JEE Main 2025 Paper 2A (B.Arch) Apr 9 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) 2025, Session 2 (April), conducted by the National Testing Agency (NTA) in Computer Based Test (CBT) mode on 9 April 2025, Shift 1. The total duration is 3 hours.

(ii) The paper has 77 questions: Mathematics (25), Aptitude Test (50), Drawing Test (2), in that order. Maximum marks: 400.

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

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

(v) Marking scheme (numerical value questions): $+4$ for a correct answer, -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 be a relation on the set $A = \{1, 2, 3, 4, \ldots, 10\}$ given by xRy if and only if x divides y. Let m be the number of elements in R and n be the number of minimum elements required to be added in R to make it a symmetric relation. Then $m + n$ is equal to [4 marks]

(A) 16

(B) 32

(C) 36

(D) 44

Correct Answer: (D) 44

Solution:

Concept:

- A relation is symmetric when every ordered pair (x, y) is accompanied by (y, x). Diagonal pairs already satisfy this condition.
- For a fixed positive integer x, the number of multiples of x in $\{1, \ldots, 10\}$ is $\lfloor 10/x \rfloor$. Count ordered pairs, not just distinct values appearing in them.

Step 1: Count all pairs in the given relation Each possible first coordinate contributes one pair for each of its multiples. Thus the contributions for first coordinates 1 through 10 are respectively 10, 5, 3, 2, 2, 1, 1, 1, 1 and 1. Adding these gives

$$m = 10 + 5 + 3 + 2 + 2 + 1 + 1 + 1 + 1 + 1 = 27.$$

This includes the ten diagonal pairs $(1, 1), \ldots, (10, 10)$, each exactly once.

Step 2: Identify the reverse pairs that are missing If two positive integers divide one another, they must be equal. Consequently no off-diagonal pair in this divisibility relation already has its reverse present. There are $27 - 10 = 17$ off-diagonal pairs, and each requires one distinct reverse pair. Adding these reverse pairs makes the relation symmetric; adding fewer leaves at least one original pair without a reverse. Therefore

$$n = 17, \qquad m + n = 27 + 17 = 44.$$

The values 16, 32 and 36 do not equal this count; in particular, doubling all 27 pairs would incorrectly count the diagonal pairs again.

Step 3: Conclusion The minimum number of additional pairs is 17, and $m + n = 44$. Hence, the correct option is (D).

Quick Tip to Solve: For divisibility on $\{1, \ldots, k\}$, subtract the k diagonal pairs before counting missing reverses.

2. If the range of the function $f(x) = \sqrt{3-x} + \sqrt{5+x}$ is $[\alpha, \beta]$, then $\alpha^2 + \beta^2$ is equal to [4 marks]

(A) 18

(B) 20

(C) 24

(D) 25

Correct Answer: (C) 24

Solution:

Concept:

- Both radicands must be nonnegative, so the real domain is $[-5, 3]$. The sum of the two radicands is the constant 8.
- For nonnegative u, v with fixed sum, their product is largest when they are equal. Squaring a nonnegative expression preserves its ordering.

Step 1: Bound the square of the function Put $u = 3 - x$ and $v = 5 + x$. On the domain, $u, v \geq 0$ and $u + v = 8$. Hence

$$f(x)^2 = u + v + 2\sqrt{uv} = 8 + 2\sqrt{uv}.$$

The product satisfies $0 \leq uv \leq 16$, since $(u - v)^2 \geq 0$ implies $4uv \leq (u + v)^2 = 64$. It follows that $8 \leq f(x)^2 \leq 16$. Both bounds must still be checked for attainability.

Step 2: Find the endpoints and the requested sum The product is zero at $x = -5$ or $x = 3$, giving $f(x) = \sqrt{8} = 2\sqrt{2}$. Equality $u = v = 4$ occurs at $x = -1$, giving $f(-1) = 4$. The function is continuous throughout its domain, so it takes every value between this minimum and maximum. Therefore

$$\alpha = 2\sqrt{2}, \qquad \beta = 4, \qquad \alpha^2 + \beta^2 = 8 + 16 = 24.$$

The other proposed values 18, 20 and 25 do not follow from these attained bounds. The endpoint value is not the maximum: both radicals contribute equally at the maximum.

Step 3: Conclusion The range is $[2\sqrt{2}, 4]$, so $\alpha^2 + \beta^2 = 24$. Hence, the correct option is (C).

Quick Tip to Solve: When two nonnegative radicands have a fixed sum, square their radical sum and maximize their product.

3. If the line $\arg(z) = \frac{\pi}{3}$ intersects the curve $|z - 2\sqrt{3}i| = 2$, $z \in \mathbb{C}$, at two distinct points A and B, then AB equals [4 marks]

(A) 1

(B) 2

(C) 4

(D) 6

Correct Answer: (B) 2

Solution:

Concept:

- Write $z = r(\cos\theta + i\sin\theta)$, where $r > 0$ and $\theta = \arg z$. A fixed argument specifies a ray from the origin.
- The equation $|z - 2\sqrt{3}i| = 2$ represents the circle with centre $(0, 2\sqrt{3})$ and radius 2. Distances along a fixed unit-direction ray equal differences of radial coordinates.

Step 1: Parameterize the ray and impose the circle condition For argument $\pi/3$, the Cartesian coordinates are

$$x = \frac{r}{2}, \qquad y = \frac{\sqrt{3}r}{2}, \qquad r > 0.$$

The circle equation is $x^2 + (y - 2\sqrt{3})^2 = 4$. Substitution gives

$$\frac{r^2}{4} + \left(\frac{\sqrt{3}r}{2} - 2\sqrt{3}\right)^2 = 4.$$

Expanding the second square carefully produces $3r^2/4 - 6r + 12$, so the equation simplifies to $r^2 - 6r + 8 = 0$.

Step 2: Find the intersection radii and their separation Factor the quadratic:

$$(r - 2)(r - 4) = 0.$$

Both roots, 2 and 4, are positive, so both intersection points lie on the required ray rather than on its opposite extension. Their position vectors are 2 and 4 times the same unit vector. Thus

$$AB = |4 - 2| = 2.$$

As a geometric check, the centre is at perpendicular distance $\sqrt{3}$ from the supporting line, making the half-chord $\sqrt{2^2 - (\sqrt{3})^2} = 1$. The full chord is therefore 2. Option 1 gives only the half-chord, while 4 is the farther radius from the origin and 6 is the sum of the radii; neither is the separation.

Step 3: Conclusion The two points have radial coordinates 2 and 4, and $AB = 2$. Hence, the correct option is (B).

Quick Tip to Solve: On a fixed argument ray, solve for positive radial coordinates and subtract them to obtain the distance.

4. If the system of linear equations : $x + y + z = 4$, $x + 2y + 3z = 6$, $4x + 5y + \lambda z = \mu$ has more than one solution, then the value of $\lambda + \mu$ is equal to [4 marks]

(A) 18

(B) 9

(C) 12

(D) 24

Correct Answer: (D) 24

Solution:

Concept:

- A linear system has more than one solution only when it is consistent and has a free variable. A zero determinant alone does not establish consistency.
- If two independent equations are fixed, a third equation allowing infinitely many solutions must be a linear combination of them, including its right-hand side.

Step 1: Express two variables in terms of the third Subtract the first equation from the second to obtain

$$y + 2z = 2, \qquad y = 2 - 2z.$$

Substitute this expression in $x + y + z = 4$:

$$x + (2 - 2z) + z = 4, \qquad x = 2 + z.$$

Thus the first two equations describe a line of solutions parameterized by z. They are independent because their coefficient rows are not proportional.

Step 2: Require the third equation to hold throughout the line Substitute $x = 2 + z$ and $y = 2 - 2z$ into the third equation:

$$4(2 + z) + 5(2 - 2z) + \lambda z = \mu.$$

After collection this becomes

$$18 + (\lambda - 6)z = \mu.$$

If $\lambda \neq 6$, this equation fixes exactly one value of z, giving a unique solution. For more than one solution the coefficient of z must vanish, and the remaining equality must also hold. Therefore $\lambda = 6$ and $\mu = 18$. These values make the third equation three times the first plus the second, confirming consistency. Hence $\lambda + \mu = 24$. The value 18 is only μ; 9 and 12 satisfy neither required sum nor the dependence check.

Step 3: Conclusion The required parameters are $\lambda = 6$ and $\mu = 18$, giving $\lambda + \mu = 24$. Hence, the correct option is (D).

Quick Tip to Solve: After solving two independent equations parametrically, make the third an identity to obtain infinitely many solutions.

5. Let $b_1 = 3, b_2, b_3, \ldots$ be a geometric progression of increasing positive numbers. Let $\sum_{n=1}^{20} b_{3n} = 4\sum_{n=1}^{20} b_{3n-2}$. Then, the sum of the first ten terms of the G. P. is [4 marks]

(A) 1023

(B) 2046

(C) 3069

(D) 3149

Correct Answer: (C) 3069

Solution:

Concept:

- For a geometric progression with first term 3 and common ratio r, $b_k = 3r^{k-1}$. Increasing positive terms require $r > 1$.
- Terms whose indices differ by two have the constant ratio r^2. The sum of the first N terms is $3(r^N - 1)/(r - 1)$ when $r \neq 1$.

Step 1: Compare corresponding terms of the two sums For every integer n in the specified range, the indices $3n$ and $3n - 2$ differ by two. Consequently

$$b_{3n} = r^2 b_{3n-2}.$$

Summing these identities over $n = 1, \ldots, 20$ gives

$$\sum_{n=1}^{20} b_{3n} = r^2 \sum_{n=1}^{20} b_{3n-2}.$$

All terms of the latter sum are positive, so this sum is nonzero and can safely be cancelled when compared with the given equation. We obtain $r^2 = 4$.

Step 2: Select the admissible ratio and sum ten terms The algebraic possibilities are $r = 2$ and $r = -2$. A negative ratio would alternate signs, contradicting positive terms, and is therefore excluded. With $r = 2$, the terms begin 3, 6, 12 and continue increasing, as required. The geometric sum is

$$S_{10} = 3\frac{2^{10} - 1}{2 - 1} = 3(1024 - 1) = 3069.$$

The value 1023 omits the first-term factor 3. The value 2046 uses 2 as the first term instead of 3, while 3149 is not the value of the required geometric sum. No expansion of the twenty-term sums is needed because their corresponding terms already have a fixed ratio.

Step 3: Conclusion The common ratio is 2 and the sum of the first ten terms is 3069. Hence, the correct option is (C).

Quick Tip to Solve: Before expanding sums of GP terms, compare the corresponding indices; a constant index shift gives a common factor.

6. If all the words, with or without meaning, made using all the letters of the word "RANCHI" are arranged as in a dictionary, then the word at 560^{th} position is : [4 marks]

(A) NICHRA

(B) NICAHR

(C) NICARH

(D) NICHAR

Correct Answer: (C) NICARH

Solution:

Concept:

- The six letters A, C, H, I, N and R are distinct. Dictionary order first compares the earliest position at which two words differ.
- With a prefix fixed and k letters remaining, that prefix accounts for $k!$ words. Use one-based positions consistently when subtracting complete blocks.

Step 1: Locate the first three letters by factorial blocks The alphabetical order is A, C, H, I, N, R. Each first-letter block contains $5! = 120$ words. The first four blocks occupy positions 1 through 480, so position 560 begins with N and has local position $560 - 480 = 80$. The remaining letters are A, C, H, I, R. Each second-letter block contains $4! = 24$ words. Three such blocks account for 72 words, so the second letter is I, with local position 8. Among the remaining A, C, H, R, each third-letter block has $3! = 6$ words. Skipping the A block leaves local position 2 in the C block. The prefix is therefore NIC.

Step 2: Resolve the final letters and check the alternatives The remaining letters are A, H and R. Each fourth-letter block has $2! = 2$ words, so local position 2 lies in the first block, beginning with A. Its two words end in HR and RH, in that order. Thus the required word is NICARH. Its rank can be checked directly:

$$4(5!) + 3(4!) + 1(3!) + 0(2!) + 1(1!) + 1 = 560.$$

For comparison, NICAHR is position 559, NICHAR is position 561 and NICHRA is position 562. These adjacent alternatives illustrate why the final one-based offset matters; a zero-based remainder must not be mistaken for a dictionary rank.

Step 3: Conclusion The word at the 560^{th} position is NICARH. Hence, the correct option is (C).

Quick Tip to Solve: Subtract complete factorial-sized prefix blocks, then retain a one-based position within the selected block.

7. The number of integral terms in the binomial expansion of $\left(11^{\frac{1}{2}}+17^{\frac{1}{8}}\right)^{1024}$ is [4 marks]

(A) 129

(B) 131

(C) 133

(D) 137

Correct Answer: (A) 129

Solution:

Concept:

- The general term in the expansion of $(a+b)^n$ is $T_{r+1}=\binom{n}{r}a^{n-r}b^r$, where r runs through all integers from zero to n, inclusive.
- For distinct prime bases, a product of rational powers is an integer only when the exponent of each prime is a nonnegative integer. An integer binomial coefficient cannot remove a fractional prime exponent.

Step 1: Write the general term Choose r copies of the second summand and $1024-r$ copies of the first. This gives

$$T_{r+1}=\binom{1024}{r}11^{(1024-r)/2}17^{r/8}, \qquad 0\le r\le 1024.$$

The coefficient is an integer, so the issue is whether either prime retains a fractional exponent. Since 11 and 17 are different primes, their radicals cannot cancel one another.

Step 2: Impose the divisibility conditions For the exponent of 17 to be integral, r must be divisible by 8. This condition also makes r even, and therefore makes $(1024-r)/2$ integral. Thus the two conditions together reduce to

$$r=8k, \qquad k=0,1,\ldots,128.$$

Both exponents remain nonnegative throughout this range, including its endpoints.

Step 3: Count both endpoints and compare the options There is one integral term for each of the 129 possible integers k. In particular, the two pure-power endpoint terms are both included; omitting either endpoint would give an incorrect count.

$$N=\frac{1024-0}{8}+1=129.$$

The proposed counts 131, 133 and 137 exceed the number of available multiples of 8 and hence cannot occur.

Step 4: Conclusion There are $\boxed{129}$ integral terms. Hence, the correct option is (A).

Quick Tip to Solve: Express each radical using its distinct prime base, find the allowed indices by divisibility, and add one when counting the two endpoints.

8. Two persons A and B alternately throw a pair of dice. A wins if he throws a sum of 4 before B throws a sum of 9 and B wins if he throws a sum of 9 before A throws a sum of 4. The probability, that A wins if B makes the first throw, is [4 marks]

(A) $\frac{1}{5}$
(B) $\frac{2}{5}$
(C) $\frac{3}{5}$
(D) $\frac{4}{5}$

Correct Answer: (B) $\frac{2}{5}$

Solution:

Concept:

- A pair of fair dice has 36 equally likely ordered outcomes. The probability of a target sum is its number of ordered pairs divided by 36.
- After both players fail in one complete round, the game returns to the same state. Repeated rounds therefore give a geometric series with independent trials.

Step 1: Find each player's success probability A obtains sum 4 from $(1,3),(2,2),(3,1)$, whereas B obtains sum 9 from $(3,6),(4,5),(5,4),(6,3)$. Hence

$$p_A = \frac{3}{36} = \frac{1}{12}, \qquad p_B = \frac{4}{36} = \frac{1}{9}.$$

The corresponding failure probabilities are $11/12$ and $8/9$. They apply only on the respective player's own turns.

Step 2: Account for B making the first throw For A to win on his first turn, B must fail first and A must then succeed. The probability is

$$u = \frac{8}{9} \cdot \frac{1}{12} = \frac{2}{27}.$$

If both fail, the next throw again belongs to B, so the original situation restarts. The probability of this complete unsuccessful round is

$$r = \frac{8}{9} \cdot \frac{11}{12} = \frac{22}{27}.$$

Step 3: Sum the mutually exclusive winning events A may win in the first, second, third or any later complete round. Their probabilities are $u, ru, r^2u, \ldots$, so

$$P(A) = \frac{u}{1-r} = \frac{2/27}{1-22/27} = \frac{2}{5}.$$

The probabilities of all possible eventual wins total one because $r < 1$. Thus B's probability is $3/5$, not A's; $1/5$ and $4/5$ also fail this recurrence.

Step 4: Conclusion The required probability is $\boxed{\frac{2}{5}}$. Hence, the correct option is (B).

Quick Tip to Solve: Group the throws into rounds beginning with the first player. Multiply the later player's success by the first player's failure before summing the geometric series.

9. The mean and standard deviation of four numbers are given by 10 and $\frac{5\sqrt{2}}{2}$, respectively. If a fifth number 15 is added to the data set, then the variance of the new data set is [4 marks]

(A) 13.5

(B) 13

(C) 14.5

(D) 14

Correct Answer: (D) 14

Solution:

Concept:

- For n observations with mean $\bar{x}$, the population variance is $\sigma^2 = \frac{1}{n}\sum x_i^2 - \bar{x}^2$. The standard deviation is its nonnegative square root.
- When an observation is added, update both the sum and the sum of squares. The mean changes, so the previous variance cannot simply be averaged with the new observation.

Step 1: Recover the original sums Let the original four observations be $x_1, \ldots, x_4$. Their mean is 10, giving

$$\sum_{i=1}^{4} x_i = 4(10) = 40.$$

Squaring the given standard deviation yields

$$\sigma^2 = \left(\frac{5\sqrt{2}}{2}\right)^2 = \frac{25}{2}.$$

Using the population-variance identity,

$$\sum_{i=1}^{4} x_i^2 = 4\left(\frac{25}{2} + 10^2\right) = 450.$$

No individual original observation needs to be determined.

Step 2: Update the data totals and mean Adding the fifth observation 15 changes the sum by 15 and the sum of squares by $15^2 = 225$. Therefore

$$n_{\text{new}} = 5, \qquad S_{\text{new}} = 40 + 15 = 55, \qquad S_{2,\text{new}} = 450 + 225 = 675.$$

The new mean is $55/5 = 11$, rather than the old mean 10. This change must be included when computing the new spread.

Step 3: Calculate the new population variance Apply the same variance identity to all five observations:

$$\sigma^2_{\text{new}} = \frac{675}{5} - 11^2 = 135 - 121 = 14.$$

As a check, the original sum of squared deviations was $4(12.5) = 50$; shifting its centre from 10 to 11 adds 4, and the new observation contributes $(15-11)^2 = 16$, giving $(50 + 4 + 16)/5 = 14$. Thus 13, 13.5 and 14.5 disagree with both calculations.

Step 4: Conclusion The variance of the new data set is $\boxed{14}$. Hence, the correct option is (D).

Quick Tip to Solve: Keep the two totals $\sum x_i$ and $\sum x_i^2$; these are enough to update the variance without reconstructing the original data.

10. Let the distance between the foci of an ellipse $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1(a>b)$ be 4 and the distance between its directrices be 10. Then the length of its latus rectum is : [4 marks]

(A) $\frac{12}{\sqrt{10}}$
(B) $\frac{6}{\sqrt{10}}$
(C) $\frac{8}{\sqrt{5}}$
(D) $\sqrt{10}$

Correct Answer: (A) $\frac{12}{\sqrt{10}}$

Solution:

Concept:

- For an ellipse with horizontal major axis, $c=ae$, $c^2=a^2-b^2$, and the foci are $(\pm c,0)$. Here $a>b>0$.
- The directrices are $x=\pm a/e$. Their separation is $2a/e$, while the length of a full latus rectum is $2b^2/a$.

Step 1: Translate the two given separations The distance between the two foci is $2c$. Therefore

$$2c=4 \quad\Longrightarrow\quad c=2.$$

The distance between the two parallel directrices is $2a/e$, so

$$\frac{2a}{e}=10 \quad\Longrightarrow\quad \frac{a}{e}=5.$$

These distances refer to pairs of foci and directrices; using either full separation as a single coordinate would introduce a factor-of-two error.

Step 2: Determine the semiaxes Since $e=c/a$, substitute into the directrix relation:

$$\frac{a}{e}=\frac{a^2}{c}=5.$$

With $c=2$, this gives $a^2=10$ and $a=\sqrt{10}$. Next,

$$b^2=a^2-c^2=10-4=6.$$

The resulting eccentricity $e=2/\sqrt{10}$ lies between zero and one, as required for an ellipse, and $a^2>b^2$ confirms the stated orientation.

