JEE Main 2024 Paper 2B (B.Planning) Jan 24 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 2B (B.Planning.) of JEE (Main) 2024, Session 1 (Jan-Feb), conducted by the National Testing Agency (NTA) in Computer Based Test (CBT) mode on 24 January 2024, Shift 2. The total duration is 3 hours.

(ii) The paper has 105 questions: Mathematics (30), Aptitude Test (50), Planning (25), in that order. Maximum marks: 400.

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

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

(v) Marking scheme (numerical value questions): $+4$ for a correct answer, -1 for an incorrect answer and 0 for an unanswered question.

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

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

1. The domain of the function $f(x) = \sqrt{4 - x^2} + \sqrt{2 + x}$ is $[a, b]$, then $a^2 + 3b^2$ is equal to [4 marks]

(A) 4

(B) 8

(C) 12

(D) 16

Correct Answer: (D) 16

Solution:

Concept:

- A real square root $\sqrt{u}$ is defined precisely when its radicand satisfies $u \geq 0$; zero is allowed, so valid endpoints belong to the domain.
- For a sum of square roots, every radicand must be nonnegative at the same input. Hence the domain is the intersection of the individual allowable sets, not their union.

Step 1: Solve the first radicand inequality The first term requires $4 - x^2 \geq 0$. Rearranging gives $x^2 \leq 4$, which is equivalent to $-2 \leq x \leq 2$. In particular, inputs below -2 or above 2 make this square root non-real, irrespective of what happens to the second term.

Step 2: Intersect with the second restriction The second term requires $2 + x \geq 0$, or $x \geq -2$. Its allowable interval is $[-2, \infty)$. Combining both requirements gives

$$[-2, 2] \cap [-2, \infty) = [-2, 2].$$

At $x = -2$, both radicands are zero; at $x = 2$, they are zero and four. Thus both endpoints are included, as required by the closed interval notation in the question.

Step 3: Evaluate the requested expression Comparing the domain with $[a, b]$, we obtain $a = -2$ and $b = 2$. Therefore

$$a^2 + 3b^2 = (-2)^2 + 3(2)^2 = 4 + 12 = 16.$$

The values 4, 8 and 12 fail to include the complete weighted sum of the squared endpoints.

Step 4: Conclusion The domain is $[-2, 2]$, and $a^2 + 3b^2 = 16$. Hence, the correct option is (D).

Quick Tip to Solve: Write one inequality for each square root, intersect the resulting intervals, and only then substitute the two endpoints into the requested expression.

2. Let $\mathbb{R}$ denote the set of real numbers, $\mathbb{Z}$ the set of integers and W the set of Non-negative integers, and define a map

(i) $f_1 : \mathbb{Z} \to \mathbb{Z}$ by $f_1(x) = x^3$. Then f_1 is one-one and not onto.

(ii) $f_2 : \mathbb{R} \to \mathbb{R}$ by $f_2(x) = x^3$. Then f_2 is one-one and onto.

(iii) $f_3 : \mathbb{Z} \to$ W by $f_3(x) = |x|$. Then f_3 is not one-one but is onto.

(iv) $f_4 : \mathbb{Z} \to \mathbb{Z}$ by $f_4(x) = x^2$. Then f_4 is neither one-one nor onto.

Then which of the following options is correct? [4 marks]

(A) (i), (iii), (iv) are true but (ii) is false

(B) All are true

(C) (ii), (iii) and (iv) are true but (i) is false

(D) (i), (ii) and (iv) are true but (iii) is false

Correct Answer: (B) All are true

Solution:

Concept:

- A function is one-one (injective) when equal outputs force equal inputs. It is onto (surjective) when every member of the specified codomain has a preimage in the domain.
- The same algebraic formula can have different surjectivity properties on different domains and codomains. In particular, an integer preimage is a stronger requirement than a real preimage.

Step 1: Check the two cubing maps For integers, $x^3 = y^3$ implies $x = y$, so f_1 is one-one. It is not onto $\mathbb{Z}$: the integer 2 has no integer cube root. Thus (i) is true. For any real target t, the real number $\sqrt[3]{t}$ maps to t. Cubing is strictly increasing on $\mathbb{R}$, so f_2 is both one-one and onto. Hence (ii) is also true.

Step 2: Check the absolute-value map For f_3, the two distinct integers 1 and -1 have the same output 1. Thus the map is not one-one. However, for each nonnegative integer $w \in W$, choosing the integer input $x = w$ gives $|x| = w$. This includes zero. Every codomain value therefore has a preimage and (iii) is true.

Step 3: Check the squaring map and compare all statements The equality $1^2 = (-1)^2$ proves that f_4 is not one-one. Its codomain is all of $\mathbb{Z}$, but no negative integer is a square, so it is not onto either. Thus (iv) is true. Option (A) incorrectly rejects (ii), option (C) incorrectly rejects (i), and option (D) incorrectly rejects (iii).

Step 4: Conclusion All four statements (i), (ii), (iii) and (iv) are true. Hence, the correct option is (B).

Quick Tip to Solve: For injectivity, seek a repeated output; for surjectivity, test every kind of codomain value, remembering that the domain controls which preimages are allowed.

3. If $\frac{\sqrt{5+12i}+\sqrt{5-12i}}{\sqrt{5+12i}-\sqrt{5-12i}} = a + bi$, then $a - b$ is : [4 marks]

(A) $\frac{5}{6}$

(B) $-\frac{5}{12}$

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

(D) $\frac{5}{12}$

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

Solution:

Concept:

- For real numbers u, v, $(u + iv)^2 = u^2 - v^2 + 2uvi$. This identifies square roots by matching their real and imaginary parts.
- The square-root symbol denotes the principal square root. For conjugate complex numbers away from the negative real axis, the principal roots are conjugates; here they have positive real parts.

Step 1: Identify both principal roots Since $3^2 - 2^2 = 5$ and $2 \cdot 3 \cdot 2 = 12$, we have

$$(3 + 2i)^2 = 5 + 12i, \qquad (3 - 2i)^2 = 5 - 12i.$$

Both numbers have positive real part, so the principal square roots are $\sqrt{5 + 12i} = 3 + 2i$ and $\sqrt{5 - 12i} = 3 - 2i$. The signs of their imaginary parts follow the signs in the original radicands.

Step 2: Simplify the ratio The numerator becomes $(3 + 2i) + (3 - 2i) = 6$, whereas the denominator becomes $(3 + 2i) - (3 - 2i) = 4i$. Thus the denominator is nonzero and

$$\frac{6}{4i} = \frac{3}{2i} = -\frac{3}{2}i,$$

where $1/i = -i$ follows from $i^2 = -1$. The ratio is purely imaginary: there is no real component to carry into a.

Step 3: Extract the required real coefficients Comparing with $a + bi$ gives $a = 0$ and $b = -3/2$. Consequently $a - b = 0 - (-3/2) = 3/2$. Options (A), (B) and (D) do not match these coefficients; the negative sign in the imaginary component must be reversed when subtracting b.

Step 4: Conclusion We obtain $a = 0$, $b = -3/2$, and hence $a - b = 3/2$. Hence, the correct option is (C).

Quick Tip to Solve: For a conjugate pair of principal roots, their sum is real and their difference is imaginary; simplify using $1/i = -i$ before reading off the coefficients.

4. Let A be a 3×3 matrix such that $\text{adj}(A) = \begin{bmatrix} 25 & 0 & 100 \\ 0 & 4 & 3 \\ 0 & 100 & 100 \end{bmatrix}$, then determinant of A is [4 marks]

(A) 25

(B) 50

(C) 100

(D) 1000

Correct Answer: The printed condition allows both determinant values 50 and -50; option (B) lists only the positive possibility.

Solution:

Concept:

- For an $n \times n$ matrix, $\det(\text{adj}\, A) = (\det A)^{n-1}$. In order three this gives a square, so the magnitude of the determinant is obtained first.
- A squared determinant does not determine its sign. Without a positivity condition, both signs must be checked rather than choosing the positive square root automatically.

Step 1: Evaluate the determinant of the given adjugate Let $B = \text{adj}\, A$ be the displayed matrix. Expanding along its first column, whose last two entries vanish, gives

$$\det B = 25 \begin{vmatrix} 4 & 3 \\ 100 & 100 \end{vmatrix} = 25(400 - 300) = 2500.$$

The entry 100 in the top right makes no contribution to this first-column expansion, so the minor is simply the bottom-right two-by-two block.

Step 2: Apply the adjugate identity As A has order three,

$$(\det A)^2 = 2500, \qquad \det A = \pm 50.$$

Neither the fact that B is invertible nor the entries of B select one of these signs. In particular, for order three, $\text{adj}(-A) = \text{adj}\, A$, because each cofactor is a determinant of order two. On the other hand $\det(-A) = -\det A$.

Step 3: Check that both signs really occur Writing $A_+ = 50B^{-1}$ and $A_- = -50B^{-1}$ gives $\det A_+ = 50$ and $\det A_- = -50$, since $\det B = 2500$. Furthermore $\text{adj}\, A_\pm = (\det A_\pm)A_\pm^{-1} = B$. Thus both satisfy the stated condition. The numbers 25, 100 and 1000 fail the squared determinant equation; 50 is the positive possible value offered in (B).

Step 4: Conclusion The condition determines $\det A = \pm 50$, so it does not uniquely determine the determinant. Option (B), 50, is the only listed possible value, but the negative value is also allowed by the printed condition.

Quick Tip to Solve: For a three-by-three adjugate question, keep the plus-or-minus sign after taking the square root; replacing A by $-A$ leaves its adjugate unchanged.

5. The total number of times the digit 3 will be written when listing integers from 1 to 1000 is

[4 marks]

(A) 297

(B) 243

(C) 273

(D) 300

Correct Answer: (D) 300

Solution:

Concept:

- Counting occurrences means counting each written digit separately: a number such as 333 contributes three occurrences, not just one number containing a 3.
- Leading-zero padding creates uniform digit positions without adding any occurrence of the nonzero digit 3. In all length-three strings, each digit appears equally often in each position.

Step 1: Use a uniform three-position list Consider the integers 0 through 999 written as 000, 001, and so on, up to 999. This is a list of $10^3 = 1000$ strings, each with hundreds, tens and units positions. Padding short numbers with zeros does not change how often 3 appears: for instance, the number 3 becomes 003 and still contributes exactly one occurrence.

Step 2: Count each position independently For an occurrence of 3 in the units position, fix the units digit at 3 and choose the other two digits freely. This gives $10 \cdot 10 = 100$ occurrences. Exactly the same argument gives 100 occurrences in the tens position and 100 in the hundreds position. Therefore

$$N = 100 + 100 + 100 = 300.$$

A number containing more than one 3 is included once for each relevant position, which is precisely what the question asks us to count.

Step 3: Adjust the endpoints The auxiliary list includes 000, which has no digit 3; removing it makes no difference. The requested endpoint 1000 also has no digit 3; adding it again makes no difference. Thus the total remains 300 for the range 1 through 1000. Options (A), (B) and (C) undercount the position-wise occurrences.

Step 4: Conclusion The digit 3 is written a total of 300 times. Hence, the correct option is (D).

Quick Tip to Solve: For a nonzero digit from 1 to 10^k, pad the preceding integers to k positions and count 10^{k-1} occurrences in each position.

6. The coefficient of x^{24} in $\left(1+x^2\right)^{12}\left(1+x^{12}\right)\left(1+x^{24}\right)$ is [4 marks]

(A) ${}^{12}C_6+3$

(B) ${}^{12}C_6$

(C) ${}^{12}C_6+1$

(D) ${}^{12}C_6+2$

Correct Answer: (D) ${}^{12}C_6+2$

Solution:

Concept:

- In $(1+x^2)^{12}$, the coefficient of x^{2r} is $\binom{12}{r}$, for $0 \le r \le 12$; no odd powers occur.
- To extract a coefficient from a product, list every way that the exponents chosen from its factors can add up to the desired exponent. Add the coefficients of those contributions.

Step 1: Expand only the two sparse factors The last two factors multiply to

$$(1+x^{12})(1+x^{24}) = 1+x^{12}+x^{24}+x^{36}.$$

To produce x^{24} after multiplication by $(1+x^2)^{12}$, these four terms would require powers x^{24}, x^{12}, x^0, and x^{-12}, respectively, from the first factor. Its polynomial expansion has no negative powers, so the fourth possibility contributes zero.

Step 2: Extract the three valid binomial coefficients The contribution paired with 1 is $\binom{12}{12}=1$, because $2r=24$ gives $r=12$. The contribution paired with x^{12} is $\binom{12}{6}$, because $2r=12$ gives $r=6$. The contribution paired with x^{24} is its constant coefficient $\binom{12}{0}=1$. Each coefficient from the sparse factors is itself one.

Step 3: Add and compare with the choices The total coefficient is

$$1+\binom{12}{6}+1=\binom{12}{6}+2.$$

Numerically $\binom{12}{6}=924$, so this is 926. Option (A) adds an extra nonexistent contribution; option (B) omits both boundary contributions; and option (C) omits one of them.

Step 4: Conclusion The coefficient is $\binom{12}{6}+2$. Hence, the correct option is (D).

Quick Tip to Solve: Expand the factors with only two terms first, then subtract each resulting exponent from the target exponent to locate the required binomial coefficients.

7. Sum to n terms of the series $\log_e a + \log_e\left(\frac{a^2}{b}\right) + \log_e\left(\frac{a^3}{b^2}\right) + \log_e\left(\frac{a^4}{b^3}\right) + \ldots\ldots\ldots\ldots$ is [4 marks]

(A) $\frac{n}{2}\left[(n+1)\log_e\left(\frac{a}{b}\right) - \log_e ab\right]$

(B) $\frac{n}{2}\left[n\log_e\left(\frac{a}{b}\right) - \log_e ab\right]$

(C) $\frac{n}{2}\left[\log_e\left(\frac{a}{b}\right) + n\log_e ab\right]$

(D) $\frac{n}{2}\left[n\log_e\left(\frac{a}{b}\right) + \log_e ab\right]$

Correct Answer: (D) $\frac{n}{2}\left[n\log_e\left(\frac{a}{b}\right) + \log_e ab\right]$

Solution:

Concept:

- For positive logarithm arguments, $\log_e(u/v) = \log_e u - \log_e v$ and $\log_e(u^r) = r\log_e u$. The printed real-valued series requires $a > 0$ and $b > 0$.
- The sum of the first n positive integers is $n(n+1)/2$, while the sum from zero to $n-1$ is $n(n-1)/2$. These two sums occur with different logarithms here.

Step 1: Write the general term The r-th term is

$$t_r = \log_e\left(\frac{a^r}{b^{r-1}}\right) = r\log_e a - (r-1)\log_e b.$$

It has the correct first term $\log_e a$ when $r = 1$, and the difference between consecutive terms is the constant $\log_e(a/b)$. Thus one may either sum these coefficients directly or treat the logarithms as an arithmetic progression.

Step 2: Sum the coefficients of both logarithms Adding from $r = 1$ to n yields

$$S_n = \frac{n(n+1)}{2}\log_e a - \frac{n(n-1)}{2}\log_e b.$$

Factoring out $n/2$, and separating each coefficient into its n-part and its constant part, gives

$$S_n = \frac{n}{2}\left[n(\log_e a - \log_e b) + (\log_e a + \log_e b)\right].$$

The coefficient of $\log_e b$ is negative in the original sum because each power of b occurs in a denominator.

Step 3: Combine the logarithms and select the formula The difference of logarithms is $\log_e(a/b)$, while their sum is $\log_e(ab)$. Therefore

$$S_n = \frac{n}{2}\left[n\log_e(a/b) + \log_e(ab)\right].$$

The plus sign before $\log_e(ab)$ rules out (A) and (B), and the multiplier n belongs to the ratio logarithm, not to the product logarithm as in (C).

Step 4: Conclusion The required sum is $\frac{n}{2}\left[n\log_e(a/b) + \log_e(ab)\right]$. Hence, the correct option is (D).

Quick Tip to Solve: Treat the logarithms as an A.P. with first term $\log_e a$ and common difference $\log_e(a/b)$; checking $n = 1$ is a useful sign check.

8. If the sum of first 10 terms and first 26 terms of an A.P. are 190 and 1326 respectively, then find the sum of its first 50 terms. [4 marks]

(A) 4900

(B) 4924

(C) 4950

(D) 4980

Correct Answer: (C) 4950

Solution:

Concept:

- For an arithmetic progression with first term a and common difference d, its first n terms sum to $S_n = \frac{n}{2}[2a + (n-1)d]$.
- Two specified partial sums provide two linear equations in a and d. Dividing by the factor $n/2$ before subtraction keeps the arithmetic short and preserves exact values.

Step 1: Convert the two sums into equations Using $S_{10} = 190$, we obtain

$$5(2a + 9d) = 190, \qquad 2a + 9d = 38.$$

Similarly $S_{26} = 1326$ gives

$$13(2a + 25d) = 1326, \qquad 2a + 25d = 102.$$

The coefficients 9 and 25 are each one less than the corresponding number of terms, as required by the sum formula.

Step 2: Solve for the progression Subtract the first equation from the second to eliminate $2a$:

$$16d = 102 - 38 = 64, \qquad d = 4.$$

Substituting back gives $2a + 36 = 38$, so $a = 1$. As a check, the tenth term is 37 and $10(1+37)/2 = 190$. The twenty-sixth term is 101 and $26(1 + 101)/2 = 1326$, confirming both supplied sums.

Step 3: Calculate the fifty-term sum The fiftieth term is $a + 49d = 1 + 196 = 197$, so

$$S_{50} = \frac{50}{2}(1 + 197) = 25 \cdot 198 = 4950.$$

Equivalently, substitute $a = 1$, $d = 4$ directly in the sum formula. The other numerical options disagree with these uniquely determined progression parameters; no rounding is involved in this integer calculation.

Step 4: Conclusion The sum of the first fifty terms is 4950. Hence, the correct option is (C).

Quick Tip to Solve: Divide each supplied partial sum by $n/2$, then subtract the equations to find the common difference before calculating the new partial sum.

9. If $\lim_{x\to 1}\frac{x^5-1}{x-1}=\lim_{x\to k}\frac{x^3-k^3}{x^2-k^2}$, then k is equal to [4 marks]

(A) $\frac{5}{3}$

(B) $\frac{7}{3}$

(C) $\frac{8}{3}$

(D) $\frac{10}{3}$

Correct Answer: (D) $\frac{10}{3}$

Solution:

Concept:

- For a polynomial, the quotient $\lim_{x\to a}(p(x)-p(a))/(x-a)$ is its derivative at a. The same limits can be evaluated by cancelling the common factor before substitution.
- When both numerator and denominator vanish, factorisation must precede substitution. The value $k=0$ needs a separate check because the remaining denominator $x+k$ also vanishes there.

Step 1: Evaluate the first limit Factor the difference of fifth powers. For $x\neq 1$,

$$\frac{x^5-1}{x-1}=x^4+x^3+x^2+x+1.$$

The polynomial on the right is continuous at 1, so the left-hand limit is $1+1+1+1+1=5$. The original quotient need not be defined at 1 for its limit to exist.

Step 2: Evaluate the second limit and equate For $k\neq 0$, cancel $x-k$ in the numerator and denominator:

$$\lim_{x\to k}\frac{x^3-k^3}{x^2-k^2}=\lim_{x\to k}\frac{x^2+kx+k^2}{x+k}=\frac{3k^2}{2k}=\frac{3k}{2}.$$

Hence $3k/2=5$, giving $k=10/3$. If $k=0$, the quotient reduces to x away from zero and its limit is 0, which does not equal 5. Thus this exceptional value is excluded. Options (A), (B) and (C) give limits $5/2$, $7/2$ and 4 respectively, so none satisfies the stated equality.

Step 3: Conclusion Therefore $k=\dfrac{10}{3}$. Hence, the correct option is (D).

Quick Tip to Solve: Cancel the difference-of-powers factors first, but check separately any parameter value that makes the simplified denominator zero.

10. Let $f : [0, \pi] \to \mathbb{R}$ be a function defined by $f(x) = \begin{cases} x + \sqrt{2}a \sin x, & 0 \le x < \frac{\pi}{4} \\ 2x \cot x + b, & \frac{\pi}{4} \le x \le \frac{\pi}{2} \\ a \cos 2x - b \sin x, & \frac{\pi}{2} < x \le \pi \end{cases}$.

If f is continuous for $0 \le x \le \pi$, then $a^2 + 140b^2$ is equal to [4 marks]

(A) 0

(B) π^2

(C) $2\pi^2$

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

Correct Answer: (B) π^2

Solution:

Concept:

- Each displayed branch is continuous in the interior of its interval. For continuity of the complete function, its left and right limits must agree at the joining points $\pi/4$ and $\pi/2$.
- At a joining point included in the middle branch, use that branch for the function value. Use $\sin(\pi/4) = 1/\sqrt{2}$, $\cot(\pi/4) = 1$, and $\cos \pi = -1$.

Step 1: Apply continuity at the first joining point The left limit at $x = \pi/4$ comes from the first branch, while the function value comes from the second:

$$\frac{\pi}{4} + a = 2\frac{\pi}{4} \cot \frac{\pi}{4} + b = \frac{\pi}{2} + b.$$

Therefore $a - b = \pi/4$. This is the first independent relation between the two constants; continuity on only one join is not enough to determine both.

Step 2: Apply the second join and calculate At $x = \pi/2$, the middle branch has value b, because $\cot(\pi/2) = 0$. The limit from the third branch is $-a - b$. Consequently,

$$b = -a - b, \qquad a = -2b.$$

Substitute this into the first relation to obtain

$$-3b = \frac{\pi}{4}, \qquad b = -\frac{\pi}{12}, \qquad a = \frac{\pi}{6}.$$

Now retain both squared contributions:

$$a^2 + 140b^2 = \frac{\pi^2}{36} + \frac{140\pi^2}{144} = \frac{4 + 140}{144}\pi^2 = \pi^2.$$

Both joins now agree, and the one-sided endpoint conditions hold because the first and last branch formulas are continuous at 0 and π. The other proposed values do not equal this evaluated sum.

Step 3: Conclusion The required value is π^2. Hence, the correct option is (B).

Quick Tip to Solve: Write one equation per join before solving for constants; at the second join the middle branch contributes only b.

11. $\int \frac{dx}{\sin^2 x \cos^2 x}$ **is equal to** [4 marks]

(A) $\tan x + \cot x + c$

(B) $(\tan x + \cot x)^2 + c$

(C) $\tan x - \cot x + c$

(D) $2(\sec x \tan x - \operatorname{cosec} x \cot x) + c$

Correct Answer: (C) $\tan x - \cot x + c$

Solution:

Concept:

- Use $\sin^2 x + \cos^2 x = 1$ to split a product in the denominator into a sum of familiar squared reciprocals.
- The fundamental derivatives are $\frac{d}{dx}\tan x = \sec^2 x$ and $\frac{d}{dx}\cot x = -\operatorname{cosec}^2 x$. These formulas apply on intervals where the functions are defined.

Step 1: Split the integrand into standard forms The denominator is nonzero only when both $\sin x$ and $\cos x$ are nonzero. On any such interval,

$$\frac{1}{\sin^2 x \cos^2 x} = \frac{\sin^2 x + \cos^2 x}{\sin^2 x \cos^2 x} = \sec^2 x + \operatorname{cosec}^2 x.$$

This identity is preferable to a substitution because both terms have immediate antiderivatives. The numerator introduced here is exactly 1, so no numerical factor is required.

Step 2: Integrate and check the sign Integrate the two terms separately:

$$\int \frac{dx}{\sin^2 x \cos^2 x} = \int \sec^2 x\, dx + \int \operatorname{cosec}^2 x\, dx = \tan x - \cot x + c.$$

Differentiating the answer gives $\sec^2 x + \operatorname{cosec}^2 x$, exactly the original integrand. Option (A) instead differentiates to their difference. Option (B) introduces the extra factor $2(\tan x + \cot x)$ upon differentiation, so it cannot be an antiderivative. At $x = \pi/4$, the derivative of option (D) is $12\sqrt{2}$, whereas the required integrand is 4; this rules it out as well. The integration constant is arbitrary on each interval avoiding singularities.

Step 3: Conclusion The integral equals $\tan x - \cot x + c$. Hence, the correct option is (C).

Quick Tip to Solve: The minus sign before cotangent is essential: its derivative is negative cosecant squared, so subtracting it supplies a positive term.

12. The solution of differential equation $\left(x+2y^3\right)\frac{dy}{dx}=y$ is [4 marks]

(A) $x=y^2+c$

(B) $y=x^2+c$

(C) $x=y\left(y^2+c\right)$

(D) $y=x\left(x^2+c\right)$

Correct Answer: (C) $x=y\left(y^2+c\right)$

Solution:

Concept:

- An equation awkward in $y(x)$ can become linear when x is treated as the dependent variable and y as the independent variable.
- For $dx/dy+P(y)x=Q(y)$, the integrating factor is $e^{\int P(y)\,dy}$. Here division by y is valid on an interval with $y\neq 0$.

Step 1: Rewrite as a linear equation in x From $(x+2y^3)\,dy/dx=y$, invert the derivative locally on a nonzero solution branch to obtain

$$\frac{dx}{dy}=\frac{x}{y}+2y^2, \qquad \frac{dx}{dy}-\frac{x}{y}=2y^2.$$

The integrating factor is $e^{-\int dy/y}$, which may be taken as $1/y$ on an interval of fixed sign. Multiplying by it gives

$$\frac{1}{y}\frac{dx}{dy}-\frac{x}{y^2}=2y.$$

The left side is the derivative of x/y, so the equation is now directly integrable.

Step 2: Integrate and verify the family Integration yields

$$\frac{x}{y}=y^2+c, \qquad x=y(y^2+c).$$

For a direct check, implicit differentiation gives $1=(3y^2+c)dy/dx$. Since the proposed family has $x+2y^3=y(3y^2+c)$, multiplication recovers the original equation wherever the derivative exists. Options (A) and (B) have derivatives involving only quadratic families and do not supply the required cubic term; option (D) reverses the roles of the dependent variables and fails the same substitution check. The constant solution $y=0$ also satisfies the original equation and is an additional solution lost when dividing by y; the listed general nonzero family is option (C).

