JEE Main 2024 Paper 2A (B.Arch) 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 2A (B.Arch.) 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 82 questions: Mathematics (30), Aptitude Test (50), Drawing Test (2), in that order. Maximum marks: 400.

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

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

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

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

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

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

1. 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 exists precisely when its radicand is non-negative. Both terms in a sum of square roots must be defined at the same input.
- The domain of the sum is the intersection of the individual domains; an endpoint is included when it makes a radicand zero.

Step 1: Restrict the first radicand The first square root requires $4 - x^2 \geq 0$. Thus $x^2 \leq 4$, giving the closed interval $[-2, 2]$. Values smaller than -2 or greater than 2 make this radicand negative, so they cannot enter the domain.

Step 2: Intersect with the second restriction The second square root requires $2 + x \geq 0$, or $x \geq -2$. Consequently the common domain is

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

Both endpoints are allowed: at -2 the two radicands are zero, and at 2 they are zero and four respectively.

Step 3: Evaluate the requested expression Comparing with $[a, b]$, take $a = -2$ and $b = 2$. Squaring removes the negative sign of the lower endpoint:

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

The alternatives 4, 8 and 12 fail to include both weighted 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: For a sum of radicals, intersect the radicand restrictions before reading off the endpoints.

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 map is one-one if equal outputs force equal inputs. It is onto if every element of its stated codomain has a preimage in the domain.
- Injectivity and surjectivity depend on the specified sets, so the same formula may behave differently over integers and real numbers.

Step 1: Check the two cubic maps For integers, $x^3 = y^3$ implies $x = y$, so f_1 is one-one. However, the integer 2 is not an integer cube, hence has no integer preimage. Therefore f_1 is not onto and (i) is true. Over the reals, every y has the real preimage $\sqrt[3]{y}$, and equality of cubes still gives equality of inputs. Thus f_2 is both one-one and onto, making (ii) true.

Step 2: Check the absolute-value and square maps For f_3, the different integers 1 and -1 both map to 1, so the map is not one-one. Each non-negative integer n is nevertheless the image of the integer n; hence it is onto W and (iii) is true. For f_4, 1 and -1 again have the same image. Moreover, the integer -1 is not a square of any integer. Thus this map is neither one-one nor onto, making (iv) true. Each remaining answer choice wrongly rejects one of these verified statements.

Step 3: Conclusion All four statements are true. Hence, the correct option is (B).

Quick Tip to Solve: To disprove injectivity use opposite inputs; to disprove surjectivity exhibit one codomain element missing from the range.

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:

- The radical symbol denotes the principal complex square root. For the two non-real conjugate inputs here, their principal roots are conjugates with positive real part.
- To identify a root $u + iv$, equate the real and imaginary parts in $(u + iv)^2 = (u^2 - v^2) + 2uvi$.

Step 1: Identify the principal square roots We have $(3 + 2i)^2 = 9 - 4 + 12i = 5 + 12i$. Its real part is positive, so it is the principal root. Similarly, $(3 - 2i)^2 = 5 - 12i$ and its real part is also positive. Therefore

$$\sqrt{5 + 12i} = 3 + 2i, \qquad \sqrt{5 - 12i} = 3 - 2i.$$

The negative roots also square to the same inputs but are not the principal values represented by the radicals.

Step 2: Simplify and compare real and imaginary parts The numerator is $(3 + 2i) + (3 - 2i) = 6$, while the denominator is $(3 + 2i) - (3 - 2i) = 4i$, which is nonzero. Thus

$$a + bi = \frac{6}{4i} = -\frac{3}{2}i.$$

It follows that $a = 0$, $b = -3/2$, and $a - b = 0 - (-3/2) = 3/2$. The fractions involving 5 do not equal this real number; 5 is a radicand component, not the resulting difference.

Step 3: Conclusion Here $a - b = \frac{3}{2}$. Hence, the correct option is (C).

Quick Tip to Solve: Check small integer complex roots by squaring, and use $1/i = -i$ before identifying the imaginary coefficient.

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 determinant can be $+50$ or -50; only $+50$, option (B), is listed, but its sign is not fixed by the data.

Solution:

Concept:

- For a square matrix of order n, $\det(\text{adj } A) = (\det A)^{n-1}$. For order three this determines the square of the determinant.
- A square equation with a nonzero positive right side has two real roots. No positivity condition on $\det A$ is included in the question.

Step 1: Calculate the adjugate determinant Let the displayed adjugate be B. 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 first row and third column does not contribute to this expansion because its complementary minor has a zero first column.

Step 2: Determine the magnitude and inspect the sign The order-three identity gives

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

This sign freedom is real: for a three by three matrix, $\text{adj}(-A) = \text{adj}(A)$, because every cofactor contains a two by two determinant. In contrast, $\det(-A) = -\det A$. Thus the supplied adjugate cannot distinguish the two signs. Values 25, 100 and 1000 have squares different from 2500. Of the listed values, only 50 satisfies the determinant identity, but the data alone do not require the positive sign.

Step 3: Conclusion The data determine $|\det A| = 50$, hence $\det A = \pm 50$. The listed admissible value is 50, option (B), but a unique signed determinant requires an additional condition.

Quick Tip to Solve: For odd order, the adjugate determinant gives an even power: retain both signs unless a separate condition fixes one.

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:

- Count appearances of a digit separately at each position. A number containing two copies of the digit contributes twice because the question asks for occurrences, not numbers.
- Leading zeroes may be used to make equal-length strings when counting a nonzero digit: these zeroes introduce no extra occurrences of 3.

Step 1: Use all three-digit strings Consider the integers 0 to 999 written as the strings 000 through 999. For an appearance of 3 in the units place, the hundreds and tens digits are arbitrary, giving $10 \times 10 = 100$ strings. The same argument gives 100 appearances in the tens place and 100 in the hundreds place. We count a number such as 333 three times, once for each position, exactly as required.

Step 2: Adjust the endpoints and add the counts Changing a string such as 003 to the ordinary integer 3 removes only zeroes, so the number of threes is unchanged. The extra integer 0 contributes no 3, and the integer 1000 likewise contributes none. Therefore the required interval 1 through 1000 has the same total as the strings 000 through 999:

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

Counting merely the numbers that contain at least one 3 would answer a different question and miss repeated occurrences. None of 297, 243 or 273 equals the three positional totals.

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

Quick Tip to Solve: For any nonzero digit in all strings of length three, each of the three positions contributes 10^2 occurrences.

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:

- The coefficient of x^{2k} in $(1+x^2)^{12}$ is $\binom{12}{k}$, for $0 \le k \le 12$; terms with negative exponents do not occur.
- To find a coefficient in a product, list every combination of exponents adding to the required exponent and sum its contributions.

Step 1: Expand the sparse factors The last two factors give

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

Their coefficients are all one. To produce x^{24}, these four terms would require exponents $24, 12, 0, -12$, respectively, from $(1+x^2)^{12}$. The last requirement is impossible in a polynomial, so the x^{36} term contributes nothing.

Step 2: Add the three surviving contributions Using the binomial theorem, exponent 24 corresponds to $2k=24$, so $k=12$ and its coefficient is $\binom{12}{12}=1$. Exponent 12 gives $k=6$ and coefficient $\binom{12}{6}$. The constant term gives $\binom{12}{0}=1$. Hence the required coefficient is

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

Keeping only the central coefficient misses the two endpoint contributions; adding three would incorrectly count the impossible negative-exponent case.

Step 3: Conclusion The coefficient is $\binom{12}{6}+2=926$. Hence, the correct option is (D).

Quick Tip to Solve: Expand sparse factors first, then match the complementary exponents in the binomial factor.

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 real logarithms take $a > 0$ and $b > 0$. The logarithm laws give $\ln(a^r/b^{r-1}) = r\ln a - (r-1)\ln b$.
- An arithmetic progression with first term u and common difference d has sum $S_n = \frac{n}{2}[2u+(n-1)d]$.

Step 1: Identify the progression The first terms are $\ln a$, $2\ln a - \ln b$, and $3\ln a - 2\ln b$. Subtracting consecutive terms always gives $\ln a - \ln b = \ln(a/b)$. Thus it is the logarithms themselves, rather than their arguments, that form an arithmetic progression. Its first term is $u = \ln a$, and its common difference is $d = \ln(a/b)$.

Step 2: Sum and rearrange the terms Substitute these quantities into the arithmetic-progression formula:

$$S_n = \frac{n}{2}\left[2\ln a + (n-1)\ln(a/b)\right].$$

Collecting the coefficients of the two logarithms gives

$$S_n = \frac{n}{2}\left[(n+1)\ln a - (n-1)\ln b\right].$$

Since $\ln(ab) = \ln a + \ln b$, this can also be written as

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

Step 3: Check the option forms The expression in (D) is exactly the last form. The negative product-logarithm terms in (A) and (B) give incorrect coefficients of $\ln a$ and $\ln b$. In (C), the coefficient of $\ln b$ is positive instead of negative for $n > 1$. As a direct check, $n = 1$ in (D) returns $\ln a$, the first term of the given series.

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

Quick Tip to Solve: Expand the logarithms first: a constant difference between their values turns this apparent product pattern into an A.P.

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:

- If the first term is a and common difference is d, the first n terms sum to $S_n = \frac{n}{2}[2a + (n-1)d]$.
- Two known partial sums produce two linear equations for a and d. Their difference eliminates the first term.

Step 1: Translate the given sums For ten terms, the sum condition reads

$$190 = \frac{10}{2}(2a + 9d), \qquad 2a + 9d = 38.$$

For twenty-six terms, it reads

$$1326 = \frac{26}{2}(2a + 25d), \qquad 2a + 25d = 102.$$

Dividing by the prefactors before solving keeps the arithmetic small and leaves the coefficient of a identical in both equations.

Step 2: Determine the progression Subtract the first reduced equation from the second:

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

Back-substitution gives

$$2a + 9(4) = 38, \qquad 2a = 2, \qquad a = 1.$$

Therefore the progression begins $1, 5, 9, 13, \ldots$. As a check, its tenth term is 37, so the first ten terms sum to $5(1 + 37) = 190$; its twenty-sixth term is 101, giving $13(1 + 101) = 1326$.

Step 3: Calculate the requested sum Using the same values for fifty terms,

$$S_{50} = \frac{50}{2}[2(1) + 49(4)] = 25(198) = 4950.$$

Equivalently, the fiftieth term is 197, and the average of the first and last terms is 99; multiplying by 50 again gives 4950. Thus (A), (B), and (D) fail the exact partial-sum formula for the progression fixed by the two given conditions.

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

Quick Tip to Solve: Divide each known sum by $n/2$ first; subtracting the resulting equations immediately isolates the common difference.

9. If $\lim_{x\to1}\frac{x^5-1}{x-1}=\lim_{x\to k}\frac{x^3-k^3}{x^2-k^2}$, 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:

- Factor a difference of powers to cancel the factor responsible for a removable $0/0$ form.
- A limit is evaluated for nearby x, so cancellation of $x-k$ is legitimate before substituting $x=k$.

Step 1: Evaluate the limit at one Factor the numerator as

$$x^5-1=(x-1)(x^4+x^3+x^2+x+1).$$

Therefore, for $x\neq1$, the quotient equals the polynomial in parentheses. Its limit is

$$\lim_{x\to1}\frac{x^5-1}{x-1}=1+1+1+1+1=5.$$

Direct substitution into the original quotient would produce an indeterminate expression, rather than the value of this limit.

Step 2: Evaluate the limit containing the parameter Using the difference-of-cubes and difference-of-squares factorizations gives

$$\frac{x^3-k^3}{x^2-k^2}=\frac{(x-k)(x^2+kx+k^2)}{(x-k)(x+k)}=\frac{x^2+kx+k^2}{x+k}.$$

If $k\neq0$, substitution after cancellation gives

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

The exceptional case $k=0$ gives the quotient x and limit zero, so cannot equal the left-hand limit of five.

Step 3: Equate the limits and compare The required equality is

$$5=\frac{3k}{2},\qquad k=\frac{10}{3}.$$

This nonzero value satisfies the condition used in evaluating the second limit. The candidates $5/3$, $7/3$, and $8/3$ would instead give second limits $5/2$, $7/2$, and 4, respectively, so none can equal five.

Step 4: Conclusion The parameter is $k=10/3$. Hence, the correct option is (D).

Quick Tip to Solve: Cancel the common linear factor before substituting, and check separately any parameter value that would make the remaining 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:

- A piecewise function is continuous at a joining point when its left limit, assigned value, and right limit coincide.
- Each displayed branch is continuous inside its interval. Only the joins $\pi/4$ and $\pi/2$ impose equations on a and b.

Step 1: Match the branches at the first join At $x=\pi/4$, the first branch approaches

$$\frac{\pi}{4}+\sqrt{2}a\sin(\pi/4)=\frac{\pi}{4}+a.$$

The second branch supplies the assigned value

$$2\left(\frac{\pi}{4}\right)\cot(\pi/4)+b=\frac{\pi}{2}+b.$$

Equality therefore gives

$$a-b=\frac{\pi}{4}.$$

The factor $\sqrt{2}$ in the first branch cancels against $\sin(\pi/4)=1/\sqrt{2}$.

Step 2: Match the branches at the second join At $x=\pi/2$, the middle branch has value b, since $\cot(\pi/2)=0$. The right-hand limit from the third branch is

$$a\cos\pi-b\sin(\pi/2)=-a-b.$$

Hence continuity requires

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

Substituting into the first relation gives

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

The endpoint branches are continuous from inside the domain, so no additional condition arises at zero or π.

Step 3: Evaluate the required combination Square the parameters before combining them:

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

The result is positive and exactly π^2, excluding zero, twice this value, and half this value in the other three options.

Step 4: Conclusion The required expression equals π^2. Hence, the correct option is (B).

Quick Tip to Solve: Write one continuity equation at each join; keep the signs of $\cos\pi = -1$ and the minus sign before $b\sin x$ separate.

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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:

- The identity $\sin^2 x + \cos^2 x = 1$ allows the reciprocal product to be decomposed into two standard integrands.
- The derivatives are $\frac{d}{dx}\tan x = \sec^2 x$ and $\frac{d}{dx}\cot x = -\operatorname{cosec}^2 x$.

Step 1: Separate the reciprocal product On an interval where both sine and cosine are nonzero, multiply the numerator one by its trigonometric identity:

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

Thus the integrand is $\sec^2 x + \operatorname{cosec}^2 x$. The original expression is undefined at multiples of $\pi/2$, so an antiderivative is understood on each interval avoiding those points.

