaries. A single added or overextended internal line is enough to reject an otherwise similar top view.

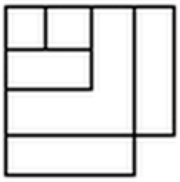
27. The 3 - D figure shows the view of an object. Identify the correct top view from amongst the answer figures. [4 marks]

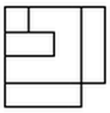


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A top view is the vertical projection of the object onto a horizontal plane. Heights disappear, but horizontal footprints and the visible boundaries between surfaces at different levels remain.
- Use the outside footprint first, then locate the highest block and follow each exposed tread. A vertical edge does not become a separate line in plan merely because it looks prominent in the three-dimensional view.

Step 1: Establish the footprint and orientation Look vertically down on the object without rotating it relative to the answer figures. Use the two perpendicular horizontal directions of the base as the plan directions. The outer boundary comes from the base, while the internal lines must come from actual changes in the height of the exposed upper surfaces. Do not copy the sloping appearance of the isometric edges into the top view.

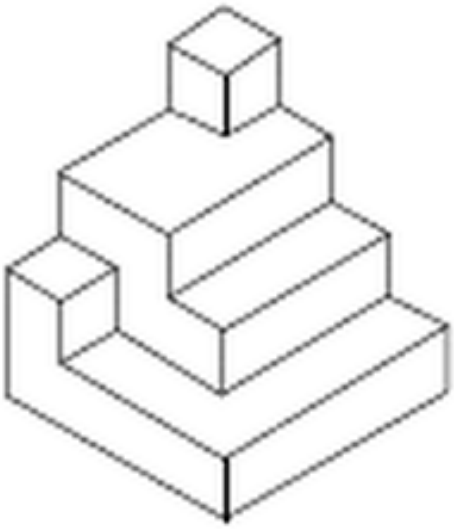
Step 2: Trace the visible upper surfaces The topmost element has a square footprint at the rear corner. Immediately below it is a broader rectangular tread, followed by a larger platform. The lowest visible tier has a re-entrant corner: the two front arms do not form a single uninterrupted rectangular band. Its outline must therefore retain that inward corner in plan. Follow each boundary only as far as the corresponding raised surface continues; a line cannot pass across an uninterrupted tread. This endpoint check distinguishes otherwise similar arrangements.

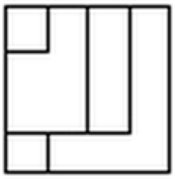
Step 3: Compare all four answer figures Option (B) contains the small rear square, the correctly placed next rectangular tread and the larger platform, while also retaining the notch in the lower outline. Option (A) continues a horizontal division into the side strip, where there is no corresponding change of level. Option (C) extends the intermediate division too far across the large platform. Option (D) adds a further vertical division through the upper rectangular tread.

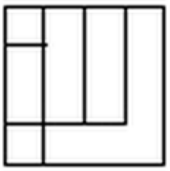
Step 4: Conclusion The vertical projection has exactly the footprint and internal step boundaries shown in option (B). Hence, the correct option is (B).

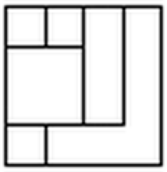
Quick Tip to Solve: Anchor the plan at the highest block, then trace the ends of the step boundaries. A single added or overextended internal line is enough to reject an otherwise similar top view.

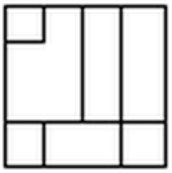
28. The 3 - D figure shows the view of an object. Identify the correct top view from amongst the answer figures. [4 marks]

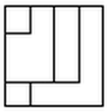


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A top view is the vertical projection of the object onto a horizontal plane. Heights disappear, but horizontal footprints and the visible boundaries between surfaces at different levels remain.
- Use the outside footprint first, then locate the highest block and follow each exposed tread. A vertical edge does not become a separate line in plan merely because it looks prominent in the three-dimensional view.

Step 1: Establish the footprint and orientation Look vertically down on the object without rotating it relative to the answer figures. Use the two perpendicular horizontal directions of the base as the plan directions. The outer boundary comes from the base, while the internal lines must come from actual changes in the height of the exposed upper surfaces. Do not copy the sloping appearance of the isometric edges into the top view.

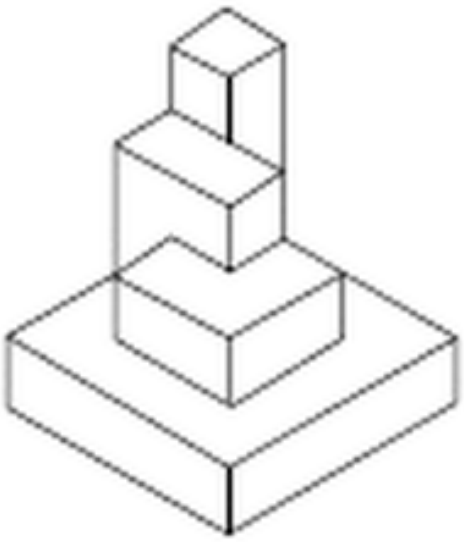
Step 2: Trace the visible upper surfaces The main mass forms a sequence of broad, nested rectangular terraces. A small square block stands at the rear corner, and a separate raised post is visible at the front-left edge. In plan the post must create a small square division near that edge, distinct from the small square marking the uppermost rear block. Follow each boundary only as far as the corresponding raised surface continues; a line cannot pass across an uninterrupted tread. This endpoint check distinguishes otherwise similar arrangements.

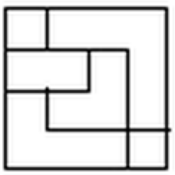
Step 3: Compare all four answer figures Option (A) shows the small rear square, the broad middle terraces and the separate front-left square post in their correct positions. Option (B) stretches the rear square into a long vertical strip instead of retaining the isolated small top block. Option (C) adds another division beside the rear block. Option (D) subdivides the front band into extra rectangles and alters the terrace boundaries.

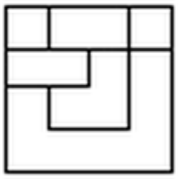
Step 4: Conclusion The vertical projection has exactly the footprint and internal step boundaries shown in option (A). Hence, the correct option is (A).

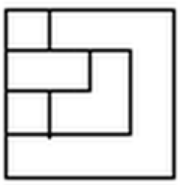
Quick Tip to Solve: Anchor the plan at the highest block, then trace the ends of the step boundaries. A single added or overextended internal line is enough to reject an otherwise similar top view.

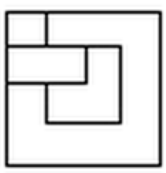
29. The 3 - D figure shows the view of an object. Identify the correct top view from amongst the answer figures. [4 marks]

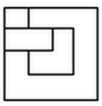


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A top view is the vertical projection of the object onto a horizontal plane. Heights disappear, but horizontal footprints and the visible boundaries between surfaces at different levels remain.
- Use the outside footprint first, then locate the highest block and follow each exposed tread. A vertical edge does not become a separate line in plan merely because it looks prominent in the three-dimensional view.

Step 1: Establish the footprint and orientation Look vertically down on the object without rotating it relative to the answer figures. Use the two perpendicular horizontal directions of the base as the plan directions. The outer boundary comes from the base, while the internal lines must come from actual changes in the height of the exposed upper surfaces. Do not copy the sloping appearance of the isometric edges into the top view.

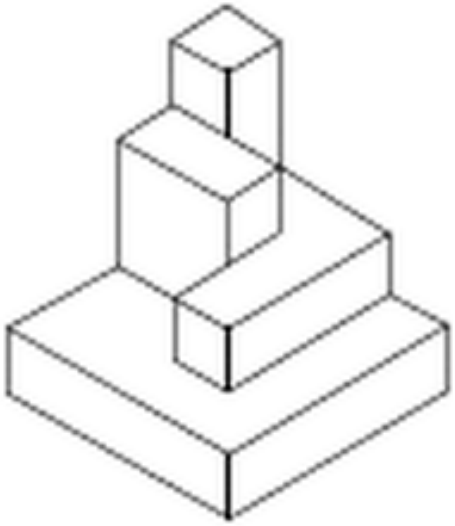
Step 2: Trace the visible upper surfaces A small square tower occupies the rear corner. Below it, the raised block turns through a right angle and steps forward; its exposed top surfaces form a compact bent arrangement within the square base. The lower raised block does not continue as a thin strip to the far right edge of the base. Follow each boundary only as far as the corresponding raised surface continues; a line cannot pass across an uninterrupted tread. This endpoint check distinguishes otherwise similar arrangements.

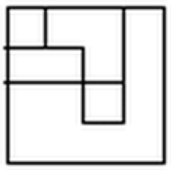
Step 3: Compare all four answer figures Option (D) retains the rear small square and the compact bent inner outline, with the surrounding base left as one exposed region on the right and below. Option (A) extends the inner arrangement to the right boundary and creates an extra lower-right cell. Option (B) continues boundaries across the upper-right area. Option (C) inserts an extra vertical division below the left end of the middle tread.

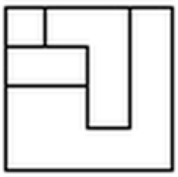
Step 4: Conclusion The vertical projection has exactly the footprint and internal step boundaries shown in option (D). Hence, the correct option is (D).

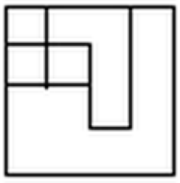
Quick Tip to Solve: Anchor the plan at the highest block, then trace the ends of the step boundaries. A single added or overextended internal line is enough to reject an otherwise similar top view.

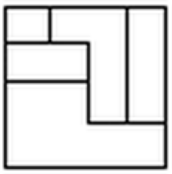
30. The 3 - D figure shows the view of an object. Identify the correct top view from amongst the answer figures. [4 marks]

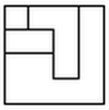


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A top view is the vertical projection of the object onto a horizontal plane. Heights disappear, but horizontal footprints and the visible boundaries between surfaces at different levels remain.
- Use the outside footprint first, then locate the highest block and follow each exposed tread. A vertical edge does not become a separate line in plan merely because it looks prominent in the three-dimensional view.

Step 1: Establish the footprint and orientation Look vertically down on the object without rotating it relative to the answer figures. Use the two perpendicular horizontal directions of the base as the plan directions. The outer boundary comes from the base, while the internal lines must come from actual changes in the height of the exposed upper surfaces. Do not copy the sloping appearance of the isometric edges into the top view.

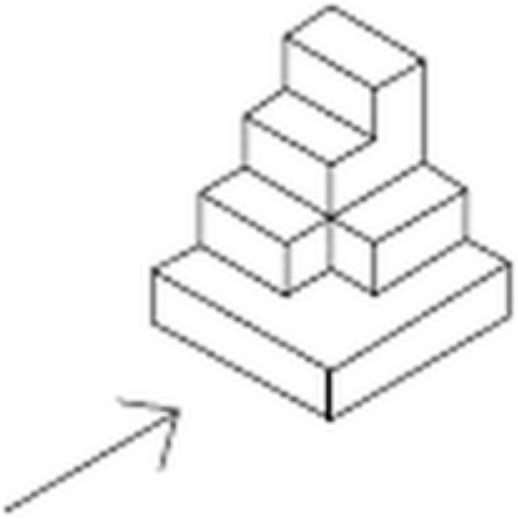
Step 2: Trace the visible upper surfaces The topmost square is at the rear corner, with a broader rectangular block below and in front of it. A long lower ledge turns along the right side of this block and has a projecting front end. From above that ledge must appear as an L-shaped strip, with a short closing edge at its forward end. Follow each boundary only as far as the corresponding raised surface continues; a line cannot pass across an uninterrupted tread. This endpoint check distinguishes otherwise similar arrangements.

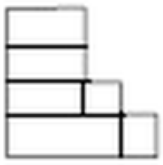
Step 3: Compare all four answer figures Option (B) shows the rear square, the rectangular raised block and the right-hand L-shaped ledge with the correct short end closure. Option (A) makes the bottom return continue too far left, adding an edge beneath the broad block. Option (C) adds a small square division in the middle-left area. Option (D) extends the ledge towards the extreme right of the outer base and changes the width and position of the exposed base region.

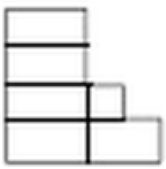
Step 4: Conclusion The vertical projection has exactly the footprint and internal step boundaries shown in option (B). Hence, the correct option is (B).

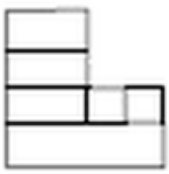
Quick Tip to Solve: Anchor the plan at the highest block, then trace the ends of the step boundaries. A single added or overextended internal line is enough to reject an otherwise similar top view.

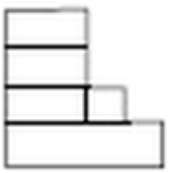
31. The 3 - D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- An orthographic elevation is the outline and visible surface edges obtained by looking parallel to the indicated arrow. Edges along the line of sight collapse; vertical heights are preserved.
- Match both the outer stepped profile and the positions and endings of internal lines. A line on a receding top face must not be transferred automatically into the elevation.

Step 1: Set the viewing direction Look along the arrow from the lower-left towards the solid. The sloping edges parallel to that arrow represent depth, so they do not produce a staircase running into the page in the required elevation. The other family of sloping horizontal edges becomes horizontal in the answer. Consequently, the tall stack appears at the left, and the shorter projection appears to its right.