Step 3: Conclusion The listed general solution is $x=y(y^2+c)$. Hence, the correct option is (C).

Quick Tip to Solve: When dy/dx is multiplied by an expression linear in x, try solving for x as a function of y; also check solutions lost by division.

13. The point diametrically opposite to the point $(-1, 1)$ on the circle $x^2+y^2-x-4y+1=0$ is [4 marks]

(A) $(-2, 5)$

(B) $(2, -5)$

(C) $(0, 3)$

(D) $(2, 3)$

Correct Answer: (D) $(2, 3)$

Solution:

Concept:

- The circle $x^2 + y^2 + 2gx + 2fy + c = 0$ has centre $(-g, -f)$. A diameter has the centre as its midpoint.
- If $P = (x_1, y_1)$ and the centre is $C = (h, k)$, its diametrically opposite endpoint is $Q = (2h - x_1, 2k - y_1)$.

Step 1: Locate the centre of the given circle Compare $x^2 + y^2 - x - 4y + 1 = 0$ with the general equation. Then $2g = -1$ and $2f = -4$, so the centre is $C = (1/2, 2)$. Equivalently, completing squares gives

$$\left(x - \frac{1}{2}\right)^2 + (y - 2)^2 = \frac{13}{4}.$$

This confirms the centre and gives a positive squared radius. Substitution of $P = (-1, 1)$ in the original circle gives $1 + 1 + 1 - 4 + 1 = 0$, confirming that the stated endpoint lies on the circle.

Step 2: Reflect the endpoint through the centre Let the opposite endpoint be $Q = (u, v)$. By the midpoint formula,

$$\frac{-1+u}{2} = \frac{1}{2}, \qquad \frac{1+v}{2} = 2.$$

Therefore $u = 2$ and $v = 3$. To check the result, the midpoint of $(-1, 1)$ and $(2, 3)$ is indeed $(1/2, 2)$, and $(2, 3)$ satisfies the circle since $4 + 9 - 2 - 12 + 1 = 0$. Points $(-2, 5)$, $(2, -5)$, and $(0, 3)$ give midpoints $(-3/2, 3)$, $(1/2, -2)$, and $(-1/2, 2)$ respectively with P. None of these is the centre, so those options cannot be diametrically opposite even without separately testing their circle equations.

Step 3: Conclusion The opposite endpoint is $(2, 3)$. Hence, the correct option is (D).

Quick Tip to Solve: A diametrically opposite point is twice the centre minus the given point; keep the signs of the original coordinates when subtracting.

14. The vertices of a triangle OAB are $(0,0)$, $(a,0)$ and $(0,b)$ respectively. The distance between its orthocentre and circumcentre is [4 marks]

(A) $(a+b)$

(B) $(a-b)$

(C) $\frac{1}{2}\sqrt{a^2+b^2}$

(D) $\frac{1}{2}\sqrt{a^2-b^2}$

Correct Answer: (C) $\frac{1}{2}\sqrt{a^2+b^2}$

Solution:

Concept:

- The orthocentre is the intersection of the altitudes. In a right triangle, the two perpendicular legs themselves are altitudes, so the orthocentre is the right-angled vertex.
- The circumcentre of a right triangle is the midpoint of its hypotenuse. The distance formula between (x_1,y_1) and (x_2,y_2) is $\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$.

Step 1: Identify both centres using the right angle The segment OA lies along the x-axis and OB lies along the y-axis. Thus $OA \perp OB$, and the right angle is at $O=(0,0)$, assuming the stated triangle is nondegenerate. The altitude from A is along AO, because it is perpendicular to OB. Similarly, the altitude from B is along BO. They intersect at O, giving the orthocentre $H=(0,0)$. The hypotenuse is AB, whose midpoint is

$$C=\left(\frac{a+0}{2},\frac{0+b}{2}\right)=\left(\frac{a}{2},\frac{b}{2}\right).$$

This is the circumcentre; its distances to O, A and B are all equal.

Step 2: Calculate the distance and compare the choices Apply the distance formula from H to C:

$$HC=\sqrt{\left(\frac{a}{2}\right)^2+\left(\frac{b}{2}\right)^2}=\frac{1}{2}\sqrt{a^2+b^2}.$$

The squares make the result nonnegative even if a coordinate is negative. The quantities $a+b$ and $a-b$ are signed sums of coordinates rather than Euclidean distances. Option (D) wrongly subtracts squared perpendicular displacements; it would even become nonreal for $|b|>|a|$. As a further check, HC equals half of AB, the circumradius, because H is itself the vertex O on the circumcircle. Thus only option (C) has the required geometric and algebraic form.

Step 3: Conclusion The distance is $\frac{1}{2}\sqrt{a^2+b^2}$. Hence, the correct option is (C).

Quick Tip to Solve: First look for a right angle: the orthocentre is then that vertex and the circumcentre is the midpoint of the opposite side.

15. The shortest distance between the lines $\vec{r} = (\hat{i} + 2\hat{j} + 3\hat{k}) + \lambda(\hat{i} - 3\hat{j} + 2\hat{k})$ and $\vec{r} = (4\hat{i} + 5\hat{j} + 6\hat{k}) + \mu(2\hat{i} + 3\hat{j} + \hat{k})$ is : [4 marks]

(A) $\frac{1}{19}$ units

(B) $\sqrt{19}$ units

(C) $\frac{3}{\sqrt{19}}$ units

(D) $\frac{1}{\sqrt{19}}$ units

Correct Answer: (C) $\frac{3}{\sqrt{19}}$ units

Solution:

Concept:

- For nonparallel lines $\vec{r} = \vec{a}_1 + \lambda\vec{b}_1$ and $\vec{r} = \vec{a}_2 + \mu\vec{b}_2$, their shortest distance is the magnitude of the projection of $\vec{a}_2 - \vec{a}_1$ on a common normal.
- The common normal is $\vec{b}_1 \times \vec{b}_2$, giving $d = |(\vec{a}_2 - \vec{a}_1) \cdot (\vec{b}_1 \times \vec{b}_2)|/|\vec{b}_1 \times \vec{b}_2|$. The absolute value ensures a nonnegative distance.

Step 1: Compute a normal to both directions Read the point vectors and direction vectors separately:

$$\vec{a}_2 - \vec{a}_1 = (3, 3, 3), \quad \vec{b}_1 = (1, -3, 2), \quad \vec{b}_2 = (2, 3, 1).$$

Their cross product is

$$\begin{aligned} \vec{b}_1 \times \vec{b}_2 &= \big((-3)(1) - 2(3),\ 2(2) - 1(1),\ 1(3) - (-3)(2)\big) \\ &= (-9, 3, 9). \end{aligned}$$

This is nonzero, so the lines are not parallel and the common-normal formula applies. A scalar multiple $(-3, 1, 3)$ would give the same distance.

Step 2: Project the displacement onto the normal The scalar triple product is

$$(3, 3, 3) \cdot (-9, 3, 9) = -27 + 9 + 27 = 9.$$

The normal has magnitude

$$\sqrt{(-9)^2 + 3^2 + 9^2} = \sqrt{171} = 3\sqrt{19}.$$

Hence $d = 9/(3\sqrt{19}) = 3/\sqrt{19}$ units. The nonzero numerator also confirms that the lines do not intersect. Options (A) and (D) result from losing factors in the normal or the triple product, while option (B) corresponds to the magnitude of the reduced normal itself, not the displacement's projection. The ratio must retain both the numerator and the normalisation factor.

Step 3: Conclusion The shortest distance is $\dfrac{3}{\sqrt{19}}$ units. Hence, the correct option is (C).

Quick Tip to Solve: Reduce a common normal by any nonzero factor if convenient, but use that same normal in both the dot product and its magnitude.

16. The projection vector of $\vec{a} = \hat{i} - 3\hat{j} - 3\hat{k}$ on $\vec{b} = 3\hat{i} - 4\hat{j}$ is [4 marks]

(A) $\frac{9}{5}\hat{i} - \frac{12}{5}\hat{j}$

(B) $\frac{3}{\sqrt{19}}\hat{i} - \frac{4}{\sqrt{19}}\hat{j}$

(C) $\frac{12}{5}\hat{i} - \frac{36}{5}\hat{j} - \frac{36}{5}\hat{k}$

(D) $9\hat{i} - 12\hat{j}$

Correct Answer: (A) $\frac{9}{5}\hat{i} - \frac{12}{5}\hat{j}$

Solution:

Concept:

- The vector projection of $\vec{a}$ onto nonzero $\vec{b}$ is $\text{proj}_{\vec{b}}\,\vec{a} = (\vec{a} \cdot \vec{b})\vec{b}/|\vec{b}|^2$. It is parallel to $\vec{b}$.
- The scalar projection is instead $(\vec{a} \cdot \vec{b})/|\vec{b}|$. Multiplying that scalar by the unit vector in the direction of $\vec{b}$ produces the vector projection.

Step 1: Evaluate the dot product and squared magnitude Use the components $\vec{a} = (1, -3, -3)$ and $\vec{b} = (3, -4, 0)$. The zero third component of b means the third component of a contributes nothing to the dot product:

$$\vec{a} \cdot \vec{b} = 1(3) + (-3)(-4) + (-3)(0) = 15, \qquad |\vec{b}|^2 = 3^2 + (-4)^2 = 25.$$

The positive dot product means the projection points in the same direction as b. Its scalar component along the unit direction is $15/5 = 3$, but this scalar alone is not the requested vector.

Step 2: Form and verify the projection vector Multiply b by the coefficient $15/25 = 3/5$:

$$\text{proj}_{\vec{b}}\,\vec{a} = \frac{3}{5}(3\hat{i} - 4\hat{j}) = \frac{9}{5}\hat{i} - \frac{12}{5}\hat{j}.$$

This vector has zero k-component and magnitude 3, as required. For an independent check, the remainder is $(-4/5, -3/5, -3)$; its dot product with b is $-12/5 + 12/5 = 0$. Option (B) has the correct direction but the wrong magnitude because its denominator is based on a rather than b. Option (C) has a nonzero k-component and cannot be parallel to b. Option (D) misses the required normalising denominator and has magnitude 15, so it also fails.

Step 3: Conclusion The projection vector is $\frac{9}{5}\hat{i} - \frac{12}{5}\hat{j}$. Hence, the correct option is (A).

Quick Tip to Solve: A vector projection onto b must be parallel to b; use that direction test first, then divide the dot product by the squared length of b.

17. Given $|\vec{a}| = |\vec{b}| = 1$ and $|\vec{a} + \vec{b}| = \sqrt{3}$. If $\vec{c}$ is a vector such that $\vec{c} - \vec{a} - 2\vec{b} = 3(\vec{a} \times \vec{b})$, then $\vec{c} \cdot \vec{b}$ is equal to [4 marks]

(A) $-\frac{1}{2}$

(B) $\frac{1}{2}$

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

(D) $\frac{5}{2}$

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

Solution:

Concept:

- The square of a vector magnitude is its scalar product with itself. Thus $|\vec{a} + \vec{b}|^2 = |\vec{a}|^2 + |\vec{b}|^2 + 2\vec{a} \cdot \vec{b}$.
- The cross product $\vec{a} \times \vec{b}$ is perpendicular to both factors, so its scalar product with $\vec{b}$ is zero. Scalar products distribute over vector sums.

Step 1: Find the scalar product of the unit vectors The magnitude condition supplies the angle information without needing to find the angle explicitly. Squaring the given positive magnitudes gives

$$3 = 1 + 1 + 2\vec{a} \cdot \vec{b}.$$

Therefore

$$\vec{a} \cdot \vec{b} = \frac{1}{2}.$$

This is consistent with the vectors making an angle of 60°.

Step 2: Take the scalar product with the required vector First isolate the vector whose projection is wanted:

$$\vec{c} = \vec{a} + 2\vec{b} + 3(\vec{a} \times \vec{b}).$$

Take its scalar product with $\vec{b}$. The cross-product term contributes nothing because it is perpendicular to $\vec{b}$:

$$\vec{c} \cdot \vec{b} = \vec{a} \cdot \vec{b} + 2|\vec{b}|^2 + 3(\vec{a} \times \vec{b}) \cdot \vec{b}$$
$$= \frac{1}{2} + 2 + 0 = \frac{5}{2}.$$

The values $-1/2$ and $1/2$ omit the contribution from $2\vec{b}$; $3/2$ also fails to include its full scalar product. The multiplier 3 on the perpendicular term does not affect the result.

Step 3: Conclusion Thus $\vec{c} \cdot \vec{b} = \boxed{5/2}$. Hence, the correct option is (D).

Quick Tip to Solve: When dotting a vector expression with one factor of a cross product, discard that perpendicular term first; then use the magnitude condition to find the remaining dot product.

18. If A and B are two events such that $P(A \cup B) = \frac{5}{8}$ and $P(A' \cup B') = \frac{3}{4}$, then $P(A') + P(B') =$

[4 marks]

(A) $\frac{1}{8}$
(B) $\frac{3}{8}$
(C) $\frac{9}{8}$
(D) $\frac{11}{8}$

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

Solution:

Concept:

- De Morgan's law gives $(A \cap B)' = A' \cup B'$, so complementary probabilities add to one.
- The addition rule is $P(A \cup B) = P(A) + P(B) - P(A \cap B)$. It applies whether or not the events are independent or disjoint.

Step 1: Recover the intersection probability The second given probability describes the complement of the intersection, not the complement of the union. Therefore

$$P(A \cap B) = 1 - P(A' \cup B') = 1 - \frac{3}{4} = \frac{1}{4}.$$

Interchanging union and intersection here would give an incorrect result. No assumption about independence is needed.

Step 2: Use the union to find the sum of individual probabilities Rearrange the addition formula before substituting:

$$P(A) + P(B) = P(A \cup B) + P(A \cap B)$$
$$= \frac{5}{8} + \frac{1}{4} = \frac{7}{8}.$$

This sum counts the intersection twice, as required for the two individual event probabilities. The union alone counts that overlap only once.

Step 3: Convert both events to their complements Apply the complement rule separately to the two requested terms:

$$P(A') + P(B') = [1 - P(A)] + [1 - P(B)]$$
$$= 2 - \frac{7}{8} = \frac{9}{8}.$$

A sum of two probabilities may exceed one, since it is not the probability of a single event. The alternatives $1/8$, $3/8$, and $11/8$ do not satisfy this complement relation with the computed sum $7/8$.

Step 4: Conclusion The required sum is $\boxed{9/8}$. Hence, the correct option is (C).

Quick Tip to Solve: Find the intersection from the union of complements first. Then add union and intersection to get the sum of the two individual probabilities.

19. The value of $\sec 15^\circ - \sqrt{3}\,\mathrm{cosec}\,15^\circ$ is [4 marks]

(A) $4\sqrt{2}$

(B) $3\sqrt{3}$

(C) $-3\sqrt{3}$

(D) $-4\sqrt{2}$

Correct Answer: (D) $-4\sqrt{2}$

Solution:

Concept:

- Angle-difference identities give $\sin(45^\circ - 30^\circ)$ and $\cos(45^\circ - 30^\circ)$ in exact radical form.
- Reciprocal functions satisfy $\sec\theta = 1/\cos\theta$ and $\mathrm{cosec}\,\theta = 1/\sin\theta$. Rationalising denominators makes their difference easy to simplify.

Step 1: Evaluate the sine and cosine of fifteen degrees Both sine and cosine are positive at this first-quadrant angle. Use the familiar values at 45° and 30°:

$$\sin 15^\circ = \frac{\sqrt{6} - \sqrt{2}}{4},$$
$$\cos 15^\circ = \frac{\sqrt{6} + \sqrt{2}}{4}.$$

The sine has the minus sign because it comes from the sine of a difference; the cosine has the plus sign.

Step 2: Rationalise the reciprocal functions Multiplying each denominator by its conjugate introduces the difference $6 - 2 = 4$, which cancels the numerator 4:

$$\sec 15^\circ = \frac{4}{\sqrt{6} + \sqrt{2}} = \sqrt{6} - \sqrt{2},$$
$$\mathrm{cosec}\,15^\circ = \frac{4}{\sqrt{6} - \sqrt{2}} = \sqrt{6} + \sqrt{2}.$$

Keeping these exact values avoids any error from decimal approximations.

Step 3: Substitute and collect the radical terms The multiplier $\sqrt{3}$ applies to the whole cosecant value:

$$\begin{aligned}\sec 15^\circ - \sqrt{3}\,\mathrm{cosec}\,15^\circ &= \sqrt{6} - \sqrt{2} - \sqrt{3}(\sqrt{6} + \sqrt{2}) \\ &= \sqrt{6} - \sqrt{2} - 3\sqrt{2} - \sqrt{6} \\ &= -4\sqrt{2}.\end{aligned}$$

The expression must be negative because the subtracted cosecant term is larger than the secant term. This rejects both positive choices, while $-3\sqrt{3}$ is not the exact radical simplification.

Step 4: Conclusion The value is $\boxed{-4\sqrt{2}}$. Hence, the correct option is (D).

Quick Tip to Solve: Use the conjugate pair: $\sec 15^\circ = \sqrt{6} - \sqrt{2}$ and $\mathrm{cosec}\,15^\circ = \sqrt{6} + \sqrt{2}$; the $\sqrt{6}$ terms then cancel.

20.

$$\cot^{-1} 7 + \cot^{-1} 8 + \cot^{-1} 5 =$$

[4 marks]

(A) $\cot^{-1} 2$

(B) $\cot^{-1} 10$

(C) $\cot^{-1} 6$

(D) $\cot^{-1} 4$

Correct Answer: (A) $\cot^{-1} 2$

Solution:

Concept:

- For positive t, the principal angle $\cot^{-1} t$ is acute and equals $\tan^{-1}(1/t)$. The branch of the answer must be checked when adding inverse functions.
- The cotangent addition identity is $\cot(u+v) = (\cot u \cot v - 1)/(\cot u + \cot v)$, whenever its denominator is nonzero.

Step 1: Add the first two inverse cotangents Let $u = \cot^{-1} 7$, $v = \cot^{-1} 8$, and $w = \cot^{-1} 5$. Each angle is positive and acute. Apply the cotangent sum formula:

$$\cot(u+v) = \frac{7 \cdot 8 - 1}{7+8} = \frac{55}{15} = \frac{11}{3}.$$

The first sum is still acute: its positive cotangent and the bound $0 < u + v < \pi$ place it in the first quadrant.

Step 2: Include the third angle Apply the same identity again, retaining the fractional value exactly:

$$\begin{aligned}\cot(u+v+w) &= \frac{(11/3)5 - 1}{11/3 + 5} \\ &= \frac{52/3}{26/3} = 2.\end{aligned}$$

This computes the cotangent of the total, but we still need to identify its principal inverse without adding an unwanted multiple of π.

Step 3: Check the branch and compare the options For a positive real number z, $0 < \tan^{-1} z < z$. Consequently

$$0 < u + v + w < \frac{1}{7} + \frac{1}{8} + \frac{1}{5} = \frac{131}{280} < \frac{\pi}{2}.$$

Thus the sum is the unique acute angle with cotangent 2, namely $\cot^{-1} 2$. The inverse cotangents of 10, 6 and 4 have different cotangents, and none equals this acute angle.

Step 4: Conclusion $\cot^{-1} 7 + \cot^{-1} 8 + \cot^{-1} 5 = \boxed{\cot^{-1} 2}$. Hence, the correct option is (A).

Quick Tip to Solve: Add inverse cotangents using their cotangents, then bound the positive angle sum to check the principal branch before taking the inverse.

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

Attempt any 5 of the 10 questions in this section.

21. Let α and β be the roots of the equation $x^2 - 6x - 2 = 0$, with $\alpha > \beta$. If $a_n = \alpha^n - \beta^n$ for $n \geq 1$, then the value of $\frac{a_{10} - 2a_8}{3a_9}$ is equal to _____ [4 marks]

Solution:

Concept:

- Every root t of $t^2 - 6t - 2 = 0$ satisfies $t^2 = 6t + 2$. Multiplication by a suitable power produces a recurrence for its powers.
- Subtracting the identities for two roots gives the same linear recurrence for their power difference $a_n = \alpha^n - \beta^n$.

Step 1: Derive the recurrence for the power differences For either root, multiply $t^2 = 6t + 2$ by t^{n-2}, where $n \geq 2$:

$$t^n = 6t^{n-1} + 2t^{n-2}.$$

Write this once for α, once for β, and subtract:

$$a_n = 6a_{n-1} + 2a_{n-2}.$$

For this recurrence at $n = 2$, the natural extension $a_0 = 1 - 1 = 0$ is consistent, though only the relation at $n = 10$ is required.

Step 2: Cancel the numerator by using the recurrence Substituting $n = 10$ gives

$$a_{10} = 6a_9 + 2a_8.$$

Hence the particular combination in the numerator was chosen to cancel the a_8 term:

$$a_{10} - 2a_8 = 6a_9.$$

There is no need to compute tenth powers of the irrational roots. Such a calculation would be longer and would hide the simple recurrence structure.

Step 3: Check the denominator before simplifying The roots are $\alpha = 3 + \sqrt{11}$ and $\beta = 3 - \sqrt{11}$. The first is positive and the second is negative. Since the ninth power is odd, $a_9 = \alpha^9 - \beta^9 > 0$. Division by $3a_9$ is therefore valid:

$$\frac{a_{10} - 2a_8}{3a_9} = \frac{6a_9}{3a_9} = 2.$$

This is an exact integer, so no rounding convention affects the response.

Step 4: Conclusion The numerical value to enter is $\boxed{2}$.

Quick Tip to Solve: When roots satisfy a quadratic, turn it into a recurrence for powers and their differences; match the numerator with that recurrence instead of evaluating large powers.

22. If α, β, γ are the angles of a triangle, then the value of the determinant $\begin{vmatrix} \cot\alpha & \cot\beta & \cot\gamma \\ 1 & 1 & 1 \\ \sin^2\alpha & \sin^2\beta & \sin^2\gamma \end{vmatrix}$ is equal to _____ [4 marks]

Solution:

Concept:

- Triangle angles satisfy $\alpha + \beta + \gamma = \pi$. This allows differences of squared sines to be expressed using cotangent differences.
- A determinant is zero when one row is a linear combination of the other rows. A common coefficient relation across all three columns is enough to prove this.

Step 1: Relate two entries in the third row Use the difference identity and the angle sum:

$$\begin{aligned} \sin^2\alpha - \sin^2\beta &= \sin(\alpha+\beta)\sin(\alpha-\beta) \\ &= \sin\gamma \sin\alpha \sin\beta(\cot\beta - \cot\alpha). \end{aligned}$$

Here $\sin(\alpha-\beta) = \sin\alpha\cos\beta - \cos\alpha\sin\beta$, which explains the order of the cotangents and fixes the minus sign.

Step 2: Find the common linear relation for all columns Set $K = \sin\alpha\sin\beta\sin\gamma$. Rearranging the identity yields

$$\sin^2\alpha + K\cot\alpha = \sin^2\beta + K\cot\beta.$$

The same argument for β and γ shows that these both equal $\sin^2\gamma + K\cot\gamma$. Call the common value L. Thus, for every triangle angle θ in the columns,

$$\sin^2\theta = L - K\cot\theta.$$

All sines are nonzero because each angle lies strictly between zero and π.

Step 3: Apply a determinant row operation If the displayed rows are R_1, R_2, R_3, the columnwise relation is

$$R_3 = LR_2 - KR_1.$$

The operation $R_3 \leftarrow R_3 + KR_1 - LR_2$ leaves the determinant unchanged and makes its entire third row zero. A determinant with a zero row vanishes. This proof includes right triangles and does not divide by a cotangent, which could be zero.

Step 4: Conclusion The determinant has the numerical value $\boxed{0}$.

Quick Tip to Solve: For a determinant built from triangle angles, seek one relation holding in every column. Here $\sin^2\theta + K\cot\theta$ is constant across the three angles.

23. If r^{th} term in the expansion of $\left(\sqrt[3]{\frac{a}{\sqrt{b}}}+\sqrt{\frac{b}{\sqrt[3]{a}}}\right)^{21}$ contains equal powers of a and b, then value of r is _____ [4 marks]

Solution:

Concept:

- The $(k+1)$th term of $(X+Y)^n$ is $\binom{n}{k}X^{n-k}Y^k$, with k starting at zero. The term number is one more than the exponent index.
- Convert nested radicals into fractional powers before using the general term. Equal powers of two variables mean equality of their resulting exponents.

Step 1: Write each radical as powers of the variables For the algebraic expansion, take the displayed radicals in their usual admissible domain, for example $a, b > 0$. Then

$$X = \sqrt[3]{\frac{a}{\sqrt{b}}} = a^{1/3}b^{-1/6}, \qquad Y = \sqrt{\frac{b}{\sqrt[3]{a}}} = a^{-1/6}b^{1/2}.$$

The negative powers arise from the denominators, so their signs must be retained when the factors are raised to further powers.

Step 2: Calculate both exponents in the general term The general term with index k is

$$\begin{aligned} T_{k+1} &= \binom{21}{k}(a^{1/3}b^{-1/6})^{21-k}(a^{-1/6}b^{1/2})^k \\ &= \binom{21}{k}a^{7-k/2}b^{-7/2+2k/3}. \end{aligned}$$

The binomial coefficient is independent of a and b, so it does not affect the equality of powers. The exponents combine contributions from both factors.

Step 3: Equate exponents and convert index to term number Equal powers require

$$7 - \frac{k}{2} = -\frac{7}{2} + \frac{2k}{3}.$$

Multiplying by 6 gives $42 - 3k = -21 + 4k$, hence $7k = 63$ and $k = 9$. Both exponents then equal $5/2$, providing a direct check. The term is T_{10}, since the index-zero term is the first term. Returning 9 would confuse the index with the requested term number.

Step 4: Conclusion The required term number is $r = k + 1 = \boxed{10}$.

Quick Tip to Solve: Rewrite the radicals as fractional powers, solve for the binomial index, and add one at the end to obtain the actual term number.