Step 2: Integrate the standard terms Integrating term by term yields

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

The minus sign is essential because cotangent has a negative derivative. Differentiating the proposed answer returns

$$\frac{d}{dx}(\tan x - \cot x) = \sec^2 x + \operatorname{cosec}^2 x = \frac{1}{\sin^2 x \cos^2 x}.$$

Step 3: Eliminate the other antiderivatives The derivative of (A) is $\sec^2 x - \operatorname{cosec}^2 x$, which has the wrong sign. The square in (B) introduces a further factor $2(\tan x + \cot x)$ under differentiation. For

(D), evaluating its derivative at $x = \pi/4$ gives $12\sqrt{2}$, while the given integrand is 4. These checks exclude all alternatives to (C).

Step 4: Conclusion The integral is $\tan x - \cot x + C$, on every interval where the integrand is defined. Hence, the correct option is (C).

Quick Tip to Solve: Insert $1 = \sin^2 x + \cos^2 x$ into the numerator to convert a reciprocal product into two immediately integrable terms.

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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:

- A differential equation nonlinear in $y(x)$ can become linear when x is treated as a function of y.
- For $dx/dy + P(y)x = Q(y)$, an integrating factor is $\exp(\int P(y)\,dy)$, converting the left side into a product derivative.

Step 1: Reverse the dependent and independent variables For a nonzero solution on an interval where inversion is valid, the given equation becomes

$$\frac{dx}{dy} = \frac{x + 2y^3}{y} = \frac{x}{y} + 2y^2.$$

Rearrange it into linear form:

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

Attempting the usual linear-equation formula directly for $y(x)$ would leave the cubic term in its coefficient; reversing the variables removes that obstacle.

Step 2: Apply the integrating factor On an interval with $y \neq 0$, we can use the integrating factor $1/y$, since it is a constant multiple of $\exp(-\ln|y|)$ on either sign interval. Multiplying the equation gives

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

Integrate with respect to y:

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

Step 3: Verify the family and identify the option Differentiating $x = y^3 + Cy$ gives $dx/dy = 3y^2 + C$. The expression $x + 2y^3$ is $3y^3 + Cy = y(3y^2 + C)$, which verifies the original differential

equation wherever the implicit curve defines a differentiable $y(x)$. The other options have a quadratic dependence with the wrong variable or lack the necessary cubic term in $x(y)$. Also, the constant solution $y = 0$ satisfies the original equation separately; it was excluded when dividing by y and does not change the listed general-family choice.

Step 4: Conclusion The nonconstant general solution is $x = y(y^2 + C)$; $y = 0$ is an additional constant solution. Hence, the correct option is (C).

Quick Tip to Solve: When dy/dx is multiplied by an expression linear in x, try solving for dx/dy before choosing an integrating factor.

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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 centre of a circle $x^2 + y^2 + 2gx + 2fy + c = 0$ is $(-g, -f)$. Completing squares gives its centre and radius without requiring a diagram.
- The centre is the midpoint of every diameter. Thus, if $P = (x_1, y_1)$ and its opposite endpoint is $Q = (x_2, y_2)$, then $Q = 2C - P$.

Step 1: Locate the centre Compare the given equation with the general equation. Here $2g = -1$ and $2f = -4$, so the centre is $C = (1/2, 2)$. Equivalently, completing squares gives

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

The given point lies on the circle because substituting $(-1, 1)$ gives $1 + 1 + 1 - 4 + 1 = 0$.

Step 2: Reflect the endpoint in the centre Let the required point be $Q = (u, v)$. The midpoint of $P = (-1, 1)$ and Q must equal C, hence

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

Solving yields $u = 2$, $v = 3$. This uses the diameter condition, rather than merely finding any second point on the circle.

Step 3: Check the answer and alternatives For $(2, 3)$, the circle expression is $4 + 9 - 2 - 12 + 1 = 0$, and its midpoint with $(-1, 1)$ is exactly $(1/2, 2)$. The midpoints obtained from (A), (B) and (C) are respectively $(-3/2, 3)$, $(1/2, -2)$ and $(-1/2, 2)$; none is the centre. Thus none can be the opposite diameter endpoint.

Step 4: Conclusion The diametrically opposite point is $\boxed{(2,3)}$. Hence, the correct option is (D).

Quick Tip to Solve: Use opposite endpoint = twice the centre minus the given endpoint; checking the midpoint prevents sign errors.

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 sides themselves are altitudes, so the right-angle vertex is the orthocentre.
- The circumcentre of a right triangle is the midpoint of its hypotenuse, and the distance formula is $d = \sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$.

Step 1: Identify the right angle and orthocentre The side OA lies along the horizontal axis and OB along the vertical axis, so $OA \perp OB$. For the stated triangle, a and b are nonzero. The altitude from A is the horizontal line through A, namely OA, because it is perpendicular to OB. Similarly, the altitude from B is OB. Their intersection is $H = (0,0)$.

Step 2: Find the circumcentre The hypotenuse joins $A = (a,0)$ to $B = (0,b)$. Its midpoint is

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

This point is equidistant from all three vertices: each squared distance is $(a^2+b^2)/4$. It therefore is the circumcentre even when a coordinate is negative; no assumption that both coordinates are positive is required.

Step 3: Calculate and compare the distance Applying 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 sum and difference in (A) and (B) are not Euclidean lengths for general coordinates. The difference of squares in (D) can even be negative and does not follow from the distance formula. Only the sum of squared perpendicular components gives the required distance.

Step 4: Conclusion The distance is $\boxed{\frac{1}{2}\sqrt{a^2+b^2}}$. Hence, the correct option is (C).

Quick Tip to Solve: In a right triangle, identify the right-angle vertex as the orthocentre and halve the hypotenuse to obtain this distance.

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 lines through $\vec{p}$, $\vec{q}$ with nonparallel directions $\vec{u}$, $\vec{v}$, their shortest distance is $d = |(\vec{q} - \vec{p}) \cdot (\vec{u} \times \vec{v})|/|\vec{u} \times \vec{v}|$.
- The cross product gives a direction perpendicular to both lines. Projecting the displacement between any two base points onto this common normal removes all components along either line.

Step 1: Extract the vectors and common normal The base-point displacement and the direction vectors are

$$\vec{q} - \vec{p} = (3, 3, 3), \quad \vec{u} = (1, -3, 2), \quad \vec{v} = (2, 3, 1).$$

Calculate the cross product component by component:

$$\vec{u} \times \vec{v} = ((-3)(1) - 2(3),\ 2(2) - 1(1),\ 1(3) - (-3)(2)) = (-9, 3, 9).$$

It is nonzero, so the lines are not parallel and the skew-line distance formula applies.

Step 2: Evaluate the numerator and denominator The scalar triple product is

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

Its absolute value is 9. The length of the common normal is

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

The nonzero triple product also confirms that the two lines are not coplanar and therefore do not intersect.

Step 3: Simplify the distance and reject the other forms Thus

$$d = \frac{9}{3\sqrt{19}} = \frac{3}{\sqrt{19}} \text{ units.}$$

The denominator must be the magnitude of the cross product, not its square, so (A) is not the projection formula. Option (D) loses a factor of three in the numerator, while (B) does not equal the computed ratio. Reversing the cross-product order changes its sign but leaves this positive distance unchanged.

Step 4: Conclusion The shortest distance is $\boxed{3/\sqrt{19}}$ units. Hence, the correct option is (C).

Quick Tip to Solve: You may simplify the common normal to $(-3, 1, 3)$, but use that same vector in both the dot product and the denominator.

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 a nonzero vector $\vec{b}$ is $\text{proj}_{\vec{b}}\vec{a} = (\vec{a}\cdot\vec{b})\vec{b}/|\vec{b}|^2$. It is a vector parallel to the target direction.
- The scalar projection $(\vec{a}\cdot\vec{b})/|\vec{b}|$ is only a signed length. Multiplying it by the unit vector $\vec{b}/|\vec{b}|$ produces the required vector projection.

Step 1: Calculate the dot product and squared length Write the vectors as $\vec{a} = (1, -3, -3)$, $\vec{b} = (3, -4, 0)$. The missing $\hat{k}$ component of $\vec{b}$ is zero, so

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

The positive dot product shows that the projection points in the same sense as $\vec{b}$.

Step 2: Form the vector projection Substituting in the projection formula gives

$$\text{proj}_{\vec{b}}\vec{a} = \frac{15}{25}(3\hat{i} - 4\hat{j}) = \frac{9}{5}\hat{i} - \frac{12}{5}\hat{j}.$$

Its magnitude is 3, which agrees with the scalar projection $15/5$. Its $\hat{k}$ component is zero because the projected vector must lie along $\vec{b}$.

Step 3: Verify orthogonality and eliminate the alternatives The remaining component is $\vec{a} - \text{proj}_{\vec{b}}\vec{a} = (-4/5, -3/5, -3)$. Its dot product with $\vec{b}$ is $-12/5 + 12/5 = 0$, confirming the perpendicular decomposition. Option (B) has magnitude $5/\sqrt{19}$, not 3. Option (C) has a nonzero third component and is parallel to the wrong vector. Option (D) is parallel to $\vec{b}$ but is five times the required projection.

Step 4: Conclusion The projection vector is $\boxed{\frac{9}{5}\hat{i} - \frac{12}{5}\hat{j}}$. Hence, the correct option is (A).

Quick Tip to Solve: The denominator is the squared length of the target vector; also check that the residual vector is perpendicular to that target.

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 identity $|\vec{a} + \vec{b}|^2 = |\vec{a}|^2 + |\vec{b}|^2 + 2\vec{a} \cdot \vec{b}$ converts the length of a sum into the mutual dot product.
- A cross product is perpendicular to each of its factors. Consequently $(\vec{a} \times \vec{b}) \cdot \vec{b} = 0$, regardless of the coefficient multiplying the cross product.

Step 1: Recover the dot product The given vectors both have unit length and their sum has length $\sqrt{3}$. Squaring that length gives

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

This corresponds to an angle of 60°, since the dot product of two unit vectors is the cosine of their angle. The sum length is squared before expanding; using $\sqrt{3}$ directly would be incorrect.

Step 2: Isolate the required vector and take its dot product Rearrange the vector equation without changing the signs:

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

Taking the dot product with $\vec{b}$ and using distributivity yields

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

The last term is zero because its two vectors are perpendicular.

Step 3: Substitute and check the alternatives With $\vec{a} \cdot \vec{b} = 1/2$ and $|\vec{b}|^2 = 1$,

$$\vec{c} \cdot \vec{b} = \frac{1}{2} + 2(1) + 0 = \frac{5}{2}.$$

Option (B) includes only the contribution from $\vec{a}$, omitting $2\vec{b}$. Option (C) would result from an incorrect coefficient for that parallel contribution. Option (A) has the wrong sign and also omits the full positive contribution of $2\vec{b}$. The coefficient three of the perpendicular cross-product term has no effect on the answer.

Step 4: Conclusion The required scalar is $\boxed{5/2}$. Hence, the correct option is (D).

Quick Tip to Solve: When taking a dot product with one cross-product factor, discard that perpendicular cross-product term immediately.

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 $(A \cap B)' = A' \cup B'$. The probability of the complement of an event is one minus the probability of that event.
- The addition law $P(A \cup B) = P(A) + P(B) - P(A \cap B)$ holds without requiring the events to be independent or mutually exclusive.

Step 1: Find the intersection probability The given probability of $A' \cup B'$ is $3/4$. This union is the complement of $A \cap B$, not the complement of $A \cup B$. Therefore

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

This distinguishes the two different unions in the data and avoids interchanging union and intersection under complementation.

Step 2: Use the addition law Rearrange the union formula to obtain the sum of the individual event probabilities:

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

There is no need to determine $P(A)$ and $P(B)$ separately; their sum alone determines the requested expression. In particular, assuming $P(A) = P(B)$ is unnecessary.

Step 3: Calculate the sum of the complementary probabilities Apply the complement rule to each term:

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

A sum of two probabilities may exceed one; it is not itself the probability of a single union. Options (A) and (B) confuse other complements or intersections with the requested sum. Option (D) would subtract the union probability alone from two, failing to include the overlap correction.

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

Quick Tip to Solve: First turn the union of complements into an intersection probability, then use inclusion-exclusion to obtain the sum of the original 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:

- The angle-difference identities give exact values at $15^\circ = 45^\circ - 30^\circ$. In particular, $\sin(A-B) = \sin A\cos B - \cos A\sin B$, while $\cos(A-B) = \cos A\cos B + \sin A\sin B$.
- Secant and cosecant are reciprocals: $\sec\theta = 1/\cos\theta$ and $\mathrm{cosec}\,\theta = 1/\sin\theta$. Rationalising their denominators keeps the calculation exact.

Step 1: Find the exact sine and cosine Using the standard values at 30° and 45°,

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

Both values are positive, since the angle is acute. Taking reciprocals and multiplying numerator and denominator by the conjugate gives

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

For example, the product of the two conjugate denominators is $6-2=4$, cancelling the numerator 4.

Step 2: Substitute and simplify Insert the reciprocal values without changing the minus sign in the expression:

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

The $\sqrt{6}$ terms cancel exactly. Option (A) has the opposite sign. Options (B) and (C) have magnitude $3\sqrt{3}$, which is different because its square is 27 whereas $(4\sqrt{2})^2 = 32$. Thus only the negative value with magnitude $4\sqrt{2}$ fits.

Step 3: Conclusion The expression equals $\boxed{-4\sqrt{2}}$. Hence, the correct option is (D).

Quick Tip to Solve: Rationalise the secant and cosecant separately: their conjugate radical forms make the $\sqrt{6}$ terms cancel immediately.

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 value $\cot^{-1} t$ lies in $(0, \pi/2)$, and its tangent is $1/t$. The quadrant of a sum must be checked when identifying an inverse trigonometric value.
- The cotangent addition identity is $\cot(u+v) = (\cot u \cot v - 1)/(\cot u + \cot v)$. Apply it successively, keeping track of the actual sum of the positive acute angles.

Step 1: Combine the first two angles Put $u = \cot^{-1} 7$, $v = \cot^{-1} 8$, and $w = \cot^{-1} 5$. Their tangents are $1/7, 1/8, 1/5$, respectively. Therefore

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

To identify the branch, use $0 < \arctan t < t$ for $t > 0$. It yields

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

Thus the total is acute, and no multiple of π can be added to its final principal inverse-cotangent value.

Step 2: Include the third angle Apply the same identity to $(u+v)+w$:

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

Since the total lies in $(0, \pi/2)$, it follows uniquely that $u + v + w = \cot^{-1} 2$. The alternatives with arguments 10, 6 and 4 have cotangents 10, 6 and 4, rather than 2. Cotangent is strictly decreasing and hence one-to-one on this interval, so none of those alternatives can represent the same angle.

Step 3: Conclusion The sum is $\boxed{\cot^{-1} 2}$. Hence, the correct option is (A).

