JEE Main 2023 Paper 2A (B.Arch) Jan 28 Single sitting Question Paper with Solutions PDF

Question Paper with Solutions

Conducted by the National Testing Agency (NTA)

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

General Instructions

(i) This paper is Paper 2A (B.Arch.) of JEE (Main) 2023, Session 1 (January), conducted by the National Testing Agency (NTA) in Computer Based Test (CBT) mode on 28 January 2023, Shift 2. The total duration is 3 hours.

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

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

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

(v) Marking scheme (numerical value questions): $+4$ for a correct answer, -1 for an incorrect answer 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 R_1 and R_2 be two relations on $\mathbb{R}^2$ defined as

$(a, b)\ R_1\ (c, d)$ **if** $ad - bc \geq 0$

$(a, b)\ R_2\ (c, d)$ **if** $a + d \geq b + c$**. Then :** [4 marks]

(A) R_1 is transitive but R_2 is not transitive

(B) R_2 is transitive but R_1 is not transitive

(C) Both R_1 and R_2 are transitive

(D) Neither R_1 nor R_2 is transitive

Correct Answer: (B) R_2 is transitive but R_1 is not transitive

Solution:

Concept:

- A relation is transitive when uRv and vRw imply uRw for every triple in its domain. A single counterexample disproves transitivity.
- For R_2, rearranging the inequality compares the real-valued differences $a - b$ and $c - d$. The usual order relation on real numbers is transitive.

Step 1: Rewrite the second relation Let $u = (a, b)$, $v = (c, d)$ and $w = (e, f)$. Then uR_2v means $a - b \geq c - d$, while vR_2w means $c - d \geq e - f$. Combining these inequalities gives

$$a - b \geq c - d \geq e - f.$$

Thus $a + f \geq b + e$, which is exactly uR_2w. Since the three pairs were arbitrary, this proves transitivity of R_2, rather than merely checking a few examples.

Step 2: Test the first relation with a counterexample Take $u = (1, 0)$, $v = (0, 1)$ and $w = (-1, -1)$. The determinant expressions for the first two relations are

$$1 \cdot 1 - 0 \cdot 0 = 1 \geq 0, \qquad 0 \cdot (-1) - 1 \cdot (-1) = 1 \geq 0.$$

Hence uR_1v and vR_1w. But the expression for uR_1w is

$$1 \cdot (-1) - 0 \cdot (-1) = -1 < 0.$$

Therefore the required implication fails for this triple, and R_1 is not transitive. Options (A) and (C) wrongly assert its transitivity; option (D) incorrectly denies transitivity of R_2.

Step 3: Conclusion R_2 is transitive, whereas R_1 is not transitive. Hence, the correct option is (B).

Quick Tip to Solve: Rewrite an inequality relation as an order of one scalar expression; for determinant inequalities, test vectors in different quadrants.

2. Let α and β be the roots of $x^2 - 3x + 9 = 0$. Then $\left(\frac{\beta^{30}}{(9\alpha)^{10}} + \frac{\alpha^{30}}{(9\beta)^{10}}\right)^2$ is equal to [4 marks]

(A) 1

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

(C) 3

(D) 9

Correct Answer: (A) 1

Solution:

Concept:

- The quadratic formula gives the conjugate roots $\frac{3\pm3\sqrt{3}\,i}{2}$, each of modulus 3. Their arguments are $\pm\pi/3$.
- De Moivre's formula states $(re^{i\theta})^n = r^n e^{in\theta}$. Conjugate powers add to twice their real part.

Step 1: Express the roots in polar form Choose $\alpha = 3e^{i\pi/3}$ and $\beta = 3e^{-i\pi/3}$; interchanging them leaves the requested symmetric expression unchanged. The factors in each quotient have the same modulus:

$$|\beta^{30}| = 3^{30}, \qquad |(9\alpha)^{10}| = 27^{10} = 3^{30}.$$

Consequently no residual power of 3 remains. This cancellation must be made before adding the two terms; keeping an extra factor of 3 would produce one of the misleading options.

Step 2: Evaluate the conjugate terms and square The first quotient has argument $-30\pi/3 - 10\pi/3 = -40\pi/3$, and the second has the opposite argument. Thus their sum is

$$e^{-40\pi i/3} + e^{40\pi i/3} = 2\cos(40\pi/3).$$

Reduce the angle by 12π: $40\pi/3 = 12\pi + 4\pi/3$. Hence

$$2\cos(40\pi/3) = 2\cos(4\pi/3) = 2(-1/2) = -1.$$

Finally the question asks for the square of the whole sum, so the answer is $(-1)^2 = 1$, not the unsquared value -1. The values $1/9$, 3 and 9 do not result from the exact modulus cancellation and angle calculation.

Step 3: Conclusion The square of the given sum is 1. Hence, the correct option is (A).

Quick Tip to Solve: When conjugate roots have equal modulus, cancel radial powers first and combine the remaining conjugate phases using $2\cos\theta$.

3. For $z = 2 + 5i$, the modulus of $2z^3 + 21z^2 - 58z + 4$ is : [4 marks]

(A) 1153

(B) 947

(C) 537

(D) 837

Correct Answer: (D) 837

Solution:

Concept:

- The conjugate pair $2 \pm 5i$ has sum 4 and product 29, so $z = 2 + 5i$ satisfies $z^2 - 4z + 29 = 0$.
- A polynomial can be reduced using this quadratic identity before taking its modulus. For a real result r, its complex modulus is $|r|$.

Step 1: Reduce the powers of the given complex number From the quadratic identity,

$$z^2 = 4z - 29.$$

Multiply this equality by z and replace z^2 again:

$$z^3 = 4z^2 - 29z = 4(4z - 29) - 29z = -13z - 116.$$

This keeps both the real and imaginary components intact without expanding $(2 + 5i)^3$ directly. It follows equally from $(z - 2)^2 = -25$, so the sign of the constant 29 is positive in the original quadratic relation.

Step 2: Substitute and calculate the modulus Use the reduced forms in the full polynomial:

$$\begin{aligned} 2z^3 + 21z^2 - 58z + 4 &= 2(-13z - 116) + 21(4z - 29) - 58z + 4 \\ &= (-26 + 84 - 58)z - 232 - 609 + 4 \\ &= -837. \end{aligned}$$

The coefficient of z vanishes exactly. Therefore the imaginary part also vanishes; there is no need to calculate a square root of two nonzero squared components. The modulus is

$$|-837| = \sqrt{(-837)^2} = 837.$$

Options (A), (B) and (C) differ from this exact constant remainder and therefore fail. In particular, the negative sign of the polynomial value cannot make its modulus negative.

Step 3: Conclusion The required modulus is 837. Hence, the correct option is (D).

Quick Tip to Solve: For $z = a + bi$, use $z^2 - 2az + (a^2 + b^2) = 0$ to reduce higher-degree polynomials before finding the modulus.

4. If the system of equations

$$Kx - \sqrt{2}y + \sqrt{5}z = \sqrt{7}$$

$$\sqrt{5}x + \sqrt{3}y - \sqrt{2}z = \sqrt{11}$$

$$30x + (3\sqrt{15} - 5\sqrt{6})y + (5\sqrt{15} - 3\sqrt{10})z = 5\sqrt{21} + 3\sqrt{55}$$

has infinitely many solutions, then K^2 is [4 marks]

(A) 27

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

(C) 9

(D) 3

Correct Answer: (D) 3

Solution:

Concept:

- Infinitely many solutions require the coefficient matrix and augmented matrix to have the same rank, smaller than the number of unknowns.
- If two independent equations are present, the third must be their linear combination, including its right-hand side. Matching the coefficients determines that combination.

Step 1: Identify the linear combination from two columns Call the equations E_1, E_2, E_3. In $5\sqrt{3}E_1 + 3\sqrt{5}E_2$, the coefficient of y is

$$-5\sqrt{6} + 3\sqrt{15},$$

which agrees with E_3. Its coefficient of z is

$$5\sqrt{15} - 3\sqrt{10},$$

and its right-hand side is $5\sqrt{21} + 3\sqrt{55}$, also agreeing exactly. The two (y, z) coefficient rows are independent since their determinant is

$$(-\sqrt{2})(-\sqrt{2}) - \sqrt{3}\sqrt{5} = 2 - \sqrt{15} \neq 0.$$

Thus these coefficients uniquely determine the combination weights.

Step 2: Match the remaining coefficient and verify the rank The coefficient of x in the same combination must be 30. Therefore

$$5\sqrt{3}K + 3\sqrt{5}\sqrt{5} = 30,$$

so $5\sqrt{3}K + 15 = 30$, giving

$$K = \frac{15}{5\sqrt{3}} = \sqrt{3}, \qquad K^2 = 3.$$

For this value, the third equation is exactly redundant and the first two remain independent by the nonzero minor above. Both relevant ranks are therefore $2 < 3$, proving infinitely many solutions, rather than only a zero determinant. The other proposed values of K^2, namely 27, $1/3$ and 9, cannot satisfy this necessary coefficient equality.

Step 3: Conclusion $K = \sqrt{3}$, and hence $K^2 = 3$. Hence, the correct option is (D).

Quick Tip to Solve: When one row contains conspicuous radical combinations, match two columns to find its row-combination weights, then check the remaining column and constant.

---

5. For $\alpha, \beta \in \mathbb{R}$, if the matrices $\mathrm{A} = \begin{pmatrix} \alpha & 0 \\ 0 & \beta \end{pmatrix}$, $\mathrm{B} = \begin{pmatrix} \alpha & 0 \\ 0 & \alpha \end{pmatrix}$ and $\mathrm{I} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ satisfy the equation $(\mathrm{A} * \mathrm{B}) * 2\mathrm{I} = 20\mathrm{I}$, where $*$ is defined as $\mathrm{A} * \mathrm{B} = \mathrm{A}^2 + \mathrm{B}^2$, then $|\alpha\beta|$ is equal to : [4 marks]

(A) $2\sqrt{3}$

(B) $2\sqrt{2}$

(C) 4

(D) 2

Correct Answer: (D) 2

Solution:

Concept:

- The operation is $X * Y = X^2 + Y^2$, so parentheses must be evaluated in order. It is not ordinary matrix multiplication.
- Powers of a diagonal matrix are obtained by raising each diagonal entry to that power. Since α, β are real, their squares are nonnegative.

Step 1: Evaluate the inner and outer operations The inner result is the diagonal matrix

$$C = A * B = A^2 + B^2 = \begin{pmatrix} 2\alpha^2 & 0 \\ 0 & \alpha^2 + \beta^2 \end{pmatrix}.$$

Now apply the same definition to C and $2I$:

$$C * (2I) = C^2 + (2I)^2 = C^2 + 4I.$$

Since this equals $20I$, we obtain $C^2 = 16I$. Equating diagonal entries yields

$$4\alpha^4 = 16, \qquad (\alpha^2 + \beta^2)^2 = 16.$$

The square on C is essential: treating the outer star as multiplication would give different equations.

Step 2: Use reality to select the admissible roots From $\alpha^4 = 4$, the nonnegative quantity α^2 must equal 2. Also $\alpha^2 + \beta^2 \geq 0$, so its square being 16 gives $\alpha^2 + \beta^2 = 4$, not -4. Consequently

$$\beta^2 = 4 - 2 = 2.$$

Therefore

$$|\alpha\beta| = \sqrt{\alpha^2\beta^2} = \sqrt{2 \cdot 2} = 2.$$

All choices of signs of the real numbers α and β give this same absolute product. The alternatives $2\sqrt{3}$, $2\sqrt{2}$ and 4 have squared values $12, 8, 16$, respectively, whereas the squared product here is exactly 4.

Step 3: Conclusion The required absolute product is $|\alpha\beta| = 2$. Hence, the correct option is (D).

Quick Tip to Solve: For an unfamiliar star operation, introduce a symbol for the inner result and apply the defining rule afresh at the outer parentheses.

6. The sum of the first eleven terms of the series is $\frac{1}{1+1^2+1^4} + \frac{2}{1+2^2+2^4} + \frac{3}{1+3^2+3^4} + \ldots$ [4 marks]

(A) $\frac{61}{133}$
(B) $\frac{66}{133}$
(C) $\frac{16}{33}$
(D) $\frac{33}{67}$

Correct Answer: (B) $\frac{66}{133}$

Solution:

Concept:

- The denominator factors as $n^4 + n^2 + 1 = (n^2 - n + 1)(n^2 + n + 1)$, allowing a partial-fraction difference.
- The two quadratic factors are consecutive members of the sequence $a_n = n^2 - n + 1$, because $a_{n+1} = n^2 + n + 1$. This makes the sum telescope.

Step 1: Write the general term as a difference For a positive integer n, the difference of the reciprocal factors is

$$\frac{1}{n^2 - n + 1} - \frac{1}{n^2 + n + 1} = \frac{2n}{(n^2 - n + 1)(n^2 + n + 1)}.$$

The denominator product equals $(n^2 + 1)^2 - n^2 = n^4 + n^2 + 1$. Thus

$$\frac{n}{1 + n^2 + n^4} = \frac{1}{2}\left(\frac{1}{n^2 - n + 1} - \frac{1}{n^2 + n + 1}\right).$$

The factor $1/2$ is needed because the difference produces $2n$, rather than the numerator n.

Step 2: Cancel consecutive terms and retain the endpoints Summing from $n = 1$ through 11 gives

$$S_{11} = \frac{1}{2}\left[(1 - \tfrac{1}{3}) + (\tfrac{1}{3} - \tfrac{1}{7}) + (\tfrac{1}{7} - \tfrac{1}{13}) + \cdots + (\tfrac{1}{111} - \tfrac{1}{133})\right].$$

Every interior reciprocal occurs once positively and once negatively. The last denominator is $11^2 + 11 + 1 = 133$, so

$$S_{11} = \frac{1}{2}\left(1 - \frac{1}{133}\right) = \frac{66}{133}.$$

This is a finite telescoping calculation; replacing the final reciprocal by zero would instead give the

infinite sum $1/2$. Options (A), (C) and (D) are unequal to the exact endpoint difference and are therefore excluded.

Step 3: Conclusion The sum of the first eleven terms is $\frac{66}{133}$. Hence, the correct option is (B).

Quick Tip to Solve: Try factoring a quartic symmetric denominator into two quadratics whose reciprocal difference has the required linear numerator.

---

7. $\lim_{x\to 0}(1+3x)^{\frac{x+2}{x}}$ **is equal to** [4 marks]

(A) e

(B) e^3

(C) e^6

(D) e^9

Correct Answer: (C) e^6

Solution:

Concept:

- For an exponential limit of the indeterminate form 1^∞, take the natural logarithm first; this converts the varying power into a product.
- The standard logarithmic limit is $\lim_{u\to 0}\log(1+u)/u = 1$. Continuity of the exponential then recovers the required limit.

Step 1: Take logarithms on the domain Let $y = (1+3x)^{(x+2)/x}$. For all sufficiently small nonzero positive or negative x, the base is positive, so the real logarithm is defined. We have

$$\log y = \frac{x+2}{x}\log(1+3x) = 3(x+2)\frac{\log(1+3x)}{3x}.$$

The base tends to one, but the exponent is unbounded; directly substituting the limiting base would therefore lose the contribution of the power.

Step 2: Apply the standard limit Set $u = 3x$, which also tends to zero. The logarithmic quotient tends to one from either side. Thus

$$\lim_{x\to 0}\log y = 3(0+2)\cdot 1 = 6.$$

Since exponentiation is continuous, $\lim y = \exp(6)$. The exponents one, three and nine in the other options do not equal the logarithmic limit: three omits the factor two coming from $x+2$, while nine introduces an extra factor not present in the expression. The two-sided domain restriction causes no difficulty near zero.

Step 3: Conclusion The required limit is e^6. Hence, the correct option is (C).

Quick Tip to Solve: For $(1+ax)^{b/x+c}$, take logarithms: the surviving exponent is ab; the bounded part of the power contributes zero.

---

8. Let $P(\alpha, \beta, \lambda)$ be the image of the point $\mathrm{Q}(1, 2, 0)$ in the line $\frac{x-5}{3} = \frac{y-12}{1} = \frac{z-10}{2}$, then $(\mathrm{PQ})^2$ is equal to [4 marks]

(A) 90

(B) 180

(C) 360

(D) 270

Correct Answer: (C) 360

Solution:

Concept:

- The image of a point in a line is obtained by a half-turn about that line. Its perpendicular foot on the line is the midpoint of the point and its image.
- If H is that foot, then $PQ = 2QH$, so $PQ^2 = 4QH^2$. A direction vector of the given line is $(3, 1, 2)$.

Step 1: Locate the perpendicular foot Write a general point on the line as

$$H = (5 + 3t, 12 + t, 10 + 2t).$$

The vector from $Q = (1, 2, 0)$ to this point is $(4 + 3t, 10 + t, 10 + 2t)$. For H to be the foot, this vector must be perpendicular to the direction vector:

$$3(4 + 3t) + (10 + t) + 2(10 + 2t) = 0.$$

Thus $42 + 14t = 0$, giving $t = -3$ and $H = (-4, 9, 4)$. This perpendicular condition selects the closest point on the line, rather than its displayed reference point $(5, 12, 10)$.

Step 2: Use the midpoint relation The squared perpendicular distance is

$$QH^2 = (-4 - 1)^2 + (9 - 2)^2 + (4 - 0)^2 = 25 + 49 + 16 = 90.$$

Reflection doubles this distance, not its square, so

$$PQ^2 = 4(90) = 360.$$

As a check, the reflected point is $P = 2H - Q = (-9, 16, 8)$. Directly, $PQ^2 = (-10)^2 + 14^2 + 8^2 = 360$. Option (A) is only the squared distance to the line; option (B) incorrectly doubles that square. Option (D) agrees with neither the midpoint nor the direct-coordinate calculation.

Step 3: Conclusion The squared distance $(PQ)^2$ is 360. Hence, the correct option is (C).

Quick Tip to Solve: For reflection in a line, find the perpendicular foot first and multiply the squared point-to-line distance by four.

9. A box contains 7 red and 9 white balls. The number of ways of drawing 8 balls such that there are at least three balls of each colour, is : [4 marks]

(A) 8820

(B) 10584

(C) 1764

(D) 3515

Correct Answer: (B) 10584

Solution:

Concept:

- An unordered selection of r distinct objects from n is counted by $\binom{n}{r}$. Drawing balls without specifying an order is a selection problem.
- For disjoint colour distributions add their counts; within a distribution multiply the independent choices of red and white balls.

Step 1: List every permitted colour distribution Let r denote the number of red balls selected. Then the number of white balls is $8-r$. The conditions require

$$r \geq 3, \qquad 8-r \geq 3,$$

so $r = 3, 4, 5$. The three possible distributions are therefore $(3,5), (4,4), (5,3)$. Each is possible with the available seven red and nine white balls. The cases cannot overlap, since a particular selection has exactly one red-ball count. Distributions with two or fewer balls of either colour are excluded even though eight balls are still selected.

Step 2: Count and add the disjoint cases For each distribution, choose its red balls from seven and its white balls from nine:

$$\begin{aligned} N &= \binom{7}{3}\binom{9}{5} + \binom{7}{4}\binom{9}{4} + \binom{7}{5}\binom{9}{3} \\ &= 35(126) + 35(126) + 21(84) \\ &= 4410 + 4410 + 1764 = 10584. \end{aligned}$$

No factor of $8!$ is needed because rearranging the same eight balls does not create a new selection. The value 8820 omits the last allowed distribution, while 1764 counts that last distribution alone. The value 3515 is not the sum of the three exhaustive case counts.

Step 3: Conclusion There are 10584 permitted selections. Hence, the correct option is (B).

Quick Tip to Solve: Convert "at least three of each colour" into a range for the red count, then sum one product of combinations for every integer in that range.

10. Let $[t]$ denote the greatest integer function. If $\int_0^1 [1 + x^2 + x^4]\,dx = a$, then $36a - 25a^2 + 8a^3 - a^4$ is equal to [4 marks]

(A) 19

(B) -19

(C) 18

(D) -21

Correct Answer: (A) 19

Solution:

Concept:

- The greatest-integer function is constant between successive integer crossings. Isolated endpoint values do not affect a definite integral.
- On $[0, 1]$, $1 + x^2 + x^4$ increases from one to three, so the only interior jump of its floor occurs where $x^2 + x^4 = 1$.

Step 1: Find the jump and evaluate the integral Let $b \in (0, 1)$ satisfy $b^2 + b^4 = 1$. With $v = b^2$, the positive root of $v^2 + v - 1 = 0$ gives

$$b = \sqrt{\frac{\sqrt{5} - 1}{2}}.$$

The integrand is one for $0 \le x < b$ and two for $b \le x < 1$. At $x = 1$ it equals three, but this single point contributes no area. Hence

$$a = \int_0^b 1\,dx + \int_b^1 2\,dx = b + 2(1 - b) = 2 - b.$$

Step 2: Reduce the polynomial using the crossing equation Rather than insert the nested radical repeatedly, substitute $a = 2 - b$ and expand:

$$36a - 25a^2 + 8a^3 - a^4 = 20 - b^2 - b^4.$$

For example, the constant term is $72 - 100 + 64 - 16 = 20$, the linear and cubic terms cancel, and the remaining square and fourth-power coefficients are both minus one. Since $b^2 + b^4 = 1$, the expression is $20 - 1 = 19$. This also avoids numerical rounding in the integral. The alternatives -19, 18 and -21 fail the exact polynomial identity, so no sign choice or endpoint convention can produce them.

Step 3: Conclusion The value of the expression is 19. Hence, the correct option is (A).

Quick Tip to Solve: Use the algebraic equation satisfied by an integral's jump point to simplify the final polynomial before substituting radicals.

11. Let $\mathrm{PL} = 8$ units and $\mathrm{QM} = 2$ units be two parallel line segments such that the line segments PM and QL intersect at the point R. If PL and QM are tangents to a circle passing through points $\mathrm{P}, \mathrm{Q}, \mathrm{R}$ then radius of this circle is [4 marks]

(A) $\sqrt{2}$

(B) 2

(C) $2\sqrt{2}$

(D) 4

Correct Answer: (B) 2

Solution:

Concept:

- Parallel tangents to a circle touch it at opposite ends of a diameter: the radii to the contact points are perpendicular to both tangent lines.
- Place the centre at the origin and the contact points at $P = (0, r)$, $Q = (0, -r)$. A point on the circle satisfies $x^2 + y^2 = r^2$.

Step 1: Choose coordinates matching the intersecting segments The parallel tangent segments have lengths $PL = 8$ and $QM = 2$. We may choose the positive horizontal direction towards their endpoints, giving

$$P = (0, r), \quad L = (8, r), \quad Q = (0, -r), \quad M = (2, -r).$$

Both endpoints must be on the same horizontal side for the segments PM and QL to intersect internally. Reversing both directions merely reflects the configuration and does not change the radius. Parametrise their intersection as

$$R = P + t(M - P) = Q + s(L - Q).$$

Comparing horizontal and vertical components yields $2t = 8s$ and $1 - 2t = -1 + 2s$, hence $t = 4/5$ and $s = 1/5$.