24. If $y = \tan^{-1}\left(\frac{3x}{1+54x^2}\right) + \tan^{-1}\left(\frac{3x}{1+18x^2}\right)$**, then** $\frac{dy}{dx}$ **at** $x = 0$ **is** _____ [4 marks]

Solution:

Concept:

- The chain rule gives $\frac{d}{dx}\tan^{-1} u(x) = u'(x)/(1 + u(x)^2)$, where the inverse tangent is the principal smooth real function.
- The derivative of a sum is the sum of the derivatives. Evaluating each inner function and its derivative at zero avoids unnecessary expansion of the full expression.

Step 1: Handle both inner functions with one parameter Write

$$u_k(x) = \frac{3x}{1 + kx^2},$$

using $k = 54$ for the first inverse tangent and $k = 18$ for the second. Both denominators are positive for real x, so the functions are differentiable near the required point. In particular $u_k(0) = 0$. This common form keeps the calculations consistent for both terms.

Step 2: Differentiate the rational inner function By the quotient rule, with the numerator derivative equal to 3 and the denominator derivative equal to $2kx$,

$$\begin{aligned} u_k'(x) &= \frac{3(1 + kx^2) - (3x)(2kx)}{(1 + kx^2)^2} \\ &= \frac{3(1 - kx^2)}{(1 + kx^2)^2}. \end{aligned}$$

Substitution at zero gives $u_k'(0) = 3$. The quadratic denominator has zero derivative there, which is why the constants 54 and 18 do not change this value.

Step 3: Apply the inverse-tangent rule and add For either of the two parameter values,

$$\frac{d}{dx}\tan^{-1} u_k(x)\Big|_{x=0} = \frac{u_k'(0)}{1 + u_k(0)^2} = \frac{3}{1 + 0} = 3.$$

There are two inverse-tangent terms, each contributing 3, so

$$y'(0) = 3 + 3 = 6.$$

The result is exact; inverse-function addition formulas and any associated branch choices are unnecessary for this local derivative.

Step 4: Conclusion The numerical value of dy/dx at $x = 0$ is $\boxed{6}$.

Quick Tip to Solve: At a point where the inverse-tangent argument is zero, its derivative equals the derivative of the inner argument. Evaluate each term at that point before simplifying the full sum.

25. The value of $\int_1^5 f(x)\mathrm{d}x$, where $f(x) = |x-1| + |x-2| + |x-3|$ is _____ [4 marks]

Solution:

Concept:

- An absolute value measures distance and is non-negative: $|x-a| = a-x$ below a, and $|x-a| = x-a$ above a.
- Linearity permits the three absolute-value terms to be integrated separately. Split each term at its own zero if that zero lies inside the interval.

Step 1: Separate the contributions On the entire interval $[1, 5]$, $x - 1 \geq 0$, so the first term contributes

$$I_1 = \int_1^5 (x-1)\,dx = \left[\frac{(x-1)^2}{2}\right]_1^5 = 8.$$

The endpoints at which an absolute value vanishes cause no problem for integration.

Step 2: Integrate across the remaining zeros The second term changes sign at 2 and the third at 3. Thus

$$I_2 = \int_1^2 (2-x)\,dx + \int_2^5 (x-2)\,dx = \frac{1}{2} + \frac{9}{2} = 5,$$
$$I_3 = \int_1^3 (3-x)\,dx + \int_3^5 (x-3)\,dx = 2 + 2 = 4.$$

Each contribution is positive, as expected for an area under a non-negative function.

Step 3: Conclusion Therefore $\int_1^5 f(x)\,dx = I_1 + I_2 + I_3 = 8 + 5 + 4 = \boxed{17}$.

Quick Tip to Solve: Integrate each distance term separately; its contribution on either side of its zero is a triangular area.

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26. Let $y = y(x)$ be the solution of differential equation $\sin x \frac{dy}{dx} + y\cos x = 4x$. If $y\left(\frac{\pi}{2}\right) = 0$ and $y\left(-\frac{\pi}{6}\right) = \frac{\alpha}{\beta}\pi^2$, where α and β are co-prime numbers, then value of $(\alpha+\beta)$ is _____ [4 marks]

Solution:

Concept:

- The product rule gives $\frac{d}{dx}(y\sin x) = \sin x\, y' + y\cos x$, exactly the left side of the equation.
- Integrate this product derivative, then use the supplied initial value to determine the constant before evaluating the requested value.

Step 1: Integrate the product Rewrite the equation without dividing by $\sin x$:

$$\frac{d}{dx}(y\sin x) = 4x.$$

Hence

$$y\sin x = 2x^2 + C.$$

At $x = \pi/2$, the given value $y = 0$ makes the left side zero, so

$$0 = \frac{\pi^2}{2} + C, \qquad C = -\frac{\pi^2}{2}.$$

The resulting relation is $y \sin x = 2x^2 - \pi^2/2$.

Step 2: Evaluate and reduce the fraction Using $\sin(-\pi/6) = -1/2$, substitute the requested argument into the relation:

$$-\frac{1}{2} y\left(-\frac{\pi}{6}\right) = \frac{\pi^2}{18} - \frac{\pi^2}{2} = -\frac{4\pi^2}{9}.$$

Therefore

$$y\left(-\frac{\pi}{6}\right) = \frac{8}{9}\pi^2.$$

The integers 8 and 9 are coprime, since their greatest common divisor is 1. The sine factor is nonzero at the evaluation point.

Step 3: Check the domain of the initial-value solution There is a domain subtlety in the printed data: the initial point lies in $(0, \pi)$, whereas the requested point lies in $(-\pi, 0)$. The expression obtained has a pole at $x = 0$, so it is not a continuous solution across zero. On the negative interval an independent integration constant is possible. The value above uses the same algebraic constant on both intervals, which is the continuation intended by the supplied numerical key; the initial condition alone does not determine that continuation.

Step 4: Conclusion With the intended same-constant continuation, $\alpha = 8$, $\beta = 9$, and $\boxed{\alpha + \beta = 17}$. Strictly, no solution on an interval containing both stated arguments satisfies these initial data, so the literal initial-value wording requires this domain qualification.

Quick Tip to Solve: Recognise a product derivative before dividing the equation by a trigonometric factor; it makes the initial condition immediate.

27. Let L denote the line in the xy-plane with x and y intercepts as 2 and 1 respectively. If the image of the point $(-1, -3)$ in this line is $\left(\frac{\alpha}{5}, \frac{\beta}{5}\right)$, then $\alpha + \beta$ is equal to _____ [4 marks]

Solution:

Concept:

- The intercept form is $x/a + y/b = 1$. Reflection in $ax + by + c = 0$ moves a point twice its signed perpendicular displacement along the normal.
- For $P = (x_0, y_0)$, its image is $P' = P - 2t(a, b)$, where $t = (ax_0 + by_0 + c)/(a^2 + b^2)$.

Step 1: Write the reflecting line The two intercepts give

$$\frac{x}{2} + y = 1, \qquad x + 2y - 2 = 0.$$

Its normal vector is $(1, 2)$. For the original point $P = (-1, -3)$, the signed line expression is

$$-1 + 2(-3) - 2 = -9, \qquad a^2 + b^2 = 1 + 4 = 5.$$

Thus $t = -9/5$; its negative sign identifies the side of the line on which the original point lies.

Step 2: Find the image and check its midpoint The reflection formula gives

$$x' = -1 - 2(1)(-9/5) = 13/5,$$
$$y' = -3 - 2(2)(-9/5) = 21/5.$$

As a check, the midpoint of P and P' is $(4/5, 3/5)$. It satisfies $x + 2y = 2$, while the displacement $P' - P = (18/5, 36/5)$ is parallel to the normal, confirming perpendicular reflection.

Step 3: Conclusion Comparison with $(\alpha/5, \beta/5)$ gives $\alpha = 13$, $\beta = 21$, hence $\boxed{\alpha + \beta = 34}$.

Quick Tip to Solve: For reflection, check both requirements: the midpoint lies on the mirror line and the joining segment is normal to it.

28. The length of projection of the line segment joining the points $(1, 0, -1)$ and $(-1, 2, 2)$ on the plane $x + 3y - 5z = 6$ is d, then find $70d^2$ _____ [4 marks]

Solution:

Concept:

- The plane $ax + by + cz = k$ has normal vector $\mathbf{n} = (a, b, c)$. A segment vector separates into perpendicular normal and parallel components.
- The squared length of its projection on the plane is $d^2 = |\mathbf{v}|^2 - (\mathbf{v} \cdot \mathbf{n})^2/|\mathbf{n}|^2$. The plane constant affects position, not direction.

Step 1: Form the segment and normal vectors Let $A = (1, 0, -1)$ and $B = (-1, 2, 2)$. Subtract coordinates in the same order to obtain

$$\mathbf{v} = \overrightarrow{AB} = (-2, 2, 3), \qquad |\mathbf{v}|^2 = 4 + 4 + 9 = 17.$$

The plane has normal $\mathbf{n} = (1, 3, -5)$, so

$$|\mathbf{n}|^2 = 1 + 9 + 25 = 35, \qquad \mathbf{v} \cdot \mathbf{n} = -2 + 6 - 15 = -11.$$

Step 2: Remove the normal component The normal component has squared magnitude $(-11)^2/35 = 121/35$. By perpendicular decomposition,

$$d^2 = 17 - \frac{121}{35} = \frac{595 - 121}{35} = \frac{474}{35}.$$

This is smaller than 17 and non-negative, as a projected length must be. The sign of the dot product disappears on squaring; reversing the segment would give the same projected length.

Step 3: Conclusion The requested quantity is

$$70d^2 = 70 \cdot \frac{474}{35} = \boxed{948}.$$

Quick Tip to Solve: When a multiple of the squared projection is required, calculate squared lengths throughout and avoid unnecessary square roots.

29. There are two bags. The first bag contains 3 white and 4 red balls and the second bag contains 4 white and 3 red balls. Two balls are drawn at random from the first bag and are put into the second bag without noticing their colours. Then two balls are drawn from the second bag. If the probability that one ball is white and the other is red is $\frac{x}{y}$, where $\frac{x}{y}$ is in the simplest form, then value of $(2x - y)$ is _____ [4 marks]

Solution:

Concept:

- Condition on the colours of the two transferred balls. The three disjoint possibilities are WW, WR and RR, and together they exhaust all transfers.
- For a bag with w white and r red balls, the probability that an unordered pair has one of each is $wr/\binom{w+r}{2}$.

Step 1: Find the transfer probabilities The first bag has seven balls, so there are $\binom{7}{2} = 21$ equally likely pairs. Consequently

$$P(WW) = \frac{\binom{3}{2}}{21} = \frac{1}{7}, \quad P(WR) = \frac{3 \cdot 4}{21} = \frac{4}{7}, \quad P(RR) = \frac{\binom{4}{2}}{21} = \frac{2}{7}.$$

These weights sum to 1. After any transfer, the second bag contains nine balls, giving $\binom{9}{2} = 36$ pairs.

Step 2: Combine the conditional probabilities For WW the second bag has 6 white and 3 red balls, giving $18/36 = 1/2$. For WR it has 5 white and 4 red balls, giving $20/36 = 5/9$. For RR it has 4 white and 5 red balls, again giving $5/9$. Thus

$$P = \frac{1}{7}\frac{1}{2} + \frac{4}{7}\frac{5}{9} + \frac{2}{7}\frac{5}{9} = \frac{1}{14} + \frac{10}{21} = \frac{23}{42}.$$

Since 23 is prime and does not divide 42, the fraction is already reduced.

Step 3: Conclusion We have $x = 23$, $y = 42$; hence $\boxed{2x - y = 46 - 42 = 4}$.

Quick Tip to Solve: Condition on the transfer first; never replace the transferred colours by their average when drawing a pair without replacement.

30. In a ΔABC, $\angle A = \frac{\pi}{2}$. If $\tan\frac{B}{2}$ and $\tan\frac{C}{2}$ are the roots of $2x^2 - bx - c = 0$, then what is the value of $(b - c)^3$ _____ ? [4 marks]

Solution:

Concept:

- Since $A = \pi/2$ in a triangle, $B + C = \pi/2$, so $B/2 + C/2 = \pi/4$. All these half-angles are acute.
- If u, v are roots of $2x^2 - bx - c = 0$, Vieta gives $u + v = b/2$ and $uv = -c/2$. The minus sign in the product is essential.

Step 1: Use the tangent addition identity Put $u = \tan(B/2)$ and $v = \tan(C/2)$. The sum of the

half-angles has tangent 1, and hence

$$1 = \tan\left(\frac{B}{2} + \frac{C}{2}\right) = \frac{u+v}{1-uv}.$$

Each half-angle is between 0 and $\pi/4$, so $uv < 1$ and the denominator is positive. Multiplication therefore gives $u + v = 1 - uv$, or $u + v + uv = 1$.

Step 2: Insert the root relations For the stated quadratic, the leading coefficient is 2, the linear coefficient is $-b$, and the constant is $-c$. Therefore

$$u + v = \frac{b}{2}, \qquad uv = -\frac{c}{2}.$$

Substituting into the angle relation yields

$$\frac{b}{2} - \frac{c}{2} = 1, \qquad b - c = 2.$$

Individual values of b and c depend on the triangle, but their difference is fixed by the right angle.

Step 3: Conclusion The required value is $\boxed{(b-c)^3 = 2^3 = 8}$.

Quick Tip to Solve: Use the sum of half-angles and Vieta together; the question asks for a combination that the angle identity fixes directly.

Aptitude Test (200 marks)

31. Saturation level of colors represents [4 marks]

(A) Distribution

(B) Darkness

(C) Brilliance

(D) Warmth

Correct Answer: (C) Brilliance

Solution:

Concept:

- Saturation describes the strength or purity of a hue relative to a neutral grey. Increasing saturation makes the colour more vivid; decreasing it makes the colour more muted.
- Hue identifies the colour family, value or lightness describes how light or dark it is, and saturation describes chromatic intensity. These properties should be distinguished.

Step 1: Identify the quality described by saturation A highly saturated red appears vivid and strong, whereas a desaturated red tends towards a greyish red. This change concerns brilliance or intensity of colour, rather than simply making the surface darker. In the vocabulary of the given alternatives, brilliance is therefore the direct match for saturation.

Step 2: Exclude the other properties Distribution describes how colours are arranged across a surface

or composition, not the purity of an individual colour. Darkness is associated with low value or lightness, which is a separate attribute: a colour may be dark yet saturated. Warmth describes associations of hues, such as reds and oranges compared with blues, and does not measure saturation. A warm or a cool hue can each be highly saturated or muted.

Step 3: Conclusion Saturation represents the brilliance or vividness of colours. Hence, the correct option is (C).

Quick Tip to Solve: Separate the three questions: which hue, how light or dark, and how vivid. The last one tests saturation.

32. Which of the following is a shell structure? [4 marks]

(A) Millenium dome

(B) Stansted airport

(C) Bank of China tower

(D) Louvre, Museum

Correct Answer: (A) Millenium dome

Solution:

Concept:

- Architectural form can be classified by how its enclosing surface spans space and transfers load. A shell or membrane enclosure uses a surface rather than a conventional solid mass to cover a large area.
- The Millennium Dome is a dome-shaped, cable-supported fabric enclosure. In strict structural terminology it is a tensile membrane roof, rather than a rigid concrete shell.

Step 1: Identify the intended enclosure type Among the named buildings, the Millennium Dome is the example associated with a curved surface spanning and enclosing a very large space. Its light roof skin works with supporting cables and masts. In the broad surface-structure classification used by this question, it is the intended shell-form example; one should not describe its fabric as carrying load by concrete-shell compression.

Step 2: Compare the alternatives Stansted Airport is identified with its modular roof carried by steel tree-like supports. The Bank of China Tower is a high-rise building with a triangulated structural framework. The Louvre Museum is not the dome-shaped surface enclosure identified here; its familiar pyramid entrance is a framed glass construction. These names therefore do not match the intended answer as directly as the Millennium Dome. The distinction between a curved form and the precise tensile load path prevents a misleading account of its engineering.

Step 3: Conclusion The intended shell-form example among the listed alternatives is the Millennium Dome, more precisely a tensile membrane enclosure. Hence, the correct option is (A).

Quick Tip to Solve: Identify the spanning system as well as the visible shape: the Millennium Dome is a lightweight cable-supported membrane.

33. Identify the building material represented in the given figure [4 marks]



(A) Tile

(B) Paving Block

(C) Wooden Plank

(D) Granite

Correct Answer: (C) Wooden Plank

Solution:

Concept:

- A building material can be identified from its characteristic surface texture as well as the shape of the piece. A long rectangular outline alone is not decisive, since several materials can be cut into rectangles.
- Timber has a grain pattern formed by its growth structure. In a drawing, this commonly appears as elongated, irregular curves with local rings or swirls around knots, rather than a uniform manufactured finish or a granular stone texture.

Step 1: Read the surface pattern The figure shows a narrow rectangular piece with continuous curved markings running mainly along its length. Some markings loop around small centres, while others bend and spread out. This combination represents wood grain and knots: the pattern follows the material rather than repeating as a regular geometric decoration.

Step 2: Identify the matching building material A wooden plank is a sawn, relatively flat length of timber. Its elongated form and visible grain match the illustrated piece. Both clues support the identification: the outline suggests a plank, and the curved fibre pattern identifies its material as wood.

Step 3: Eliminate the remaining choices Tile and paving block describe manufactured units commonly used for surface finishes and paving; their names alone do not explain the conspicuous natural grain drawn here. Granite is a crystalline stone, whose conventional texture is granular or speckled rather than the long fibre curves and knot-like loops shown. A tile can imitate wood in practice, but the

question's conventional material representation supplies no such additional indication, so the direct identification is timber.

Step 4: Conclusion The figure represents a **wooden plank**, identified by its elongated shape and the wood-grain pattern on its surface. Hence, the correct option is (C).

Quick Tip to Solve: In material-identification drawings, check the surface pattern before the outline: elongated grain with knot-like loops points to wood, while a granular texture points to stone.

34. Before plastering, the surface has to be : [4 marks]

(A) Cemented

(B) Polished

(C) Smooth

(D) Rough

Correct Answer: (D) Rough

Solution:

Concept:

- Plaster is a mortar coating applied to a wall or ceiling; its bond to the supporting surface must resist separation.
- A clean, adequately rough background provides mechanical keying: the fresh mortar enters surface irregularities and grips them when it hardens.

Step 1: Identify the purpose of surface preparation Before applying plaster, the important property among the choices is the ability of the background to hold the wet mortar. A rough surface has small recesses and projections that increase the effective contact and provide a key. Surface preparation also involves removing dust and loose particles, but the question asks specifically which surface condition is needed.

Step 2: Compare the four conditions Polishing produces a smooth face and reduces the mechanical grip available to the plaster; therefore both polished and smooth are unsuitable answers. Cementing is not a necessary condition for every background, since plaster may be applied to properly prepared masonry. Roughness is the condition that directly promotes adhesion and anchorage.

Step 3: Conclusion The surface should be rough before plastering so that the mortar obtains a sound mechanical key. Hence, the correct option is (D).

Quick Tip to Solve: Think of the surface as a key for the plaster: roughen a smooth background and remove loose dust before applying the coat.

35. Who designed the 'Sydney Opera House'? [4 marks]

(A) Jorn Utzon

(B) Jan Gehl

(C) Bjarke Ingels

(D) Henning Lorsen

Correct Answer: (A) Jorn Utzon

Solution:

Concept:

- Architectural awareness questions require matching a named landmark to its architect, rather than choosing an architect solely by nationality.
- The Sydney Opera House is associated with the Danish architect Jorn Utzon, whose design is recognised by its sculptural, sail-like roof forms.

Step 1: Match the landmark to its designer The named building is the Sydney Opera House in Australia. Its architectural design is credited to Jorn Utzon. The dramatic grouped roof shells are the identifying feature that links this landmark to Utzon in standard architect-building pairs.

Step 2: Eliminate the other architect names Jan Gehl is known particularly for studies and design concerning public life and pedestrian-oriented urban spaces; he did not design this opera house. Bjarke Ingels is a different Danish architect of a later generation. Henning Larsen, whose surname is printed as Lorsen in the option, is also a distinct architect. None of these three replaces Utzon as the designer of the Sydney Opera House.

Step 3: Conclusion The Sydney Opera House was designed by Jorn Utzon. Hence, the correct option is (A).

Quick Tip to Solve: Associate the Sydney Opera House's shell-like roofs with Jorn Utzon; do not select merely by the architect's Danish nationality.

36. The design elements which are associated with the sense of touch [4 marks]

(A) Pattern, Shape, Form

(B) Texture, Shape, Form

(C) Shape, Pattern, Texture

(D) Form, Pattern, Texture

Correct Answer: (B) Texture, Shape, Form

Solution:

Concept:

- Tactile perception is the perception obtained by touching an object: it includes the character of its surface and the physical configuration of its boundary.
- Texture describes surface qualities such as roughness or smoothness. Shape describes a boundary, while form describes an object's three-dimensional volume.

Step 1: Identify the elements that can be felt By moving the fingers over an object, a person can distinguish a smooth surface from a rough one: this is texture. Tracing its edge reveals shape, and handling the whole object gives information about form, including its volume and spatial configuration. These three elements therefore have direct tactile associations.

Step 2: Distinguish pattern from the tactile group Pattern is an arrangement or repetition of elements and is commonly recognised visually, for example through a printed coloured motif on a flat surface. Such a motif need not change what the hand feels. Every other listed group includes pattern and omits one member of the texture-shape-form group. The group containing all three directly tactile elements is therefore the best answer.

Step 3: Conclusion The required group is Texture, Shape, Form. Hence, the correct option is (B).

Quick Tip to Solve: For touch, ask what the hand can detect without seeing: surface texture, boundary shape and three-dimensional form.

37. The First World Environment Day was held in which year? [4 marks]

(A) 1973

(B) 1976

(C) 1978

(D) 1970

Correct Answer: (A) 1973

Solution:

Concept:

- World Environment Day is observed on 5 June and promotes public awareness and action for environmental protection.
- For a question about its first celebration, distinguish the establishment of the observance from the year in which it was first held.

Step 1: Recall the first observance The first World Environment Day was held in 1973. The question asks for the year of the first event, so this historical starting year is the deciding fact. The annually recurring calendar date, 5 June, does not by itself answer a question asking for the first year.

Step 2: Check the offered years Among 1973, 1976, 1978 and 1970, only 1973 is the first World Environment Day year. The dates 1976 and 1978 are later years and cannot be the inaugural observance. The year 1970 precedes its establishment and is not the first World Environment Day. Thus the first choice supplies the relevant year, with no calculation or chronological approximation required.

Step 3: Conclusion The first World Environment Day was held in 1973. Hence, the correct option is (A).

Quick Tip to Solve: Keep two facts together: World Environment Day falls on 5 June, and its first observance was in 1973.

38. Elephanta Caves are dedicated to which God? [4 marks]

(A) Budha

(B) Tirthankar Mahavir

(C) Shiva

(D) Vishnu

Correct Answer: (C) Shiva

Solution:

Concept:

- Indian cave architecture includes Buddhist, Jain and Hindu monuments; identifying the principal deity helps distinguish their religious dedication.
- The principal Hindu caves at Elephanta are Shaivite, meaning that their main religious and sculptural focus is Shiva.

Step 1: Identify the principal religious association Elephanta Caves are especially associated with monumental sculptures of Shiva. The celebrated three-headed representation of Shiva, often called the Maheshmurti, is a characteristic identifying feature of the main cave. This establishes the Shaivite association asked for in the question.

Step 2: Compare the possible dedications Buddha is associated with Buddhism, and Tirthankar Mahavir with Jainism; neither is the principal deity of the celebrated main Elephanta cave complex referred to here. Vishnu is a Hindu deity but does not supply the principal dedication identified by these Shiva sculptures. Therefore the option naming Shiva is the correct architectural-awareness match.

Step 3: Conclusion The Elephanta Caves referred to here are dedicated to Shiva. Hence, the correct option is (C).

Quick Tip to Solve: Use the three-headed Maheshmurti as the visual memory cue linking Elephanta's main cave with Shiva.

39. Which one of the following is not a city type? [4 marks]

(A) Garden City

(B) Linear City

(C) Radiant City

(D) Stack City

Correct Answer: (D) Stack City

Solution:

Concept:

- In urban planning, a city type or model is a recognised approach to organising settlement, transport, open space and built form.
- Garden City, Linear City and Radiant City are established named planning concepts, each expressing

a different organising idea.

Step 1: Recognise the established city models The Garden City concept is associated with Ebenezer Howard and combines planned settlement with surrounding green space. The Linear City is a recognised model organised along a longitudinal transport or development axis. The Radiant City is associated with Le Corbusier and is a recognised modernist urban-planning proposal. Hence the first three names belong to standard planning terminology.

Step 2: Select the name outside this group Stack City is not one of these established city types in the classification tested by the question. Buildings may certainly be stacked vertically or discussed using similar descriptive language, but that does not make this option the recognised historic planning model represented by the other names. Since the wording asks which is not a city type, eliminate the three recognised concepts and retain Stack City.

Step 3: Conclusion The name outside the recognised city types listed is Stack City. Hence, the correct option is (D).

Quick Tip to Solve: Notice the negative word not, then eliminate the familiar models: Howard's Garden City, the Linear City and Le Corbusier's Radiant City.

40. A gigantic chariot with elaborately carved stone wheels, pillars and walls are the characteristics of : [4 marks]

(A) Konark Sun temple

(B) Golden temple

(C) Meenakshi temple

(D) Dilwara temple

Correct Answer: (A) Konark Sun temple

Solution:

Concept:

- A distinctive architectural form can identify a monument more reliably than a general feature shared by many temples, such as carved pillars.
- The Konark Sun Temple is conceived as the monumental stone chariot of the Sun God, with elaborately carved wheels as a defining feature.

Step 1: Use the decisive chariot description The question describes a gigantic chariot, rather than merely a richly decorated temple. The stone wheels, together with the sculpted walls and supporting architectural elements, point to the chariot conception of the Konark Sun Temple in Odisha. The wheel motif is the decisive clue in this description.