Step 3: Find the complete latus rectum The latus rectum is the chord through a focus perpendicular

to the major axis, so its full length is

$$L = \frac{2b^2}{a} = \frac{2(6)}{\sqrt{10}} = \frac{12}{\sqrt{10}}.$$

Option (B) gives only the semilatus rectum. Option (D) is the major semiaxis rather than this chord, and option (C) does not equal the value obtained from the two prescribed separations.

Step 4: Conclusion The latus rectum has length $\boxed{\frac{12}{\sqrt{10}}}$. Hence, the correct option is (A).

Quick Tip to Solve: Use $2c$ for focal separation and $2a/e$ for directrix separation, then eliminate e using $ae = c$.

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11. Let e_1 and e_2 be the eccentricities of the ellipse $2x^2 + 9y^2 = 36$ and the hyperbola $4x^2 - 9y^2 = 36$, respectively. Then the distance between the point of intersection of the lines $5x - 7y = 3$ and $3x + y = 7$, and the point $(9e_1^2, 9e_2^2)$ is [4 marks]

(A) 11

(B) 12

(C) 13

(D) 15

Correct Answer: (C) 13

Solution:

Concept:

- For the ellipse $x^2/a^2 + y^2/b^2 = 1$, with $a > b$, $e^2 = 1 - b^2/a^2$. For the hyperbola $x^2/a^2 - y^2/b^2 = 1$, $e^2 = 1 + b^2/a^2$.
- The distance between (x_1, y_1) and (x_2, y_2) is $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$. The line intersection is obtained by solving both equations together.

Step 1: Calculate the two squared eccentricities Dividing the ellipse equation by 36 gives

$$\frac{x^2}{18} + \frac{y^2}{4} = 1, \qquad e_1^2 = 1 - \frac{4}{18} = \frac{7}{9}.$$

Dividing the hyperbola equation by 36 gives

$$\frac{x^2}{9} - \frac{y^2}{4} = 1, \qquad e_2^2 = 1 + \frac{4}{9} = \frac{13}{9}.$$

Thus the specified point is $R = (9e_1^2, 9e_2^2) = (7, 13)$. The plus sign in the hyperbola formula is essential.

Step 2: Find the intersection of the lines From $3x + y = 7$, write $y = 7 - 3x$. Substitute this into the other line:

$$5x - 7(7 - 3x) = 3 \quad \Longrightarrow \quad 26x = 52.$$

Hence $x = 2$, and then $y = 1$. The point $S = (2, 1)$ satisfies both equations: $10 - 7 = 3$ and $6 + 1 = 7$.

Step 3: Evaluate and check the distance The horizontal and vertical differences from S to R are 5 and 12. Therefore

$$SR = \sqrt{(7-2)^2 + (13-1)^2} = \sqrt{25+144} = \sqrt{169} = 13.$$

This is also the familiar 5–12–13 right-triangle relation. The alternatives 11, 12 and 15 have squares 121, 144 and 225, respectively; none equals the sum of the squared coordinate differences.

Step 4: Conclusion The required distance is $\boxed{13}$. Hence, the correct option is (C).

Quick Tip to Solve: Calculate e^2 directly rather than taking square roots, because the point coordinates already contain squared eccentricities.

12. Let $A(3,4)$, $B(5,-2)$ and $P(\alpha,\beta)$, $\alpha\beta \neq 0$, be three point such that $PA = PB$ and the area of ΔPAB is 10. Then the distance of the point $Q\left(2\alpha - 5\beta, \alpha - \beta^2\right)$, from the line having intercepts 3 and 1 on x- and y- axis respectively, is [4 marks]

(A) 10

(B) $\sqrt{10}$

(C) 15

(D) 2

Correct Answer: (B) $\sqrt{10}$

Solution:

Concept:

- The condition $PA = PB$ places P on the perpendicular bisector of AB; subtracting the two squared-distance equations removes the quadratic terms.
- The area of a triangle is half the absolute value of its two-dimensional determinant. The distance from (x_0, y_0) to $ux + vy + w = 0$ is $|ux_0 + vy_0 + w|/\sqrt{u^2+v^2}$.

Step 1: Use the equality of distances Equating the squared distances to $A(3,4)$ and $B(5,-2)$ gives

$$(\alpha-3)^2 + (\beta-4)^2 = (\alpha-5)^2 + (\beta+2)^2.$$

After expanding and cancelling the squared terms,

$$4\alpha - 12\beta - 4 = 0, \qquad \alpha = 3\beta + 1.$$

This linear relation uses the actual coordinates of both fixed points and is the perpendicular-bisector equation.

Step 2: Apply the triangle area and exclude the forbidden point Using $B - A = (2,-6)$ and $P - A = (\alpha-3, \beta-4)$,

$$\text{Area} = \frac{1}{2}|2(\beta-4) + 6(\alpha-3)| = |3\alpha + \beta - 13| = 10.$$

Thus $3\alpha + \beta = 23$ or 3. Substituting $\alpha = 3\beta + 1$ yields $(\alpha,\beta) = (7,2)$ or $(1,0)$. The second point

violates $\alpha\beta \neq 0$, so only $(7, 2)$ is admissible.

Step 3: Construct Q and measure its distance from the line The admissible values give

$$Q = (2\alpha - 5\beta, \alpha - \beta^2) = (14 - 10, 7 - 4) = (4, 3).$$

The intercept form of the required line is $x/3 + y = 1$, or $x + 3y - 3 = 0$. Hence

$$d = \frac{|4 + 3(3) - 3|}{\sqrt{1^2 + 3^2}} = \frac{10}{\sqrt{10}} = \sqrt{10}.$$

The numerator 10 alone is not the distance; division by the normal-vector length is required. Neither 15 nor 2 agrees with this formula.

Step 4: Conclusion The required distance is $\boxed{\sqrt{10}}$. Hence, the correct option is (B).

Quick Tip to Solve: Keep both signs of the area equation, then apply $\alpha\beta \neq 0$ before forming Q; use the normalized point-to-line distance formula.

13. The number of integral values of n, for which the equation $3\cos x + 5\sin x = 2n + 1$ has a solution, is [4 marks]

(A) 4

(B) 6

(C) 8

(D) 10

Correct Answer: (B) 6

Solution:

Concept:

- The range of $a\cos x + b\sin x$ is $[-R, R]$, where $R = \sqrt{a^2 + b^2}$. Write the expression as a shifted sine to see that every value in this interval is attained.
- The equation has a real solution precisely when its right-hand side belongs to that range. After finding the allowed interval for n, count integers, not real numbers or values of x.

Step 1: Find the exact range Write $3\cos x + 5\sin x = \sqrt{34}\sin(x + \phi)$, where $\sin\phi = 3/\sqrt{34}$ and $\cos\phi = 5/\sqrt{34}$. Both coefficients are thereby reproduced, and the sine covers its entire range as x varies. Hence the necessary and sufficient condition is

$$-\sqrt{34} \leq 2n + 1 \leq \sqrt{34}.$$

There is no additional restriction on x, so every admissible right-hand side is attained.

Step 2: Count the admissible integers Subtract 1 and divide all sides by the positive number 2:

$$\frac{-\sqrt{34} - 1}{2} \leq n \leq \frac{\sqrt{34} - 1}{2}.$$

Since $5 < \sqrt{34} < 6$, the left endpoint lies strictly between -3.5 and -3, while the right endpoint lies strictly between 2 and 2.5. Thus the complete list is

$$n = -3, -2, -1, 0, 1, 2.$$

The corresponding odd values $2n + 1$ are $-5, -3, -1, 1, 3, 5$, all inside the exact range. The next choices give -7 or 7 and fail. Therefore counts 4, 8 and 10 omit admissible integers or include impossible ones.

Step 3: Conclusion There are $\boxed{6}$ integral values of n. Hence, the correct option is (B).

Quick Tip to Solve: Bound the odd integer $2n + 1$ first: only $-5, -3, -1, 1, 3, 5$ fit between $-\sqrt{34}$ and $\sqrt{34}$.

14. Let the points $A(a, -1, 2)$, $B(1, b, -4)$, $C(-1, 1, c)$ and $D(1, -2, 8)$ be the vertices of a parallelogram $ABCD$. Then its area is equal to [4 marks]

(A) $2\sqrt{73}$

(B) $2\sqrt{51}$

(C) 28

(D) 14

Correct Answer: (C) 28

Solution:

Concept:

- In a parallelogram $ABCD$, opposite vertices have the same diagonal midpoint, so their position vectors satisfy $A + C = B + D$. This determines the unknown coordinates without assuming the shape is a rectangle.
- The area is $|\overrightarrow{AB} \times \overrightarrow{AD}|$, the magnitude of the cross product of two adjacent sides. Half this magnitude is the area of a triangle, not the parallelogram.

Step 1: Determine the missing coordinates Equate coordinates in $A + C = B + D$:

$$(a - 1, 0, 2 + c) = (2, b - 2, 4).$$

Thus $a = 3$, $b = 2$ and $c = 2$. In particular, $A = (3, -1, 2)$. Taking both side vectors from this same vertex gives

$$\overrightarrow{AB} = (-2, 3, -6), \qquad \overrightarrow{AD} = (-2, -1, 6).$$

Using a diagonal in place of one adjacent side would require a separate justification; these two vectors directly span the parallelogram.

Step 2: Compute the cross product and its magnitude Evaluate the determinant with the usual alternating signs:

$$\begin{aligned}\overrightarrow{AB} \times \overrightarrow{AD} &= (3 \cdot 6 - (-6)(-1),\ (-6)(-2) - (-2)6,\ (-2)(-1) - 3(-2)) \\ &= (12, 24, 8).\end{aligned}$$

Its squared length is

$$12^2 + 24^2 + 8^2 = 144 + 576 + 64 = 784.$$

Therefore the area is $\sqrt{784} = 28$ square units. The option 14 would result from incorrectly taking half the cross-product magnitude. The other proposed squared areas, $4 \cdot 73 = 292$ and $4 \cdot 51 = 204$, do not equal 784 and are also excluded.

Step 3: Conclusion The area of $ABCD$ is $\boxed{28}$ square units. Hence, the correct option is (C).

Quick Tip to Solve: Find unknown vertices from equal diagonal midpoints, then use two side vectors starting at one vertex; do not divide the cross product by 2.

15. Let (α, β, γ) be the foot of the perpendicular from the point $(25, 2, 41)$ on the line $\frac{x-4}{3} = \frac{y+1}{7} = \frac{z-2}{3}$. Then $\alpha + \beta + \gamma$ is equal to [4 marks]

(A) 41

(B) 42

(C) 44

(D) 45

Correct Answer: (C) 44

Solution:

Concept:

- A point on the given line has the form $H = (4, -1, 2) + t(3, 7, 3)$, where t is a real parameter and $(3, 7, 3)$ is its direction vector.
- For the foot of a perpendicular from P, the displacement $P - H$ is orthogonal to the line direction. Its dot product with that direction must therefore be zero.

Step 1: Impose the perpendicularity condition Let $P = (25, 2, 41)$. From the symmetric equation,

$$H = (4 + 3t, -1 + 7t, 2 + 3t).$$

Subtracting from P yields

$$P - H = (21 - 3t, 3 - 7t, 39 - 3t).$$

Hence

$$(21 - 3t)3 + (3 - 7t)7 + (39 - 3t)3 = 0.$$

The constant terms sum to $63 + 21 + 117 = 201$; the coefficient subtracted from them is $(9 + 49 + 9)t = 67t$. Thus $201 - 67t = 0$, and the unique parameter is $t = 3$.

Step 2: Find and verify the foot Substitute $t = 3$ into every coordinate, retaining the minus sign in the initial y-coordinate:

$$(\alpha, \beta, \gamma) = (13, 20, 11).$$

As a check, the three line ratios are $(13 - 4)/3 = 3$, $(20 + 1)/7 = 3$, and $(11 - 2)/3 = 3$. Also $P - H = (12, -18, 30)$, whose dot product with $(3, 7, 3)$ is $36 - 126 + 90 = 0$, confirming the

perpendicular foot rather than merely a point on the line. Finally,

$$\alpha + \beta + \gamma = 13 + 20 + 11 = 44.$$

Consequently 41, 42 and 45 fail the coordinate sum of the independently verified foot.

Step 3: Conclusion $\boxed{\alpha + \beta + \gamma = 44}$. Hence, the correct option is (C).

Quick Tip to Solve: Use $t = ((P - A) \cdot d)/(d \cdot d)$ for projection onto $A + td$; here the dot products are 201 and 67.

16. Consider a sphere of volume 36π. Then the height, of the cone of maximum volume that can be inscribed in the sphere, is [4 marks]

(A) 1

(B) 4

(C) $\sqrt{3}$

(D) $2\sqrt{3}$

Correct Answer: (B) 4

Solution:

Concept:

- A sphere of radius R has volume $4\pi R^3/3$. The cone volume is $\pi r^2 h/3$, where r is its base radius and h its height.
- For a right circular cone inscribed in the sphere, a central axial section gives $r^2 = R^2 - (h - R)^2 = 2Rh - h^2$, with $0 \le h \le 2R$. Maximising volume therefore becomes a one-variable problem.

Step 1: Express the cone volume in terms of its height The stated sphere volume gives

$$\frac{4}{3}\pi R^3 = 36\pi \quad \Rightarrow \quad R^3 = 27 \quad \Rightarrow \quad R = 3.$$

Place the cone vertex at the top of the sphere. Its base plane is a distance $|R - h|$ from the centre, so the base circle satisfies the right-triangle relation used above. Substitution into the volume formula yields

$$V(h) = \frac{\pi}{3}h(6h - h^2) = \frac{\pi}{3}(6h^2 - h^3), \qquad 0 \le h \le 6.$$

This keeps the base radius linked to the height; varying them independently would ignore the inscribed condition.

Step 2: Locate the global maximum Differentiate:

$$V'(h) = \frac{\pi}{3}(12h - 3h^2) = \pi h(4 - h).$$

Thus the interior stationary point is $h = 4$. The derivative is positive for $0 < h < 4$ and negative for $4 < h < 6$, so this is a maximum. Equivalently $V''(4) = \pi(4 - 8) = -4\pi < 0$. At both endpoints the cone is degenerate and has zero volume, whereas $V(4) = 32\pi/3 > 0$. Hence the interior maximum is

also the global one. The heights 1, $\sqrt{3}$ and $2\sqrt{3}$ are not stationary and therefore cannot maximise the volume.

Step 3: Conclusion The required height is $\boxed{4}$ units. Hence, the correct option is (B).

Quick Tip to Solve: For an inscribed maximum-volume cone, derive $r^2 = 2Rh - h^2$; differentiating then gives the reusable result $h = 4R/3$.

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17. If $f(x) = \begin{vmatrix} -\cos x & \tan x & 3\sin x \\ 1 & -3x & 2x^2 \\ x^3 & x & x^2 \end{vmatrix}$, **then the value of** $\lim_{x\to 0} \frac{(1+x)f(x) - 3x\sin x}{x^3}$ **is** [4 marks]

(A) 3

(B) 5

(C) 7

(D) 8

Correct Answer: (C) 7

Solution:

Concept:

- Expand a third-order determinant along its first row, using the cofactor signs $+, -, +$. Retain terms sufficiently far to survive the division by x^3.
- The standard limits $\sin x/x \to 1$, $\tan x/x \to 1$ and $\cos x \to 1$ as $x \to 0$ evaluate the resulting expression without repeated differentiation.

Step 1: Expand and separate the cancelling term The three first-row contributions give exactly

$$\begin{aligned} f(x) &= (-\cos x)(-3x^3 - 2x^3) \\ &\quad - \tan x\,(x^2 - 2x^5) + 3\sin x\,(x + 3x^4) \\ &= 3x\sin x + g(x), \end{aligned}$$

where

$$g(x) = 5x^3\cos x - x^2\tan x + 2x^5\tan x + 9x^4\sin x.$$

The first term is the one explicitly subtracted in the numerator, but multiplying $f(x)$ by $1 + x$ leaves a further contribution from it. Dropping that extra term would give the wrong limit.

Step 2: Divide by the correct power and evaluate Using the separation above,

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

For nonzero x near zero,

$$\frac{g(x)}{x^3} = 5\cos x - \frac{\tan x}{x} + 2x^2\tan x + 9x\sin x.$$

The four terms tend respectively to $5, -1, 0, 0$. The desired limit is therefore

$$3 + (1)(5 - 1) = 7.$$

As an order check, $g(x) = 4x^3 + o(x^3)$, while the residual $3x^2 \sin x$ contributes another $3x^3 + o(x^3)$. Thus none of the other proposed values 3, 5 or 8 accounts for all terms with their correct signs.

Step 3: Conclusion The limit is $\boxed{7}$. Hence, the correct option is (C).

Quick Tip to Solve: Before taking a limit, isolate the determinant term that cancels; the multiplier $1 + x$ leaves an extra cubic contribution.

18. The area of the region $\left\{(x, y) : \sin x \le y \le \sqrt{\pi^2 - x^2}\right\}$ is: [4 marks]

(A) π^3
(B) $\frac{\pi^3}{2}$
(C) $\frac{\pi^3}{4}$
(D) $\frac{\pi^3}{8}$

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

Solution:

Concept:

- The graph $y = \sqrt{\pi^2 - x^2}$ is the upper semicircle of radius π, defined on $[-\pi, \pi]$. The area between an upper and a lower curve is the integral of their vertical difference wherever their ordering holds.
- The function $\sin x$ is odd, so its integral over the symmetric interval $[-\pi, \pi]$ is zero. This cancellation concerns signed integrals, while the vertical difference itself remains nonnegative.

Step 1: Check the complete horizontal extent For $-\pi \le x \le 0$, the sine is nonpositive and the semicircle nonnegative, so the required ordering holds. For $0 \le x \le \pi/2$, the semicircle is at least $\sqrt{3}\pi/2 > 1$, hence exceeds $\sin x$. For $\pi/2 \le x \le \pi$, put $t = \pi - x$, so $0 \le t \le \pi/2$. Since $\sin x = \sin t \le t$ and

$$\pi^2 - x^2 = t(2\pi - t) \ge t^2,$$

the semicircle is again at least $\sin x$. Thus no internal interval is excluded and the integration limits really are $-\pi$ and π.

Step 2: Integrate the vertical difference The area is

$$A = \int_{-\pi}^{\pi} \left(\sqrt{\pi^2 - x^2} - \sin x\right) dx.$$

The first integral is the area of an entire upper semicircle, namely $\frac{1}{2}\pi(\pi)^2 = \pi^3/2$. The second is zero by oddness, or by evaluating $[-\cos x]_{-\pi}^{\pi} = 0$. Therefore

$$A = \frac{\pi^3}{2} - 0 = \frac{\pi^3}{2}.$$

Option A would use a full circle. Options C and D incorrectly restrict the horizontal region or take an extra fraction of the semicircle; the domain includes negative as well as positive x.

Step 3: Conclusion The area is $\boxed{\pi^3/2}$ square units. Hence, the correct option is (B).

Quick Tip to Solve: Check the domain of the radical before integrating; on symmetric limits the odd sine contribution cancels, leaving the semicircle area.

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19. Let $f(x) = \begin{cases} 3x, & x < 0 \\ 1 + x + [x], & 0 \le x \le 2 \\ 5, & x > 2 \end{cases}$ **, where** $[x]$ **denotes the greatest integer function. If** α **and** β **are the number of points in** $\mathbb{R}$**, where** f **is not continuous and is not differentiable, then** $\alpha + \beta$ **equals** [4 marks]

(A) 3

(B) 4

(C) 5

(D) 6

Correct Answer: (D) 6

Solution:

Concept:

- A function is continuous at a only when both one-sided limits exist and equal the assigned value $f(a)$. A mismatch of either limit makes the point a discontinuity.
- The greatest integer function $[x]$ is constant between consecutive integers and jumps at integers. Here it occurs only on $[0, 2]$, so the only points needing special checks are $0, 1, 2$.
- Differentiability implies continuity. Thus every discontinuity is also a point of non-differentiability; additional such points could occur at continuous junctions with unequal one-sided derivatives.

Step 1: Check continuity at the left junction For $x < 0$, the formula is $3x$. For $0 \le x < 1$, the greatest integer is zero, so the formula is $1 + x$. Therefore

$$\lim_{x \to 0^-} f(x) = 0, \qquad \lim_{x \to 0^+} f(x) = 1, \qquad f(0) = 1.$$

The left and right limits differ, so f is discontinuous at 0. In particular, it cannot be differentiable there, regardless of the slopes of the separate formulae.