Quick Tip to Solve: Use the cotangent addition formula twice, but verify that the sum is acute before choosing the principal inverse value.

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 $t^2 = 6t + 2$. Multiplying this relation by a power of the root produces a recurrence without expanding large powers.
- For $a_n = \alpha^n - \beta^n$, subtract the power identities for the two roots. Before cancelling a term in a quotient, check that the denominator is nonzero.

Step 1: Obtain the recurrence For either root t, multiply $t^2 = 6t + 2$ by t^{n-2}, where $n \geq 3$. This gives

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

Writing this once for α and once for β, and subtracting, yields

$$\alpha^n - \beta^n = 6(\alpha^{n-1} - \beta^{n-1}) + 2(\alpha^{n-2} - \beta^{n-2}),$$
$$a_n = 6a_{n-1} + 2a_{n-2}.$$

This recurrence preserves the minus sign in the definition of a_n; no explicit calculation of the tenth powers is needed.

Step 2: Evaluate the requested quotient At $n = 10$, the recurrence reads

$$a_{10} = 6a_9 + 2a_8, \qquad a_{10} - 2a_8 = 6a_9.$$

The roots are $\alpha = 3 + \sqrt{11}$ and $\beta = 3 - \sqrt{11}$. Thus $\alpha > 0 > \beta$, so $a_9 = \alpha^9 - \beta^9 > 0$. Cancellation by a_9 is therefore valid, and

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

The result is a pure number. In particular, it depends on the coefficient 6 in the quadratic recurrence, rather than on the sizes of the individual powers.

Step 3: Conclusion The required numerical value is $\boxed{2}$.

Quick Tip to Solve: When roots of a quadratic appear to high powers, multiply their defining equation by a lower power and subtract to build a recurrence.

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:

- If α, β, γ are angles of a nondegenerate triangle, then $\alpha + \beta + \gamma = \pi$. All three sines are nonzero, so their cotangents and the divisions used below are defined.
- The identity $\sin^2 u - \sin^2 v = \sin(u+v)\sin(u-v)$ connects the third row to the first row. A determinant vanishes when one row is a linear combination of the others.

Step 1: Relate differences in the first and third rows Write $P = \sin\alpha \sin\beta \sin\gamma$. As $\alpha + \beta = \pi - \gamma$,

$$\sin^2\alpha - \sin^2\beta = \sin\gamma \sin(\alpha - \beta).$$

On the other hand,

$$\cot\alpha - \cot\beta = \frac{\cos\alpha\sin\beta - \cos\beta\sin\alpha}{\sin\alpha\sin\beta} = -\frac{\sin(\alpha-\beta)}{\sin\alpha\sin\beta}.$$

Consequently,

$$\sin^2\alpha - \sin^2\beta = -P(\cot\alpha - \cot\beta).$$

The same argument for β, γ gives the corresponding equality for that pair, including when two angles coincide.

Step 2: Use row dependence Rearranging the pairwise equalities shows that

$$\sin^2\alpha + P\cot\alpha = \sin^2\beta + P\cot\beta = \sin^2\gamma + P\cot\gamma = K,$$

where K is their common value. In the given determinant perform $R_3 \leftarrow R_3 + PR_1$. Adding a multiple of another row leaves its value unchanged. The third row then becomes (K, K, K), whereas the second row is $(1, 1, 1)$. Therefore $R_3 = KR_2$, so the transformed determinant, and hence the original determinant, is zero. This proof applies to every triangle, without assuming that it is equilateral or right-angled.

Step 3: Conclusion The determinant has value $\boxed{0}$.

Quick Tip to Solve: For triangle-angle determinants, compare differences of $\sin^2$ values with differences of cotangents to reveal dependent rows.

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 in $(u+v)^{21}$ is $T_{k+1}=\binom{21}{k}u^{21-k}v^k$, for $0\le k\le 21$. The term number is one greater than the exponent chosen from the second summand.
- Convert radicals into fractional exponents before collecting powers. Equal powers of a and b mean their exponents in the general term must be equal, not that either exponent must be zero.

Step 1: Write the general term using fractional powers The two summands in the bracket can be written as

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

Using the usual algebraic interpretation of these powers, the general term is

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

The binomial coefficient is independent of a and b, so it does not affect the equality of their powers.

Step 2: Equate exponents and recover the term number Set the two collected exponents equal:

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

Multiplying by 6 and simplifying gives

$$42-3k=-21+4k,\qquad 7k=63,\qquad k=9.$$

The value lies in the allowed range $0\le k\le 21$. Substitution checks that both exponents equal $5/2$, since $7-9/2=5/2$ and $-7/2+6=5/2$. Therefore the qualifying term is $T_{10}=\binom{21}{9}a^{5/2}b^{5/2}$. The requested r denotes the position of the term, so it is $k+1$, not k.

Step 3: Conclusion The term with equal powers is the tenth term, so $\boxed{r=10}$.

Quick Tip to Solve: Label the general term T_{k+1} first; after equating powers, add one to the solved index 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 $\frac{d}{dx}\tan^{-1} u(x) = \frac{u\prime(x)}{1+u(x)^2}$. Here $\tan^{-1}$ denotes the inverse tangent rather than a reciprocal.
- For $u_c(x) = 3x/(1+cx^2)$, the quotient rule differentiates numerator and denominator separately. Evaluate the resulting expression at the requested point before attempting any longer simplification.

Step 1: Differentiate a common rational form Both arguments of inverse tangent have the form

$$u_c(x) = \frac{3x}{1+cx^2},$$

with $c = 54$ or $c = 18$. Their denominators are positive for real x, so both functions are differentiable at zero. By the quotient rule,

$$\begin{aligned} u_c\prime(x) &= \frac{3(1+cx^2) - (3x)(2cx)}{(1+cx^2)^2} \\ &= \frac{3-3cx^2}{(1+cx^2)^2}. \end{aligned}$$

At $x = 0$, this yields $u_c(0) = 0$ and $u_c\prime(0) = 3$, independently of the constant c.

Step 2: Apply the chain rule to both summands The derivative of the full sum is

$$y\prime(x) = \frac{u_{54}\prime(x)}{1+u_{54}(x)^2} + \frac{u_{18}\prime(x)}{1+u_{18}(x)^2}.$$

Substitute the values just obtained:

$$y\prime(0) = \frac{3}{1+0^2} + \frac{3}{1+0^2} = 3+3 = 6.$$

The constants 54 and 18 occur only in terms containing x^2, so they do not change either contribution at zero. As a direct local check, each rational argument has leading term $3x$, and $\tan^{-1} t$ has derivative 1 at $t = 0$, giving the same total slope. No inverse-tangent addition identity or branch adjustment is necessary to compute this derivative.

Step 3: Conclusion The value of $\frac{dy}{dx}$ 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 that argument; evaluate locally to save algebra.

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 integral is linear: the integral of a sum equals the sum of the integrals. Each term $|x-a|$ changes its algebraic expression only at $x = a$.
- For $x < a$, $|x-a| = a - x$; for $x \geq a$, $|x-a| = x - a$. The area under each absolute-value graph is nonnegative.

Step 1: Split the integral into three simpler integrals On the interval $[1, 5]$, the first term is always $x - 1$, while the other terms change sign at 2 and 3. Therefore write

$$I = \int_1^5 (x-1)\,dx + \int_1^5 |x-2|\,dx + \int_1^5 |x-3|\,dx.$$

The endpoints 2 and 3 must be used where their respective absolute-value expressions change sign; removing all modulus signs at once would give an incorrect area.

Step 2: Evaluate each nonnegative contribution For the first term,

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

For the second term, split at 2:

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

Similarly, the third term splits at 3:

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

These values are also the areas of the relevant triangles, giving a direct check on the signs and limits.

Step 3: Combine the three integrals By linearity, all three contributions must be added, rather than averaged. Thus

$$I = I_1 + I_2 + I_3 = 8 + 5 + 4 = 17.$$

As a check, the original integrand equals $5 - x$ on $[1, 2]$, $x + 1$ on $[2, 3]$, and $3x - 6$ on $[3, 5]$; their integrals are $7/2$, $7/2$, and 10, again totalling 17.

Step 4: Conclusion The required definite integral is $\boxed{17}$.

Quick Tip to Solve: Integrate each modulus term separately; its contribution is the sum of triangle areas on either side of its zero.

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 $\frac{d}{dx}(y\sin x) = \sin x\,\frac{dy}{dx} + y\cos x$. Recognising this derivative avoids a lengthy integrating-factor calculation.
- After integration, use the specified value of the solution to determine the integration constant, then substitute the second argument and reduce the resulting fraction.

Step 1: Recognise and integrate the product derivative The entire left side is the derivative of $y\sin x$, so the given equation becomes

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

Integrating with respect to x gives

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

Step 2: Apply the specified initial value At $x = \pi/2$, the given solution value is zero and $\sin(\pi/2) = 1$. Substituting into the integrated relation,

$$0 = 2\left(\frac{\pi}{2}\right)^2 + C = \frac{\pi^2}{2} + C.$$

Consequently $C = -\pi^2/2$, and the required integrated expression is

$$y\sin x = 2x^2 - \frac{\pi^2}{2}.$$

Step 3: Evaluate the requested value and identify the integers Substitute $x = -\pi/6$, for which $\sin(-\pi/6) = -1/2$:

$$-\frac{y(-\pi/6)}{2} = 2\frac{\pi^2}{36} - \frac{\pi^2}{2} = -\frac{4\pi^2}{9}.$$

Hence

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

The integers 8 and 9 are coprime. Thus $\alpha = 8$, $\beta = 9$, and $\alpha + \beta = 17$.

Step 4: State the domain of the expression The formula $y = (2x^2 - \pi^2/2)/\sin x$ is defined only where $\sin x \neq 0$. The initial condition determines the solution branch on $(0, \pi)$. The calculation at $-\pi/6$ uses the same integrated expression, which gives the intended numerical answer. Strictly, no differentiable solution on one interval containing both arguments exists: at $x = 0$, the original equation requires $y(0) = 0$, whereas this expression diverges. Thus 17 is the intended formula-based answer; a regular solution cannot continue through zero.

Step 5: Conclusion With the same integrated expression evaluated at the requested argument, the intended answer gives $\alpha/\beta = 8/9$, so the requested value is $\boxed{17}$.

Quick Tip to Solve: Look for a product derivative before dividing by a trigonometric factor; here the two left-hand terms are exactly $(y\sin x)'$.

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:

- A line with intercepts a, b has equation $x/a + y/b = 1$. For $ax+by+c=0$, a normal vector is (a,b).
- The reflection of $P=(x_0,y_0)$ in that line is $P - 2\dfrac{ax_0+by_0+c}{a^2+b^2}(a,b)$. The midpoint of a point and its image lies on the mirror line.

Step 1: Write the line in standard form The intercepts are 2 on the x-axis and 1 on the y-axis. Thus

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

Take $a=1$, $b=2$, $c=-2$. For the point $P=(-1,-3)$, the signed expression in the line equation is

$$ax_0+by_0+c=-1+2(-3)-2=-9, \qquad a^2+b^2=5.$$

The negative value fixes the direction in which the point must move along the normal to reach the line.

Step 2: Calculate the image coordinates Applying the reflection formula to both coordinates,

$$x'=-1-2\frac{-9}{5}(1)=\frac{13}{5},$$
$$y'=-3-2\frac{-9}{5}(2)=\frac{21}{5}.$$

Both displacements use the same signed normal factor. Reflecting in the line requires twice the displacement to the perpendicular foot; using it only once would return the foot, not the image.

Step 3: Check the reflection and extract the sum The midpoint of the original point and its proposed image is

$$M=\left(\frac{-1+13/5}{2},\frac{-3+21/5}{2}\right)=\left(\frac{4}{5},\frac{3}{5}\right).$$

It satisfies $4/5+2(3/5)-2=0$, and the displacement vector $(18/5,36/5)$ is parallel to the normal $(1,2)$. Thus the image is correctly reflected. Comparing with $(\alpha/5,\beta/5)$ gives $\alpha=13$, $\beta=21$.

Step 4: Conclusion Therefore $\alpha+\beta=13+21=\boxed{34}$.

Quick Tip to Solve: Check a reflected point by verifying both facts: its midpoint with the original lies on the line, and their joining vector is normal to the line.

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 vector joining A to B is $\mathbf{v} = B - A$. A plane $ax + by + cz = k$ has normal vector $\mathbf{n} = (a, b, c)$.
- The squared length of the projection onto a plane is $d^2 = |\mathbf{v}|^2 - (\mathbf{v} \cdot \mathbf{n})^2/|\mathbf{n}|^2$, by resolving the vector into perpendicular in-plane and normal components.

Step 1: Find the segment vector and the plane normal Let $A = (1, 0, -1)$ and $B = (-1, 2, 2)$. The directed segment is

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

For the plane $x + 3y - 5z = 6$, use the normal

$$\mathbf{n} = (1, 3, -5), \qquad |\mathbf{n}|^2 = 1 + 9 + 25 = 35.$$

The constant 6 determines the plane's position, but not the length of the projection of a vector onto it; only the normal direction is relevant.

Step 2: Remove the normal component The scalar product is

$$\mathbf{v} \cdot \mathbf{n} = (-2)(1) + (2)(3) + (3)(-5) = -11.$$

Therefore the squared length of the component perpendicular to the plane is

$$\frac{(\mathbf{v} \cdot \mathbf{n})^2}{|\mathbf{n}|^2} = \frac{121}{35}.$$

The in-plane projection is perpendicular to this normal component. Applying Pythagoras to the two components gives

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

This is positive and less than 17, as a projection must be no longer than the original segment.

Step 3: Calculate the expression asked for The question requests $70d^2$, so there is no need to find the square root of $474/35$. Multiplying directly,

$$70d^2 = 70\left(\frac{474}{35}\right) = 2(474) = 948.$$

Using the squared projection throughout avoids rounding and also prevents confusion between projection onto the plane and projection onto its normal.

Step 4: Conclusion The requested value is $\boxed{948}$.

Quick Tip to Solve: For projection onto a plane, subtract the squared normal projection from the squared segment length; the dot product alone gives the normal component.

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:

- For unordered sampling without replacement, each pair has equal probability and the number of pairs from n balls is $\binom{n}{2}$.
- Partition the transfer into two white, one white and one red, and two red. The law of total probability weights the desired second-draw probability by each transfer probability.

Step 1: Find the probabilities of the three transfer cases The first bag contains 3 white and 4 red balls, so its total number of possible transferred pairs is $\binom{7}{2} = 21$. Thus

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

These events are disjoint and exhaustive, and their probabilities sum to 1. The mixed transfer is counted by selecting one ball of each colour; there is no extra ordering factor for an unordered pair.