Step 2: Exclude the other temple names The Golden Temple is associated with its gilded shrine and surrounding sacred pool, not this monumental stone-chariot conception. The Meenakshi Temple is recognised for its extensive Dravidian temple complex and prominent gopurams. The Dilwara temples are noted for their finely carved marble Jain architecture. None matches the complete chariot-and-wheel description as Konark does.

Step 3: Conclusion The described monument is the Konark Sun Temple. Hence, the correct option is (A).

Quick Tip to Solve: When a temple question stresses a huge chariot and carved stone wheels, connect the description directly to Konark and the Sun God.

41. Who built the Moti Masjid in Red Fort at Delhi? [4 marks]

(A) Shah Jahan

(B) Aurangzeb

(C) Qutub-Ud-Din Aibak

(D) Akbar

Correct Answer: (B) Aurangzeb

Solution:

Concept:

- Monument identification requires both the building name and its location: monuments with the same name can have different patrons.
- The Moti Masjid inside the Red Fort at Delhi is a Mughal mosque commissioned by Emperor Aurangzeb.

Step 1: Identify the precise monument The location is the decisive clue. The question specifies the Moti Masjid within the Red Fort at Delhi, rather than the mosque of the same name at Agra. It is a small white-marble mosque associated with the later Mughal occupation of the Delhi fort. We must identify the patron of this particular addition, rather than the founder of the entire fort complex.

Step 2: Match the patron to the building Aurangzeb commissioned the Delhi Red Fort Moti Masjid for his personal use. Thus the correct association is Delhi Red Fort Moti Masjid and Aurangzeb. Shah Jahan commissioned the Red Fort itself and is associated with the Moti Masjid at Agra, which explains why his name is a tempting distractor when the location is overlooked.

Step 3: Eliminate the other rulers Qutub-Ud-Din Aibak belonged to the early Delhi Sultanate, centuries before the Mughal Red Fort complex. Akbar was an earlier Mughal emperor and was not the patron of this mosque. Therefore neither the general association with Delhi nor the general association with Mughal architecture is sufficient: the exact mosque and fort must be matched.

Step 4: Conclusion Aurangzeb built the Moti Masjid in the Red Fort at Delhi. Hence, the correct option is (B).

Quick Tip to Solve: Keep the two Moti Masjids separate: Delhi Red Fort points to Aurangzeb; Agra Fort points to Shah Jahan.

42. Spray painting is used to : [4 marks]

(A) Get a textured pain

(B) Reach high areas

(C) Apply paint without touching surface

(D) Apply large amount of paint

Correct Answer: (C) Apply paint without touching surface

Solution:

Concept:

- Spray painting atomises liquid paint into droplets and directs them from a nozzle towards the work surface.
- The defining distinction from brushing or rolling is that the paint-applying tool need not touch the coated surface.

Step 1: Describe the application process In spray painting, paint is forced through a spray nozzle and broken into fine droplets. These droplets travel across a small gap and settle on the object, forming a coating. Unlike a brush or roller, the nozzle is held away from the work. Paint itself necessarily contacts the surface; it is the applicator that does not touch it.

Step 2: Identify the defining purpose Option (C) describes this contact-free application of paint. Spraying is useful on curved, recessed or irregular shapes because the droplets can be directed onto surfaces that a brush would have to contact individually. The method can also provide a uniform finish when nozzle distance, motion and coating thickness are controlled.

Step 3: Distinguish effects from the method A textured finish can be produced by special materials and spray settings, but texture is not an essential result of every spray-painting operation. High areas still require appropriate access and equipment, so reaching height is not its defining feature. Applying a large amount of paint is also not the objective: excessive deposition can cause runs, and some paint can be lost as overspray.

Step 4: Conclusion Spray painting applies paint without the applicator touching the surface. Hence, the correct option is (C).

Quick Tip to Solve: Identify a painting method by how paint reaches the surface: brush and roller make contact, whereas a spray nozzle projects droplets.

43. An escalator looks like which one of the following? [4 marks]

(A) Ladder

(B) Stair case

(C) Ramp

(D) Lift

Correct Answer: (B) Stair case

Solution:

Concept:

- An escalator is a mechanically driven, continuously moving series of steps used to carry people between levels.
- Its appearance is identified by its stepped profile, even though its steps circulate around a concealed return path.

Step 1: Recognise the visible arrangement The passenger-carrying part of an escalator consists of successive horizontal treads separated by risers on an incline. The treads become level near the entrances and exits so that passengers can step on and off. Along the main inclined portion, the overall form is therefore that of a staircase.

Step 2: Compare the other forms A ladder has narrow rungs supported between rails and normally requires the user to climb while holding on. A ramp is a continuous sloping surface without distinct steps. A lift carries passengers in a cabin or platform that travels between floors. None of these describes the visible series of stair treads on an escalator.

Step 3: Separate appearance from motion The word escalator refers to a moving stairway. Although both an escalator and a lift transport passengers vertically, the question asks what the escalator looks like, not merely what it does. Function alone would make several circulation devices plausible, but the stepped shape uniquely matches the staircase option. The moving handrail along either side further supports the identification as a stairway with mechanical movement.

Step 4: Conclusion An escalator looks like a staircase. Hence, the correct option is (B).

Quick Tip to Solve: For circulation questions, separate shape from function: an escalator has moving steps, a ramp has a slope, and a lift has a travelling cabin.

44. Concrete is a mixture of [4 marks]

(A) Cement + Sand + Water

(B) Cement + Coarse Aggregate + Fine Aggregate + Water

(C) Cement + Water + Brick Bat

(D) Cement + Sand + Water + Brick Bat

Correct Answer: (B) Cement + Coarse Aggregate + Fine Aggregate + Water

Solution:

Concept:

- Ordinary concrete combines a cementitious binder, fine aggregate, coarse aggregate and water.
- Cement reacts with water to form a hardened binding paste; aggregates form the main granular skeleton of the material.

Step 1: List the essential constituents In conventional cement concrete, cement and water produce the paste that coats and binds the aggregate particles. Fine aggregate, usually sand, fills spaces between the larger particles. Coarse aggregate, commonly crushed stone or gravel, supplies the larger particles. All four constituent groups are therefore present in the standard description.

Step 2: Distinguish concrete from mortar Cement, sand and water alone form cement mortar in the usual building-material classification. Option (A) omits coarse aggregate and is therefore the mortar description rather than the complete ordinary-concrete description. This distinction is important because both materials contain cement and water, but their aggregate size distribution and usual applications differ.

Step 3: Check the brick-bat alternatives Option (B) explicitly names cement, coarse aggregate, fine aggregate and water, so it gives the general composition. Option (C) does not include fine aggregate. Brick fragments can serve as aggregate in specialised forms of concrete, but options (C) and (D) describe particular brick-bat combinations rather than the standard general definition asked here. They do not replace the complete generic constituent list.

Step 4: Conclusion Concrete is a mixture of cement, coarse aggregate, fine aggregate and water. Hence, the correct option is (B).

Quick Tip to Solve: Use the aggregate test: cement + sand + water is mortar; ordinary concrete also contains coarse aggregate.

45. What type of tile are suitable for air - conditioned rooms and gymnasium? [4 marks]

(A) Cork Tile

(B) Ceramic Tile

(C) Concrete Tile

(D) Wooden Tile

Correct Answer: (D) Wooden Tile

Solution:

Concept:

- Flooring selection depends on the use of the room, including comfort, thermal behaviour, resilience and resistance to repeated movement.
- Timber flooring provides a comparatively warm walking surface and is widely associated with indoor gymnasium and sports-floor construction.

Step 1: Match the floor to the activities A gymnasium floor experiences repeated foot impacts and movement. A timber floor, especially when installed as an appropriate sports-floor system, offers more comfortable footing and useful resilience compared with a rigid concrete or ceramic finish. The supporting construction contributes to shock absorption; the wood surface alone should not be confused with a complete sprung floor.

Step 2: Relate timber to conditioned interiors Wood has relatively low thermal conductivity and does not feel as cold underfoot as dense mineral finishes. It is therefore suitable for controlled indoor environments, including air-conditioned rooms. Keeping indoor humidity within a suitable range also helps maintain the dimensional stability of wooden flooring, which can otherwise swell or shrink with moisture changes.

Step 3: Compare the listed alternatives Ceramic and concrete tiles are hard, rigid surfaces and are less suited to the cushioning and comfort expected of the gymnasium application. Cork is also a resilient and thermally insulating flooring material and can be suitable for interiors, so it should not be described as universally unsuitable. For the intended combined application in this question, the listed timber flooring answer is Wooden Tile, option (D).

Step 4: Conclusion Wooden tile is the intended flooring choice for the stated application. Hence, the correct option is (D).

Quick Tip to Solve: For gymnasium flooring, think of a timber sports-floor system; check comfort and resilience as well as surface hardness.

46. Famous Tassel House was designed by [4 marks]

(A) Victor Horta

(B) Gerrit Rietvelt

(C) Mies Van der Rohe

(D) Frank Lloyd Wright

Correct Answer: (A) Victor Horta

Solution:

Concept:

- Architectural attribution links a named building with its designer, rather than merely with an architectural style or country.
- Tassel House, also known as Hotel Tassel in Brussels, is a work of the Belgian architect Victor Horta and an important example of Art Nouveau.

Step 1: Identify the building and architect The name Tassel House refers to the Brussels residence designed by Victor Horta. Its association with Art Nouveau provides a useful recognition clue: the design integrates curving ornamental lines, ironwork, circulation and interior space. The attribution is to the architect of the house, not to its original client or a later owner.

Step 2: Use the stylistic association carefully Horta is strongly associated with the development of Art Nouveau architecture in Belgium. Tassel House belongs to that body of work. Recognising the style supports the direct building-designer connection, but the answer should still name Victor Horta explicitly rather than merely identify the Art Nouveau movement.

Step 3: Eliminate the other designers Gerrit Rietveld is associated with De Stijl and the Schroder House. Mies van der Rohe is associated with modernist architecture and works such as the Barcelona Pavilion. Frank Lloyd Wright is associated with American organic architecture and buildings such as Fallingwater. These are significant architects, but none is the designer of Tassel House. Thus a familiar architectural name must not replace the specific attribution.

Step 4: Conclusion Tassel House was designed by Victor Horta. Hence, the correct option is (A).

Quick Tip to Solve: Remember the pair Tassel House–Victor Horta, with Brussels and Art Nouveau as supporting identification clues.

47. Who is the Author of "Toward an Architecture"? [4 marks]

(A) Frank Ching

(B) Le Corbusier

(C) Kevin A. Lynch

(D) Frank Wright

Correct Answer: (B) Le Corbusier

Solution:

Concept:

- Architectural awareness includes identifying influential books and matching their titles to the correct authors.
- Toward an Architecture is the English title of Le Corbusier's architectural manifesto Vers une architecture.

Step 1: Recognise the title The title Toward an Architecture, also encountered in English as Towards a New Architecture, is associated with Le Corbusier. The book presents his arguments about modern architecture, including the influence of engineering, industrial production and functional thinking. The question asks for authorship, so the decisive fact is the connection between this title and Le Corbusier.

Step 2: Distinguish the other writers Francis D. K. Ching, named Frank Ching in the options, is known for architectural drawing and explanatory books such as Architecture: Form, Space, and Order. Kevin A. Lynch is associated with The Image of the City and the study of how people perceive urban environments. Their contributions are important but concern different named books.

Step 3: Check the remaining architect Frank Lloyd Wright, abbreviated as Frank Wright in the option, wrote on his own architectural ideas and is associated with organic architecture. He did not author Toward an Architecture. The presence of several well-known architects and writers makes exact title recognition important: the subject of a book being architecture does not make every architectural author a plausible attribution.

Step 4: Conclusion The author of Toward an Architecture is Le Corbusier. Hence, the correct option is (B).

Quick Tip to Solve: Keep the title-author pairs distinct: Toward an Architecture–Le Corbusier; The Image of the City–Kevin Lynch.

48. Hiroshima Peace Memorial Museum in Japan was designed by : [4 marks]

(A) I. M. Pie

(B) Tadao Ando

(C) Kenzo Tange

(D) Kisho Kurokawa

Correct Answer: (C) Kenzo Tange

Solution:

Concept:

- Building-designer questions require the precise monument or institution to be matched with its architect.
- The Hiroshima Peace Memorial Museum and the planning of the Peace Memorial Park are associated with the Japanese architect Kenzo Tange.

Step 1: Identify the specified institution The question names the Hiroshima Peace Memorial Museum in Japan. This museum is part of the post-war memorial landscape at Hiroshima and was designed by Kenzo Tange. The wording is specific to the museum: it should not be confused with the surviving Atomic Bomb Dome, which is a different building within the broader memorial setting.

Step 2: Connect the work to the architect Tange's museum design is associated with the modern architectural reconstruction of Hiroshima and the Peace Memorial Park. The museum building uses a modernist architectural language, including an elevated main volume. The relevant attribution remains Kenzo Tange regardless of the fact that many other prominent Japanese architects designed museums and public buildings.

Step 3: Eliminate the other options I. M. Pei, misspelled Pie in the option, is associated with projects such as the Louvre pyramid and is not the architect of this museum. Tadao Ando is known for works such as the Church of the Light. Kisho Kurokawa is associated with the Metabolist movement and the Nakagin Capsule Tower. These names belong to other works and do not match the Hiroshima museum asked here.

Step 4: Conclusion The Hiroshima Peace Memorial Museum was designed by Kenzo Tange. Hence, the correct option is (C).

Quick Tip to Solve: Distinguish the Peace Memorial Museum from the Atomic Bomb Dome; associate the museum and Peace Memorial Park with Kenzo Tange.

49. Which of the following is not a principle of Design? [4 marks]

(A) Emphasis

(B) Focal Point

(C) Unity

(D) Rhythm

Correct Answer: (B) Focal Point

Solution:

Concept:

- Design principles describe how visual elements are organised into a coherent composition. Emphasis, unity and rhythm are standard principles used to judge this organisation.
- A focal point is the particular place or element that attracts attention. It is usually produced by applying emphasis, rather than listed as an independent organising principle in this classification.

Step 1: Distinguish the principle from its result Emphasis is the deliberate creation of visual importance, for example through contrast in size, colour or placement. The resulting dominant area is called the focal point. Thus emphasis names the organising method, while focal point names the location or feature made prominent by that method. The question tests this distinction between a principle and an outcome within a composition.

Step 2: Check the other listed terms Unity describes the sense that different elements belong together as one whole; consistent forms, materials or colours can establish it. Rhythm is visual movement created through repetition, alternation or progression of elements, such as a repeated sequence of windows. Both are recognised design principles, as is emphasis. Consequently options (A), (C) and (D) should be retained as principles rather than chosen as the exception.

Step 3: Conclusion Focal Point is the exception in the stated classification: it is created through emphasis. Hence, the correct option is (B).

Quick Tip to Solve: Pair emphasis with its result, the focal point; unity and rhythm describe ways to organise the whole composition.

50. Which of the following software is not used by architects [4 marks]

(A) Staad. Pro

(B) 3D Max

(C) Revit

(D) Sketch Up

Correct Answer: (A) Staad. Pro

Solution:

Concept:

- Architectural software supports spatial design, building modelling, documentation and visualisation. Different programs specialise in different parts of the building workflow.

- Structural analysis software primarily checks how structural members behave under loads. This is usually the structural engineer's specialised task, even though disciplines may share models.

Step 1: Classify the three architectural tools Revit is used for building information modelling, where coordinated building elements support design and documentation. SketchUp is widely used for quickly constructing and communicating three-dimensional design models. The option written as 3D Max refers to 3ds Max, which is used for three-dimensional modelling, rendering and architectural visualisation. These functions directly support the architect's typical design and presentation work.

Step 2: Identify the specialised structural tool STAAD.Pro is primarily a structural analysis and design program. It is used to model structural systems, apply loads and examine responses such as forces, deflections and member adequacy. Among the four choices it belongs to structural engineering rather than the group of conventional architectural modelling and visualisation tools. The question uses the usual professional classification; it should not be read as a claim that an architect could never open or use it.

Step 3: Conclusion STAAD.Pro is the structural analysis and design package singled out by the question. Hence, the correct option is (A).

Quick Tip to Solve: Classify software by its principal task: analysis of load-bearing members points to structural engineering.

51. Who built the Shalimar Bagh, Srinagar? [4 marks]

(A) Bega Begum

(B) Akbar

(C) Shah Jahan

(D) Jahangir

Correct Answer: (D) Jahangir

Solution:

Concept:

- Shalimar Bagh in Srinagar is a Mughal garden associated with Emperor Jahangir. The location Srinagar is essential because similarly named gardens occur elsewhere.
- Historical attribution distinguishes the establishment of a garden from later extensions, embellishments or maintenance under subsequent rulers.

Step 1: Identify the garden and its founder The question names Shalimar Bagh at Srinagar in Kashmir. Its establishment is attributed to Jahangir, who developed the garden in the early seventeenth century. The garden is associated with his patronage and with Nur Jahan. For this direct attribution question, Jahangir is the ruler who must be selected; later work on the complex does not replace that founding association.

Step 2: Eliminate the competing rulers Bega Begum is associated with the commissioning of Humayun's Tomb in Delhi, rather than this Srinagar garden. Akbar belongs to an earlier phase of Mughal patronage and is not the founder asked for here. Shah Jahan is associated with extensive

Mughal architecture and with later development of gardens, which makes him a tempting distractor. However, the establishment of Srinagar's Shalimar Bagh belongs to Jahangir. The city qualifier also prevents confusion with Shalimar Gardens in Lahore, associated with Shah Jahan.

Step 3: Conclusion Jahangir built Shalimar Bagh in Srinagar. Hence, the correct option is (D).

Quick Tip to Solve: Remember the location pair: Srinagar Shalimar Bagh with Jahangir; Lahore Shalimar Gardens with Shah Jahan.

52. Kanpur, Uttar Pradesh is also known as : [4 marks]

(A) The Leather City

(B) Wine Capital of India

(C) The Orange City

(D) City of Nawabs

Correct Answer: (A) The Leather City

Solution:

Concept:

- Indian city nicknames commonly refer to a major industry, a distinctive product or a historical cultural association. The correct match depends on the named city.
- Kanpur in Uttar Pradesh is strongly associated with the leather industry, including tanning, leather processing and leather goods.

Step 1: Connect Kanpur with its industrial identity Kanpur is an important industrial city of Uttar Pradesh. Its established leather-processing and leather-goods industries give it the nickname The Leather City. The description in option (A) therefore directly matches the city in the question. This is an industry-based nickname rather than a description of the state as a whole, so the city-level association is the deciding fact.

Step 2: Compare every alternative nickname Wine Capital of India is associated with Nashik in Maharashtra and its wine-producing region, so option (B) does not identify Kanpur. The Orange City refers to Nagpur, also in Maharashtra, making option (C) a different city-product association. City of Nawabs refers to Lucknow, the capital of Uttar Pradesh, rather than Kanpur. Since Lucknow and Kanpur are both in Uttar Pradesh, the state name alone cannot decide between them: the industrial identity of Kanpur distinguishes the correct choice from this nearby-city distractor.

Step 3: Conclusion Kanpur is also known as The Leather City. Hence, the correct option is (A).

Quick Tip to Solve: Use four distinct pairs: Kanpur–leather, Nashik–wine, Nagpur–oranges and Lucknow–Nawabs.

53. How the load is transfered from the super structure to sub structure?

A. Beam

B. Slab

C. Foundation

D. Earth

E. column

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

(A) A, B, E, D, C

(B) E, A, C, B, D

(C) A, B, C, D, E

(D) B, A, E, C, D

Correct Answer: (D) B, A, E, C, D

Solution:

Concept:

- In a conventional framed building, gravity loads pass through successive supporting members from the floor system down to the ground. Each member delivers its load to the member supporting it.
- A slab transfers load to beams, beams transfer it to columns, and columns deliver it to foundations. Foundations spread the load safely into the supporting earth.

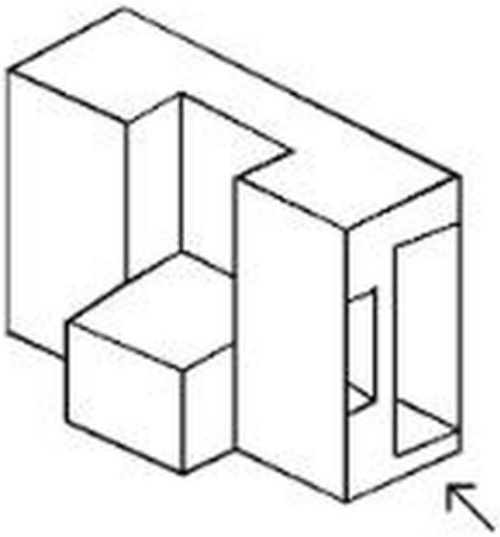
Step 1: Follow the physical load path Start with the floor slab, which carries its self-weight and imposed loads from use of the building. The slab transfers these loads to supporting beams. Beams carry the collected loads to columns, and columns convey the resulting axial loads downwards to the foundations. The foundations distribute these loads over the supporting soil, represented here by Earth. This sequence connects the superstructure to its substructure and finally to the ground.

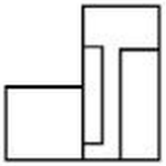
Step 2: Translate the path into the supplied letters The list assigns B to Slab, A to Beam, E to column, C to Foundation and D to Earth. Substituting these letters in the physical sequence gives B, A, E, C, D. Option (D) reproduces this order exactly. Option (A) reverses the slab-beam relation and places earth before foundation; option (B) begins with a column and interrupts the load path with a slab after the foundation; option (C) likewise starts at a beam and leaves the column until after earth. None describes the normal framed-building gravity-load sequence.

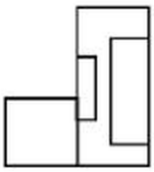
Step 3: Conclusion The load path is Slab, Beam, Column, Foundation, Earth: B, A, E, C, D. Hence, the correct option is (D).

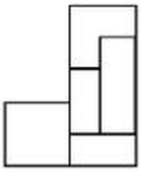
Quick Tip to Solve: Trace gravity loads downwards: floor surface to horizontal support, vertical support, foundation and finally soil.

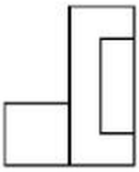
54. The Question figure shows the 3D view of an object. Identify the correct view, looking in the direction of Arrow, identify the correct view of the object. [4 marks]

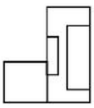


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- An orthographic view projects the object along the indicated viewing direction. Depth along that direction disappears, while heights and sideways positions are retained.
- The outer silhouette and the visible boundaries of openings must both agree. A matching outline alone is insufficient when several answer figures have the same outline.

Step 1: Follow the viewing arrow The arrow points towards the right-hand end of the object. From this direction, the tall end face is seen directly, while the low projecting block appears to its left. The outline must therefore have a low rectangular portion on the left joined to a taller rectangle on the right. Perspective sloping edges are not retained as slopes in this straight-on view.

Step 2: Locate both openings The tall face contains a large, narrow opening towards its right edge and a smaller opening along its left side. The large opening begins below the top edge and finishes

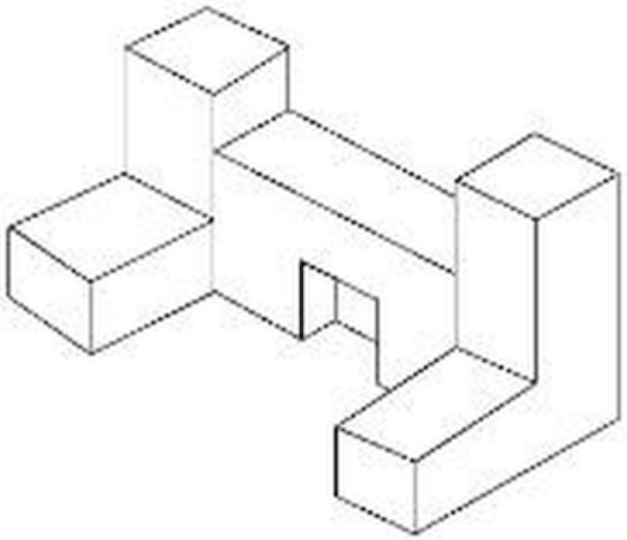
above the base, leaving a visible bottom strip. The small opening occupies an intermediate height and does not extend all the way to the base. Preserve these two distinct heights and the solid strips around the openings.

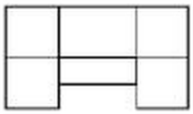
Step 3: Compare the answer figures Option (B) retains the low block, the small left opening and the taller right opening with a bottom strip beneath it. Option (A) carries the right opening down to the base and gives the low block the wrong relative height. Option (C) joins the internal divisions into a different arrangement, including a continuous lower horizontal division. Option (D) omits the smaller opening. Thus only (B) preserves the visible features together.

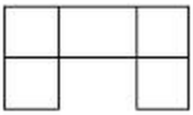
Step 4: Conclusion The view in the direction of the arrow is the figure in option (B). Hence, the correct option is (B).

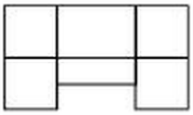
Quick Tip to Solve: After matching the silhouette, compare the top and bottom levels of every opening; internal edges usually separate the similar-looking alternatives.

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

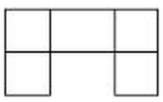


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A top view is obtained by looking vertically downward. It records the horizontal footprint and the boundaries between exposed surfaces at different heights.
- A doorway beneath a solid bridge does not create a gap in the top surface. Its vertical opening must not be drawn as an extra strip in the plan.

Step 1: Trace the footprint from above The two end supports project forward, with a connecting member across their rear portions. Their combined footprint is therefore U-shaped: a continuous rear band and two side arms, leaving an open rectangular region between the forward portions. The opening beneath the middle member does not interrupt that member when viewed from above.

Step 2: Retain the visible changes in level Each end has a raised square tower above a lower projecting arm. From above, the tower tops and the lower arm tops are both visible. The edges where these surfaces meet remain in the plan. The connecting member is lower than the tower tops, so its junction with each tower also produces a boundary. These boundaries divide the rear band into the left tower, the connecting strip and the right tower.