Step 2: Check the interior integer and the right junction Immediately below 1, $[x] = 0$; immediately above 1, $[x] = 1$. Thus

$$\lim_{x \to 1^-} f(x) = 2, \qquad \lim_{x \to 1^+} f(x) = 3, \qquad f(1) = 3.$$

Hence 1 is a discontinuity. Immediately below 2, the formula is $2 + x$, whereas $f(2) = 1 + 2 + [2] = 5$

and the formula beyond 2 is the constant 5. Consequently

$$\lim_{x\to 2^-} f(x) = 4, \qquad \lim_{x\to 2^+} f(x) = 5, \qquad f(2) = 5.$$

Thus 2 is also discontinuous. Both points are necessarily non-differentiable.

Step 3: Exclude all other real points and count On the open intervals $(-\infty, 0)$, $(0, 1)$, $(1, 2)$ and $(2, \infty)$, the function is respectively $3x$, $1 + x$, $2 + x$ and 5. Each is a polynomial or a constant and is both continuous and differentiable throughout its own open interval. There are therefore no additional exceptional points, including integers outside $[0, 2]$, where the greatest integer formula does not apply.

$$\alpha = 3, \qquad \beta = 3, \qquad \alpha + \beta = 6.$$

Options (A), (B) and (C) undercount these two sets: each of the three jumps belongs to both counts, so none of the totals $3, 4, 5$ is correct.

Step 4: Conclusion The discontinuities and points of non-differentiability are both exactly $\{0, 1, 2\}$. Hence $\alpha + \beta = 3 + 3 = 6$. Hence, the correct option is (D).

Quick Tip to Solve: Restrict greatest-integer jump checks to the interval where that formula is actually used, and check its endpoints separately before counting derivative failures.

20. Let $f(x) = \int \left(\frac{1}{\log_e x} - \frac{2}{(\log_e x)^3}\right) dx$. If $f(e) = 2e$, then $f\left(e^2\right)$ is equal to [4 marks]

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

Correct Answer: (C) $\frac{3e^2}{4}$

Solution:

Concept:

- An indefinite integral is a family of antiderivatives. The condition at $x = e$ fixes its additive constant on the interval $x > 1$, which also contains e^2.
- For expressions involving powers of $\log_e x$, differentiate $x(\log_e x)^{-n}$ using the product and chain rules. The derivative of $\log_e x$ is $1/x$.

Step 1: Construct a matching antiderivative Put $L = \log_e x$. Differentiating the two simple trial terms gives

$$\frac{d}{dx}\left(\frac{x}{L}\right) = \frac{1}{L} - \frac{1}{L^2}, \qquad \frac{d}{dx}\left(\frac{x}{L^2}\right) = \frac{1}{L^2} - \frac{2}{L^3}.$$

Adding cancels the intermediate inverse-square term, so the given integrand is exactly the derivative of $x/L + x/L^2$. Thus

$$f(x) = \frac{x}{\log_e x} + \frac{x}{(\log_e x)^2} + C.$$

This verifies the proposed primitive directly rather than treating $1/\log_e x$ in isolation.

Step 2: Use the initial value and evaluate At $x = e$, the logarithm is 1, so

$$f(e) = e + e + C = 2e + C.$$

The stated value $2e$ therefore gives $C = 0$. At $x = e^2$, the logarithm is 2, whence

$$f(e^2) = \frac{e^2}{2} + \frac{e^2}{4} = \frac{3e^2}{4}.$$

Option (A) retains only the inverse-square contribution, while option (B) retains only the inverse-first-power contribution. Both terms are required by the derivative check; option (D) is not their sum.

Step 3: Conclusion Therefore $f(e^2) = \dfrac{3e^2}{4}$. Hence, the correct option is (C).

Quick Tip to Solve: Differentiate a short sum of $x/(\log x)^n$ terms: adjacent inverse powers often cancel, avoiding unnecessary special-function integration.

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

21. Let the value of p, such that the sum of the squares of the roots of the quadratic equation $x^2 + (7-p)x + 4 = p$ has least value, be α and the corresponding roots be β and γ. Then $\alpha^3 + \beta^3 + \gamma^3$ equals _____. [4 marks]

Solution:

Concept:

- For roots u, v of $x^2 + Bx + C = 0$, Vieta gives $u + v = -B$ and $uv = C$. Their squared sum is $(u+v)^2 - 2uv$.
- Complete the square to minimize a quadratic in the parameter. The identity $u^3 + v^3 = (u+v)^3 - 3uv(u+v)$ then avoids solving for individual roots.

Step 1: Express and minimize the squared sum First move the parameter on the right to the constant term:

$$x^2 + (7-p)x + (4-p) = 0.$$

If the roots are u, v, then $u + v = p - 7$ and $uv = 4 - p$. Consequently

$$u^2 + v^2 = (p-7)^2 - 2(4-p) = p^2 - 12p + 41 = (p-6)^2 + 5.$$

The square is nonnegative and vanishes only at $p = 6$; hence the minimizing parameter is $\alpha = 6$. The discriminant there is $1 + 8 = 9 > 0$, so this minimum is attained with real roots as well.

Step 2: Calculate the cubic expression at the minimum The corresponding roots β, γ satisfy $\beta + \gamma = -1$ and $\beta\gamma = -2$. Applying the cubic identity gives

$$\beta^3 + \gamma^3 = (-1)^3 - 3(-2)(-1) = -1 - 6 = -7.$$

Thus

$$\alpha^3 + \beta^3 + \gamma^3 = 6^3 - 7 = 216 - 7 = 209.$$

As a separate check, the quadratic at the minimum is $x^2 + x - 2 = (x-1)(x+2)$, whose roots are 1 and -2; their cubes indeed sum to -7.

Step 3: Conclusion The required numerical value is $\boxed{209}$, a dimensionless number.

Quick Tip to Solve: Minimize the symmetric expression using Vieta before calculating roots; only substitute the minimizing parameter into the cubic-sum identity.

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22. Let $25^x + 25^{-x}, \frac{\alpha}{3}, 20^{1+x} + 20^{1-x}$, $x, \alpha \in \mathbb{R}$ be the first three terms of an A.P. of increasing terms. For the least value of α, the sum of its first 10 terms is _____. [4 marks]

Solution:

Concept:

- For consecutive terms a, b, c of an A.P., $2b = a + c$. Its first ten terms have sum $S_{10} = 5(2a + 9d)$, where $d = b - a$.
- For every positive t, $t + t^{-1} \geq 2$, with equality exactly when $t = 1$. This follows from $(\sqrt{t} - 1/\sqrt{t})^2 \geq 0$.

Step 1: Find the least possible middle term The A.P. condition implies

$$\frac{2\alpha}{3} = 25^x + 25^{-x} + 20(20^x + 20^{-x}).$$

Both bases are positive. Applying the reciprocal-sum inequality separately yields

$$25^x + 25^{-x} \geq 2, \qquad 20(20^x + 20^{-x}) \geq 40.$$

Therefore $2\alpha/3 \geq 42$, or $\alpha \geq 63$. The equality conditions for both inequalities hold together at $x = 0$, so the bound is actually attained, rather than merely approached.

Step 2: Check the progression and sum ten terms At $x = 0$, the first three terms become

$$a = 1 + 1 = 2, \qquad b = 63/3 = 21, \qquad c = 20 + 20 = 40.$$

Their common difference is $d = 19 > 0$, meeting the requirement that the terms increase. The tenth term is $a_{10} = 2 + 9(19) = 173$. Hence

$$S_{10} = \frac{10}{2}(a + a_{10}) = 5(2 + 173) = 875.$$

It is essential to determine the common difference from the actual terms; the middle term 21 is not the difference.

Step 3: Conclusion For the least $\alpha = 63$, the required sum is $\boxed{875}$, a dimensionless number.

Quick Tip to Solve: When several reciprocal exponential pairs occur, minimize each pair and check that their equality conditions share the same x; then verify the A.P. increases.

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23. If the circles $x^2 + y^2 - 2x - 8y + 17 = r$ and $x^2 + y^2 - 26x - 18y + 234 = 0$ intersect at exactly one point, then the sum of all possible values of r is _____. [4 marks]

Solution:

Concept:

- Completing squares identifies a circle's centre and radius. Two nonconcentric circles have exactly one common point when they touch externally or internally.
- If their radii are R, s and their centre distance is d, the tangency conditions are $R + s = d$ or $|R - s| = d$. Both must be tested for positive radii.

Step 1: Identify the geometry of the two circles The equations can be written as

$$(x-1)^2 + (y-4)^2 = r, \qquad (x-13)^2 + (y-9)^2 = 16.$$

Thus the first radius is $R = \sqrt{r}$, not r, and the second radius is 4. Their centres are $(1, 4)$ and $(13, 9)$, so

$$d = \sqrt{(13-1)^2 + (9-4)^2} = \sqrt{144 + 25} = 13.$$

A negative r gives no real circle. If $r = 0$, the single first-centre point is not on the second circle because its distance is 13 rather than 4.

Step 2: Include both kinds of tangency External touching requires $R + 4 = 13$, so $R = 9$ and $r = 81$. Internal touching requires $|R - 4| = 13$. The admissible solution is $R = 17$; the other algebraic possibility $R = -9$ cannot be a radius. Hence the second value is $r = 289$. These circles are nonconcentric, so neither tangency case can give coincident circles or infinitely many intersections. The sum of all possible parameter values is therefore

$$81 + 289 = 370.$$

Step 3: Conclusion The required sum is $\boxed{370}$, a dimensionless number.

Quick Tip to Solve: Compute possible radii from external and internal tangency first, then square them: here the parameter denotes radius squared.

---

24. Let $\vec{a} = 2\hat{i} + 3\hat{j} + 5\hat{k}$, $\vec{b} = \hat{i} - \hat{j} + 3\hat{k}$ and $\vec{c}$ be a vector such that $\vec{a} \cdot \vec{c} = 104$ and $\vec{a} \times \vec{c} = \vec{c} \times \vec{b}$. Then $\vec{b} \cdot \vec{c}$ is equal to _____. [4 marks]

Solution:

Concept:

- The cross product is anticommutative: $\vec{c} \times \vec{b} = -\vec{b} \times \vec{c}$. Its distributivity converts the given equality into a single zero cross product.
- For a nonzero vector $\vec{u}$, $\vec{u} \times \vec{c} = \vec{0}$ means $\vec{c} = t\vec{u}$ for a scalar t. A dot-product condition then determines that scalar.

Step 1: Use the cross-product condition to find a direction The equality in the question gives

$$\vec{a} \times \vec{c} = -\vec{b} \times \vec{c}, \qquad (\vec{a} + \vec{b}) \times \vec{c} = \vec{0}.$$

Now

$$\vec{a} + \vec{b} = 3\hat{i} + 2\hat{j} + 8\hat{k},$$

which is nonzero. Hence write $\vec{c} = t(3\hat{i} + 2\hat{j} + 8\hat{k})$. This includes the zero-vector possibility initially; the nonzero specified dot product will rule it out. The plus sign in the direction is crucial because reversing the order of a cross product changes its sign.

Step 2: Determine the scale and the requested dot product Using $\vec{a} \cdot \vec{c} = 104$ yields

$$t(2 \cdot 3 + 3 \cdot 2 + 5 \cdot 8) = 104, \qquad 52t = 104, \qquad t = 2.$$

Thus $\vec{c} = 6\hat{i} + 4\hat{j} + 16\hat{k}$. Direct substitution into the remaining dot product gives

$$\vec{b} \cdot \vec{c} = 1 \cdot 6 + (-1) \cdot 4 + 3 \cdot 16 = 6 - 4 + 48 = 50.$$

As a check, $\vec{a} \cdot \vec{c} = 12 + 12 + 80 = 104$, so the scale satisfies the original condition exactly.

Step 3: Conclusion Therefore $\vec{b} \cdot \vec{c} = \boxed{50}$, a dimensionless scalar.

Quick Tip to Solve: Rewrite both cross products with $\vec{c}$ on the same side before combining them; this immediately exposes the direction of $\vec{c}$.

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25. Let $y = y(x)$ be the solution of the differential equation $x\frac{dy}{dx} + y + xy\cot x = x$, $\frac{\pi}{4} \le x \le \frac{3\pi}{4}$, $y\left(\frac{\pi}{4}\right) = 0$. Then $6y\left(\frac{3\pi}{4}\right)$ equals _____. [4 marks]

Solution:

Concept:

- An equation of the form $y' + P(x)y = Q(x)$ has integrating factor $\exp(\int P(x)\,dx)$. Multiplication by this factor turns the left side into the derivative of a product.
- On the given interval, $x > 0$ and $\sin x > 0$, so division by x and use of the integrating factor $x \sin x$ are valid throughout. The initial condition fixes the constant of integration.

Step 1: Put the equation in linear form Divide the given equation by x, retaining both terms multiplying the dependent variable. This gives

$$y' + \left(\frac{1}{x} + \cot x\right) y = 1.$$

The coefficient is continuous on the whole stated interval, so the initial-value solution can be evaluated at its other endpoint.

Step 2: Multiply by the integrating factor Integrating the coefficient gives $\log x + \log(\sin x)$, hence

the integrating factor is $x \sin x$. Therefore

$$\frac{d}{dx}(xy \sin x) = x \sin x.$$

Integration by parts, with the factor x differentiated, yields

$$xy \sin x = -x \cos x + \sin x + C.$$

Step 3: Apply the initial condition and evaluate At $x = \pi/4$, the left side is zero because $y(\pi/4) = 0$. Thus

$$C = \frac{\pi/4 - 1}{\sqrt{2}}.$$

At $x = 3\pi/4$, use $\sin x = 1/\sqrt{2}$ and $\cos x = -1/\sqrt{2}$. The numerator of the solution becomes

$$\frac{3\pi/4 + 1 + \pi/4 - 1}{\sqrt{2}} = \frac{\pi}{\sqrt{2}}.$$

Consequently,

$$y(3\pi/4) = \frac{\pi/\sqrt{2}}{(3\pi/4)/\sqrt{2}} = \frac{4}{3}.$$

Step 4: Conclusion The requested numerical value is $6y(3\pi/4) = 6(4/3) = \boxed{8}$. This quantity is dimensionless.

Quick Tip to Solve: When the coefficient contains both 1/x and cot x, try the integrating factor x sin x; apply the initial condition before substituting the final endpoint.

Aptitude Test (200 marks)

26. The concept of scale in architecture is more clearly associated with: [4 marks]

(A) The durability of materials

(B) The relative size of elements compared to human dimensions.

(C) The energy efficiency of the building.

(D) The colour scheme of the façade

Correct Answer: (B) The relative size of elements compared to human dimensions.

Solution:

Concept:

- Architectural scale concerns perceived or measured size in relation to a reference. For buildings used by people, the human body supplies an especially direct reference for dimensions and spatial experience.
- Scale and proportion are related but distinct: proportion compares dimensions within a form, while human scale compares architectural elements with people. Material performance, energy use and colour are separate design considerations.

Step 1: Identify the reference implied by scale A doorway, stair, window or room feels large or small because a person compares it with familiar body dimensions. Door height, handrail height and the width of a passage can therefore be understood through standing height, reach and the space needed for movement. This connection between the size of elements and the human body is exactly the relative-size relationship described in option (B).

Step 2: Eliminate the unrelated design attributes Option (A) concerns how long materials resist weathering, wear and other deterioration; a durable wall may have either monumental or intimate scale. Option (C) concerns energy consumption and thermal or environmental performance, which do not define the size relationship. Option (D) concerns the facade colour scheme and visual finish. Colour can affect perception, but a colour palette alone does not establish how architectural dimensions relate to human dimensions. These three attributes may influence a design, yet none is the clearest meaning of architectural scale.

Step 3: Conclusion Architectural scale is most clearly associated with the relative size of elements compared to human dimensions. Hence, the correct option is (B).

Quick Tip to Solve: For a scale question, ask: size compared with what? If the reference is the human body, human scale is the intended concept.

27. BRICK :MASONRY : : TILES : _____ [4 marks]

(A) Carpentry

(B) Wiring

(C) Plumbing

(D) Flooring

Correct Answer: (D) Flooring

Solution:

Concept:

- A verbal analogy preserves the same relationship in both pairs. Here the first word names a building material or unit, and the second names the construction work or application characteristically made with it.
- Bricks are laid and bonded in masonry. Tiles are commonly laid to form flooring, so the required relationship is material to associated construction application, rather than merely two words connected with buildings.

Step 1: Determine the relation in the first pair Read BRICK : MASONRY as: bricks are units used in masonry construction. Masonry is not a property such as colour or strength; it is the work or construction produced by arranging and bonding units. The second pair must therefore link tiles to an application in the same direct way. Simply selecting a familiar building trade would not preserve this relationship.

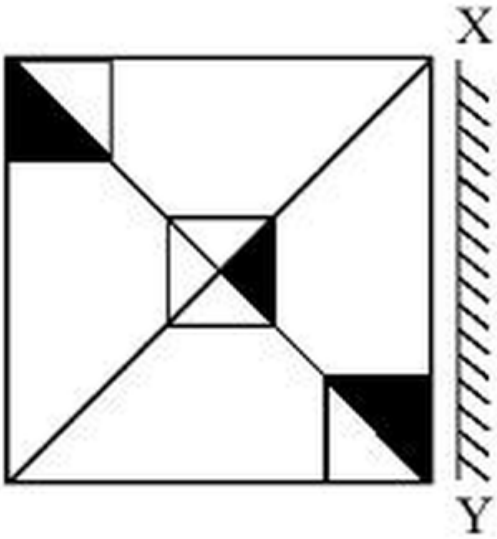
Step 2: Test each proposed application Tiles are laid in a regular arrangement over a prepared base to make a floor finish, so TILES : FLOORING repeats the material-to-construction relation. Carpentry in option (A) primarily concerns timber and related joinery, rather than tile laying. Wiring in option

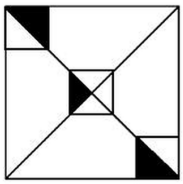
(B) concerns electrical conductors and circuits. Plumbing in option (C) concerns pipes, fittings and water or drainage services. A tiled room can contain wiring and plumbing, but that association is incidental: the tiles are not the material from which either service is constructed. Among the given choices, flooring is therefore the precise parallel to masonry.

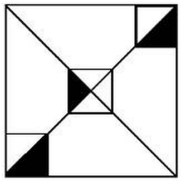
Step 3: Conclusion The completed analogy is BRICK : MASONRY :: TILES : FLOORING. Hence, the correct option is (D).

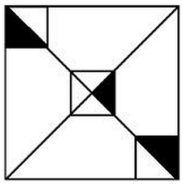
Quick Tip to Solve: First state the relationship as a short sentence, then substitute each proposed pair into that same sentence; shared subject matter alone is insufficient.

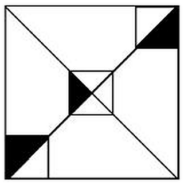
28. Identify the correct mirror image of the given figure along XY-axis. [4 marks]

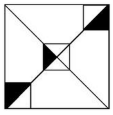


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- Reflection in a vertical mirror reverses left and right but preserves the height of every point. The line XY is vertical, so this is a horizontal reversal of the whole square.
- Both the positions of the smaller squares and the shaded triangles inside them must be reflected. Matching only the central shading is not enough.

Step 1: Reflect the three marked regions The small square in the upper-left corner moves to the upper-right corner; its black triangle, which originally touches the left and bottom sides of that small square, must now touch the right and bottom sides. The lower-right small square moves to the lower-left, with its black triangle now touching the top and left sides. In the central square, the black triangle pointing towards the centre from the right edge moves to the corresponding triangle on the left edge. All these changes occur together, without turning the figure upside down.

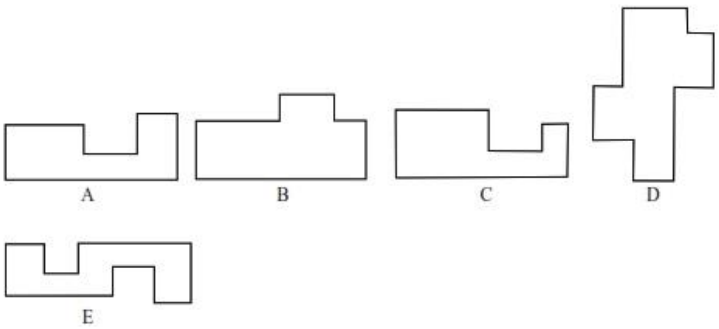
Step 2: Compare the corner shading in every option Option (D) puts the two corner squares at upper right and lower left, places the central black triangle on the left, and gives both corner triangles the required reflected orientation. Option (A) retains the corner squares at upper left and lower right, so it cannot be the vertical-mirror image. Option (C) likewise retains those original corner positions and also keeps the central shading on the right. Option (B) moves the corner squares and central shading to the appropriate sides, but its lower-left black triangle occupies the wrong half of that small square: it touches the bottom side instead of the top. Thus the lower corner distinguishes (B) from the correct complete reflection.