Step 2: Find the conditional probability after each transfer The second bag starts with 4 white and 3 red balls. After any transfer it has 9 balls, so there are $\binom{9}{2} = 36$ equally likely pairs. The desired pair has one ball of each colour:

$$P(\text{mixed} \mid WW) = \frac{6 \cdot 3}{36} = \frac{1}{2},$$
$$P(\text{mixed} \mid WR) = \frac{5 \cdot 4}{36} = \frac{5}{9},$$
$$P(\text{mixed} \mid RR) = \frac{4 \cdot 5}{36} = \frac{5}{9}.$$

The denominator is 36 in every case, while the numerator changes with the colour composition produced by the transfer.

Step 3: Combine and reduce the probability Weighting by the transfer probabilities gives

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

Since 23 is prime and does not divide 42, the fraction is in simplest form. Hence $x = 23$, $y = 42$, giving $2x - y = 46 - 42 = 4$.

Step 4: Conclusion The probability is $23/42$, and the required value is $\boxed{4}$.

Quick Tip to Solve: Condition on the transferred colour pair first; use the same second-bag pair denominator in all three cases, then weight and add.

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:

- In a triangle, $A + B + C = \pi$. Here $A = \pi/2$, so the half-angles satisfy $B/2 + C/2 = \pi/4$.
- For roots u, v of $ax^2 + dx + e = 0$, Vieta's relations give $u + v = -d/a$ and $uv = e/a$. The tangent addition identity relates their sum and product.

Step 1: Relate the two half-angle tangents Set

$$u = \tan\frac{B}{2}, \qquad v = \tan\frac{C}{2}.$$

Since the triangle is right angled at A, the sum of these two half-angles is $\pi/4$. Applying the tangent addition formula,

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

Both half-angles lie strictly between 0 and $\pi/4$, so their tangents are positive and less than 1. In particular, $1 - uv$ is positive and the denominator does not vanish.

Step 2: Use the coefficients of the quadratic The roots are specified to satisfy $2x^2 - bx - c = 0$. Comparing with the usual quadratic coefficients gives

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

The minus sign in the constant term is essential: the product is $-c/2$, not $c/2$. Substituting these values into the tangent relation yields

$$1 = \frac{b/2}{1 + c/2} = \frac{b}{2+c}.$$

The denominator is nonzero because it equals $2(1 - uv)$.

Step 3: Eliminate the unnecessary coefficients Multiplication by $2 + c$ gives

$$b = 2 + c, \qquad b - c = 2.$$

The individual values of b and c depend on the particular acute angles, but their difference is fixed by the right-angle condition. Therefore the expression in the question is determined without solving the quadratic or finding either angle:

$$(b-c)^3 = 2^3 = 8.$$

Step 4: Conclusion The required value is $\boxed{8}$.

Quick Tip to Solve: When half-angle tangents are quadratic roots, apply tangent addition and Vieta together; their sum and product often eliminate both angles.

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 purity or intensity of a colour: highly saturated colours look vivid and brilliant, while low-saturation colours look dull or greyed.
- Hue identifies the colour family, value describes lightness or darkness, and saturation describes its strength. These are distinct attributes.

Step 1: Identify the attribute being tested Imagine two samples having the same hue and approximately the same lightness. A pure, intense red looks more vivid than a greyish red. The difference is saturation, so the term sought concerns the brilliance or vividness of a colour rather than its position or temperature.

Step 2: Compare all four descriptions Distribution describes where colours occur in a composition and how much area they occupy; it does not measure their purity. Darkness belongs to value or lightness. Warmth describes the warm-cool association of hues such as orange and blue. Brilliance is the description among the options that corresponds to intensity and purity, so it is the appropriate match.

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

Quick Tip to Solve: Separate the three attributes: hue is the colour name, value is light or dark, and saturation is vivid or dull.

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:

- A shell or surface structure encloses space with a comparatively thin surface, rather than with a massive load-bearing wall. Its overall shape is central to its structural action.

- In broad architectural aptitude classifications, a dome-like lightweight surface enclosure is contrasted with a framed building or a tall braced tower.

Step 1: Identify the surface enclosure The Millennium Dome is a large dome-shaped enclosure whose lightweight roof covers a wide uninterrupted space. It is the surface-enclosure example intended by this list. In precise structural terminology its roof is a tensioned fabric membrane supported by cables and masts; it should not be described as a rigid concrete shell carrying compression.

Step 2: Distinguish the other structural examples Stansted airport is recognised for its modular roof supported by tree-like steel structural units. The Bank of China Tower is a tall braced structural frame. The Louvre Museum alternative does not identify a comparable dome or shell enclosure; its famous entrance pyramid is a glazed framed structure. Thus the dome is the matching answer under the broad classification used by the question.

Step 3: Conclusion The intended shell or surface-enclosure example is the Millennium Dome. Hence, the correct option is (A).

Quick Tip to Solve: Recognise the structural family, but distinguish a rigid shell from a tensioned membrane when a question asks for the precise load-carrying system.

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:

- Building materials can be identified from their characteristic surface texture and the form in which they are supplied. Wood commonly shows elongated grain lines and curved patterns around knots.
- A plank is a relatively long, flat piece of timber. Its rectangular outline alone is not decisive, since tiles and stone slabs can also be rectangular; the surface grain provides the stronger clue.

Step 1: Identify the visible grain pattern The figure shows a long, narrow rectangular piece containing several curved and elongated lines. These lines follow the length of the piece and bend around rounded knot-like features. Such a pattern represents the natural grain of timber, including the irregular growth pattern around knots. It is not a regular geometric decoration or a granular stone texture. The combination of the elongated piece and its wood-grain markings identifies the material as a wooden plank.

Step 2: Compare all four material choices A tile is generally represented as a thin manufactured unit with a plain, glazed or deliberately patterned face; it is not identified by natural timber grain. A paving block is a compact unit for paving, commonly shown through its solid profile or interlocking shape, rather than longitudinal grain. Granite is a stone whose characteristic visual texture is formed by mineral grains or speckles, unlike the sweeping lines and knots in this figure. Wooden plank is therefore the choice supported by both the shape and the illustrated surface texture.

Step 3: Conclusion The natural grain lines and knot patterns show that the building material is a wooden plank. Hence, the correct option is (C).

Quick Tip to Solve: In material-identification sketches, inspect surface texture before relying on the outline: long grain lines with knots suggest timber, whereas a speckled mineral texture suggests 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 must adhere firmly to its background; surface preparation provides a mechanical key so the fresh mortar grips the wall.
- A sound, clean, suitably rough and appropriately damp background supports adhesion; polishing or smoothing the background reduces the mechanical key.

Step 1: Relate texture to adhesion Fresh plaster is spread as a layer over masonry or another prepared background. A rough texture provides small irregularities into which the plaster can enter, creating mechanical interlock after setting. This helps resist separation of the plaster from the backing. The

relevant choice therefore describes a texture that improves grip, rather than the final appearance of the plastered face.

Step 2: Eliminate unsuitable preparations A polished background is deliberately made very smooth and offers little key. A smooth background similarly reduces mechanical interlock unless it receives an appropriate treatment. Simply describing the background as cemented does not establish that it is clean, sound or rough enough for adhesion. Rough is the direct and relevant condition among the four options. Dust and loose particles should also be removed and suction controlled before plastering.

Step 3: Conclusion Before plastering, the surface should be rough to provide a good key. Hence, the correct option is (D).

Quick Tip to Solve: Distinguish the rough background needed for adhesion from the smooth finish that may be produced on the completed plaster.

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 connect a landmark to its original designer; identifying the correct architect is different from naming the engineer, builder or a later contributor.
- The Sydney Opera House is associated with Danish architect Jorn Utzon and its distinctive sculptural roof forms.

Step 1: Recall the landmark and its designer The Sydney Opera House stands on Bennelong Point in Sydney and is widely recognised for its expressive curved roof forms. Jorn Utzon won the international design competition for the project, and the building is identified with his architectural design. This direct architect-building association selects the first name in the list.

Step 2: Distinguish the alternative names Jan Gehl is known especially for human-centred urban design and public spaces, rather than the design of this opera house. Bjarke Ingels belongs to a later generation of Danish architects and is not its designer. Henning Larsen, spelled Lorsen in the option, is another Danish architect but is not the architect associated with this project. Sharing a nationality or profession does not make these alternatives interchangeable.

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

Quick Tip to Solve: Learn landmark-architect pairs as complete associations; several options may be architects from the same country.

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:

- Touch reveals texture and the physical boundaries of an object. Texture concerns surface qualities such as roughness, smoothness or softness.
- Shape is the outline or boundary of an object, while form refers to its three-dimensional volume. Both can be explored through tactile perception.

Step 1: Identify the directly tactile attributes Running a hand over a surface reveals its texture. Exploring its boundary conveys shape, and handling the object conveys its volume or form. Texture, shape and form therefore constitute the grouping most directly connected with the sense of touch. This is especially clear when imagining identifying an object with the eyes closed.

Step 2: Compare the groups in the options Pattern means an arrangement or repetition of elements. A pattern can sometimes be embossed and therefore felt, but it can also be entirely visual, such as printed colour motifs on a smooth surface. It is not inherently tactile. Options (A), (C) and (D) all include pattern and omit one member of the direct tactile grouping. Option (B) includes texture, shape and form together, so it best matches the question. The distinction concerns the design elements themselves, not whether a particular patterned object might also have relief.

Step 3: Conclusion The elements are texture, shape and form. Hence, the correct option is (B).

Quick Tip to Solve: Use the eyes-closed test: surface feel gives texture, the boundary gives shape, and volume gives 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 the United Nations observance devoted to environmental awareness and action. The date of the observance is 5 June.
- The establishment of an observance and its first celebration need not occur in the same year. Here

the question asks for the first celebration.

Step 1: Identify the first observance The first World Environment Day was celebrated on 5 June 1973. Its theme was "Only One Earth, linking the observance with the international discussion of environmental protection that followed the 1972 Stockholm Conference. The requested year is therefore 1973, rather than the year in which that conference took place.

Step 2: Compare the listed years Option (A) gives 1973 and matches the first celebration. The years 1976 and 1978 in options (B) and (C) are later than the first observance. The year 1970 in option (D) predates this United Nations observance and is associated with the first Earth Day, a different environmental event. Distinguishing World Environment Day from Earth Day removes the most plausible date confusion.

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

Quick Tip to Solve: Pair World Environment Day with 5 June 1973; keep it distinct from Earth Day on 22 April.

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:

- A rock-cut religious monument can be identified by its principal deity and the iconography of its sculptures.
- The main Hindu cave at Elephanta is a Shaiva sanctuary: Shiva is the central religious subject.

Step 1: Identify the principal deity The Elephanta Caves near Mumbai are especially associated with Shiva. The great three-headed representation of Shiva, commonly called the Trimurti or Maheshmurti, is a distinctive feature of the main cave. Its other Shaiva sculptural panels reinforce this identification, so the answer follows from the monument's central iconography rather than its geographical location.

Step 2: Eliminate the other dedications Buddha, written as "Budha in option (A), belongs to the Buddhist tradition; this is not the principal dedication meant by the question. Tirthankar Mahavir in option (B) belongs to Jainism. Vishnu in option (D) is another Hindu deity, but does not identify the celebrated main sanctuary at Elephanta. Although a cave complex can contain remains from more than one religious tradition, the usual architectural-awareness identification of Elephanta is its Shiva caves.

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

Quick Tip to Solve: Recognise Elephanta by its monumental three-headed Shiva sculpture and its Shaiva rock-cut sanctuary.

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:

- Named city models describe a recognisable planning idea, such as a city organised around green belts or along a transport corridor.
- Garden City, Linear City and Radiant City are established concepts in the history of modern urban planning.

Step 1: Recognise the established models Garden City is associated with Ebenezer Howard and combines planned settlement with open space and a surrounding green belt. Linear City organises development along a principal line or corridor, especially a transport route, and is associated with Arturo Soria y Mata. These are recognised city-planning models, so options (A) and (B) cannot be the requested exception.

Step 2: Find the exception Radiant City is the English name for Le Corbusier's Ville Radieuse, a modernist planning proposal involving ordered functional zones and tall buildings with open space. Thus option (C) also names an established city model. "Stack City in option (D) does not name a corresponding standard historical city type in this list. Vertical stacking can describe a design strategy, but that descriptive expression does not put this option among the three recognised named models.

Step 3: Conclusion Stack City is the exception among the listed standard city types. Hence, the correct option is (D).

Quick Tip to Solve: Match the recognised models first: Garden–Howard, Linear–Soria y Mata, and Radiant–Le Corbusier.

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 monument can be recognised from its overall architectural form as well as its material and ornament.
- The Konark Sun Temple in Odisha represents the chariot of the Sun god, with carved stone wheels and sculptural decoration.

Step 1: Use the chariot clue The decisive words are "gigantic chariot and "elaborately carved stone wheels. The Konark Sun Temple was conceived as the monumental stone chariot of Surya, the Sun god. Its large carved wheels form part of the architectural composition rather than being movable vehicle wheels. The chariot symbolism makes this description much more specific than a general reference to decorated temple pillars or walls.

Step 2: Check the alternative monuments The Golden Temple at Amritsar is recognised by its gilded shrine and sacred pool, rather than a stone chariot composition. The Meenakshi Temple at Madurai is famous for its tall, richly sculpted gateway towers or gopurams. The Dilwara temples near Mount Abu are Jain temples celebrated for intricate marble carving. Although these monuments also have impressive decoration, none matches the stated chariot-and-wheels identification as directly as Konark.

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

Quick Tip to Solve: In monument-identification questions, carved chariot wheels point to Konark and its dedication to Surya.

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:

- A monument's patron must be identified for the stated location; buildings with the same name may belong to different rulers.

- The Moti Masjid inside the Red Fort at Delhi was commissioned by the Mughal emperor Aurangzeb.

Step 1: Keep the location explicit The question specifies the Moti Masjid in the Red Fort at Delhi. This small white-marble mosque, also known as the Pearl Mosque, was built for Aurangzeb. The location is essential: the name Moti Masjid is also used for a mosque in Agra Fort, associated with Shah Jahan. Confusing these two mosques would lead to the wrong ruler even though the monument name sounds familiar.

Step 2: Compare the four patrons Aurangzeb in option (B) is therefore the correct patron. Shah Jahan in option (A) built the Red Fort complex, but that fact does not make him the builder of every later addition within it. Qutub-Ud-Din Aibak in option (C) belongs to the much earlier Delhi Sultanate period. Akbar in option (D) was also an earlier Mughal ruler and is not the patron of this mosque. The specific building and its later addition to the fort decide the answer.