Step 3: Eliminate the other plans Option (B) shows the U-shaped footprint and the visible divisions of the two towers and connecting member. Options (A) and (C) insert an additional horizontal strip across the central opening, treating a vertical detail beneath the connector as though it were an exposed horizontal projection. Option (D) removes the divisions between the raised tower tops and the central member. Neither an extra strip nor the loss of these visible edges agrees with the given solid.

Step 4: Conclusion The correct top view is the U-shaped plan with the divisions shown in option (B). Hence, the correct option is (B).

Quick Tip to Solve: For a plan, trace exposed horizontal surfaces first. Do not transfer the outline of a doorway underneath a solid top into the footprint.

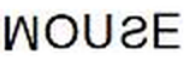
56. **Identify the mirror image of the given word with respect to X-X** [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- Reflection in a horizontal mirror line reverses the up-down orientation of each character, while preserving the left-to-right order of the characters.
- Corresponding points lie on opposite sides of the mirror line at equal perpendicular distances. A horizontal reflection is different from turning the word through half a revolution.

Step 1: Identify the direction of reflection The line X-X is horizontal and lies above the word MOUSE. Its image must lie above that line, with the top and bottom of each letter interchanged. The leftmost letter remains the reflected M and the rightmost letter remains the reflected E. The letter order is not reversed because horizontal positions do not change.

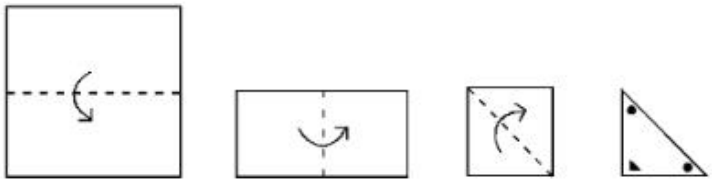
Step 2: Check the distinctive letters The reflected M has the up-down reversed form, and the U opens downward instead of upward. The O keeps its circular shape. The S must also be reflected: its top and bottom bends exchange places, producing the reversed-looking S shown in the correct figure. The E retains its rightward horizontal strokes under this up-down reflection; it must not become a left-facing E.

Step 3: Compare the four images Option (B) makes all these changes together: M and U are turned upside down, O is unchanged, S has its reflected shape, and E still faces right. Option (A) leaves S in its original orientation. Option (C) leaves U upright and reverses E sideways. Option (D) also leaves U upright. Those alternatives apply an incomplete reflection or change a direction that a horizontal mirror does not reverse.

Step 4: Conclusion The horizontal mirror image of MOUSE is the figure in option (B). Hence, the correct option is (B).

Quick Tip to Solve: For a horizontal mirror, keep letter order fixed and test U and E: U must open downward, while E must still face to the right.

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

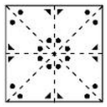


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- Unfolding reverses the folds in the opposite order. Each cut is reflected across the crease being opened, so its shape and distance from that crease are preserved.
- A cut near a folded edge gives a repeated symmetric pattern. To distinguish the alternatives, track the triangular cut separately from the circular cuts; counting holes alone is insufficient.

Step 1: Locate the cuts in the folded triangle The final folded piece has a right-angled triangular outline. It carries two round cuts near the ends of the sloping side and a small triangular cut near the right-angled corner. Keep these two kinds of opening separate while unfolding: a triangular opening cannot turn into a circular one.

Step 2: Reverse the three folds First open the diagonal fold, reflecting all three cuts across the diagonal. Then open the vertical fold, and finally the horizontal fold. The right-angled corner of the folded triangle corresponds to an edge-midpoint region of the fully opened square. Consequently, the triangular openings appear in reflected pairs near the midpoints of the four outer sides, while the round openings repeat around the corners and central region.

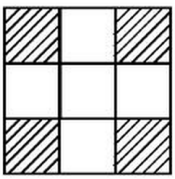
Step 3: Compare the resulting positions Option (B) has triangular pairs at the outer side midpoints and the corresponding repeated round cuts. Options (A) and (D) place triangular openings in the central cluster instead. Option (C) places them near the outer corners. Those positions would require the original triangular cut to lie near different vertices of the folded piece, so they do not follow the given folds.

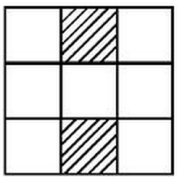
Step 4: Conclusion The unfolded pattern has triangular openings near the midpoints of its four outer

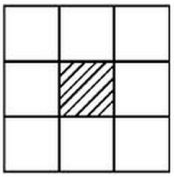
sides, as in option (B). Hence, the correct option is (B).

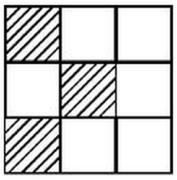
Quick Tip to Solve: Track the distinctive triangular cut first: its distance from the folded corner identifies whether triangles must appear at the centre, side midpoints or corners.

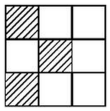
58. Identify the figure which is odd from rest of the figures. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- In an odd-figure problem, compare a structural property shared by three figures. Here the position of the shaded cells, rather than their number alone, supplies the useful test.
- A figure has vertical reflection symmetry when every shaded cell on the left has a shaded partner in the corresponding position on the right. A cell on the central column is unchanged by this reflection.

Step 1: Test the four-corner pattern Option (A) shades all four corner cells of its three-by-three square. Reflection about the vertical centre line interchanges the top corners and interchanges the bottom corners, leaving the shaded pattern unchanged. It also has horizontal reflection symmetry.

Step 2: Check the two central patterns Option (B) shades the top and bottom cells of the middle column. Both cells lie on the vertical axis, and horizontal reflection interchanges them. Option (C) shades only the middle cell, which lies at the intersection of both axes. Thus (A), (B) and (C) each retain their shaded arrangement under reflection about either the vertical or horizontal centre line.

Step 3: Identify the exception Option (D) shades the top-left cell, the centre cell and the bottom-left cell. Horizontal reflection preserves it, but vertical reflection would move the two shaded left-corner cells to the unshaded right corners. The pattern therefore lacks the vertical symmetry possessed by all the other three. The different number of shaded squares is not the deciding test: their placement is.

Step 4: Conclusion Option (D) is the only figure without vertical reflection symmetry. Hence, the correct option is (D).

Quick Tip to Solve: Check the left and right partners of shaded cells. A difference in cell count may distract you, while a shared symmetry gives a clear three-against-one test.

59. Given below are two statements :

Statement I : Stone masonary is classified into two parts - Random rubble and ashlar masonary.

Statement II : Random Rubble masonary, each stone is cut to uniform size and shape with all sides rectangular so that stones gives perfect joints.

In the light of the 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:

- Stone masonry is distinguished by the dressing and regularity of its stones. Rubble construction uses rough or comparatively irregular stones, whereas ashlar construction uses accurately dressed stone blocks.
- Random rubble does not require every unit to have the same rectangular dimensions. Uniform rectangular faces and close, regular joints are characteristic of ashlar masonry.

Step 1: Interpret the classification in Statement I The contrast intended in Statement I is between rubble work, represented here by random rubble, and ashlar work. In rubble masonry the natural irregularity of the stones is substantially retained; stones may be selected and roughly dressed so that they can be bonded securely. Ashlar masonry instead uses finely dressed blocks laid with regular joints. On this rubble-versus-ashlar distinction, Statement I is taken as true. More precisely, random rubble is a type within the broader rubble category; that terminology does not turn the description in Statement II into a property of random rubble.

Step 2: Test the description in Statement II Cutting every stone to a uniform size and shape, with rectangular sides that give close, regular joints, describes ashlar work. Random rubble stones are irregular in shape and size, and the mason fits and bonds them rather than making every exposed block an identical rectangle. Therefore Statement II is false: it transfers the defining feature of ashlar masonry to random rubble masonry.

Step 3: Compare the offered truth combinations Option (A) fails because Statement II is false. Option (B) rejects the intended rubble-and-ashlar distinction in Statement I. Option (D) reverses the two evaluations and also treats the incorrect description of random rubble as true. The combination matching the intended classification and the dressing properties is true for I and false for II.

Step 4: Conclusion Statement I is true in the intended rubble-versus-ashlar classification, while Statement II describes ashlar rather than random rubble masonry and is false. Hence, the correct option is (C).

Quick Tip to Solve: In masonry questions, connect accurately dressed rectangular blocks and fine regular joints with ashlar; connect rough, irregular stones with rubble work.

60. Identify the type of Garden by understanding the elements used in the given picture: [4 marks]



(A) Roman Garden

(B) Japanese Garden

(C) French Garden

(D) Chinese Garden

Correct Answer: (D) Chinese Garden

Solution:

Concept:

- A garden style can be identified from the relationship between buildings, water, rocks and planting. Use the collection of visible features, rather than water or greenery considered alone.
- Classical Chinese gardens integrate ponds, ornamental rocks, covered galleries and pavilions into a sequence of framed views. Upturned tiled roofs and richly detailed structures are especially useful architectural clues.

Step 1: Read the visible architectural features The photograph shows a covered gallery extending beside and over the water, together with a substantial pavilion on the right. The tiled roofs have conspicuously upturned eaves; the pavilion has dark framing and red architectural accents. Ornamental rocks and irregular planting are arranged around the pond, so the setting combines architecture with a deliberately composed natural scene.

Step 2: Connect the features to the garden tradition The covered waterside gallery, elaborate pavilion, pond and rock compositions form the characteristic combination of a Chinese garden. The gallery also acts as a route from which the water and planting can be viewed in changing frames. This ensemble is stronger evidence than the mere presence of a pond, which is common to several landscape traditions.

Step 3: Eliminate the other alternatives A French formal garden is associated with axial organisation, geometric parterres and carefully ordered planting; those are not the dominant features here. A Roman garden would not be identified by this Chinese-style gallery and pavilion roof. Japanese gardens may also contain water, rocks and bridges, but the ornate, upturned-roof architectural ensemble shown here points specifically to the Chinese tradition.

Step 4: Conclusion The pond, ornamental rocks, covered gallery and ornate upturned-roof pavilion

identify a Chinese Garden. Hence, the correct option is (D).

Quick Tip to Solve: When Chinese and Japanese gardens are both offered, inspect the architecture as well as the planting: the elaborate covered gallery and pavilion are the decisive clues here.

61. Match List I with List II

LIST I	LIST II		
A.	Rila Monastery	I.	Egypt
B.	Moha Bodhi Temple	II.	Bulgaria
C.	Wadi al Hitan	III.	Malta
D.	Valletta	IV.	India

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

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

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

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

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

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

Solution:

Concept:

- Matching a heritage site to its country requires identifying the place itself rather than guessing from similar architectural or religious associations.
- The Roman numerals refer to the country list: I is Egypt, II is Bulgaria, III is Malta and IV is India. Each site must be paired with the numeral belonging to its country.

Step 1: Locate Rila Monastery and the Mahabodhi Temple Rila Monastery stands in the Rila Mountains in Bulgaria. Thus A matches II. The temple written as Moha Bodhi Temple in the question is the Mahabodhi Temple at Bodh Gaya, Bihar, India, associated with the Buddha's enlightenment. Thus B matches IV. These two matches already eliminate options (A) and (C), because both assign Rila Monastery to India. They also place the Indian temple correctly, without confusing its Buddhist association with a country outside India.

Step 2: Locate Wadi al Hitan and Valletta Wadi al Hitan, the Valley of the Whales, is in Egypt's Western Desert. Its fossil remains are the basis of its heritage significance, so C matches I. Valletta is the capital city of Malta, a Mediterranean island country; consequently D matches III. These two matches distinguish the remaining options (B) and (D). Option (D) would put Wadi al Hitan in Malta and Valletta in Egypt, reversing their actual locations.

Step 3: Assemble and check the matching sequence In the order A, B, C and D, the countries are Bulgaria, India, Egypt and Malta. Reading their numerals from List II gives II, IV, I and III respectively. Option (A) incorrectly places Rila Monastery and the Indian temple; option (C) also starts with the wrong Rila pairing. Option (D) starts correctly but exchanges the last two countries. Only option (B) gives all four correct pairs together.

Step 4: Conclusion The correct matches are A-II, B-IV, C-I and D-III: Rila Monastery–Bulgaria, Mahabodhi Temple–India, Wadi al Hitan–Egypt and Valletta–Malta. Hence, the correct option is (B).

Quick Tip to Solve: Fix the secure pair Valletta–Malta or Bodh Gaya–India first, then use the country numerals to eliminate mismatched sequences without changing the order of the sites.

62. Identify the name of the monument : [4 marks]



(A) The Pantheon

(B) The Cathedral of Pisa

(C) The Parthenon

(D) Great Temple of Karnak

Correct Answer: (A) The Pantheon

Solution:

Concept:

- Identify a monument from a combination of architectural features: the entrance form, column arrangement, roof profile and mass of the building behind the facade.
- The Pantheon in Rome combines a classical temple-like portico with a large circular domed rotunda. Its familiar frontal view has tall columns supporting a triangular pediment.

Step 1: Examine the entrance shown The photograph shows a deep columned portico with a row of tall columns across the front and a large triangular pediment above. Behind the portico there is a massive rounded building, rather than a long rectangular temple surrounded by a colonnade. The inscription band across the entablature and the recognisable pediment-and-portico composition support the identification.

Step 2: Match the portico and rotunda The combination of a classical columned entrance with the great circular mass behind it is characteristic of the Pantheon. The front portico is the most immediately recognisable feature in this view, while the visible curved building behind helps distinguish it from

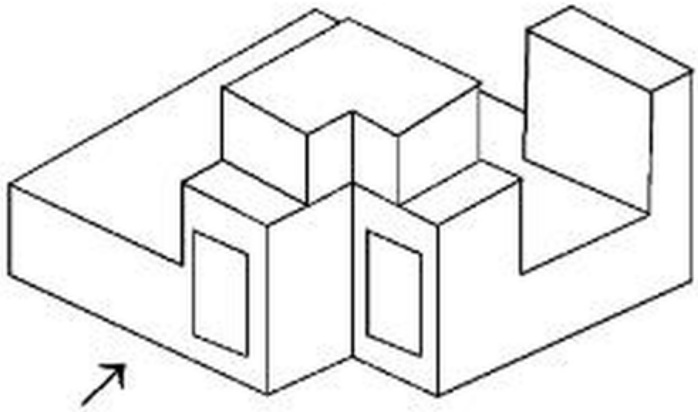
superficially similar Greek temple fronts.

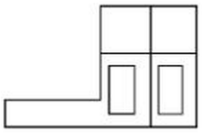
Step 3: Reject the other named monuments The Parthenon is a Greek peripteral temple with columns around a rectangular cella; it does not have the Pantheon's domed rotunda behind an entrance portico. The Cathedral of Pisa has a medieval cathedral facade with arcaded tiers and a different composition. Karnak is an Egyptian temple complex identified by pylons, massive Egyptian columns and courts, not this Roman pediment-and-rotunda arrangement.

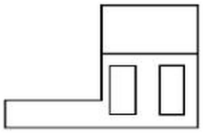
Step 4: Conclusion The monument shown is the Pantheon in Rome. Hence, the correct option is (A).

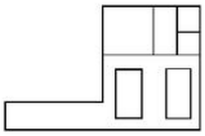
Quick Tip to Solve: Use the building behind the columns to separate Pantheon from Parthenon: the Pantheon has a circular domed rotunda, whereas the Parthenon is a rectangular Greek temple.

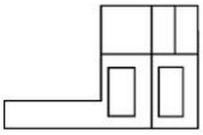
63. The question figure shows the 3D view of an object. Identify the correct view, looking in the direction of Arrow : [4 marks]

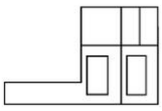


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- An orthographic view is obtained by looking parallel to the indicated arrow. Height is retained, while distances along the viewing direction collapse onto the same line of sight.
- The outline alone may not distinguish the options. Visible vertical edges of recesses and changes of face must also appear in the correct projected positions; perspective diagonals are not copied as

sloping lines.

Step 1: Fix the viewing direction Look from the lower-left side of the drawing along the arrow, towards the faces carrying the rectangular inset panels. The low platform extends to the left in this view, while the raised part occupies the right. Therefore the projected outside boundary is an L-shaped stepped outline, with a low horizontal strip on the left and a taller block on the right.

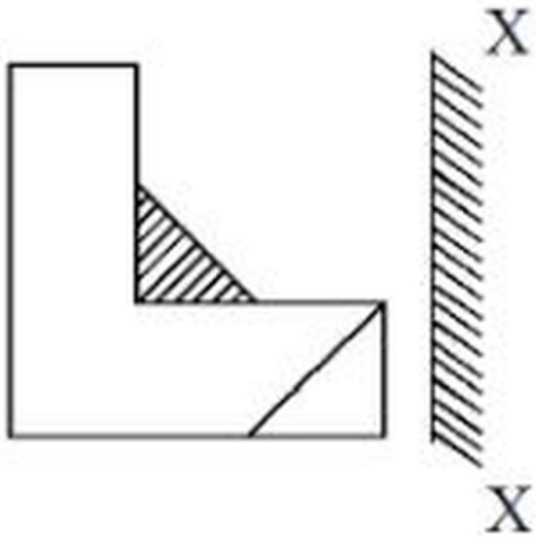
Step 2: Project the visible face divisions Keep the two rectangular panels in their side-by-side positions below the horizontal change of level. The upper solid has a recessed corner and offset vertical edges. Viewed along the arrow, these produce vertical divisions in the upper right part, including the narrow strip near its right edge. The front change of face also supplies the vertical division between the lower panels. No extra horizontal step is present across the narrow upper strip.

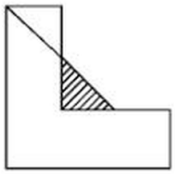
Step 3: Compare the internal lines Option (D) preserves the stepped outside boundary, both rectangular panels, the lower vertical division and the upper offset vertical divisions. Option (B) omits the face divisions. Option (A) reduces the upper divisions to a single central line and loses the narrow strip. Option (C) introduces an extra horizontal segment within the upper-right strip and does not reproduce the lower division as shown in the required projection.

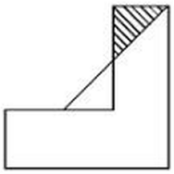
Step 4: Conclusion The view along the arrow is the L-shaped elevation with the internal vertical divisions shown in option (D). Hence, the correct option is (D).

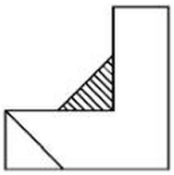
Quick Tip to Solve: After matching the outer silhouette, compare the recess edges and panel positions. An option with the right outline can still contain a missing or extra internal line.

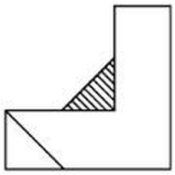
64. Identify the correct mirror image of the given figure along X-axis. [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: Options (C) and (D) both display the required reflected feature arrangement; the supplied final key selects (D), but the reproduced drawings do not distinguish a unique answer.

Solution:

Concept:

- A plane mirror reverses the component perpendicular to its surface and preserves the component parallel to it. The mirror labelled X–X in this diagram is vertical, so left and right exchange while top and bottom remain unchanged.
- Every feature must be reflected together: the L-shaped boundary, the hatched triangle at its inner corner and the diagonal inside the lower horizontal arm.

Step 1: Reflect the outside boundary The given L shape has its tall vertical arm on the left and its horizontal arm extending to the right. A reflection in the drawn vertical X–X mirror puts the tall arm on the right, with the horizontal arm extending to the left. It does not turn the object upside down. Option (A), which retains the tall arm on the left, therefore cannot be the mirror image.

Step 2: Reflect the triangle and diagonal The hatched triangular region must remain at the inner corner, now on the left side of the tall right-hand arm. The diagonal originally at the right end of the lower arm must move to its left end and reverse its slope. Option (B) moves the hatched region towards the top of the vertical arm instead of retaining it at the inner corner, so it fails this check.

Step 3: Compare the two remaining drawings Both options (C) and (D), as displayed, have the tall arm on the right, a hatched triangle at the inner corner and the correctly reversed diagonal in the left end of the bottom arm. Their small drawing-proportion differences do not establish a distinct reflection operation or a different arrangement of the features. Thus the displayed alternatives do not provide a reliable geometric reason to reject (C) while accepting (D). The supplied final key selects (D), but the displayed figure also supports (C).

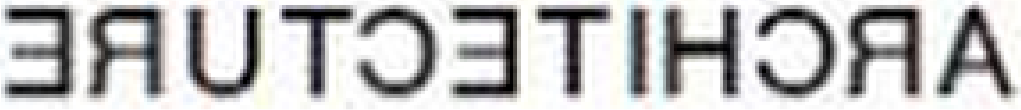
Step 4: Conclusion The supplied final key designates option (D). However, both (C) and (D) show the required left-right reflection of the displayed figure, so the reproduced alternatives do not establish a unique defensible choice.

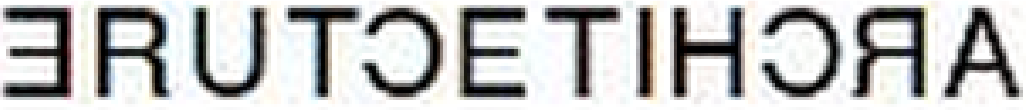
Quick Tip to Solve: Use the mirror line drawn in the question, not an assumed horizontal coordinate axis. Check each internal feature as well as the L-shaped outline.

65. **Identify the Mirror image of given word** [4 marks]



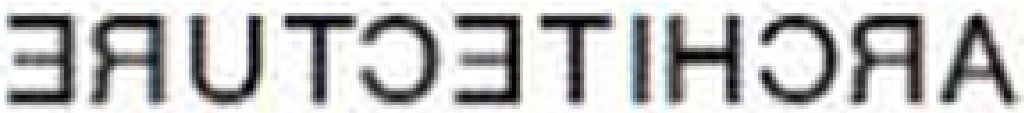
(A) 

(B) 

(C) 

(D) 

Correct Answer: (B)



Solution:

Concept:

- A reflection in a vertical mirror reverses left and right while keeping the top and bottom unchanged. The order of the letters and the shape of each asymmetric letter must both be reflected.
- The letters A, H, I, T and U in the displayed capital style are vertically symmetric. Letters such as

R, C and E provide the decisive checks because their reflected shapes differ from their ordinary shapes.

Step 1: Reverse the order of the letters The given word is ARCHITECTURE. Read it from its right-hand end to obtain the sequence E, R, U, T, C, E, T, I, H, C, R, A. This is the order in which the reflected letter shapes must appear from left to right. Simply writing some letters backwards while leaving the original order is insufficient.

Step 2: Reflect the asymmetric letters Both E characters must have their vertical spine on the right and their horizontal strokes extending left. Both R characters must have their bowl and diagonal leg directed to the left of the spine. Each C must open to the left. In option (B), these requirements hold at both occurrences of every repeated asymmetric letter.

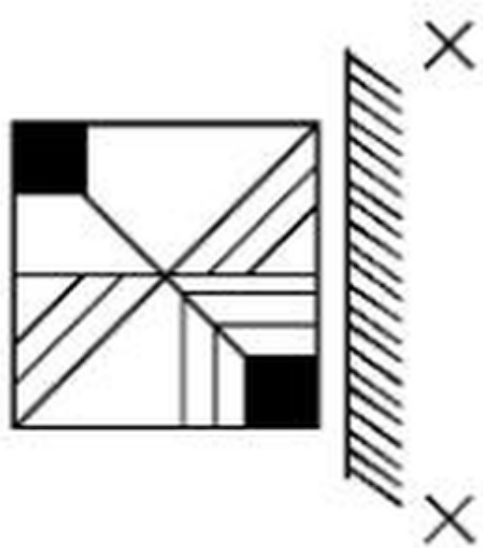
Step 3: Eliminate the other figures Option (A) retains ARCHIT in its original left-to-right orientation, so it is not a reflection of the whole word. Option (C) retains ordinary, unreflected shapes among the asymmetric letters, including the central E. Option (D) is close, but its central E still has the ordinary orientation; the E at that position must also be reversed. Option (B) alone reflects both the order and every asymmetric letter correctly.

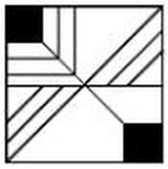
Step 4: Conclusion The complete vertical-mirror reflection of ARCHITECTURE is the figure in option (B). Hence, the correct option is (B).

Quick Tip to Solve: Check a repeated asymmetric letter at every occurrence. Here the central E distinguishes the correct complete reflection from an almost-correct image.

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

[4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A vertical mirror maps each point to the opposite horizontal side at the same height and the same perpendicular distance from the mirror. It does not interchange the top and bottom of the figure.
- A correct reflected pattern preserves all connections and spacings. Corner shading gives a quick first check, but the directions and arrangements of the internal lines must also match.

Step 1: Track the shaded corners The mirror X-X is vertical and lies to the right of the square. In the given pattern the filled corners are at the top left and bottom right. Their reflected positions are therefore top right and bottom left. Options (A) and (B) fail this requirement: (A) retains the original diagonal pair of filled corners, while (B) places both filled corners on the left.

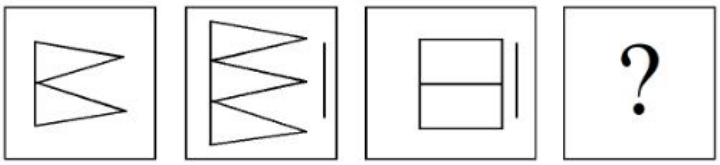
Step 2: Reflect the diagonal bands The parallel diagonal lines occupying the upper-right region of the original must occupy the upper-left region in the reflection. Likewise, the lower-left diagonal band moves to the lower right. Their slopes reverse under reflection, while their endpoints remain at corresponding heights. Option (C) has these diagonal bands in the required positions.

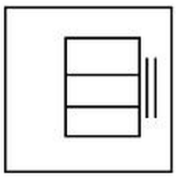
Step 3: Check the corner-line arrangement The original lower-right region contains a filled corner and a nested set of horizontal and vertical segments approaching that corner. This complete arrangement must move to the lower left; the upper-left simple filled corner moves to the upper right. Option (C) preserves these associations. Although option (D) has the right pair of filled corners, it puts the nested corner-line arrangement at the top right instead of the bottom left. It therefore is not the required mirror reflection.