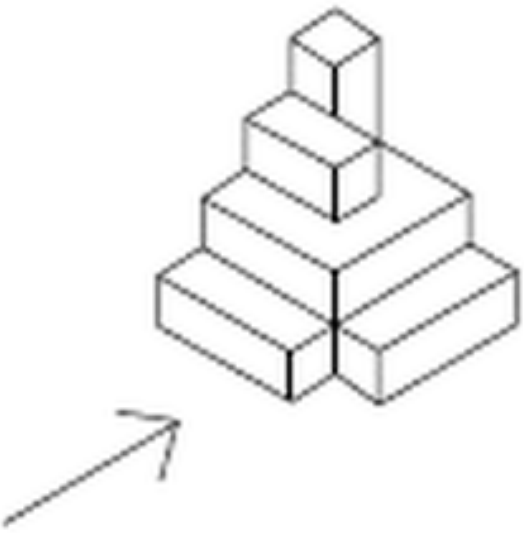
Step 2: Trace the visible tiers Start at the bottom: the base projects as one complete rectangle, without an internal vertical joint. Above it, the left-hand stack rises through successive levels to the highest rectangular tier. The shorter block on the right reaches only the lower intermediate level. At that level, its front edge produces the short vertical division beside the taller stack; this division stops at the base top.

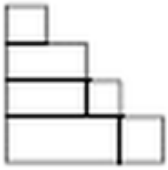
Step 3: Compare the internal lines Option (D) has both the correct stepped outline and the correct termination of the short internal line. Option (A) adds a vertical line through the base near the right end. Option (B) continues the central division down through the base. Option (C) raises the far-right portion into a separate upright shape. None of those extra edges is part of the visible projection of the solid.

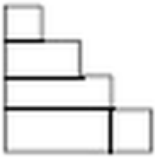
Step 4: Conclusion The visible profile and the internal edge arrangement agree with answer figure (D). Hence, the correct option is (D).

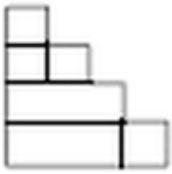
Quick Tip to Solve: After fixing the arrow direction, check whether the base is continuous and where each internal vertical line stops; these details distinguish similar stepped outlines.

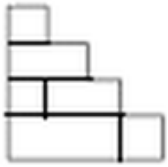
32. The 3 - D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- An orthographic elevation is the outline and visible surface edges obtained by looking parallel to the indicated arrow. Edges along the line of sight collapse; vertical heights are preserved.
- Match both the outer stepped profile and the positions and endings of internal lines. A line on a receding top face must not be transferred automatically into the elevation.

Step 1: Project along the arrow View the solid from the lower-left in the arrow direction. Edges pointing away along this direction collapse in an elevation, while vertical heights remain unchanged. The small top post is therefore at the left of the answer, above the broader supporting levels. Read the outline from top to bottom rather than counting all the oblique lines visible in the perspective drawing.

Step 2: Follow each supporting layer The top post has the narrowest width. The next horizontal

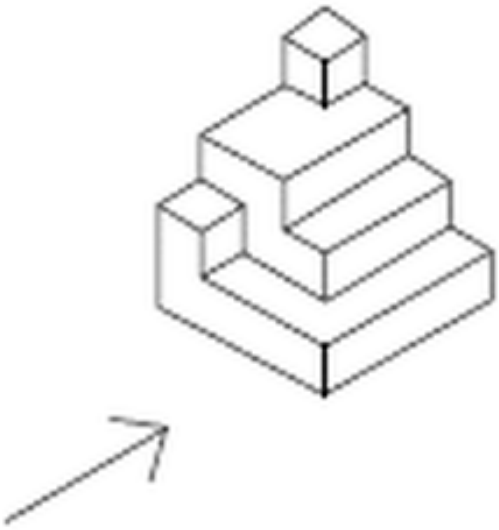
block extends farther to the right, and the slab below extends farther again. Its visible front band is continuous: it is not divided by an upright line below the end of the upper block. At the lowest level, the offset base pieces do leave a vertical junction near the right-hand end, which must be retained.

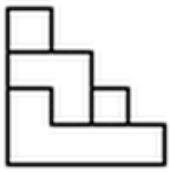
Step 3: Eliminate incorrect partitions Option (B) shows the narrow top post, successively wider steps, the uninterrupted broad band, and the junction in the base at the correct side. Option (A) inserts a vertical division in the intermediate band. Options (C) and (D) place an additional upright division nearer the left in that band. Those divisions mistake edges on receding surfaces for edges visible in the requested elevation.

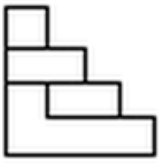
Step 4: Conclusion The visible profile and the internal edge arrangement agree with answer figure (B). Hence, the correct option is (B).

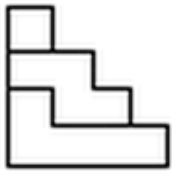
Quick Tip to Solve: After fixing the arrow direction, check whether the base is continuous and where each internal vertical line stops; these details distinguish similar stepped outlines.

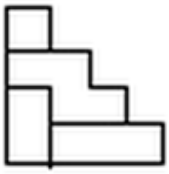
33. The 3 - D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]

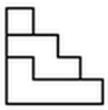


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- An orthographic elevation is the outline and visible surface edges obtained by looking parallel to the indicated arrow. Edges along the line of sight collapse; vertical heights are preserved.
- Match both the outer stepped profile and the positions and endings of internal lines. A line on a receding top face must not be transferred automatically into the elevation.

Step 1: Establish the elevation outline Sight along the arrow towards the object. The highest small block lies at the left of this elevation. The main stack then descends in steps towards the right. Although all four alternatives have a similar outline, the outline alone cannot identify the answer: the short upright block at the front-left changes the visible internal edges.

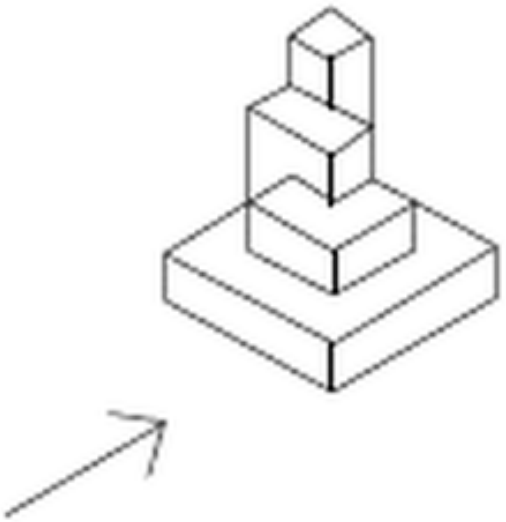
Step 2: Trace the front-left upright The front-left block hides the lower part of the main stack behind it. Its top gives a short horizontal line from the left edge. At the right end of that top, the visible edge drops to the next lower level and then continues horizontally towards the right. Thus the important interior boundary is an L-shaped step, with no extra division cutting the lowermost band into separate rectangles.

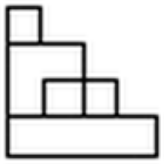
Step 3: Check the options against that boundary Option (C) preserves that stepped internal boundary and the correct descending silhouette. Option (A) adds an extra vertical division farther right in the intermediate region. Option (B) carries a horizontal division across the upper broad portion, contrary to the visible continuous face. Option (D) continues an upright division into the bottom region. These are line-position errors, even though their outer contours resemble the solid.

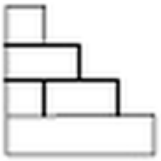
Step 4: Conclusion The visible profile and the internal edge arrangement agree with answer figure (C). Hence, the correct option is (C).

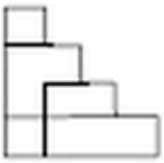
Quick Tip to Solve: After fixing the arrow direction, check whether the base is continuous and where each internal vertical line stops; these details distinguish similar stepped outlines.

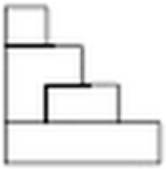
34. The 3 - D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]

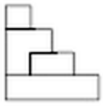


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- An orthographic elevation is the outline and visible surface edges obtained by looking parallel to the indicated arrow. Edges along the line of sight collapse; vertical heights are preserved.
- Match both the outer stepped profile and the positions and endings of internal lines. A line on a receding top face must not be transferred automatically into the elevation.

Step 1: Fix left and right from the arrow Look towards the solid along the lower-left arrow. The uppermost post lies on the left of the resulting elevation. The next block spreads to the right below it, followed by the lower ledge and the broad base. Depth distances along the arrow disappear, but the upright supporting faces and the edges at changes of height remain visible.

Step 2: Identify the support under the upper block The middle upright is not simply a series of independent full-width slabs. The upper block projects to the right of its supporting vertical portion,

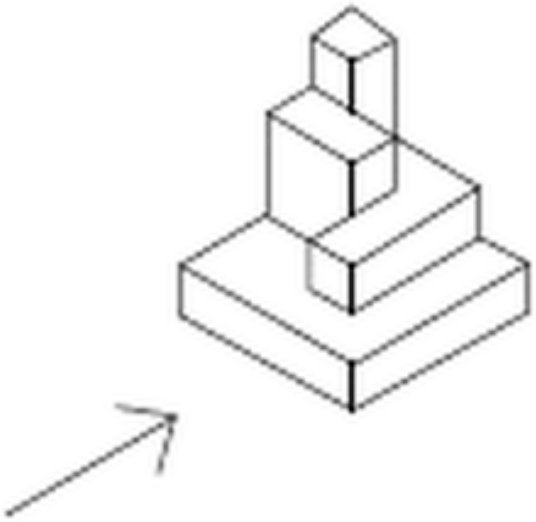
making an inward corner underneath the overhang. Below this corner, the support edge runs down to the top of the base. The lower ledge extends rightwards from this region, so its junction must be shown at the appropriate height, not as a wholly detached rectangle.

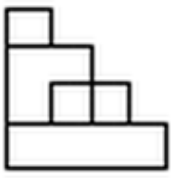
Step 3: Match the inward corner and line endings Option (D) puts the inward corner under the upper projection and joins the supporting vertical edge to the base at the correct position. Option (A) substitutes rectangular cells in the lower middle region. Option (B) introduces a slab-like band across the upper middle region. Option (C) extends the supporting vertical line through the base, splitting a band that must remain continuous. Compare these internal edges after confirming the common stepped outline.

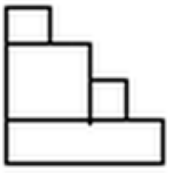
Step 4: Conclusion The visible profile and the internal edge arrangement agree with answer figure (D). Hence, the correct option is (D).

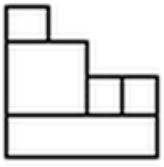
Quick Tip to Solve: After fixing the arrow direction, check whether the base is continuous and where each internal vertical line stops; these details distinguish similar stepped outlines.

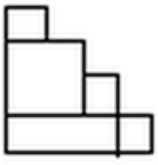
35. The 3 - D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]

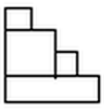


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- An orthographic elevation is the outline and visible surface edges obtained by looking parallel to the indicated arrow. Edges along the line of sight collapse; vertical heights are preserved.
- Match both the outer stepped profile and the positions and endings of internal lines. A line on a receding top face must not be transferred automatically into the elevation.

Step 1: Read the viewing direction Take the elevation looking along the arrow from the lower-left. The tallest part is at the left and the low projecting platform is towards the right. The uppermost small post rises above a wider upright face. In this direction the front face of that upright is visible as one broad unbroken region, rather than as several horizontal stacked bands.

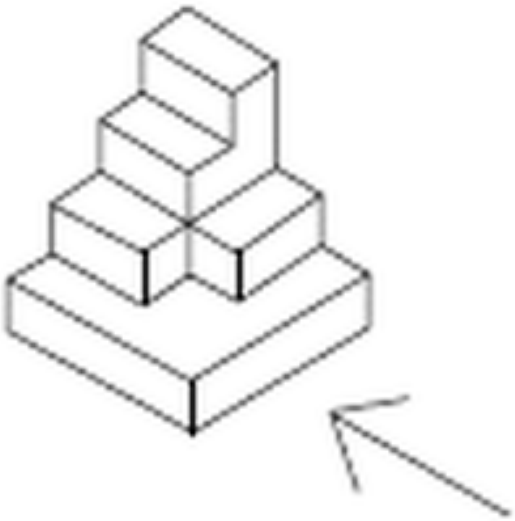
Step 2: Trace the upright and the lower ledge Follow the right edge of the broad upright downwards. It continues to the base level, with the lower projecting ledge attached on its right. That ledge forms a single smaller rectangular region beside the upright. The base itself forms one uninterrupted bottom band. Receding edges on top surfaces do not justify drawing extra vertical partitions on either the ledge or the base.

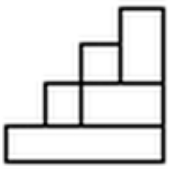
Step 3: Reject added divisions Option (B) shows the continuous broad upright, the single lower rectangle at its right, and the complete base band. Option (A) divides the middle into small rectangular regions that do not represent the visible front face. Option (C) splits the lower side region into two compartments. Option (D) adds a short vertical division through the base near its right-hand end. Removing these imagined surface divisions leaves precisely the arrangement in (B).

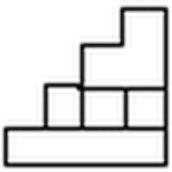
Step 4: Conclusion The visible profile and the internal edge arrangement agree with answer figure (B). Hence, the correct option is (B).

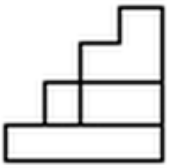
Quick Tip to Solve: After fixing the arrow direction, check whether the base is continuous and where each internal vertical line stops; these details distinguish similar stepped outlines.