Step 2: Apply the circle equation to the intersection The intersection coordinates are consequently

$$R = \left(\frac{8}{5}, -\frac{3r}{5}\right).$$

The circle passes through R, so

$$\frac{64}{25} + \frac{9r^2}{25} = r^2 \quad \Longrightarrow \quad 64 = 16r^2.$$

Thus $r^2 = 4$, and the positive radius is $r = 2$. The alternatives have squared radii 2, 8 and 16; none satisfies the derived equation. Notice that using half the difference of the tangent lengths would not impose the essential condition that their cross-joining segments intersect on the circle.

Step 3: Conclusion The radius of the circle is 2 units. Hence, the correct option is (B).

Quick Tip to Solve: With parallel tangents, put the contact points at opposite ends of a vertical diameter; intersect the cross-joining segments and use the circle equation.

12. For some $\alpha \in \mathbb{N}$, let PQR be a triangle with two fixed vertices $\mathrm{P}(2,5)$ and $\mathrm{Q}(\alpha,-11)$. If the point R moves on the line $l_1 : 9x+7y+\alpha=0$, then the centroid of $\Delta\mathrm{PQR}$ moves on the line l_2, which is parallel to l_1 at a distance $\frac{20}{3\sqrt{130}}$ units from it. If the distance of Q from l_2 is $\frac{k}{3\sqrt{130}}$, then k is equal to : [4 marks]

(A) 117

(B) 129

(C) 131

(D) 133

Correct Answer: (C) 131

Solution:

Concept:

- If $G=(h,k)$ is the centroid, its coordinates are the averages of the three vertex coordinates. Express the moving vertex in terms of h,k to obtain the centroid locus.
- For parallel lines $Ax+By+C_1=0$, $Ax+By+C_2=0$, their distance is $|C_1-C_2|/\sqrt{A^2+B^2}$. A point-to-line distance uses the same denominator.

Step 1: Derive the centroid line Write $R=(x,y)$ and $G=(h,k)$. From $P=(2,5)$, $Q=(\alpha,-11)$,

$$h=\frac{2+\alpha+x}{3}, \qquad k=\frac{y-6}{3}.$$

Therefore $x=3h-2-\alpha$ and $y=3k+6$. Substitution in the locus of R gives

$$9(3h-2-\alpha)+7(3k+6)+\alpha=0,$$

or $l_2 : 27h+21k+24-8\alpha=0$. Dividing by three makes its normal coefficients equal to those of l_1.

Step 2: Use the separation to determine alpha The prescribed separation now gives

$$\frac{|24-11\alpha|}{3\sqrt{130}}=\frac{20}{3\sqrt{130}}.$$

Consequently $24-11\alpha=20$ or -20, so $\alpha=4/11$ or 4. Since α is a natural number, only $\alpha=4$ is allowed. The centroid locus is therefore $27x+21y-8=0$.

Step 3: Calculate the required point-to-line distance Using $Q=(4,-11)$,

$$d(Q,l_2)=\frac{|27(4)+21(-11)-8|}{\sqrt{27^2+21^2}}=\frac{131}{3\sqrt{130}}.$$

Comparing with the stated form identifies $k=131$. The alternatives 117, 129 and 133 do not equal the absolute numerator obtained by substituting the fixed vertex; in particular, the constant term -8 must be retained.

Step 4: Conclusion The required value is $k=131$. Hence, the correct option is (C).

Quick Tip to Solve: Find a centroid locus by substituting $x_R=3h-x_P-x_Q$, $y_R=3k-y_P-y_Q$, then normalise parallel-line coefficients before taking distances.

13. Let $\mathrm{A}_i(x_i, y_i)$, $i = 1, 2, 3$ be points on the circle $x^2 + y^2 = 10$ such that A_1 lies in the 1^{st} quadrant and it is the image of point A_2 with respect to y-axis. If the distance of point A_1 from each of the points A_2 and A_3 is 2, then twenty times the area of the $\Delta\,\mathrm{A}_1\mathrm{A}_2\mathrm{A}_3$ is [4 marks]

(A) 12

(B) 30

(C) 24

(D) 48

Correct Answer: (C) 24

Solution:

Concept:

- Reflection in the y-axis changes (x, y) to $(-x, y)$, so the reflected points have the same ordinate.
- The area of a triangle is half its base times the perpendicular height. A horizontal base makes the height the difference of ordinates.

Step 1: Locate the reflected pair Write $A_1 = (a, b)$ with $a, b > 0$. Reflection gives $A_2 = (-a, b)$, so their distance is $2a = 2$. Thus $a = 1$. Both lie on the given circle, hence

$$1 + b^2 = 10 \quad \Longrightarrow \quad b = 3.$$

The positive root is necessary because A_1 lies in the first quadrant. Therefore $A_1 = (1, 3)$ and $A_2 = (-1, 3)$.

Step 2: Find the third vertex Let $A_3 = (x, y)$. Its two conditions are

$$x^2 + y^2 = 10, \qquad (x - 1)^2 + (y - 3)^2 = 4.$$

Subtracting and simplifying gives $x + 3y = 8$, so $x = 8 - 3y$. Substitute in the circle:

$$(8 - 3y)^2 + y^2 = 10 \quad \Longrightarrow \quad 5y^2 - 24y + 27 = 0.$$

The roots are $y = 3$ and $y = 9/5$. The first gives $(-1, 3) = A_2$, so the distinct third vertex is $A_3 = (13/5, 9/5)$.

Step 3: Calculate the required scaled area The base A_1A_2 has length 2 and lies on $y = 3$. Its perpendicular height from A_3 is

$$3 - \frac{9}{5} = \frac{6}{5}.$$

Consequently,

$$[A_1A_2A_3] = \frac{1}{2} \cdot 2 \cdot \frac{6}{5} = \frac{6}{5}, \qquad 20[A_1A_2A_3] = 24.$$

The other proposed values, 12, 30 and 48, do not equal this scaled area; in particular 48 would double-count the triangular area.

Step 4: Conclusion Twenty times the area is $\boxed{24}$. Hence, the correct option is (C).

Quick Tip to Solve: For reflected points on a circle, first use their horizontal separation; then subtract circle equations to obtain the second chord line.

14. The remainder when 7^{89} is divided by 15 is [4 marks]

(A) 5

(B) 7

(C) 9

(D) 11

Correct Answer: (B) 7

Solution:

Concept:

- Two integers are congruent modulo 15 when their difference is divisible by 15. Congruences are preserved under multiplication.
- A short repeating cycle of powers reduces a large exponent to its remainder modulo the cycle length; the division remainder must lie between 0 and 14.

Step 1: Find a power congruent to one Calculate the first few powers modulo 15, keeping only the remainders:

$$7^1 \equiv 7, \qquad 7^2 = 49 \equiv 4 \pmod{15}.$$

Squaring the second congruence gives

$$7^4 \equiv 4^2 = 16 \equiv 1 \pmod{15}.$$

This identity is sufficient to evaluate the much larger power; it avoids writing an enormous integer. It also shows that multiplying an exponent by blocks of four does not change the remaining factor.

Step 2: Reduce the exponent The exponent has the exact division

$$89 = 4 \cdot 22 + 1.$$

Therefore,

$$7^{89} = (7^4)^{22} \cdot 7 \equiv 1^{22} \cdot 7 = 7 \pmod{15}.$$

Because 7 is already in the permitted remainder interval, this congruence directly supplies the ordinary division remainder. There is no need to add or subtract another multiple of 15.

Step 3: Check against the answer choices For an independent cycle check, the consecutive remainders of the powers of 7 are $7, 4, 13, 1$; multiplying the last by 7 restarts the cycle. An exponent congruent to 1 modulo 4 must therefore give the first entry, 7. The choices 5, 9 and 11 are different residues and cannot be remainders of this power. In particular, reducing the exponent modulo 15 would be invalid: the relevant period is the period of the powers, which here is four.

Step 4: Conclusion The remainder on division of 7^{89} by 15 is $\boxed{7}$. Hence, the correct option is (B).

Quick Tip to Solve: Look for a small power equal to 1 modulo the divisor; here $7^4 \equiv 1 \pmod{15}$, so only the exponent modulo 4 matters.

15. If the plane $y = \alpha x - \beta z + \gamma$ passing through the point $(1, -1, 3)$ is perpendicular to each of the planes $2x + y + z = 1$ and $3x - 2y + 2z = 0$, then $\alpha + \beta + \gamma$ is equal to : [4 marks]

(A) 5

(B) 13

(C) 19

(D) 27

Correct Answer: (D) 27

Solution:

Concept:

- A normal vector to $ax + by + cz = d$ is (a, b, c). Perpendicular planes have perpendicular normal vectors, whose dot product is zero.
- The plane must also contain the specified point; substitute its coordinates only after determining the coefficients fixed by perpendicularity.

Step 1: Write the normal vectors correctly Rearrange the required plane as

$$\alpha x - y - \beta z + \gamma = 0.$$

Its normal is $\mathbf{n} = (\alpha, -1, -\beta)$. The normals to the other two planes are $\mathbf{n}_1 = (2, 1, 1)$ and $\mathbf{n}_2 = (3, -2, 2)$. The constants on the right-hand sides do not affect these normal directions and hence do not enter the perpendicularity conditions.

Step 2: Apply both perpendicularity conditions The two zero dot products give

$$2\alpha - 1 - \beta = 0,$$
$$3\alpha + 2 - 2\beta = 0.$$

From the first equation, $\beta = 2\alpha - 1$. Substitute this into the second:

$$3\alpha + 2 - 2(2\alpha - 1) = 0 \quad \Longrightarrow \quad -\alpha + 4 = 0.$$

Thus $\alpha = 4$ and $\beta = 7$. The resulting normal $(4, -1, -7)$ has dot products $8 - 1 - 7 = 0$ and $12 + 2 - 14 = 0$, checking both requirements.

Step 3: Use the given point and evaluate the sum Since $(1, -1, 3)$ is on the plane, insert it into the original equation:

$$-1 = 4(1) - 7(3) + \gamma = -17 + \gamma.$$

It follows that $\gamma = 16$. The desired sum is therefore

$$\alpha + \beta + \gamma = 4 + 7 + 16 = 27.$$

Checking the plane $y = 4x - 7z + 16$ at the specified point gives $-1 = 4 - 21 + 16$, as required. The other options 5, 13 and 19 fail this uniquely determined sum; changing the sign of the z-coefficient would also fail the normal-vector checks.

Step 4: Conclusion $\alpha + \beta + \gamma = \boxed{27}$. Hence, the correct option is (D).

Quick Tip to Solve: When a plane is given with y isolated, move all variable terms to one side before reading off its normal; this prevents sign errors.

16. Let $\vec{a} = \hat{i} + 2\hat{j} + 3\hat{k}$, $\vec{b} = \hat{i} - \hat{j} + 2\hat{k}$, $\vec{c} = 2\hat{i} + \hat{j} - 4\hat{k}$ be three vectors. If $\vec{r}$ is the vector such that $\vec{r} \times \vec{a} = (\vec{b} + \vec{c}) \times \vec{a}$ and $\vec{r} \cdot (\vec{b} - \vec{c}) = 0$, then $\vec{r} \cdot (\hat{i} + \hat{j} - \hat{k})$ is equal to : [4 marks]

(A) 3

(B) 4

(C) 5

(D) 6

Correct Answer: (C) 5

Solution:

Concept:

- If $\mathbf{u} \times \mathbf{a} = \mathbf{0}$ with $\mathbf{a} \neq \mathbf{0}$, then $\mathbf{u}$ is a scalar multiple of $\mathbf{a}$.
- The dot product is linear. A second scalar constraint determines the remaining component parallel to $\mathbf{a}$, unless its coefficient vanishes.

Step 1: Express the unknown vector with one parameter Move the cross-product equation to one side:

$$(\vec{r} - \vec{b} - \vec{c}) \times \vec{a} = \vec{0}.$$

Since $\vec{a} = (1, 2, 3) \neq \vec{0}$, there is a real number t such that

$$\vec{r} = \vec{b} + \vec{c} + t\vec{a}.$$

Here $\vec{b} + \vec{c} = (3, 0, -2)$ and $\vec{b} - \vec{c} = (-1, -2, 6)$. The cross-product equation alone does not allow us to set $t = 0$; it fixes only the component perpendicular to $\vec{a}$.

Step 2: Apply the dot-product constraint Take the dot product with $\vec{b} - \vec{c}$:

$$\begin{aligned} 0 &= (3, 0, -2) \cdot (-1, -2, 6) + t(1, 2, 3) \cdot (-1, -2, 6) \\ &= -15 + 13t. \end{aligned}$$

Thus $t = 15/13$. This gives $\vec{r} = (54/13, 30/13, 19/13)$. As a check, its dot product with $(-1, -2, 6)$ is $(-54 - 60 + 114)/13 = 0$, exactly as required.

Step 3: Evaluate the requested projection Let $\vec{d} = (1, 1, -1)$. Notice that

$$\vec{a} \cdot \vec{d} = 1 + 2 - 3 = 0.$$

Therefore the parameter term contributes nothing:

$$\vec{r} \cdot \vec{d} = (\vec{b} + \vec{c}) \cdot \vec{d} + t\vec{a} \cdot \vec{d} = 3 + 0 + 2 = 5.$$

The explicit coordinates give the same result, $(54 + 30 - 19)/13 = 65/13 = 5$. Thus 3, 4 and 6 are excluded by direct substitution. The value is a scalar and has no physical unit in this purely algebraic vector question.

Step 4: Conclusion The required dot product is $\boxed{5}$. Hence, the correct option is (C).

Quick Tip to Solve: After writing $\vec{r} = \vec{b} + \vec{c} + t\vec{a}$, test whether the requested dot-product direction is perpendicular to $\vec{a}$; the parameter may disappear.

17. The probability that a randomly selected root of the equation $1 + x + x^2 + \ldots + x^{118} = 0$ satisfies the equation $x^7 = 1$, is [4 marks]

(A) 0

(B) $\frac{1}{59}$

(C) $\frac{3}{59}$

(D) $\frac{7}{118}$

Correct Answer: (C) $\frac{3}{59}$

Solution:

Concept:

- For $x \neq 1$, the finite geometric sum satisfies $1 + x + \cdots + x^{118} = (x^{119} - 1)/(x - 1)$.
- Uniform selection from distinct roots gives probability equal to the number of favourable roots divided by the total number of roots.

Step 1: Identify the complete root set Multiplying the given equation by $x - 1$ gives $x^{119} = 1$. The point $x = 1$ must be excluded because the original sum there equals 119, not zero. The polynomial $x^{119} - 1$ has 119 distinct complex roots: its derivative $119x^{118}$ is nonzero at each of them. Removing 1 leaves exactly 118 distinct roots of the original degree-118 equation. Thus the denominator of the probability is 118.

Step 2: Count the roots satisfying the second equation Since $119 = 7 \cdot 17$, every root satisfying $x^7 = 1$ also satisfies

$$x^{119} = (x^7)^{17} = 1.$$

There are seven distinct seventh roots of unity. Of these, 1 is not a root of the original sum, while the other six all are. Equivalently, writing the original roots as $e^{2\pi ik/119}$, $1 \leq k \leq 118$, the second condition requires k to be a multiple of 17: $17, 34, 51, 68, 85, 102$.

Step 3: Form and check the probability The six favourable roots are equally likely among the 118 available roots. Hence

$$P = \frac{6}{118} = \frac{3}{59}.$$

Zero is incorrect because the six nontrivial seventh roots are common roots. The value $1/59$ would count only two common roots, while $7/118$ incorrectly includes $x = 1$, which was introduced when multiplying by $x - 1$. This exclusion is essential: the second equation has seven solutions, but only six belong to the experiment's sample space.

Step 4: Conclusion The probability is $\boxed{\frac{3}{59}}$. Hence, the correct option is (C).

Quick Tip to Solve: When converting a geometric-sum equation into a roots-of-unity equation, always remove $x = 1$ before counting common roots.

18. Let X have the binomial distribution $\mathrm{B}(n, p)$. If its mean is 3 and variance is 2, then $\mathrm{P}\left(X < \frac{n}{4}\right)$ is equal to : [4 marks]

(A) $\frac{29\times 2^8}{3^9}$

(B) $\frac{25\times 2^9}{3^9}$

(C) $\frac{163}{3^9}$

(D) $\frac{835}{3^9}$

Correct Answer: (A) $\frac{29\times 2^8}{3^9}$

Solution:

Concept:

- For $X \sim B(n, p)$, the mean is np and the variance is $np(1-p)$. Their ratio gives $1-p$.
- The binomial probability is $P(X=k) = \binom{n}{k}p^k(1-p)^{n-k}$, for integer values $k = 0, 1, \ldots, n$.

Step 1: Find the distribution parameters The supplied mean and variance imply

$$np = 3, \qquad np(1-p) = 2.$$

Divide the second equation by the first, which is nonzero:

$$1 - p = \frac{2}{3} \quad \Longrightarrow \quad p = \frac{1}{3}.$$

Consequently $n = 3/p = 9$. The parameters satisfy both statements: $9(1/3) = 3$ and $9(1/3)(2/3) = 2$. The success probability is $1/3$, whereas $2/3$ is the failure probability.

Step 2: Translate the strict inequality Here $n/4 = 9/4 = 2.25$. Since a binomial random variable takes only nonnegative integer values,

$$\left\{X < \frac{9}{4}\right\} = \{X = 0, 1, 2\}.$$

In particular, the value $X = 2$ must be included: it is less than 2.25. The value $X = 3$ must be excluded. We therefore add exactly three binomial terms, with their appropriate combination factors.

Step 3: Add and simplify the three terms Using the common denominator 3^9,

$$\begin{aligned} P(X < 9/4) &= \sum_{k=0}^{2} \binom{9}{k} \frac{2^{9-k}}{3^9} \\ &= \frac{2^9 + 9\cdot 2^8 + 36\cdot 2^7}{3^9} \\ &= \frac{2^7(4 + 18 + 36)}{3^9} = \frac{29\cdot 2^8}{3^9}. \end{aligned}$$

The numerator is 7424. By comparison option (B) has numerator 12800, and options (C) and (D) have numerators 163 and 835; none equals the required sum. This arithmetic check also guards against interchanging success and failure probabilities or omitting the $X = 2$ term.

Step 4: Conclusion $\mathrm{P}(X < n/4) = \boxed{\dfrac{29 \times 2^8}{3^9}}$. Hence, the correct option is (A).

Quick Tip to Solve: Use variance divided by mean to find $1 - p$, then convert a noninteger threshold into the exact permitted integer values before summing.

19. The domain of the function $f(x) = \cos^{-1}\left(\frac{x^2-3x+2}{x^2+2x-1}\right)$ is : [4 marks]

(A) $\left(\sqrt{2}-1, \frac{3}{5}\right]$
(B) $\left[\frac{3}{5}, \infty\right)$
(C) $\mathbb{R} - \{-\sqrt{2}-1, \sqrt{2}-1\}$
(D) $(-\infty, -1-\sqrt{2}) \cup (\sqrt{2}-1, \infty)$
Correct Answer: (B) $\left[\frac{3}{5}, \infty\right)$

Solution:

Concept:

- The real-valued inverse cosine $\cos^{-1} u$ exists exactly when $-1 \le u \le 1$. The rational expression inside it must also be defined.
- Writing the numerator as N and denominator as D, the condition $|N/D| \le 1$, with $D \neq 0$, is equivalent to $D^2 - N^2 \ge 0$. Squaring here is valid because both absolute values are nonnegative.

Step 1: Factor the domain inequality Set $N = x^2 - 3x + 2$ and $D = x^2 + 2x - 1$. The denominator excludes the roots $x = -1 \pm \sqrt{2}$. Instead of multiplying a double inequality by a denominator of unknown sign, use the difference of squares:

$$\begin{aligned} D^2 - N^2 &= (D - N)(D + N) \\ &= (5x - 3)(2x^2 - x + 1). \end{aligned}$$

Thus the inverse-cosine condition reduces to a product inequality, retaining the requirement that D is nonzero.

Step 2: Determine the sign and check the endpoint Complete the square in the quadratic factor:

$$2x^2 - x + 1 = 2\left(x - \frac{1}{4}\right)^2 + \frac{7}{8} > 0.$$

Consequently the product is nonnegative precisely when $5x - 3 \ge 0$, or $x \ge 3/5$. Neither excluded denominator root lies in this interval: the positive root $\sqrt{2} - 1$ is less than $3/5$, while the other is negative. At $x = 3/5$, $D = N = 14/25$, so the argument is 1 and the endpoint is included. Option (A) contains points below $3/5$ and incorrectly stops there. Options (C) and (D) merely describe denominator restrictions or larger intervals and include points where the inverse cosine is not real.

Step 3: Conclusion The domain is $\left[\dfrac{3}{5}, \infty\right)$. Hence, the correct option is (B).

Quick Tip to Solve: For an inverse cosine of a rational expression, factor denominator squared minus numerator squared; then separately exclude zero denominators.

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

(A) $((p \Rightarrow q) \vee p) \Rightarrow q$

(B) $((p \wedge q) \Rightarrow p) \Rightarrow q$

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

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

Correct Answer: (C) $((p \wedge q) \wedge (\sim q)) \Rightarrow p$

Solution:

Concept:

- A tautology is true for every assignment of truth values to its constituent statements. An implication $A \Rightarrow B$ is false only when A is true and B is false.
- The identities $p \Rightarrow q \equiv (\sim p) \vee q$ and $q \wedge (\sim q) \equiv \text{False}$ simplify the given statements without a full truth table.

Step 1: Simplify the candidate with a contradictory antecedent In option (C), the antecedent contains both q and its negation:

$$(p \wedge q) \wedge (\sim q) = p \wedge \big(q \wedge (\sim q)\big) \equiv \text{False}.$$

It follows that the entire statement is $\text{False} \Rightarrow p$, which is true whether p itself is true or false. This establishes truth for all possible values of both variables; it is not just a check of a favourable assignment.

Step 2: Eliminate the remaining statements For options (A) and (D), their common antecedent simplifies as

$$(p \Rightarrow q) \vee p \equiv (\sim p) \vee q \vee p \equiv \text{True}.$$

Therefore (A) reduces to q, and (D) reduces to p. Neither is always true: choosing q false disproves (A), and choosing p false disproves (D). In option (B), $(p \wedge q) \Rightarrow p$ is always true, since whenever both statements hold, p holds. Thus (B) is also equivalent to q and fails whenever q is false. For instance, p true and q false makes both (A) and (B) false. These counterexamples exclude each competing option individually.

Step 3: Conclusion Only $((p \wedge q) \wedge (\sim q)) \Rightarrow p$ is true for every truth assignment. Hence, the correct option is (C).

Quick Tip to Solve: Look first for an antecedent containing a statement and its negation: an implication from a contradiction is always true.

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

Attempt any 5 of the 10 questions in this section.

21. The curve $y = x^2 + 1$ divides the area enclosed by the curves $y + |x| = 3$ and $y = |x - 1|$ in the ratio m : n, where m and n are coprime, then m + n is equal to _____. [4 marks]

Solution:

Concept:

- For a bounded region between graphs, integrate the upper ordinate minus the lower ordinate. Absolute values require splitting at their changes of formula.
- The two areas separated by a third curve can be computed by integrating its ordinate only where it lies inside the original region; elsewhere the whole vertical strip lies on one side.