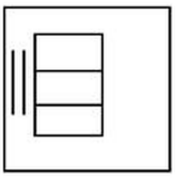
Step 4: Conclusion Option (C) reverses left and right throughout the pattern while preserving each feature at its original height. Hence, the correct option is (C).

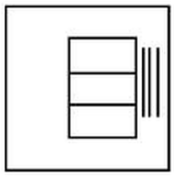
Quick Tip to Solve: First transfer the black corners, then check one asymmetric internal detail. The nested corner lines distinguish (C) from (D) after the shading check.

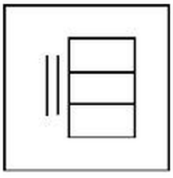
67. Identify the correct figure to complete the sequence : [4 marks]

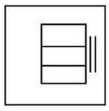


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- In a figure-sequence problem, track separate attributes such as polygon shape, the number of stacked components and the number and position of detached strokes.
- The same change from the first figure to the second can be applied to the third figure to find the missing partner. A valid choice should preserve all unchanged features as well as make the required additions.

Step 1: Read the first pair The first frame contains two triangular components stacked on a common vertical side, with no detached vertical stroke on the right. The second frame contains three triangular components and one detached stroke on the right. Thus this pair increases the number of stacked components by one and also increases the number of right-hand detached strokes by one.

Step 2: Apply the change to the square pair The third frame changes the polygon family to quadrilateral compartments. It contains two stacked compartments and one detached vertical stroke on their right. Applying the same pairwise change gives three stacked compartments and two detached strokes, still on the right. The outline remains a vertical stack; the rule does not move its detached strokes to the other side.

Step 3: Compare every choice Option (A) shows the required three quadrilateral compartments with two detached strokes on the right. Options (B) and (D) both move the two strokes to the left, unlike the placement established by the sequence. Option (C) keeps the strokes on the right but shows three of them, whereas adding one to the single stroke in the third frame gives two. Only option (A) satisfies both the component count and the stroke count and position.

Step 4: Conclusion The missing figure has three stacked quadrilateral compartments and two

detached vertical strokes on the right, as in option (A). Hence, the correct option is (A).

Quick Tip to Solve: Tabulate component count and detached-stroke count separately: the first pair is (2,0) to (3,1), so the second pair is (2,1) to (3,2).

68. Complete the number series

10, 30, 68, 130, _____, 350 [4 marks]

(A) 222

(B) 192

(C) 220

(D) 216

Correct Answer: (A) 222

Solution:

Concept:

- A number series can be identified by expressing its entries as simple functions of consecutive integers. Check the same rule against every supplied term, including the term after the blank.
- Here use $a_n = n^3 + n$, beginning with $n = 2$. Both the cube and the added integer increase together; the missing position corresponds to $n = 6$.

Step 1: Recognise and verify the rule The first number is close to the cube of 2, the second to the cube of 3, and so on. The differences from those cubes are precisely the corresponding bases:

$$2^3 + 2 = 8 + 2 = 10,$$
$$3^3 + 3 = 27 + 3 = 30,$$
$$4^3 + 4 = 64 + 4 = 68,$$
$$5^3 + 5 = 125 + 5 = 130.$$

Thus four consecutive entries obey one uniform rule rather than separate unrelated operations. The next base must be 6; it is not sufficient to add only the preceding difference because the differences themselves are increasing.

Step 2: Fill the blank and check the final term At the missing position the rule gives

$$6^3 + 6 = 216 + 6 = 222.$$

The supplied number after the blank provides an independent check:

$$7^3 + 7 = 343 + 7 = 350.$$

Therefore the complete progression is $10, 30, 68, 130, 222, 350$. Option (B), 192, and option (C), 220, do not equal the required cube plus its base. Option (D), 216, is tempting because it is 6^3, but it omits the additional 6 that is present at every other position.

Step 3: Conclusion The missing number is $\boxed{222}$. Hence, the correct option is (A).

Quick Tip to Solve: When terms lie just above consecutive cubes, subtract those cubes and check whether the residuals repeat their bases. Always test the term after a blank too.

69. In a clock, the time is 11:35 AM. The clock is so placed that its hour hand is facing North-West. In which direction will be minute hand facing? [4 marks]

(A) South- East

(B) South-West

(C) North-West

(D) North- East

Correct Answer: No listed option matches the exact bearing 177.5 degrees; the keyed South-West answer uses an inaccurate clock-hand approximation.

Solution:

Concept:

- At $h : m$, the clockwise angle of the hour hand from the twelve mark is $30h + 0.5m$ degrees; the minute hand angle is $6m$ degrees. The hour hand moves continuously between hour marks.
- A compass bearing is measured clockwise from North. North-West has bearing 315°. Rotating the whole clock adds the same angle to both hands and therefore preserves their signed angular separation.

Step 1: Calculate the actual hand positions At 11:35 the hour hand is not at the eleven mark: in 35 minutes it has advanced $35 \times 0.5^\circ = 17.5^\circ$ beyond it. Relative to the twelve mark,

$$\theta_h = 30(11) + 0.5(35) = 347.5^\circ, \qquad \theta_m = 6(35) = 210^\circ.$$

Consequently the minute hand is $210^\circ - 347.5^\circ = -137.5^\circ$ from the hour hand, with clockwise angles taken as positive. This relative angle is unaffected by how the clock is placed.

Step 2: Rotate the clock and compare the choices With the hour hand at bearing 315°, the minute hand has bearing

$$315^\circ - 137.5^\circ = 177.5^\circ.$$

It therefore points 2.5° east of due South. This is neither South-East (135°), South-West (225°), North-West (315°), nor North-East (45°). The listed answer key selects (B), which can arise from a coarse clock-face interpretation that holds the hour hand at eleven and classifies directions broadly. That approximation changes the stated hand position and does not describe a real clock at 11:35. Even under an eight-sector compass classification, 177.5° lies in the South sector.

Step 3: Conclusion The actual minute-hand direction is $\boxed{177.5^\circ}$ clockwise from North, almost due South. None of (A)-(D) is correct for the literal question; the keyed option (B), South-West, does not follow from the continuously moving hour hand.

Quick Tip to Solve: Include the hour hand's half-degree movement per minute before rotating the clock. Keep a signed angle between the hands, then add the given compass bearing.

70. Match List I with List II

LIST I	LIST II		
A.	Brick	I.	Dampness Prevention
B.	Arch	II.	Bevelled closer
C.	Lintel	III.	Openings
D.	Cavity wall	IV.	Span

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

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

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

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

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

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

Solution:

Concept:

- Match a building term to its characteristic constructional use, rather than to a material that it could merely contain. A closer is a specially shaped masonry unit, while arches and lintels are structural members.
- An arch carries load across a span through curved compressive action. A lintel is a horizontal member above an opening. A cavity wall separates two leaves of masonry to hinder moisture penetration.

Step 1: Match the brick and arch entries A bevelled closer is a brick cut along its length so that its width changes from one end to the other. It is used in arranging the masonry bond and is therefore associated with Brick: A-II. An arch bridges a span between supports. Its curved arrangement transfers the load towards its supports primarily by compression, so Arch matches Span: B-IV. These specific relationships are stronger than a general statement that bricks can occur around an opening or that an arch could form part of a wall.

Step 2: Match the remaining functions and eliminate alternatives A lintel crosses the top of a door, window or other opening and supports the masonry above it; hence Lintel matches Openings: C-III. A cavity wall has an outer and an inner leaf separated by an air space, which interrupts the path by which rainwater could reach the inside face. Thus Cavity wall matches Dampness Prevention: D-I. The full code is A-II, B-IV, C-III, D-I. Option (A) incorrectly links brick with span and lintel with damp prevention. Option (B) gives arch damp prevention and cavity wall span. Option (C) pairs lintel with a bevelled closer. Each fails characteristic component-function relationships.

Step 3: Conclusion The matches are $\boxed{\text{A-II, B-IV, C-III, D-I}}$. Hence, the correct option is (D).

Quick Tip to Solve: Anchor this matching set with cavity wall and damp prevention, then distinguish the horizontal lintel above an opening from the curved arch spanning between supports.

71. Match List I with List II

LIST I(Buildings)	LIST II(Architects)		
A.	Habital 67	I.	F. L. Wright
B.	Falling Water	II.	Moshe Safdi
C.	Gherkin Tower	III.	Louis Kahn
D.	Fisher House	IV.	Norman Foster

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

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

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

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

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

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

Solution:

Concept:

- Architectural-awareness matching requires linking each named building with its designer. Similar fame or nationality does not establish a design credit; use the specific building-architect association.
- The relevant associations are Habitat 67 with Moshe Safdie, Fallingwater with Frank Lloyd Wright, the Gherkin with Norman Foster, and Fisher House with Louis Kahn.

Step 1: Identify the first two buildings The entry printed as Habital 67 refers to Habitat 67, the modular housing complex associated with Moshe Safdie. The spelling Moshe Safdi in the architect list designates that architect; therefore A-II. Falling Water, commonly written Fallingwater, is Frank Lloyd Wright's house designed over a waterfall. Its projecting terraces are a familiar example of Wright's approach to integrating a building with its natural setting. Hence B-I. These two associations already narrow the code substantially, but the remaining pairs should still be checked rather than selected by elimination alone.

Step 2: Verify the tower and house associations Gherkin Tower is the London tower at 30 St Mary Axe, designed by Norman Foster's practice. Its rounded, tapering profile distinguishes it from the residential works in the list, giving C-IV. Fisher House is a residential design by Louis Kahn, giving D-III. Combining the independently identified pairs produces A-II, B-I, C-IV, D-III. Option (B) assigns Habitat to Foster and Fallingwater to Safdie. Option (C) gives the Gherkin to Safdie despite retaining the correct Fallingwater and Fisher pairs. Option (D) assigns Habitat to Wright and Fallingwater to Kahn. None preserves all four design credits.

Step 3: Conclusion The correct code is $\boxed{\text{A-II, B-I, C-IV, D-III}}$. Hence, the correct option is (A).

Quick Tip to Solve: Recall one distinctive image for each name: Habitat's stacked housing modules, Fallingwater's terraces, the Gherkin's curved tower, and Kahn's Fisher House.

72. Identify the famous building in the given picture : [4 marks]



(A) Mysore Palace

(B) Khalsa Heritage Complex

(C) Hotel Taj Mahal Palace

(D) Victoria Memorial

Correct Answer: (C) Hotel Taj Mahal Palace

Solution:

Concept:

- An architectural photograph is identified by a combination of its overall massing, roof profile, facade composition and distinctive domes or towers. A single dome is rarely a sufficient identifier.
- The Taj Mahal Palace hotel in Mumbai is recognizable by its prominent reddish central dome, long multistorey facade and richly articulated arched openings and corner elements.

Step 1: Observe the building in the photograph The photograph shows a long, densely windowed multistorey building with a prominent reddish dome rising above the main roof. Repeated arched openings and contrasting facade bands extend across the building, while projecting corner elements contribute to the elaborate silhouette. These features form a coherent identification rather than relying on the dome alone.

Step 2: Identify the matching landmark This combination of a long hotel facade, the characteristic central red dome and the ornate roofline identifies the Taj Mahal Palace hotel. The option names it as Hotel Taj Mahal Palace. The photographed structure is the historic palace wing, whose appearance is strongly associated with this Mumbai landmark.

Step 3: Rule out the alternatives Mysore Palace has a different palace composition and skyline; it is not this long, tightly repeated hotel frontage. The Khalsa Heritage Complex has a modern sculptural architectural composition rather than the photographed ornate facade with its rows of arches and central red dome. Victoria Memorial is a predominantly white marble monument with a different central domed composition, not the multistorey red-domed hotel shown here. Therefore these three names do not match the visible building.

Step 4: Conclusion The building in the photograph is Hotel Taj Mahal Palace in Mumbai. Hence, the correct option is (C).

Quick Tip to Solve: Use the central red dome together with the long ornate hotel facade as the identifying combination; do not choose a landmark merely because it also has a dome.

73. 'LEED' stands for : [4 marks]

(A) Leadership in Energy and Environmental Design

(B) Leadership in Environmental and Energy Design

(C) Leadership in Energy Efficient Design

(D) Leadership in Environmental Energy Design

Correct Answer: (A) Leadership in Energy and Environmental Design

Solution:

Concept:

- LEED is the name of a green-building rating system. Its full form is Leadership in Energy and Environmental Design.
- In an acronym question, the expansion must match the established title word for word. Similar environmental expressions do not become correct merely because they describe green buildings.

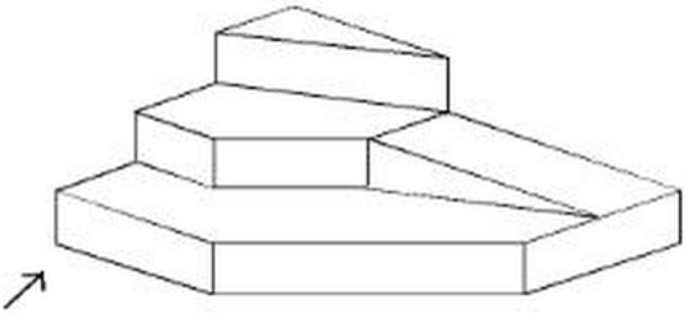
Step 1: Expand the letters in their established order Read the acronym as L for Leadership, E for Energy, E for Environmental and D for Design. The connecting words are "in" and "and", giving Leadership in Energy and Environmental Design. The phrase refers to designing and assessing buildings with attention to energy use and their wider environmental effects. Both Energy and Environmental belong in the title; neither is an optional descriptive addition.

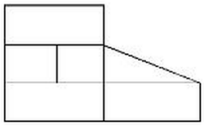
Step 2: Compare the four proposed expansions Option (A) reproduces the established name exactly. Option (B) reverses Energy and Environmental, and so gives a different phrase. Option (C) replaces Environmental with Efficient: energy efficiency is relevant to sustainable buildings, but that does not make Energy Efficient the expansion used by LEED. Option (D) omits the conjunction joining Energy and Environmental and changes their order to Environmental Energy. Thus the presence of familiar sustainability terms in an option is insufficient; the complete official wording must agree.

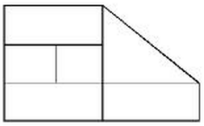
Step 3: Conclusion LEED stands for Leadership in Energy and Environmental Design. Hence, the correct option is (A).

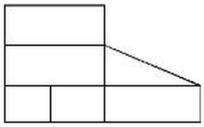
Quick Tip to Solve: Remember the central pair in order: Energy and Environmental. Then attach Leadership in before it and Design after it.

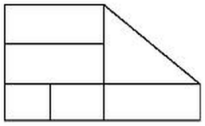
74. From the given 3D view of an object, identify the most appropriate elevation looking in the direction of the given arrow : [4 marks]

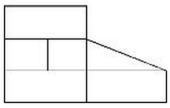


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An elevation is an orthographic projection in the direction of the viewing arrow. Depth along that direction disappears, while height and position across the view remain.
- Visible edges must agree with the solid: a sloping face begins at its actual upper edge, not at the highest point of an unrelated raised part.

Step 1: Follow the viewing arrow The arrow at the lower left points towards the object. Look squarely along this direction and compare the heights of the base, the intermediate platform and the upper rear block. The upper block gives a rectangular outline above the intermediate level on the left of the projected view.

Step 2: Locate the start of the ramp The sloping face on the right meets the intermediate platform. Its upper end is below the top of the rear block, and it descends to the top of the base. Thus the descending outline must start at the intermediate horizontal level. Options (B) and (D) incorrectly start that outline at the highest level.

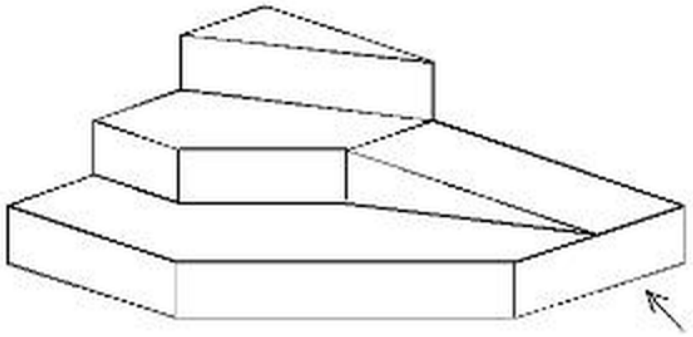
Step 3: Compare the remaining visible edges The intermediate platform changes direction in plan, so its visible upright edge appears within the intermediate band in this elevation. Option (A) places that short upright in the middle band and preserves the base outline. Option (C) instead puts a short division in the lower base band and omits the required intermediate division. Compare these edges independently of the overall stepped silhouette: matching only the outer boundary is insufficient.

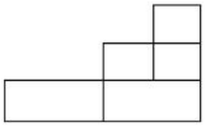
Step 4: Conclusion The ramp starts at the intermediate level and the internal upright is in the

intermediate band, as in option (A). Hence, the correct option is (A).

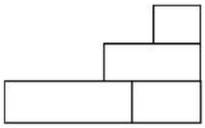
Quick Tip to Solve: First locate the upper end of a ramp in an elevation; then check the band containing each short vertical edge.

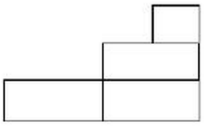
75. From the given 3D view of an object, identify the most appropriate elevation looking in the direction of the given arrow. [4 marks]

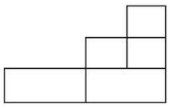


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An orthographic elevation keeps heights and positions perpendicular to the viewing direction while collapsing depth.
- After finding the silhouette, check projected visible edges inside it; two options can have identical stepped outlines but different internal divisions.

Step 1: Look from the indicated side Here the arrow is at the lower right of the object. View the solid from that side, without rotating the object into the direction used in another elevation. The base extends across the whole view, the intermediate level occupies the right-hand part, and the upper block rises at the far right. The result is a three-level stepped silhouette.

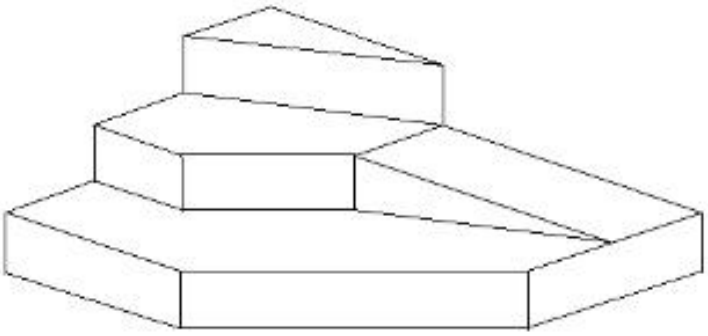
Step 2: Project the edges within the silhouette The corner of the base gives a vertical division aligned with the beginning of the intermediate step. The upright edge at the left of the upper block continues down through the intermediate band as a visible edge. It does not continue through the full base band as an extra division. These positions reproduce the edge pattern in option (A).

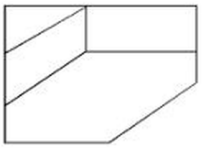
Step 3: Eliminate the other drawings Option (B) extends the division beneath the upper block into the base band, adding a line that is not the required visible base edge in this view. Option (C) places the base division farther right than the start of the intermediate step and lacks the intermediate internal upright. Option (D) has the correct general stair-like outline, but omits that upright inside the intermediate band. Therefore the silhouette alone cannot select the answer; both boundary and internal edges must match.

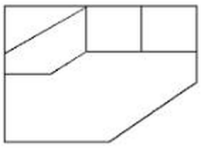
Step 4: Conclusion The indicated side elevation has the three ascending levels and internal divisions shown in option (A). Hence, the correct option is (A).

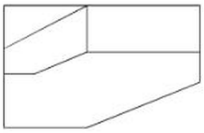
Quick Tip to Solve: Once the staircase outline matches, compare where each vertical line starts and stops; those endpoints often distinguish the choices.

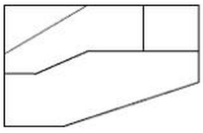
76. Choose the correct top view of the given 3D image from the options. [4 marks]

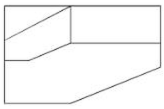


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A top view projects the solid vertically onto a horizontal plane. Heights disappear, but the horizontal positions and boundaries of exposed surfaces remain.
- The plan must include the footprint and the visible boundaries of raised platforms and sloping surfaces; an elevation-like height step is not added to the plan.

Step 1: Trace the footprint from above Look vertically down at the base. Its boundary is a polygon

with a cut-off corner towards the lower right in the answer orientation. The long outer edges and the oblique corner form the envelope within which all of the raised surfaces must project.

Step 2: Trace the raised and sloping surfaces The intermediate platform has a short horizontal boundary on the left followed by an oblique boundary rising towards the central junction. From this junction, the boundary of the sloping face extends across towards the right side. The rear raised block also has an oblique boundary in the upper-left part and an upright projected edge leading to that junction. Option (C) preserves these connections without adding a division to the broad upper-right surface.

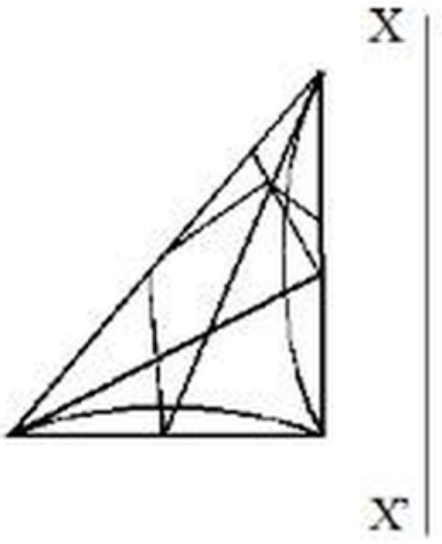
Step 3: Check each alternative Option (A) extends an oblique intermediate boundary directly to the left outer edge instead of retaining the short horizontal segment shown by the platform footprint. Options (B) and (D) insert an extra vertical division in the upper-right area and do not reproduce the same junction arrangement. Option (C) alone gives the required footprint, short left horizontal edge, oblique platform boundary and connected upper edges together. No hidden height should be interpreted as a new line across an otherwise continuous top surface.

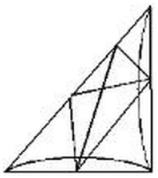
Step 4: Conclusion The correct vertical projection of the solid is the plan shown in option (C). Hence, the correct option is (C).

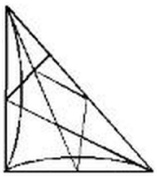
Quick Tip to Solve: Trace the outer footprint first, then follow each exposed surface boundary from junction to junction instead of comparing shading or apparent height.

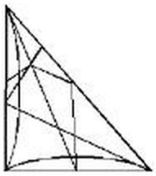
77. **Identify the True mirror image of the figure amongst the answer figures with respect to X-X.**

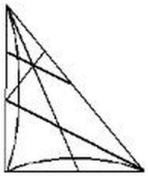
[4 marks]

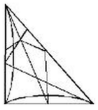


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- Reflection in a vertical mirror reverses left and right while preserving height. Each point and its image lie at equal perpendicular distances from the mirror.
- A correct mirror image preserves every line connection, intersection and curved segment. Turning the drawing through an angle is not the same operation.

Step 1: Reflect the outer triangular boundary The mirror X-X is vertical and lies to the right of the original figure. Consequently the original upright right edge becomes the upright left edge in the reflected drawing. The lower-left vertex moves to the lower right, while the top vertex stays at the same height. Option (A) retains the original handedness and can be rejected immediately.

Step 2: Reflect the internal lines as a connected pattern Track the segment from the original lower-left vertex towards the right side: after reflection it must run from the lower-right vertex towards the left side. Similarly, the long segment from the top vertex to a point on the base must slope down towards the right. The short interior upright and the small intersections near the upper sloping side must all reverse sideways without moving vertically. The curved line close to the base remains a low arch with its endpoints reflected.

Step 3: Compare all surviving candidates Option (C) keeps the reflected outer triangle and the full arrangement of interior crossings and short segments. Option (B) changes the upper internal junction and the attachment of the short interior segment; it is therefore not an exact reflection even though its outer triangle faces the correct way. Option (D) has a different interior network, with the long crossings and their contact points shifted. Exact correspondence of the internal connections selects (C).

Step 4: Conclusion Only option (C) reverses the figure about the vertical line X-X while preserving every internal connection. Hence, the correct option is (C).

Quick Tip to Solve: After using the outer boundary to reject an option, trace one distinctive interior junction and the endpoints of its connected lines.

78. Given below are two statements : One is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : Green buildings have a lower life cycle cost than conventional buildings.

Reason R : Green buildings require less maintenance and have lower energy and water consumption.

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

(A) Both **A** and **R** are correct and **R** is the correct explanation of **A**

(B) Both **A** and **R** are correct but **R** is NOT the correct explanation of **A**

(C) **A** is correct but **R** is not correct

(D) **A** is not correct but **R** is correct

Correct Answer: (A) Both **A** and **R** are correct and **R** is the correct explanation of **A**

Solution:

Concept:

- Life cycle cost considers expenditure over a building's service life, rather than only its initial construction cost. Operation, energy, water and maintenance therefore affect the comparison.
- Green-building measures aim to reduce resource consumption and operating expenditure. A reason explains an assertion when it states the mechanism producing the asserted outcome.

Step 1: Evaluate the assertion using life cycle expenditure The assertion concerns the overall cost during the building's life. A green building can require investment in efficient equipment, suitable materials and resource-saving design at construction. However, this initial expenditure is only one component of life cycle cost. Lower running expenses over many years can offset that investment. In the intended general comparison with conventional buildings, green buildings have lower life cycle cost, so Assertion A is correct. This must not be confused with a claim that every green building has the lowest initial purchase or construction price.

Step 2: Evaluate the stated reason Reduced energy consumption lowers the cost of operating lighting, cooling and other building services. Reduced water consumption lowers water-related operating expenditure. Appropriate durable materials and efficient systems can also reduce maintenance requirements. These are the savings referred to in Reason R. The statement describes the operational benefits of a green building and is correct in the comparison being tested.