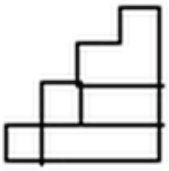
36. The 3 - D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]

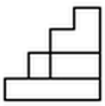


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- An orthographic elevation is the outline and visible surface edges obtained by looking parallel to the indicated arrow. Edges along the line of sight collapse; vertical heights are preserved.
- Match both the outer stepped profile and the positions and endings of internal lines. A line on a receding top face must not be transferred automatically into the elevation.

Step 1: Reverse the side of observation Here the arrow approaches the object from the lower-right. Look along that arrow rather than automatically using the left-facing view of a similar stepped solid. The highest upright consequently appears on the right of the required elevation, and the profile rises from the low left end towards the right. This establishes the orientation before checking the small internal lines.

Step 2: Trace the projected faces The broad base remains a single rectangular band across the entire

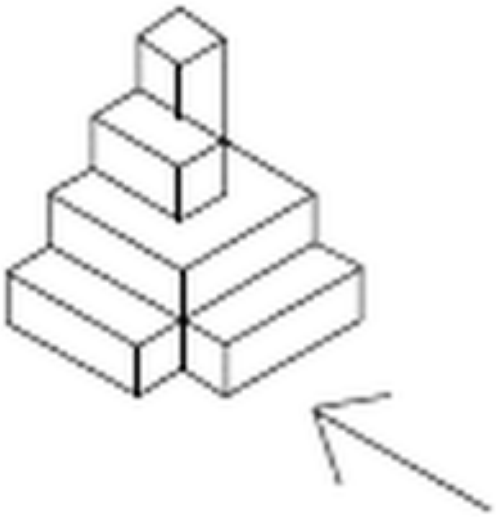
width. Above it, the lower visible faces form the stepped left-to-right rise. A vertical boundary is visible near the left portion of the intermediate band, while the upper central-to-right face remains continuous up to the taller upright. No visible edge continues down through the base, and no extra partition is required inside the upper broad face.

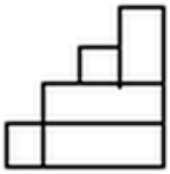
Step 3: Compare line continuity Option (C) gives the correct rising profile, the required intermediate vertical boundary, and the uninterrupted bottom band. Option (A) adds an upright subdivision in the upper part of the stack. Option (B) inserts several small partitions in the intermediate band. Option (D) carries an internal line down into the base. These alternatives preserve much of the silhouette but misrepresent where the visible edges actually end.

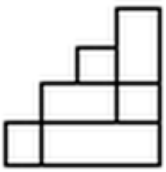
Step 4: Conclusion The visible profile and the internal edge arrangement agree with answer figure (C). Hence, the correct option is (C).

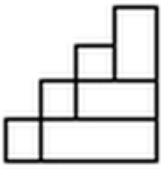
Quick Tip to Solve: After fixing the arrow direction, check whether the base is continuous and where each internal vertical line stops; these details distinguish similar stepped outlines.

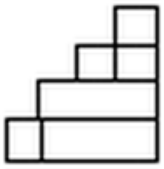
37. The 3 - D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]

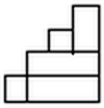


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An elevation is the perpendicular projection obtained by looking along the arrow. Depth in the viewing direction disappears, while height and horizontal position remain.
- Visible edges must be checked separately from the outer staircase silhouette; a line is retained only where an actual exposed boundary projects.

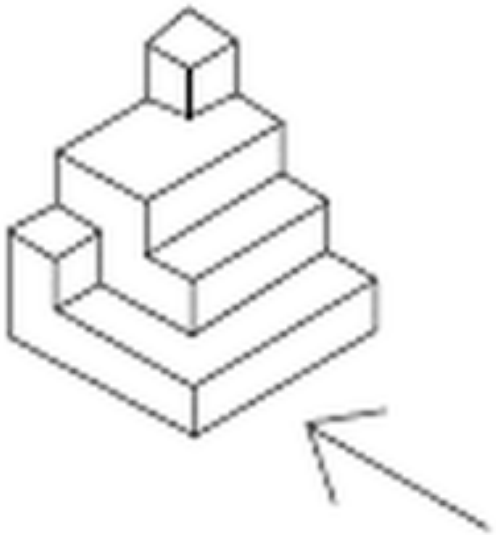
Step 1: Fix the viewing direction Look from the lower-right side of the object towards the arrowhead. The broad lower slab supplies the bottom strip. The successive upper blocks give a rising staircase towards the right, ending in the tall narrow upright. The oblique edges in the perspective drawing must become horizontal or vertical in the elevation.

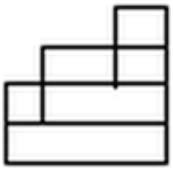
Step 2: Compare the internal edges The near lower step introduces a short vertical division at the left of the bottom strip. At the next levels, the exposed changes of block width introduce short vertical divisions successively farther right. The tall upright has an uninterrupted vertical side above the supporting block. These positions and terminations agree with (A). In (B), a vertical division continues too far down on the right. In (C), the middle division extends through lower strips where the projected face is uninterrupted. In (D), an additional horizontal subdivision crosses the upper upright, which the object does not have.

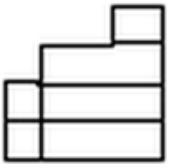
Step 3: Conclusion The staircase profile and the positions of all exposed edge divisions match (A). Hence, the correct option is (A).

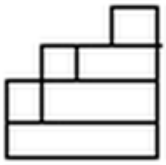
Quick Tip to Solve: After matching the outline, check where each vertical line stops; the alternatives here differ mainly in those terminations.

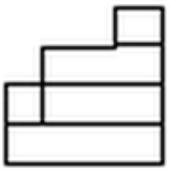
38. The 3 - D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]

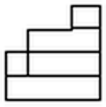


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- An orthographic view collapses the depth parallel to the arrow without changing the vertical heights.
- The highest small cube and the broad supporting blocks can overlap in projection; hidden rear edges are not added as visible lines.

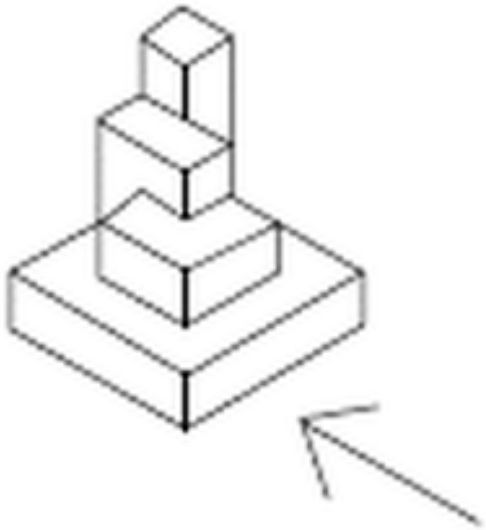
Step 1: Project the main masses View the object from the lower-right towards the indicated arrowhead. The base projects as a broad rectangular strip. Above it the object has successively narrower levels, rising to the small cube at the upper right. The small projection at the left produces a short vertical edge in the middle strip, but this edge does not divide the entire base.

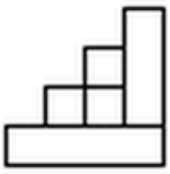
Step 2: Match the visible boundaries Follow the outline from left to right and then compare the seams inside it. The left-hand short division ends at the top of the base, while the rightmost small cube rises above the long horizontal ledge. In the required view the long middle face is continuous except for the exposed short left division. This arrangement is shown in (D). Option (A) adds an internal vertical division across the upper right ledge. Option (B) prolongs the left division through the bottom strip. Option (C) inserts vertical divisions into the upper strip rather than leaving the projected face continuous.

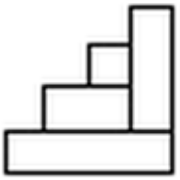
Step 3: Conclusion The projected arrangement of the base, left projection, long ledge and top cube is the one in (D). Hence, the correct option is (D).

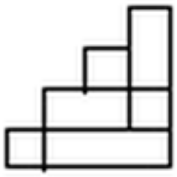
Quick Tip to Solve: Treat the little left block and the top cube as checkpoints: their visible seams distinguish this view more reliably than its outline.

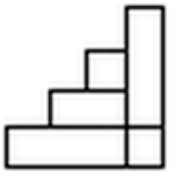
39. The 3 - D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]

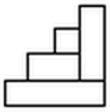


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- Projection along the arrow removes depth; coincident outlines are drawn once.
- A continuous face is not divided merely because another part of the object lies behind it. Compare both the perimeter and the internal exposed edges.

Step 1: Obtain the staircase outline Look from the lower-right along the arrow. The lowest slab becomes a single wide base rectangle. The middle supports recede in width towards the upper right, producing the stepped left outline. The narrow upright at the extreme right reaches the greatest height and projects as a continuous tall strip.

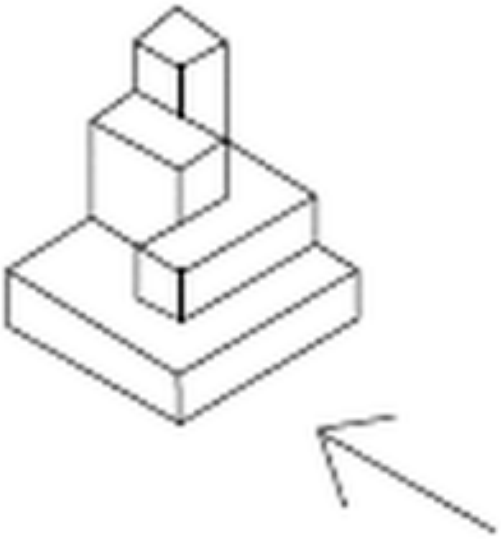
Step 2: Check the divisions against the choices The supporting block just left of the upright contributes a short vertical edge in the next upper band. There is no extra vertical seam through the broad bottom slab, and the front face below that short upper edge remains uninterrupted. Option (B) has exactly

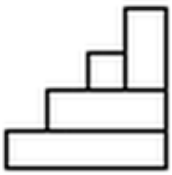
these features: one broad base, the short upper division and the continuous right upright. Option (A) extends an internal edge down through the middle supporting region. Option (C) adds a vertical seam in the base and a lower internal division. Option (D) subdivides the right upright horizontally and carries its edge through the base, neither of which matches the visible projected faces.

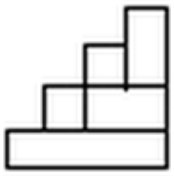
Step 3: Conclusion Only (B) preserves the continuous base and upright while placing the short upper division correctly. Hence, the correct option is (B).

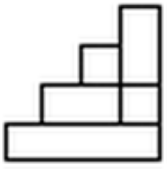
Quick Tip to Solve: Trace one face at a time. Do not introduce a seam into a flat projected face simply because the perspective figure contains a rear edge.

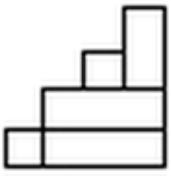
40. The 3 - D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]

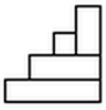


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- In an elevation, horizontal and vertical dimensions survive, while the depth along the viewing arrow is suppressed.
- An exposed vertical boundary can continue through several projected levels; its length must agree with the actual changes of the visible faces.

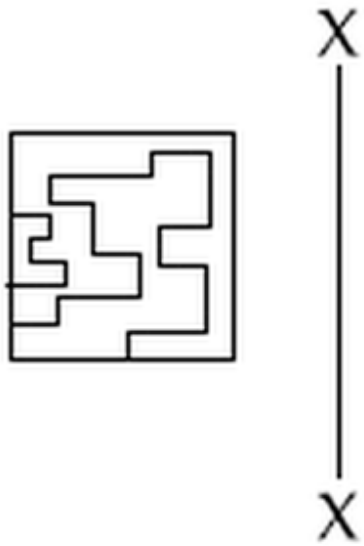
Step 1: Trace the exterior from the arrow side The viewing arrow points towards the object from the lower-right. From this side the wide base forms the bottom rectangle. The first raised block, the wider upper block and the narrow highest upright make a staircase rising to the right. The base itself has a continuous rectangular front outline.

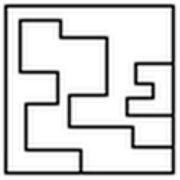
Step 2: Locate the internal vertical edge The intermediate supporting block presents a continuous face in the lower raised strip. Above it, the wider upper block contributes a short vertical edge beside the tallest upright. This edge stops at the top of the supporting strip; it does not continue down into that strip or the base. Option (A) has precisely this arrangement. In (B), an extra vertical division continues through the lower raised strip. Option (C) also divides that strip and extends a line beneath the upright. Option (D) adds a seam through the bottom slab. None of these extra seams represents a visible exposed boundary in the required projection. The uninterrupted base and lower raised strip, together with the short upper division, therefore select (A).

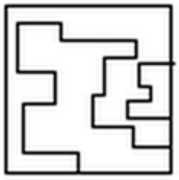
Step 3: Conclusion The view has a continuous base and lower raised strip, with the short upper vertical division shown in (A). Hence, the correct option is (A).

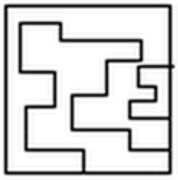
Quick Tip to Solve: Check the two lowest strips first: both are continuous here. Then match the short vertical division just below the highest part.

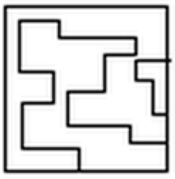
41. Which one of the answer figures is the correct mirror image of the problem figure with respect to X – X ? [4 marks]

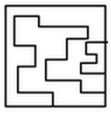


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- Reflection in the vertical line X–X reverses left and right but preserves top and bottom.
- Every corner stays at the same height and at an equal perpendicular distance from the mirror. A mirror image is not a rotation.