Step 3: Conclusion Only option (D) reverses every left-right feature while keeping the vertical positions and the appropriate shaded halves unchanged in height. Hence, the correct option is (D).

Quick Tip to Solve: For this figure, check the lower corner last: its reflected black triangle must touch the top and left edges of the lower-left small square. This eliminates the close distractor (B).

29. Five diagrams A, B, C, D, E are given. Three out of these when put together form a square. Find out the diagrams.

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



(A) A, C, D

(B) B, C, D

(C) A, B, C

(D) C, D, E

Correct Answer: (A) A, C, D

Solution:

Concept:

- Pieces form a square only when their outer boundary has four straight equal sides and the interior has neither a gap nor an overlap. A protruding step must fit a corresponding recess in a neighbouring piece.
- The pieces may be translated and rotated as whole rigid shapes. Compare their long straight edges and the sequence of steps; do not change the shapes to make them fit.

Step 1: Use the long edges to locate the outer boundary Take piece A as a lower strip, with its long straight edge along the bottom. Turn piece C through a half-turn and place its long straight edge along the top. The two strips have stepped inner boundaries facing one another. Their remaining space is not a plain rectangle: it has the alternating wider and narrower portions needed to accommodate the uneven arms of piece D. The straight ends of the strips provide portions of the left and right sides of the required square.

Step 2: Fit the central stepped piece and test the alternatives Turn D through a quarter-turn so that its long direction runs horizontally, and fit it between A and the inverted C. Its projecting parts occupy their recesses, while the wider solid portions of the strips occupy the indentations beside D. Following the outside boundary then gives four straight sides of a square; the internal steps are shared seams. This uses A, C and D, which is option (A). In option (B), replacing A by B introduces a projecting tab where this arrangement needs A's recess. Option (C) replaces the irregular connecting piece D by B, whose single central tab does not match the stepped space between A and C. Option (D) replaces A by the thinner, differently notched piece E; its inner boundary does not complement the remaining pieces to close the square. The matching of whole boundaries, rather than a resemblance of one corner, selects the required set.

Step 3: Conclusion The three complementary pieces are A, C and D. Hence, the correct option is (A).

Quick Tip to Solve: Place A and the half-turned C along opposite straight sides first. The outline of the space between their stepped edges identifies the quarter-turned piece D.

30. A man is looking at a photograph of a woman and his friend asked him "Who is she?" Then the man replied "I have no brother and sister, but the father of the woman in the photograph is my father's son". Who is the woman in the photograph? [4 marks]

(A) His daughter

(B) His wife

(C) His sister

(D) His mother

Correct Answer: (A) His daughter

Solution:

Concept:

- A kinship statement should be simplified from the speaker outward. The phrase my father's son refers to a male child of the speaker's father, so it must be resolved using the speaker's information about siblings.
- Because the speaker is a man and explicitly has no brother or sister, he is his father's only child. A woman whose father is that man is his daughter; the generation and the gender both matter.

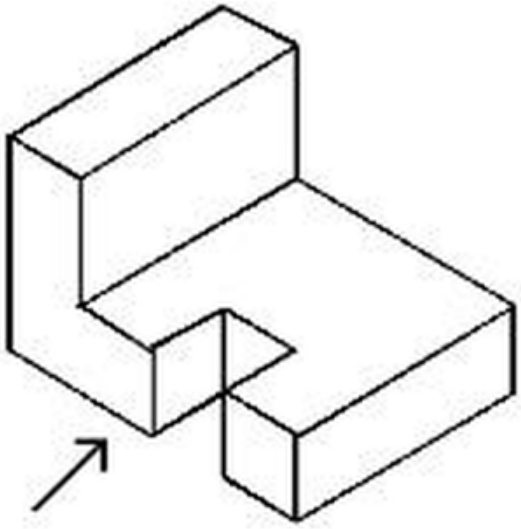
Step 1: Resolve the phrase about the father's son The speaker says that he has no brother and no sister. Thus there is no other son of his father who could be meant by my father's son. Since the speaker himself is male, the phrase must identify the speaker. Replace it with myself rather than adding another relative. The statement now reads: the father of the woman in the photograph is myself.

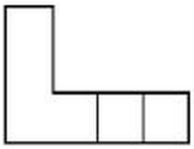
Step 2: Identify the woman and check the alternatives If the speaker is the woman's father, she is his daughter, which is option (A). His wife, option (B), would be his spouse and would not be described by the stated father-child relationship. His sister, option (C), would have the same father as him; the statement would then name his father, not his father's son, and would contradict his explicit lack of siblings. His mother, option (D), belongs to the preceding generation, whereas the stated woman is a child of the speaker. These generation checks exclude the alternatives without relying on the woman's age or any unprovided family details.

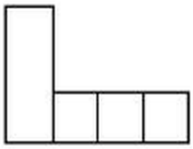
Step 3: Conclusion The woman in the photograph is the man's daughter. Hence, the correct option is (A).

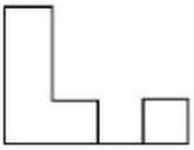
Quick Tip to Solve: Replace my father's son with the speaker himself when he is male and has no siblings, then read the remaining father-child relationship directly.

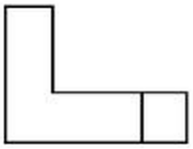
31. The question figure shows the 3D view of an object. Identify the correct view looking in the direction of the arrow. [4 marks]

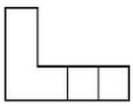


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An orthographic view projects an object along parallel lines in the indicated viewing direction. Distances along the line of sight collapse, while height and transverse width remain visible.
- Draw the outer silhouette first, then include only visible boundaries between faces. A recess may produce internal vertical edges without removing material from the projected silhouette.

Step 1: Fix the viewing direction The arrow points from the lower left towards the object, parallel to the long direction of its raised wall. Consequently the wall is seen end-on. Its height appears at the left of the projected view, and the low platform extends to the right. The outline must therefore be an L, with a tall left limb and a low horizontal limb.

Step 2: Project the rectangular recess The recess opens towards the observer, but it does not pass through the entire depth of the platform. Material behind it still projects into the same bottom strip. Thus the lower outline remains continuous. The two sides of the recess appear as two vertical edges

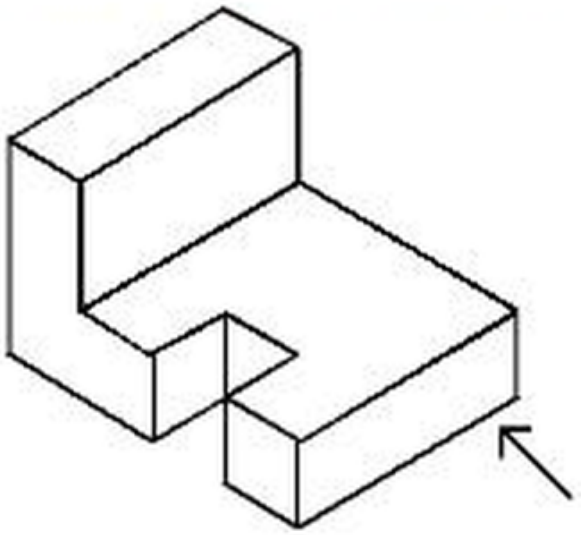
within that strip, at the positions of the recess sides. The change from wall to platform defines the upper step, not an extra vertical seam down the whole base.

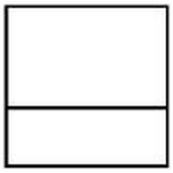
Step 3: Compare the four drawings Option (A) has the correct L-shaped outline and the two visible recess boundaries in the lower strip. Option (B) adds an unnecessary vertical boundary directly below the wall step. Option (C) treats the recess as an opening through the projected silhouette, ignoring the material behind it. Option (D) retains only one of the two recess boundaries. These differences distinguish the choices even though their overall stepped profiles are similar.

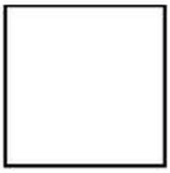
Step 4: Conclusion The required end view is the L-shaped profile with a continuous base and both recess-edge lines shown in (A). Hence, the correct option is (A).

Quick Tip to Solve: For a front recess, check whether material remains behind it before cutting a gap out of the projected outline.

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

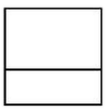


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An orthographic elevation retains height and width perpendicular to the viewing direction, while depth along the viewing arrow is suppressed.
- A visible step gives a line in the elevation. Edges concealed behind a nearer face are not drawn as extra solid lines in the choices.

Step 1: Look from the indicated side The arrow approaches the long right-hand face of the low platform. From this side, the raised wall lies behind the platform and extends across the whole width of the projection. The wall supplies the full upper rectangle, while the low platform supplies the lower portion. Their combined outer silhouette is therefore rectangular, not L-shaped.

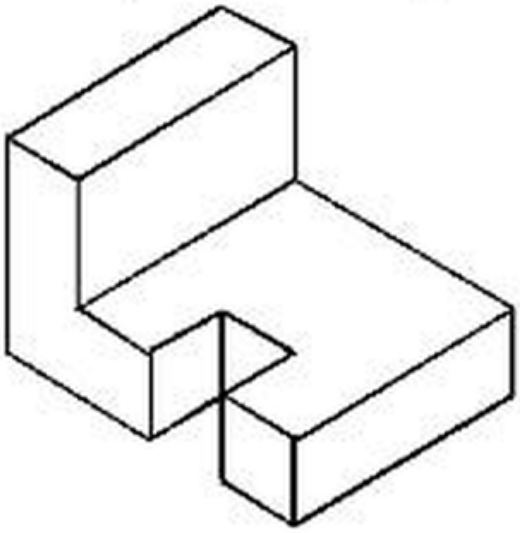
Step 2: Locate the single visible level change The top edge of the nearer platform is below the top of the rear wall. In the elevation this produces one horizontal line across the rectangle at the platform level. The rectangular recess lies on the other side of the object and is masked by the uninterrupted near face. It therefore adds no solid internal line in this view. The thickness of the wall runs along the viewing direction and must not be represented by a second horizontal band near the top.

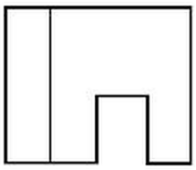
Step 3: Reject the extra and missing edges Option (A) shows the rectangle with exactly one horizontal division in its lower part. Option (B) has no division and loses the visible platform edge. Option (C) introduces an additional horizontal line near the base without a corresponding exposed edge. Option (D) adds another line near the top as well, incorrectly retaining depth information. Only (A) follows the indicated direction and the visible level change.

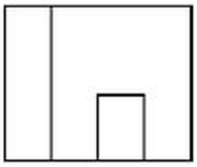
Step 4: Conclusion The elevation is a rectangle divided once at the top level of the low platform. Hence, the correct option is (A).

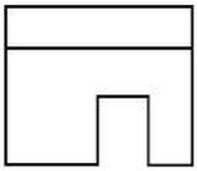
Quick Tip to Solve: When a taller wall stands behind a low slab, keep the slab top as one horizontal line and suppress depth edges.

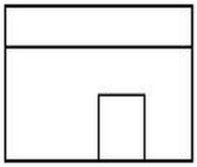
33. The question figure shows the 3D view of an object. Identify the correct top view . [4 marks]

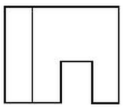


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A top view looks vertically down on the object: horizontal footprints are preserved and height is suppressed.
- A raised wall appears as a strip equal to its footprint. An open notch in the horizontal slab remains a gap in the plan outline.

Step 1: Trace the plan footprint Viewed from above, the platform is broadly rectangular with a rectangular recess entering its near edge. The recess is open at that edge rather than enclosed inside the slab. Its two sides and its rear boundary therefore form an inward rectangular notch, and there must be no line joining its two mouth corners across the open edge.

Step 2: Place the raised wall correctly The raised portion runs along the left-hand side of the object, parallel to the depth direction. Its top surface projects to a narrow strip along the left edge of the plan. The edge separating this strip from the lower platform is a longitudinal line. Although its height

disappears in the plan, the boundary between the wall top and the lower surface remains a visible edge. The strip must not be moved to the back merely because the wall is taller.

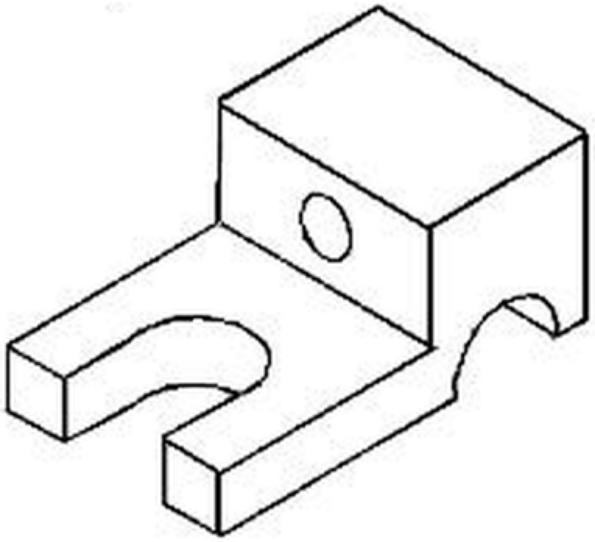
Step 3: Match both independent features Option (A) preserves the left-side strip and the open rectangular notch. Option (B) has the strip in the right position, but closes the mouth of the notch with an extra straight baseline. Option (C) keeps an open notch but puts the raised strip across the back rather than down the left side. Option (D) makes both mistakes: a transverse strip and a closed notch. Comparing the wall footprint and the notch separately selects one drawing unambiguously.

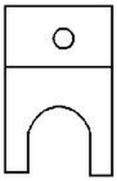
Step 4: Conclusion The plan with a left-side wall strip and an open rectangular recess is (A). Hence, the correct option is (A).

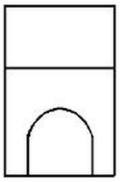
Quick Tip to Solve: In a plan view, use the footprint of the raised wall and the open mouth of a notch as two separate checks.

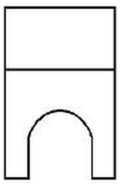
34. The question figure shows the 3D view of an object. Identify the correct top view of the object.

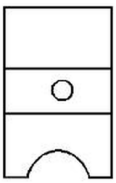
[4 marks]

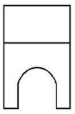


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- The top view preserves the horizontal outline of an object and the visible edges of horizontal surfaces; vertical heights collapse.
- A hole on a vertical face is not seen as a circle from directly above. An open slot through a horizontal slab remains open in its plan outline.

Step 1: Trace the slab and its rounded slot The front portion is a low slab with two projecting arms. The space between them has parallel sides and a rounded inner end. Seen vertically from above, this produces a U-shaped indentation entering the front boundary. The mouth remains open; it is not an enclosed arch drawn inside a complete rectangular outer boundary.

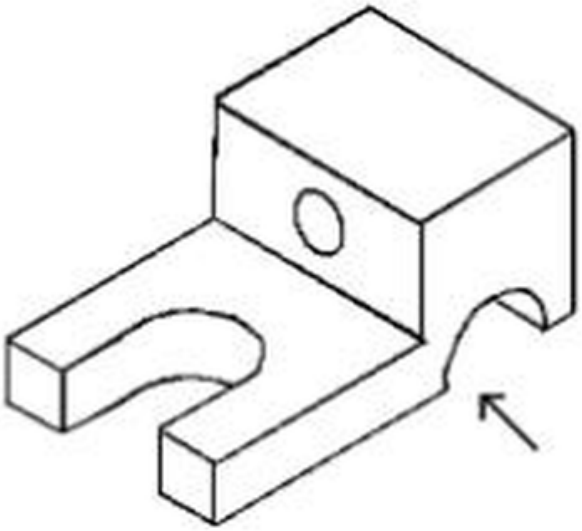
Step 2: Project the rear block The taller rear block occupies a rectangular band across the back of the footprint. Its front top edge becomes the horizontal division between the rear band and the forward slab in the plan. The circular opening shown on the block faces forward on a vertical surface, so it must not appear as a visible circle on the top surface. Likewise, the curved cut-out in the side is below the upper surface and does not replace the front slot in this top view.

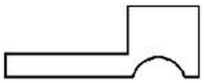
Step 3: Eliminate the inconsistent plans Option (C) has the rear rectangular band, the separating straight edge, and the correctly open rounded slot at the front. Option (A) incorrectly puts the front-face circular hole onto the top band. Option (B) closes the slot mouth with a baseline. Option (D) introduces an extra band and a circle in the plan, and substitutes a shallow curved indentation for the long open slot. These features do not match the visible horizontal footprint.

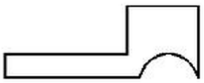
Step 4: Conclusion Only (C) shows the rear band and the open rounded slot without importing a hole from a vertical face. Hence, the correct option is (C).

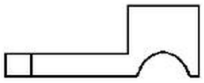
Quick Tip to Solve: For a top view, first identify which surface contains each hole; a circle on a vertical face is not a plan circle.

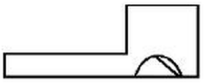
35. The question figure shows the 3D view of an object. Identify the correct view looking in the direction of the arrow. [4 marks]

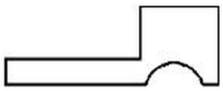


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A side elevation projects the shape in the arrow direction and removes distances parallel to that direction.
- Openings visible on the viewed side modify the silhouette, whereas features hidden by the near material do not create extra solid lines.

Step 1: Obtain the stepped outline The arrow points towards the right-hand side of the object. In this elevation the thin forward slab extends horizontally to the left, and the taller rear block rises on the right. The upper outline is therefore a long low ledge followed by a vertical step and a high flat top. The front-face circular hole is not viewed face-on from this direction and must not be shown as a circle.

Step 2: Project the lower curved cut-out The semicircular opening lies in the side face being viewed. Its arc therefore appears as a curved indentation in the bottom edge beneath the tall block. The source shows solid material between the right end of this opening and the outer back corner, so the arc must finish before that corner and leave a short bottom segment to its right. The slot between the forward arms is concealed in this side projection by the nearer arm.

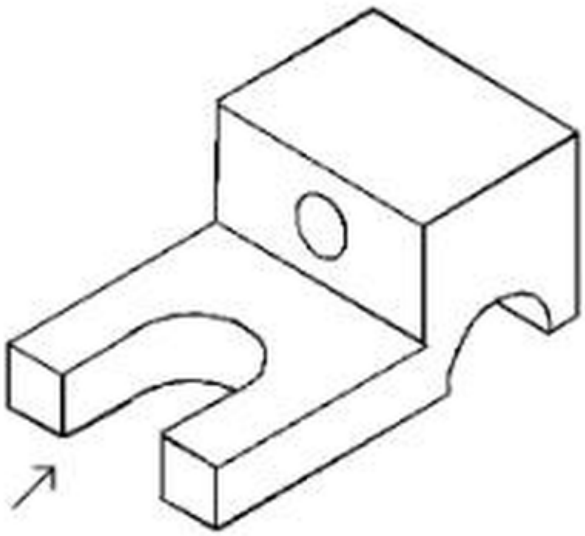
Step 3: Inspect the distinguishing edges Option (A) has the correct step, a single curved opening, and

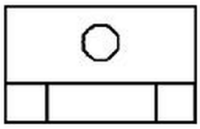
solid material to the right of the opening. Option (B) extends its curve to the far right edge, removing that material. Option (C) adds a vertical subdivision near the front of the thin slab that is not a visible boundary in this direction. Option (D) closes the opening along the bottom and shows overlapping curved lines, instead of the single open arc of the side silhouette.

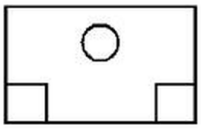
Step 4: Conclusion The stepped side elevation with one lower curved cut-out ending before the right corner is (A). Hence, the correct option is (A).

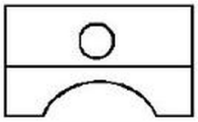
Quick Tip to Solve: Check where a curved opening meets the bottom outline: a small remaining end segment can distinguish otherwise similar views.