Step 3: Test whether the reason explains the assertion Energy, water and maintenance expenditure are components of the cost paid throughout the service life. Reducing these recurring expenses directly accounts for the lower life cycle cost in A. Therefore R is an explanation, not merely an unrelated correct statement. Option (B) wrongly denies this connection. Options (C) and (D) each incorrectly reject one of the two correct statements.

Step 4: Conclusion Both A and R are correct, and R is the correct explanation of A. Hence, the correct option is (A).

Quick Tip to Solve: For a life cycle cost assertion, look for savings that recur throughout operation; initial construction cost alone cannot decide it.

79. Match List I with List II

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

LIST I		LIST II	
A.	Tower Bridge	I.	
B.	Torii	II.	
C.	Stonehenge	III.	
D.	Petronas Tower	IV.	

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

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

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

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

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

Solution:

Concept:

- Architectural landmarks can be recognized from characteristic forms such as twin bridge towers, a gateway lintel, upright stones or linked skyscrapers.
- A matching-list answer must pair every name in List I with its corresponding numbered figure in List II; matching one pair alone is insufficient.

Step 1: Identify the bridge and the gateway Tower Bridge is represented by figure IV: two bridge towers stand on opposite sides of the central opening above water, with a high connection between them. Therefore A-IV. A Torii is the traditional Japanese gateway with two posts and horizontal members above the opening. That form is figure I, so B-I. It is not the row of separate upright stones in figure II.

Step 2: Identify the stone monument and twin towers Stonehenge is represented by figure II, which shows massive upright stones with horizontal stone lintels across some of them. Hence C-II. The Petronas towers are the pair of tall, slender, spired towers linked by a skybridge, represented by figure III. Therefore D-III. The linked skyscrapers must not be confused with the lower bridge towers in figure IV.

Step 3: Assemble and test the complete mapping The four matches are A-IV, B-I, C-II and D-III. This is exactly option (D). Option (A) incorrectly pairs Tower Bridge with the skyscrapers and Torii with the stone monument. Option (B) gets A-IV but incorrectly assigns Torii to III and Stonehenge to I.

Option (C) also begins with the wrong A-III and B-II pairs. Thus only (D) satisfies all four independent identifications.

Step 4: Conclusion Tower Bridge-IV, Torii-I, Stonehenge-II and Petronas Tower-III give A-IV, B-I, C-II, D-III. Hence, the correct option is (D).

Quick Tip to Solve: Use the most distinctive silhouette first: the two-post Torii gateway fixes B-I, then verify all three remaining pairs.

80. Identify the building material primarily used for cladding in Lotus Temple : [4 marks]



(A) Dolomite

(B) Lime

(C) Marble

(D) Granite

Correct Answer: (C) Marble

Solution:

Concept:

- Cladding is the outer facing or covering applied to a building. Its material need not be the same as the material carrying the structural loads.
- The Lotus Temple is recognized by its petal-like form and white marble exterior; the question asks specifically about that exterior facing.

Step 1: Identify the part of the building being asked about The photograph shows the Lotus Temple with its white petal-shaped shells above the surrounding pools. The demand is to identify the material primarily used for cladding. Focus on the facing of the petals, rather than on the structural support, the paving, the water or a binding material used during construction.

Step 2: Select the characteristic facing stone The exterior petals are clad with white marble. Marble is a natural stone that can be cut into facing panels, providing the pale finished surface associated

with the building. Thus the required material corresponds to option (C). The fact that a building has a structural shell does not make the shell construction material the answer to a question about its cladding.

Step 3: Distinguish the other choices Dolomite in option (A) names a mineral or carbonate rock and is not the named primary cladding material of the Lotus Temple. Lime in option (B) is associated with binding and finishing materials, not the marble panels identifying this exterior. Granite in option (D) is another durable stone widely used in buildings, but it is not the stone specified for these white petal facings. A general statement that a material is used in construction is insufficient; it must match this particular building and component.

Step 4: Conclusion The Lotus Temple is primarily clad in white marble. Hence, the correct option is (C).

Quick Tip to Solve: In landmark-material questions, distinguish the visible cladding from the load-bearing structure before selecting the material.

Planning (100 marks)

81. What is the full form of NABARD? [4 marks]

(A) National Bank for Agriculture and Rural Development

(B) National Bank for Agriculture and Road Development

(C) National Bank for Agriculture and River Development

(D) National Bank for Agro farming and Reproduction

Correct Answer: (A) National Bank for Agriculture and Rural Development

Solution:

Concept:

- NABARD is the apex development bank concerned with agriculture and rural development in India. An institutional abbreviation must be expanded using its official name, rather than by choosing words that merely sound relevant.
- The abbreviation groups the words National Bank, Agriculture and Rural Development. The connecting words “for and “and are included in the full name even though they do not produce separate prominent letters in NABARD.

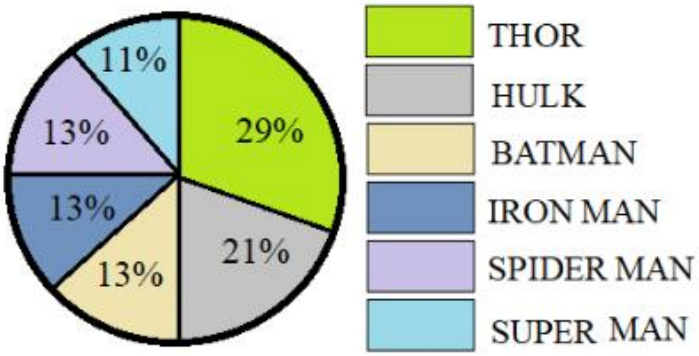
Step 1: Expand the institutional name NABARD stands for National Bank for Agriculture and Rural Development. The phrase identifies both the main productive activity, agriculture, and the wider development of rural areas. Rural development includes more than cultivation alone, so the final part of the name is broader than farming.

Step 2: Compare every alternative Option (A) reproduces the complete name. Option (B) replaces Rural with Road: roads may be rural infrastructure, but road development is not the expansion of the institution’s name. Option (C) similarly substitutes River for Rural. Option (D) changes Agriculture to Agro farming and replaces Rural Development with Reproduction; neither phrase is part of the official title. Thus only the first option preserves all the required words in their correct order.

Step 3: Conclusion NABARD means National Bank for Agriculture and Rural Development. Hence, the correct option is (A).

Quick Tip to Solve: Remember NABARD as the bank for agriculture plus the wider rural economy; the final RD is Rural Development.

82. As per the following pie chart which superhero is second most popular hero ? [4 marks]



(A) HULK

(B) THOR

(C) SUPERMAN

(D) SPIDERMAN

Correct Answer: (A) HULK

Solution:

Concept:

- A pie chart divides a whole into sectors. Each sector's percentage represents that category's share of the total, so a larger percentage means greater popularity here.
- Read a sector together with the colour key. To find the second most popular superhero, rank the percentages rather than choosing the largest sector or relying on the order of names in the legend.

Step 1: Match the sectors with their superhero names The green sector represents Thor and is labelled 29%. The grey sector represents Hulk and is labelled 21%. Batman, Iron Man and Spider Man each have 13%, while Super Man has 11%. These readings account for the whole chart:

$$29 + 21 + 13 + 13 + 13 + 11 = 100.$$

The colours are essential: the grey sector must be matched with Hulk, not with a neighbouring legend entry.

Step 2: Rank the shares and select the second position Arrange the different shares in descending order:

$$29\% > 21\% > 13\% > 11\%.$$

Thor occupies the first position, and Hulk occupies the second. The tie among the three superheroes

at 13% does not affect the second position because all three are below Hulk. Thus option (A) fits the question. Option (B), Thor, would answer a question asking for the most popular superhero. Option (C), Superman, has only 11%, and option (D), Spiderman, has 13%; neither has the second-largest share. The total number of respondents is unnecessary because percentages already allow the required comparison.

Step 3: Conclusion Hulk is the second most popular superhero, with 21%, below Thor's 29% and above every other share. Hence, the correct option is (A).

Quick Tip to Solve: For a ranking question, identify the two largest sector percentages first, then use the colour key to attach the correct names; do not select the largest when asked for second place.

83. When was Indian National Congress set-up? [4 marks]

(A) 28th December 1885

(B) 28th November 1887

(C) 28th October 1886

(D) 28th December 1888

Correct Answer: (A) 28th December 1885

Solution:

Concept:

- The Indian National Congress was established in December 1885. Distinguish its foundation from the dates of later annual sessions and later phases of the freedom movement.
- The inaugural session took place in Bombay, now Mumbai, under the presidency of Womesh Chandra Bonnerjee. Its opening on 28 December 1885 supplies the foundation date asked here.

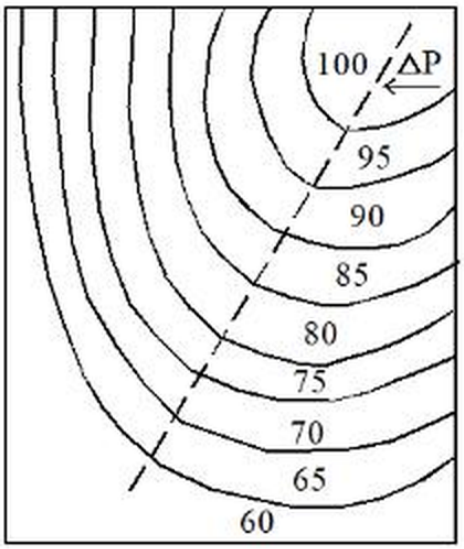
Step 1: Recall the first Congress session The first session of the Indian National Congress opened on 28 December 1885 in Bombay. A. O. Hume was closely associated with its organisation, and W. C. Bonnerjee presided. These identifying details distinguish the founding meeting from the later Congress sessions held in other cities. The question asks when the organisation was set up, so the first session is the relevant event.

Step 2: Check the complete date in each option Option (A) gives 28 December 1885, matching the day, month and year. Option (B) gives November 1887, which is a different month and two years later. Option (C) gives October 1886, again a different month and year. Option (D) retains 28 December but changes the year to 1888. Matching only the day and month would therefore be insufficient: the foundation year must also be 1885.

Step 3: Conclusion The Indian National Congress was set up on 28 December 1885. Hence, the correct option is (A).

Quick Tip to Solve: Associate the Congress foundation with Bombay, Bonnerjee and December 1885; then check all three parts of the date.

84. In the given diagram the ΔP line represents a _____. [4 marks]



(A) Ridge line

(B) Slope line

(C) Valley line

(D) Vertical line

Correct Answer: (A) Ridge line

Solution:

Concept:

- A contour joins points at the same elevation. Successive contour values and their bends show the shape of the land, so identifying a ridge or a valley requires both the contour geometry and the direction of increasing height.
- A ridge is an elongated high part of the ground. Its contours bulge towards lower ground, whereas a valley's contour bends point towards higher ground, upstream. The line along the crest of the elongated high ground is the ridge line.

Step 1: Establish the direction of increasing elevation Read the contour labels along the dashed line indicated by ΔP. They rise from 60 through $65, 70, 75, 80, 85, 90, 95$ to 100, towards the upper-right part of the diagram. Therefore the upper-right end is the higher end, and the lower-left end leads towards lower elevations. The contours are spaced at an elevation interval of 5, but their shape, rather than this interval alone, decides the landform.

Step 2: Interpret the contour bends and eliminate the alternatives The contour bends along the dashed line project towards the lower-elevation end. The dashed line passes through the projecting noses of successive contours, tracing the crest of a spur or ridge descending from the high ground. This is the ridge-line pattern, so option (A) applies. A valley line, option (C), would follow indentations whose contour bends point towards the higher elevations, which is the opposite relationship. Option (B), slope line, describes a more general direction across sloping terrain and misses the specific crest indicated by the contour pattern. Option (D), vertical line, does not name this topographic feature;

the dashed line is drawn across a map and represents a line on the ground, not a vertical height measurement. Identifying the high end before interpreting the bends prevents confusing a ridge with a valley.

Step 3: Conclusion The line indicated by ΔP follows the projecting contour noses towards lower ground and represents a ridge line. Hence, the correct option is (A).

Quick Tip to Solve: Read the contour heights before interpreting a bend: a ridge nose points downhill, while a valley's contour bend points uphill. Follow the sequence of noses to identify the ridge line.

85. Match List I with List II

LIST I(World Heritage site)	LIST II(State)		
A.	Agra fort	I.	Chittorgarh, Kumbhalgarh
B.	Ellora caves	II.	Uttar Pradesh
C.	Hills forts of Rajasthan	III.	Maharashtra
D.	Buddhist Monuments at Sanchi	IV.	Madhya Pradesh

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

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

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

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

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

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

Solution:

Concept:

- A matching question is solved by independently locating each heritage site before comparing the combined codes. A familiar match can eliminate distractors, but all four pairs should still be checked.
- Agra Fort is in Uttar Pradesh; Ellora Caves are in Maharashtra; the Hill Forts of Rajasthan include Chittorgarh and Kumbhalgarh; Sanchi is in Madhya Pradesh.

Step 1: Match the sites to the listed locations Agra Fort is in Agra, Uttar Pradesh, so A matches II. Ellora Caves are near Aurangabad in Maharashtra, so B matches III. Chittorgarh and Kumbhalgarh are Rajasthan hill forts, so C matches I. The Buddhist monuments at Sanchi are in Madhya Pradesh, so D matches IV. Although the heading says State, entry I names two forts rather than a state; those names still identify the Rajasthan hill-fort group unambiguously.

Step 2: Test the full code against the options Combining the four matches gives A-II, B-III, C-I, D-IV, exactly option (A). Option (B) incorrectly pairs Agra with Chittorgarh and Kumbhalgarh and Ellora with Uttar Pradesh. Option (C) wrongly places Agra in Madhya Pradesh and the Rajasthan hill forts in Uttar Pradesh. Option (D) again mispairs Agra and Ellora, and also assigns the Rajasthan hill forts to Madhya Pradesh. Therefore none of the other codes preserves all four geographical associations.

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

Quick Tip to Solve: Start with the distinctive Ellora-Maharashtra and Sanchi-Madhya Pradesh pairs, then verify Agra and the Rajasthan forts.

86. "Jai Vigyan" slogan was given by which Prime Minister of India? [4 marks]

(A) Rajiv Gandhi

(B) Atal Bihari Vajpayee

(C) Narendra Modi

(D) H.D. Deve Gowda

Correct Answer: (B) Atal Bihari Vajpayee

Solution:

Concept:

- National slogans must be associated with the leader who introduced the particular wording. Similar slogans can be extensions of an earlier formulation rather than entirely separate phrases.
- Atal Bihari Vajpayee added "Jai Vigyan to the earlier slogan "Jai Jawan, Jai Kisan. Vigyan means science, highlighting the contribution of scientific progress to the nation.

Step 1: Identify the addition asked about The question singles out the words "Jai Vigyan, not the original phrase "Jai Jawan, Jai Kisan. The earlier phrase is associated with Lal Bahadur Shastri. Atal Bihari Vajpayee expanded it by adding "Jai Vigyan, stressing science alongside the soldier and the farmer. Keeping the original author and the author of the extension separate prevents a common confusion.

Step 2: Compare the named Prime Ministers Option (B), Atal Bihari Vajpayee, is the Prime Minister associated with this addition. Rajiv Gandhi is remembered for technology and telecommunications initiatives, but that association alone does not make him the originator of this slogan. Narendra Modi is associated with the later addition "Jai Anusandhan, meaning research, to the expanded formulation. H. D. Deve Gowda is not the Prime Minister credited with "Jai Vigyan. The exact phrase, rather than a general connection with science or agriculture, determines the answer.

Step 3: Conclusion The slogan "Jai Vigyan was given by Atal Bihari Vajpayee. Hence, the correct option is (B).

Quick Tip to Solve: Keep the sequence separate: Shastri gave Jai Jawan, Jai Kisan; Vajpayee added Jai Vigyan.

87. Given below are two statements:

Statement I : Planning Commission of India was launched in the year of 1952.

Statement II : From 1st January 2015, Planning Commission of India was replaced by NITI Ayog.

In the light of the 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:

- The Planning Commission was constituted in March 1950. Its establishment is distinct from the starting year of a Five-Year Plan or from the first general election.
- NITI Aayog, the National Institution for Transforming India, was established on 1 January 2015 as the institution replacing the Planning Commission. Evaluate each statement independently before selecting the truth combination.

Step 1: Evaluate Statement I Statement I claims that the Planning Commission was launched in 1952. The Commission was actually constituted on 15 March 1950, before the First Five-Year Plan began in 1951. Thus 1952 is not the establishment year, and Statement I is false. Do not confuse a planning institution with a plan period: the Commission existed to formulate and coordinate planning, while a Five-Year Plan covered a particular span of years.

Step 2: Evaluate Statement II and select the combination Statement II says that from 1 January 2015 the Planning Commission was replaced by NITI Aayog. This date and institutional transition are correct, so Statement II is true. We therefore require the false-true combination. Option (A) wrongly treats the first statement as true. Option (B) wrongly rejects the second. Option (C) reverses both truth values. Option (D) states exactly that Statement I is false and Statement II is true, and hence is the only matching alternative.

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

Quick Tip to Solve: Use the institutional dates: Planning Commission, 1950; NITI Aayog, 1 January 2015. Do not substitute a plan year.

88. GST was introduced as which amendment act? [4 marks]

(A) 100^{th}

(B) 101^{st}

(C) 102^{nd}

(D) 103^{rd}

Correct Answer: (B) 101^{st}

Solution:

Concept:

- The constitutional framework for the Goods and Services Tax was introduced by the Constitution (One Hundred and First Amendment) Act, 2016. The amendment number and the later commencement of GST are different facts.
- The amendment enabled a coordinated GST system involving the Union and the States and provided for the GST Council. Its Act number, rather than the number of the earlier Bill, is what the question asks.

Step 1: Identify the constitutional amendment GST required changes to the Constitution to create the necessary legislative and institutional framework. These changes were made through the 101st Constitutional Amendment Act, 2016. The framework includes GST legislative powers and the GST Council. The subsequent introduction of GST in July 2017 should not be mistaken for the year or ordinal number of the constitutional amendment.

Step 2: Eliminate the neighbouring amendment numbers Option (B), 101st, gives the correct amendment. The 100th Amendment concerned the India-Bangladesh land boundary arrangement, so option (A) does not identify GST. The 102nd Amendment gave constitutional status to the National Commission for Backward Classes, so option (C) concerns a different institution. The 103rd Amendment introduced the framework for reservation for economically weaker sections, so option (D) also concerns a separate subject. Matching the amendment to its specific purpose therefore leaves only 101st.

Step 3: Conclusion GST was introduced through the 101st Constitutional Amendment Act, 2016. Hence, the correct option is (B).

Quick Tip to Solve: Link GST with the 101st Amendment; keep the 2016 constitutional change separate from the July 2017 GST rollout.

89. Which of the following trade did the early enterpreneurs make a fortune ?

A. Textile trade

B. Trade in tea

C. Industries

D. China trade

E. Wooden

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

(A) A only

(B) B only

(C) D only

(D) C only

Correct Answer: (C) D only

Solution:

Concept:

- Early industrial entrepreneurs often accumulated trading capital before investing in factories. Their source of initial wealth must be distinguished from their later industrial activity.
- The China trade connected Indian merchants with a large overseas market. Earnings from this trade helped finance later enterprises in India.

Step 1: Identify the historical trade The question refers to the commercial background of early entrepreneurs rather than asking which industry eventually employed their capital. Indian merchants participated in the China trade, particularly the export of opium and the exchange of goods associated with the tea trade. Such overseas commerce provided substantial profits and enabled several merchant families to accumulate capital before expanding into industrial ventures.

Step 2: Map the statement to the answer code In the statement list, China trade is statement D. The options use letters in a second sense: option (C) reads D only. Therefore the statement letter D must not be confused with option (D), which actually selects statement C, Industries. Textile trade and tea trade are narrower alternatives and do not identify the named overseas trading connection asked for here. Industries describes the subsequent investment activity, rather than the trade through which the initial fortune was made. The unused statement E is also not the required historical answer.

Step 3: Conclusion The early entrepreneurs made their fortune in the China trade, statement D. Hence, the correct option is (C).

Quick Tip to Solve: For coded history questions, identify the correct statement first, then map its letter to the separate option letter.

90. Who gave the statement "Agriculture is the soul of India" ? [4 marks]

(A) Sardar Vallabhbhai Patel

(B) Jawaharlal Nehru

(C) Mahatma Gandhi

(D) Sarojini Naidu

Correct Answer: (C) Mahatma Gandhi

Solution:

Concept:

- Mahatma Gandhi placed villages, agriculture and rural livelihoods at the centre of his understanding of Indian society.
- An attribution question asks for the person associated with the quoted statement, rather than a leader who merely supported agricultural development.

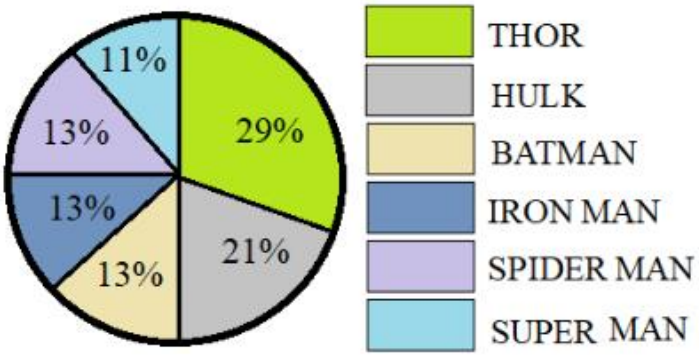
Step 1: Identify the idea expressed in the statement Calling agriculture the soul of India stresses its central place in the lives of rural communities and in the social and economic organisation of the country. The statement expresses the village-centred outlook associated with Mahatma Gandhi. His emphasis on rural livelihoods, village self-reliance and the dignity of manual work makes this attribution consistent with his wider thinking. The question requires the named speaker, so the answer should directly identify Gandhi without replacing the given statement by another quotation.

Step 2: Check the four names Mahatma Gandhi is listed as option (C). Sardar Vallabhbhai Patel was closely associated with peasant movements, but that association alone does not make him the attributed speaker here. Jawaharlal Nehru supported both agricultural progress and modern industrial development; his presence in the list is not evidence for the quotation. Sarojini Naidu was a poet and national leader, but she is not the person associated with this statement. Distinguishing a general connection with farming from the specific attribution avoids choosing a plausible but incorrect name.

Step 3: Conclusion The statement is attributed to Mahatma Gandhi. Hence, the correct option is (C).

Quick Tip to Solve: Connect this statement with Gandhi's emphasis on village life; do not choose solely because another leader led a peasant movement.

91. As per the following pie chart which super hero is the most popular hero? [4 marks]



(A) HULK

(B) SUPER MAN

(C) BAT MAN

(D) THOR

Correct Answer: (D) THOR

Solution:

Concept:

- In a pie chart, each sector represents a category's share of the same total. A larger percentage therefore means greater popularity in this survey.
- The legend connects each colour to a superhero. Identify the largest sector and then read its matching label; the position of a name in the legend does not determine its popularity.

Step 1: Match the sectors to the legend The bright green sector represents THOR and is labelled 29%. The grey sector represents HULK and is labelled 21%. BATMAN, IRON MAN and SPIDER MAN each have a 13% share, while SUPER MAN has 11%. These shares cover the whole chart:

$$29 + 21 + 13 + 13 + 13 + 11 = 100.$$

Step 2: Compare the popularity shares The largest percentage is 29%, belonging to THOR. It exceeds HULK's 21% by 8 percentage points and is also greater than every 13% and 11% sector. Hence no conversion to respondent counts or sector angles is needed to identify the maximum.

Step 3: Check the answer options Option (A), HULK, is the second largest share, so it is not the most popular. Option (B), SUPER MAN, has only 11%, the smallest share. Option (C), BAT MAN, has 13%, below both THOR and HULK. Option (D), THOR, is the only listed superhero with the largest sector. The three equal 13% shares produce a tie among those categories, but do not affect the unique maximum.

Step 4: Conclusion THOR is the most popular superhero, with 29% of the total. Hence, the correct option is (D).

Quick Tip to Solve: For a largest-share question, locate the highest percentage first and match its colour to the legend. Compare percentages directly; the total number of respondents is unnecessary.

92. Name of the ports which grew during the colonial period.

A. Bombay

B. Calcutta

C. Surat

D. Shillong

E. Kanpur

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

(A) A, C only

(B) A, B only

(C) A, D only

(D) A, E only

Correct Answer: (B) A, B only

Solution:

Concept:

- Colonial trade redirected economic activity towards major coastal ports controlled and developed by European trading powers.
- Bombay and Calcutta became major colonial commercial and administrative centres; older ports did not all share the same growth trajectory.

Step 1: Identify the expanding colonial ports Bombay on the western coast and Calcutta on the eastern side developed into major centres of overseas trade under British rule. Their harbours and trading networks connected the Indian hinterland with international markets. Colonial administrative functions, commercial establishments and transport links reinforced their importance. Thus statement A, Bombay, and statement B, Calcutta, fit the question about ports that grew during the colonial period.

Step 2: Exclude the remaining combinations Surat was an important older trading port, but its earlier prominence declined as colonial trade shifted towards centres such as Bombay. It should therefore not replace Calcutta in the selected pair. Shillong is an inland hill city, so it cannot be the relevant maritime port. Kanpur is also inland and became known as an industrial city rather than as a sea port. Option (A) wrongly includes Surat; option (C) wrongly includes Shillong; option (D) wrongly includes Kanpur. Only option (B) combines the two growing colonial port cities, A and B. The statement letters must be mapped to this option after checking the geography and historical trend.

Step 3: Conclusion The growing colonial ports were Bombay and Calcutta, statements A and B. Hence, the correct option is (B).

Quick Tip to Solve: Check both coastal location and colonial growth: being an old trading centre alone does not establish growth under colonial rule.

93. Given below are two statements : One is labelled as Assertion A and the other is labelled as Reason R

Assertion A : Ninteenth century indenture has been described as a 'new system of slavery'.

Reason R : New races of slaves were bought and encouraged to work far away from their home land.