Step 1: Find the original enclosed area The upper boundary is $U = 3 - |x|$ and the lower boundary is $L = |x - 1|$. Their intersections occur at $x = -1$ and $x = 2$. On the successive intervals $[-1, 0]$, $[0, 1]$, and $[1, 2]$, the heights $U - L$ are respectively $2 + 2x$, 2, and $4 - 2x$. Thus

$$A = \int_{-1}^{0} (2 + 2x)\, dx + \int_{0}^{1} 2\, dx + \int_{1}^{2} (4 - 2x)\, dx = 1 + 2 + 1 = 4.$$

These are the only intervals needed, since outside $[-1, 2]$ the two boundaries do not enclose the region.

Step 2: Locate the parabola within the region Let $P = x^2 + 1$. On $[-1, 0]$, $P - L = x^2 + x \leq 0$, so the parabola lies below the region. On $[0, 1]$, it lies between the boundaries because $P - L = x^2 + x \geq 0$ and $U - P = 2 - x - x^2 \geq 0$. On $[1, 2]$, $P - U = x^2 + x - 2 \geq 0$, so the entire region is below the parabola. The area of the portion below it is therefore

$$A_1 = \int_{0}^{1} (x^2 + x)\, dx + \int_{1}^{2} (4 - 2x)\, dx = \frac{1}{3} + \frac{1}{2} + 1 = \frac{11}{6}.$$

The remaining portion has area $A_2 = 4 - 11/6 = 13/6$. Both portions are positive and add back to the full enclosed area, providing a consistency check.

Step 3: Conclusion The two areas have ratio $11 : 13$, or the reverse if the portions are named in the opposite order. Since 11 and 13 are coprime, $m + n = \boxed{24}$.

Quick Tip to Solve: Before integrating a dividing curve, check where it lies above, inside, or below the bounded region; do not integrate it across the entire enclosure.

22. The number of ways in which 30 identical pens can be distributed among 12 students so that each student gets at least one pen and exactly two students get at least two pens each, is _____.

[4 marks]

Solution:

Concept:

- Identical pens give an occupancy-counting problem: only the number received by each distinct student matters, not the order in which pens are handed out.
- To impose exactly two students with at least two pens, first choose those students. Every other student must receive exactly one pen, because each receives at least one and cannot belong to the distinguished pair.

Step 1: Choose the students who receive more than one pen Choose the two students from the twelve:

$$\binom{12}{2} = \frac{12 \cdot 11}{2} = 66.$$

For any fixed pair, the remaining ten students are forced to receive one pen each. They use ten pens, leaving twenty pens for the chosen two. The pair is an unordered choice of recipients, but its members remain distinguishable students. Thus allocations giving different numbers to the two students are distinct allocations, even though no ordering of the choice of pair is used.

Step 2: Count the allocations to a fixed pair Write the allocations to the two chosen students as a and b. Then

$$a + b = 20, \qquad a \geq 2, \quad b \geq 2.$$

With $u = a - 2$, $v = b - 2$, this becomes $u + v = 16$, where both variables are nonnegative integers. Hence there are $16 + 1 = 17$ solutions, corresponding to $a = 2, 3, \ldots, 18$. Each has exactly two recipients with at least two pens and ten with exactly one. There is no overlap between different chosen pairs because every admissible distribution uniquely identifies its two recipients with more than one pen. Multiplying the independent choice and allocation counts gives

$$66 \times 17 = 1122.$$

No factorial for arranging the pens is needed because the pens are identical.

Step 3: Conclusion The required number of distributions is $\boxed{1122}$.

Quick Tip to Solve: When exactly a fixed number of recipients exceed a lower occupancy, choose those recipients first and force all the others to the minimum.

23. Let $(1+x^2-x^4)^{12}=\sum_{n=0}^{48}a_nx^n$. Then $a_0+a_2+a_4+\ldots+a_{44}$ is equal to _____. [4 marks]

Solution:

Concept:

- The sum of all coefficients of a polynomial $P(x)$ is $P(1)$. Here every exponent is even, since each term in the base contains only an even power of x.
- The requested sum ends at degree 44. Subtract the degree-46 and degree-48 coefficients from the complete sum, rather than expanding all twelve factors.

Step 1: Evaluate the sum of all even coefficients Put $P(x)=(1+x^2-x^4)^{12}$. No odd powers can arise when multiplying terms with even exponents. Evaluating at $x=1$ therefore gives

$$a_0+a_2+\cdots+a_{48}=P(1)=(1+1-1)^{12}=1.$$

This total includes two coefficients beyond the upper limit in the question. They must both be removed; stopping at degree 44 does not mean removing only the leading coefficient.

Step 2: Compute the two coefficients at the top degree To obtain degree 48, choose $-x^4$ from every factor, giving $a_{48}=(-1)^{12}=1$. To obtain degree 46, reduce that maximum total degree by exactly two. The only possibility is to replace one selected $-x^4$ by x^2. Replacing a factor by 1 would reduce the degree by four and cannot contribute here. There are twelve choices for the factor supplying x^2; the other eleven supply a negative sign. Hence

$$a_{46}=\binom{12}{1}(-1)^{11}=-12.$$

Consequently the desired partial sum is

$$\begin{aligned}a_0+a_2+\cdots+a_{44}&=P(1)-a_{46}-a_{48}\\&=1-(-12)-1=12.\end{aligned}$$

Keeping the minus sign in a_{46} is essential: subtracting this coefficient increases the partial sum.

Step 3: Conclusion The required coefficient sum is $\boxed{12}$.

Quick Tip to Solve: For a coefficient sum missing only the highest few powers, evaluate at 1 and count the omitted top-degree terms by their degree deficit.

24. If S_n denotes the sum of first n terms of the series $7+10+16+25+37+\ldots$, then $S_{30}-S_{20}$ is equal to _____. [4 marks]

Solution:

Concept:

- The differences of the displayed terms are $3,6,9,12,\ldots$. Thus the difference between the kth and $(k+1)$th terms is $3k$.
- If S_n is the sum of the first n terms, $S_{30}-S_{20}$ is the sum of terms numbered 21 through 30,

inclusive. Standard sums of integers and squares evaluate this block.

Step 1: Express the general term Let t_n denote the nth term. Starting with $t_1 = 7$, add the first $n-1$ differences:

$$\begin{aligned} t_n &= 7 + 3(1 + 2 + \cdots + (n-1)) \\ &= 7 + \frac{3n(n-1)}{2}. \end{aligned}$$

This gives $t_2 = 10$, $t_3 = 16$, $t_4 = 25$, and $t_5 = 37$, checking the indexing against every displayed term. The factor $n(n-1)$, rather than $n(n+1)$, occurs because reaching term n uses only $n-1$ differences.

Step 2: Sum the required ten terms Using $t_n = 7 + \frac{3}{2}(n^2 - n)$, we obtain

$$S_{30} - S_{20} = 70 + \frac{3}{2}\left(\sum_{n=21}^{30} n^2 - \sum_{n=21}^{30} n\right).$$

The integer sum is $10(21 + 30)/2 = 255$. For the squares, subtract the two prefix sums:

$$\begin{aligned} \sum_{n=21}^{30} n^2 &= \frac{30 \cdot 31 \cdot 61}{6} - \frac{20 \cdot 21 \cdot 41}{6} \\ &= 9455 - 2870 = 6585. \end{aligned}$$

It follows that

$$S_{30} - S_{20} = 70 + \frac{3}{2}(6585 - 255) = 70 + 9495 = 9565.$$

There are ten terms in this difference of sums, so the constant contribution is $10 \times 7 = 70$, not thirty copies of the first term.

Step 3: Conclusion The value of $S_{30} - S_{20}$ is $\boxed{9565}$.

Quick Tip to Solve: When first differences form an arithmetic progression, write the term as the first term plus the sum of the preceding differences before summing a block.

---

25. If $[t]$ denotes the greatest integer $\le t$, then the number of points, at which the function $f(x) = [x + x^3] + |x - x^3| + |x + \frac{1}{2}|$ is not differentiable in the open interval $(-10, 10)$, is _____. [4 marks]

Solution:

Concept:

- The greatest-integer function jumps whenever its argument crosses an integer. A jump discontinuity implies failure of differentiability.
- A modulus of a differentiable function can have a corner at a simple zero of its argument. Count the union of exceptional points rather than adding overlapping counts.

Step 1: Count the integer crossings Put $g(x) = x + x^3$. Its derivative is $g'(x) = 1 + 3x^2 > 0$, so it is strictly increasing and every integer in its image has exactly one preimage. Since the interval for x is open,

$$g((-10, 10)) = (-1010, 1010).$$

The integers strictly between these endpoints are $-1009, -1008, \ldots, 1008, 1009$. Their number is

$$1009 - (-1009) + 1 = 2019.$$

At every corresponding point, $[g(x)]$ has a unit jump. Both modulus terms are continuous, so neither can cancel this jump. Thus all these 2019 points are already nondifferentiability points.

Step 2: Check the additional modulus corners The zeros of $x - x^3 = x(1-x)(1+x)$ are $-1, 0, 1$; all are simple and may create corners. However, their respective values of $g(x)$ are $-2, 0, 2$, which are integers. These three points have already been counted among the jumps and must not be counted twice. The remaining modulus has its corner at $x = -1/2$, where

$$g(-1/2) = -\frac{1}{2} - \frac{1}{8} = -\frac{5}{8}.$$

This is not an integer, so the floor term is locally constant there. Also $x - x^3 \neq 0$ there, making its modulus smooth. Hence the corner of $|x + 1/2|$ survives and contributes exactly one new point. Away from this union every term is differentiable.

Step 3: Conclusion The required number of distinct points is $2019 + 1 = \boxed{2020}$.

Quick Tip to Solve: First count the floor-function jumps using the monotone argument; then add only modulus zeros outside that set.

26. If $\int \frac{dx}{(3x^2+5)\sqrt{10x^2+7}} = -\frac{1}{\sqrt{580}} \log_e |f(x)| + C$ where C is an arbitrary constant, then $f(0)$ is equal to _____. [4 marks]

Solution:

Concept:

- For a quadratic radical, the substitution $t = x/\sqrt{10x^2 + 7}$ can turn the integrand into a rational function of t.
- The difference-of-squares integral gives a logarithmic ratio. Multiplicative constants in the logarithm can be absorbed into the arbitrary integration constant.

Step 1: Transform the differential and denominator Let $t = x/\sqrt{10x^2 + 7}$. Direct differentiation and rearrangement give

$$dt = \frac{7\,dx}{(10x^2 + 7)^{3/2}}, \qquad x^2 = \frac{7t^2}{1 - 10t^2}.$$

In particular, $1 - 10t^2 = 7/(10x^2 + 7) > 0$. Therefore

$$\frac{dx}{\sqrt{10x^2 + 7}} = \frac{dt}{1 - 10t^2}, \qquad 3x^2 + 5 = \frac{5 - 29t^2}{1 - 10t^2}.$$

The two factors $1 - 10t^2$ cancel, and the integral reduces exactly to $\int dt/(5 - 29t^2)$. This also checks that no factor of 7 has been lost during substitution.

Step 2: Identify the logarithmic function and evaluate it Using partial fractions for the difference of

squares,

$$\int \frac{dt}{5-29t^2} = \frac{1}{2\sqrt{145}} \log_e \left| \frac{\sqrt{5}+\sqrt{29}t}{\sqrt{5}-\sqrt{29}t} \right| + C.$$

As $2\sqrt{145} = \sqrt{580}$, reverse the ratio to obtain the negative coefficient in the question. A corresponding canonical choice is

$$f(x) = \frac{\sqrt{5}\sqrt{10x^2+7} - \sqrt{29}x}{\sqrt{5}\sqrt{10x^2+7} + \sqrt{29}x}.$$

Both numerator and denominator are positive for real x, since their squared difference is $21x^2+35 > 0$. At zero their common value is $\sqrt{35}$, so this logarithmic ratio equals 1. The conventional ratio fixes the irrelevant multiplicative constant: replacing f by a nonzero constant multiple only changes C, not the antiderivative family.

Step 3: Conclusion For the canonical logarithmic ratio, $f(0) = \sqrt{35}/\sqrt{35} = \boxed{1}$, the stated key value. Strictly, an arbitrary multiplicative normalization of f is absorbed into C, so this value uses the conventional ratio displayed above.

Quick Tip to Solve: When the required logarithm has a negative coefficient, invert the ratio rather than changing the substitution or losing a sign.

27. Let the equation of the hyperbola with foci $(1,5),(1,-1)$ and eccentricity $\sqrt{3}$ be $x^2-2y^2+ax+by+c=0$. Then $|a+b+c|$ is equal to _____. [4 marks]

Solution:

Concept:

- The centre is the midpoint of the foci. If the foci share their x-coordinate, the transverse axis is vertical.
- For a hyperbola, the focal distance c_f, transverse semiaxis a_h and conjugate semiaxis b_h satisfy $e = c_f/a_h$ and $c_f^2 = a_h^2 + b_h^2$.

Step 1: Find the centre and semiaxes The foci are $(1,5)$ and $(1,-1)$, so their midpoint is

$$(h,k) = \left(1, \frac{5+(-1)}{2}\right) = (1,2).$$

The distance from the centre to either focus is $c_f = 3$. Use a separate subscript for the semiaxes to avoid confusing them with the coefficients called a, b, c in the requested expanded equation. From the eccentricity,

$$a_h = \frac{c_f}{e} = \frac{3}{\sqrt{3}} = \sqrt{3}, \qquad a_h^2 = 3.$$

For a hyperbola the focal distance is larger than the transverse semiaxis. Hence

$$b_h^2 = c_f^2 - a_h^2 = 9 - 3 = 6.$$

The two foci lie on the vertical line through the centre, so the positive squared term must involve $y-2$, rather than $x-1$.

Step 2: Expand into the prescribed coefficient form Write the standard equation with this vertical orientation:

$$\frac{(y-2)^2}{3} - \frac{(x-1)^2}{6} = 1.$$

Multiplying by 6 and rearranging to make the coefficient of x^2 equal to 1 yields

$$(x-1)^2 - 2(y-2)^2 + 6 = 0.$$

Expand both squares carefully:

$$x^2 - 2x + 1 - 2y^2 + 8y - 8 + 6 = 0,$$

$$x^2 - 2y^2 - 2x + 8y - 1 = 0.$$

Comparing like terms with the equation in the question gives $a = -2$, $b = 8$, $c = -1$. As a check, completing squares returns the centre $(1, 2)$, and $\sqrt{a_h^2 + b_h^2} = 3$ reproduces both original foci. The sign of the final sum is positive before the absolute value is taken.

Step 3: Conclusion Thus $|a + b + c| = |-2 + 8 - 1| = \boxed{5}$.

Quick Tip to Solve: Locate the transverse axis from the foci before writing the hyperbola; a vertical axis puts the positive term on the y-square.

---

28. Let α_1, α_2 be the values of α such that the distance between the point $(2, 4, 3)$ and the plane $3x + y + \alpha z + 10 = 0$ is $\sqrt{35}$ units. Then the area of the triangle with vertices $(\alpha_1, \alpha_2, 0)$, $(\alpha_2, \alpha_1, 0)$ and $\left(\frac{164}{13}, 5, 0\right)$ is _____ unit^2. [4 marks]

Solution:

Concept:

- The perpendicular distance from (x_0, y_0, z_0) to $Ax + By + Cz + D = 0$ is $|Ax_0 + By_0 + Cz_0 + D|/\sqrt{A^2 + B^2 + C^2}$.
- All three vertices have z-coordinate zero, so their triangle area can be calculated in the xy-plane as half a base times the perpendicular height.

Step 1: Solve the distance condition Substitute $(2, 4, 3)$ into the plane expression. The numerator is $|6 + 4 + 3\alpha + 10| = |20 + 3\alpha|$, and the normal has length $\sqrt{10 + \alpha^2}$. Consequently,

$$\frac{|20 + 3\alpha|}{\sqrt{10 + \alpha^2}} = \sqrt{35}.$$

Both sides are nonnegative and the denominator is nonzero, so squaring is legitimate:

$$(20 + 3\alpha)^2 = 35(10 + \alpha^2).$$

Expansion and simplification produce

$$26\alpha^2 - 120\alpha - 50 = 0, \qquad 13\alpha^2 - 60\alpha - 25 = 0.$$

Factor the latter as $(\alpha - 5)(13\alpha + 5) = 0$. Thus the two values are 5 and $-5/13$. Both satisfy the unsquared distance equation, since their absolute numerators give the required positive distance.

Step 2: Choose a horizontal base and compute the height The naming of the roots only interchanges the first two triangle vertices, so choose $\alpha_1 = 5$ and $\alpha_2 = -5/13$. The vertices in the xy-plane become

$$A = (5, -5/13), \quad B = (-5/13, 5), \quad C = (164/13, 5).$$

Points B, C share y-coordinate 5, making BC a horizontal base. Its length is

$$BC = \frac{164}{13} - \left(-\frac{5}{13}\right) = 13.$$

The perpendicular height from A to its supporting line $y = 5$ is

$$h = \left|5 - \left(-\frac{5}{13}\right)\right| = \frac{70}{13}.$$

The foot need not lie within the base segment for the base-height formula to apply. The zero z-coordinates ensure this planar calculation is also the spatial triangle area.

Step 3: Conclusion The area is $\frac{1}{2}(13)(70/13) = \boxed{35 \text{ unit}^2}$.

Quick Tip to Solve: After finding the two plane parameters, look for equal coordinates among the triangle vertices to obtain an easy base and height.

29. Let O be the origin and let the vectors $\overrightarrow{OA} = -3\hat{i} + 7\hat{j} + 5\hat{k}$, $\overrightarrow{OB} = -5\hat{i} + 7\hat{j} - 3\hat{k}$ and $\overrightarrow{OC} = \hat{u}$ represent three sides of a parallelopiped, where $\hat{u}$ is a unit vector in the xy- plane. If the maximum volume of the parallelopiped is $2\sqrt{\alpha}$, then α is equal to _____. [4 marks]

Solution:

Concept:

- The volume of a parallelepiped is the absolute scalar triple product $|(\vec{a} \times \vec{b}) \cdot \vec{u}|$.
- When a unit vector is restricted to the xy-plane, the maximum dot product is the length of the xy-projection of the other vector, by the Cauchy–Schwarz inequality.

Step 1: Compute the cross product of the fixed sides Write $\vec{a} = (-3, 7, 5)$ and $\vec{b} = (-5, 7, -3)$. Their cross product has components

$$(\vec{a} \times \vec{b})_x = 7(-3) - 5(7) = -56,$$
$$(\vec{a} \times \vec{b})_y = 5(-5) - (-3)(-3) = -34,$$
$$(\vec{a} \times \vec{b})_z = (-3)(7) - 7(-5) = 14.$$

Thus $\vec{a} \times \vec{b} = (-56, -34, 14)$. These signs follow the usual cyclic component formula; using the opposite cross-product order would reverse all three signs but leave the volume unchanged because of the absolute value. We now impose the actual restriction on the third side rather than maximizing

over all unit vectors in space.

Step 2: Maximize over the permitted unit vectors Because $\hat{u}$ lies in the xy-plane, set $\hat{u} = (p, q, 0)$ with $p^2 + q^2 = 1$. The volume reduces to

$$V = |-56p - 34q|.$$

The z-component 14 does not contribute to this dot product. By Cauchy–Schwarz,

$$V \le \sqrt{56^2 + 34^2}\sqrt{p^2 + q^2} = \sqrt{4292} = 2\sqrt{1073}.$$

This is an attainable maximum, not merely an upper bound: take $(p, q) = (-56, -34)/\sqrt{4292}$, or its negative. The resulting vector has zero z-component and unit length, as required, and its dot product attains the displayed bound. Including 14^2 under the square root would instead allow a third side pointing out of the xy-plane, contrary to the question.

Step 3: Conclusion Comparing $V_{\max} = 2\sqrt{1073}$ with $2\sqrt{\alpha}$ gives $\boxed{\alpha = 1073}$.

Quick Tip to Solve: Project the cross product onto the allowed plane before maximizing the triple product; its perpendicular component cannot contribute.

---

30. If the solution curve of the differential equation $\frac{x+y-2}{x+y-1}\frac{dy}{dx} = \frac{x+y+2}{x+y+1}$, $x + y > 2$ passes through the points $(\sqrt{2}, \sqrt{2})$ and $(2, \alpha)$, then $2\alpha - \log_e\left(\frac{\alpha^2+4\alpha+2}{6}\right)$ is equal to _____. [4 marks]

Solution:

Concept:

- When a differential equation depends on $x + y$, set $s = x + y$; then $ds/dx = 1 + dy/dx$.
- The condition $x + y > 2$ makes $s^2 - 2 > 0$, so the logarithm obtained on integration has a positive argument throughout the solution interval.

Step 1: Reduce the equation to a separable form Set $s = x + y > 2$. Rearranging the printed differential equation gives

$$\frac{dy}{dx} = \frac{(s+2)(s-1)}{(s+1)(s-2)}.$$

All denominators here are nonzero on the specified domain. Therefore

$$\frac{ds}{dx} = 1 + \frac{dy}{dx} = \frac{2(s^2-2)}{(s+1)(s-2)}.$$

The right-hand side is positive for $s > 2$, so we may invert and separate:

$$\frac{dx}{ds} = \frac{s^2 - s - 2}{2(s^2-2)} = \frac{1}{2} - \frac{s}{2(s^2-2)}.$$

Integration now uses $d(s^2 - 2) = 2s\,ds$, leading to

$$x = \frac{s}{2} - \frac{1}{4}\log_e(s^2 - 2) + C.$$

This reduction keeps the extra 1 in ds/dx, which is essential: substituting dy/dx directly for ds/dx would produce a different equation.

Step 2: Use the two points to eliminate the constant Multiply the integrated relation by 4 and substitute $s = x + y$. Rearrangement yields the invariant

$$2(y - x) - \log_e((x + y)^2 - 2) = K,$$

where K is constant along the solution curve. At the point $(\sqrt{2}, \sqrt{2})$, we have $x + y = 2\sqrt{2}$, so

$$K = 0 - \log_e(8 - 2) = -\log_e 6.$$

At the second point $(2, \alpha)$, the same relation gives

$$2\alpha - 4 - \log_e(\alpha^2 + 4\alpha + 2) = -\log_e 6.$$

Since this point is on the same domain $\alpha + 2 > 2$, its logarithm argument is positive. Combine the logarithms and move 4 to the other side:

$$2\alpha - \log_e\left(\frac{\alpha^2 + 4\alpha + 2}{6}\right) = 4.$$

There is no need to solve a transcendental equation for α; the requested expression is exactly the invariant evaluated at the second point.

Step 3: Conclusion The value of the required expression is $\boxed{4}$.

Quick Tip to Solve: For an equation in x+y, integrate after substituting s=x+y, then use both points in the same invariant instead of finding alpha explicitly.

Aptitude Test (200 marks)

31. Adobe is a [4 marks]

(A) Type of cement

(B) Type of floor finish

(C) Type of paint

(D) Type of Brick

Correct Answer: (D) Type of Brick

Solution:

Concept:

- Adobe is an earthen construction material made by shaping a mixture of soil, water and usually fibrous material into blocks.
- Building materials should be classified by their physical form and principal use. A masonry unit is different from a binder, a surface finish or a coating.