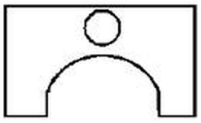
36. The question figure shows the 3D view of an object. Identify the correct view looking in the direction of arrow. [4 marks]

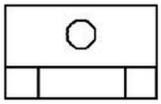


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A front elevation looks along the arrow and preserves height and transverse width, while distances away from the observer collapse.

- A hole perpendicular to the line of sight appears face-on. A rounded slot in a horizontal surface is seen edge-on in the elevation and does not retain its plan curvature.

Step 1: Identify the face seen directly The arrow looks from the open ends of the two forward arms towards the tall block. The vertical face of that block is directly opposite the observer. Its round opening is therefore visible as a circle in the upper part of the elevation. The rear block spans the full width and produces the rectangular outer boundary of the view.

Step 2: Project the lower slab and slot The top level of the thin forward slab appears as a horizontal line across the lower part of the rectangle. The two inner sides of the open slot project to vertical lines within that bottom strip, separating the two near arm ends from the central recessed portion. The slot does not remove the whole projected lower middle region: material behind its rounded end remains. Its rounded horizontal end is viewed edge-on, so it does not become an arch in the elevation.

Step 3: Compare the four alternatives Option (A) combines the upper circle, the complete horizontal slab-level line, and the two lower vertical slot boundaries. Option (B) omits the central part of the slab-level boundary and does not show the same projected face separation. Option (C) incorrectly uses an arched lower outline in place of the projected slot boundaries. Option (D) similarly carries a large arch into the front view and removes the horizontal slab division. The front circle alone is insufficient; the lower strip must also match.

Step 4: Conclusion The complete front elevation, including the round hole and the correctly divided lower strip, is (A). Hence, the correct option is (A).

Quick Tip to Solve: Distinguish a curved slot lying horizontally from a hole facing the observer: only the latter keeps its face-on outline.

37. A man walks 10 km north, then turns to his left and walks 5 km, then turns to his left again and walks 10 km. How far is he from his starting point? [4 marks]

(A) 10 km

(B) 20 km

(C) 15 km

(D) 5 km

Correct Answer: (D) 5 km

Solution:

Concept:

- Distance travelled is the length of the entire route, whereas distance from the starting point is the magnitude of the final displacement. The question asks for the latter.
- Use east as the positive horizontal direction and north as the positive vertical direction. A left turn is a quarter turn anticlockwise relative to the direction in which the walker is currently facing.

Step 1: Track the successive directions Initially the man walks north for $10\,\mathrm{km}$. His first left turn therefore points west, not east, so the second stretch is $5\,\mathrm{km}$ west. While facing west, his next left turn points south. Hence the third stretch is $10\,\mathrm{km}$ south. Each turn must be interpreted using his

current heading rather than the original northward heading.

Step 2: Calculate the remaining displacement The northward and southward stretches have equal lengths and opposite directions, so their vertical displacements cancel exactly. If the starting point is $(0, 0)$, his successive positions, in kilometres, are $(0, 10)$, $(-5, 10)$, and $(-5, 0)$. Thus

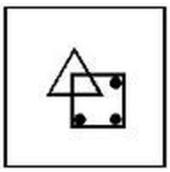
$$d = \sqrt{(-5)^2 + 0^2} = 5\,\text{km}.$$

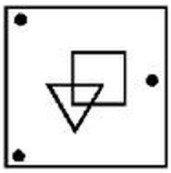
The route length is $10 + 5 + 10 = 25\,\text{km}$, but that is not the distance from the start. Options (A), (B), and (C), giving 10, 20, and 15 km, respectively, do not equal the magnitude of the net displacement.

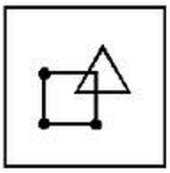
Step 3: Conclusion The man finishes $5\,\text{km}$ west of his starting point, so his distance from it is $\boxed{5\,\text{km}}$. Hence, the correct option is (D).

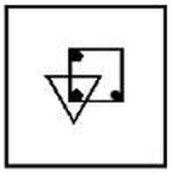
Quick Tip to Solve: Cancel equal stretches in opposite directions before applying the distance formula; here only the westward stretch survives.

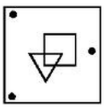
38. Identify the figure which is odd from rest of the figures. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- An odd-one-out figure differs in a relation shared by the other three figures. Compare the position of the three black dots relative to the smaller square, rather than the direction in which the triangle points.
- Rotation changes orientation but does not change whether a dot lies inside, on the boundary of, or outside a closed square. A boundary dot is associated with the square, whereas a separated exterior dot is not.

Step 1: Identify the repeated components Every option contains a large enclosing square, a smaller square, a triangle overlapping the smaller square and three black dots. Thus the number of components alone cannot distinguish the answer. The triangle points upwards in some figures and downwards in others, so its orientation does not give a property shared by exactly three options.

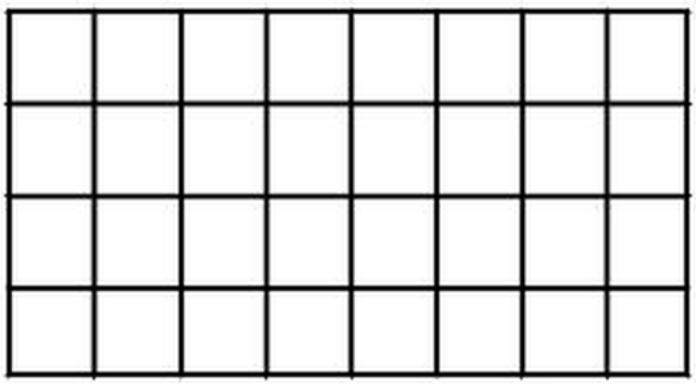
Step 2: Compare the dots with the smaller square In (A), all three dots lie inside the smaller square near three of its corners. In (C), the three dots lie at corners of the smaller square, on its boundary. In (D), the dots again lie within the smaller square near three corners. Hence in each of these three figures, all the dots are within or on the boundary of the smaller square.

Step 3: Locate the exception In (B), the three dots are separated from the smaller square: one is near the upper-left corner of the large square, one is to the right of the small square and one is near the lower-left corner of the large square. All three are outside the smaller square. This is the only option that breaks the common positional relation; the upward or downward orientation of the triangle does not affect this test.

Step 4: Conclusion Figure (B) is the odd one because its three dots lie outside the smaller square, whereas in the other three figures they lie inside or on its boundary. Hence, the correct option is (B).

Quick Tip to Solve: For overlapping-shape questions, test containment and contact before rotation: here the decisive feature is where the dots lie relative to the smaller square.

39. How many squares are there in the given figure? [4 marks]



(A) 32

(B) 48

(C) 78

(D) 70

Correct Answer: (D) 70

Solution:

Concept:

- A square must have equal horizontal and vertical side lengths, with all four sides present in the diagram. Count squares of each possible size separately to avoid omitting larger ones.
- In an m-column, n-row unit grid, the number of squares of side k units is $(m-k+1)(n-k+1)$. The shorter dimension determines the largest possible square.

Step 1: Read the grid dimensions The figure has eight columns and four rows of small square cells. There are nine vertical grid lines and five horizontal grid lines, including the outside boundaries. A

square can therefore have side length one, two, three or four cells; a five-cell-high square cannot fit.

Step 2: Count each possible side length For side one, there are eight choices across and four down. For side two, the upper-left corner has seven choices across and three down. Continuing in the same way gives

$$N_1 = 8 \times 4 = 32,$$
$$N_2 = 7 \times 3 = 21,$$
$$N_3 = 6 \times 2 = 12,$$
$$N_4 = 5 \times 1 = 5.$$

Every square of a fixed size has a unique upper-left corner, so this method counts it exactly once. Overlapping squares are distinct and must all be counted.

Step 3: Add the counts and check the alternatives The complete count is

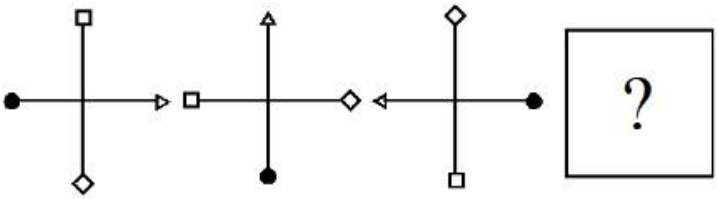
$$N = 32 + 21 + 12 + 5 = 70.$$

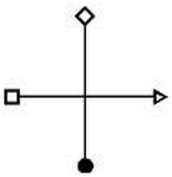
Option (A), 32, counts only the smallest cells and omits all larger squares. Options (B), 48, and (C), 78, disagree with the size-by-size count. There are no diagonal segments forming tilted square boundaries, and rectangles with unequal side lengths do not contribute additional squares.

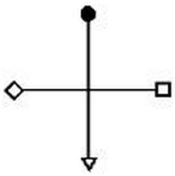
Step 4: Conclusion The figure contains 70 squares of all sizes. Hence, the correct option is (D).

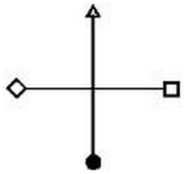
Quick Tip to Solve: For a rectangular grid, count equal-sized horizontal and vertical spans together: $8 \times 4 + 7 \times 3 + 6 \times 2 + 5 \times 1$, stopping when the shorter dimension is exhausted.

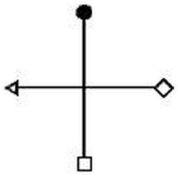
40. [4 marks]

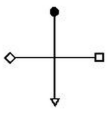


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A figure sequence can be generated by rotating the complete arrangement. Track distinct markers at the top, right, bottom and left to identify both the angle and direction of rotation.
- A 90° anticlockwise turn moves the right marker to the top, the top marker to the left, the left marker to the bottom and the bottom marker to the right.

Step 1: Record the first two arrangements In the first figure, the top marker is a hollow square, the right marker is an arrowhead, the bottom marker is a hollow diamond and the left marker is a filled circle. In the second figure, the arrowhead is at the top, the diamond at the right, the circle at the bottom and the square at the left. Each marker has moved one position anticlockwise.

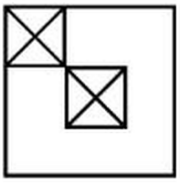
Step 2: Verify the same change in the third figure Applying another 90° anticlockwise turn puts the diamond at the top, the circle at the right, the square at the bottom and the arrowhead at the left. These are exactly the positions in the third supplied figure. The arrowhead continues to point outwards from the centre as the entire arrangement rotates.

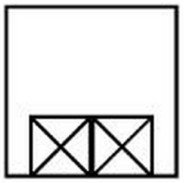
Step 3: Predict the missing figure and compare all options One more identical turn places the filled circle at the top, the hollow square at the right, the downward-pointing arrowhead at the bottom and the hollow diamond at the left. Option (B) shows all four positions correctly. Option (A) leaves the diamond at the top and circle at the bottom. Option (C) also keeps the circle at the bottom and places the arrowhead at the top. Option (D) has the circle at the top but puts the other three markers in the wrong positions, so checking the circle alone is insufficient.

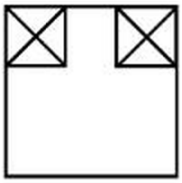
Step 4: Conclusion The next figure has circle above, square to the right, arrowhead below and diamond to the left, obtained by a further 90° anticlockwise turn. Hence, the correct option is (B).

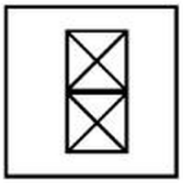
Quick Tip to Solve: Track one distinctive marker to infer the turn, then verify the other three. The filled circle moves left, bottom, right, top through this sequence.

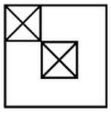
41. Find the odd one when the object is divided vertically through the centre. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A figure has vertical mirror symmetry when its left and right halves match after reflection in the vertical line through the centre of the enclosing square.
- Reflection preserves height and reverses horizontal position. It must match every small square and both of its diagonals, rather than merely give equal numbers of shapes on each side.

Step 1: Test the side-by-side arrangements In (B), the two crossed small squares are side by side near the bottom and occupy matching positions on the two sides of the vertical centre line. Reflection interchanges them, including their diagonal crosses. In (C), the crossed squares occupy the upper-left and upper-right corners, again at equal heights and matching distances from the centre line. Thus both (B) and (C) have matching left and right halves.

Step 2: Check the centrally stacked arrangement In (D), two crossed small squares are stacked vertically and centred horizontally within the large square. The vertical centre line passes through each small square. Each square and its pair of diagonals reflect onto themselves, so the complete stacked arrangement also has vertical mirror symmetry. A horizontal arrangement is not necessary for vertical symmetry.

Step 3: Identify the unmatched arrangement In (A), one crossed square is at the upper-left corner and the other is displaced diagonally down and right. Reflecting the upper-left square in the vertical centre line would require a matching square at the upper-right corner at the same height, but no such square is present. The lower square cannot supply that counterpart because it lies at a different height. Therefore the left and right halves do not match in (A), while they do in all three other options.

Step 4: Conclusion Figure (A) is the odd one because it lacks symmetry about the vertical line through the centre. The other three figures retain matching halves. Hence, the correct option is (A).

Quick Tip to Solve: When testing a specified vertical cut, compare left-right partners at the same height. Diagonally displaced shapes cannot be mirror partners across that line.

42. A man is facing East, turns 90° clockwise, then 180° anti clockwise, and then another 90° clockwise. In which direction is he facing? [4 marks]

(A) West

(B) East

(C) North

(D) South

Correct Answer: (B) East

Solution:

Concept:

- A clockwise quarter turn moves through north, east, south and west in that cyclic order. An anticlockwise turn follows the reverse order.
- Turns can also be added algebraically: take clockwise angles as positive and anticlockwise angles as negative. A net turn of zero leaves the initial direction unchanged.

Step 1: Follow the heading after each turn The initial heading is east. Turning 90° clockwise changes it to south. From south, turning 180° anticlockwise reverses the heading, so the man faces north. Finally, a 90° clockwise turn from north takes him back to east. The intermediate northward heading is not the final answer because one more turn remains.

Step 2: Verify the total turn and eliminate the other directions The signed total turn is

$$\theta = 90^\circ - 180^\circ + 90^\circ = 0^\circ.$$

Thus the two clockwise quarter turns together cancel the anticlockwise half turn. Since there is no net rotation, the final heading agrees with the initial eastward heading. West in option (A) would require a net half turn, which does not occur. North in option (C) is the heading only after the second turn, and south in option (D) is the heading only after the first turn. Neither intermediate direction can be selected after the complete sequence. This angular check agrees with tracking the compass directions individually.

Step 3: Conclusion The final direction is $\boxed{\text{East}}$. Hence, the correct option is (B).

Quick Tip to Solve: Assign opposite signs to clockwise and anticlockwise turns, add the angles, then apply the net angle to the initial heading.

43. What is the mirror image of PRODUCTION along X-X' axis. [4 marks]



(A) ЯUOIƆUDORP

(B) ЯUOIƆUDOЯd

(C) ЬЯODUCTION

(D) ЬЯODUCTION

Correct Answer: (D) ЬЯODUCTION

Solution:

Concept:

- A plane mirror produces a reflection: every point remains at the same perpendicular distance from the mirror line on the opposite side.
- For the horizontal mirror line $X - X'$, left-to-right positions remain unchanged while the vertical orientation of each letter is reversed.

Step 1: Identify the mirror orientation The line marked $X - X'$ lies horizontally below PRODUCTION. Therefore the required image is a top-to-bottom reflection, not a left-to-right reversal. The first letter remains P at the left and the last letter remains N at the right; merely reversing the order of the word would apply the wrong transformation.

Step 2: Track the asymmetric letters Reflect each letter about the horizontal line. The bowl of P moves to the lower part of its stem. The diagonal leg of R moves above its bowl. The open top of U becomes an open bottom, while the top bar of T moves to the bottom. Letters such as O and I do not provide as strong a test because of their symmetry.

Step 3: Compare all four alternatives Option (D) preserves the horizontal order of all ten letters and reverses the vertical features consistently. Option (A) gives incorrect orientations to the initial P and R. Option (B) also fails the initial-letter reflection test. Option (C) resembles the required image, but leaves the U opening upward instead of downward. Thus only (D) satisfies the same reflection for every letter.

Step 4: Conclusion The horizontal reflection of PRODUCTION is the image in option (D). Hence, the correct option is (D).

Quick Tip to Solve: For a mirror below a word, check the bowl of P and the opening of U first: their vertical positions reverse, but their places in the word do not.

44. Identify the mirror image of given word ALTITUDE along Y-Y' axis. [4 marks]



(A) ƎDUTITΓA

(B) ƎDUTIIΓA

(C) ƎDUTITJA

(D) ∀LTITUDE

Correct Answer: (C) ƎDUTITJA

Solution:

Concept:

- A mirror image reverses the coordinate perpendicular to the mirror while preserving the coordinate parallel to it.
- For the vertical line $Y - Y'$, the letters appear in reverse horizontal order and each asymmetric letter is reversed left to right; their tops and bottoms stay unchanged.

Step 1: Read the axis and reverse the order The mirror is the vertical line to the right of ALTITUDE. The E nearest the mirror becomes the first letter of the image when read from left to right. The positions consequently follow E, D, U, T, I, T, L, A, with the shapes of asymmetric letters reflected as well. The image must not be turned upside down.

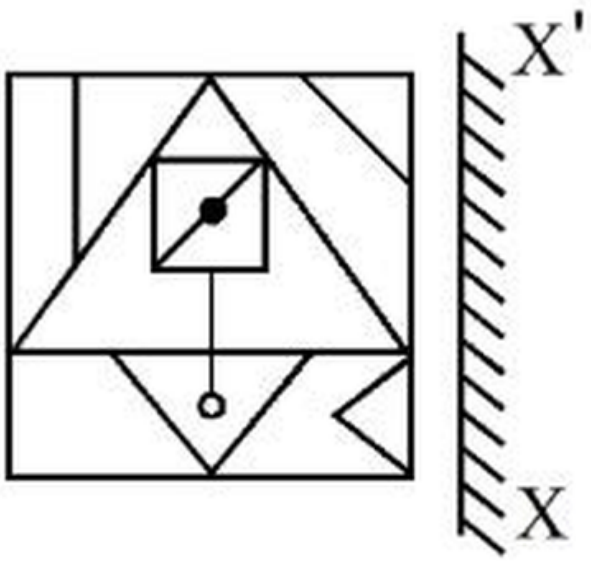
Step 2: Check the individual letter shapes The reflected E has its vertical stroke on the right and its horizontal bars extending left. The reflected D has its straight side on the right. The reflected L retains its foot at the bottom but its vertical stroke moves to the right. A, T, I and U retain their vertical orientation; in particular, both T bars remain at the top and U remains open upward.

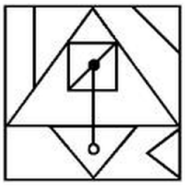
Step 3: Eliminate inconsistent alternatives Option (C) combines the reversed order with all these letter orientations. Option (A) places the horizontal stroke of the reflected L at the top instead of the bottom. Option (B) puts the T bars at the bottom and also gives the L an incorrect orientation. Option (D) also inverts vertically symmetric-order landmarks, including the final A. Those changes do not result from a vertical mirror.

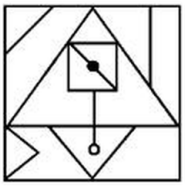
Step 4: Conclusion The image that correctly reflects ALTITUDE in the vertical mirror is option (C). Hence, the correct option is (C).

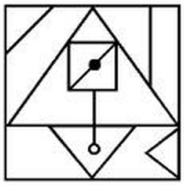
Quick Tip to Solve: For a vertical mirror, reverse the order and the sideways letter shapes, but keep the feet of L and the bars of T at their original heights.

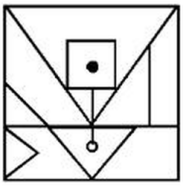
45. Identify the correct mirror image of given figure along XX'-axis. [4 marks]

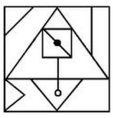


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A reflection in a vertical line reverses left and right while retaining the height of every point.
- Each line segment, dot and subfigure must undergo the same reflection; matching only the outer outline is insufficient.

Step 1: Locate stable and moving features The given mirror line is vertical and lies to the right of the square. The large triangle therefore keeps its apex at the top and its horizontal base at the same height. The small inverted triangle remains below the base, and the hanging open circle remains beneath the inner square. These features must not exchange top and bottom positions.