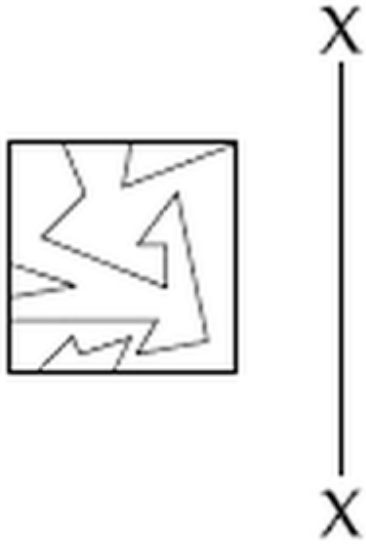
Step 1: Reflect the distinctive turns The original square has a stepped path near its top: a high horizontal segment on the right is joined to a lower segment towards the left. In the reflection this high segment moves to the left, while every change of height remains unchanged. Similarly the small indentations beside the original left boundary must appear beside the right boundary.

Step 2: Compare the complete reflected path Follow the path from the top through the central rectangular turns and then along the bottom. The central inward step changes its horizontal direction, the small right-side notch is the reversed form of the original left-side notch, and the bottom change of level moves to the opposite side. Option (C) preserves all these heights and reverses their left-right order. Option (A) changes the central turns rather than merely reflecting them. Option (B) alters the top and middle path arrangement. Option (D) changes the small right-hand notch, so that its succession of inward and outward turns no longer matches the original.

Step 3: Conclusion The complete horizontal reflection of the problem figure is (C). Hence, the correct option is (C).

Quick Tip to Solve: For a stepped mirror pattern, track three landmarks at fixed heights: the top step, the smallest side notch and the bottom step.

42. Which one of the answer figures is the correct mirror image of the problem figure with respect to X – X ? [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A vertical mirror reverses the horizontal coordinate only. Thus a slant rising towards the right becomes a slant rising towards the left, while its endpoints keep their heights.
- The sharp turns, boundary intersections and relative vertical levels must all be preserved under reflection.

Step 1: Reverse the main angular path Reflect the original about X–X by moving each point to the opposite side at the same height. The long diagonal in the upper-right part moves to the upper-left part. The inward angular point near the centre changes its horizontal direction, and the long lower sloping segment reverses its slope. The zigzag near the bottom remains near the bottom rather than moving to the top.

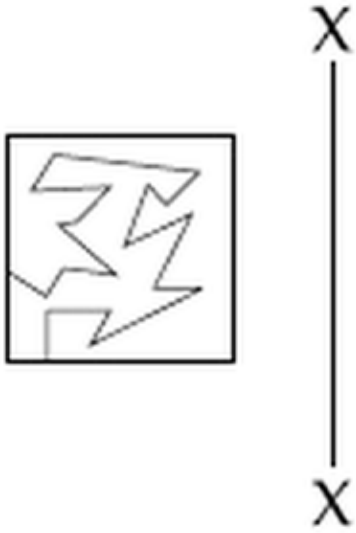
Step 2: Eliminate altered angular figures Option (C) preserves the reflected upper notch, the central

pointed turn and the succession of lower zigzags. Check especially the long segment reaching the right boundary: its height and slope are the left-right reversal of the corresponding original segment. Option (A) changes the shape of the central inward turn into a different corner arrangement. Option (B) changes the upper-right angular path instead of reflecting it faithfully. Option (D) has an additional lower line arrangement at the right that does not correspond to the original reflected path. These differences remain even though the four choices share a similar square outline.

Step 3: Conclusion The position and orientation of every angular segment match the vertical mirror reflection in (C). Hence, the correct option is (C).

Quick Tip to Solve: Keep the height of each sharp vertex fixed as you reflect it. A changed height or an extra boundary intersection immediately rejects a choice.

43. Which one of the answer figures is the correct mirror image of the problem figure with respect to X – X ? [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A plane mirror reverses left and right relative to a vertical mirror line, while preserving the height of every point.
- Reflection preserves lengths, angles and the order of connected segments. A pointed corner must remain pointed; it cannot become a rectangular step.

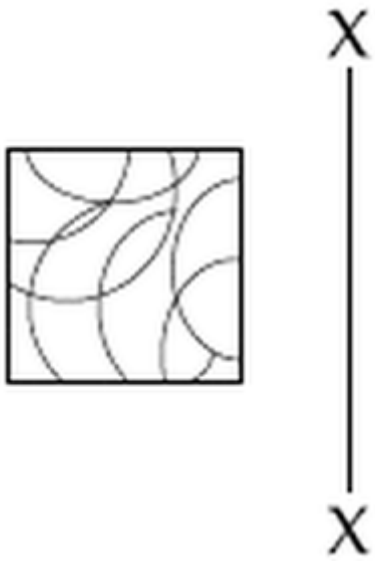
Step 1: Reflect the large landmarks The line X–X is vertical and lies to the right of the problem figure. Therefore, the upper sloping edge remains at the top, but its slope reverses. The narrow rectangular indentation touching the bottom edge moves from the left side to the right side. The zigzag that meets the left boundary moves to the right boundary at the same relative height. These checks eliminate rotations and vertical reversals.

Step 2: Trace the inner zigzag Now follow the connected line from the upper edge through its successive sharp turns, comparing the lengths and directions after reversing left and right. The prominent inward triangular points must still occur at the same heights. In option (A), the upper pointed notch, the central diagonal zigzag, the lower long diagonal and the bottom rectangular indentation occur in the reflected order. It retains the small intermediate turn in the central boundary. Option (B) alters this central detail, option (C) replaces an oblique turn by a rectangular stepped portion, and option (D) changes the lower indentation and diagonal junction. A broad resemblance is insufficient: each bend must match.

Step 3: Conclusion The complete left-right reflection is figure (A). Hence, the correct option is (A).

Quick Tip to Solve: Check the bottom indentation first, then trace the central zigzag one corner at a time; similar outer outlines can conceal a changed bend.

44. Which one of the answer figures is the correct mirror image of the problem figure with respect to X – X ? [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A reflection in a vertical line preserves the height of each point and reverses its horizontal position.
- For curved-line figures, compare complete continuous arcs, their boundary endpoints and their intersections; isolated curved fragments can look misleadingly similar.

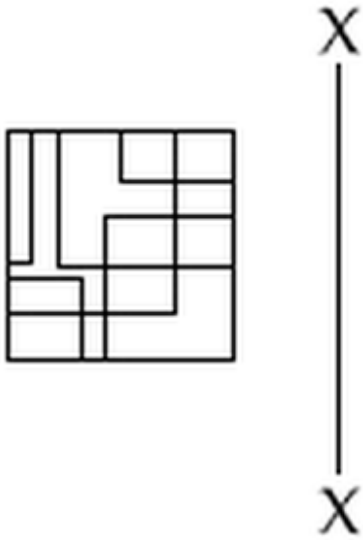
Step 1: Locate boundary landmarks Keep the top and bottom of the square fixed and interchange its left and right sides. Thus, curves meeting the left boundary in the problem must meet the right boundary in its mirror image at the corresponding heights. Likewise, the curved segments nearest the original right edge must appear nearest the reflected left edge. The top curved cap remains at the top and is laterally reversed, rather than being turned upside down.

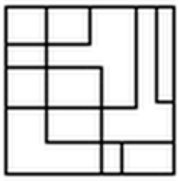
Step 2: Follow the continuous curves Trace each curve from a boundary endpoint across the square and through the intersections, reversing every leftward bend into a rightward bend. Compare the upper cap, the short near-horizontal boundary segment, the central lens-like crossing and the lower arcs together. Option (C) preserves their reflected connections and endpoint positions. The other choices reproduce some local arcs, but change a junction or continue an arc through a different part of the square. In particular, checking only the large curve beside the left border does not distinguish all the options: its connection to the middle and upper curves must also be checked. The reflected arrangement as a whole matches (C), not (A), (B) or (D).

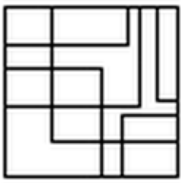
Step 3: Conclusion The correct mirror image of the entire curved pattern is figure (C). Hence, the correct option is (C).

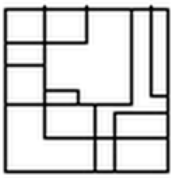
Quick Tip to Solve: For an intricate mirror image, start at an edge endpoint and follow one whole curve; use its crossings to distinguish close alternatives.

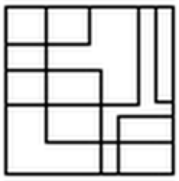
45. Which one of the answer figures is the correct mirror image of the problem figure with respect to X – X ? [4 marks]

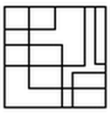


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A vertical mirror changes left into right but leaves vertical positions and horizontal alignments unchanged.
- Rectangular line networks are best compared by tracing connected paths and checking the height and length of each crossbar.

Step 1: Reverse the boundary features The thin rectangular channel originally next to the left side must appear next to the right side. Its bottom turn remains at the same height. The small rectangular compartment near the upper right shifts to the upper left, and the lower-left group shifts to the lower right. The square frame itself keeps its orientation; the diagram is reflected, not rotated.

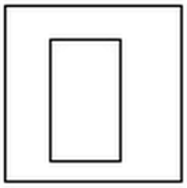
Step 2: Check the interior crossbars After identifying the right-side narrow channel, trace the upper-left compartment and then the horizontal lines through the middle of the reflected square. Every

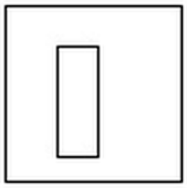
original horizontal segment must end at the reflected position of its original endpoint. Figure (D) gives the correct short upper-left compartment, the middle rectangular projection and the lower-right compartment, with matching vertical continuations. In (A), the lower part of the right-side path does not have the required reflected connection. In (B), the upper horizontal segment is extended into a different compartment. In (C), the central horizontal and vertical joins differ from the reflected network. These differences are structural, so merely having a narrow strip at the right is not sufficient.

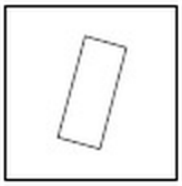
Step 3: Conclusion All the rectangular paths have their required reflected positions in figure (D). Hence, the correct option is (D).

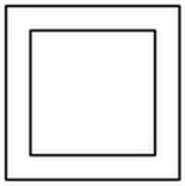
Quick Tip to Solve: Use the narrow boundary channel as an anchor, then compare the endpoints of each horizontal crossbar from top to bottom.

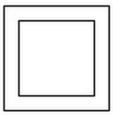
46. Find the odd figure out of the problem figures given below. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- An odd-figure question asks for a common geometric property shared by three choices and absent from the fourth.
- Rotation changes the direction in which a figure is drawn, but does not change its side lengths, angles or geometric class. A square has equal adjacent sides.

Step 1: Compare the inner shapes Ignore the identical outer square frames and examine only the inner quadrilaterals. Figures (A) and (B) contain upright elongated rectangles: their length and breadth are unequal. Figure (C) also contains an elongated rectangle, simply tilted within its frame. Its orientation is different, but it still has two longer opposite sides and two shorter opposite sides.

Step 2: Identify the distinguishing property Figure (D) contains a square, whose four sides are equal. Thus, (A), (B) and (C) form the group of non-square rectangles, whereas (D) differs by equality of all its sides. It would be tempting to choose (C) because it is tilted, but that uses the placement of the shape rather than the more fundamental property of the shape itself. Rotating (C) upright would bring it into the same elongated-rectangle class as (A) and (B). Rotating (D) cannot make its adjacent

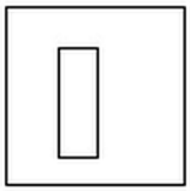
sides unequal. The common outer frame supplies no distinction because it is the same type in every option.

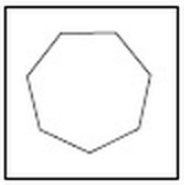
Step 3: Conclusion Figure (D) is the odd one out because its inner figure is a square; the other inner figures are non-square rectangles. Hence, the correct option is (D).

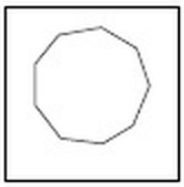
Quick Tip to Solve: Before choosing a tilted figure as odd, mentally rotate it upright and compare side equality; rotation does not change a rectangle into a square.

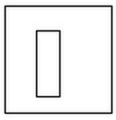
47. Find the odd figure out of the problem figures given below. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A polygon can be classified by the number of straight sides on its boundary.
- The parity of the side count, meaning odd or even, is unchanged by rotation, size or the direction in which the polygon is drawn.

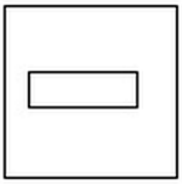
Step 1: Count the inner polygon sides Ignore the common outer square and walk once around each inner boundary, counting every straight edge exactly once. Figure (A) is a triangle and therefore has three sides. Figure (B) is a rectangle and has four sides. The multi-sided polygon in (C) has seven sides, and the polygon in (D) has nine sides. Count successive corners around the boundary rather than counting only the most prominent edges.

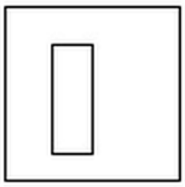
Step 2: Group the counts by parity The side counts for (A), (C) and (D) are 3, 7 and 9 respectively; all three are odd numbers. Figure (B) has 4 sides, an even number. Consequently, (B) alone falls outside the common odd-sided group. Selecting (A) merely because it has the fewest sides would not express the property shared by all the remaining figures. Similarly, the more nearly circular appearance of (D) results from its larger side count and does not exclude it from the odd-sided set. The odd-versus-even test gives a consistent classification of every choice.