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

(A) Both **A** and **R** are correct and **R** is the correct explanation of **A**

(B) Both **A** and **R** are correct but **R** is NOT the correct explanation of **A**

(C) **A** is correct but **R** is not correct

(D) **A** is not correct but **R** is correct

Correct Answer: (C) **A** is correct but **R** is not correct

Solution:

Concept:

- Indenture was a labour contract that bound a migrant worker to an employer for a specified period, often under coercive and exploitative conditions.
- Assertion-reason questions require the literal truth of each statement to be checked before deciding whether the reason explains the assertion.

Step 1: Evaluate Assertion A Assertion A is correct. Nineteenth-century indenture has been called a new system of slavery because workers faced deception in recruitment, harsh working conditions, restrictions on freedom and severe employer control. The comparison describes the coercive reality of their lives, despite the formal existence of labour contracts. It does not mean that the legal institution of slave ownership simply continued unchanged under another name.

Step 2: Evaluate Reason R literally Reason R is not correct as written. Indentured migrants were recruited as contracted labourers; the defining process was not the purchase of new races of slaves. Recruitment could be misleading or coercive, and workers were sent far from home, but those facts do not make the statement about buying slaves accurate. The distinction between a harsh contract-labour regime and legal chattel slavery is essential to interpreting the phrase new system of slavery.

Step 3: Select the logically matching option With A true and R false, the correct logical combination is option (C). The supplied question-sheet key selects (A), but that would require the assertion that new races of slaves were bought to be true. The printed wording does not support that claim, so the literal historical meaning leads to (C), rather than forcing agreement with the key.

Step 4: Conclusion A is correct but R is not correct. The supplied key accepts both statements, but the printed reason incorrectly describes indentured recruitment as buying slaves. Hence, the correct option is (C).

Quick Tip to Solve: In assertion-reason history questions, distinguish a comparison such as slavery-like conditions from the literal legal purchase of slaves.

94. Which of the following are included in basic services in a developing country

A. Water supply

B. Broad Band

C. Transport

D. Electricity [4 marks]

(A) A, B, C

(B) A, B, D

(C) B, C, D

(D) A, C, D

Correct Answer: (D) A, C, D

Solution:

Concept:

- Basic services provide essential infrastructure for health, everyday living and the functioning of economic activities.
- In the conventional infrastructure classification used here, water supply, transport and electricity form the required set.

Step 1: Identify the essential infrastructure items Water supply is a basic service because safe and reliable water is necessary for households, sanitation and public health. Transport is basic infrastructure because people and goods need access between homes, jobs, markets and public facilities. Electricity supports domestic needs, public services and productive activity. These are statements A, C and D respectively. They therefore form the complete required combination rather than three unrelated services.

Step 2: Compare each offered combination Broadband is an important communications service and can contribute strongly to development, but the question uses the conventional grouping of fundamental physical services. Each option that includes broadband leaves out one of the three listed essentials: option (A) omits electricity, option (B) omits transport and option (C) omits water supply. Option (D) retains water supply, transport and electricity together. This comparison identifies the intended answer without claiming that broadband has no value or cannot be treated as important infrastructure in contemporary policy. The task is to select the set matching the classification used by the question.

Step 3: Conclusion The required basic services are water supply, transport and electricity, statements A, C and D. Hence, the correct option is (D).

Quick Tip to Solve: For a combination question, inspect what each option leaves out; here every broadband combination drops an essential physical service.

95. The first garden city 'Letchworth' was designed by [4 marks]

(A) Clarence Perry

(B) Ebenezer Howard

(C) Raymond Unwin

(D) Patrick Geddes

Correct Answer: (C) Raymond Unwin

Solution:

Concept:

- Ebenezer Howard proposed the garden city idea: planned settlements combining the advantages of town and country.
- The originator of a planning concept and the professional who designs a particular town need not be the same person.

Step 1: Separate the concept from the town design Letchworth was the first garden city developed to put the garden city idea into practice. Ebenezer Howard supplied the influential planning vision and promoted the movement, but the question asks who designed Letchworth. Its physical planning and design are associated with Barry Parker and Raymond Unwin. Among the four names offered, Raymond Unwin is therefore the relevant designer. Recognising the collaboration does not change which listed option answers the question.

Step 2: Eliminate the other planning figures Clarence Perry is associated with the neighbourhood unit concept, so he is not the designer sought. Ebenezer Howard is the strongest distractor because of his central role in establishing the garden city movement; however, identifying the movement's theorist is different from identifying Letchworth's designer. Patrick Geddes is associated with regional planning and the survey-before-plan approach, rather than this design commission. Raymond Unwin is listed as option (C), and his design role fits the precise wording. Reading the verb designed avoids confusing proposal, promotion and implementation in planning history.

Step 3: Conclusion Letchworth was designed by Barry Parker and Raymond Unwin; the listed designer is Raymond Unwin. Hence, the correct option is (C).

Quick Tip to Solve: Remember Howard for the garden city concept and Parker with Unwin for Letchworth's physical design.

96. In case of residential apartments, the effective floor area available for use within an apartment is known as: [4 marks]

(A) Carpet area

(B) Built up area

(C) Plinth area

(D) Super built up area

Correct Answer: (A) Carpet area

Solution:

Concept:

- Carpet area denotes the effective usable floor area within an apartment, distinguished from measures that include walls or shared facilities.
- Built-up and plinth measures include the footprint occupied by the building fabric; super built-up area also allocates common building areas.

Step 1: Identify the usable internal area The decisive words are effective floor area available for use within an apartment. They refer to the interior space that occupants can actually use, rather than the larger area occupied by the structure or a share of common facilities. This is called carpet area. The name is a useful practical cue: it directs attention to usable internal floor space, rather than exterior wall thickness or common circulation outside the dwelling.

Step 2: Distinguish the larger area measures Built-up area adds the area occupied by walls and other covered components to the usable internal area. Plinth area is generally measured as the covered built-up area at floor level, so it also does not isolate only the usable apartment space. Super built-up area includes a proportionate share of common areas such as circulation spaces serving multiple apartments. Thus options (B), (C) and (D) describe broader measurements than the effective usable internal area asked for. These distinctions are about the basis of measurement, not simply alternative names for identical space. Since option (A) names carpet area, it is the precise match to the wording.

Step 3: Conclusion The effective usable floor area within an apartment is its carpet area. Hence, the correct option is (A).

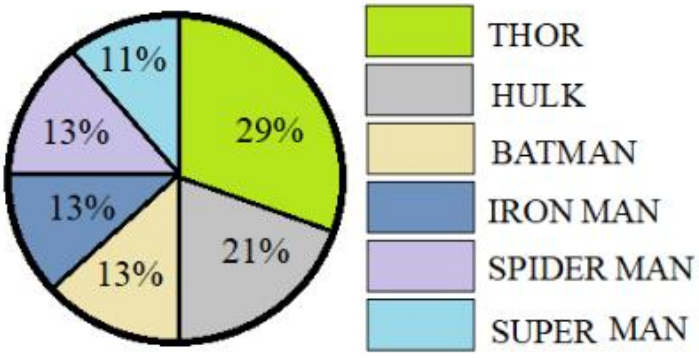
Quick Tip to Solve: Use the progression usable interior, then walls, then shared facilities to distinguish carpet, built-up and super built-up area.

97. The following pie chart gives us a picture of popularity of super hero. From this pie chart identify which of the following statement is/are correct.

A. Spider man is the most popular super hero

B. Iron man is the least popular super hero

C. Popurlity of Batman and Spider man are equal. [4 marks]



(A) A only

(B) B and A only

(C) C only

(D) A and C only

Correct Answer: (C) C only

Solution:

Concept:

- A pie chart divides the whole into sectors whose percentages give the relative sizes of the categories. The legend must be matched to the sector colours before comparing the figures.
- A statement about the most or least popular category requires comparison with every category; equal popularity requires equal percentages, not adjacent sectors.

Step 1: Read all six shares The chart gives Thor 29%, Hulk 21%, Batman 13%, Iron Man 13%, Spider Man 13%, and Super Man 11%. These sum to 100%, which checks that every sector has been included. Thor has the largest share, while Super Man has the smallest share.

Step 2: Test statements A and B Statement A says that Spider Man is the most popular. His share is only 13%, below both Thor and Hulk, so A is false. Statement B says that Iron Man is the least popular. His 13% is greater than Super Man's 11%, so B is also false. Sharing the same value as two other heroes does not make Iron Man the minimum.

Step 3: Test statement C and compare the options Batman and Spider Man each account for 13%. Their popularity is therefore equal, and statement C is true. Option (A) includes false statement A; option (B) includes false statements A and B; and option (D) includes false statement A along with true statement C. Only option (C) contains exactly the true statement.

Step 4: Conclusion Only statement C is correct: Batman and Spider Man have equal popularity, 13% each. Hence, the correct option is (C).

Quick Tip to Solve: Read the legend first, then list the maximum, minimum and equal percentages before testing a set of pie-chart statements.

98. Given below are two statements:

Statement I : America's civil war is responsible for cut off raw cotton from US.

Statement II : America's civil war is responsible for cut off crops that came from US.

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

(A) Both Statement I and Statement II are correct

(B) Both Statement I and Statement II are incorrect

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

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

Correct Answer: (C) Statement I is correct but Statement II is incorrect

Solution:

Concept:

- The American Civil War of 1861–1865 disrupted the supply of raw cotton from the southern United States, an important source for British textile mills.
- Distinguish the particular raw material whose supply was interrupted from a general claim about all crops exported by the United States. A statement about cotton does not establish the broader statement about crops.

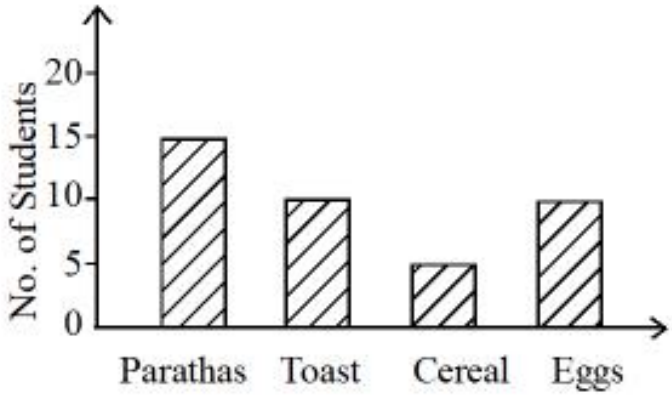
Step 1: Evaluate Statement I Before the Civil War, British cotton manufacturers relied heavily on cotton grown in the American South. Warfare, the blockade of southern ports and disruption of production interrupted this trade. Consequently, British manufacturers looked to other cotton-producing regions, including India, for their raw material. Thus the statement that the Civil War cut off raw cotton supplies from the United States describes the cotton shortage correctly; Statement I is correct.

Step 2: Evaluate Statement II and compare the choices Statement II changes the specific shortage of raw cotton into a general claim that crops coming from the United States were cut off. This is not the historical consequence being described: the cotton-producing South was particularly affected, while other American agricultural regions and crop trades did not all cease to supply the world. Therefore Statement II is incorrect. Option (A) incorrectly accepts that broader claim; option (B) wrongly rejects the cotton disruption; option (D) reverses the two truth values.

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

Quick Tip to Solve: For this event, remember the chain: American Civil War, shortage of southern cotton, and increased demand for cotton from alternative suppliers such as India.

99. The bar graph shows the preferred breakfast food for 40 students. The number of students who prefer parathas as a percentage of the total number of students is [4 marks]



(A) 25%

(B) 40%

(C) 37.5%

(D) 27.5%

Correct Answer: (C) 37.5%

Solution:

Concept:

- The height of a bar, read against the numbered vertical axis, gives the number of students in that category. Category labels on the horizontal axis identify which bar to read.
- The percentage of the whole belonging to a category is $\frac{\text{category count}}{\text{total count}} \times 100$. The denominator includes all students, not just those in another selected category.

Step 1: Read the paratha count The Parathas bar reaches the vertical-axis mark 15. Thus 15 students prefer parathas. The other bars give 10 for Toast, 5 for Cereal and 10 for Eggs. The check $15 + 10 + 5 + 10 = 40$ agrees with the total stated in the question, confirming the scale has been read correctly.

Step 2: Convert the fraction into a percentage Take the paratha count as the part and all 40 students as the whole. Then

$$\text{Percentage} = \frac{15}{40} \times 100 = \frac{3}{8} \times 100 = 37.5\%.$$

The count 15 is not itself a percentage: it must be related to the total. Equivalently, each student represents $100/40 = 2.5\%$, so 15 students represent $15 \times 2.5 = 37.5\%$.

Step 3: Check the alternatives Option (A), 25%, would correspond to 10 students; option (B), 40%, would correspond to 16 students; and option (D), 27.5%, would correspond to 11 students. None matches the Parathas bar. Option (C) alone gives the percentage of the observed 15 students.

Step 4: Conclusion The students who prefer parathas form 37.5% of the total. Hence, the correct option is (C).

Quick Tip to Solve: With a total of 40 students, each student is 2.5 percent of the class; multiply the selected bar height by 2.5.

100. Which city planning is related to Lutyens?

A. Chandigarh

B. Gandhinagar

C. New Delhi

D. Chennai

E. Kolkata

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

(A) A only

(B) C only

(C) D only

(D) E only

Correct Answer: (B) C only

Solution:

Concept:

- Edwin Lutyens is associated with the planning and architecture of New Delhi, the new imperial capital developed after the decision to shift the capital from Calcutta.
- Separate the letter assigned to a city in the question from the letter of the final answer option: city C is New Delhi, whereas answer option (B) reads "C only.

Step 1: Identify the city associated with Lutyens The decisive association is Edwin Lutyens and New Delhi. Lutyens, working with Herbert Baker, contributed to the monumental capital complex and its planned setting. The broad ceremonial axis, major government buildings and the layout of the central capital area are characteristic references for this association. Therefore city C in the list is the city required by the question. The question asks for the city associated with Lutyens, rather than for every architect or every stage in the development of that city.

Step 2: Eliminate the other cities and decode the option Chandigarh belongs to a different capital-planning project, associated especially with Le Corbusier and his team. Gandhinagar is another planned capital, associated with H. K. Mewada and Prakash Apte. Chennai and Kolkata are not the New Delhi capital-planning project associated with Lutyens. Thus A, B, D and E in the city list do not supply the requested association. The only selected city is C, and the answer option that states "C only is option (B), not option (C).

Step 3: Conclusion The city is New Delhi, labelled C in the city list. Hence, the correct option is (B).

Quick Tip to Solve: Resolve two-level options in two stages: first identify the city letter, then locate the answer option that contains that letter. Lutyens is the New Delhi association.

101. Given below are two statements:

Statement I : Fourth five year plan was launched in 1969 under the leadership of Indira Gandhi.

Statement II : Green revolution was an important aspect of third five year plan.

In the light of the 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 is correct but Statement II is false

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

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

Solution:

Concept:

- The Fourth Five Year Plan covered 1969–1974 and began during Indira Gandhi's tenure as Prime Minister.
- The Third Plan emphasized agriculture and self-sufficiency in food. Its intensive agricultural development and technological preparation are linked with the emergence of the Green Revolution; distinguish these foundations from the later spread of the programme.

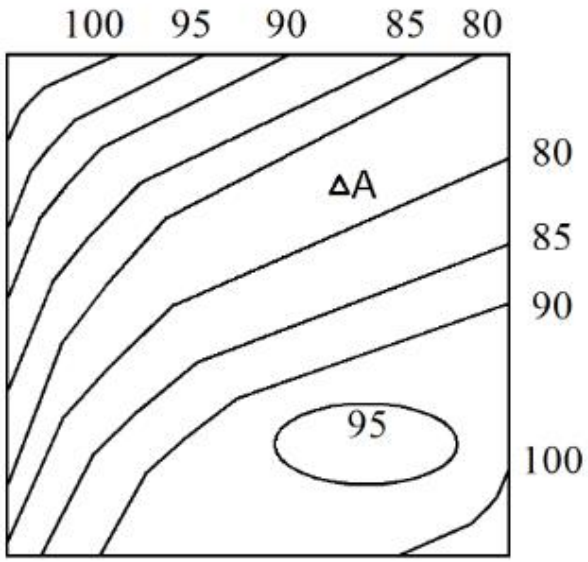
Step 1: Check the Fourth Plan statement The Fourth Five Year Plan started in 1969, after the intervening Annual Plans of 1966–1969. Indira Gandhi was Prime Minister at its launch. Its period is therefore 1969–1974, and both the year and the leadership given in Statement I are correct. Do not confuse the Fourth Plan with the Third Plan, which covered 1961–1966, or with the Annual Plans that separated the two. Statement I is true.

Step 2: Assess the agricultural statement and select the combination The Third Plan placed substantial importance on agriculture and the aim of making India self-sufficient in food production. Intensive cultivation, improved seeds, irrigation, fertilizers and associated agricultural development provided the groundwork for the Green Revolution. In this planning context, Statement II identifies an important agricultural aspect of that period. The widespread high-yielding-variety programme and its later achievements should not be read as having all occurred within the Third Plan itself. With Statement I true and Statement II true in the stated planning context, option (A) gives the required combination. Option (B) rejects both statements; options (C) and (D) each reject one statement incorrectly.

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

Quick Tip to Solve: Use the chronology Third Plan 1961–1966, Annual Plans 1966–1969, Fourth Plan 1969–1974; distinguish preparation for agricultural change from its later expansion.

102. In the given diagram the ΔA is located in a _____ [4 marks]



(A) Ridge

(B) Lake

(C) Plain Land

(D) Valley

Correct Answer: (D) Valley

Solution:

Concept:

- A contour line joins points at the same elevation. To identify a landform, compare the elevations on either side of the marked position rather than relying only on the slope of a drawn line.
- A valley is a strip of relatively low ground between higher ground; a ridge is the opposite, a strip of relatively high ground. Closely spaced contours indicate greater slope than widely spaced contours.

Step 1: Follow the labelled contours Across the upper edge of the diagram, the labels decrease from 100 through $95, 90, 85$ to 80. Down the right edge, the labels increase from 80 through $85, 90$ to 100. The marked point ΔA lies in the low central corridor associated with the 80 contours, rather than on either higher flank.

Step 2: Compare the ground on the two sides Moving from the corridor towards the upper-left side takes us towards contours of greater elevation. Moving from it towards the lower-right side likewise reaches successively higher contours. Thus the marked position is flanked by higher ground on both sides. This is the defining arrangement of a valley, whose low axis runs along the corridor.

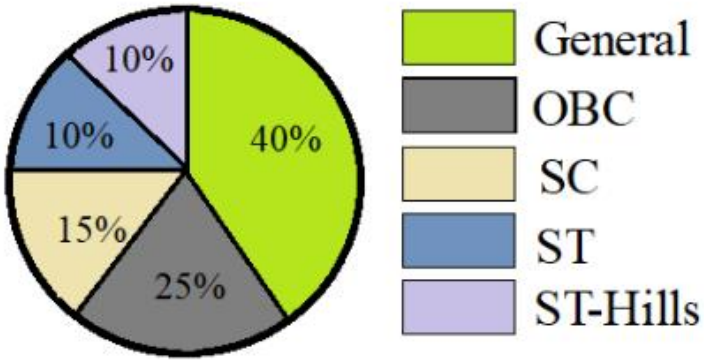
Step 3: Eliminate the other landforms A ridge would require the marked central strip to be higher than the ground on both sides, contradicting the labelled levels. A lake is not indicated by the map: there is no water boundary or water symbol around A, and low ground alone does not establish a lake. Plain land is also inappropriate because the surrounding sequence of elevation contours identifies a shaped relief feature. The valley interpretation fits both the contour values and their arrangement.

Step 4: Conclusion The point ΔA is located in a valley. Hence, the correct option is (D).

Quick Tip to Solve: For ridge-versus-valley questions, move across the marked strip: higher ground on both sides indicates a valley, while lower ground on both sides indicates a ridge.

103. In reference to the given pie chart. Two statements are given
statements I : The population of ST-hills is equal to SC category
statements II : The population of OBC category is lesser than combined population of SC & ST Hills.
In the light of the 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:

- The percentage shown in each pie-chart sector is the share of the total population for the category identified by the legend. Categories with similar names must still be read separately.
- For disjoint population categories, their combined percentage is the sum of their percentages. The phrase lesser than requires a strict inequality; equality does not satisfy it.

Step 1: Match the categories to their shares The chart shows General 40%, OBC 25%, SC 15%, ST 10%, and ST-Hills 10%. Their sum is 100%. In particular, ST-Hills is the separate 10% sector, and SC is the 15% sector; the two must not be confused.

Step 2: Evaluate statement I Statement I claims that the ST-Hills population equals the SC population. Both shares are measured against the same total, so equality of their populations would require equal percentages. Instead,

$$10\% \neq 15\%.$$

The ST-Hills share is smaller by 5 percentage points. Statement I is therefore false.

Step 3: Evaluate statement II The combined share of SC and ST-Hills is

$$15\% + 10\% = 25\%.$$

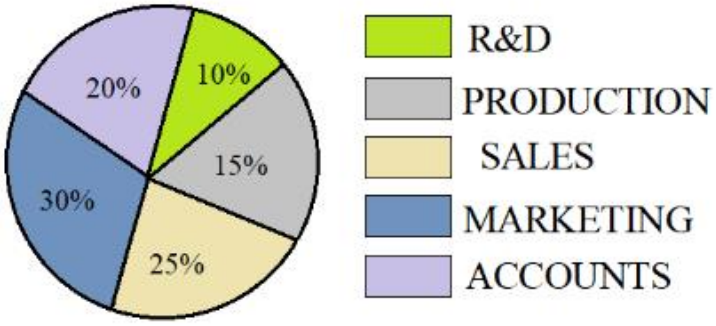
OBC also has a 25% share. The OBC population is therefore equal to the combined population, not

lesser than it. Statement II is false as well. Option (A) requires both statements to be true, and options (C) and (D) each require one to be true; all three contradict these comparisons.

Step 4: Conclusion Both statement I and statement II are false. Hence, the correct option is (B).

Quick Tip to Solve: Add only the categories named in a statement, and distinguish equality from a strict less-than comparison.

104. The given pie chart shows the division of employees in different department of a company where the total no. of employees is 3000. Find out the number of employees working in accounts and R & D department respectively. [4 marks]



(A) 600, 200

(B) 600, 300

(C) 900, 300

(D) 900, 200

Correct Answer: (B) 600, 300

Solution:

Concept:

- A pie-chart percentage can be converted to a number of employees by multiplying it by the total workforce: count $= \frac{\text{percentage}}{100} \times$ total.
- The chart legend associates each sector with its department. The word respectively means the requested department order must also be retained in the answer pair.

Step 1: Identify the two relevant sectors The Accounts sector is the lavender sector labelled 20%, while the R&D sector is the green sector labelled 10%. The remaining sectors are Production 15%, Sales 25%, and Marketing 30%. These percentages total 100%. In particular, the 30% sector belongs to Marketing, not Accounts.

Step 2: Calculate the Accounts workforce The total number of employees is 3000, and Accounts represents one fifth of that total. Therefore,

$$N_{\text{Accounts}} = \frac{20}{100} \times 3000 = 600.$$

Using the 30% Marketing sector instead would give 900, which is not the Accounts count.

Step 3: Calculate R and D and preserve the requested order R&D represents one tenth of the total workforce. Hence,

$$N_{\text{R\&D}} = \frac{10}{100} \times 3000 = 300.$$

The requested pair, Accounts first and R&D second, is $(600, 300)$. Option (A) has an incorrect R&D count; option (C) has an incorrect Accounts count; and option (D) has both counts incorrect. The value 200 would represent only $6\frac{2}{3}\%$ of 3000, not the printed 10%.

Step 4: Conclusion There are 600 employees in Accounts and 300 in R&D, respectively. Hence, the correct option is (B).

Quick Tip to Solve: For 3000 employees, each percentage point represents 30 employees; multiply the two chart percentages by 30, keeping their requested order.

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105. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R

Assertion A : In 20th century, handloom cloth production expanded steadily.

Reason R : This was partly reason of the technological changes.

In the light of the above statements, choose the correct answer from the options given below:

[4 marks]

(A) Both **A** and **R** are true and **R** is the correct explanation of **A**

(B) Both **A** and **R** are true but **R** is NOT the correct explanation of **A**

(C) **A** is true but **R** is false

(D) **A** is false but **R** is true

Correct Answer: (A) Both **A** and **R** are true and **R** is the correct explanation of **A**

Solution:

Concept:

- Industrialisation did not replace every form of hand production. Indian handloom weaving survived competition from mills and expanded during the twentieth century.
- Small technical improvements could raise the productivity of a hand-operated loom without turning it into a power loom. The fly shuttle is a key example of such an improvement.

Step 1: Evaluate Assertion A Assertion A describes the growth of handloom cloth production in the twentieth century. It is true in the historical context of the Indian textile industry. Although weavers faced competition from machine-made cloth, handloom production did not simply disappear. Weavers adapted their methods, and the output of the handloom sector expanded steadily. Do not confuse the growth of mills with the complete elimination of hand production: the two forms of production could coexist.

Step 2: Evaluate Reason R Reason R is also true. Technological changes helped handloom weavers improve output. For example, fitting looms with a fly shuttle allowed the shuttle to pass rapidly across

the loom and increased the speed of weaving. Such improvements raised productivity and reduced the labour required for weaving. They could be adopted on hand-operated looms, so technical progress was not confined to factories using powered machinery.

Step 3: Test whether the reason explains the assertion The reason identifies a cause of the expansion stated in A: better loom technology enabled weavers to produce cloth more efficiently. The wording says that technology was partly responsible; it does not claim that this was the only cause. Therefore R correctly explains A. Option (B) incorrectly denies this causal connection, option (C) incorrectly calls the technological explanation false, and option (D) incorrectly denies the expansion of handloom production.

Step 4: Conclusion Both Assertion A and Reason R are true, and Reason R is the correct explanation of Assertion A. Hence, the correct option is (A).

Quick Tip to Solve: Link the fly shuttle to higher handloom productivity. A technological improvement can strengthen hand production without converting it into factory production.