Step 3: Conclusion Aurangzeb built the Moti Masjid in the Red Fort at Delhi. Hence, the correct option is (B).

Quick Tip to Solve: Separate the two Pearl Mosques: Delhi Red Fort–Aurangzeb; Agra Fort–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 fine droplets and directs the spray onto a surface.
- Unlike a brush or roller, the applicator does not need to touch the substrate; coating is transferred across the intervening air.

Step 1: Identify the defining action A spray gun or aerosol nozzle breaks paint into droplets and projects them onto the surface. The operator keeps the nozzle at a suitable distance and moves it steadily so that the spray overlaps evenly. Consequently paint can be deposited without a brush, roller or other applicator making mechanical contact with the surface. This is the distinguishing method described by option (C).

Step 2: Distinguish possible effects from the method A textured finish can be produced with suitable materials or techniques, but texture is not the necessary purpose of every spray application; smooth finishes are also common. Reaching a high area depends on access equipment and the spraying arrangement, so option (B) is not the definition. Spray painting is normally controlled to produce thin, even coats rather than simply to apply a large amount of paint. Thus option (D) also fails to describe the defining advantage of this application method.

Step 3: 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: spray droplets cross an air gap, unlike a brush or roller.

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 powered staircase that carries people continuously between different floor levels.
- The appearance of a circulation element depends on its walking surface: steps distinguish a stair from a continuous inclined ramp.

Step 1: Identify the visible form An escalator has a succession of horizontal treads separated by risers. The steps travel on a continuous mechanism, but their exposed upper flight retains the stepped profile of a staircase. Handrails move alongside the steps to assist the users. Therefore, when the question asks what it looks like, the relevant comparison is with a staircase rather than with the machinery that drives it.

Step 2: Compare the alternatives A ladder has separated rungs and normally requires the user to climb using both hands and feet; that is not the escalator form. A ramp provides one continuous inclined surface rather than individual steps. A lift carries passengers in a car or platform moving between levels, so it does not present a visible flight of stairs. Option (B), stair case, alone describes the escalator's characteristic stepped appearance.

Step 3: Conclusion An escalator looks like a staircase. Hence, the correct option is (B).

Quick Tip to Solve: Look for treads and risers: moving steps indicate an escalator; a continuous inclined belt resembles a ramp.

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 cement binder, fine aggregate, coarse aggregate and water.
- Fine aggregate is generally sand; coarse aggregate is generally gravel or crushed stone. Cement paste binds the aggregate particles as it hardens.

Step 1: List the essential constituents Water reacts with cement through hydration to form the binding paste. Fine aggregate fills spaces between larger particles, while coarse aggregate provides the larger pieces in the mixture. All four classes of constituent must therefore appear in the standard description of concrete. Cement is the binder within concrete; the terms cement and concrete are not interchangeable.

Step 2: Eliminate incomplete descriptions Cement, sand and water in option (A) describe cement mortar, since coarse aggregate is absent. Option (C) omits the fine aggregate and substitutes brick bats for the complete aggregate description. Option (D) names brick bats rather than the standard general coarse-aggregate component. Brick fragments may be used in specialised mixes, but they do not define ordinary concrete. Option (B) explicitly includes cement, coarse aggregate, fine aggregate and water, and is the complete standard answer.

Step 3: Conclusion Concrete is a mixture of cement, coarse aggregate, fine aggregate and water. Hence, the correct option is (B).

Quick Tip to Solve: Distinguish mortar from concrete by checking for coarse aggregate: cement, sand and water alone form mortar.

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:

- Wooden floor tiles provide a comparatively warm, comfortable surface and can form part of a resilient flooring system.

- Floor finishes are selected for the intended activity and indoor environment. Timber flooring is conventionally associated with conditioned interiors and gymnasiums.

Step 1: Identify the conventional flooring application The question asks for a material commonly specified for both air-conditioned rooms and gymnasiums. Wooden tiles provide a comfortable floor finish in conditioned interiors. Timber flooring is also well established in gymnasiums, where an appropriately designed floor offers resilience during exercise and movement. The shared application in the question therefore points to wooden tiles, rather than to a hard mineral tile finish.

Step 2: Compare the competing choices Ceramic tiles and concrete tiles are hard surfaces and do not provide the characteristic timber-floor response used for gymnasium activities. Cork has useful acoustic, insulating and cushioning properties, so it is a tempting alternative. However, those properties alone do not identify the conventional application pair in this question: wooden flooring is the specified match for air-conditioned rooms and gymnasiums. The answer is based on that standard building-material use, not on a claim that other finishes can never be installed in such rooms. Option (D) gives the required wooden tile finish.

Step 3: Conclusion Wooden tiles are the conventional flooring choice for the stated air-conditioned rooms and gymnasiums. Hence, the correct option is (D).

Quick Tip to Solve: Associate wooden flooring with conditioned interiors and gymnasiums; distinguish an established application from a material having only some useful properties.

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:

- Tassel House, also known as the Hotel Tassel in Brussels, is a work of the Belgian architect Victor Horta.
- Architectural attribution questions are solved by matching the building to its designer, using its location and architectural movement as cross-checks.

Step 1: Identify the building and its architect The name Tassel House refers to the Brussels residence designed by Victor Horta. It is associated with early Art Nouveau architecture, including curving ornamental forms and the expressive use of iron and glass. These identifying features support the Horta attribution. The question asks for the designer of a particular building, so the correct response is the architect's name, not merely the style or country.

Step 2: Distinguish the other architects Gerrit Rietveld is associated with the De Stijl movement and the Rietveld Schroder House. Mies van der Rohe is associated with modernist steel-and-glass

architecture, including the Barcelona Pavilion. Frank Lloyd Wright is associated with works such as Fallingwater and the Prairie houses. None of these associations identifies the designer of Tassel House. Victor Horta in option (A) is the architect whose established body of work includes the building named here.

Step 3: Conclusion Tassel House was designed by Victor Horta. Hence, the correct option is (A).

Quick Tip to Solve: Remember the association Tassel House–Brussels–Art Nouveau–Victor Horta to distinguish it from other modern houses.

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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:

- Toward an Architecture is the English title of Le Corbusier's architectural text Vers une architecture.
- For a book-attribution question, identify the exact title before comparing the writers; similarity of subject is not sufficient.

Step 1: Recognise the title Toward an Architecture is associated with Le Corbusier and his arguments about modern architecture. Its original French title, Vers une architecture, provides a useful cross-check because the English wording can vary slightly between editions. Recognising this title immediately connects the book to Le Corbusier rather than to a general author of architectural drawing or urban design.

Step 2: Separate the alternative authors Frank Ching is known for architectural drawing and design reference books, including 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. Frank Lloyd Wright wrote about his own architectural ideas, but he is not the author of the title asked here. These writers are relevant to architecture, which makes them plausible distractors; the exact book-to-author match is Le Corbusier in option (B).

Step 3: Conclusion The author of Toward an Architecture is Le Corbusier. Hence, the correct option is (B).

Quick Tip to Solve: Pair Vers une architecture with Le Corbusier; use The Image of the City to distinguish Kevin Lynch.

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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:

- The Hiroshima Peace Memorial Museum is a major work of the Japanese architect Kenzo Tange.
- Architectural awareness requires distinguishing a building's designer from other architects who worked in the same country or period.

Step 1: Make the exact building attribution The Hiroshima Peace Memorial Museum belongs to Kenzo Tange's work in Hiroshima. It forms part of the memorial setting dedicated to peace and remembrance. The exact building name is important: this question concerns the Peace Memorial Museum, not an unrelated museum or another structure elsewhere in Japan. Its established designer attribution is therefore Kenzo Tange.

Step 2: Check the competing names I. M. Pei, printed as I. M. Pie in option (A), is associated with projects such as the Louvre Pyramid, not this museum. Tadao Ando is associated with carefully composed exposed-concrete architecture, including the Church of the Light. Kisho Kurokawa is associated with Japanese Metabolism and the Nakagin Capsule Tower. Their prominence makes them plausible alternatives, but neither nationality nor fame determines the answer. The named Hiroshima museum is the work of Kenzo Tange, which corresponds to option (C).

Step 3: Conclusion The Hiroshima Peace Memorial Museum was designed by Kenzo Tange. Hence, the correct option is (C).

Quick Tip to Solve: Use the direct pair Hiroshima Peace Memorial Museum–Kenzo Tange; avoid choosing another Japanese architect merely by nationality.

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:

- Principles of design describe how visual elements are organised into an effective whole. They include emphasis, unity, rhythm, balance and proportion.

- A focal point is the particular part of a composition that attracts the viewer first; emphasis is the principle used to establish that visual priority.

Step 1: Separate a principle from its visual result A principle describes a relationship or organising rule. Emphasis makes one element dominant through contrast, position, size or colour. The element that becomes dominant is the focal point. Thus these expressions are closely related, but they do not name the same category: emphasis is the organising principle and a focal point is the area produced by applying it.

Step 2: Check the four alternatives Emphasis is a recognised design principle because it establishes hierarchy. Unity describes the coherence of the parts, making the composition read as a whole rather than as unrelated fragments. Rhythm describes organised visual movement produced by repetition or progression. All three therefore belong to the list asked about. Focal Point names a location or element of concentrated attention rather than an independent principle in this classification. Choosing it does not imply that focal points are unimportant; it distinguishes a design feature from the principle that creates it.

Step 3: Conclusion Focal Point is the intended exception; emphasis, unity and rhythm are principles of design. Hence, the correct option is (B).

Quick Tip to Solve: Ask whether the term names an organising rule or the visual feature that results from that rule; emphasis creates a focal point.

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 is commonly classified by its principal purpose: building modelling and documentation, sketch modelling, visualisation, or structural analysis.
- The examination distinguishes tools used primarily for architectural design from a specialist engineering package used primarily for structural analysis and member design.

Step 1: Classify the architectural tools Revit is a building information modelling application: walls, floors and other building components are modelled as coordinated objects and used to produce architectural documentation. SketchUp supports quick three-dimensional conceptual modelling and exploration of form. 3D Max, commonly referring to 3ds Max, supports three-dimensional modelling, rendering and visualisation. Each therefore directly serves a familiar architectural design or presentation task.

Step 2: Identify the specialist structural package STAAD.Pro is primarily a structural analysis and

design package. It analyses a structural model under specified loads and assists with the design and checking of structural members. In the usual aptitude-test classification this belongs to the structural engineering workflow, whereas the other three choices are identified with architectural modelling or visualisation. The distinction concerns the main role of the software: collaboration between disciplines can involve several packages, so it should not be interpreted as a universal ban on an architect ever using STAAD.Pro.

Step 3: Conclusion The intended specialist structural-engineering package is Staad. Pro. Hence, the correct option is (A).

Quick Tip to Solve: Classify the tools by their main task: Revit for BIM, SketchUp for conceptual models, 3ds Max for visualisation, and STAAD.Pro for structural analysis.

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:

- Architectural-awareness questions connect a monument or garden with its patron and location. Gardens sharing the name Shalimar must be distinguished by their city.
- The Shalimar Bagh at Srinagar is a Mughal garden associated with Emperor Jahangir, who established it for Nur Jahan in the early seventeenth century.

Step 1: Use the place to identify the garden The question specifies Srinagar, so the garden is the Shalimar Bagh in Kashmir near Dal Lake. Its historical association is with Jahangir and Nur Jahan. The location is decisive because Shalimar is also the name of a different celebrated Mughal garden at Lahore; transferring the patron of that garden to Srinagar would give the wrong response.

Step 2: Eliminate the other patrons Jahangir matches the Srinagar garden and is therefore the required patron. Shah Jahan is strongly associated with major Mughal buildings and the Shalimar Gardens at Lahore, which makes him a tempting but incorrect choice for this location. Bega Begum is associated with the commissioning of Humayun's Tomb at Delhi rather than this garden. Akbar was an important Mughal builder, but he is not the patron identified with the Shalimar Bagh asked about. Checking the place-patron pair is more reliable than simply choosing a ruler famous for Mughal architecture.

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

Quick Tip to Solve: Keep the two place-patron pairs separate: Srinagar Shalimar is associated with Jahangir; Lahore Shalimar is associated 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:

- City sobriquets often refer to a characteristic industry, agricultural product or historical identity. The name must be matched to the particular city in the question.
- Kanpur in Uttar Pradesh is traditionally identified with its leather industry and leather goods, giving it the sobriquet Leather City.

Step 1: Match Kanpur with its industrial identity The question supplies both Kanpur and Uttar Pradesh, which fixes the geographical identity. Kanpur is a major industrial centre with a long-established leather-processing and leather-products industry. Leather City therefore expresses the industrial association needed here. This is an identity question rather than a ranking of current production, so no numerical comparison of cities or factories is necessary.

Step 2: Check the other city labels Wine Capital of India is associated with Nashik, especially its grape-growing and wine-producing region. The Orange City refers to Nagpur and its well-known association with oranges. City of Nawabs refers to Lucknow, whose cultural identity is linked to the Nawabs of Awadh. Lucknow is also in Uttar Pradesh, so the state alone cannot separate that alternative from Kanpur; the city name and its characteristic industrial identity do. None of these three labels is the requested sobriquet for Kanpur. Only the leather-industry connection matches both the place and the description.

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

Quick Tip to Solve: Pair each name with its city: leather–Kanpur, wine–Nashik, oranges–Nagpur, and Nawabs–Lucknow.

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:

- A load path is the continuous sequence through which gravity loads travel from the building surfaces to the supporting ground.
- For the conventional framed building represented by these choices, slabs transfer load to beams, beams to columns, and columns to foundations, which distribute it to the soil.

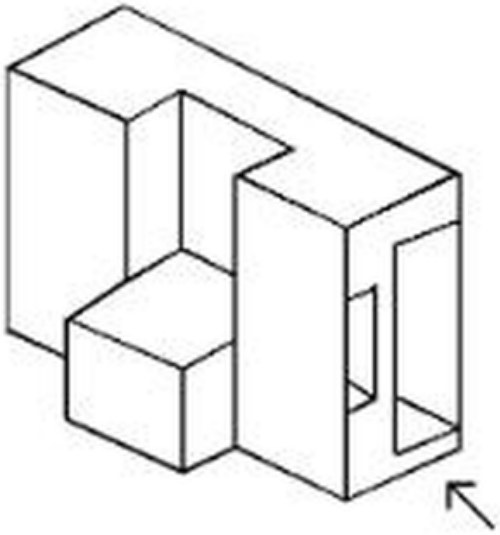
Step 1: Follow the load through the superstructure Begin with the slab, which carries its own weight and the imposed load on the floor. The slab passes that load to its supporting beams. Beams collect the slab reactions and transfer them at their supports to columns. Columns carry the accumulated vertical loads down through the building. With the letters given in the question, these stages are B for Slab, A for Beam and E for column. They must appear in that order before the foundation and earth.