Step 1: Identify the material and its manufacture Adobe is a sun-dried, unfired earthen brick. Suitable earth is mixed with water, often with straw or other fibres to help control cracking, and placed in moulds. The shaped blocks are dried in air and sunlight instead of being fired in a kiln. They can then be laid in courses to construct masonry walls. Thus the name identifies a form of brick rather than a manufactured cement product.

Step 2: Compare the four categories Option (D), type of brick, matches both the block form and the masonry use of adobe. Cement in option (A) is a binding material used in mortar or concrete; it is not the moulded earth block described by adobe. A floor finish in option (B) is the exposed wearing surface of a floor, whereas adobe names a construction unit. Paint in option (C) is a coating applied to a surface and does not describe these sun-dried blocks. These distinctions remain valid even though earth can also be used in plaster or floors: the conventional architectural meaning of adobe here is the brick.

Step 3: Conclusion Adobe is a type of sun-dried earthen brick. Hence, the correct option is (D).

Quick Tip to Solve: Link adobe with moulded earth blocks dried in the sun; distinguish the masonry unit from the binder or coating used with it.

32. Given below are two statements:

Statement I : Chandigarh is the first planned city of Independent India

Statement II : Chandigarh city was designed by Swiss French architect Le Corbusier

In the light of above statements, choose the most appropriate answer form the options given below

[4 marks]

(A) Both Statement I and Statement II are correct

(B) Both Statement I and Statement II are incorrect

(C) Statement I is correct but statement II is incorrect

(D) Statement I is incorrect but statement II is correct

Correct Answer: (A) Both Statement I and Statement II are correct

Solution:

Concept:

- The expression planned city refers to a settlement developed according to a coordinated urban plan, including roads, land uses, public spaces and civic functions.
- Chandigarh is conventionally identified in architectural general knowledge as the first planned city of independent India; Le Corbusier is associated with its master plan and major civic architecture.

Step 1: Evaluate Statement I Statement I places Chandigarh in the period after Indian independence. In the conventional architectural description used in this question, Chandigarh is the first planned city of independent India. It was conceived as a new capital with an organised sector system and a coordinated network of circulation and public functions. The statement does not claim that no planned settlements existed anywhere in India before independence, so earlier historical examples do not invalidate its intended meaning. Statement I is therefore correct.

Step 2: Evaluate Statement II and select the combination Le Corbusier was a Swiss-born French architect and is the architect principally associated with the planning of Chandigarh. His work on the city included its master plan and prominent Capitol Complex buildings. The involvement of other architects and planners does not make the stated attribution false; the statement gives the accepted principal association. Statement II is therefore also correct. Option (A) records two correct statements. Option (B) rejects both, while (C) and (D) reject one of the two valid statements, so none of those three combinations fits.

Step 3: Conclusion Both Statement I and Statement II are correct. Hence, the correct option is (A).

Quick Tip to Solve: For a two-statement city question, check the historical description and the architect independently before choosing the combined option.

---

33. Given below are two statements:

Statement I : Glass has low thermal conductivity

Statement II : Glass can absorb, refract and transmit light.

In the light of above statements, choose the most appropriate answer form the options given below

[4 marks]

(A) Both Statement I and Statement II are correct

(B) Both Statement I and Statement II are incorrect

(C) Statement I is correct but statement II is incorrect

(D) Statement I is incorrect but statement II is correct

Correct Answer: (A) Both Statement I and Statement II are correct

Solution:

Concept:

- Thermal conductivity measures the ability of a material to conduct heat through itself. Glass has relatively low thermal conductivity compared with common structural metals.
- Light incident on glass can be transmitted, refracted and partly absorbed. Thermal behaviour and optical behaviour describe different properties of the same material.

Step 1: Test the thermal statement Ordinary building glass conducts heat much less readily than metals such as aluminium or steel. In this materials comparison it is correctly described as having low thermal conductivity, so Statement I is correct. This does not mean that a single glass pane provides excellent overall insulation: heat transfer through glazing also depends on thickness, surface exchange, radiation and any air gap. The statement concerns the material property of conductivity rather than the performance of a complete window assembly.

Step 2: Test the optical statement and reject the alternatives A beam entering glass changes speed and generally changes direction at an oblique interface; this is refraction. Some of the beam passes through the glass, which is transmission, while part of its energy can be absorbed within the material. These processes can occur together and their proportions depend on the glass composition, thickness and wavelength. The wording says glass can exhibit them, not that all incident light undergoes only

one process. Thus Statement II is correct. Option (A) matches this result; (B) wrongly rejects both properties, (C) wrongly rejects the optical statement, and (D) wrongly rejects the thermal statement.

Step 3: Conclusion Both statements about glass are correct. Hence, the correct option is (A).

Quick Tip to Solve: Do not confuse low material conductivity with perfect window insulation; assess the optical statement separately from heat conduction.

34. Match List I with List II

LIST I	LIST II		
A.	PMUY	I.	KAUSHAL VISKAS YOJNA
B.	PMAY	II.	JAN DHAN YOJANA
C.	PMKVY	III.	UJJWALA YOJANA
D.	PMJDY	IV.	AWAS YOJANA

Choose the correct answer from the options given below: [4 marks]

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

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

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

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

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

Solution:

Concept:

- An abbreviation can be matched by expanding its distinctive words rather than by guessing from the shared prefix PM.
- PM denotes Pradhan Mantri in these scheme names. The remaining letters distinguish Ujjwala, Awas, Kaushal Vikas and Jan Dhan.

Step 1: Expand the first two abbreviations PMUY expands to Pradhan Mantri Ujjwala Yojana. The distinctive U refers to Ujjwala, so List I entry A matches List II entry III, Ujjwala Yojana. PMAY expands to Pradhan Mantri Awas Yojana. Here A identifies Awas, meaning housing, so entry B matches entry IV. The shared opening Pradhan Mantri is common to several programmes and cannot by itself determine a match; the letters after PM are decisive.

Step 2: Complete and cross-check the matching PMKVY expands to Pradhan Mantri Kaushal Vikas Yojana, linking skill development with the letters KV. Thus entry C matches List II entry I, despite the spelling variation in the printed list. PMJDY expands to Pradhan Mantri Jan Dhan Yojana, so entry D matches entry II. The complete order is A-III, B-IV, C-I, D-II. Option (B) contains all four links. Option (A) already sends PMUY to the skill scheme and fails; option (C) sends it to Awas and fails; option (D) also sends it to Awas and incorrectly sends PMAY to Ujjwala. Checking every link confirms that the selection does not rest on one coincidental match.

Step 3: Conclusion The matching is A-III, B-IV, C-I, D-II. Hence, the correct option is (B).

Quick Tip to Solve: Ignore the common PM prefix and use U, A, KV and JD to identify the four distinctive scheme names.

35. Match List I with List II

LIST I	LIST II		
A.	CP Kukreja	I.	IIM Ahmedabad
B.	Louis I Kahn	II.	Jawahar Lal Nehru University
C.	B.V Doshi	III.	IIT Kanpur
D.	Achyut Kanvinde	IV.	IIM Bengaluru

Choose the correct answer from the options given below: [4 marks]

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

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

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

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

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

Solution:

Concept:

- Campus-identification questions link an architect with the institution for which the architect is conventionally credited.
- The relevant associations are C. P. Kukreja with JNU, Louis I. Kahn with IIM Ahmedabad, B. V. Doshi with IIM Bengaluru, and Achyut Kanvinde with IIT Kanpur.

Step 1: Establish the two IIM associations Louis I. Kahn is associated with the original Indian Institute of Management Ahmedabad campus, known for its strong geometric forms and exposed brick architecture. Therefore entry B matches entry I. B. V. Doshi is associated with the Indian Institute of Management Bengaluru campus, with its linked courts, passages and landscape-responsive organisation. Therefore entry C matches entry IV. Keeping the two cities distinct prevents the common error of swapping the architects simply because both institutions are IIMs.

Step 2: Match the remaining campuses and check the options C. P. Kukreja is associated with the Jawaharlal Nehru University campus, giving A-II. Achyut Kanvinde is associated with the Indian Institute of Technology Kanpur campus, giving D-III. Together the four associations give A-II, B-I, C-IV, D-III, which is option (C). Option (A) misassigns Kukreja and Kahn, while option (B), though it preserves Kahn-Ahmedabad, wrongly links Kukreja with IIT Kanpur and Doshi with JNU. Option (D) wrongly assigns Ahmedabad to Kukreja and Bengaluru to Kahn. Checking the full sequence therefore rules out every distractor rather than relying on a single familiar campus.

Step 3: Conclusion The correct matching is A-II, B-I, C-IV, D-III. Hence, the correct option is (C).

Quick Tip to Solve: Fix the anchors Kahn-Ahmedabad and Doshi-Bengaluru first, then verify Kukreja-JNU and Kanvinde-IIT Kanpur.

36. Which one of these is not a complimentary colour? [4 marks]

(A) Blue-Orange

(B) Red-Green

(C) Blue-Green

(D) Violet-Yellow

Correct Answer: (C) Blue-Green

Solution:

Concept:

- In the traditional artist colour wheel based on red, yellow and blue, complementary colours lie opposite each other.
- The standard complementary pairs are red-green, blue-orange and yellow-violet. Neighbouring hues such as blue and green are analogous rather than complementary.

Step 1: Identify the colour model used by the options The options use the conventional artist colour wheel. Orange is formed from red and yellow and lies opposite blue. Green is formed from blue and yellow and lies opposite red. Violet is formed from red and blue and lies opposite yellow. A primary colour is therefore paired with the secondary colour made from the other two primaries. The problem asks for the pair that does not follow this relationship, so the negative wording must be retained while testing the choices.

Step 2: Test all four pairs Blue-orange in option (A) occupies opposite positions on this wheel and is complementary. Red-green in option (B) also occupies opposite positions and is complementary. Blue-green in option (C) joins neighbouring, closely related hues on the cool side of the wheel; it is an analogous pair and is not complementary. Violet-yellow in option (D) is the same complementary pairing as yellow-violet with its order reversed, so it is also valid. Thus only (C) fails the required complementary relationship. The traditional pigment wheel is the relevant convention here; substituting a different additive-light colour model would ignore the system indicated by the other three options.

Step 3: Conclusion Blue-green is not a complementary colour pair on the traditional artist colour wheel. Hence, the correct option is (C).

Quick Tip to Solve: For a question asking which pair is not complementary, cross out red-green, blue-orange and yellow-violet, then select the neighbouring-hue pair.

37. In which State of India, Robbers cave is situated: [4 marks]

(A) Himachal Pradesh

(B) Uttarakhand

(C) Uttar Pradesh

(D) Madhya Pradesh

Correct Answer: (B) Uttarakhand

Solution:

Concept:

- A landmark is located by identifying its town or district first, and then the state containing that place. The requested answer here is a state, rather than the name of the cave or its nearest city.
- Robbers Cave is also called Guchhupani and is associated with Dehradun. Dehradun is in Uttarakhand, so these two names provide a direct location link.

Step 1: Identify the place Robbers Cave is the natural cave attraction near Dehradun, commonly known as Guchhupani. The name in the question refers to this particular attraction, so it should not be matched with a different cave merely because that cave is also in northern India.

Step 2: Match the city to the state Dehradun lies in Uttarakhand. Therefore the required state is Uttarakhand. Himachal Pradesh is another Himalayan state, but it does not contain Dehradun; geographical similarity is insufficient. Uttar Pradesh and Madhya Pradesh are also incorrect because the identified landmark is not located in either of them.

Step 3: Conclusion Robbers Cave is situated in Uttarakhand. Hence, the correct option is (B).

Quick Tip to Solve: Use the association Robbers Cave–Guchhupani–Dehradun–Uttarakhand; identifying the nearest city makes the state choice immediate.

38. Choose the correct option among the following:

Petronas Tower is situated in: [4 marks]

(A) Paris

(B) Dubai

(C) Kuala Lumpur

(D) New York

Correct Answer: (C) Kuala Lumpur

Solution:

Concept:

- Architectural awareness questions often test the association between a named building and the city where it stands. A city famous for high-rise buildings is not automatically the location of every famous tower.
- The Petronas Twin Towers stand in Kuala Lumpur, Malaysia. The question uses the singular Tower, but the identifying name is the Petronas tower complex.

Step 1: Recall the landmark and its city The Petronas Twin Towers are the paired skyscrapers in Kuala Lumpur. Their name is the decisive identifier: the question asks where this particular building complex is situated, rather than which listed city has the tallest buildings or most skyscrapers.

Step 2: Eliminate the other cities Kuala Lumpur is therefore the correct location. Paris, Dubai and New York are all internationally known cities with prominent buildings, but none is the city in which the Petronas Twin Towers stand. In particular, Dubai should not be selected just because it is strongly associated with modern high-rise architecture; that association belongs to other towers.

Step 3: Conclusion The Petronas Tower complex is situated in Kuala Lumpur, Malaysia. Hence, the correct option is (C).

Quick Tip to Solve: Memorise building–city–country triples: Petronas Twin Towers–Kuala Lumpur–Malaysia. This avoids confusion between famous skyscraper cities.

39. The Konark Temple is located in which state? [4 marks]

(A) Madhya Pradesh

(B) Odisha

(C) Karnataka

(D) Rajasthan

Correct Answer: (B) Odisha

Solution:

Concept:

- The Konark Temple is the Sun Temple at Konark, in the coastal region of Odisha. The location of a monument is distinct from the wider geographical spread of the architectural tradition to which it belongs.
- For a question asking for the state, the town name Konark must be linked to Odisha; the answer is not another state with well-known historical temples.

Step 1: Identify the monument The name Konark Temple refers to the Sun Temple at Konark. Recognising this complete monument name is useful because temple-location questions can otherwise be confused with the many other major temple centres of India. Here the location is the town of Konark itself.

Step 2: Select the matching state Konark lies in Odisha, making the second option the required answer. Madhya Pradesh has important historic temple sites, Karnataka has its own major temple traditions, and Rajasthan has numerous celebrated monuments; nevertheless, none of those states contains the Konark Sun Temple. Their architectural importance does not establish the specific location asked for.

Step 3: Conclusion The Konark Temple is located in Odisha. Hence, the correct option is (B).

Quick Tip to Solve: Link Konark directly with the Sun Temple and Odisha; do not substitute the state of a different famous temple complex.

40. Who is the architect of the Lotus Temple? [4 marks]

(A) Louis I Kahn

(B) Mohse Safdi

(C) Fariborz Sahba

(D) Richard Meyer

Correct Answer: (C) Fariborz Sahba

Solution:

Concept:

- An architect-identification question requires the correct designer–building association. Similarity of architectural reputation, nationality or period does not establish authorship.
- The Lotus Temple in New Delhi was designed by Fariborz Sahba. Its lotus-inspired form is the defining feature that helps connect the building with its architect.

Step 1: Identify the building and its designer The Lotus Temple is the lotus-shaped Bahai House of Worship in New Delhi. Its architect is Fariborz Sahba. This is a direct association between a named work and its designer; the answer does not follow merely from deciding which listed architect worked with modern materials or designed monumental buildings.

Step 2: Compare the names in the options Fariborz Sahba appears in option (C), so that is the matching name. Louis I Kahn is a different architect and is not the designer of the Lotus Temple. The name printed as Mohse Safdi refers to another architect, not Sahba, and Richard Meyer is likewise not the designer of this building. Consequently none of the other three listed names satisfies the specific authorship asked for.

Step 3: Conclusion Fariborz Sahba is the architect of the Lotus Temple. Hence, the correct option is (C).

Quick Tip to Solve: Revise architects as pairs with their named works: Lotus Temple–Fariborz Sahba. A distinctive building form is a useful memory cue.

41. A small lift for carrying only a small load is known as: [4 marks]

(A) A dead Bearer

(B) A Dumb Waiter

(C) A Jockey Boy

(D) A push upper

Correct Answer: (B) A Dumb Waiter

Solution:

Concept:

- A dumb waiter is a small service lift used to move goods between floors, rather than to carry passengers. Its small load space distinguishes it from an ordinary passenger lift.
- Building-service terminology identifies equipment by its function. Carrying small articles, food or

similar loads vertically is the characteristic function of a dumb waiter.

Step 1: Identify the function described The question describes a small lift that carries only a small load. Such equipment is used to transfer goods between levels of a building, for example food or utensils between service areas. The defining feature is goods transport in a small compartment, rather than the movement of people in a passenger cabin.

Step 2: Match the technical term The established term for this type of lift is a dumb waiter, printed as A Dumb Waiter in option (B). A dead Bearer is not the standard name for this equipment. A Jockey Boy and A push upper are also not the building-services term for a small goods lift. Thus the functional description singles out the second option without requiring a numerical load capacity.

Step 3: Conclusion A small lift for carrying a small load is known as a dumb waiter. Hence, the correct option is (B).

Quick Tip to Solve: Remember dumb waiter as a small goods or food lift between floors; distinguish it from a passenger lift by what it carries.

42. Which are often referred as 'twin cities' of Odisha? [4 marks]

(A) Bhubaneshwar-Puri

(B) Puri-Cuttack

(C) Bhubaneshwar-Cuttack

(D) Bhubaneshwar-Rourkela

Correct Answer: (C) Bhubaneshwar-Cuttack

Solution:

Concept:

- Twin cities are two neighbouring urban centres commonly treated as a linked pair because of their geographical proximity and closely connected urban functions. The phrase identifies a conventional city pairing.
- In Odisha, Bhubaneswar and Cuttack are commonly referred to as the twin cities. Their identity as a pair should be distinguished from a tourist circuit that may also include Puri.

Step 1: Recall the conventional city pair The expression twin cities of Odisha refers to Bhubaneswar and Cuttack. The question is testing this recognised geographical association, not asking for any two important cities of the state or for the two places most closely associated with tourism.

Step 2: Check the alternatives against that pair Option (C), printed as Bhubaneshwar-Cuttack, gives the recognised pair. Bhubaneshwar-Puri omits Cuttack, while Puri-Cuttack omits Bhubaneswar, so neither is the required combination. Bhubaneshwar-Rourkela also replaces one member of the conventional pair with a different city. All four options name important urban places, but only the third preserves both members of the twin-city association.

Step 3: Conclusion Bhubaneswar and Cuttack are the twin cities of Odisha. Hence, the correct option is (C).

Quick Tip to Solve: Keep the twin-city pair Bhubaneswar–Cuttack separate from the wider Bhubaneswar–Puri–Konark tourist circuit.

43. Which is the correct chronology of Human Civilizations in terms of their existence? [4 marks]

(A) Mesopotamia-Harappa-Egyptian-Chinese

(B) Mesopotamia-Egyptian-Harappa-Chinese

(C) Mesopotamia-Chinese-Harappa-Egyptian

(D) Egyptian-Mesopotamia-Harappa-Sumerian

Correct Answer: (B) Mesopotamia-Egyptian-Harappa-Chinese

Solution:

Concept:

- Chronology arranges civilizations by the conventional dates of their emergence, rather than by the dates at which they disappeared. These civilizations overlapped in time.
- Early urban Mesopotamia precedes dynastic Egypt, followed by the mature Harappan civilization and then the early Chinese dynastic civilization in the conventional sequence used here.

Step 1: Identify the earliest two civilizations Mesopotamian urban civilization developed in the fourth millennium BCE, with Sumerian cities in the Tigris-Euphrates region. Dynastic Egypt is conventionally dated from about 3100 BCE. Thus Mesopotamia comes before Egypt in this ordering. Sumerian civilization belongs within early Mesopotamian civilization; it is not a separate late civilization to place after Harappa.

Step 2: Place Harappa and China and compare the options The mature Harappan urban phase is conventionally dated from about 2600 BCE, whereas the early Chinese dynastic sequence is placed later. The intended sequence is therefore Mesopotamia, Egyptian, Harappan, Chinese. Option (A) reverses Egypt and Harappa. Option (C) places China too early, before both Harappa and Egypt. Option (D) begins with Egypt rather than Mesopotamia and incorrectly ends with Sumerian civilization. Option (B) preserves the conventional order. Dates depend on which developmental phase is compared, so the comparison here uses the standard broad urban/dynastic milestones rather than claiming that human settlement began at these dates.

Step 3: Conclusion The correct chronology is Mesopotamia–Egyptian–Harappa–Chinese. Hence, the correct option is (B).

Quick Tip to Solve: For a chronology question, compare like milestones such as mature urban or dynastic phases; do not confuse the earliest settlement at a site with its mature civilization.

44. Qutub-Minar in Delhi was built by: [4 marks]

(A) Shah Jahan

(B) Jahangir

(C) Akbar

(D) Qutub ud-din Aibak

Correct Answer: (D) Qutub ud-din Aibak

Solution:

Concept:

- A monument is commonly attributed to the ruler who commissioned or initiated it, even when later rulers completed or repaired parts of it.
- Qutub ud-din Aibak initiated the Qutub Minar at Delhi in the late twelfth century; Iltutmish subsequently extended it.

Step 1: Identify the ruler associated with the construction Qutub ud-din Aibak established the early Delhi Sultanate and began construction of the Qutub Minar around 1199. This identifies him as the correct name among the four choices. The wording asks for the ruler associated with building the monument, rather than requiring the name of every ruler who contributed to its later fabric.

Step 2: Separate the original work from later additions The minaret was not completed entirely during Aibak's lifetime: Iltutmish added further storeys, and later repairs also formed part of its history. Those later contributions do not make any of the listed Mughal rulers its original builder. Akbar ruled in the sixteenth century, while Jahangir and Shah Jahan ruled in the seventeenth century, centuries after the minaret had been initiated. Therefore options (A), (B) and (C) are chronologically incompatible with its foundation. Option (D) correctly names the ruler who began it, while allowing for the important distinction between initiation and subsequent completion.

Step 3: Conclusion Qutub ud-din Aibak began the construction of the Qutub Minar. Hence, the correct option is (D).

Quick Tip to Solve: Link Qutub Minar with the early Delhi Sultanate and Aibak; remember Iltutmish when a question specifically asks about its extension or completion.

45. Which direction in the southern hemisphere would you get glare free (diffused) light throughout the year? [4 marks]

(A) North

(B) South

(C) East

(D) West

Correct Answer: (B) South

Solution:

Concept:

- For steady diffuse daylight, an opening is conventionally oriented towards the pole-facing sky, away from the stronger equator-facing solar exposure.
- The pole-facing direction is south in the southern hemisphere and north in the northern hemisphere. East and west receive low-angle morning and afternoon sunlight.

Step 1: Reverse the familiar northern-hemisphere orientation In the southern hemisphere, the equator lies to the north. Consequently a north-facing facade generally receives the stronger direct solar exposure, especially around the middle of the day. The corresponding pole-facing facade is the south-facing one. Its exposure to the southern sky is the conventional choice when the design aim is relatively even, diffuse light rather than strong direct sun.

Step 2: Reject the orientations prone to direct sunlight An east-facing opening receives direct morning sun, while a west-facing opening receives direct afternoon sun. Low solar angles at these times can make glare difficult to control. North is the equator-facing direction here, so it is also unsuitable as the general answer to this daylight-orientation question. South is therefore the intended direction. The architectural rule describes the preferred orientation for diffuse daylight; actual glare control also depends on latitude, season, shading, reflected light and the opening design. Orientation alone is not an absolute guarantee at every geographical location.

Step 3: Conclusion South-facing orientation is the conventional choice for diffuse, glare-free daylight in the southern hemisphere. Hence, the correct option is (B).