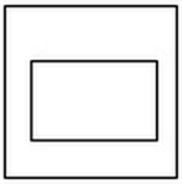
Step 3: Conclusion Figure (B), the four-sided rectangle, is the only even-sided inner polygon. Hence, the correct option is (B).

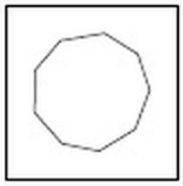
Quick Tip to Solve: Count the inner sides first and compare odd/even counts; do not let the common outer frame enter the count.

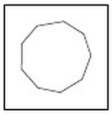
48. Find the odd figure out of the problem figures given below. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A rectangle is a quadrilateral with four right angles and two pairs of parallel opposite sides.
- Changing the size or rotating a rectangle leaves it in the same geometric class. The number and arrangement of sides are more reliable than its orientation.

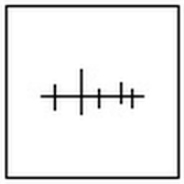
Step 1: Compare the first three inner boundaries The outer square is only a common frame. The inner figure in (A) is a horizontal rectangle; that in (B) is a vertical rectangle; and that in (C) is a larger horizontal rectangle. Each of these three shapes has exactly four straight sides and four right angles, with its opposite sides parallel. The different length-to-breadth ratios and the vertical placement in (B) do not alter this classification.

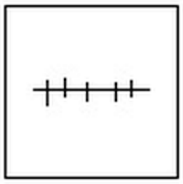
Step 2: Test the remaining inner figure The inner figure in (D) is a many-sided polygon, rather than a four-sided rectangle. Its boundary has several oblique edges and more than four corners, so it does not possess the common rectangular structure of (A), (B) and (C). One should not select (B) solely because it is upright: turning the page would reverse that visual distinction while leaving the geometry unchanged. Nor does the greater size of (C) matter, because enlargement preserves the shape. The stable common property is that the first three inner figures are rectangles, and the fourth is not.

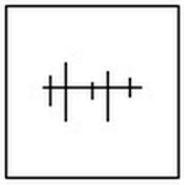
Step 3: Conclusion Figure (D) is the odd one out because its inner polygon is not a rectangle. Hence, the correct option is (D).

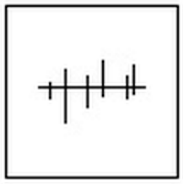
Quick Tip to Solve: Ignore size and whether the long side is horizontal or vertical; compare the number of sides and the right-angle structure.

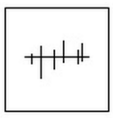
49. Find the odd figure out of the problem figures given below. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- An odd-figure problem requires a relation common to three complete figures; merely counting the five transverse strokes does not distinguish these options.
- Compare the orientation of the carrier line with the transverse strokes, rather than the position of the square enclosing each pattern.

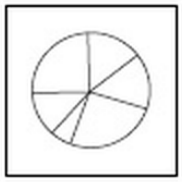
Step 1: Identify the common construction All four options contain a long carrier line crossed by five shorter strokes. The enclosure and the total number of crossings are therefore common features. Compare the angle made at each crossing: translating the whole pattern or changing a stroke length does not alter this angular relation.

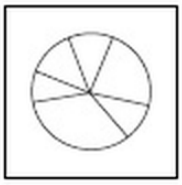
Step 2: Compare the exceptional orientation In (A), (B) and (C), the carrier is horizontal and the crossing strokes are vertical, producing right-angle intersections. In (D), the carrier rises obliquely from left to right while the crossing strokes retain their upright direction. Its intersections therefore do not retain the same perpendicular construction. The differing lengths in the other options are distractors; the structural exception is the inclined carrier in (D).

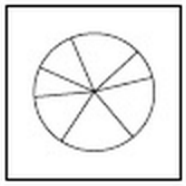
Step 3: Conclusion The odd figure is (D), whose carrier line is oblique to the upright crossing strokes. Hence, the correct option is (D).

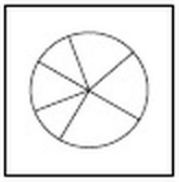
Quick Tip to Solve: Check a relation between lines before using the number or length of strokes; here the angle at the crossings is decisive.

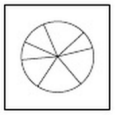
50. Find the odd figure out of the problem figures given below. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- For radial partitions of a circle, the number of sectors is unchanged by rotating the figure.
- Count each region between two neighbouring rays once by moving around the circumference in one consistent direction.

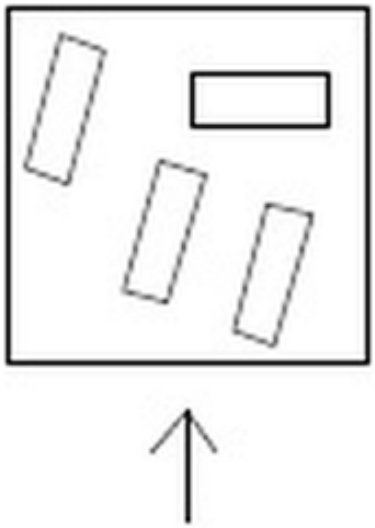
Step 1: Count sectors in the first three patterns Start at a clearly identifiable radial boundary and move clockwise around each circle. Count a region only when the next boundary is passed; do not count the initial region again on returning to the starting ray. Applying this procedure gives six sectors in (A), six in (B), and seven in (C). Different orientations of the divisions do not change these counts, and the enclosing square plays no part in the classification.

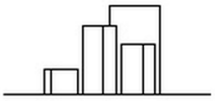
Step 2: Check the final pattern and compare Repeat the same clockwise count for (D): it also contains six sectors. Thus (A), (B) and (D) share a six-part division of their circles, whereas (C) has one additional radial division and hence seven sectors. This common numerical property distinguishes three figures without relying on their rotation or on small differences in the shapes and sizes of individual sectors. The seventh region makes (C) the odd figure.

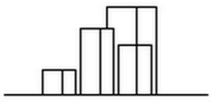
Step 3: Conclusion Figure (C) has seven sectors, one more than the six sectors in every other figure. Hence, the correct option is (C).

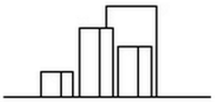
Quick Tip to Solve: Choose one starting ray and count sectors clockwise until you return to it; marking the start prevents double counting.

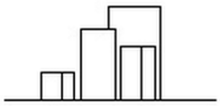
51. The problem figure shows the top view of objects. Looking in the direction of the arrow, identify the correct elevation, from amongst the answer figures. [4 marks]

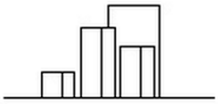


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- An elevation viewed along the arrow collapses front-to-back depth while preserving the left-to-right positions of the objects.
- A vertical edge is visible when it belongs to a nearer face and is not hidden by another object; a rotated rectangular footprint can therefore produce an internal vertical edge.

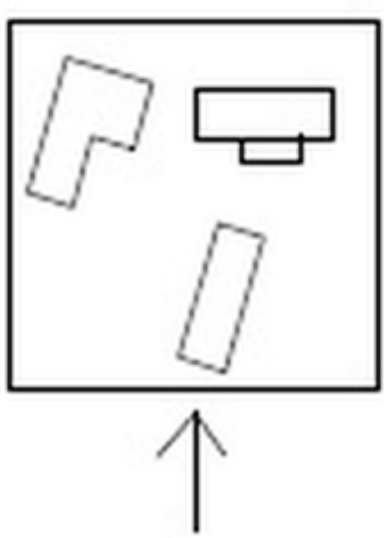
Step 1: Order the projected objects Look upwards along the arrow from the lower side of the plan. The four footprints project, from left to right, as a short block, a taller oblique block, the high rear horizontal block, and the nearer oblique block on the right. Their horizontal overlaps must be retained; one must not simply place four unrelated rectangles side by side.

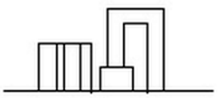
Step 2: Check the visible edge pattern The three oblique rectangular footprints give a change of face within their projected widths, so their elevations include the appropriate internal vertical edges. The horizontal rear rectangle presents a single broad face, without an extra central seam. Option (C) has the required internal edges in the short left, middle and right blocks while keeping the high rear face undivided. Option (B) adds a seam to the rear face; (D) loses the middle face edge; and (A) misplaces the edge divisions relative to the projected footprints.

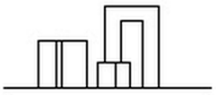
Step 3: Conclusion The correct elevation, including the visible vertical edges and overlaps, is (C). Hence, the correct option is (C).

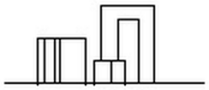
Quick Tip to Solve: First mark the left-to-right footprint spans; then add only those face edges that remain visible from the arrow.

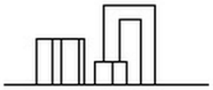
52. The problem figure shows the top view of objects. Looking in the direction of the arrow, identify the correct elevation, from amongst the answer figures. [4 marks]

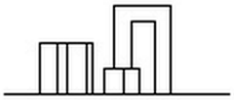


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- In a front elevation, plan depth is removed but lateral position and the visibility of front edges remain.
- A stepped or L-shaped footprint may expose an additional vertical face edge; a nearer rotated rectangular block can obscure the lower part of a rear object.

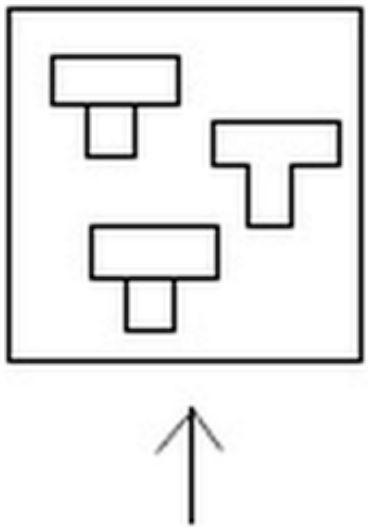
Step 1: Read the plan in the indicated direction View the plan from its lower side along the upward arrow. The L-shaped object lies on the left. The horizontal rear object lies on the right, and the oblique foreground rectangle occupies a narrower span in front of it. Project each span vertically and keep the foreground overlap in that right-hand region.

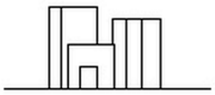
Step 2: Match the steps and visible seams The left elevation must retain the face changes implied by the L-shaped footprint. On the right, the rear stepped form includes the narrower central vertical face, with the low foreground block obscuring its lower portion. Because that foreground block is oblique in plan, its elevation includes a visible internal edge close to its right side. Option (D) preserves these positions and edge divisions together. Option (A) omits the foreground face edge, while (B) and (C) place the left-hand or foreground divisions differently from the plan.

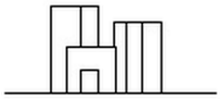
Step 3: Conclusion The elevation consistent with the stepped footprints and front overlap is (D). Hence, the correct option is (D).

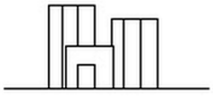
Quick Tip to Solve: For stepped footprints, check both the outer silhouette and the internal vertical seams; the silhouette alone can leave several options.

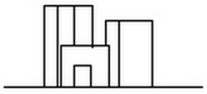
53. The problem figure shows the top view of objects. Looking in the direction of the arrow, identify the correct elevation, from amongst the answer figures. [4 marks]

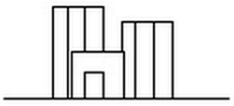


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- Objects nearer the observer hide the overlapping portions of objects behind them in an orthographic elevation.

- A T-shaped footprint seen from its stem side exposes the two lateral boundaries of that stem within the projected width of its crossbar.

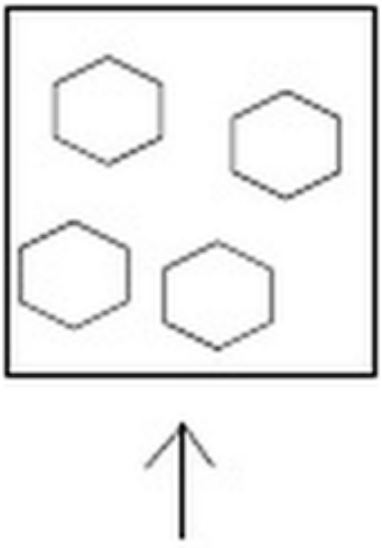
Step 1: Identify front and rear footprints The arrow points upwards from below the plan. The lower central T is therefore the foreground object. The upper-left T is behind it and projects to the left; the right-hand T projects to the right. Keep their lateral spans while discarding the distances in depth.

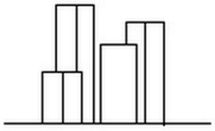
Step 2: Retain exactly the visible face edges For the two rear T-shaped objects, the stems face the observer and create two visible vertical face junctions within their broad projected widths. The foreground T is represented by the low central form, including its narrower central stem face; it obscures the portions of the rear forms that lie directly behind its projected width. Option (C) shows both rear objects with the pair of required vertical edges and lets the foreground object hide their overlapping lower portions. Options (A) and (B) omit one of the left rear junctions; (D) fails to retain the corresponding pair on the right.

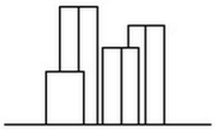
Step 3: Conclusion Option (C) gives the required visible-edge pattern and foreground overlap. Hence, the correct option is (C).