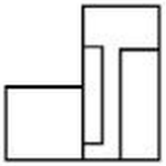
Step 2: Continue into the substructure and ground The column load enters the foundation, labelled C. The foundation spreads the force over a suitable bearing area so that it can be resisted by the underlying earth, labelled D. The complete chain is therefore Slab, Beam, column, Foundation, Earth, or B, A, E, C, D. Option A incorrectly starts with a beam before the slab and places earth before the foundation. Option B starts with a column and later inserts the slab after the foundation. Option C places columns after the earth. These reverse or interrupt the physical load path; only option D follows the continuous downward transfer.

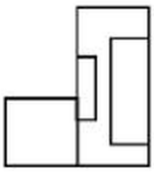
Step 3: Conclusion The order is Slab to Beam to column to Foundation to Earth: B, A, E, C, D. Hence, the correct option is (D).

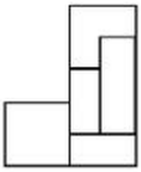
Quick Tip to Solve: Trace gravity loads from the occupied floor downward: slab, beam, column, foundation, and finally the supporting soil.

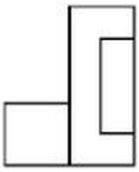
54. The Question figure shows the 3D view of an object. Identify the correct view, looking in the direction of Arrow, identify the correct view of the object. [4 marks]

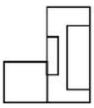


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- An orthographic view is obtained by looking straight along the indicated arrow. Depth in that direction collapses, while heights and positions across the viewing plane remain visible.
- A correct view must preserve both the outer silhouette and the visible openings. Matching the outline alone is insufficient when the alternatives differ in the lower edges or number of apertures.

Step 1: Establish the outline from the arrow direction Look at the solid from the lower-right direction indicated by the arrow. The tall right-hand face is seen frontally in this view, while the short projecting block appears to its left. The resulting outer boundary therefore consists of a tall rectangular portion on the right and a lower rectangular extension on the left. The sloping edges of the three-dimensional drawing represent depth and do not remain sloping in the required straight-on view. This identifies the general outline shared by the answer figures, so the internal edges must decide between them.

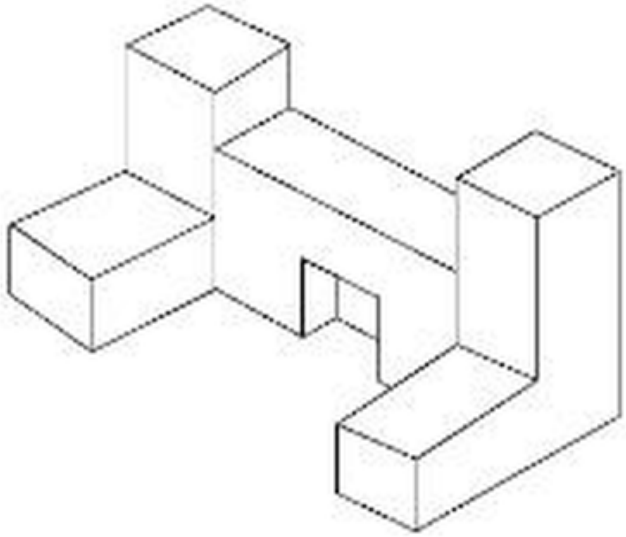
Step 2: Retain both openings and their lower borders The tall face contains a broad vertical opening toward its right edge and a narrower opening near its left edge. In the given solid, neither opening continues to the bottom of the object: a solid border remains below each one. Project these edges without shifting their heights. The broad right opening must have a visible horizontal lower edge above the baseline, and the narrow left opening must also terminate above the baseline. Option (B) shows these two apertures together with the low block at the left, preserving the required outline and internal arrangement.

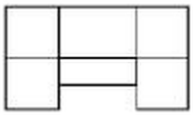
Step 3: Reject the three altered views Option (A) extends the broad right opening down to the outer baseline and loses its lower solid border. Option (C) changes the lower internal edge into a horizontal division across the tall part and alters the arrangement of the two openings. Option (D) retains the broad aperture but omits the narrow one. These are changes to visible edges, not merely perspective differences. Only option (B) retains the two separate openings with their lower borders in the appropriate positions.

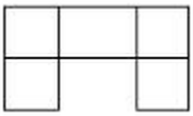
Step 4: Conclusion The view along the arrow has the low block on the left and the tall face with both openings ending above the baseline on the right. Hence, the correct option is (B).

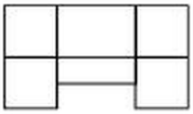
Quick Tip to Solve: When several projected views share the same silhouette, check each opening's bottom edge and count the apertures before selecting an option.

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

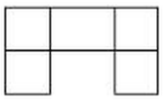


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A top view is an orthographic projection looking vertically downward. It preserves the horizontal footprint and visible changes of height, but does not show vertical faces as areas.
- A recess beneath a bridge does not create a gap in its top projection when the bridge surface covers it. Compare visible edges as well as the outside outline.

Step 1: Trace the horizontal footprint The object has a transverse connecting member with a tall block at each end. Two lower arms extend forward from the end blocks. Looking down gives an inverted U-shaped footprint: a continuous rear strip with two forward side legs and an open central region between those legs. The two arms must have the same direction in the plan.

Step 2: Mark the visible top edges The tall end blocks have their own rectangular top faces. Their boundaries separate these faces from the lower connecting surface and the forward arms. The central opening under the connecting member is a vertical-face feature. Its bottom and side edges are hidden from a downward observer, so no extra horizontal bar should be drawn across the open region between the arms.

Step 3: Compare all four answer figures Option (B) preserves the two end-block divisions, the continuous transverse connector and the two projecting arms, with the middle below the connector open. Options (A) and (C) insert an additional horizontal line across that central opening, incorrectly projecting a feature underneath the connector into the plan. Option (D) removes the divisions between the tall end-block tops and the connecting surface in the rear strip. Thus only (B) represents both the footprint and the visible height-change edges.

Step 4: Conclusion The correct top view is the inverted U-shaped plan with separately outlined end-block tops and no added bar across the central opening. Hence, the correct option is (B).

Quick Tip to Solve: First trace the footprint, then add only edges visible from directly above; an opening beneath a bridge is not automatically an opening in its top surface.

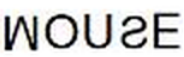
56. Identify the mirror image of the given word with respect to X-X [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- Reflection in a horizontal mirror reverses the top and bottom of each letter while preserving the left-to-right order of the letters.
- The line X-X lies above MOUSE. Every point of a letter appears the same perpendicular distance on the other side of that horizontal line.

Step 1: Identify the direction of reflection The mirror is horizontal, not vertical. Therefore the word keeps the sequence M, O, U, S, E from left to right, but each letter must be turned upside down by reflection. Reversing the sequence to E, S, U, O, M would answer a different question involving a vertical mirror.

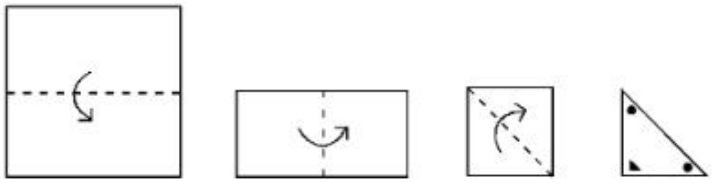
Step 2: Reflect the distinctive letters The capital M acquires a W-like outline. O is unchanged by top-bottom reflection. U becomes an inverted U, with its opening downward. S becomes its vertically reflected form, which must be checked against the supplied glyph rather than left upright. E remains left-to-right facing in the same direction because its top and bottom arms interchange; it must not become a backward E.

Step 3: Eliminate the mismatching images Option (B) has the W-like first letter, unchanged O, inverted U, reflected S and normally facing E in that order. In (A), the S retains the original orientation. In (C), the final E faces backward, which a horizontal reflection cannot produce. In (D), the U remains open upward instead of becoming inverted. These local letter checks eliminate the distractors without rotating the whole word or reversing its order.

Step 4: Conclusion Reflecting MOUSE vertically across the horizontal line X-X produces the letter pattern shown in option (B). Hence, the correct option is (B).

Quick Tip to Solve: For a horizontal mirror, keep the letter order fixed and check U and E: U flips top-to-bottom, while E must not turn backward.

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]

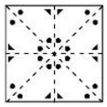


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- Unfold a cut sheet by reflecting each cut across the fold lines in reverse order. A cut affects every layer lying beneath it.
- Three successive folds produce eight overlapping triangular layers. Both the locations and orientations of the cut shapes must be reflected.

Step 1: Identify the folded layers and cuts The square is first folded along its horizontal middle line, then the resulting rectangle along its vertical middle line. The last fold is diagonal across the smaller square, leaving a right triangle. The final triangle contains two circular cuts and a triangular cut near its right-angle corner. Keep track of the triangular cut separately because its position distinguishes the answer figures most clearly.

Step 2: Undo the diagonal fold first Reflect the two circular cuts and the triangular cut across the diagonal crease to reconstruct the small square. The triangular cut produces a pair near the corresponding outside corner of this small square. That corner is associated with a midpoint of an edge of the original square, not with the centre of the original sheet. Thus a star of triangular holes at the sheet centre cannot be correct.

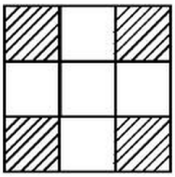
Step 3: Undo the two middle folds and compare Reflect the reconstructed small square across the vertical crease and then across the horizontal crease. The triangular cuts occur in matching pairs near the four side midpoints of the original sheet. The circular cuts reproduce around the centre and near the four corners. Option (B) has exactly this arrangement. Options (A) and (D) incorrectly put triangular openings around the centre, while option (C) places the triangular features near the outer

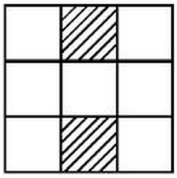
corners. These locations contradict the tracked right-angle corner of the folded triangle.

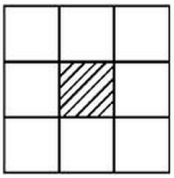
Step 4: Conclusion The unfolded pattern has paired triangular cuts near all four side midpoints, with the circular cuts repeated symmetrically as in (B). Hence, the correct option is (B).

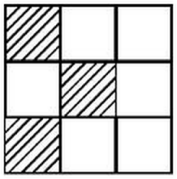
Quick Tip to Solve: Track one distinctive cut through the folds in reverse order before counting all the holes; its final position often eliminates every distractor.

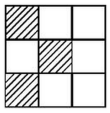
58. Identify the figure which is odd from rest of the figures. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- In an odd-figure problem, identify one structural property shared by three figures and absent from the fourth; merely counting shaded cells may not provide a common rule.
- Reflection symmetry can be tested on the positions of shaded cells in a grid. Corresponding cells on opposite sides of a middle line must have the same shaded or unshaded status.

Step 1: Describe the shaded positions Each choice is a three-by-three grid. In (A), the four corner cells are shaded. In (B), the top and bottom cells of the middle column are shaded. In (C), only the centre cell is shaded. In (D), the upper-left, centre and lower-left cells are shaded. Compare the placement of the shaded cells rather than the decorative diagonal hatching within them.

Step 2: Find the common relation in three figures The shaded-cell arrangements in (A), (B) and (C) are each symmetric about both the horizontal and vertical middle lines. In (A), corner cells occur in complete corresponding pairs. In (B), the two cells lie on the central column and form a top-bottom pair. In (C), the central cell lies on both axes and maps onto itself. They also remain unchanged after a half-turn about the grid centre.

Step 3: Test the remaining arrangement Option (D) is symmetric about the horizontal middle line, since its two left-hand shaded cells exchange positions. However, reflection across the vertical middle line would require shaded upper-right and lower-right cells, which are absent. A half-turn would likewise move its two left-hand shaded cells to unshaded right-hand positions. Thus (D) lacks the

two-axis symmetry common to (A), (B) and (C); the number of shaded cells is not needed as an arbitrary rule.

Step 4: Conclusion Option (D) is the odd figure because its shaded-cell arrangement is not symmetric about the vertical middle line, unlike the other three figures. Hence, the correct option is (D).

Quick Tip to Solve: Ignore the direction of decorative hatching and test the shaded-cell positions under reflection across the grid midlines.

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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 commonly distinguished as rubble masonry and ashlar masonry according to the extent to which stones are dressed and the regularity of the joints.
- Random rubble uses irregular stones, whereas ashlar uses accurately dressed blocks of regular dimensions. The workmanship distinguishes the two forms.

Step 1: Examine the classification in Statement I Statement I contrasts random rubble with ashlar masonry. In the classification intended here, the rubble form represents work with irregular stones and the ashlar form represents work with carefully dressed stones. Random rubble is a form of rubble masonry; the statement uses that familiar form to express the contrast. On this intended rubble-versus-ashlar distinction, Statement I is taken as true. More precisely, the broad category is rubble masonry, of which random rubble is one variety.

Step 2: Test the description in Statement II A random rubble wall does not require every stone to be cut to the same rectangular shape and size. Its stones have irregular shapes and are selected and fitted together; smaller pieces can fill spaces between larger stones. Carefully dressed rectangular blocks and close, regular joints instead describe ashlar workmanship. Thus Statement II assigns the characteristics of ashlar to random rubble and is false.

Step 3: Match the truth values to the options The intended pair is true for Statement I and false for Statement II. Option (A) incorrectly accepts the description of random rubble. Option (B) rejects the intended classification as well as the second statement, while option (D) reverses both truth values.

Only option (C) expresses the required combination.

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

Quick Tip to Solve: Associate irregular, roughly fitted stones with random rubble and accurately dressed rectangular blocks with ashlar; use this contrast to test descriptions of their joints.

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:

- Garden identification uses a combination of landscape and architectural elements: water, rocks, planting, circulation routes and the design of pavilions.
- Classical Chinese gardens combine water and irregular rock scenery with ornamental pavilions, upturned rooflines and covered galleries that frame changing views.

Step 1: Read the visible elements The photograph shows a pond surrounded by irregular rocks and dense planting. A long roofed gallery follows the water edge, and an elaborate red-pillared building with upturned tiled eaves stands on the right. The covered route and pavilion form part of the landscape composition rather than being isolated decorative objects.

Step 2: Match the combined visual vocabulary Water, rockwork, picturesque planting, covered galleries and richly articulated Chinese-style pavilions are characteristic of a classical Chinese garden. The image presents a sequence of framed views around the pond, with the built elements closely integrated into the naturalistic scene. The architectural details support the identification more strongly than the presence of water alone.