Step 2: Reflect the asymmetric details The short vertical segment near the upper-left boundary moves to the upper-right boundary. The sloping segment across the upper-right corner moves to the upper-left corner. The small triangular notch at the lower-right edge moves to the lower-left edge. Inside the small square, the diagonal rising from bottom left to top right becomes a diagonal

descending from top left to bottom right, with the filled dot still on it.

Step 3: Check the options feature by feature Option (B) has the corner segment, short vertical segment and lower notch on the reflected sides, and reverses the inner diagonal correctly. Option (A) largely retains the original left-right arrangement. Option (C) moves the upper short segment but keeps the lower notch and inner diagonal on their original orientations. Option (D) turns the large triangular arrangement upside down and loses the required inner diagonal. Only (B) reflects the entire figure consistently.

Step 4: Conclusion The complete mirror image is shown in option (B). Hence, the correct option is (B).

Quick Tip to Solve: Use three asymmetric landmarks: the corner diagonal, the edge notch and the diagonal inside the small square. A correct option must reverse all three together.

46. Identify the most used building material seen in the facade of the building. [4 marks]



(A) Sand Stone

(B) Granite

(C) Marble

(D) Slate

Correct Answer: (C) Marble

Solution:

Concept:

- The question asks for the predominant visible facade material, which can differ from the material of the plinth, path or internal structural core.
- The pictured white, finely decorated Mughal tomb is the Tomb of Itimad-ud-Daulah; its pale facade and delicate inlay work are characteristic of marble.

Step 1: Identify the visible architectural evidence Observe the pale walls, corner towers, central arched opening and fine decorative surfaces. The building is the Tomb of Itimad-ud-Daulah at Agra.

The white marble facade is the relevant surface here; the reddish platform and approach do not determine the answer because the question specifically names the facade.

Step 2: Connect the appearance to the material Marble can be polished and carved into fine decorative surfaces, and the tomb's facade uses white marble with coloured inlay. This combination explains the light overall appearance together with the intricate patterns visible on the walls and towers. Select the material forming most of those exterior faces, rather than treating every visible colour as a different main wall material.

Step 3: Exclude the other listed materials Sandstone is associated with the reddish platform and many Mughal structures, but is not the dominant material of this white facade. Granite is a hard crystalline stone and is not the identified facade material of this monument. Slate is a layered stone commonly split into thin sheets and does not explain the pictured white carved and inlaid facade. Marble is therefore the only matching alternative among the four.

Step 4: Conclusion The predominant building material visible in the facade is marble. Hence, the correct option is (C).

Quick Tip to Solve: Separate the facade from its base and paving. In this image, the white decorated walls and towers are decisive, not the red approach.

47. Identify the name of the monument. [4 marks]



(A) Tower of Victory

(B) Connaught Place

(C) The Pantheon

(D) The Parthenon

Correct Answer: (D) The Parthenon

Solution:

Concept:

- Monument identification uses the overall building form, the arrangement of columns and the roof or pediment, rather than a single isolated feature.

- The Parthenon is a classical Greek temple on the Acropolis at Athens, recognisable by its rectangular plan, surrounding colonnade and Doric columns.

Step 1: Read the main features in the photograph The image shows a ruined rectangular temple standing on a raised stone platform. Tall closely spaced columns extend along both the front and the long side. Above them are the horizontal entablature and surviving portions of the triangular pediment. This is the recognisable colonnaded form of the Parthenon.

Step 2: Distinguish the two similar names The Parthenon is the Greek temple shown here. The Pantheon is a different monument in Rome: its columned entrance is attached to a large round domed hall. The photographed structure instead has a long exposed side colonnade and the rectangular ruined temple form. Similar names do not make these buildings architecturally interchangeable.

Step 3: Reject the remaining alternatives The Tower of Victory is a tall multi-storeyed tower, not a low rectangular temple surrounded by columns. Connaught Place is a modern urban commercial ensemble arranged around circular streets, not the isolated ancient temple pictured. Option (C), the Pantheon, fails the overall-form comparison above. Option (D), the Parthenon, matches the visible platform, colonnade, entablature and pediment together.

Step 4: Conclusion The monument shown is the Parthenon in Athens. Hence, the correct option is (D).

Quick Tip to Solve: Parthenon: rectangular Greek temple with a surrounding colonnade. Pantheon: Roman monument with a round domed hall behind its portico.

48. Which book by Robert Venturi is considered as pivoted text in the development of post modern architecture? [4 marks]

(A) The timeless way of building

(B) The poetics of space

(C) Complexity and contradiction in architecture

(D) Architecture : Form, Space and Order

Correct Answer: (C) Complexity and contradiction in architecture

Solution:

Concept:

- Architectural theory links an influential text to its author and to the movement whose ideas it helped articulate. Robert Venturi challenged the exclusive preference for simplicity and purity associated with orthodox modernism.
- Postmodern architectural thinking admits historical reference, layered meanings and the coexistence of apparently conflicting elements. The title *Complexity and Contradiction in Architecture* expresses this approach directly.

Step 1: Connect Venturi with the relevant architectural argument Venturi's *Complexity and Contradiction in Architecture* argues for richness, ambiguity and the accommodation of different demands within a building. Instead of treating complexity as a defect to be eliminated, it treats complexity as a

source of architectural meaning. This challenge to reductive modernist rules made the book a pivotal theoretical reference for the development of postmodern architecture. The pairing of author and title, rather than the presence of the word architecture alone, decides the answer.

Step 2: Distinguish the other authors and titles *The Timeless Way of Building* is associated with Christopher Alexander and his account of patterns and the quality of built environments, so option (A) is not Venturi's book. *The Poetics of Space* is Gaston Bachelard's philosophical exploration of inhabited space and imagination, eliminating (B). *Architecture: Form, Space and Order* is Francis D. K. Ching's explanation of architectural form and spatial organisation, eliminating (D). Option (C) is the only title that both belongs to Venturi and matches the theoretical role described in the question.

Step 3: Conclusion Robert Venturi's *Complexity and Contradiction in Architecture* is the pivotal text described. Hence, the correct option is (C).

Quick Tip to Solve: Link Venturi with complexity and contradiction; associate Alexander with patterns, Bachelard with the poetics of inhabited space, and Ching with form, space and order.

49. Which material is used traditionally to make Sandpaper? [4 marks]

(A) Brick

(B) Silica

(C) Iron

(D) Rubber

Correct Answer: (B) Silica

Solution:

Concept:

- Sandpaper is a coated abrasive: hard particles are attached to a flexible paper backing so that rubbing removes small irregularities from a surface.
- The traditional abrasive is sand containing silica. Silica grains are sufficiently hard to abrade wood or other softer surfaces; the backing holds those grains in place.

Step 1: Identify the part that performs abrasion The question asks for the material traditionally used in sandpaper, rather than the backing or an object being polished. During rubbing, projecting mineral grains scrape the workpiece. An abrasive therefore needs hardness and a granular texture. Silica, the main constituent of common quartz sand, supplies those hard grains and explains the traditional name sandpaper.

Step 2: Eliminate the other materials Option (B), silica, matches this abrasive function. Brick is a manufactured masonry unit; although crushed brick can be gritty, it is not the traditional material identified here. Iron is a metal used in tools and construction, rather than the traditional sand coating. Rubber is relatively flexible and resilient and does not provide the hard mineral cutting grains required for this purpose. Modern coated abrasives may use other manufactured minerals, but that does not change the traditional silica answer asked for.

Step 3: Conclusion The traditional abrasive material used to make sandpaper is silica. Hence, the

correct option is (B).

Quick Tip to Solve: Connect the word sandpaper with hard quartz-rich sand: identify its abrasive grains, rather than its paper backing.

50. The 'Sagrada Familia' in Barcelona, a masterpiece of unique design and organic forms, was designed by: [4 marks]

(A) Antoni Gaudi

(B) Santiago Calatrava

(C) Renzo Piano

(D) Zaha Hadid

Correct Answer: (A) Antoni Gaudi

Solution:

Concept:

- Architectural attribution means matching a building with the architect responsible for its defining design, rather than matching only a city or a broad visual style.
- The Sagrada Familia in Barcelona is associated with Antoni Gaudi and his nature-inspired architectural language, including branching structural forms and organic geometry.

Step 1: Match the building with its designer The identifying building is the Sagrada Familia, a basilica in Barcelona. Its distinctive design uses a rich sculptural vocabulary and forms inspired by nature. Antoni Gaudi is the architect identified with this celebrated work. The clue about unique design and organic forms reinforces that association, so the direct building-to-architect match selects option (A).

Step 2: Check the competing attributions Santiago Calatrava is associated with expressive engineering and sculptural contemporary structures, but he is not the designer of the Sagrada Familia. Renzo Piano is associated with modern architectural works and carefully developed structural and material systems; this Barcelona basilica is not attributed to him. Zaha Hadid is known for dynamic contemporary forms, but an organic appearance by itself cannot transfer the authorship of Gaudi's building to her. Thus the visual clue should support, rather than replace, the specific attribution.

Step 3: Conclusion The Sagrada Familia in Barcelona was designed by Antoni Gaudi. Hence, the correct option is (A).

Quick Tip to Solve: Remember the direct pair Barcelona–Sagrada Familia–Gaudi; organic forms alone are too broad to identify an architect.

51. Pointed arches and flying buttresses were the prominent architectural style introduced in:

[4 marks]

(A) Romanesque

(B) Renaissance

(C) Gothic

(D) Baroque

Correct Answer: (C) Gothic

Solution:

Concept:

- A pointed arch has sides that meet at an apex, unlike the semicircular arch commonly associated with Romanesque architecture.
- A flying buttress is an external structural support that transfers lateral thrust from a high wall or vault to an outer pier. Pointed arches and flying buttresses are defining features of Gothic architecture.

Step 1: Identify the combined structural clues The question gives two features together: pointed arches and flying buttresses. In Gothic construction, the pointed arch and vaulted roof system permit an emphasis on height, while external buttressing resists outward thrust. Because some arch forms occur in more than one architectural tradition, the combination of both clues is more decisive than identifying a pointed arch alone. This characteristic combination selects Gothic.

Step 2: Distinguish the remaining styles Romanesque buildings are generally associated with rounded arches, thick walls and comparatively heavy masses, so option (A) does not match the given pair. Renaissance architecture draws strongly on classical proportion, symmetry and classical orders, rather than defining itself by flying buttresses. Baroque architecture emphasises dramatic spatial effects, movement and rich articulation, but it is not the style identified by this Gothic structural system. Consequently neither option (B) nor option (D) answers the stated historical-style association.

Step 3: Conclusion Pointed arches and flying buttresses are prominent characteristics of Gothic architecture. Hence, the correct option is (C).

Quick Tip to Solve: Use the pair pointed arch plus external flying buttress as a strong Gothic clue, rather than relying on ornament alone.

52. "Acoustical Design" deals with: [4 marks]

(A) Structure of building

(B) Sound in the building

(C) Ventilation of the building

(D) Facade design

Correct Answer: (B) Sound in the building

Solution:

Concept:

- Acoustics concerns sound: its production, propagation, reflection, absorption and perception within an environment.
- Architectural acoustical design controls how sound behaves in and between building spaces, including speech clarity, reverberation, unwanted noise and sound insulation.

Step 1: Relate the technical term to its purpose The word acoustical refers directly to sound. In a building, acoustical design may require speech to remain intelligible, music to have suitable reverberation, and external or mechanical noise to be reduced. Choices of room shape, absorbing finishes, partitions and insulation influence these outcomes. Their common purpose is the control of sound in the building, which is exactly option (B).

Step 2: Separate acoustics from the other design tasks Structural design deals primarily with loads, stability, strength and the safe transfer of forces to the foundations. Ventilation concerns the supply, movement and removal of air. Facade design concerns the building's external envelope and its architectural and environmental performance. These subjects can interact with acoustics: a window or ventilation opening can also transmit noise. However, an interaction does not make them the definition of acoustical design. The subject named in the question remains sound, so options (A), (C) and (D) are not the best answer.

Step 3: Conclusion Acoustical design deals with sound in the building. Hence, the correct option is (B).

Quick Tip to Solve: When you see acoustical, ask about sound quality and noise control; ventilation instead concerns air movement.

53. What is the primary purpose of using a 'mullion' in window design? [4 marks]

(A) For decoration

(B) To enhance ventilation

(C) To support the glass within the window frame

(D) To block sunlight

Correct Answer: (C) To support the glass within the window frame

Solution:

Concept:

- A mullion is a vertical member that separates adjacent window lights or glazed divisions and forms part of the framing system.
- Window framing locates and supports glazing and helps transfer loads acting on it. The horizontal dividing member is generally called a transom, whereas the vertical divider is a mullion.

Step 1: Identify the framing function A window may contain several glazed lights rather than one uninterrupted sheet of glass. A vertical framing member between those lights is called a mullion. It divides the opening, gives the adjacent glazing an edge support and forms part of the assembly that holds the glass securely within the window frame. Among the alternatives, supporting the glass within the frame describes this practical function most directly.

Step 2: Compare purpose with incidental effects A mullion may contribute to the visual pattern of a facade, but decoration alone is not its primary purpose, so option (A) is incomplete. Ventilation depends on openable parts, vents and the movement of air; a fixed vertical divider does not inherently increase it, ruling out option (B). Sunlight is mainly controlled with shading devices, glazing properties and the size or orientation of openings. A mullion can cast a small shadow, but blocking sunlight is not the defining function asked for. Option (C) therefore fits better than option (D) as well.

Step 3: Conclusion The primary purpose is to support the glass within the window frame. Hence, the correct option is (C).

Quick Tip to Solve: Identify a mullion as a vertical glazing divider and support; do not confuse it with a sunshade or an opening mechanism.

54. The usable area of floor is called: [4 marks]

(A) Carpet area

(B) Plinth area

(C) Surface area

(D) Built-up area

Correct Answer: (A) Carpet area

Solution:

Concept:

- Carpet area describes the usable floor area of a building unit, in contrast with measurements that include the thickness of walls or other built components.
- Plinth area or built-up area is measured over the covered built footprint and includes wall area. A generic surface area does not specifically name usable internal floor space.

Step 1: Interpret the word usable The question asks for the name of the floor area that can be used, rather than the full footprint occupied by a building. The standard architectural aptitude term for this usable internal area is carpet area. The image of laying a carpet within the usable floor space helps distinguish it from the additional area occupied by enclosing walls. This identifies option (A).

Step 2: Compare the other area terms Plinth area is associated with the covered built area measured at floor level, including the footprint of walls, so it is broader than the usable floor area asked for. Built-up area similarly includes the carpet area together with wall thickness and the relevant covered built portions; it is therefore not simply the usable floor space. Surface area is a general mathematical term for the area of a surface and could refer to walls, roofs or other objects; it is not the specific building measurement in this question. Thus options (B), (C) and (D) do not match the intended definition.

Step 3: Conclusion The usable area of floor is called carpet area. Hence, the correct option is (A).

Quick Tip to Solve: For a usable-floor-area question, choose carpet area; wall-inclusive footprint measurements point to plinth or built-up area.

55. Name the place where 'Statue of Unity' is situated. [4 marks]

(A) Gandhinagar, Gujarat

(B) Kadi, Gujarat

(C) Anand, Guajarat

(D) Kewadia, Gujarat

Correct Answer: (D) Kewadia, Gujarat

Solution:

Concept:

- The Statue of Unity commemorates Sardar Vallabhbhai Patel. A location question requires the particular town or locality, rather than merely the state in which the monument stands.

- The monument is associated with Kevadia in Gujarat, near the Sardar Sarovar Dam on the Narmada. Kewadia in the options is a spelling variant of Kevadia.

Step 1: Identify the monument and its locality The identifying name is Statue of Unity, the monumental statue of Sardar Vallabhbhai Patel. Its site is at Kevadia in the Narmada district of Gujarat. The river setting and proximity to the Sardar Sarovar Dam distinguish this site from other towns in the same state. Thus the required response must name Kevadia rather than simply selecting any place in Gujarat.

Step 2: Compare all the listed places Option (D), Kewadia, names the required locality. Gandhinagar in (A) is the capital of Gujarat, but being the state capital does not make it the location of this monument. Kadi in (B) and Anand in (C) are other towns in Gujarat; neither is the site of the Statue of Unity. All four choices name the same state, so the decisive information is the town name, not the state name.

Step 3: Conclusion The Statue of Unity is situated at Kewadia (Kevadia), Gujarat. Hence, the correct option is (D).

Quick Tip to Solve: Associate Statue of Unity with Patel, Kevadia and the Narmada; do not confuse its location with Gujarat's capital.

56. What is the proportional relationship in classical architecture, represented as 1.628? [4 marks]

(A) Fibonacci sequence

(B) Symmetry ratio

(C) Golden ratio

(D) Modular scale

Correct Answer: (C) Golden ratio

Solution:

Concept:

- A golden proportion divides a length so that the ratio of the whole to its larger part equals the ratio of the larger part to the smaller part.
- For larger and smaller lengths a and b, the defining equality is $(a+b)/a = a/b = \phi$, giving $\phi = (1+\sqrt{5})/2 \approx 1.618$.

Step 1: Recognise the named proportional relationship Let the ratio of the larger length to the smaller be $r = a/b$. The equality of the two ratios gives $r = 1 + 1/r$, or $r^2 - r - 1 = 0$. Its positive root is $(1+\sqrt{5})/2$, approximately 1.618. This is the golden ratio, a named proportion often discussed in relation to classical architectural composition. The printed number 1.628 is slightly different from the standard value; it does not change which named relationship the question identifies.

Step 2: Distinguish the other architectural terms A Fibonacci sequence is a sequence in which each term is the sum of the preceding two. Ratios of successive positive terms approach the golden ratio, but the sequence itself is not the name of a single proportional relationship. Symmetry describes correspondence about an axis or centre; it does not specify this fixed numerical proportion. A modular

scale is a system of related dimensions and may use different ratios, so it is not uniquely represented by the number given here.

Step 3: Conclusion The named relationship is the golden ratio, whose standard value is approximately 1.618 rather than the printed 1.628. Hence, the correct option is (C).

Quick Tip to Solve: Recall the defining equality of whole-to-larger and larger-to-smaller lengths; it identifies the golden ratio even when a decimal is misstated.

57. Rings of the wooden log represents: [4 marks]

(A) Strength of wood

(B) Age of the wood

(C) Colour of wood

(D) Defects of wood

Correct Answer: (B) Age of the wood

Solution:

Concept:

- A tree adds layers of secondary wood as it grows. Seasonal differences in growth produce visible bands in a transverse section of the trunk.
- An annual growth ring normally represents one growing year. Counting such rings therefore provides an estimate of the age represented by the wood section.

Step 1: Interpret the concentric bands In a cross-section of a wooden log, the rings surround the central region or pith. During a growing season, changes in cell size and density distinguish earlywood from latewood. The resulting pattern repeats as the tree grows through successive years. It is this repeated growth record, rather than a decorative surface marking, that makes the rings useful for estimating age. Count from the central growth region toward the bark to follow the sequence of growth.

Step 2: Eliminate properties not directly counted by rings Option (B) identifies age, which is the property directly indicated by the number of annual rings. Ring width can provide clues about growth conditions, but the ring count is not itself a direct measurement of strength, so (A) is unsuitable. Wood colour in (C) depends on species and the nature of heartwood and sapwood; it is not the meaning of the ring count. Defects such as knots, splits and decay are separate features, so (D) does not describe ordinary growth rings.

Step 3: Conclusion The rings in a wooden log indicate the age of the wood or tree. Hence, the correct option is (B).

Quick Tip to Solve: For timber identification questions, distinguish ring count (age) from ring width (growth rate and growing conditions).

58. Which ancient civilization is credited with inventing the arch, a fundamental structural element in architecture? [4 marks]

(A) Greek

(B) Roman

(C) Egyptian

(D) Mesopotamian

Correct Answer: (D) Mesopotamian

Solution:

Concept:

- A true arch spans an opening using a curved arrangement of wedge-like units that transmit compressive forces toward its supports.
- The earliest development of the arch is associated with ancient Mesopotamia. The Romans subsequently developed and employed arches extensively in large architectural and engineering works.

Step 1: Separate invention from widespread development The question asks which civilization is credited with inventing the arch, rather than which civilization is most famous for its use. Early brick arch construction belongs to Mesopotamian building traditions. This identification is consistent with the use of small masonry units arranged to bridge an opening through compression. Later monumental examples do not establish the place of first invention, so the chronology is the decisive distinction in this question.