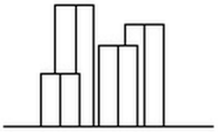
Quick Tip to Solve: For each T, decide whether its stem points toward or away from the observer before counting the vertical face junctions.

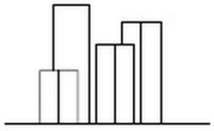
54. The problem figure shows the top view of objects. Looking in the direction of the arrow, identify the correct elevation, from amongst the answer figures. [4 marks]

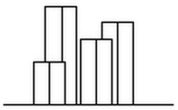


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A hexagonal footprint with a vertex directed towards the observer presents two adjoining front faces, separated by a visible vertical arris.
- Depth controls which portion is hidden, but it does not remove a visible face junction above the obscuring foreground object.

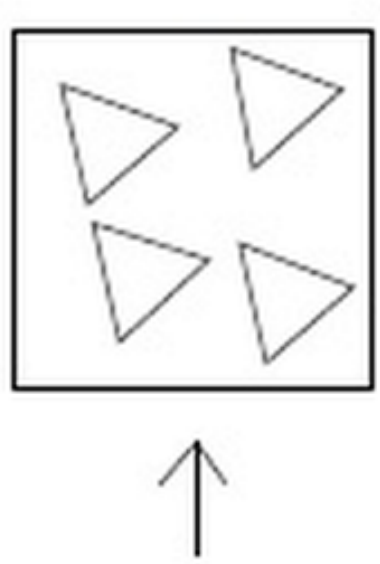
Step 1: Project the four footprints Looking upward along the arrow, the lower-left and lower-middle hexagons are the nearer pair. The upper-left and upper-right hexagons lie behind them. Preserve their left-to-right extents: the nearer left object overlaps the lower part of the tall left rear object, while the nearer middle object overlaps part of the right rear region.

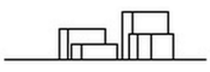
Step 2: Compare the vertical arrises Each displayed hexagon has a vertex directed towards the viewing side rather than a complete flat face parallel to it. Its elevation must therefore show the central vertical edge separating its two visible faces, wherever that edge is not occluded. Option (C) retains the edges in both foreground objects and the exposed upper portions of the rear objects. Option (A) omits the central edge of the middle foreground block; (B) omits the corresponding edge of the left foreground block; and (D) suppresses visible rear face divisions.

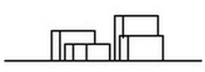
Step 3: Conclusion The correct elevation of the four hexagonal objects is (C). Hence, the correct option is (C).

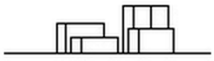
Quick Tip to Solve: For a polygonal prism, check whether a vertex or a flat side faces the arrow; that decides whether a central vertical edge should appear.

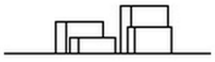
55. The problem figure shows the top view of objects. Looking in the direction of the arrow, identify the correct elevation, from amongst the answer figures. [4 marks]

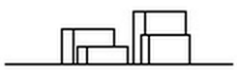


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- An elevation is an orthographic view obtained by looking horizontally in the indicated direction. Depth is suppressed, while left-to-right positions remain unchanged.
- For objects with triangular plans, each vertical edge projects at the horizontal position of its corresponding plan vertex. A nearer face hides the overlapping portion of a rear face.

Step 1: Fix the viewing direction The arrow points upwards from the bottom of the plan. Thus the two lower triangles are nearer the observer, while the two upper triangles lie behind them. Keep the left pair on the left and the right pair on the right; looking along the arrow does not exchange these groups.

Step 2: Project the visible edges Within either pair, the nearer triangle is displaced slightly to the right of the rear triangle. Its frontmost vertex is near its left side, so its visible vertical division must also occur near the left of its projected rectangular face. Above a nearer object, only the unobscured upper portion of the rear object and its appropriate vertical edge are visible.

Step 3: Compare all four elevations Option (D) preserves these offsets and the visible-edge arrangement in both groups. Option (A) introduces an extra division into the right-hand lower face, and option (B) introduces an extra division into the left-hand lower face. Option (C) adds an extra division in the upper face of the right-hand group. Those extra lines do not follow from the corresponding triangular vertices and visibility in the plan.

Step 4: Conclusion The projection that preserves the horizontal offsets and the visible vertical edges is (D). Hence, the correct option is (D).

Quick Tip to Solve: First mark the horizontal positions of the three vertices of each triangular plan; then hide rear edges covered by the nearer object.

56. Which one of the answer figure will complete the sequence of the three problem figures ? [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A figure sequence can be tested by following a distinctive part of the figure through each successive position.
- A rigid rotation preserves the number of radii, their cyclic order and the angular gaps between neighbouring radii; it changes only their direction.

Step 1: Identify the unchanged structure Each problem figure is a circle divided by six radii. The sectors are unequal, so counting the radii alone is not enough: the small sector formed by two nearby radii is a useful reference. There is no indication that a radius is added or deleted between consecutive figures.

Step 2: Follow the rotation From the first circle to the second, the full arrangement advances approximately thirty degrees clockwise. The second to the third makes the same advance. For example, the radius initially directed vertically upwards progresses to the upper right and then farther clockwise. The close pair that initially lies towards the lower left moves to the left and then towards the upper left.

Step 3: Continue once and eliminate distractors One more clockwise turn brings the close pair into the upper-left region and places two of the other radii approximately vertically upwards and horizontally rightwards. Option (A) has the complete six-radius arrangement in that position. Option (B) adds a leftward radius, option (C) omits the upper-left close-pair member, and option (D) adds an upper-right radius. They therefore change the sector structure rather than rotating it intact.

Step 4: Conclusion A further clockwise rotation gives the circle in option (A). Hence, the correct option is (A).

Quick Tip to Solve: Track the narrowest sector as well as the total number of radii; distractors can have the correct orientation but an extra or missing line.

57. Which one of the answer figure will complete the sequence of the three problem figures ? [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A rigid rotation moves the outside boundary and every internal segment through the same angle, preserving their connections.
- For a triangle with an internal segment, track the vertex where that segment begins and the side on which it ends. The outer triangular outline alone is insufficient.

Step 1: Track the complete triangle The triangular outline successively points right, upwards and left. The internal segment begins at the upper-left vertex in the first figure, at the top vertex in the second, and at the upper-right vertex in the third. These changes are consistent with successive clockwise turns of approximately thirty degrees of the entire divided triangle.

Step 2: Carry the internal segment forward After the same turn, the fourth triangular outline points downwards. The segment must begin at its upper-right vertex. Its other end remains on the opposite side, close to the upper-left vertex: rotation preserves this unequal division of the side and does not move the endpoint towards the bottom vertex.

Step 3: Test the answer figures Option (C) shows the downward-pointing triangle with a segment from the upper-right vertex to the left side near its upper end, exactly preserving the connection and side division. In option (A) the endpoint is too far down that side. In option (B) the segment starts at the bottom vertex. In option (D) it starts at the upper-left vertex. Each of those alternatives changes an internal relation that should remain fixed during rotation.

Step 4: Conclusion The boundary and internal segment rotate together into option (C). Hence, the correct option is (C).

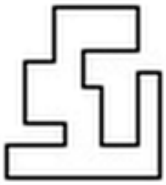
Quick Tip to Solve: When all options share the same outline, follow the internal line and which end of the opposite side it approaches.

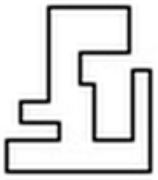
58. Which one of the answer figure will complete the sequence of the three problem figures ? [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A reflection in a vertical line interchanges left and right, while preserving top and bottom.
- When more than one visual feature changes in a sequence, examine the outline orientation and the line treatment separately.

Step 1: Compare the first two outlines The second problem figure is the left-right reflection of the first. The long lower horizontal part remains at the bottom, but the narrow upright side and the stepped projections exchange sides. The entire shape has not turned upside down or rotated through a quarter turn.

Step 2: Use the third figure to establish the cycle The third figure returns to the orientation of the first, while its outline is now visibly doubled. Thus the orientation alternates between a shape and its vertical mirror image, and the doubled line treatment belongs to the next pair. The fourth figure must have the second figure's orientation with the third figure's doubled outline.

Step 3: Match both features Option (C) is the mirrored outline with the doubled boundary and the correct width of the upper block and middle projection. Option (A) loses the narrow right-hand upright. Option (B) does not retain the doubled treatment and also alters the upper shape. Option (D) extends the left vertical portion too far and changes the middle projection. Merely choosing a broadly similar stepped silhouette would miss these local differences.

Step 4: Conclusion The next member is the doubled mirror image shown in (C). Hence, the correct option is (C).

Quick Tip to Solve: Check the orientation first, then inspect line doubling and every small step; a mirror-image sequence can use a second independent feature.

59. **Which one of the answer figure will complete the sequence of the three problem figures ?** [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A rigidly rotating polygon retains every side, notch and corner in the same cyclic order around its boundary.
- For an irregular outline, use an unmistakable pointed projection and its neighbouring indentation to determine the turn; do not judge only the overall silhouette.

Step 1: Choose a reference feature The outline contains narrow pointed projections and inward notches. Select one pointed projection together with the adjacent sharp V-shaped recess. Keeping both features together distinguishes a real rotation from a similar-looking polygon in which one notch has been changed.

Step 2: Continue the repeated turn The first outline turns clockwise to obtain the second, and the second undergoes the same clockwise turn to obtain the third. The angular step is approximately sixty degrees. Applying it once more places the long pointed portion towards the upper-left region, while the second pronounced projection extends towards the right. The lower stepped portion turns with the rest of the boundary.

Step 3: Inspect the local boundary details Option (A) has this orientation and preserves the two pointed projections and the shapes of their adjacent recesses. In option (B), a sloping edge and recess are replaced by a longer nearly vertical edge. Option (C) turns the upper-left recess into a squared indentation. Option (D) alters the lower-left indentation into a much deeper angular cut. These local changes cannot result from a rigid turn of the supplied figure.

Step 4: Conclusion The unchanged outline after the next clockwise turn is option (A). Hence, the correct option is (A).

Quick Tip to Solve: Trace the boundary from one sharp tip through the next few corners; a changed notch rules out an option even when the silhouette looks right.

60. **Which one of the answer figure will complete the sequence of the three problem figures ?** [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- Rotation preserves the shape and order of straight and concave curved portions of a boundary.
- A distinctive narrow neck is a useful reference for determining the direction and amount of turn in an irregular curved figure.

Step 1: Locate the narrow neck In the first problem figure a short straight edge caps the narrow upward projection. In the second figure this narrow projection has moved towards the upper right; in the third it has moved farther clockwise. The other straight ends and the concave arcs maintain their order, so the change is a rotation rather than a reflection.

Step 2: Apply the same angular advance The turn between consecutive figures is about thirty degrees clockwise. One further turn carries the narrow projection to the right. At the same time, the longer straight portion comes to the left side, and the remaining straight portions occupy the upper and lower positions. Each intervening concave curve must keep its original depth and connection to its neighbours.

Step 3: Compare the curved boundaries Option (C) gives the rightward narrow projection with the correctly placed straight left edge and the same sequence of concave arcs. Option (A) makes the upper-right curved recess too deep and changes its junction near the top. Option (B) replaces the straight left boundary by an inward curve. Option (D) creates a deep upper-left recess absent from the rotated original. A matching rightward projection by itself does not establish a correct match.

Step 4: Conclusion The complete rotated boundary agrees with option (C). Hence, the correct option is (C).

Quick Tip to Solve: Follow the narrowest projection, then verify the neighbouring arcs; never infer rotation from one protrusion alone.

61. 10 Downing Street is the residence of which one of the following ? [4 marks]

(A) President of America

(B) Prime Minister of England

(C) President of France

(D) President of Sri Lanka

Correct Answer: (B) Prime Minister of England

Solution:

Concept:

- An address can identify the official residence associated with a public office, independently of the individual holding that office.
- 10 Downing Street in London is associated with the Prime Minister of the United Kingdom.

Step 1: Identify the address 10 Downing Street is the official residence and office traditionally associated with the British Prime Minister. The question uses the familiar expression "Prime Minister of England" for this office. The precise national title is Prime Minister of the United Kingdom; the address is in London, England.

Step 2: Eliminate the other offices The President of America is associated with the White House in Washington, D.C., not Downing Street. The French presidency is associated with the Elysee Palace in Paris. The Sri Lankan presidency is also a different national office and has no official residence at this London address. Thus the only offered office matching the given address is the prime ministerial one.

Step 3: Conclusion 10 Downing Street is associated with the British Prime Minister, described in the question as Prime Minister of England. Hence, the correct option is (B).

Quick Tip to Solve: Associate 10 Downing Street with the British Prime Minister and the White House with the American President.

62. In the Northern Hemisphere the winter sun sets in which one of the following directions ? [4 marks]

(A) North East

(B) North West

(C) South East

(D) South West

Correct Answer: (D) South West

Solution:

Concept:

- The Sun appears to move from the eastern side of the horizon towards the western side during the day.
- In Northern Hemisphere winter, the Sun has a southerly declination, so its rising and setting points shift south of due east and due west.

Step 1: Locate the winter solar path During Northern Hemisphere winter the northern half of Earth is tilted away from the Sun. For the usual inhabited northern latitudes where sunrise and sunset occur, the Sun follows a lower, shorter arc across the southern part of the sky. Its setting point therefore lies on the western horizon but to the south of the due-west point.