Step 3: Rule out the other styles A Roman garden is associated with a different classical architectural vocabulary, commonly courts, columns, statuary and ordered planting; those are not the defining features here. A French formal garden is recognised by strong axes, geometric parterres and controlled symmetry, which this irregular pond-and-rock composition does not display. Japanese gardens can also use ponds and rocks, so those features alone cannot distinguish them. Here the elaborate red-pillared pavilion and extensive roofed gallery favour the Chinese tradition over the typically more restrained Japanese treatment. Taken together, the pictured elements identify option (D).

Step 4: Conclusion The pond, irregular rock scenery, covered gallery and ornate upturned-eave pavilion identify a Chinese Garden. Hence, the correct option is (D).

Quick Tip to Solve: When Chinese and Japanese gardens both seem plausible, use the pavilion and gallery architecture together with the landscape, rather than water or rocks alone.

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:

- Match a heritage site to its geographic country, distinguishing the name of a monument or city from the country containing it.
- A matching-code question requires all four pairs to be correct simultaneously. One familiar pair can eliminate choices, but the remaining pairs must also be checked.

Step 1: Locate the monastery and temple Rila Monastery is the Bulgarian Orthodox monastery in the Rila Mountains of Bulgaria, so A matches II. The Moha Bodhi Temple named in the list is the Mahabodhi Temple at Bodh Gaya in Bihar, India, associated with the Buddha's enlightenment; hence B matches IV. These two identifications retain the code with A-II and B-IV. A-IV wrongly places Rila in India, while B-I incorrectly places the Buddhist temple in Egypt. Similar religious functions do not imply that the buildings share a country.

Step 2: Locate the fossil valley and fortified city Wadi al Hitan, the Valley of the Whales, is in Egypt's Western Desert, so C matches I. Valletta is Malta's capital and historic fortified city, so D matches III.

Thus the complete sequence is A-II, B-IV, C-I, D-III. Option (A) misplaces the monastery, temple and Valletta; option (C) misplaces Rila, the temple and Wadi al Hitan. Option (D) gets the first two pairs right but interchanges Egypt and Malta for the last two. Only option (B) respects every geographic identification, so selecting it does not rely merely on recognising the first pair.

Step 3: Conclusion The correct matching is Rila Monastery–Bulgaria, Moha Bodhi Temple–India, Wadi al Hitan–Egypt and Valletta–Malta: A-II, B-IV, C-I, D-III. Hence, the correct option is (B).

Quick Tip to Solve: Anchor the distinctive names first: Wadi al Hitan means the Egyptian fossil valley, while Valletta is Malta's capital; then check the religious sites independently.

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 by a combination of its entrance, roof profile and the building mass behind the entrance, rather than by a single column.
- The Pantheon in Rome has a classical columned portico with a triangular pediment in front of its great circular rotunda.

Step 1: Read the main architectural features The photograph shows a deep, dark entrance portico supported by tall classical columns. A broad triangular pediment crowns the portico, and an inscription runs across the horizontal band immediately below it. Behind the straight temple-like front, the building continues as a substantial curved mass. This combination is characteristic of the Pantheon in

Rome.

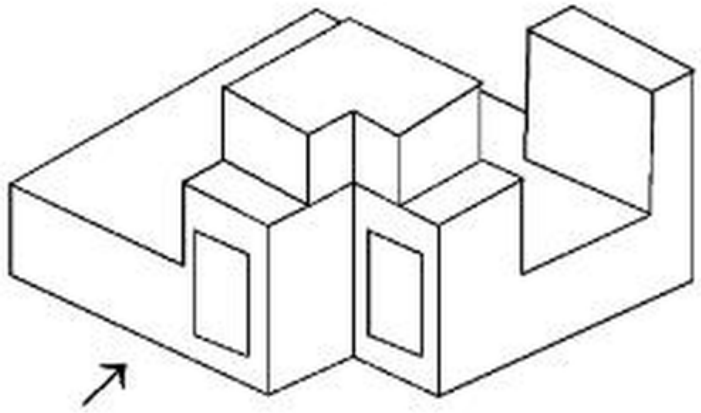
Step 2: Distinguish the two classical temple names The Pantheon and the Parthenon have similar-sounding names, but they are different monuments. The Pantheon is the Roman building whose portico stands before a circular rotunda. The Parthenon in Athens is a rectangular Greek temple surrounded by an external colonnade; its surviving appearance is an open, ruined temple, not this enclosed Roman entrance and rear mass. Thus option (C) does not match the photograph.

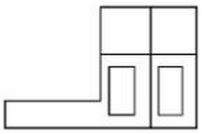
Step 3: Eliminate the remaining monuments The Cathedral of Pisa has a much lighter, richly articulated facade with stacked arcades and a different roof and frontage arrangement; it is not the heavy classical portico shown here. The Great Temple of Karnak is an Egyptian temple complex associated with monumental pylons and Egyptian column forms. It does not have the triangular classical pediment and Latin-inscribed entrance visible in this photograph. These checks exclude (B) and (D).

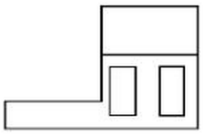
Step 4: Conclusion The monument is the Pantheon, Rome. Hence, the correct option is (A).

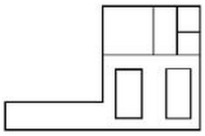
Quick Tip to Solve: Distinguish Pantheon from Parthenon by the building behind the columns: a Roman rotunda belongs to the Pantheon; a rectangular Greek temple belongs to the Parthenon.

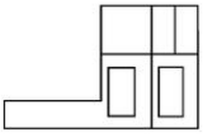
63. The question figure shows the 3D view of an object. Identify the correct view, looking in the direction of Arrow : [4 marks]

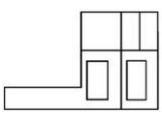


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- An orthographic view projects every visible point along parallel lines in the indicated viewing direction. Depth along the line of sight disappears, while height and sideways position remain.
- Compare the outer silhouette first, then visible changes of face and recesses. Do not erase a real edge merely because adjacent regions have equal height.

Step 1: Fix the viewing direction The arrow points towards the object along the direction in which its receding faces must be projected. Imagine moving directly towards the object along that arrow without turning it. The low extended portion forms the left-hand arm of the elevation, while the taller stepped portion occupies the right. The outer boundary is therefore an L-shaped outline, as in the answer figures.

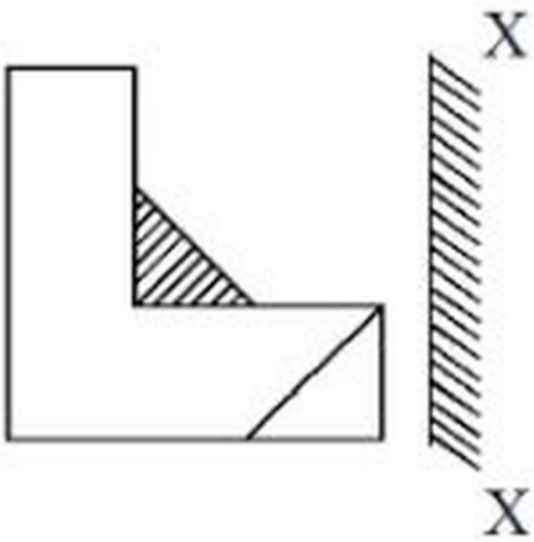
Step 2: Project the face details In the lower tall portion, two rectangular inset outlines remain visible side by side. The change of face between them produces a vertical dividing edge. Above the horizontal level through the top of these lower faces, the stepped upper portion produces further vertical changes of face. The required elevation retains the narrow strips on the upper right instead of treating the whole upper region as one plain rectangle.

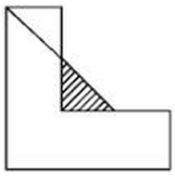
Step 3: Compare all four drawings Option (B) suppresses the vertical face divisions and makes the upper part a single uninterrupted rectangle. Option (A) retains only one upper division, losing the additional narrow step visible in the projection. Option (C) introduces a short horizontal subdivision in the upper-right region, rather than the full-height vertical boundaries of the stepped faces. Option (D) preserves both the central lower division and the additional upper vertical edges, together with the two rectangular details and the low left extension.

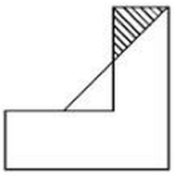
Step 4: Conclusion The elevation seen along the arrow matches option (D). Hence, the correct option is (D).

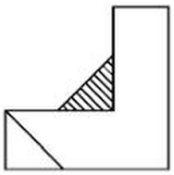
Quick Tip to Solve: After matching an elevation outline, trace each visible corner of the solid along the viewing direction; the remaining face boundaries usually distinguish otherwise similar options.

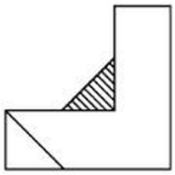
64. Identify the correct mirror image of the given figure along X-axis. [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: The key selects (D), but both (C) and (D) show the same required reflection about the vertical X-X mirror.

Solution:

Concept:

- The labelled X-X line in the figure is vertical. Reflection in that line reverses left and right while preserving the height of each point.
- The complete L-shaped outline, the interior triangular hatching and the diagonal in the bottom arm must all be reflected. A correct choice must preserve their relative positions.

Step 1: Reflect the L-shaped boundary The source has its tall vertical arm at the left and its short horizontal arm extending to the right. In the mirror image the tall arm must be at the right, with the bottom arm extending left. Top and bottom are not interchanged. Although the wording calls it an X-axis, the actual labelled mirror is the vertical X-X line drawn beside the object; the reflection follows that printed line.

Step 2: Transfer the two interior details The hatched triangle originally touches the inner right edge of the upright arm. In the reflected figure it must touch the inner left edge of the right-hand upright. The hatching must reverse its slope. The separate diagonal originally runs from a point on the bottom

edge up to the outer upper-right corner of the bottom arm. After reflection it runs from the outer upper-left corner of the bottom arm down towards a point on the bottom edge to its right.

Step 3: Compare the supplied alternatives without inventing a distinction Option (A) leaves the upright on the left and moves the diagonal to an incorrect location. Option (B) moves the hatching to the upper part of the right-hand upright and puts the diagonal through the wrong region. Both (C) and (D), however, show the upright on the right, the hatched triangle at the inner corner and the required diagonal at the lower left. Their visible line arrangements give the same reflection; minor drawing proportions do not establish a stated geometric condition that rejects one. Therefore the supplied alternatives do not support a unique visual choice.

Step 4: Conclusion Option (D) is the keyed answer. However, option (C) also shows the required reflection in the supplied figure, so (C) and (D) are visually defensible and the choice is ambiguous.

Quick Tip to Solve: Check the labelled mirror line, then track the upright arm, the hatched triangle and the separate diagonal. Do not infer a new difference when two alternatives show the same reflected features.

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



(A) 

(B) 

(C) 

(D) 

Correct Answer: (B)



Solution:

Concept:

- Reflection in a vertical mirror reverses left and right but preserves top and bottom. It reverses both the order of letters and the shape of each asymmetric letter.
- Letters such as A, H, I, T and U in this printed style are vertically symmetric, whereas C, E and R must individually appear reversed.

Step 1: Reverse the order of the word The mirror is the vertical dashed line to the right of ARCHITECTURE. The final E is nearest the mirror and therefore appears first when the reflected word is read from left to right. Reading the original letters from the end gives the sequence E, R, U, T, C, E, T, I, H, C, R, A. This describes the letter order only; asymmetric letter shapes must still be reflected.

Step 2: Reflect the asymmetric letter shapes Both E letters must have their vertical strokes on the right and their three horizontal strokes directed left. Both C letters must open towards the left. Both R letters must have their main upright stroke on the right and their leg reversed. The symmetric letters retain their usual appearance, so they are less useful for distinguishing the close alternatives.

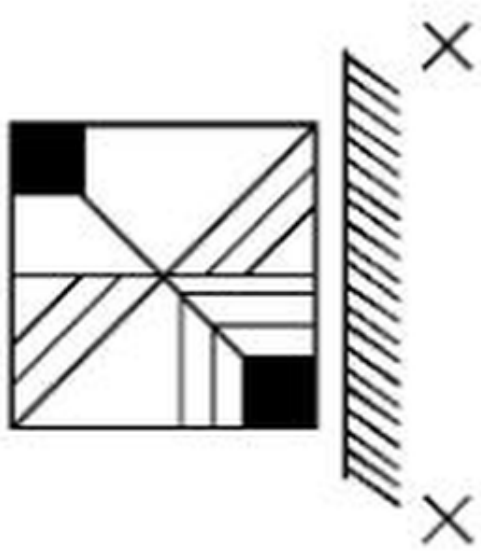
Step 3: Test the alternatives at the decisive positions Option (A) starts with the original A and does not reverse the complete word order. Option (C) leaves the first R encountered after the leading reversed E in its ordinary orientation, and also leaves the middle E unreversed. Option (D) reverses the order and the R shapes, but its middle E is still an ordinary E. Option (B) has the reversed order and correctly reverses the middle E as well as both C and R shapes.

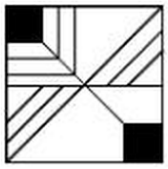
Step 4: Conclusion Only option (B) reflects the complete word consistently about the vertical mirror. Hence, the correct option is (B).

Quick Tip to Solve: For mirror-word questions, check an asymmetric letter in the middle as well as the ends; here the middle E separates the two closest alternatives.

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 reflection about the vertical line X-X interchanges left and right at the same height. It is not a quarter-turn or a half-turn of the square.
- Every feature must reflect: solid black regions, diagonal slopes, horizontal stripes and vertical stripes. Matching only the outer square is insufficient.

Step 1: Locate the reflected black corners The original square has black regions at the upper-left and lower-right corners. A vertical reflection places them at the upper-right and lower-left corners. This immediately excludes option (A), which retains the original black-corner positions, and option (B), whose two black corner regions lie on the left.

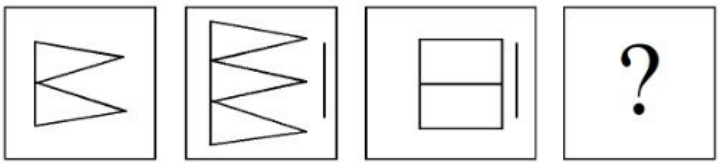
Step 2: Reflect the striped regions The original upper-right portion contains diagonal stripes rising towards the right. Its reflected image belongs in the upper-left portion, with the diagonals sloping the opposite way. Similarly, the original diagonally striped lower-left portion moves into the lower-right portion. The original horizontal stripes near the right-hand side, below the centre, move to the left-hand side at the same vertical level.