Quick Tip to Solve: First locate the equator-facing side: north in the southern hemisphere. Choose the opposite, pole-facing side for the usual diffuse-daylight orientation.

46. Who is the architect of the famous "Jawaharlal Kala Complex" in Jaipur? [4 marks]

(A) Raj Rewal

(B) Charles Correa

(C) Achyut Kanvinde

(D) Hafeez Contractor

Correct Answer: (B) Charles Correa

Solution:

Concept:

- Architectural awareness questions require matching the named building with its designer, rather than matching the building merely with its city or period.
- The arts complex at Jaipur known as Jawahar Kala Kendra is a work of Charles Correa, combining a cultural programme with a geometrical planning concept.

Step 1: Identify the Jaipur arts complex The name in the question refers to Jaipur's Jawahar Kala Kendra, a cultural and arts complex designed by Charles Correa. Its plan is associated with a nine-square mandala and the Navagraha idea, connecting the organization of the complex with the cultural and geometrical traditions used in Jaipur's planning. This is the identifying building-designer association required here.

Step 2: Check the alternative architects Raj Rewal is associated with buildings such as the Hall of Nations and the Asian Games Village in Delhi, rather than this Jaipur complex. Achyut Kanvinde is an important modern Indian architect associated with institutional and educational architecture, but he is not the designer of Jawahar Kala Kendra. Hafeez Contractor is known for many contemporary commercial and residential projects, but this cultural complex is not attributed to him. Thus the location and distinctive planning concept both support Charles Correa, corresponding to option (B), while options (A), (C) and (D) name other architects.

Step 3: Conclusion The Jaipur arts complex was designed by Charles Correa. Hence, the correct option is (B).

Quick Tip to Solve: Remember the pair Jawahar Kala Kendra–Charles Correa, and use its nine-square planning concept as an additional recognition cue.

47. Dhajji-Dewari is a construction style popular predominantly in _____. [4 marks]

(A) Coastal Areas

(B) Plains

(C) Mountainous Region

(D) Desert Areas

Correct Answer: (C) Mountainous Region

Solution:

Concept:

- Dhajji-Dewari is a traditional timber-framed wall system in which a network of small framed panels contains masonry infill.
- The construction is associated particularly with Kashmir and other Himalayan areas; its regional association is mountainous terrain.

Step 1: Recognize the construction system A Dhajji-Dewari wall uses timber members to divide the wall into relatively small panels. Stone or brick masonry fills the spaces between the timber members. This should be distinguished from a massive, uninterrupted masonry wall: the timber framework and subdivided infill form a characteristic composite vernacular construction system. Its performance depends on suitable connections and construction quality.

Step 2: Connect the system with its predominant region The system is strongly associated with Kashmir and the Himalayan mountain belt, where timber and local masonry materials have traditionally been used together. The arrangement is also discussed in relation to traditional construction in earthquake-prone mountain areas, since the framing can help retain and subdivide masonry infill. The question asks where it is predominantly popular, not where it could possibly be built. Coastal areas, plains and deserts are therefore not the defining regional associations represented by options (A), (B) and (D). The mountainous region in option (C) is the correct geographical classification for this building tradition.

Step 3: Conclusion Dhajji-Dewari is predominantly associated with mountainous regions, especially the Himalayan region. Hence, the correct option is (C).

Quick Tip to Solve: Associate Dhajji-Dewari with Kashmir: a timber framework divided into small masonry-filled panels is the key identification feature.

48. Which stone is used for roofing in mountainous regions? [4 marks]

(A) Marble

(B) Granite

(C) Shale

(D) Sand Stone

Correct Answer: (C) Shale

Solution:

Concept:

- Traditional pitched roofs in mountain areas commonly use thin stone pieces that can overlap so that rain and snowmelt run down the slope.
- Among the listed materials, shale is distinguished by fissility: it tends to split along closely spaced bedding planes into relatively thin pieces. Slate, a different rock derived through metamorphism, is the familiar durable roofing stone.

Step 1: Identify the material property tested by the choices The useful property in this comparison is the ability to obtain thin, flat pieces for covering a pitched roof. Shale is a fine-grained sedimentary rock with pronounced fissility, so it can separate along its bedding into thin layers. This property explains why shale is the intended choice among the four named stones. The selection is based on its layered character, rather than simply choosing the hardest or most decorative stone.

Step 2: Compare the other stones without confusing shale and slate Marble is generally associated with decorative work, flooring and facing; granite is a hard, crystalline stone widely used for structural and finish applications. Neither has shale's characteristic fine fissility. Sandstone is commonly used as building and paving stone, but it is not the intended thin-layer roofing answer in these options. Therefore choose shale, option (C). Keep the geological distinction clear: slate is a metamorphic rock and is widely recognized as a roofing material; it must not be called identical to shale. Since slate is not offered, the listed fissile sedimentary material supplies the expected answer.

Step 3: Conclusion Among the given options, shale is the intended roofing stone. Hence, the correct option is (C).

Quick Tip to Solve: For these choices, look for thin-layer splitting: shale is fissile. Keep shale distinct from slate, the commonly used metamorphic roofing stone.

49. Chandigarh is an example of which type of city planning. [4 marks]

(A) Radio Centric

(B) Grid-iron

(C) Linear

(D) Organic

Correct Answer: (B) Grid-iron

Solution:

Concept:

- A grid-iron plan organises the principal roads as intersecting sets, producing a repeated network of rectangular urban blocks.
- The classification of a city plan depends on its overall road and sector structure, rather than the shape of an individual building or open space.

Step 1: Identify the organising pattern Chandigarh is a planned city divided into sectors. Its main circulation network separates these sectors into a broadly rectangular arrangement. The repeated sector units and their connecting roads are the decisive clues: this is the grid-iron family of plans. A grid need not mean that every minor lane is perfectly straight or that all blocks have identical dimensions; it describes the dominant framework of the city.

Step 2: Compare the four alternatives Radio-centric planning would organise major routes as spokes converging on a centre, usually with connecting rings. That is different from Chandigarh's sector grid. Linear planning develops primarily along a single elongated corridor, such as a transport route, rather than a repeated two-directional sector network. Organic planning grows in an irregular, incremental way and does not explain this deliberately laid-out framework. Thus the alternatives fail on their defining geometric feature, while grid-iron fits the stated city.

Step 3: Conclusion Chandigarh is an example of grid-iron city planning. Hence, the correct option is (B).

Quick Tip to Solve: For Chandigarh, recall the repeated rectangular sectors; identify the road framework before comparing planning names.

50. If you have to build on the seashore in Goa, which rooms would have the best view of the sea? [4 marks]

(A) Those facing North

(B) Those facing South

(C) Those facing East

(D) Those facing West

Correct Answer: (D) Those facing West

Solution:

Concept:

- A room faces a direction according to the outward view from its principal opening or frontage.
- For a coastal site, the sea-facing orientation follows the geographical position of the sea relative to the land.

Step 1: Locate the sea relative to Goa Goa lies on the western coast of India, with the Arabian Sea along its western side. Therefore the broad seaward direction from the land is west. The question asks for a sea view, so the relevant criterion is orientation towards the water, rather than the direction of sunrise, prevailing wind or the position of a road. Use the regional coastline direction to select the intended orientation.

Step 2: Test the room orientations A west-facing room looks outward towards the Arabian Sea and therefore provides the intended direct sea view. An east-facing room looks generally inland, away from the western coast. North-facing and south-facing rooms look broadly along the coastal region rather than directly out towards the sea. Those directions do not provide the intended principal sea-facing frontage. Accordingly, west is the only listed orientation that matches the geographical relationship in the question. This directional reasoning identifies the answer without introducing any extra dimensions or building layout.

Step 3: Conclusion Rooms facing west would have the best sea view in the coastal orientation intended here. Hence, the correct option is (D).

Quick Tip to Solve: Locate the sea on a map first: Goa has the Arabian Sea to its west, so select the west-facing frontage.

51. "NIFT" National Institute of Fashion Technology, Delhi is designed by [4 marks]

(A) B.V Doshi

(B) C.P Kukreja

(C) Raj Rewal

(D) Bimal Patel

Correct Answer: (A) B.V Doshi

Solution:

Concept:

- Architectural awareness questions require the correct association between a named building or campus and its designer.
- The National Institute of Fashion Technology campus in New Delhi is associated with architect Balkrishna Vithaldas Doshi, commonly written B. V. Doshi.

Step 1: Identify the campus and its architect The question specifies NIFT in Delhi, so the required association is with that campus rather than the designers of other institutions or other NIFT centres. B. V. Doshi designed the Delhi campus. Its design is a recognised institutional project in his architectural work. The name B. V. Doshi in the options is the abbreviated form of Balkrishna Vithaldas Doshi; it is therefore a direct match to the designer being asked for.

Step 2: Eliminate the other names C. P. Kukreja, Raj Rewal and Bimal Patel are architects, but their presence as plausible professional names does not establish an association with NIFT Delhi. The task is to recall this specific architect-project pair, and none of those three names is the designer required for this campus. Do not select an architect simply because he is connected with another major public or educational building. Among the four choices, only B. V. Doshi matches the stated institution. This resolves the question by the campus identity rather than by a stylistic guess from an unseen photograph.

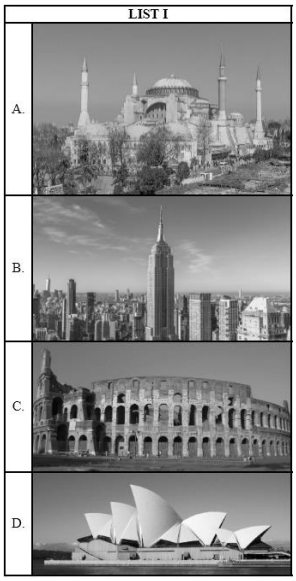
Step 3: Conclusion NIFT, Delhi was designed by B. V. Doshi. Hence, the correct option is (A).

Quick Tip to Solve: Learn architect-project pairs together: associate NIFT Delhi with B. V. Doshi, keeping the city attached to the campus name.

52. Match List I with List II

LIST II	
I.	Empire state Building
II.	Hagia Sophia
III.	Sydney Opera House
IV.	Colosseum

Choose the correct answer from the options given below: [4 marks]



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

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

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

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

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

Solution:

Concept:

- Architectural landmarks can be identified by their distinctive massing, roof form and facade. The photograph must be matched to the building itself rather than merely to a country or an architectural style.
- The Roman numerals in List II name buildings; the letters A to D label the photographs. Each building must be used once in the completed correspondence.

Step 1: Identify the four photographs Photograph A shows Hagia Sophia, with its great central dome, subsidiary domes and surrounding slender minarets. It therefore matches II. Photograph B shows the Empire State Building: its tall stepped skyscraper profile terminates in a narrow spire, identifying I. Photograph C shows the Colosseum, whose surviving oval outer wall has successive tiers of open arches; this is IV. Photograph D shows the Sydney Opera House, recognised by its repeated white sail-like roof shells, and matches III.

Step 2: Compare the complete correspondence with the options The resulting sequence is A-II, B-I, C-IV, D-III. Option A gives all four matches in this order. Option B incorrectly identifies the domed building A as the Empire State Building and the skyscraper B as the Sydney Opera House. Option C also starts with that incorrect A-I correspondence. Option D identifies A as the Colosseum, which conflicts with the domes and minarets visible in A. Thus none of these three alternatives preserves the photographic identities.

Step 3: Conclusion The correct matching is A-II, B-I, C-IV, D-III. Hence, the correct option is (A).

Quick Tip to Solve: Start with the sail-shaped roof of the Sydney Opera House (D-III), then verify the dome, skyscraper and arched amphitheatre before selecting the complete option.

53. Match List I with List II

LIST II	
I.	Tesla
II.	Ferrari
III.	Porsche
IV.	Toyota

Choose the correct answer from the options given below: [4 marks]

LIST I	
A.	
B.	
C.	
D.	

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

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

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

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

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

Solution:

Concept:

- A brand emblem is identified by its characteristic arrangement of shapes and symbols. Similar motifs, such as a horse appearing in two badges, must be distinguished by the complete enclosing design.
- Matching pairs connect each lettered emblem in List I to the corresponding numbered manufacturer in List II. A correct answer must preserve all four pairs simultaneously.

Step 1: Recognise each emblem from its defining features Emblem A consists of overlapping oval forms enclosed by a larger oval, identifying Toyota and therefore IV. Emblem B is the stylised T used by Tesla, so it matches I. Emblem C has the Ferrari prancing horse within a shield, with the letters S F beneath it; this identifies II. Emblem D is the Porsche crest, divided into heraldic fields around a central horse and the word Stuttgart, and therefore matches III. Although both C and D contain a horse, their surrounding shield details distinguish the two manufacturers.

Step 2: Check the proposed pairings against every option The four identifications give A-IV, B-I, C-II, D-III, exactly the sequence in option A. Option B misidentifies the Toyota ovals as Ferrari and the Tesla T as Porsche. Option C likewise assigns the Toyota emblem to Porsche and the Tesla emblem to Ferrari. Option D begins correctly with Toyota but then calls the Tesla T Porsche and the Porsche crest Tesla. Each rejected option therefore contradicts a clearly visible emblem rather than differing merely in the order in which the pairs are written.

Step 3: Conclusion The correct matching is A-IV, B-I, C-II, D-III. Hence, the correct option is (A).

Quick Tip to Solve: Use the distinctive Toyota ovals and Tesla T first; then distinguish Ferrari's simple prancing-horse shield from Porsche's detailed Stuttgart crest.

---

54. Given below are two statements:

Statement I : Red, Blue and Yellow are the primary colours of a colour wheel.

Statement II : The colours which are positioned opposite to each other in a colour wheel are known as complementary colours.

In the light of above statements, choose the correct answer form the options given below [4 marks]

(A) Both Statement I and Statement II are correct

(B) Both Statement I and Statement II are incorrect

(C) Statement I is correct but statement II is incorrect

(D) Statement I is incorrect but statement II is correct

Correct Answer: (A) Both Statement I and Statement II are correct

Solution:

Concept:

- The traditional artists' colour wheel uses red, yellow and blue as its primary colours; this is the RYB model used in basic art and design.
- Complementary colours occupy opposite positions on a colour wheel. In the traditional wheel the

familiar pairs are red-green, blue-orange and yellow-violet.

Step 1: Evaluate Statement I in its colour-wheel context The question concerns the conventional colour wheel used for painting and design. In that model, red, blue and yellow are the three primary colours. Mixing appropriate pairs gives the secondary colours: yellow with blue gives green, red with yellow gives orange, and blue with red gives violet. These secondary colours lie between their parent primaries around the wheel. Statement I is therefore correct in the model intended by the question.

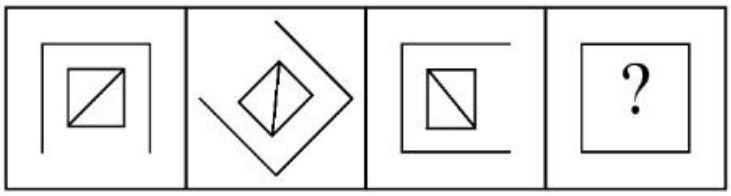
Step 2: Evaluate Statement II and combine the results Colours directly across the wheel are called complementary colours. For example, red is opposite green, and blue is opposite orange. This opposition gives strong visual contrast when the colours are placed beside one another. Statement II correctly describes the positional definition. Since each statement is true, select the option accepting both. Option (B) wrongly rejects both true statements; (C) wrongly rejects the definition of complementary colours; and (D) wrongly rejects the traditional primary-colour set. Neither statement needs to be made false by switching to a different colour model such as RGB light.

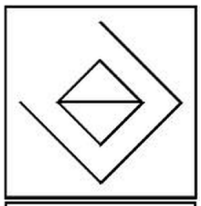
Step 3: Conclusion Both Statement I and Statement II are correct for the traditional artists' colour wheel. Hence, the correct option is (A).

Quick Tip to Solve: Identify the colour model first: use RYB for the traditional art wheel, then check complementary pairs by looking directly across it.

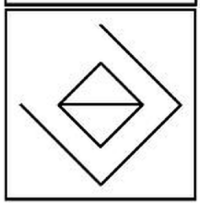
55. Following question consists of problem figures followed by answer figures. Select a figure from amongst the answer figures which will continue the same series or pattern as established by the problem figures.

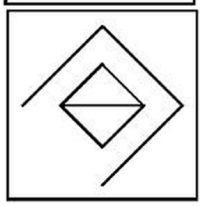
PROBLEM FIGURES [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A figure series can combine two separate transformations: rotation of an outer frame and rotation of an internal dividing line. Both must continue together.
- Compare the position of the missing outer side separately from the direction of the diagonal inside the small square. A rotation preserves size and shape while changing orientation.

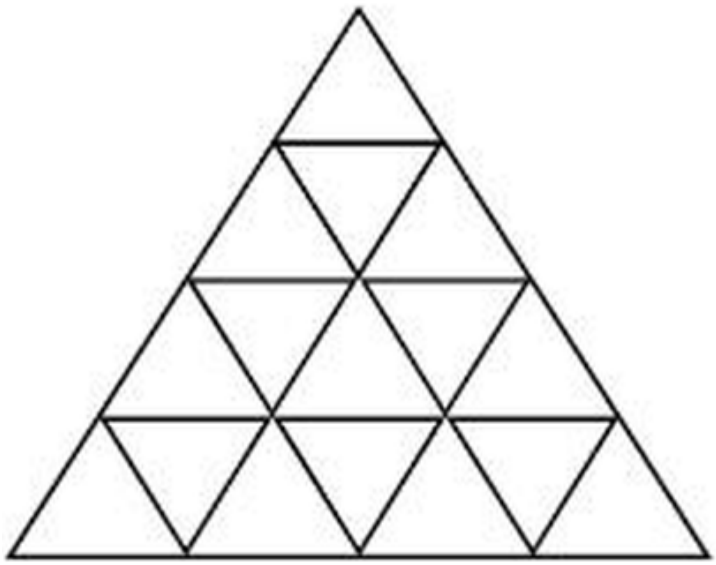
Step 1: Track the outer frame The first outer square is open at the bottom. In the second frame, the opening lies on the upper-left sloping side; in the third it lies on the right. These positions advance by 135° clockwise on each transition. Continuing that motion puts the next opening on the lower-left sloping side of a diamond. The outline must therefore rise from its leftmost corner to the top and continue down to the rightmost corner, with the lower-left side absent. This eliminates (A) and (C), whose openings occupy the other sloping side.

Step 2: Track the internal division The small inner square turns into a diamond and then returns to an upright square. Its dividing segment is first an ascending diagonal, then vertical, then a descending diagonal. Thus the next internal division must be horizontal across the diamond. Option (B) has the appropriate outer opening but a vertical internal division, so it fails the second rule. Option (D) has both the lower-left outer opening and the horizontal internal division. Checking both components avoids selecting an option that continues only half of the pattern.

Step 3: Conclusion The next figure is the diamond with its outer lower-left side absent and a horizontal line through the inner diamond. Hence, the correct option is (D).

Quick Tip to Solve: Track the missing outer side and the inner line separately; accept an answer figure only when both orientation sequences agree.

56. How many triangles are there in given figure:- [4 marks]



(A) 26

(B) 25

(C) 27

(D) 24

Correct Answer: (C) 27

Solution:

Concept:

- Count triangles by size and orientation so that overlapping composite triangles are included exactly once.
- The displayed equilateral triangle has four smallest intervals along each side. Its line segments form a triangular lattice, with triangles pointing either upwards or downwards.

Step 1: Count all upward triangles An upward triangle of side one smallest interval can start in four rows containing $4, 3, 2, 1$ positions. Hence there are $4 + 3 + 2 + 1 = 10$ smallest upward triangles. For side two intervals, the possible starting positions number $3 + 2 + 1 = 6$. For side three intervals there are $2 + 1 = 3$, and for side four intervals there is the one complete outer triangle. The upward subtotal is therefore

$$10 + 6 + 3 + 1 = 20.$$

The count by side length includes composite triangles whose interiors contain additional lines.

Step 2: Count all downward triangles Downward triangles of one interval occur in rows containing $3, 2, 1$, giving $3 + 2 + 1 = 6$. There is also one downward triangle of side two intervals: its top side joins the two midpoints of the large triangle's sloping sides, and its bottom vertex is the midpoint of the large base. A larger downward triangle cannot fit inside a triangle with only four intervals along a side. Thus the downward subtotal is

$$6 + 1 = 7.$$

Adding orientations gives

$$N = 20 + 7 = 27.$$

Therefore (A), 26, (B), 25, and (D), 24, each omit at least one valid triangle; only (C) gives the complete count.

Step 3: Conclusion The figure contains $\boxed{27}$ triangles. Hence, the correct option is (C).

Quick Tip to Solve: Make a size-by-orientation tally: upward counts are 10, 6, 3, 1 and downward counts are 6, 1 for this four-division grid.

57. Find the odd one out:-

7, 9, 25, 32, 43, 59 [4 marks]

(A) 59

(B) 32

(C) 25

(D) 9

Correct Answer: (B) 32

Solution:

Concept:

- Parity classifies an integer as even or odd: an even integer is divisible by 2, while an odd integer leaves remainder 1.
- For an odd-one-out problem, compare the same simple property across every entry; the exceptional entry must differ from all the others under that property.

Step 1: Test divisibility by two Inspect the units digits of the given numbers. The numbers $7, 9, 25, 43$ and 59 end in odd digits, so none is divisible by 2. In contrast, 32 ends in the even digit 2, so it is divisible by 2 without a remainder. This test applies consistently to the entire list rather than just to the four answer choices.

Step 2: Verify the unique exception The divisions can be expressed as

$$7 = 2(3) + 1, \quad 9 = 2(4) + 1, \quad 25 = 2(12) + 1,$$

$$43 = 2(21) + 1, \quad 59 = 2(29) + 1, \quad 32 = 2(16).$$

Thus five entries have remainder 1, and exactly one has remainder 0. Option (A), 59, is odd; option (C), 25, is also odd, despite being a square; and option (D), 9, is odd as well. The presence of several composite numbers means primality would not isolate a unique listed exception, whereas parity does.

Step 3: Conclusion 32 is the only even number in the list; all five other numbers are odd. Hence, the correct option is (B).

Quick Tip to Solve: Check parity before searching for a complicated numerical pattern: a single even entry among otherwise odd integers is immediately distinguishable.

58. A residential building has 15 floors. The height of ground floor is 4.2 meter (including length and slab thickness). Rest all other floors are of 3.3 meter high (including slab thickness). What is the total height of the building (from ground to terrace) in meters? [4 marks]

(A) 45.6 meter

(B) 50 meter

(C) 50.4 meter

(D) 51.6 meter

Correct Answer: (C) 50.4 meter

Solution:

Concept:

- Total building height is the sum of the heights of all floors measured successively from ground to terrace.
- When the ground floor has a different height, count it once and multiply the common height by the number of remaining floors. Slab thickness is already included in the stated floor heights.

Step 1: Count the two floor categories The building has 15 floors in total, of which one is the ground floor. Its height is $4.2\,\mathrm{m}$. Therefore the number of other floors is

$$15 - 1 = 14.$$

Each of these 14 floors contributes $3.3\,\mathrm{m}$. The ground floor must not be added as an extra sixteenth floor, and its height must not be replaced by the height used for the upper floors.