Step 2: Compare the four civilizations Mesopotamian in (D) is the appropriate early origin. Roman in (B) is the tempting alternative because Roman aqueducts, bridges and vaulted buildings demonstrate highly developed arch construction; their achievement was extensive development and application, not the earliest invention. Classical Greek architecture in (A) is especially associated with column-and-lintel systems. Egyptian architecture in (C) also prominently used massive stone post-and-lintel construction. Neither is the credited origin intended by this question.

Step 3: Conclusion The invention of the arch is credited to ancient Mesopotamia: brick arches and vaults there predate Roman architecture. The supplied key selects Roman, but Roman development of an existing structural form is not its invention, which is what the question asks. Hence, the correct option is (D).

Quick Tip to Solve: In architecture history, separate the first development of a structural form from the civilization that later made it famous.

59. Which architectural structure in Paris is known for its iconic wrought iron lattice work and was completed in 1889? [4 marks]

(A) Notre Dame Cathedral

(B) Louvre Museum

(C) Eiffel Tower

(D) Arc de Triumph

Correct Answer: (C) Eiffel Tower

Solution:

Concept:

- A landmark can be identified by combining its city, construction material, structural system and completion date rather than relying on its silhouette alone.
- The Eiffel Tower in Paris is a wrought-iron lattice tower completed in 1889. Its open metal framework distinguishes it from masonry landmarks in the same city.

Step 1: Combine the material and date clues The statement provides three linked clues: the structure is in Paris, it has wrought-iron latticework, and it was completed in 1889. The Eiffel Tower satisfies all three. Its lattice consists of an open framework of metal members, so the material and structural description are particularly distinctive. The date also ties the monument to the 1889 Paris exhibition, providing a second independent identification rather than relying only on the general fact that it is a Paris landmark.

Step 2: Check the alternatives against the same clues Option (C) is Eiffel Tower and matches the complete description. Notre Dame Cathedral in (A) is a Gothic cathedral with masonry construction, not an iron lattice tower. The Louvre Museum in (B) is a palace and museum complex, not the open metal tower described. The Arc de Triumph in (D), conventionally called the Arc de Triomphe, is a monumental masonry triumphal arch. Their shared location in Paris is insufficient because none of those three matches the ironwork and completion-date clues.

Step 3: Conclusion The structure is the Eiffel Tower, completed in Paris in 1889. Hence, the correct option is (C).

Quick Tip to Solve: Pair the Eiffel Tower with the two strong clues iron lattice and 1889; the city clue alone cannot distinguish Paris monuments.

60. 'Char bagh' concept is an important characteristic of which Garden style? [4 marks]

(A) Chinese Garden

(B) Mughal Garden

(C) Japanese Garden

(D) French Garden

Correct Answer: (B) Mughal Garden

Solution:

Concept:

- Char bagh means a four-part garden. Its organising principle is a quadripartite layout, commonly formed by intersecting paths or water channels.
- The char bagh tradition is associated with Persian garden ideas and is an important characteristic of Mughal garden design in the Indian subcontinent.

Step 1: Identify the spatial organisation in the term Read char bagh as a garden divided into four principal parts. A pair of intersecting axes organises the layout, often with water channels, paths and a central feature. The design is deliberately geometric and provides a clear framework for planting and movement. In architectural aptitude, this named arrangement is a defining clue for the Mughal garden tradition rather than a general description of any garden that happens to contain four planted beds.

Step 2: Compare the named garden traditions Mughal Garden in (B) matches the char bagh concept. Chinese gardens in (A) are more typically associated with composed natural scenery, rocks, water and winding spatial sequences, rather than this named Persian-derived fourfold scheme. Japanese gardens in (C) have their own traditions of landscape symbolism and carefully arranged natural elements. French gardens in (D) may also be strongly axial and geometric, but the specific term char bagh identifies the Mughal tradition among these choices; geometry alone is not sufficient to select French Garden.

Step 3: Conclusion Char bagh is an important characteristic of the Mughal Garden style. Hence, the correct option is (B).

Quick Tip to Solve: Translate char bagh as four gardens and recall intersecting water channels; this points directly to Mughal garden planning.

61. If a room is painted with dark colour, what will be the appeareance of the room? [4 marks]

(A) Room will appear smaller than the original room size

(B) Room will appear larger then the original room size

(C) Room will look brighter and appear larger than the original size.

(D) Room will look brighter

Correct Answer: (A) Room will appear smaller than the original room size

Solution:

Concept:

- Dark surfaces reflect a smaller proportion of incident light than pale surfaces under comparable illumination. Surface colour therefore changes perceived brightness without changing the measured dimensions of the room.
- In ordinary interior-design perception, dark enclosing walls tend to feel visually closer, making a room appear more compact. This question asks about that visual impression, rather than an actual reduction of floor area.

Step 1: Identify the effect of the finish A dark paint finish absorbs more visible light and returns less diffuse light to the observer than a light finish. With the same windows, lamps and room geometry, the walls usually look less luminous. The physical lengths, width and height remain the same; painting is changing the visual enclosure rather than moving its boundaries.

Step 2: Compare the four descriptions The darker enclosure gives the usual impression of a smaller and more enclosed space, which matches option (A). Option (B) reverses the expected size impression. Option (C) combines an increase in brightness with apparent enlargement, neither of which is the standard effect described here. Option (D) also incorrectly attributes increased brightness to the dark colour itself. Additional lamps could brighten a dark room, but no such change is part of this question.

Step 3: Conclusion The room will appear smaller than its original room size. Hence, the correct option is (A).

Quick Tip to Solve: Keep actual dimensions separate from visual size: pale reflective finishes usually open up a room, while dark enclosing finishes tend to make it feel more compact.

62. The ground floor plan of a building has 3 entrances. If each entrance can be connected by stairs or an elevator externally, in how many ways can a person enters the building through the entrance? [4 marks]

(A) 03

(B) 06

(C) 09

(D) 12

Correct Answer: (B) 06

Solution:

Concept:

- A complete route is specified by two choices: which entrance is used, and which external means of access is used at that entrance.
- When each of several entrances offers the same number of mutually alternative access modes, the multiplication principle gives the number of entrance-and-mode combinations. Count the modes separately rather than treating their shared destination as one route.

Step 1: List the choices at one entrance The question gives three distinct entrances. At each entrance the person may arrive by stairs or by an elevator, so there are two external access modes for that entrance. These are alternative routes: choosing the elevator does not also require choosing the stairs. Labeling the entrances 1, 2 and 3 makes the count explicit and avoids confusing entrances with access combinations.

Step 2: Count the complete combinations For entrance 1 the routes are stairs-1 and elevator-1; for entrance 2 they are stairs-2 and elevator-2; for entrance 3 they are stairs-3 and elevator-3. Thus there are $3 \times 2 = 6$ ways. Option (A), 3, counts only the entrances and ignores the two stated connections. Option (C), 9, would require three modes at each entrance, and option (D), 12, would require four; neither is given.

Step 3: Conclusion There are 6 entrance-and-access combinations. Hence, the correct option is (B). The supplied key differs, but counting the stated stairs and elevator alternatives separately gives six, not three.

Quick Tip to Solve: Write a route as an ordered pair (entrance, access mode); then multiply the three entrance choices by the two mode choices.

63. Given below are two statements:

Statement I: The concept of "form follows function" suggest that a building's design should primarily consider its use.

Statement II: The concept of "form follows functions" means that aesthetics should take precedence over functionality.

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

(A) Both Statement I and Statement II are true

(B) Both Statement I and Statement II are false

(C) Statement I is true but Statement II is false

(D) Statement I is false but Statement II is true

Correct Answer: (C) Statement I is true but Statement II is false

Solution:

Concept:

- In the architectural principle form follows function, the organisation and shape of a building develop from what the building must do and how it will be used.
- Function includes the required activities, circulation, spatial relationships and practical performance. A building may still be aesthetically successful; the principle does not say appearance should override those requirements.

Step 1: Evaluate Statement I Statement I says the design should primarily consider the building's use. This expresses the functional approach: for example, spaces and connections are arranged to serve their intended activities, and the overall form responds to that arrangement. It therefore correctly describes form following function. The word primarily identifies the organising priority without claiming that all other design concerns disappear.

Step 2: Evaluate Statement II and choose the combination Statement II gives aesthetics precedence over functionality. That reverses the priority in the quoted principle, making function subordinate to an independently preferred appearance. It is therefore false. The required truth pair is true for Statement I and false for Statement II. Option (A) wrongly accepts the reversed priority; option (B) wrongly rejects the accurate first statement; option (D) gets both truth values reversed.

Step 3: Conclusion Statement I is true, but Statement II is false. Hence, the correct option is (C).

Quick Tip to Solve: Read follows as a direction of dependence: building form responds to the intended use, so an option giving appearance priority reverses the principle.

64. Given below are two statements:

Statement I: The sun has a maximum altitude of 90° on Tropic of Capricorn on 22nd June at 12 noon and gradually decreases thereafter till 22nd December.

Statement II: The tilt of earth on axis of 23.5° has no role to play in the change of altitude of sun on Tropic of Capricorn.

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

(A) Both Statement I and Statement II are true

(B) Both Statement I and Statement II are false

(C) Statement I is true but Statement II is false

(D) Statement I is false but Statement II is true

Correct Answer: (B) Both Statement I and Statement II are false

Solution:

Concept:

- At local solar noon, the altitude of the Sun is $h = 90^\circ - |\phi - \delta|$, where ϕ is latitude and δ is solar declination, with north positive and south negative.
- The Tropic of Capricorn is approximately 23.5° south. Earth's axial tilt makes the Sun's declination vary between approximately 23.5° north in June and 23.5° south in December.

Step 1: Test the date and altitude in Statement I At Capricorn, take $\phi = -23.5^\circ$. Near 22 June, $\delta = +23.5^\circ$, so the noon altitude is

$$h = 90^\circ - |-23.5^\circ - 23.5^\circ| = 43^\circ.$$

Near 22 December, $\delta = -23.5^\circ$, giving $h = 90^\circ$. Thus the Sun is overhead at Capricorn near the December solstice, not the June solstice. From June to December its noon altitude increases rather than decreases. Statement I is false.

Step 2: Test the cause in Statement II The seasonal change in declination is a consequence of the tilted terrestrial axis as Earth orbits the Sun. The tilt therefore directly controls the changing noon solar altitude at Capricorn. Saying that it has no role is false. Both statements are false, so option (B) fits. Options (A) and (C) incorrectly accept Statement I; option (D) incorrectly accepts Statement II.

Step 3: Conclusion Both Statement I and Statement II are false. Hence, the correct option is (B). The supplied key differs, but the solar-noon altitude calculation disproves Statement I for the printed June date.

Quick Tip to Solve: Associate Capricorn with the December overhead Sun and Cancer with the June overhead Sun; then use latitude minus declination to check the altitude.

65. Given below are two statements:

Statement I: 'Granite' is the hardest stone.

Statement II: 'Marble' is a soft stone.

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

(A) Both Statement I and Statement II are true

(B) Both Statement I and Statement II are false

(C) Statement I is true but Statement II is false

(D) Statement I is false but Statement II is true

Correct Answer: (D) Statement I is false but Statement II is true

Solution:

Concept:

- Hardness measures resistance to scratching or abrasion. Calling a stone hard does not establish that it is the hardest of every stone; an absolute superlative must be distinguished from a practical building-stone classification.
- Granite is a hard crystalline building stone containing minerals such as quartz and feldspar. Marble is commonly a calcite-rich stone, whose principal mineral has a much lower scratch hardness and is comparatively easy to carve.

Step 1: Examine the absolute claim about granite Granite is strong and abrasion resistant, and it is widely used for durable building surfaces. However, Statement I says it is the hardest stone, not merely a hard stone. That absolute assertion is false: stones such as quartzite can consist predominantly of quartz, whereas granite also contains softer feldspar and mica. A trade description of granite as a hard stone must not be expanded into a universal maximum-hardness claim.

Step 2: Evaluate marble and combine the truth values Ordinary calcitic marble has calcite as its principal constituent. Calcite has a Mohs hardness of about 3, substantially below quartz at 7, and marble is consequently classed as a relatively soft decorative stone. Statement II is true in this building-material context. Option (A) wrongly accepts the superlative for granite; option (B) wrongly rejects marble's relative softness; option (C) reverses the required truth pair. The pair false and true selects (D).

Step 3: Conclusion Statement I is false, but Statement II is true. Hence, the correct option is (D).

Quick Tip to Solve: Check words such as hardest separately from hard: a durable granite surface can be hard without holding a universal hardness record.

66. Given below are two statements:

Statement I : "Wind speed" should be considered while designing tall buildings.

Statement II : "Buildings" should be rigid in an earthquake high risk zone.

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

(A) Both Statement I and Statement II are true

(B) Both Statement I and Statement II are false

(C) Statement I is true but Statement II is false

(D) Statement I is false but Statement II is true

Correct Answer: (C) Statement I is true but Statement II is false

Solution:

Concept:

- Wind applies lateral forces to tall buildings. Wind speed affects the pressure and resultant force; for otherwise comparable conditions, velocity pressure varies approximately with the square of wind speed.
- Earthquake-resistant design needs adequate strength, controlled stiffness and ductility. The structure must tolerate imposed lateral displacement and dissipate energy without brittle collapse; being simply rigid is not a sufficient seismic design rule.

Step 1: Evaluate the wind requirement A tall building presents a large exposed surface to moving air, and wind can create lateral sway, overturning and occupant discomfort. Design must therefore consider the appropriate wind speed together with exposure, height, shape and dynamic response. Ignoring wind speed would prevent a meaningful assessment of these loads. Statement I is consequently true; it identifies a necessary design consideration rather than claiming that wind is the only load.

Step 2: Evaluate the earthquake requirement and select the pair Statement II treats rigidity by itself as the desired property in a high-risk earthquake zone. A structure that cannot accommodate seismic movement may develop large internal forces and fail in a brittle manner. Good seismic behaviour instead requires an engineered combination of stiffness, strength, ductile detailing and appropriate flexibility or isolation. Thus the unqualified rigid-building prescription is false. Option (A) incorrectly accepts it, option (B) incorrectly rejects the valid wind statement, and option (D) reverses both evaluations.

Step 3: Conclusion Statement I is true, but Statement II is false. Hence, the correct option is (C).

Quick Tip to Solve: For seismic questions look for ductility and controlled movement as well as strength; rigid by itself is not a complete earthquake-resistance criterion.

67. Match the LIST-I with LIST-II

LIST-I(Building)	LIST-II(Shape)		
A.	Sanchi Stupa	I.	Cylinder
B.	Circular Column	II.	Triangular Surfaces
C.	Pyramid	III.	Dome
D.	Palaces	IV.	Cuboids

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

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

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

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

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

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

Solution:

Concept:

- Architectural forms can be compared with elementary solids by examining their dominant mass and surface shape, rather than small decorative details.
- A cylinder has a circular cross-section maintained along its axis; a dome is a rounded roof or hemispherical form; a cuboid has rectangular faces.

Step 1: Identify the curved forms Sanchi Stupa is characterised by its rounded hemispherical mound. Among the supplied shapes, dome is the appropriate description, so A matches III. A circular column has a circular cross-section along its height. Its elementary solid is therefore a cylinder, giving B matches I. These identifications distinguish the rounded mound from an elongated circular support; the presence of a circular plan alone does not make both shapes cylinders.

Step 2: Identify the faceted and block forms A pyramid is bounded by triangular sloping side faces that converge towards an apex. Thus C matches II, triangular surfaces. Palace buildings are generally composed of rectangular rooms and block-like volumes; in the elementary shape comparison supplied here, D matches IV, cuboids. The matching concerns the broad architectural masses, not a claim that every ornament or roof on a palace is a cuboid.

Step 3: Compare the complete code Collecting the four matches gives A-III, B-I, C-II, D-IV. This is precisely option (B). Option (A) incorrectly makes the stupa a cuboid; option (C) makes it a cylinder and the pyramid a dome; option (D) associates the stupa with triangular surfaces. Each is rejected by the first secure geometric identification.

Step 4: Conclusion The matching is A-III, B-I, C-II, D-IV. Hence, the correct option is (B).

Quick Tip to Solve: Match the most distinctive form first: Sanchi Stupa gives dome, and a circular column gives cylinder.

68. Match the LIST-I with LIST-II

LIST-I	LIST-II		
A.	Column and Beam	I.	Aesthetics
B.	Trees and Plants	II.	Services
C.	Building form	III.	Landscape
D.	Water supply	IV.	Structures

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

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

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

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

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

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

Solution:

Concept:

- A building is understood through complementary aspects: load-bearing structure, visual form, landscape and services.
- The structural system carries loads, while services supply utilities; landscape concerns planted outdoor spaces and aesthetics concerns visual composition.

Step 1: Match the structural and landscape elements Columns and beams are members of a load-carrying framework. Beams receive loads across a span and transfer them towards supports; columns carry loads mainly downwards. Thus A matches IV, structures. Trees and plants are the living elements used to organise and improve outdoor space. They therefore belong to landscape, so B matches III. Although trees can improve appearance, landscape is the specific category provided for vegetation.

Step 2: Match form and utility Building form means the overall configuration, massing and visible shape of the building. Its appearance and compositional quality are addressed under aesthetics, making C match I. Water supply is a utility system that distributes usable water through pipes and fixtures. It belongs to building services, making D match II. This separates what supports the building from what enables its everyday operation.

Step 3: Check each offered code The resulting code is A-IV, B-III, C-I, D-II, exactly option (B). Option (A) mistakes columns and beams for services and water supply for aesthetics. Option (C) incorrectly places the structural members under landscape and plants under structures. Option (D) makes water supply a structure and building form a service. All four entries in option (B) agree with their primary architectural roles.

Step 4: Conclusion The correct code is A-IV, B-III, C-I, D-II. Hence, the correct option is (B).

Quick Tip to Solve: Separate physical support from utilities: columns and beams are structures; water supply is a service.

69. Match the LIST-I with LIST-II

LIST-I	LIST-II		
A.	Sun Temple	I.	Tirupati
B.	Shiva Temple	II.	Pushkar
C.	Balaji Temple	III.	Modhera
D.	Brahma Temple	IV.	Ujjain

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

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

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

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

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

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

Solution:

Concept:

- A monument-location matching question is answered through the association of each named temple with its established place.
- The supplied names refer to well-known religious landmarks: the Sun Temple at Modhera, Mahakaleshwar at Ujjain, Balaji at Tirupati and Brahma Temple at Pushkar.

Step 1: Identify the Sun and Shiva temple pairs The Sun Temple at Modhera is the well-known solar temple in Gujarat. Therefore A matches III, Modhera. Ujjain is associated with the Mahakaleshwar Shiva Temple, so B matches IV, Ujjain, among the listed choices. The description Shiva Temple is broad in isolation, but this matching list identifies its intended association through the named temple towns and the other established pairs.

Step 2: Identify the remaining temple towns Balaji refers here to Lord Venkateswara, associated with the Tirupati pilgrimage centre. Accordingly C matches I, Tirupati. Pushkar is especially known for its Brahma Temple, so D matches II, Pushkar. These two strong associations also prevent swapping Tirupati with Modhera or Ujjain. Each location is used once, as required by the one-to-one matching format.

Step 3: Select the complete matching Combining the associations gives A-III, B-IV, C-I, D-II. Option (A) lists exactly these four pairs. Option (B) puts the Sun Temple at Ujjain and Balaji at Modhera; option (C) puts the Sun Temple at Pushkar and Brahma Temple at Modhera; option (D) associates the Sun Temple with Tirupati. Each alternative contradicts a well-established monument-location pair, so none provides the correct complete code.

Step 4: Conclusion The matching is A-III, B-IV, C-I, D-II. Hence, the correct option is (A).

Quick Tip to Solve: Anchor this list with Brahma Temple–Pushkar and Balaji–Tirupati, then complete the remaining pairs.

70. Match the LIST-I with LIST-II

LIST-I (Construction equipments)		LIST-II (Functions)	
A.	Buldozer	I.	Used for transporting smaller loads over short distances at site.
B.	Crane	II.	Mixes cement, sand and aggregate with water to produce concrete.
C.	Concrete Mixer	III.	Used to transport concrete to different location at site.
D.	Wheel Barrow	IV.	Used to level and move debris from the site.

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

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

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

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

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

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

Solution:

Concept:

- Construction equipment is classified by the operation it performs: earthmoving, lifting, mixing or short-distance manual transport.
- A correct matching uses the primary function of each machine and assigns each listed operation once.