Step 2: Choose the correct quadrant A setting direction must have a westward component, so North East and South East are sunrise-side directions and can be rejected. North West is the northerly sunset direction characteristic of Northern Hemisphere summer. Combining westward setting with the southward winter displacement gives South West. At polar locations there can be periods without a daily sunset; this does not change the conventional seasonal direction tested here.

Step 3: Conclusion The winter Sun sets south of west, in the South West direction. Hence, the correct option is (D).

Quick Tip to Solve: Remember the seasonal pair for northern latitudes: winter sunrise is south of east and winter sunset is south of west.

63. The famous Badrinath temple is located in which one of the following States ? [4 marks]

(A) Kerala

(B) Tamil Nadu

(C) Assam

(D) Uttarakhand

Correct Answer: (D) Uttarakhand

Solution:

Concept:

- A monument-location question is answered by identifying the geographical site of the named building, rather than its architectural appearance alone.
- Badrinath is a Himalayan temple town in the Chamoli district of Uttarakhand.

Step 1: Identify the temple site The Badrinath temple, dedicated to Vishnu, stands at Badrinath in the Garhwal Himalayas. Its setting is in the upper Alaknanda valley, and it is associated with the pilgrimage circuit of the Himalayan shrines. This geographical identification places the temple in the northern Indian Himalayan state of Uttarakhand.

Step 2: Compare the offered states Kerala and Tamil Nadu are southern Indian states; neither contains the Himalayan town of Badrinath. Assam lies in north-eastern India and is not the Garhwal location of this shrine. Uttarakhand is the state containing Chamoli and Badrinath, so it is the only option consistent with the named temple. Do not confuse Badrinath with other famous temples located in the southern or north-eastern states.

Step 3: Conclusion The famous Badrinath temple is located in Uttarakhand. Hence, the correct option is (D).

Quick Tip to Solve: Connect Badrinath and Kedarnath with the Garhwal Himalayas of Uttarakhand when revising temple locations.

64. What is the thickness of a one brick thick wall ? [4 marks]

(A) 4.5”

(B) 9”

(C) 13.5”

(D) 12”

Correct Answer: (B) 9”

Solution:

Concept:

- Wall thickness expressed in bricks is measured across the wall: a one-brick wall is approximately one brick length thick.
- In the conventional imperial brick dimensions used by these options, the length is about 9 inches and the width about 4.5 inches.

Step 1: Interpret one-brick thickness A half-brick wall has its thickness equal to the width of a brick, approximately 4.5 inches in the conventional imperial system. A one-brick wall instead has a thickness equal to the length of one brick, approximately 9 inches. The term does not mean the height of one course or simply any wall built using bricks.

Step 2: Match the dimension to the options The 4.5-inch option describes half-brick thickness. The 13.5-inch option corresponds approximately to one-and-a-half-brick thickness in the same convention. A 12-inch thickness is not the one-brick dimension of this imperial series. Therefore 9 inches is the matching choice. Actual dimensions vary with the brick standard, mortar joints and plaster; the offered dimensions clearly indicate the conventional imperial masonry terminology.

Step 3: Conclusion A one-brick-thick wall is conventionally 9 inches thick in the system used here. Hence, the correct option is (B).

Quick Tip to Solve: Use the imperial wall-thickness sequence: half brick 4.5 inches, one brick 9 inches, one-and-a-half bricks 13.5 inches.

65. Why is the depth of a beam normally more than its width ? [4 marks]

(A) Horizontal Force

(B) Momentum

(C) Moment of Inertia

(D) Balance

Correct Answer: (C) Moment of Inertia

Solution:

Concept:

- For a rectangular beam of width b and vertical depth d, the second moment of area about its horizontal centroidal axis is $I = bd^3/12$.
- Bending stiffness is EI, where E is Young’s modulus; increasing the relevant second moment of

area reduces bending deflection.

Step 1: Examine the effect of depth Under the usual vertical loading of a horizontal beam, bending occurs about the horizontal centroidal axis of its cross-section. The depth enters the second moment of area cubically, whereas the width enters only linearly. Thus increasing depth is a particularly effective way to increase resistance to bending. For the same material and cross-sectional area $A = bd$, the relation becomes $I = Ad^2/12$.

Step 2: Select the structural reason A deeper section places more material farther from the neutral axis, increasing the second moment of area and making the beam more efficient against bending. Horizontal force alone does not explain this cubic dependence. Momentum concerns motion and is unrelated to the ordinary static design argument. Balance is too general and does not identify the governing section property. The intended option is Moment of Inertia, understood here as the area moment of inertia rather than the mass moment of inertia.

Step 3: Conclusion The depth is normally greater because it increases the relevant area moment of inertia efficiently. Hence, the correct option is (C).

Quick Tip to Solve: For a rectangular beam under vertical loading, remember $I = bd^3/12$: depth has a much stronger effect than width.

66. Where is the famous Notre Dame Cathedral which caught fire recently located ? [4 marks]

(A) Paris

(B) Hague

(C) Venice

(D) Rome

Correct Answer: (A) Paris

Solution:

Concept:

- Notre-Dame de Paris is the Gothic cathedral on the Ile de la Cite in Paris, France.
- The fire referred to in this historical question is the April 2019 fire at Notre-Dame de Paris.

Step 1: Identify the named cathedral The wording refers to Notre-Dame de Paris, the famous cathedral whose roof and spire were severely damaged by fire on 15 April 2019. Its name includes Paris, and its site is the Ile de la Cite, an island in the River Seine. These identifying features establish the city directly rather than merely indicating that the building is somewhere in France.

Step 2: Reject the other cities The Hague is in the Netherlands and is not the location of Notre-Dame de Paris. Venice and Rome are Italian cities with their own well-known churches and monuments, but neither contains the Paris cathedral involved in the cited fire. Therefore the landmark and event both point to Paris. The word "recently" belongs to the time of this examination; the location is determined by the particular cathedral and event, not by a search for a newer fire.

Step 3: Conclusion The Notre-Dame Cathedral referred to is located in Paris. Hence, the correct option is (A).

Quick Tip to Solve: Use the full name Notre-Dame de Paris to retain the city and distinguish this cathedral from other churches named Notre-Dame.

67. The concept of CharBagh garden found in which one of the following garden concepts ? [4 marks]

(A) Christian

(B) Chinese

(C) Islamic

(D) Zen

Correct Answer: (C) Islamic

Solution:

Concept:

- Charbagh is a formal four-part garden composition associated with the Persian and Islamic garden tradition.
- Intersecting paths or water channels establish two main axes and divide an enclosed garden into four principal compartments.

Step 1: Identify the organising idea The name Charbagh refers to a fourfold garden. Its characteristic composition uses a strong geometric order rather than a naturalistic arrangement: two crossing axes divide the ground into four major parts. Water channels, paths, planted compartments and an axial view are common elements. The important clue is this four-part spatial organisation, not simply the presence of flowers or trees.

Step 2: Match the garden tradition The fourfold arrangement belongs to the Persian-Islamic garden tradition and was developed in Mughal garden design in the Indian subcontinent. Its geometric order and flowing water are associated with the idea of a garden paradise. Therefore Islamic is the matching category. Chinese gardens commonly compose apparently natural scenes with rocks, water and winding movement; Zen gardens are associated with Japanese Buddhist contemplation and restrained rock-and-gravel compositions. Christian is not the historical category for the Charbagh concept.

Step 3: Conclusion The Charbagh concept belongs to Islamic garden design. Hence, the correct option is (C).

Quick Tip to Solve: Link Charbagh with four compartments and crossing water axes; these identify the Persian-Islamic garden tradition.

68. Where is the Bara Imambara located ? [4 marks]

(A) Kolkata

(B) Mumbai

(C) Hyderabad

(D) Lucknow

Correct Answer: (D) Lucknow

Solution:

Concept:

- An architectural-awareness question can be answered by matching a named monument with its city.
- The Bara Imambara is a major monument of Lucknow in Uttar Pradesh, associated with the Nawabi architecture of Awadh.

Step 1: Identify the monument The Bara Imambara, also called the Asafi Imambara, is the large imambara complex in Lucknow. It was commissioned by Nawab Asaf-ud-Daula in the eighteenth century. The complex is especially known for its great central hall and the labyrinth, or Bhul Bhulaiya. These identifying features connect the monument to the architectural heritage of Awadh.

Step 2: Compare the proposed locations Lucknow is the city that contains this particular complex, so option D gives the required location. Kolkata and Mumbai are not the location of the Bara Imambara. Hyderabad has its own important Islamic architectural landmarks, but that does not make it the location of the monument named here. The task is to identify the specific building-city pair rather than select any city with historic Islamic buildings. The presence of imambaras in different places must not be confused with the proper name Bara Imambara.

Step 3: Conclusion The Bara Imambara is located in Lucknow. Hence, the correct option is (D).

Quick Tip to Solve: Remember the pair Bara Imambara–Lucknow, with Awadh and Asaf-ud-Daula as supporting memory cues.

69. Which one of the colors reflects the maximum light ? [4 marks]

(A) Red

(B) Green

(C) White

(D) Black

Correct Answer: (C) White

Solution:

Concept:

- A surface appears white under white illumination when it reflects a substantial fraction of light across the visible spectrum.
- For comparable ordinary surfaces, white has greater overall visible-light reflectance than saturated

red or green, while black absorbs most incident light.

Step 1: Relate colour to reflected light Incident white light contains a range of visible wavelengths. A white surface returns light over this broad range instead of mainly returning a narrow colour band. Consequently, an ordinary white finish has high total visible reflectance. This is why white surfaces are commonly used when the aim is to make a space brighter by distributing reflected light.

Step 2: Compare all four colours A red surface predominantly returns the red part of the incident spectrum and absorbs much of the remaining visible light. A green surface similarly returns mainly the green region. Neither ordinarily reflects as much total white light as a comparable white surface. Black lies at the opposite end of the comparison: it absorbs most visible light and returns very little. The question is the standard colour-reflectance comparison; it does not compare a specially polished coloured mirror with a dull white material.

Step 3: Conclusion White reflects the maximum light among the listed colours under comparable conditions. Hence, the correct option is (C).

Quick Tip to Solve: For ordinary finishes under the same light, use white for high overall reflectance and black for high absorption.

70. Which one of the following colors denotes equality ? [4 marks]

(A) White

(B) Blue

(C) Indigo

(D) Red

Correct Answer: (A) White

Solution:

Concept:

- Colour symbolism assigns conventional associations to colours; these associations are distinct from optical properties such as reflectance.
- In the colour-symbolism convention used here, white signifies neutrality, impartiality and equality.

Step 1: Interpret equality as a symbolic association The question asks what a colour denotes, so the task concerns colour meaning rather than a calculation involving light. White is associated with impartiality and a neutral starting point: it does not privilege a particular chromatic hue. Within the conventional design-symbolism association tested by this question, this neutrality is linked with fairness and equality.

Step 2: Distinguish the other associations Blue is commonly associated with calmness, trust or stability, while indigo is commonly linked with depth, intuition or contemplation. Red is associated with energy, urgency, passion or danger. These associations do not match the equality cue as directly as white in the convention being tested. Colour meanings can vary with culture and context, so the answer should be understood as the expected symbolic association rather than a physical law or a claim that a colour has one universal meaning in every application.

Step 3: Conclusion White is the colour denoting equality in the convention tested here. Hence, the correct option is (A).

Quick Tip to Solve: Keep symbolic meanings separate from optical properties: equality here cues white through neutrality and impartiality.

71. Which one of the following describes the texture of a hand made brick ? [4 marks]

(A) Smooth

(B) Glossy

(C) Rough

(D) Silky

Correct Answer: (C) Rough

Solution:

Concept:

- Texture describes the visible or tactile character of a surface, including whether it is smooth, rough, glossy or fibrous.
- A typical handmade brick has an irregular granular clay surface rather than a polished, glazed or silky finish.

Step 1: Consider the manufacturing surface Handmade bricks are formed from clay in moulds and then dried and fired. Small variations in the moulding process, particles on the surface and minor irregularities give the typical exposed face an uneven, granular character. A handmade brick is therefore recognised by its rough texture. This description concerns the ordinary material surface, before an added coating or special finishing treatment.

Step 2: Eliminate the incompatible descriptions Smooth describes a surface with little perceptible unevenness and does not best characterise the typical handmade brick. Glossy means a lustrous surface producing noticeable directional reflections, as in a glazed tile; such a glaze is not an inherent feature of an ordinary handmade brick. Silky describes a fine, soft or smoothly lustrous character and is also unsuitable for the fired-clay face. Rough is the only option that directly describes the usual irregular brick surface.

Step 3: Conclusion A handmade brick typically has a rough texture. Hence, the correct option is (C).

Quick Tip to Solve: Identify the untreated material surface first; do not confuse a rough brick face with a smooth plaster or glossy glaze applied over it.

72. What are shafts used for in buildings ? [4 marks]

(A) Beauty

(B) Concealing pipes

(C) Structural strength

(D) Stability

Correct Answer: (B) Concealing pipes

Solution:

Concept:

- A service shaft is a planned vertical space through a building that accommodates service runs between floors.
- Plumbing and drainage pipes can be routed inside a service shaft, keeping them organised and concealed while allowing planned maintenance access.

Step 1: Identify the service function In the context of building services, a shaft provides a vertical route for installations passing between storeys. Water-supply pipes, drainage stacks and related service lines can be collected in this dedicated space instead of being scattered across occupied rooms. Access panels or doors can permit inspection and repair. Concealment therefore works together with orderly routing and maintenance provision.