Step 2: Add the vertical contributions First calculate the combined height of the upper floors:

$$H_{\text{upper}} = 14 \times 3.3 = 46.2\,\mathrm{m}.$$

Now include the ground floor:

$$H = 4.2 + 46.2 = 50.4\,\mathrm{m}.$$

No additional slab allowance is required, because the problem explicitly includes slab thickness in both stated heights. Counting fifteen upper floors would overcount the building, while multiplying all fifteen floors by 3.3 would ignore the taller ground floor. Among the choices, only option (C) equals the complete sum; 45.6, 50 and $51.6\,\mathrm{m}$ do not satisfy the stated floor count and heights.

Step 3: Conclusion The total height from ground to terrace is $\boxed{50.4\,\mathrm{m}}$. Hence, the correct option is (C).

Quick Tip to Solve: For one exceptional floor among n floors, use $H = h_{\text{ground}} + (n-1)h_{\text{typical}}$; do not add slab thickness twice.

59. Identify the mirror image of the given word:- [4 marks]



(A) SSECCUS
(B) SUCCESS
(C) SUCCESS
(D) SSECCUS

Correct Answer: (A) SSECCUS

Solution:

Concept:

- A vertical mirror reverses left and right while preserving top and bottom. Every letter must be reflected, and the order of letters across the word must reverse.
- The mirror line is to the right of SUCCESS. The final S is nearest the mirror, so its reflected counterpart appears first when the mirror image is read from left to right.

Step 1: Reverse the sequence across the mirror The original sequence from left to right is S, U, C, C, E, S, S. Reflection in the indicated vertical line places their counterparts in the reverse positional order: S, S, E, C, C, U, S. These are the identities of the letters, not ordinary typed replacements: each character must additionally have its shape reflected. The two terminal S letters therefore appear together at the left of the mirror image, while the original initial S becomes its rightmost character. This positional test already rejects a figure that merely repeats SUCCESS.

Step 2: Check the reflected letter shapes In particular, each C opens to the left after reflection, the E has its vertical stroke at the right with its horizontal strokes extending left, and the S shapes reverse their curvature. The U remains recognisably symmetric about its own vertical axis, but its position moves near the right end. Option (A) shows both the reversed order and these reflected glyphs. Option (B) does not reverse the entire sequence correctly. Option (C) simply prints the original word without the required reflection. Option (D) reverses the order using ordinary, unreflected letter shapes, so its C and E strokes still point the wrong way.

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

Quick Tip to Solve: For a vertical word mirror, check two things: reverse the order of the letters and reverse each letter shape; ordinary backward spelling is insufficient.

60. The scale of a map is 1:1000. If a car travels 7 cm from point 'A' to point 'B' on the Map. Then how much the car has travelled in original:- [4 marks]

(A) 0.7 km

(B) 7000 mm

(C) 7 km

(D) 70 meter

Correct Answer: (D) 70 meter

Solution:

Concept:

- A map scale of $1 : 1000$ means that one unit of map distance represents 1000 of the same units on the ground.
- Multiply the map length by the scale denominator before changing units. The conversions are $100\,\text{cm} = 1\,\text{m}$ and $1000\,\text{m} = 1\,\text{km}$.

Step 1: Apply the stated scale The map distance between A and B is $7\,\text{cm}$. Since the real distance is 1000 times its map representation,

$$d_{\text{real}} = 7 \times 1000 = 7000\,\text{cm}.$$

The ratio is dimensionless, so multiplying centimetres by 1000 still gives centimetres. It does not directly give metres, millimetres or kilometres. Keeping this unit visible prevents a scale-factor error.

Step 2: Convert and compare all choices Convert the real distance into metres:

$$7000\,\text{cm} = \frac{7000}{100}\,\text{m} = 70\,\text{m}.$$

Equivalently it is $0.07\,\text{km}$ or $70{,}000\,\text{mm}$. Option (A), $0.7\,\text{km}$, means $700\,\text{m}$, ten times the required distance. Option (B), $7000\,\text{mm}$, means $7\,\text{m}$, one tenth of it. Option (C), $7\,\text{km}$, means $7000\,\text{m}$, one hundred times it. Only option (D), 70 metres, matches the scaled distance. As a quick check, each centimetre on this map represents 10 metres on the ground.

Step 3: Conclusion The car has travelled $\boxed{70\,\text{m}}$ in the original setting. Hence, the correct option is (D).

Quick Tip to Solve: At a $1 : 1000$ scale, $1\,\text{cm}$ represents $10\,\text{m}$; multiply the map length in centimetres by ten to obtain metres.

61. A land size of 80 meter $\times$ 40 meter for a house design is drawn on paper at a scale of 1:100, then what size is drawn on paper to represent the land? [4 marks]

(A) 8 meter $\times$ 4 meter

(B) 80 meter $\times$ 40 meter

(C) 8 centimeter $\times$ 4 centimeter

(D) 4 meter $\times$ 2 meter

Correct Answer: None of the options gives the required 80 cm by 40 cm rectangle.

Solution:

Concept:

- A scale of $1:100$ means that each length on the drawing is one hundredth of the corresponding real length, with both expressed in the same unit.
- Scale is a ratio of lengths, so apply it separately to the length and width. The area ratio would be $1:10000$, but is not used to find the two drawn dimensions.

Step 1: Convert the real dimensions to a convenient unit The land is a rectangle of length $80\,\text{m}$ and width $40\,\text{m}$. Since paper dimensions are conveniently stated in centimetres, use $1\,\text{m} = 100\,\text{cm}$. Thus the actual dimensions are $8000\,\text{cm}$ and $4000\,\text{cm}$. Keep both dimensions in the same unit before applying the ratio.

Step 2: Apply the scale to both sides The drawn length and width are therefore

$$L_d = \frac{8000}{100} = 80\,\text{cm}, \qquad W_d = \frac{4000}{100} = 40\,\text{cm}.$$

Equivalently, dividing the original metre values by 100 gives $0.8\,\text{m}$ and $0.4\,\text{m}$. The aspect ratio remains $2:1$, as a correctly scaled drawing requires.

Step 3: Check the offered dimensions Option (A), $8\,\text{m} \times 4\,\text{m}$, corresponds to $1:10$, not the stated scale. Option (B) reproduces the land at full size, or $1:1$. Option (C), $8\,\text{cm} \times 4\,\text{cm}$, corresponds to $1:1000$. Option (D), $4\,\text{m} \times 2\,\text{m}$, corresponds to $1:20$. Thus retaining the correct aspect ratio alone does not make any of them correct.

Step 4: Conclusion The drawing must measure $\boxed{80\,\text{cm} \times 40\,\text{cm}}$. None of the printed options is correct. The official final key dropped this question and awarded bonus marks to all candidates.

Quick Tip to Solve: For a scale of 1:100, a real length stated in metres has the same numerical drawing length in centimetres: 80 m becomes 80 cm.

62. Find the missing number in given series.

16, 33, 65, 131, 261, (.....) [4 marks]

(A) 523

(B) 521

(C) 524

(D) 520

Correct Answer: (A) 523

Solution:

Concept:

- A number-series rule should explain all consecutive transitions with a consistent operation; a repeating alternation is a common pattern.
- Compare each term with twice its predecessor. The difference from that doubled value reveals the small correction, including its sign.

Step 1: Inspect the successive operations Doubling the first term gives $2 \times 16 = 32$, which is one less than 33. Doubling 33 gives 66, which is one more than 65. Continue the same comparison rather than looking only at the raw gaps:

$$33 = 2(16) + 1, \qquad 65 = 2(33) - 1.$$

These first two transitions suggest alternating additions of one and subtractions of one after doubling.

Step 2: Confirm the alternation with the remaining terms The next transitions agree with this same repeating pair of operations:

$$131 = 2(65) + 1, \qquad 261 = 2(131) - 1.$$

Both checks matter: an operation inferred from only one gap could fit accidentally. The series has now used the corrections $+1, -1, +1, -1$, so the next correction is $+1$. There is no reason to repeat the subtraction at this point.

Step 3: Calculate and compare the next term Apply doubling followed by addition of one to the final given term:

$$2(261) + 1 = 522 + 1 = 523.$$

Option (B), 521, would use -1 twice in succession and break the alternating rule. Options (C) and (D), 524 and 520, differ from the doubled value by $+2$ and -2, whereas every observed correction has magnitude one. Option (A) alone continues the established pattern.

Step 4: Conclusion The missing term is $\boxed{523}$. Hence, the correct option is (A).

Quick Tip to Solve: Write the corrections relative to twice each previous term: +1, -1, +1, -1. This exposes the alternation faster than analysing large gaps.

63. In a code language if ROMAN is written as TQOCP: then ITALY is..... [4 marks]

(A) KVCMA

(B) KWCNB

(C) KUCLA

(D) KVCNA

Correct Answer: (D) KVCNA

Solution:

Concept:

- In a fixed-shift alphabet code, each letter is replaced by the letter a fixed number of positions later in the alphabet.
- Alphabet shifts wrap around after Z to A. The same rule must apply to every letter of the example and then to every letter of the requested word.

Step 1: Extract the shift from the given example Compare ROMAN with TQOCP letter by letter. The replacements are $\mathrm{R} \to \mathrm{T}$, $\mathrm{O} \to \mathrm{Q}$, $\mathrm{M} \to \mathrm{O}$, $\mathrm{A} \to \mathrm{C}$, and $\mathrm{N} \to \mathrm{P}$. Each replacement advances two alphabet positions. Since all five letters obey the same shift, use a uniform forward shift of two rather than rearranging the letters or alternating operations.

Step 2: Apply the shift to ITALY Process the requested word in its original order. Advancing I by two gives K, and advancing T by two gives V. Advancing A gives C and advancing L gives N. For the last letter, count cyclically: one position after Y is Z and the next is A. Hence

$$\mathrm{I} \to \mathrm{K}, \quad \mathrm{T} \to \mathrm{V}, \quad \mathrm{A} \to \mathrm{C}, \quad \mathrm{L} \to \mathrm{N}, \quad \mathrm{Y} \to \mathrm{A}.$$

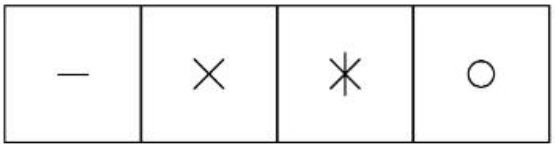
Joining these five coded letters gives KVCNA.

Step 3: Eliminate the competing codes Option (A), KVCMA, incorrectly converts L to M, which is a shift of only one position. Option (B), KWCNB, changes T to W and Y to B, giving shifts of three at those positions. Option (C), KUCLA, changes T to U and leaves L unchanged. Those options therefore do not preserve the single rule already verified for every letter of ROMAN. Option (D) matches all five replacements, including the wrap from Y to A.

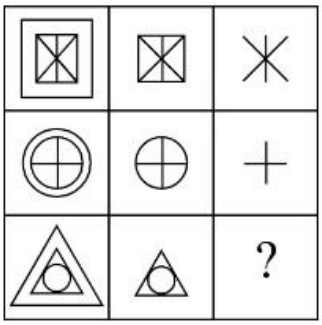
Step 4: Conclusion ITALY is coded as $\boxed{\mathrm{KVCNA}}$. Hence, the correct option is (D).

Quick Tip to Solve: Check the wraparound letter first: Y shifted forward twice becomes A. Then check L to N to distinguish KVCNA from KVCMA.

64. Select a suitable figure from the four alternatives which will come in the empty box. [4 marks]



(A) (B) (C) (D)



(A) D

(B) C

(C) B

(D) A

Correct Answer: (A) D

Solution:

Concept:

- In each row of the matrix, the first two figures are nested combinations of an outer boundary and an inner figure. The third cell retains the inner figure after the surrounding boundary is removed.
- Apply the same operation in every row. Figure letters printed above the matrix identify shapes; the answer-option letters beside the question identify the listed choices, so these two sets of labels must be distinguished.

Step 1: Identify the operation in the first row The first square cell contains a larger square enclosing a smaller square with intersecting lines. The next cell removes the larger square. The third removes the remaining square and leaves the intersecting straight lines. Thus the row progressively strips away its enclosing boundaries rather than adding strokes or rotating the figure.

Step 2: Check the operation in the second row The first circle cell has concentric circles surrounding a plus sign. The second retains a circle and that plus sign. The third is the plus sign alone. This confirms that successive removal of enclosing outlines is the common rule; it is not a rule about the number of corners or the orientation of diagonal strokes.

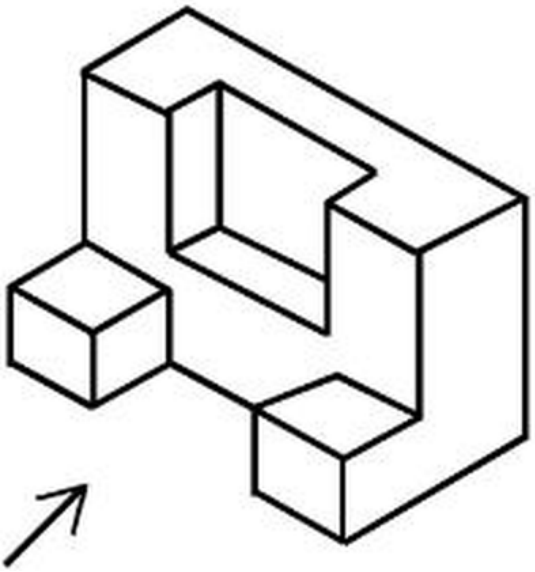
Step 3: Apply the rule to the third row The lower-left figure contains nested triangles and a small circle. The lower-middle figure contains the remaining triangle with the circle. Removing that last enclosing triangle leaves the circle alone. Among the four figures printed above the matrix, the circle is labelled D. The line labelled A, crossed strokes labelled B, and multi-stroke star labelled C cannot result because they introduce straight segments absent from the retained central circle.

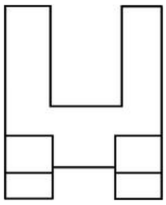
Step 4: Match the figure label to the listed choice The question lists figure D as option (A), figure C as option (B), figure B as option (C), and figure A as option (D). Therefore selecting the circle means selecting the first listed option, not selecting option (D) merely because the circle itself bears the label D.

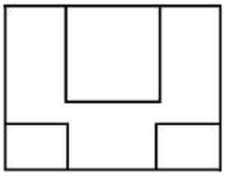
Step 5: Conclusion The missing figure is the small circle, labelled D in the figure set and listed under option (A). Hence, the correct option is (A).

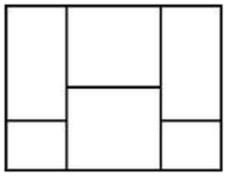
Quick Tip to Solve: Remove the enclosing outlines row by row, then map the surviving figure's printed letter to the question's option list.

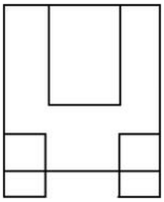
65. The 3D figure shows the view of an object. Looking in the direction of arrow, identify the most appropriate elevation from the given answer figures. [4 marks]

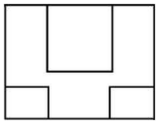


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- An elevation is an orthographic projection in the specified viewing direction: depth is suppressed, while horizontal widths and vertical heights remain.
- Visible edges in front can cover edges behind them. A line indicating a lower step must stop where the nearer blocks obscure that edge; it must not be extended across a face without a physical edge.

Step 1: Fix the viewing direction The arrow points towards the open front of the object, between the two projecting low blocks. We therefore look along the depth direction towards the tall rear portion. The oblique depth edges in the pictorial view collapse in the elevation; their lengths must not be treated as extra height below the object's base.

Step 2: Project the upper portion The tall side portions and the rear material provide the rectangular overall silhouette. The recess in the upper front portion appears as an internal downward rectangular notch, with two vertical lines joined by a horizontal line at the recess floor. Its top remains within the rectangular envelope supplied by the rear portion. This is the arrangement seen in option (B); option (C) instead depicts a central horizontal band and omits the required downward recess profile.

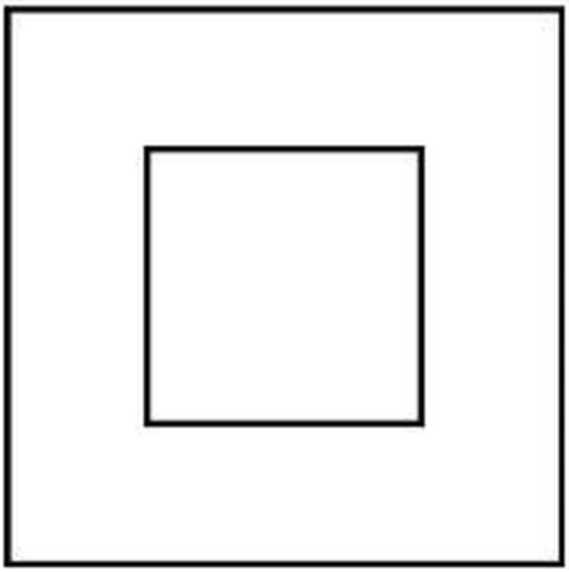
Step 3: Project the two front blocks The two projecting blocks are lower than the tall wall. In elevation they occupy the lower left and lower right corners, with their upper horizontal edges visible. The central low material projects between them to the same baseline. Consequently there is no additional pair of legs projecting below this common bottom edge and no extra continuous horizontal division across the front faces of the blocks.

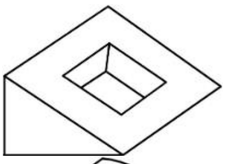
Step 4: Compare the remaining alternatives Option (B) combines the outer rectangle, internal upper recess and the two lower corner outlines at a single base level. Options (A) and (D) add a lower strip or extend the side blocks below the central baseline, introducing vertical levels that the object does not have in this viewing direction. Option (C) changes the internal opening into a band. Thus only (B) preserves both the outline and the visible internal edges.

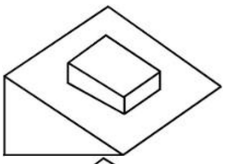
Step 5: Conclusion The elevation viewed along the arrow is the figure in option (B). Hence, the correct option is (B).

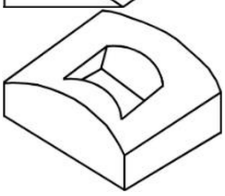
Quick Tip to Solve: Suppress depth first; then trace the common baseline and visible recess edges before comparing similar elevation choices.

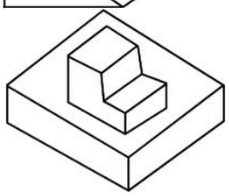
66. Question figure shows top view/ plan of an object. Identify the INCORRECT 3D view from the given answers figure. [4 marks]

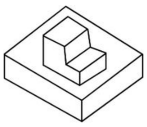


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A top view records the horizontal projection of the object. Different heights can have the same plan, so a raised square and a square recess can both appear as a smaller square inside a larger square.
- Every visible change of level with a sharp exposed boundary contributes an edge to the plan. To reject a candidate, find an unavoidable projected line that is absent from the given plan.

Step 1: Read the information in the given plan The plan has one large square outline and one smaller complete square inside it. There is no line dividing the inner square. Thus the allowed object may have a square opening, an inset square platform, or a suitable curved surface, but it must not introduce an exposed step across that central square when seen from above.

Step 2: Check the first two views Option (A) shows a square opening recessed into the larger body. Its outer footprint gives the large square and the rim of its opening gives the inner square. Option (B)

shows a raised square platform on a larger square base. Viewed directly from above, the vertical sides collapse onto the platform boundary, again leaving the two nested squares. Neither view requires an extra line inside the inner square.

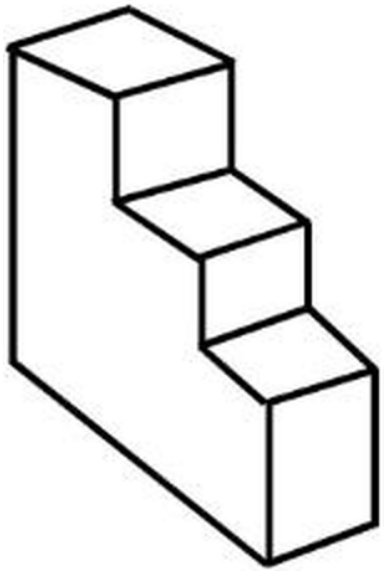
Step 3: Check the curved view Option (C) changes the vertical profile of the body and opening by using curved surfaces. A curve in an oblique pictorial view does not by itself force a curved plan: its horizontal projection can still follow the square opening and square outer footprint. The roof curvature changes heights along the surface, rather than adding a sharp step across the inner region. It therefore does not supply the forbidden internal division.

Step 4: Identify the compulsory extra edge Option (D) has two adjacent raised levels in its central feature, forming an exposed step. The boundary between the higher part and lower terrace runs across the central region. Looking down vertically does not hide this step, so its projected edge would subdivide the inner square. The supplied plan shows that inner square undivided. This mismatch cannot be removed by changing the height scale or rotating the object, whereas (A), (B) and (C) do not impose such an additional central edge.

Step 5: Conclusion Option (D) is the incorrect three-dimensional view because its central step adds an internal edge absent from the given plan. Hence, the correct option is (D).

Quick Tip to Solve: For plan-view questions, test exposed step boundaries: an extra central edge can reject a view even when the outer footprint matches.

67. How many surfaces does the object have? [4 marks]



(A) 9

(B) 10

(C) 8

(D) 11

Correct Answer: (B) 10

Solution:

Concept:

- A surface is one maximal planar face of the solid. Adjacent coplanar regions form one surface; a change of level or direction creates a different face.
- The solid is a prism of constant width with a three-step side profile. For a prism with an eight-sided profile, the number of faces is the number of profile edges plus its two end profiles.

Step 1: Identify the two side faces Look at the large stair-shaped side on the left. It is one connected planar surface, even though its boundary has several steps. The opposite side is a second planar surface of the same shape. Do not divide either side into separate rectangles merely because its outline is stepped.

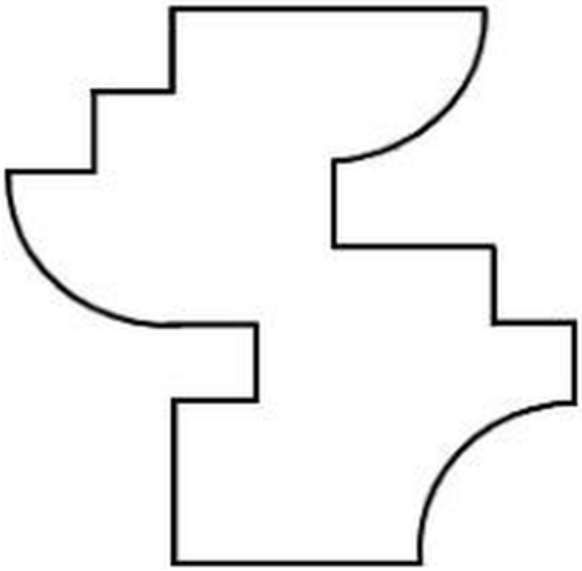
Step 2: Count the horizontal and vertical faces There are three horizontal tread surfaces, one at each height. The underside is a fourth horizontal surface. Along the stepped front there are three vertical riser faces, including the lowest front face. The tall back is one more vertical surface. Thus the faces parallel to the width direction contribute four horizontal and four vertical faces.