Step 1: Match the earthmoving and lifting equipment A bulldozer uses a broad front blade to push earth, level ground and move debris. It therefore matches IV, giving A-IV. A crane raises and transfers suspended loads at a construction site. It can move a concrete bucket to another working location, so the listed concrete-transport function III is the suitable match for B. This is distinct from mixing the ingredients to manufacture concrete.

Step 2: Match the mixer and wheelbarrow A concrete mixer rotates or agitates cement, sand, coarse aggregate and water to obtain a reasonably uniform concrete mix. Thus C matches II. A wheelbarrow is a small manually pushed carrier used to move relatively small loads over short distances within a site. Thus D matches I. The mixer prepares the material; the wheelbarrow carries a small quantity of material, so these functions should not be interchanged.

Step 3: Eliminate the incorrect codes The complete sequence is A-IV, B-III, C-II, D-I, shown in option (D). Option (A) makes the bulldozer a concrete mixer and the wheelbarrow a levelling machine. Option (B) assigns mixing to the crane and small-load transport to the concrete mixer. Option (C) assigns small-load transport to the bulldozer and levelling to the mixer. The functional distinction between preparing concrete and transporting it rejects these alternatives.

Step 4: Conclusion The correct matching is A-IV, B-III, C-II, D-I. Hence, the correct option is (D).

Quick Tip to Solve: Use the action words as anchors: bulldozer levels, crane lifts, mixer mixes and wheelbarrow carries.

71. 'SDG' stands for: [4 marks]

(A) Sequential Design Goals

(B) Systematic Development Goals

(C) Strategic Development Goals

(D) Sustainable Development Goals

Correct Answer: (D) Sustainable Development Goals

Solution:

Concept:

- SDG is the established abbreviation for Sustainable Development Goals, the internationally used goals for development that considers social, economic and environmental needs.
- An acronym question requires the exact recognised expansion, not merely a phrase whose initial letters happen to fit.

Step 1: Recall the recognised expression The letters S, D and G refer respectively to Sustainable, Development and Goals. Sustainable development connects present improvements in living conditions with the long-term protection of resources and environmental systems. The phrase names a broad set of development objectives rather than a sequence of design operations or an isolated management strategy. Hence the key distinguishing word is Sustainable.

Step 2: Compare the four expansions Option (A), Sequential Design Goals, changes both the first and second words and describes a design sequence rather than the established development terminology. Option (B), Systematic Development Goals, retains Development Goals but substitutes Systematic for the recognised first word. Option (C), Strategic Development Goals, makes the same kind of substitution with Strategic. Neither an orderly method nor a strategic plan is the exact expression represented by SDG.

Step 3: Choose the exact wording Option (D) is Sustainable Development Goals, with every word in the recognised expression and in the correct order. The choice should be made from the full term, not from the fact that all options begin with words starting with S. In architecture and planning this terminology is relevant to settlements, resource use and environmental responsibility, but that context does not alter the expansion.

Step 4: Conclusion SDG stands for Sustainable Development Goals. Hence, the correct option is (D).

Quick Tip to Solve: For SDG, remember the complete phrase Sustainable Development Goals; the first word distinguishes the close distractors.

72. GRIHA stands for: [4 marks]

(A) Green Rating for Integrated Habitat Assessment

(B) Glare Rating for Integrated Heat Assessment

(C) Green Rating for Insulation Heat Assessment

(D) Glare Rating for Insulation Heat Assessment

Correct Answer: (A) Green Rating for Integrated Habitat Assessment

Solution:

Concept:

- GRIHA expands to Green Rating for Integrated Habitat Assessment, a recognised framework for assessing the environmental performance of buildings and habitats.
- The expansion combines Green Rating with Integrated Habitat Assessment; each part must be retained exactly when choosing an acronym expansion.

Step 1: Expand the first part of the name The initial portion is Green Rating. Green refers to the environmental approach of the assessment, while rating indicates evaluation against a set of criteria. It is not Glare Rating: glare is a particular lighting-comfort concern, whereas this name concerns the broader environmental assessment of a built habitat. This observation immediately removes options (B) and (D), both of which begin with Glare.

Step 2: Expand the remaining part The remaining words are for Integrated Habitat Assessment. Integrated indicates consideration of interacting aspects of building performance rather than a single isolated property. Habitat refers to the built setting being assessed. It is not Insulation Heat Assessment, a phrase restricted to thermal characteristics that does not give the established name. Therefore option (C), despite correctly beginning with Green Rating, has the wrong final words.

Step 3: Check the complete option Joining the two parts gives Green Rating for Integrated Habitat Assessment. Option (A) reproduces this complete expression. Option (B) changes Green to Glare and Habitat to Heat; option (C) changes Integrated Habitat to Insulation Heat; option (D) changes both portions. Only option (A) preserves the recognised wording throughout. Expanding the whole acronym avoids being misled by the similar beginnings of the alternatives.

Step 4: Conclusion GRIHA stands for Green Rating for Integrated Habitat Assessment. Hence, the correct option is (A).

Quick Tip to Solve: Memorise GRIHA in two chunks: Green Rating, followed by Integrated Habitat Assessment.

73. ECBC stands for: [4 marks]

(A) Electricity Conservation Building Code

(B) Electricity Consumption Building Code

(C) Energy Conversion Building Code

(D) Energy Conservation Building Code

Correct Answer: (D) Energy Conservation Building Code

Solution:

Concept:

- ECBC is the abbreviation of Energy Conservation Building Code. Its subject is energy performance in buildings, so the expansion must preserve both the words Energy Conservation and Building Code.
- Building energy performance covers the building envelope and services, rather than electricity alone. The envelope includes walls, roofs and glazing; building services include lighting and conditioning systems. These examples explain why the broader word energy is appropriate.

Step 1: Expand the abbreviation accurately Read the letters as E for Energy, C for Conservation, B for Building and C for Code. The complete name is therefore Energy Conservation Building Code. Conservation means reducing unnecessary energy use while meeting the building's intended needs. It does not mean changing energy from one form to another. The question asks for the official name, so related-sounding descriptions cannot replace its words.

Step 2: Eliminate the altered names Option (A) substitutes Electricity for Energy. This narrows the title incorrectly. Option (B) changes both Energy to Electricity and Conservation to Consumption; consumption describes use, rather than the stated conservation objective. Option (C) retains Energy but replaces Conservation with Conversion. Conversion is a different concept and is not the name of this code. Only option (D) preserves all four words in their proper order.

Step 3: Conclusion ECBC stands for Energy Conservation Building Code. Hence, the correct option is (D).

Quick Tip to Solve: For ECBC, remember the pair Energy Conservation first, then add Building Code; this immediately rules out both Electricity and Conversion.

74. 'HRIDAY' stands for: [4 marks]

(A) Heritage City in Developed Association Yojana

(B) High Residential in Densified Augmented Yojana

(C) Heritage City Development and Augmentation Yojana

(D) Hermitage Centre of Development and Association Yojana

Correct Answer: (C) Heritage City Development and Augmentation Yojana

Solution:

Concept:

- HRIDAY stands for Heritage City Development and Augmentation Yojana. It is a scheme name associated with the development and preservation of heritage cities.
- An abbreviation question requires the exact expanded title. Similar words such as heritage and hermitage, or development and developed, cannot be treated as interchangeable merely because the initials look plausible.

Step 1: Recall the complete scheme title Write the name as Heritage City Development and Augmentation Yojana. The key ideas are the heritage city and its development and augmentation. In this context, augmentation means enhancing or strengthening the setting and facilities associated with the heritage city. The name combines conservation of a historic urban identity with improvements to its surrounding urban environment. It is not the title of a generic residential densification programme.

Step 2: Compare every alternative with the title Option (A) gives Heritage City in Developed Association Yojana, which replaces Development and Augmentation with a different phrase. Option (B), High Residential in Densified Augmented Yojana, concerns a supposed residential description and does not name the heritage-city scheme. Option (D) begins with Hermitage Centre and ends with Association, so both its subject and wording differ from the required title. Option (C) alone states Heritage City Development and Augmentation Yojana exactly.

Step 3: Conclusion HRIDAY stands for Heritage City Development and Augmentation Yojana. Hence, the correct option is (C).

Quick Tip to Solve: Remember HRIDAY through Heritage City plus Development and Augmentation; check those complete phrases before selecting an expansion.

75. What is the architectural term for a semi circular or polygonal recess, often found at the end of a church nave? [4 marks]

(A) Atrium

(B) Apse

(C) Cloister

(D) Ambulatory

Correct Answer: (B) Apse

Solution:

Concept:

- An apse is a semicircular or polygonal recess, commonly at the liturgical end of a church. Its curved or faceted enclosing form is the identifying feature in this question.
- Atrium, cloister and ambulatory identify other spatial elements. Distinguish an enclosed terminal recess from an entrance court, a cloistered court and a circulation passage.

Step 1: Identify the space described The question gives three linked clues: the feature is a recess, its plan can be semicircular or polygonal, and it is often found at the end of a church nave. An apse matches this combination. In a church plan it forms a terminal architectural space, often associated with the sanctuary or altar end. The shape may be smoothly curved or composed of several straight sides, so the reference to a polygon does not exclude an apse.

Step 2: Separate the other church elements An atrium is a court or entrance space rather than the described terminal recess, so option (A) is unsuitable. A cloister is a covered walk associated with an enclosed courtyard, often in a religious complex; it is not defined by a semicircular termination, which rules out option (C). An ambulatory is a circulation aisle or passage, frequently continuing around the choir or apse. It may follow a curved path but is the surrounding passage, not the recess itself. Thus option (D) confuses access around the space with the space being named. Option (B), Apse, matches both the form and the location.

Step 3: Conclusion The architectural term for the semicircular or polygonal recess is Apse. Hence, the correct option is (B).

Quick Tip to Solve: On a church plan, label the terminal recess apse and the passage that may run around it ambulatory; this prevents the closest confusion.

Drawing Test (100 marks)

76. Using black and white medium only, draw a proportionate sketch of the image given below in detail with proper light and Shade. [50 marks]



Solution:

Concept:

- A proportionate architectural sketch preserves the relative heights, widths and positions of the monument's parts. Begin with its overall envelope and large masses before drawing mouldings or ornament.
- Perspective gives the arch depth: the broad front face, narrower visible left side, inner arch surfaces and receding ground edges must remain consistent with the viewpoint in the reference.
- Black and white rendering uses paper white, intermediate greys and deep darks to describe illumination, depth and cast shadow. Tonal contrast, rather than colour, separates the monument from its surroundings.

Step 1: Establish the composition and overall proportions Use a portrait composition matching the reference. Place the India Gate monument slightly left of the sheet's centre, with its base spanning the lower part of the composition and its stepped crown approaching the upper margin. Leave room for the tall flagpole on the right and the spreading cast shadow in the foreground. Lightly mark the monument's total height and width, then compare the width of the arched opening with each supporting pier. Locate the crown, projecting cornice, springing level of the main arch and stepped plinth before adding detail. Retain the open sky around the top instead of enlarging the monument until it touches the borders.

Step 2: Construct the arch and its receding surfaces Block in the two heavy piers and the broad front face. Draw the rounded arch opening between them, keeping the opening tall and the piers substantial. Establish the narrower visible left side and the depth within the passage; their receding edges must agree with the reference viewpoint. Keep the main vertical edges approximately upright

and compare the slopes of the cornice, plinth and ground edges as related perspective families. Add the curved underside of the arch and the more distant opening visible through it. Do not treat the arch as a flat cut-out: its thickness and shaded inner surfaces are essential to the monument's volume.

Step 3: Develop architectural detail in the correct hierarchy Add the stepped upper mass and central raised crest, then the strongly projecting cornice with its small repeated details. Place the circular medallions high on the front piers and the rectangular relief panels below them, matching their positions and relative sizes. Draw the horizontal mouldings, recessed panels, curved lower pier transitions and layered base. Suggest fine carving with controlled short strokes after the large structure is secure. Maintain the visible asymmetry caused by perspective; the two piers need not have identical apparent widths. Avoid invented inscriptions or decorative motifs that the reference does not show clearly.

Step 4: Place the trees, flagpole and ground Sketch the slim branching trees along the left edge and the softer groups of trees behind the monument. On the right, draw the tall narrow flagpole and the hanging, folded flag in the position shown. Indicate the small birds in the upper-right sky with a few light curved strokes. Place the low rounded planting forms around the base and the long paving or kerb edges across the foreground. Use overlap to establish depth: the monument stands in front of the distant foliage, while its steps, surrounding ground and cast shadow lead towards the viewer. Keep the secondary elements subordinate so they support, rather than compete with, the arch.

Step 5: Build light, shade and material character Preserve the lightest paper values on the illuminated front planes and the bright ground to the right. Lay a middle-grey tone across the visible left side of the monument, with darker accents under projecting ledges. Deepen the curved underside and recesses of the arch, while retaining the lighter opening and ground visible beyond it. Develop the broad dark cast shadow spreading across the lower-left foreground, following its shape and direction in the image. Give the sky a soft grey gradient and render the background foliage as quieter tonal masses. Use harder edges for architectural corners and softer broken strokes for leaves, distant trees and the shadow's textured boundary. Distinguish adjacent planes by changes in value, not merely by heavy outlines.

Step 6: Refine the monochrome finish Work from light grey towards the darkest accents so that the tonal range stays controlled. Use closely spaced hatching or smooth pencil layers on stone surfaces, reserving rougher marks for vegetation and ground texture. Express the flag entirely through black, white and grey values; introduce no colour. Check the arch's symmetry in its own front plane, the perspective of the side face, the crown-to-pier proportions and the alignment of the base. Remove construction lines, sharpen selected foreground edges and preserve highlights. Finally compare the silhouette and the pattern of the largest light and dark regions with the reference before adjusting small details.

Step 7: Conclusion The completed sketch should show a proportionate India Gate in its surrounding setting: a detailed arched monument with a visible left side and recessed passage, trees, a right-hand flagpole, birds and foreground paving. A consistent black-and-white tonal treatment, including the shaded arch and broad foreground cast shadow, should convey depth, material and the lighting shown in the image.

Quick Tip to Solve: Before detailing the carving, check three shapes: the monument's outer silhouette, the arch opening and the broad foreground shadow. Accurate proportions and clear tonal separation in these shapes establish the drawing's structure.

77(a). Sketch a unique treehouse that reconnects with nature. Include features such as wooden decks, ladder using natural materials. The structure should blend harmoniously with the surrounding. Depict natural light, shadow and textures effectively. Colour it as per your choice. [50 marks]

Solution:

Concept:

- A successful treehouse composition integrates architecture with the living tree. The trunk, branches and foliage should remain visually dominant, with the built enclosure and deck fitted around them rather than appearing as an unrelated building.
- Consistent perspective, relative scale, a single light direction and distinct material textures make a proposed design spatially convincing. Colour should reinforce the relationship between timber, foliage and daylight.

Step 1: Establish the viewpoint and main masses Plan a slightly low, three-quarter view so both the deck surface and two faces of the treehouse can be understood. Place the main trunk a little off centre and let its principal branches spread across the upper composition. Lightly mark the horizon, then block in a compact wooden enclosure nestled beside the trunk. Set the deck at a believable height above the ground, with enough space around the enclosure to show access and a viewing area. Keep people, the ladder and openings in a consistent scale so the house does not appear miniature or impossibly large.

Step 2: Integrate the enclosure, deck and natural access Give the treehouse a modest roof and openings looking toward the surrounding greenery. Shape the deck around the trunk, leaving a clear opening for the tree, and show its outer edge, supporting members and a simple protective railing. Place a ladder made of timber or natural poles where it reaches a visible landing. Draw its side rails and rungs consistently in perspective. Indicate connections and supports clearly enough to explain the design, while keeping major branches free to grow. Use a few irregular timber edges or branch-like railing members to strengthen the natural character without making the structure unreadable.

Step 3: Build the surrounding landscape and depth Add a foreground patch of grass, roots and a few stones, with smaller shrubs around the base of the tree. Let overlapping leaves and branches frame the house without covering the deck or ladder. Keep nearby edges stronger and more detailed; use lighter, simpler trees and foliage farther away. Converge parallel deck boards and roof edges toward the appropriate vanishing directions. A restrained human figure on the deck or near the ladder can clarify scale, but should remain secondary to the treehouse and landscape.

Step 4: Apply light, texture and a coherent colour scheme Choose daylight from the upper left and maintain it throughout. Leave the lit roof and upper deck lighter; darken the underside of the deck, the interior behind openings and the shaded side of the trunk. Project cast shadows in the opposite direction, following the ground and deck planes. Suggest bark with irregular longitudinal strokes, wood grain with directional lines and leaves with grouped tonal masses instead of identical individual marks. Use warm muted browns for timber and varied greens for foliage, balanced by small cool shadows. Preserve lighter gaps for sunlight filtering through the canopy and avoid colouring every surface with equal intensity.

Step 5: Conclusion The finished composition should clearly show a distinctive treehouse, wooden deck and natural-material ladder integrated with the existing tree. Consistent perspective and scale

explain the structure, while directional sunlight, cast shadows, bark and timber textures, and a restrained brown-and-green palette create a harmonious connection with nature.

Quick Tip to Solve: Before adding texture, check that the ladder actually meets the deck, that deck boards share a perspective system, and that every cast shadow agrees with the chosen sunlight direction.

OR

77(b). Visualize a vibrant street food festival set in an urban environment. Consider street food stalls, chefs preparing dishes, people standing in line and a variety of cuisines. Include street decorations and seating arrangements capturing the lively and diverse scene. Use suitable colours of your choice.

[50 marks]

Solution:

Concept:

- A festival scene communicates activity through a clear focal area, overlapping figures and objects, and varied but organised stalls. The urban setting must be recognisable while remaining subordinate to the food festival.
- Perspective and human scale unite the stalls, seating and buildings within one space. Repeated decorative elements create rhythm, while controlled colour contrast and a consistent light direction establish a lively atmosphere.

Step 1: Lay out the street and principal activity Choose an eye-level view looking along a street or open urban lane. Mark a horizon and a main vanishing direction, then arrange food stalls on both sides of an open central circulation route. Set a prominent foreground stall slightly to one side as the focal point, leaving enough room to see a chef preparing food and customers waiting. Place a second cluster of activity farther back to lead the eye into the scene. Establish simple building fronts, pavements and street elements around the festival so the viewer recognises an urban environment without being distracted by excessive architectural detail.

Step 2: Show varied stalls and visible cooking actions Vary the canopies, counters, serving vessels and food displays to suggest a range of cuisines. At the main stall, show a chef working at a hot plate or preparation counter, with suitable utensils and ingredients arranged logically within reach. At other stalls, suggest different cooking or serving methods through a pot, grill, display tray or stack of plates. Give each stall a readable identity using a few clear visual cues rather than covering the drawing with lettering. Align counter edges and canopy frames with the scene's perspective, and keep their heights comparable to the people using them.

Step 3: Organise the crowd, queue and seating Show a recognisable queue beside one stall, with people facing the serving point, while other figures carry food, converse or move along the central route. Vary postures and group sizes to avoid a row of identical figures. Place shared tables and stools along one edge, with seated visitors eating and talking. Preserve clear gaps between the queue, seating and main pedestrian route so the space remains understandable. Make foreground figures larger and more detailed, reducing their size toward the vanishing area. Overlap some people with counters and furniture to create depth while keeping the chef's principal action and the main serving

point visible.

Step 4: Add decorations, light and colour Suspend strings of flags, bunting or lights above the street, following the depth of the scene. Add a few banners, planters or bins where they support the setting without filling every empty space. Choose warm reds, oranges and yellows for selected stall canopies and food displays, balanced by cooler building tones and quieter pavement colours. Repeat a small set of accent colours across the scene to unite the diverse stalls. Use one main light direction; shade the undersides of canopies and seating, and place cast shadows consistently beneath figures and counters. Keep the focal cooking area rich in contrast and simplify distant details to preserve a clear visual hierarchy.

Step 5: Conclusion The composition should present a lively urban food festival with varied cuisine stalls, chefs actively preparing dishes, orderly queues, people eating at shared seating, and festive street decorations. Perspective, overlapping figures and coordinated colour accents should connect these elements into one readable scene while retaining the energy and diversity of the event.

Quick Tip to Solve: Block in the open walking route before drawing the crowd; then use a foreground chef, a visible queue and a seating group to communicate three different festival activities clearly.