Step 2: Compare the proposed purposes Concealing pipes is the option that describes this use of a service shaft. Beauty may be helped indirectly because exposed pipe runs are reduced, but it is not the primary technical function stated by the term. Structural strength and stability are provided by the designed load-resisting system, such as columns, walls, beams and foundations; an ordinary service void is not introduced for those purposes. A lift shaft or a designed structural core has additional functions, but that does not change the intended service-shaft answer among these options.

Step 3: Conclusion Shafts are used for concealing and routing pipes in buildings. Hence, the correct option is (B).

Quick Tip to Solve: When a building-services question says shaft, think of a vertical service route linking floors, especially plumbing stacks.

73. Which one of the following is the most suitable material for toilet floors ? [4 marks]

(A) Polished granite

(B) Non skid tiles

(C) Wood

(D) Carpet

Correct Answer: (B) Non skid tiles

Solution:

Concept:

- A toilet floor is a wet-area surface. Its finish must provide traction even when water is present, rather than merely look smooth or glossy.
- A suitable finish should also resist moisture, tolerate frequent washing and allow hygienic cleaning. Slip resistance and water resistance are separate requirements.

Step 1: Identify the governing requirement Water, soap and cleaning liquids can make a toilet floor slippery. A textured non-skid tile provides a more secure walking surface than a highly polished one. Its joints and falls should be detailed to drain water; a non-skid finish does not remove the need for proper drainage.

Step 2: Compare the alternatives Polished granite is durable but its smooth polished finish can become slippery when wet. Ordinary wood is vulnerable to sustained moisture and requires special protection. Carpet absorbs water and retains dirt, making it unsuitable for this regularly washed space. Non-skid tiles best combine the required grip with a cleanable, moisture-resistant finish.

Step 3: Conclusion Non-skid tiles are the most suitable material for the toilet floor. Hence, the correct option is (B).

Quick Tip to Solve: For wet-area finishes, first check slip resistance, then water resistance and ease of cleaning; a glossy finish is not automatically suitable.

74. Who amongst the following designed Indian Institute of Management ? [4 marks]

(A) Charles Correa

(B) B.V. Doshi

(C) Louis Kahn

(D) A.P. Kanvinde

Correct Answer: (C) Louis Kahn

Solution:

Concept:

- The familiar architect-building association tested here is Louis Kahn and the Indian Institute of Management at Ahmedabad.
- An institute name without a campus can be imprecise: different IIM campuses have different architects. The examination key identifies the intended association.

Step 1: Identify the intended campus association Louis Kahn designed the original Indian Institute of Management Ahmedabad campus, known for its exposed brickwork, monumental geometric openings and carefully arranged courts. This is the standard association represented by the keyed answer to this question.

Step 2: Distinguish the other names and the wording limitation B. V. Doshi designed IIM Bangalore, so his name cannot be rejected as unrelated to all Indian Institutes of Management. Without a city the question is underspecified. Charles Correa and A. P. Kanvinde are major Indian architects, but neither is the architect in the intended IIM Ahmedabad association. Read the keyed response as referring to Ahmedabad, while retaining the distinction between campuses.

Step 3: Conclusion The examination answer key selects Louis Kahn, referring to IIM Ahmedabad. Hence, the correct option is (C). The unspecified campus makes the wording less precise, since B. V. Doshi designed IIM Bangalore.

Quick Tip to Solve: Learn architect-campus pairs together: Louis Kahn–IIM Ahmedabad; B. V. Doshi–IIM Bangalore. The city resolves the otherwise ambiguous institute name.

75. Who amongst the following designed The Falling Waters ? [4 marks]

(A) Frank Ghery

(B) Zaha Hadid

(C) Norman Foster

(D) Frank Lloyd Wright

Correct Answer: (D) Frank Lloyd Wright

Solution:

Concept:

- Fallingwater is the residence designed by Frank Lloyd Wright, associated with organic architecture and the integration of a building with its natural setting.
- Its projecting horizontal terraces and relationship to the waterfall make it a distinctive architect-building identification rather than a generic modern house.

Step 1: Recognise the building The name in the question refers to Fallingwater. Wright placed the house in close relationship with the stream and waterfall, using cantilevered terraces to project into the landscape. These features identify his approach to organic architecture.

Step 2: Eliminate the other architects Frank Gehry, Zaha Hadid and Norman Foster are different architects with different bodies of work; none designed Fallingwater. Similar first names must not confuse Frank Gehry with Frank Lloyd Wright. The surname and the complete building association decide the answer, not the broad fact that all the names belong to modern architecture.

Step 3: Conclusion Fallingwater was designed by Frank Lloyd Wright. Hence, the correct option is (D).

Quick Tip to Solve: Associate Fallingwater with Wright, cantilevered terraces and a waterfall; use the full name to avoid confusing him with Frank Gehry.

Drawing Test (100 marks)

76. In the space provided for the answer of this question, draw an aesthetic composition appropriate to this space using only rectangles. There is no restriction to numbers, sizes, placement and directions of these shapes. Color this composition so that it becomes visually exciting. [50 marks]

Solution:

Concept:

- A composition gains unity through repeated shapes and controlled colour, and gains variety through changes of scale, orientation, spacing and overlap.
- The only permitted shapes are rectangles. Positive coloured shapes and the uncoloured negative spaces should together form a balanced arrangement within the given answer space.

Step 1: Plan the rectangle hierarchy Lightly mark the limits of the answer space and choose one dominant rectangle placed slightly away from the centre. Add two or three medium rectangles to lead the eye towards it, then a small number of narrow accent rectangles. Change their lengths and widths so that the composition has a clear hierarchy rather than an even scatter of identical pieces. Keep every outline four-sided with right-angled corners; a rotated rectangle remains a rectangle.

Step 2: Build balance and rhythm Use the long directions of the medium rectangles to establish a visual path across the space. Balance one large dark area with a group of smaller, lighter rectangles elsewhere, instead of mirroring both sides mechanically. Overlap selected rectangles to create depth, but keep enough quiet negative space around the focal area. Avoid accidental near-tangencies, tiny leftover slivers and heavy crowding against one edge. Check the whole arrangement from a distance before adding colour.

Step 3: Apply a controlled, exciting palette Choose a limited palette such as blue, orange and yellow, with a pale neutral background. Use the complementary blue-orange contrast near the main focal rectangle and repeat smaller amounts of those colours elsewhere to connect the composition. Place the brightest accent sparingly so that it attracts attention without competing everywhere. Vary light and dark values to separate touching or overlapping rectangles. Fill each shape evenly with a flat colour; keep boundaries crisp and avoid adding circular motifs or non-rectangular decoration.

Step 4: Refine the final presentation Erase unnecessary construction lines, strengthen only the intended edges and clean colour outside the boundaries. Verify that the rectangles use the available space convincingly, that the largest visual mass is balanced and that the eye has a clear route through the work. A successful answer can use a different arrangement or palette, but it must preserve rectangle-only geometry and show deliberate organisation rather than random placement.

Step 5: Conclusion A suitable response is a balanced, rectangle-only abstract composition with one dominant shape, supporting rectangles of varied sizes and directions, deliberate negative space and a vivid but controlled colour scheme.

Quick Tip to Solve: Test the arrangement in a tiny thumbnail first. Establish the largest rectangle and light-dark balance before committing to the final colours.

77(a). Draw from imagination a highway on which cars and trucks are moving in both directions.

[50 marks]

Solution:

Concept:

- Linear perspective makes the road edges, lane markings and vehicles diminish towards a common horizon; this creates convincing depth in a highway scene.
- A clear arrangement of cars and trucks in opposing streams must communicate both directions through visible front and rear views, with consistent scale, lighting and overlap.

Step 1: Establish the road and viewpoint Choose a slightly elevated roadside viewpoint looking along a broad highway. Place the horizon above the middle of the sheet and a vanishing point slightly off centre. Lightly construct the two carriageways and their central divider so that their parallel ground edges converge towards that point. Keep the near roadway broad enough to show the traffic clearly; make the distant road progressively narrower. Continue the same perspective through the shoulders, guardrails and dashed lane markings.

Step 2: Arrange traffic moving in both directions Place a large truck in the near lane travelling away from the viewer, showing its rear panel, rear wheels and visible side. On the other carriageway place an approaching car with its windscreen, bonnet and front lamps visible. Add another truck and several cars farther along the road in both streams, with smaller dimensions and closer spacing towards the horizon. Keep every vehicle inside its own lane and use overlap sparingly so that cars and trucks remain identifiable. Align wheels with the road surface and retain a plausible truck-to-car size relationship at comparable distances.

Step 3: Develop depth and finish the scene Add a few receding roadside trees, poles or a sign as scale cues, without allowing them to obscure the moving traffic. Let roadside objects also decrease towards the horizon. Use one light direction for all vehicles and place contact shadows beneath them so that they sit on the road. Give foreground tyres, body edges and lane markings stronger contrast; use lighter, simpler detail in the distance. Finish with restrained road and vegetation tones if colour is used, leaving vehicle silhouettes distinct. Check that the road geometry, wheel positions and opposing traffic directions remain clear.

Step 4: Conclusion A suitable composition shows a highway receding towards the horizon, with cars and trucks visibly travelling in both directions. Consistent perspective, vehicle scale, overlap and unified shadows give the imagined scene depth and coherence.

Quick Tip to Solve: Construct the road first, then place one front-facing and one rear-facing vehicle on opposite carriageways before adding smaller traffic in the distance.

OR

77(b). Draw from imagination an interior of cinema hall. [50 marks]

Solution:

Concept:

- An interior perspective uses a horizon at the viewer's eye level and converging lines to relate the screen, seating, aisles, walls and ceiling within one coherent space.
- Rhythm in repeated seat rows and controlled tonal contrast can direct attention towards the screen while preserving a convincing sense of an enclosed cinema hall.

Step 1: Choose the viewpoint and construct the hall Imagine standing near the rear of the hall, slightly above the seating, looking towards the screen. Establish the eye-level horizon and a central vanishing point on the screen wall. Lightly construct the floor, side walls and ceiling as a room in one-point perspective. Place the rectangular screen on the far wall with a surrounding frame or curtain. Keep the screen centred in the visual field and leave sufficient wall visible to communicate the hall enclosure.

Step 2: Organise the seats and circulation Lay out repeated rows of upholstered seats in two blocks separated by a central aisle, or in a central block with side aisles. Make seat backs in the foreground larger and more widely spaced, then gradually reduce their apparent size and row spacing towards the screen. Guide the aisle edges and row arrangement consistently into depth. If the floor is stepped, show the changing levels clearly while keeping seats upright. Include a few seated spectators as modest scale cues; avoid filling every seat with a detailed figure, which would hide the structure of the interior.

Step 3: Add architectural detail and light Indicate side-wall acoustic panels, a ceiling pattern and discreet aisle lighting, keeping all repeated forms consistent with the chosen perspective. Place an exit door or illuminated exit sign on a side wall without competing with the screen. Use the screen as the principal bright area and render the seating and walls with quieter tonal values. Apply shading to show seat thickness, wall recesses and ceiling depth; keep the aisle legible rather than making the whole room uniformly dark. Finish by checking that the screen, seats, aisles and enclosure form one believable space, with stronger detail in the foreground and simplified distant forms.

Step 4: Conclusion A suitable cinema interior contains a clear screen focal point, receding rows of seats, readable aisles and the surrounding walls and ceiling. Repetition in perspective and controlled lighting establish both depth and the character of the hall.

Quick Tip to Solve: Locate the screen and aisle vanishing lines before repeating seat rows; reduce both seat size and row spacing together as they recede.

OR

77(c). Draw from memory your best teachers face. [50 marks]

Solution:

Concept:

- A recognisable portrait depends on the remembered person's distinctive proportions, facial structure, expression and features rather than on a generic formula for a face.
- Construction lines establish the head angle and feature relationships; a consistent light source and gradual tonal modelling describe the three-dimensional form.

Step 1: Recall the teacher and compose the portrait First recall the teacher's actual appearance: face shape, hairline, hairstyle, eyebrows, eyes, nose, mouth, chin and any familiar spectacles or facial hair. Choose a frontal or gentle three-quarter view that you can remember clearly. Place the head at a comfortable scale on the sheet with some space above it and in the direction of the gaze. Lightly establish the head mass, centre line and eye line for that chosen angle, followed by the neck and a small portion of the shoulders. Use general proportion guides only as starting points, adapting them to the remembered individual.

Step 2: Build the features and likeness Compare the distances between the eyes, the width of the nose, the position of the mouth and the shape of the jaw before adding small details. In a three-quarter view, let the centre line curve around the face and make the farther side appropriately narrower. Construct both eyes on the same tilted eye line rather than drawing them as isolated symbols. Develop the teacher's characteristic expression through the eyebrows, eyelids and corners of the mouth. If spectacles are remembered, align their frames with the face and retain the visibility of the eyes. Keep correcting the large relationships before refining pupils, hair strands or clothing.

Step 3: Model the form and preserve character Choose one light direction and shade the forehead, cheek planes, nose, eye sockets, lower lip and neck consistently. Treat the hair as a mass with a few directional accents rather than outlining every strand. Use softer transitions over rounded forms and stronger accents at selected features; avoid a heavy outline around the entire face. Suggest familiar clothing near the shoulders without letting it dominate. Leave the background simple so that the face remains the focal point. Finally compare the silhouette, feature spacing and expression with the mental image of the teacher, correcting those relationships rather than adding decorative detail.

Step 4: Conclusion A suitable response is a recognisable portrait of the remembered teacher, with their distinctive facial proportions and expression. Coherent construction, selective detail and unified tonal modelling should support the likeness.

Quick Tip to Solve: Identify three distinctive remembered features before starting; check the head silhouette and feature spacing before adding fine hair or clothing detail.