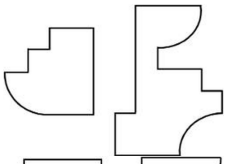
Step 3: Include hidden faces and check the total The count must include the underside, back and opposite side, although these are hidden in the perspective view. Adding the two side faces to the eight faces following the side-profile boundary gives $4 + 4 + 2 = 10$. Nine and eight omit required faces; eleven results from splitting a continuous planar side or counting an edge as a face.

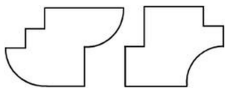
Step 4: Conclusion The object has 10 surfaces. Hence, the correct option is (B).

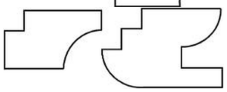
Quick Tip to Solve: For a solid formed by extruding a stepped profile, count the edges of that profile and add its two end faces.

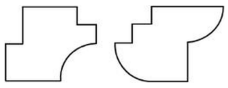
68. If the question figure is cut into two parts, which of the answer figures complete the question figure without any overlappings? [4 marks]

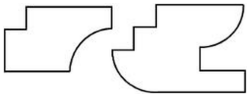


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- Two pieces complete a figure only when their union has the required outer boundary and their interiors do not overlap.
- Rotating a piece is allowed in a dissection comparison. Match the curved arcs and the stepped boundary before checking the internal joining edge.

Step 1: Track the three curved boundary portions The question outline has an outward curved portion at the upper right, an outward curved portion at the lower left, and an inward curved cut at the lower right. Mark their positions relative to the short rectangular steps. Matching only the overall area or the number of curves is insufficient: the curved portions must meet the correct straight segments.

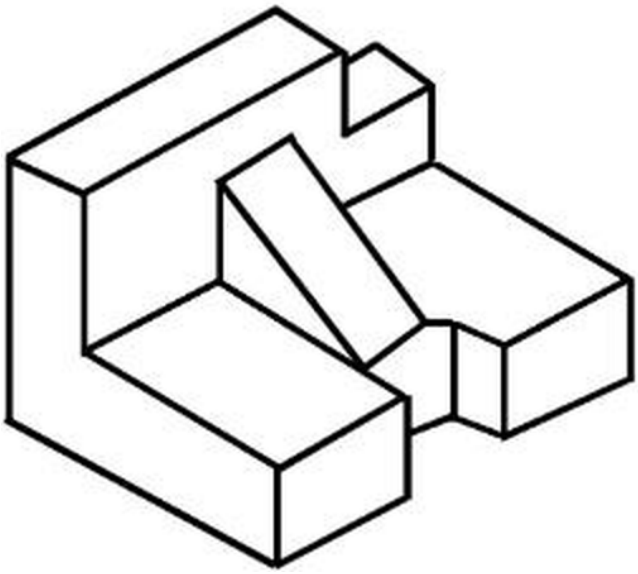
Step 2: Fit the two pieces in option C Take the larger piece of option C as the part containing the two outward curves. Turn the smaller piece to align its inward curved edge with the concave corner in the question. Its concave curved boundary then occupies the lower-right cut of the completed figure, while its stepped straight edges supply the remaining lower-left and lower boundary. Slide it against the open straight boundary of the larger piece so that the joining segments coincide.

Step 3: Check the complete boundary Trace around the assembled outside edge. It reproduces the upper stair-step, the upper-right curved corner, the right-hand rectangular jog, the lower-right concavity, the bottom edge and the left outward curve of the question. The matching join is internal and introduces neither an extra notch nor an overlap. In the other pairs, matching one curved portion leaves a mismatch in the position or length of a rectangular step, so their complete outside outlines fail the test.

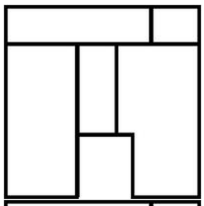
Step 4: Conclusion The two pieces in option (C) complete the question figure without overlapping. Hence, the correct option is (C).

Quick Tip to Solve: Use the concave arc as an anchor, rotate its piece into place, and then trace every step of the combined outer boundary.

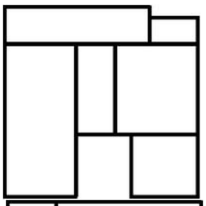
69. The 3D problem figure shows the view of an object. Identify its appropriate top view from the answer figures. [4 marks]



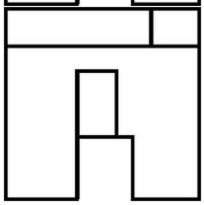
(A)



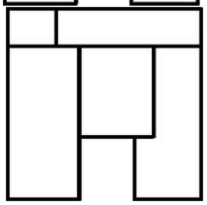
(B)



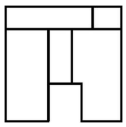
(C)



(D)



Correct Answer: (A)



Solution:

Concept:

- A top view is an orthographic projection onto a horizontal plane. Height does not alter the footprint, while edges separating different visible upper surfaces remain in the projection.
- A sloping rectangular face generally projects as a rectangle from above. Its appearance in perspective must not be mistaken for its plan shape.

Step 1: Establish the outer footprint Viewed from above, the two broad lower platforms lie to the left and right of a narrow central opening at the near edge. The footprint is therefore a nearly square outline with a rectangular notch entering at the front centre. The back raised wall extends across the width; its right end has a separate short upper block.

Step 2: Project the central sloping member The central inclined member runs forward from the back wall towards the notch. Its two parallel sides project as two vertical lines in the plan. Its front

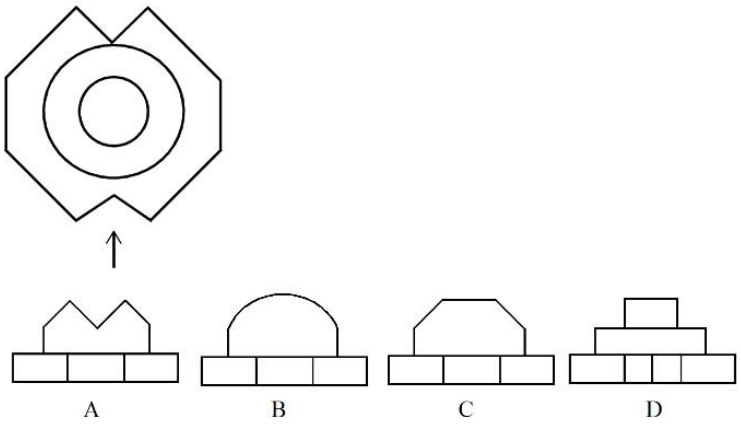
boundary occurs just behind the open notch. Thus the central strip must connect directly to the back transverse strip rather than appear as an isolated enclosed rectangle.

Step 3: Compare the projected edges with the options Option A retains the front-centre notch, the long transverse strip at the back, its short right-hand subdivision, and the central strip descending towards the notch. Option B adds a horizontal division across the right platform and alters the outer rear outline. Option C places an enclosed rectangle inside the platform instead of the correctly connected inclined member. Option D reverses the back subdivision and changes the central member. These differences are structural, not merely changes of apparent height.

Step 4: Conclusion Option (A) is the correct top view of the object. Hence, the correct option is (A).

Quick Tip to Solve: First project the footprint and any open notches; then add the boundaries between the upper faces, ignoring perspective slopes.

70. Identify the correct elevation when you look into the object from the marked arrow side of the plan of the object. [4 marks]



(A) D

(B) A

(C) B

(D) C

Correct Answer: (A) D

Solution:

Concept:

- A plan shows the horizontal outline of an object. An elevation shows its vertical outline from the marked viewing direction.
- Concentric circles in a plan indicate circular features at different radii, whereas sloping lines in the plan of a polygonal base describe its footprint rather than its height.

Step 1: Read the features in the plan The outermost boundary is a polygonal base with a symmetric notch at the top and bottom of its plan outline. Inside this outline are two concentric circles. The outer circle represents the circular middle tier and the inner circle represents the smaller circular

upper tier, both centred on the base.

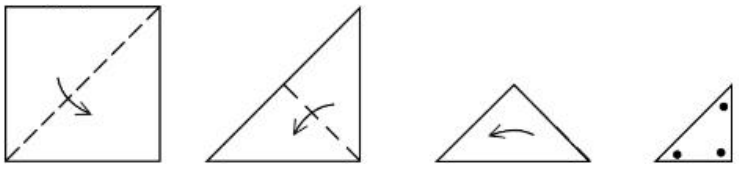
Step 2: Project along the marked arrow Look towards the object from the arrow below the plan. A vertical circular tier projects to a rectangle: its apparent width is its diameter, and its top boundary is horizontal. Therefore the larger circular tier gives a wider rectangular middle level and the smaller circular tier gives a narrower rectangle above it. The base is wider still; its changes of direction in plan give vertical subdivision lines in its elevation.

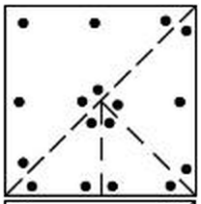
Step 3: Choose the matching labelled elevation Elevation D shows precisely these three decreasing widths: the broad low base, the narrower rectangular middle tier and the smallest rectangular upper tier. Elevation A improperly carries the angular plan outline upward as a pointed top. Elevation B shows a curved upper silhouette and elevation C a bevelled one, neither matching the flat tops of the circular tiers. The answer choices name the candidate elevations in a different order: candidate D is listed as option A.

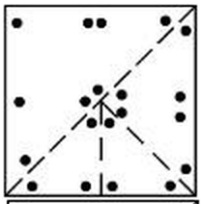
Step 4: Conclusion The correct elevation is the figure labelled D, which is option (A). Hence, the correct option is (A).

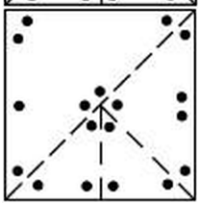
Quick Tip to Solve: Distinguish a candidate diagram label from its option letter: here elevation D is listed under option A.

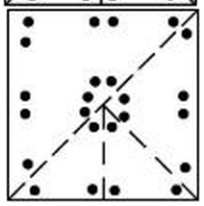
71. A paper is folded in a given pattern and it is cut at the end. Identify which pattern is formed when the paper is unfold. [4 marks]

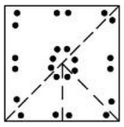


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- Unfolding reflects every cut across the last fold line, then across the preceding fold lines in reverse order.
- A cut strictly inside a region doubled by three folds has eight copies in the fully opened sheet. Reflection also fixes the relative distances of the holes from each fold.

Step 1: Identify the folds and the final cuts The square is first folded on its diagonal to make a triangle. The triangle is folded again to a smaller triangle, then once more to form the final narrow triangular packet. Three circular cuts are shown inside this packet: one near the lower side, one near the right side and one near their corner. None is centred on a fold line.

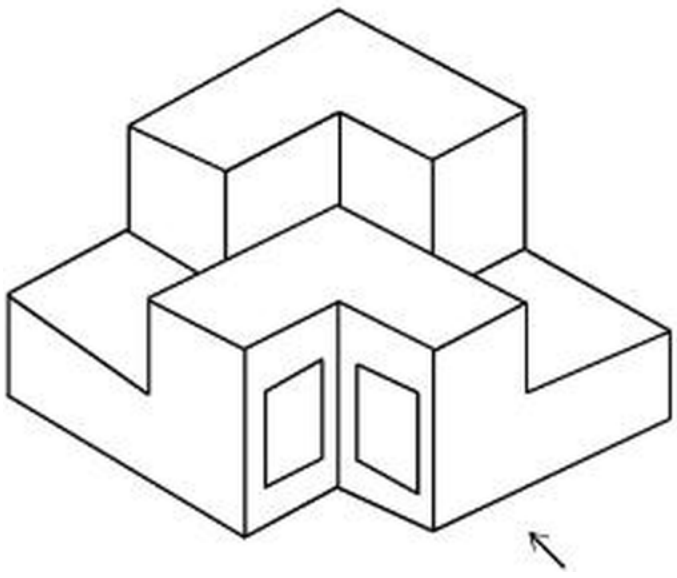
Step 2: Reverse the last fold and then the earlier folds Reflect the three cut positions across the last fold. This produces six positions in the preceding triangle. Reflect that set across the second fold to obtain twelve positions, then across the original diagonal to recover the complete square. Since the cuts are interior and do not coincide under these reflections, the final pattern contains $3 \times 2^3 = 24$ holes. Copies occur in symmetric groups at the corners, side regions and centre.

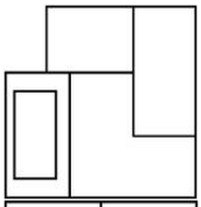
Step 3: Compare both number and symmetry Option D displays all eight reflected copies of each of the three cuts. In particular it contains the full paired groups near the sides and the complete central group. Options A, B and C omit members of these reflection pairs: each loses holes on one or more sides or around the centre. A pattern with fewer holes cannot result from these three interior cuts through all folded layers, even when some of its corner positions look correct.

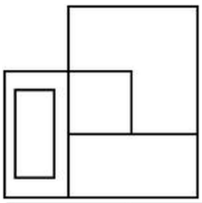
Step 4: Conclusion Unfolding produces the pattern shown in option (D). Hence, the correct option is (D).

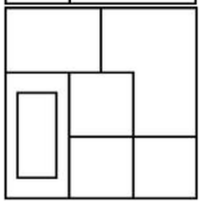
Quick Tip to Solve: Unfold in reverse order and reflect all existing holes at every step; use the total hole count as a check, not as the only test.

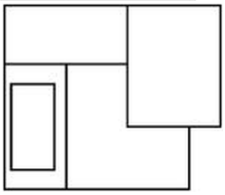
72. The question figure shows the 3-D view of an object. Identify the correct view, looking in the direction of arrow. [4 marks]

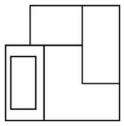


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A directional view collapses depth along the arrow while preserving horizontal positions and heights.
- A nearer opaque face hides features directly behind it. An outline seen from another direction cannot be chosen solely because it contains a similar rectangular opening.

Step 1: Fix the viewing direction and front features The arrow points from the lower-right towards the object. View along this direction rather than from the perspective drawing position. The nearer upright face bearing a rectangular inset remains visible on the left of the required elevation. Its opening is contained within that low rectangular face, so an option must preserve both its location and its surrounding border.

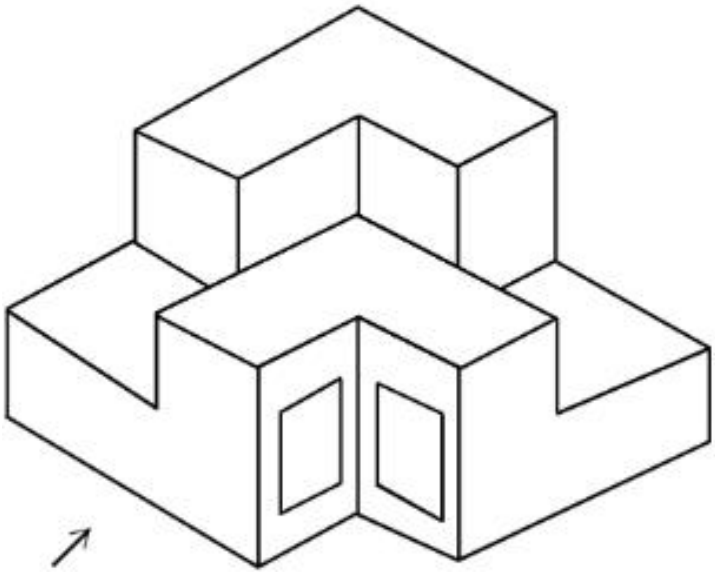
Step 2: Project the raised rear portion The higher rear portion lies beyond the low foreground and projects above it. Its upper edge is horizontal. Its right-hand vertical face extends down behind the lower front portion, producing a step in the visible boundary and an internal vertical edge on the right. At the top, the visible raised strip is divided by the change between its two perpendicular arms.

Step 3: Match the complete arrangement Option A has the opening within the lower left rectangle, the raised horizontal strip above, its vertical subdivision, and the right-hand descending step in the correct positions. Option B moves the raised portion and changes its lower junction. Option C adds a different arrangement of horizontal and vertical boundaries through the low right area. Option D changes the subdivision of the upper block and the lower right outline. Only A preserves the heights, overlap and edge alignments together.

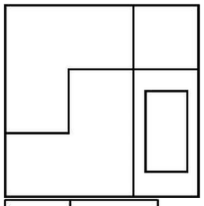
Step 4: Conclusion The correct view in the direction of the arrow is option (A). Hence, the correct option is (A).

Quick Tip to Solve: Follow the arrow first, locate the nearer face with its opening, and only then project the higher surfaces behind it.

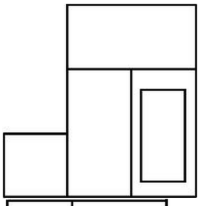
73. The question figure shows the 3-D view of an object. Identify the correct view, looking in the direction of arrow. [4 marks]



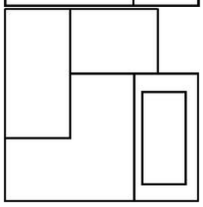
(A)



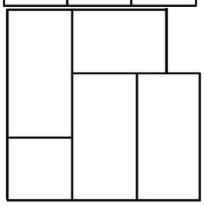
(B)



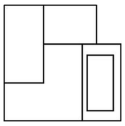
(C)



(D)



Correct Answer: (C)



Solution:

Concept:

- An orthographic view projects the object along the indicated direction. All sight lines are parallel; depth along the sight line disappears while transverse widths and vertical heights remain.
- A visible change of height produces a step in the outer silhouette. A rectangular marking appears only on a face presented towards the viewer; a hidden rear edge is not added as a solid visible boundary.

Step 1: Fix the viewing direction The arrow approaches the object from its lower-left side. Look along that arrow rather than at the corner facing the reader in the perspective drawing. The two sloping horizontal directions in the drawing represent perpendicular directions of the solid. Collapse only the direction parallel to the arrow, and keep the vertical edges upright.

Step 2: Trace the silhouette and face detail Following the visible outline across the projection, the

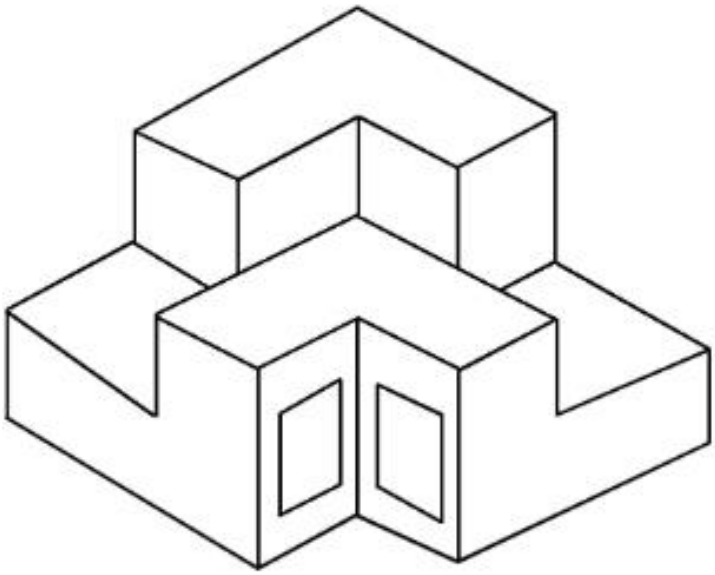
taller raised part extends over the left and middle portions. The right-hand portion has the lower top level, so the outline steps down near the right side. The rectangular panel lies on the right-hand visible face in this view. The internal height-change lines also retain their order: the low horizontal segment on the left meets an upright edge, above which the higher horizontal segment continues to the right.

Step 3: Compare the four projections Option (C) preserves both the stepped outer top edge and the rectangular panel in its right-hand portion. Option (A) makes the outer top a single full-width level; option (B) puts the low portion at the left instead of the required arrangement. Option (D) has a similar stepped top but omits the rectangular face detail. Thus neither silhouette alone nor panel alone is sufficient: both must agree.

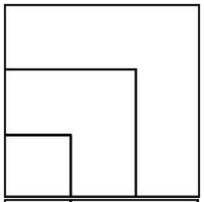
Step 4: Conclusion The view looking along the arrow is the projection shown in option (C). Hence, the correct option is (C).

Quick Tip to Solve: Check the stepped outer silhouette first, then use the rectangular panel to distinguish the remaining similar views.

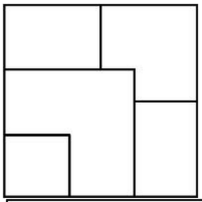
74. From the given options below, choose the correct plan of the 3-D object, when viewed from the top. [4 marks]



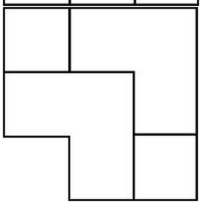
(A)



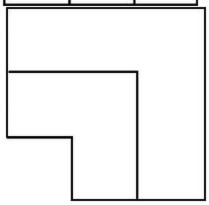
(B)



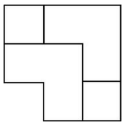
(C)



(D)



Correct Answer: (C)



Solution:

Concept:

- A plan is the orthographic projection seen vertically from above. Vertical heights collapse, but the horizontal footprint and the boundaries between visible top surfaces remain.
- An opening or panel in a vertical face does not become a rectangle in the plan. Trace the outside footprint before comparing internal edges; perspective slopes must be replaced by perpendicular plan directions.

Step 1: Look vertically down on the object Ignore the side elevation of the front rectangular panels, because their faces are vertical. Follow the perimeter of the horizontal top surfaces instead. The object is not a solid rectangular slab throughout its footprint: its front boundary has an inward step. The raised upper part also changes the visible top-surface boundaries, even though its height itself is not represented in a plan.

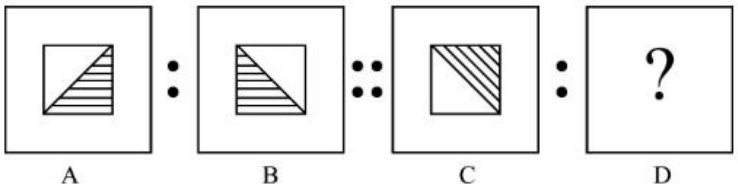
Step 2: Trace the footprint and visible top edges When the two horizontal axes of the perspective view are straightened into perpendicular directions, the plan has a missing rectangular corner at the lower left in the orientation used by the answer figures. Along the top, the raised part contributes the short left division and the longer adjoining top surface. On the right, a transverse boundary divides the side strip. Keep these visible changes of horizontal surface rather than drawing the rectangular face panels from the elevation.

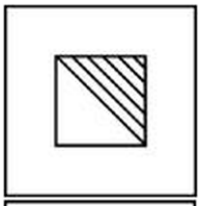
Step 3: Eliminate plans with the wrong boundary or divisions Option (C) has the required inward corner at the lower left and the correct arrangement of the top and right-hand surface divisions. Options (A) and (B) retain a complete rectangular outer footprint, which fills in the required recess. Option (D) has an indented outline but lacks the additional top and right-hand boundaries of the raised and adjoining surfaces. The complete set of visible edges therefore selects (C).

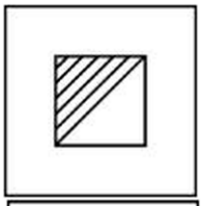
Step 4: Conclusion The correct plan of the object is the figure in option (C). Hence, the correct option is (C).

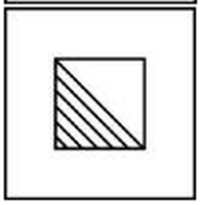
Quick Tip to Solve: For a plan, remove vertical-face details mentally and compare the outside footprint before the internal top-surface edges.

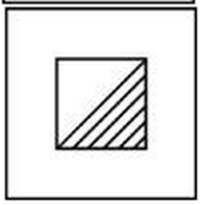
75. The second figure in the first part of the problem figures bears certain relationship to the first figure. Similarly, one of the figures of answer figures bears the same relationship to the first figure of the second part. Identify the correct option from the given answer figures. [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A visual analogy applies the same transformation to the second pair as to the first. Position, diagonal direction and the direction of the hatch lines must all transform together.
- Reflection in a vertical line reverses left and right while preserving top and bottom. A diagonal rising to the right becomes a diagonal falling to the right, and horizontal hatch lines stay horizontal.

Step 1: Identify the transformation from A to B In figure A the hatched triangular half of the inner square occupies the lower-right side of a rising diagonal. In figure B it occupies the lower-left side of a falling diagonal. The bottom side remains the bottom side and the horizontal hatch lines remain horizontal. Thus the operation is a left-right reflection of the inner pattern, rather than a rotation that would turn the horizontal hatching vertical.

Step 2: Reflect figure C in the same way The hatched triangle in figure C occupies the upper-right half of the inner square. Under left-right reflection it must occupy the upper-left half. Its diagonal boundary must rise from the lower-left to the upper-right. The slant of each hatch stroke reverses as well, while the outer and inner squares retain their sizes and positions.

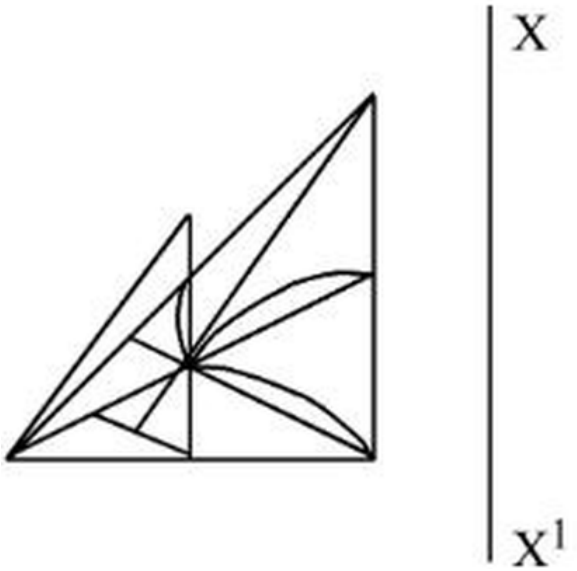
Step 3: Match every feature with the options Option (B) has the upper-left hatched triangle, the rising diagonal boundary and the reflected hatch direction. Option (A) leaves the shaded triangle at the upper right. Option (C) moves the shading to the lower left, and option (D) puts it at the lower right. Those latter choices change top and bottom as well as, or instead of, left and right; they do not repeat the first pair's operation.

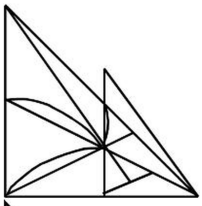
Step 4: Conclusion The missing analogy figure is option (B). Hence, the correct option is (B).

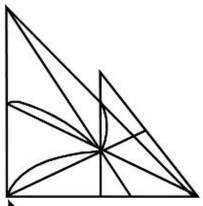
Quick Tip to Solve: Use the hatch direction to distinguish reflection from rotation when the shaded triangle alone seems to fit more than one rule.

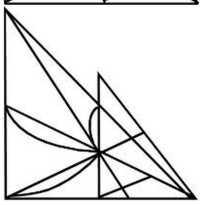
76. Identify the true mirror image of the figure amongst the answer figures with respect to X-X

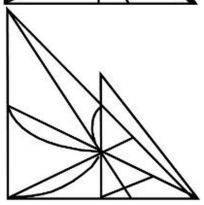
[4 marks]

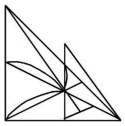


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A plane mirror on the vertical line X–X′ reverses horizontal positions. A point and its image lie at equal perpendicular distances from that mirror line and at the same height.
- Reflection reverses the handedness of the whole drawing, including curved boundaries and small internal intersections. It is not enough for the outside triangle alone to face the other way.

Step 1: Reverse the main outline The mirror is drawn to the right of the source figure. The tall vertical side nearest that mirror becomes the tall left side of the image. The long low point at the left of the source becomes the long low point at the right. The shorter upright near the middle moves to the corresponding position on the right of the reflected figure. The horizontal base remains horizontal.

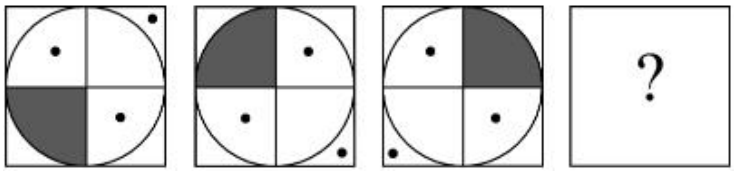
Step 2: Follow the internal curves and crossings Track the curves from the tall vertical side through the central meeting point. Their reflected endpoints must be at the same heights, and each curve must bow in the reversed horizontal direction. Also follow the small triangular subdivisions between the short upright, the base and the long slanting line. The crossing order of these lines is preserved by reflection even though their left-right orientation reverses.

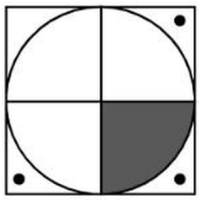
Step 3: Compare the detailed answer figures Option (A) reverses both the main outline and the internal arrangement: the long left source tip moves to the right, the tall side moves to the left, and the curved lobes and small lower subdivisions occupy their reflected positions. Option (B) changes the placement of a small internal subdivision. Options (C) and (D) have the wrong bowing or attachment of the large curved parts. A rotation or a roughly similar triangle therefore cannot replace the exact mirror image.

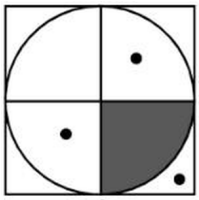
Step 4: Conclusion The true mirror image with respect to X–X′ is option (A). Hence, the correct option is (A).

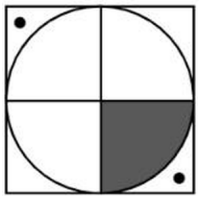
Quick Tip to Solve: After checking the tall side and long tip, trace one curved lobe and one small triangle; these expose the close distractors.

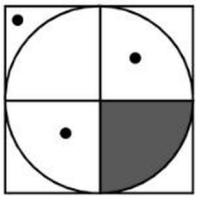
77. Choose the correct option amongst the answer figures which complete the series. [4 marks]

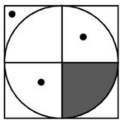


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A visual series may contain several simultaneous rules. Track the shaded quadrant, the internal dots and the dot outside the circle separately before selecting an answer.
- The circle is divided into four fixed quadrants. A quarter-turn moves a feature to the next quadrant, whereas a half-turn exchanges opposite quadrants.

Step 1: Continue the shaded quadrant The shaded quarter moves from lower left in the first figure to upper left in the second and upper right in the third. It advances clockwise by one quarter-turn each time. The next shaded quarter must therefore be the lower-right quadrant. All candidate figures have that shading, so this feature alone does not identify the answer.

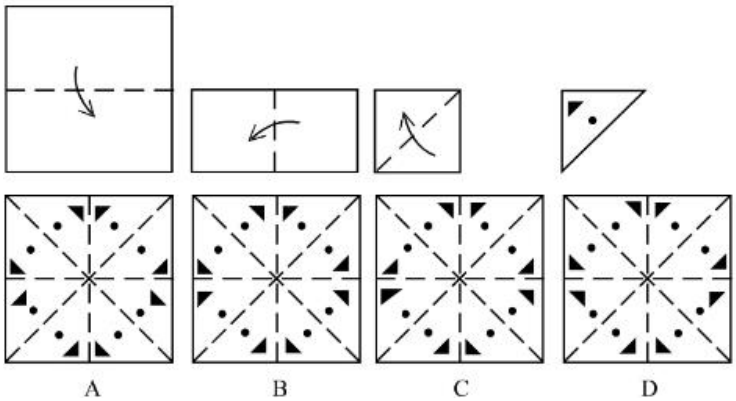
Step 2: Continue the internal and external dots The two dots inside the circle alternate between opposite diagonal pairs. They occupy upper left and lower right in figures one and three, but upper right and lower left in figure two. The fourth figure must return to upper right and lower left. Meanwhile the dot outside the circle advances clockwise around the corners: upper right, lower right, lower left, and therefore upper left next.

Step 3: Require all three continuations together Option (D) combines lower-right shading, internal dots at upper right and lower left, and an external dot at the upper-left corner. Option (A) has incorrect dot positions, including more than one exterior dot. Option (B) has the proper internal diagonal but leaves the exterior dot at lower right. Option (C) places the exterior dot correctly but does not retain the required pair of interior dots. Thus only (D) satisfies the complete series rather than just its shaded sector.

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

Quick Tip to Solve: Write a separate short sequence for the shaded quarter, the inner-dot diagonal and the outer corner; combine them only at the end.

78. Sheet is folded in marked format and cut led at last as shown. Identify from the options below, how the pattern will be made when it's fully unfold? [4 marks]



(A) B

(B) A

(C) D

(D) C

Correct Answer: (A) B

Solution:

Concept:

- Unfolding a cut sheet reverses the folds in reverse order. Every cut is reflected in the most recent crease first, then each resulting cut is reflected in each earlier crease.
- A circular hole remains circular under reflection. A triangular cut reverses its orientation across a fold, so the directions of the triangular holes distinguish patterns having the same number of holes.

Step 1: Read the folds and the final cuts The sheet is first folded across the horizontal middle line, then across the vertical middle line of the folded rectangle. The square packet is then folded along its marked diagonal into the triangular packet shown. The final packet has a small triangular cut and a small circular cut. Since these cuts pass through the folded layers, their reflected copies must appear as the folds are opened.

Step 2: Reverse the diagonal fold Open the last diagonal fold first. Reflect the circular hole and triangular cut across that diagonal. The square packet now contains a pair of circular holes and a pair of triangular cuts. The two triangles are mirror counterparts, not two identical triangles translated to different locations. This diagonal reflection is the step most easily missed when choosing among the very similar answer patterns.

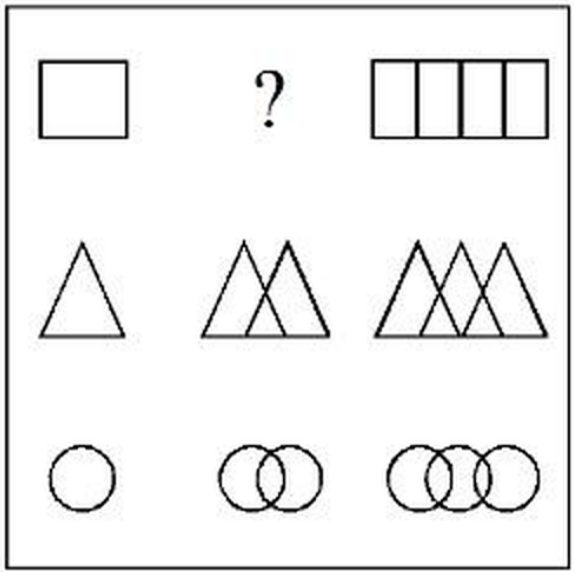
Step 3: Reverse the two middle folds and compare Open the vertical fold next and finally the horizontal fold. Each operation duplicates the pattern by reflection, giving eight circular holes and eight triangular cuts distributed symmetrically about the original middle lines. Trace the right-angle corner and sloping side of a triangle through those reflections, rather than checking only the dots. The resulting triangular orientations and their positions relative to the nearby circular holes match the pattern labelled B in the supplied answer figures. Patterns A, C and D reverse or misplace one or more of those triangle orientations, even where their dot arrangement appears similar.

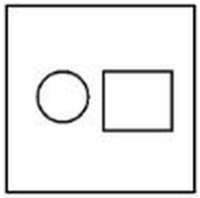
Step 4: Translate the figure label to the option letter The question's answer choices list the printed patterns in the order B, A, D, C. Therefore the required pattern B is the first listed choice. The pattern label and the MCQ option letter must not be confused.

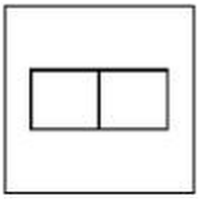
Step 5: Conclusion The unfolded sheet has the pattern labelled B, which is listed as option (A). Hence, the correct option is (A).

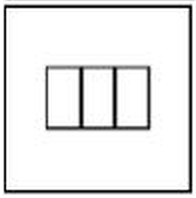
Quick Tip to Solve: Undo the diagonal fold before the two straight folds, and follow a triangular cut as well as a circular hole to avoid the close alternatives.

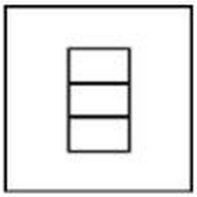
79. In the figure mentioned below find the missing series:- [4 marks]

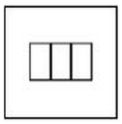


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A figure matrix is completed by finding a transformation common to the rows. The shape may change between rows while the number and arrangement of repeated copies follow the same rule.
- Overlapping squares retain vertical boundaries inside their common outer outline. Count copies of the original shape rather than treating every narrow compartment as a separate square.

Step 1: Find the rule in the complete rows The second row begins with one upright triangle, then shows two horizontally overlapping upright triangles, and finally three such triangles. The bottom row likewise begins with one circle and adds an overlapping circle at each move to the right. Thus the columns represent one, two and three overlapping copies respectively; their orientation remains unchanged.

Step 2: Apply the same construction to the top row The first entry is a single square. The right-hand entry has the extended outline and internal vertical divisions made by horizontally overlapping copies

of that square. The missing middle entry must therefore show two overlapping squares: their left and right edges create three upright compartments within a horizontal rectangular outline. Option (C) has exactly this structure.

Step 3: Eliminate the competing arrangements Option (A) combines a circle and a square, changing the shape rather than repeating it. Option (B) places two square compartments side by side without the overlap that the complete rows establish. Option (D) stacks compartments vertically, whereas the triangles, circles and final square pattern all extend horizontally. Only the horizontal three-compartment pattern preserves both overlap and direction.

Step 4: Conclusion The missing entry is the horizontal arrangement of two overlapping squares shown in option (C). Hence, the correct option is (C).

Quick Tip to Solve: Use the complete triangle and circle rows to establish overlap and direction before counting the narrow compartments of the square row.

80. The diagram shows the supply and demand of different users for different items. Which of the following is/are correct?

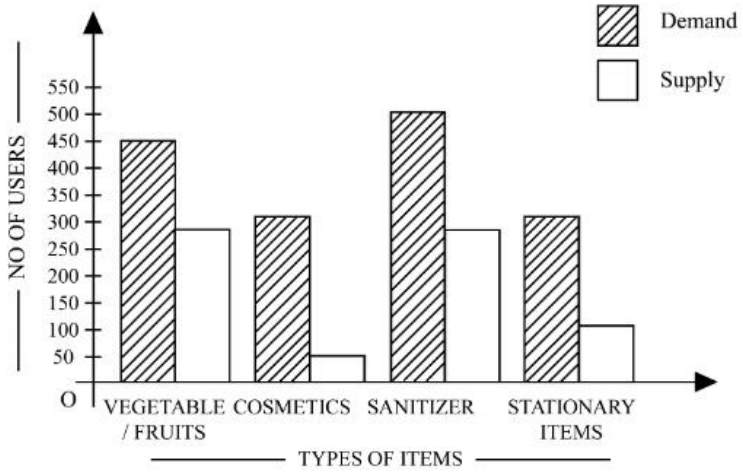
A. Sanitizer only meet 50% of the demand

B. Cosmetics has the least supply among all.

C. Among all, two items have equal demand but difference in supply

D. Among all, two items have equal supply and two items have equal demand.

Choose the correct answer from the options given below:- [4 marks]



(A) B and D only

(B) A and B only

(C) A and C only

(D) B, C and D only

Correct Answer: (D) B, C and D only

Solution:

Concept:

- The hatched bars denote demand and the unshaded bars denote supply. Read each category against the same vertical scale before comparing heights.
- The fraction of demand met is supply divided by demand, multiplied by 100 percent. Equal demand does not imply equal supply.

Step 1: Read the four pairs of bars Vegetables/fruits have demand 450 and supply 300 users; cosmetics have demand 300 and supply 50; sanitizer has demand 500 and supply 300; stationery items have demand 300 and supply 100. These values must be read by matching each bar to its category and its legend, rather than interchanging the hatched and plain bars.

Step 2: Test statements A and B For sanitizer the percentage of demand met is

$$\frac{300}{500} \times 100 = 60\%.$$

It therefore does not meet only 50 percent of demand: statement A is false. Cosmetics supply is 50, lower than stationery supply 100 and the two supplies of 300. Statement B is true.

Step 3: Test statements C and D Cosmetics and stationery both have demand 300, but their supplies are 50 and 100 respectively. This verifies statement C. Vegetables/fruits and sanitizer have equal supply 300; cosmetics and stationery have equal demand 300. This verifies statement D. The equal-supply pair and the equal-demand pair need not be the same categories.

Step 4: Match the true statements to the options The true statements are B, C and D. Option (A) omits the true statement C. Option (B) includes false A and omits C and D; option (C) includes false A and omits B and D. Option (D) alone lists all three true statements without including A.

Step 5: Conclusion Statements B, C and D are correct, while A is incorrect because sanitizer meets 60 percent of demand. Hence, the correct option is (D).

Quick Tip to Solve: Write each category as a demand/supply pair first; then check percentage claims and equal-height claims separately.

Drawing Test (100 marks)

81. Draw a proportionate sketch of given reference image. Use black and white rendering techniques of your choice. [50 marks]



Solution:

Concept:

- A proportionate reference sketch preserves the relative position, size and direction of the visible features. Establish the overall head-and-shoulder silhouette before drawing facial details.
- Black-and-white rendering separates light, middle and dark values through pencil pressure, hatching or blended shading. The darkest accents should support the form rather than flatten every feature into an outline.

Step 1: Block in the portrait and its main proportions Place the upright portrait centrally with room for the feathers extending to the left and the long hair descending around the shoulders. Lightly mark the top of the head, chin, face centre line and eye line. Compare the face width with its height directly against the reference and transfer the relative positions of eyes, nose and mouth. Reserve the surrounding shapes of the hair and feather arrangement before committing to detail.

Step 2: Construct the visible facial and decorative features Draw the face within the enclosing hair silhouette, keeping the two eyes aligned and the nose and mouth centred as in the reference. Add the headband across the forehead, its diagonal internal divisions, the attached feathers on the left and the small decorations along the right side of the head. Place the round earrings beside the face and establish the several horizontal neck bands. Indicate the central necklace ornament and the small hanging forms below it without enlarging them relative to the face.

Step 3: Build a controlled range of monochrome values Begin with pale shading on the skin, preserving the lighter planes of the forehead, nose bridge and cheeks. Deepen the shadows beside the nose, under the lower lip and beneath the chin to turn the facial form. Render the hair with strokes following its downward curved strands; leave selected narrow highlights and place deeper

dark masses between locks. Give the feathers a central shaft and lighter directional strokes, keeping their edges readable against the darker hair. Use fine hatching or restrained blending on the skin so that it remains distinct from the hair texture.

Step 4: Refine the focal area and review the likeness Strengthen the eyes, eyebrows and lips with carefully placed accents while retaining small highlights. Add the visible bead and jewellery details only after their larger shapes are correct. Keep the forehead band, feather attachments, ear ornaments, neck bands and necklace consistent with their locations in the reference. Step back to compare the complete silhouette, feature spacing and balance of light and dark. Erase construction lines, soften unnecessary hard skin contours and keep the background clean so that the face remains the focal point.

Step 5: Conclusion A suitable finished response is a proportionate monochrome portrait matching the given face, hair, feathered head decoration and jewellery, with clear facial features and controlled tonal modelling. The composition plan keeps the reference arrangement while using black-and-white values to show form and texture.

Quick Tip to Solve: Check the head silhouette and eye line first; correcting these early protects the likeness before time is spent on feathers, hair strands and jewellery.

82. Use the basic 2D shapes found in a motor cycle and create an interesting 2D composition of your choice, colour with any three colours of your choice. [50 marks]

Solution:

Concept:

- An abstract composition can retain the visual vocabulary of a motorcycle without becoming a realistic illustration. Circles suggest wheels, triangles suggest the frame, and rectangles and curved shapes suggest the seat, engine and fuel tank.
- Balance, rhythm, overlap and variation in scale connect separate shapes into one design. A restricted palette of exactly three colours creates unity, while their relative areas establish emphasis.

Step 1: Select and simplify the shapes Choose two large circles from the wheels as the main motif. Extract a long narrow rectangle from the seat, a triangle from the frame, a rounded tank shape and several small rectangles from the engine. Reduce each element to a clear flat outline. Remove bolts, lettering and mechanical details: the task asks for a two-dimensional composition using basic shapes, so the design should depend on relationships between shapes rather than realistic motorcycle anatomy.

Step 2: Arrange a balanced composition Within a lightly drawn rectangular boundary, place a large circle towards the lower left and a smaller circle towards the upper right. Link their visual movement with an oblique triangle and a narrow rectangle crossing the centre. Place the rounded tank shape beside the triangle and repeat three small engine rectangles along the same diagonal. Let selected shapes overlap to create interlocking regions. Keep a generous open area beside the dominant circle and smaller gaps elsewhere; unequal spacing and sizes produce rhythm without clutter. Check that the smaller shapes on the right balance the heavier circular mass on the left.

Step 3: Apply exactly three colours Use blue, orange and yellow throughout. Give blue the largest area, use orange for the secondary shapes, and reserve yellow for small focal accents near the centre. Fill each bounded region with one of these colours, reusing the same colour in separated places to connect the whole page. Avoid blending that produces additional colours. Where shapes overlap, distinguish the regions by assigning one of the three existing colours rather than adding a fourth. Use the boundary between adjoining colour fields to define the shapes instead of introducing a separate black outline.

Step 4: Refine the final presentation Review the silhouette and make sure circles, triangles and rectangles remain recognisable after overlap. Repeat selected curves and diagonals so that the eye travels around the page and returns to the central accent. Erase construction lines before colouring, fill the areas evenly, and keep the edges crisp. Check the outer margins and distribute the remaining spaces deliberately. The finished work should read as an intentional flat design, with the motorcycle serving as the source of its shapes rather than a literal object drawn in perspective.

Step 5: Conclusion A suitable finished composition combines wheel circles, frame triangles, seat rectangles and a simplified tank shape in a balanced diagonal arrangement. Flat blue, orange and yellow regions provide a unified three-colour design with rhythm, controlled overlap and a clear focal point.

Quick Tip to Solve: Make a small thumbnail using only the main wheel circles and frame triangle first; settle the balance before adding smaller shapes or applying the three colours.