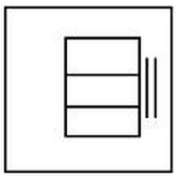
Step 3: Use the remaining detail to choose the figure The small stepped arrangement adjoining the original lower-right black corner must move to the lower-left, retaining its vertical position. In option (C), the diagonal hatching occupies upper-left and lower-right, the black corners are upper-right and lower-left, and the horizontal and vertical short lines lie around the lower-left step as required. Option (D) puts the short stepped-line arrangement near the upper-right instead. That is not the left-right reflection of its original position; its black corners alone are not enough to make it correct.

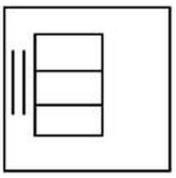
Step 4: Conclusion The complete reflected pattern is shown in option (C). Hence, the correct option is (C).

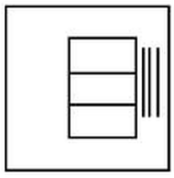
Quick Tip to Solve: Use two checks for a patterned mirror image: first the black corner positions, then one unequal group of short stripes. The second check prevents confusing reflection with rotation.

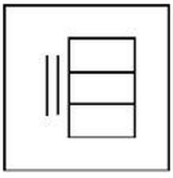
67. Identify the correct figure to complete the sequence : [4 marks]

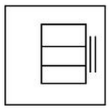


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A figure sequence can be checked by separating the internal compartments from the detached strokes outside them. Both the number of parts and their positions must follow the same rule.
- Here the first two frames form a pair of triangular figures, while the next pair uses rectangular compartments. Apply the change within the triangular pair to the rectangular pair.

Step 1: Compare the first two frames In the first frame, two right-pointing triangular compartments share the left vertical line, and there is no detached vertical stroke on the right. In the second frame there are three triangular compartments and one detached vertical stroke on the right. Thus the change within this pair adds one internal compartment and one external stroke; the stroke is placed to the right, not to the left.

Step 2: Apply the same change to the third frame The third frame starts the rectangular pair. It contains two rectangular compartments, one above the other, with a single detached vertical stroke to their right. Applying the same change gives three rectangular compartments stacked vertically, together with two detached vertical strokes on the right. The outer square is only the frame and does not count as a compartment or an external stroke.

Step 3: Test every proposed completion Option (A) has exactly three stacked rectangular compartments and two right-hand strokes, satisfying both changes. Option (B) has two strokes but places them on the left, reversing the position without support from the sequence. Option (C) keeps the strokes on the right but has three instead of two. Option (D) also puts the two strokes on the left, so it fails the positional rule. Counting compartments alone would not distinguish the options; the detached strokes decide the answer.

Step 4: Conclusion The missing frame must contain three stacked rectangular compartments with two detached vertical strokes on their right. Hence, the correct option is (A).

Quick Tip to Solve: For this sequence, compare frames in pairs: add one compartment and one right-hand stroke. Check the side of the strokes as carefully as their count.

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 should be checked with a single consistent rule at every supplied position, including the term after the blank.
- Here the terms are generated by $a_n = n^3 + n$, for consecutive integers $n = 2, 3, 4, 5, 6, 7$. The cube supplies the main growth and the added integer is the correction.

Step 1: Recognise the consecutive cubes Compare the given numbers with the nearby cubes. We have $10 = 8 + 2 = 2^3 + 2$, $30 = 27 + 3 = 3^3 + 3$, $68 = 64 + 4 = 4^3 + 4$, and $130 = 125 + 5 = 5^3 + 5$. Thus the same expression works from the very first term; it is not a rule fitted only around the blank. The integer inside the cube increases by one each time.

Step 2: Calculate and verify the missing term The blank occupies the position corresponding to $n = 6$. Hence

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

Check the final supplied term: $7^3 + 7 = 343 + 7 = 350$, which agrees exactly. The successive differences are then $20, 38, 62, 92, 128$; their differences are $18, 24, 30, 36$, with constant third difference 6, consistent with a cubic rule. Option (D), 216, is only the cube and omits the required correction. Options (B), 192, and (C), 220, do not satisfy the verified rule or the difference check.

Step 3: Conclusion The completed series is $10, 30, 68, 130, 222, 350$. Hence, the correct option is (A).

Quick Tip to Solve: For rapidly increasing integer sequences, compare terms with consecutive cubes and inspect the small remainders before building a difference table.

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: Exact bearing 177.5°, or 2.5° east of south; no exact listed direction. Key (B) uses an hour-mark approximation.

Solution:

Concept:

- On an ordinary clock the minute hand moves 6° per minute and the hour hand moves 30° per hour plus 0.5° per minute.
- Rotating the entire clock changes both hand bearings by the same angle. Their relative angle must therefore be preserved; compass bearings are measured clockwise from north.

Step 1: Find the exact hand positions At 11:35 the minute hand points at the numeral 7, with dial angle $35 \times 6^\circ = 210^\circ$ clockwise from 12. The hour hand is between 11 and 12, not exactly on 11. Its dial angle is

$$11 \times 30^\circ + 35 \times 0.5^\circ = 347.5^\circ.$$

Hence the minute hand is $210^\circ - 347.5^\circ = -137.5^\circ$ relative to the hour hand. This relative angle is unaffected by placing the clock in a different orientation.

Step 2: Rotate to the stated compass orientation North-west has bearing 315°. With the hour hand at that bearing, the minute-hand bearing is

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

Thus it points 2.5° east of due south. None of the four exact diagonal directions offered has this bearing. The answer key selects (B), South-West, which follows the simplified convention of treating the hour hand as fixed at the numeral 11: that gives a relative angle $210^\circ - 330^\circ = -120^\circ$ and minute bearing 195°, lying in the south-west quadrant. But this convention discards the hour hand movement during the 35 minutes. The exact clock geometry does not give the keyed direction. South-East describes only the quadrant of the exact bearing, not an exact diagonal; North-West and North-East are incompatible with either calculation.

Step 3: Conclusion The exact direction is 2.5° east of south (bearing 177.5°); no listed exact diagonal matches it. The supplied key gives (B) under a simplified hour-mark convention, which does not describe a continuously moving hour hand.

Quick Tip to Solve: Include the extra 0.5° per minute in the hour-hand angle whenever the time is not exactly on the hour.

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 each construction term with its characteristic function or associated component, rather than reading adjacent entries as pairs.
- A bevelled closer is a specially cut brick; arches span spaces; lintels bridge openings; cavity walls impede rainwater transfer through a wall.

Step 1: Match brick and arch A bevelled closer belongs to brickwork. It is a brick cut along a sloping plane to obtain the shape required for bonding or a particular masonry arrangement. Thus A pairs with II. An arch bridges or spans a space between its supports; the wedge-shaped units transfer loading predominantly through compression toward the supports. Of the terms supplied in List II, Span is therefore the intended association for Arch, giving B–IV. Dampness prevention is not the defining purpose of an arch, so the B–I entries in options (B) and (C) are unsuitable.

Step 2: Match lintel and cavity wall A lintel is the approximately horizontal structural member placed above a door, window or other opening. It carries the masonry and loads above that opening, so C–III. A cavity wall has two leaves separated by an air space. The separation helps prevent rain penetrating the outer leaf from reaching the inner leaf, provided the cavity and ties are correctly detailed. Thus D–I, Dampness Prevention. Combine the four independent pairs: A–II, B–IV, C–III, D–I. Option (A) incorrectly links brick to span and lintel to dampness prevention; options (B) and (C) also assign the cavity wall to span. Only option (D) preserves all four associations.

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

Quick Tip to Solve: Start with a distinctive pair such as cavity wall–dampness prevention, then verify the remaining pairs rather than selecting on one match alone.

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 questions require matching a building to its designer, using the complete set of associations to check the answer.
- Habitat 67 is associated 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 building designers The entry printed as Habital 67 refers to Habitat 67, the modular residential complex in Montreal designed by Moshe Safdie. It is known for the composition of stacked concrete residential units, so A pairs with II, the architect printed as Moshe Safdi. Falling Water is Fallingwater, the house designed by Frank Lloyd Wright over a waterfall in Pennsylvania. Its horizontal cantilevered terraces and relationship with the surrounding landscape are characteristic identifiers. Thus B pairs with I. These are building–designer associations, not a chronological ordering or a match to the country where a building stands.

Step 2: Complete and check the four-way match The Gherkin Tower, the rounded, tapering tower at 30 St Mary Axe in London, is associated with Norman Foster and Foster + Partners. Therefore C–IV. Fisher House in Pennsylvania is a residential work by Louis Kahn, giving D–III. Putting the entries in the order of List I gives A–II, B–I, C–IV, D–III. Option (B) assigns Habitat 67 to Foster and Fallingwater to Safdie; option (C) also assigns Habitat 67 to Foster and the Gherkin to Safdie. Option (D) assigns Habitat 67 to Wright and Fallingwater to Kahn. Those combinations contradict the individual building identities. Option (A) gives all four correct pairs.

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

Quick Tip to Solve: Associate each building with a visual signature as well as its designer: modular Habitat, cantilevered Fallingwater, rounded Gherkin and geometric 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:

- Identify a landmark from a combination of visible features: the roof silhouette, dominant dome, facade material, window pattern and overall massing. One isolated dome is not sufficient because several buildings can have domes.
- The Hotel Taj Mahal Palace in Mumbai is recognised by its prominent red dome and its long, ornate multistorey facade with repeated arched openings and contrasting light architectural trim.

Step 1: Read the building's visible features The photograph shows a long and richly ornamented multistorey building. Repeated windows and arches form horizontal rows along the facade, with light-coloured trim outlining the darker wall surfaces. A large red dome rises prominently above the roof, and the corner portions have smaller elevated roof features. These details together match the familiar exterior of the Taj Mahal Palace hotel.

Step 2: Compare the other landmarks Mysore Palace is a palace composition organised around its central tower and entrance frontage, rather than the long hotel frontage shown here. The Khalsa Heritage Complex is known for its modern sculptural forms and broad curved roofs, which do not resemble this ornate historic facade. Victoria Memorial is a predominantly white marble monument with a central dome and a different, symmetrical monument-like composition. Its appearance does not match the red dome and repeated hotel-window rows in this picture.

Step 3: Select the matching name Option (C), Hotel Taj Mahal Palace, matches both the dominant red dome and the detailed facade seen in the photograph. The other options fail when the overall form and the facade are checked together. The identification is therefore based on the building visible in the image, not merely on the presence of a dome or on the word Palace in an option.

Step 4: Conclusion The photograph depicts Hotel Taj Mahal Palace, Mumbai. Hence, the correct

option is (C).

Quick Tip to Solve: Recognise this landmark by the combination of its red dome, long ornate frontage and rows of arched windows; a dome alone is not a reliable identifier.

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 a green-building rating system whose full name is Leadership in Energy and Environmental Design.
- Energy performance is one part of sustainable design; environmental design also addresses water, materials, site impacts and indoor environmental quality.

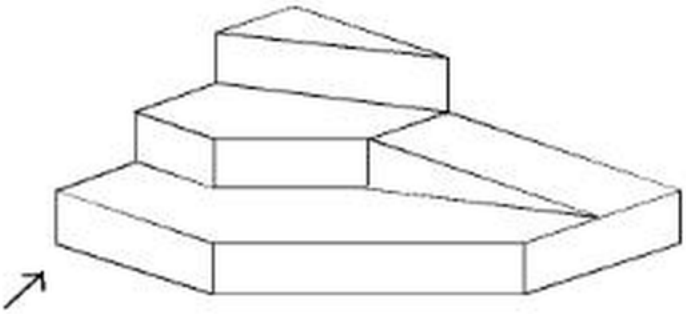
Step 1: Expand the abbreviation in its established order Read the name as Leadership, followed by the linked phrase Energy and Environmental Design. The two central words are therefore Energy and Environmental, in that order. The abbreviation identifies a building-rating framework rather than a particular construction material or a single energy-saving device. Its scope explains why the name includes both energy and the broader environment.

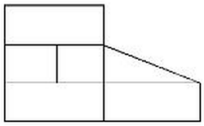
Step 2: Compare each offered expansion Option (A) reproduces Leadership in Energy and Environmental Design exactly. Option (B) interchanges Environmental and Energy, so it does not reproduce the established name. Option (C) replaces Environmental with Efficient and reduces the name to an energy-efficiency description; although energy efficiency is relevant to green buildings, that is not the expansion. Option (D) omits the conjunction and changes the expression to Environmental Energy Design, which is also not the name. Similar environmental terminology does not make those alternatives equivalent to the official expansion.

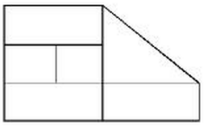
Step 3: Conclusion LEED stands for Leadership in Energy and Environmental Design. Hence, the correct option is (A).

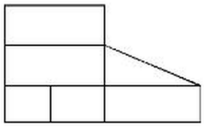
Quick Tip to Solve: Remember the sequence "Energy and Environmental Design"; swapping the two E-words changes the established expansion.

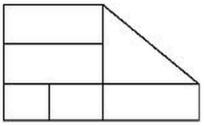
74. From the given 3D view of an object, identify the most appropriate elevation looking in the direction of the given arrow : [4 marks]

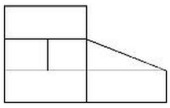


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An elevation is the two-dimensional view obtained by looking parallel to the given arrow. Heights remain visible, but distances along the viewing direction collapse.
- Compare the outer profile first, then the visible edges inside it. A sloping surface must start and finish at the heights shown on the original solid.

Step 1: Establish the viewing direction and profile The arrow approaches the object from its lower-left side. Looking along this direction gives a tall rectangular portion at the left and a sloping portion extending towards the right. The solid has a bottom slab, a middle raised portion, and a highest rear portion. The inclined surface joins the middle level, rather than the very top of the highest portion, and descends to the upper surface of the bottom slab.

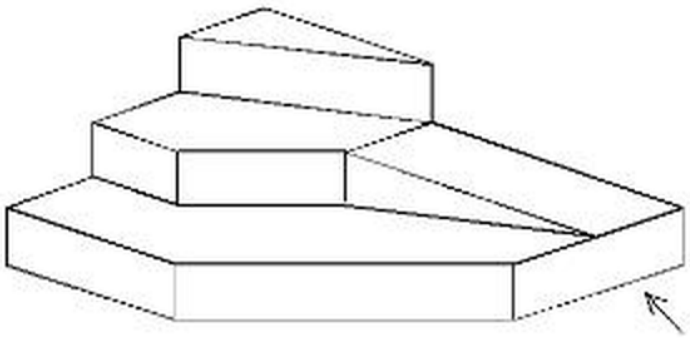
Step 2: Track the visible internal edges The uppermost rectangular region is undivided in this elevation. Below it, a vertical edge is visible within the middle band because the middle raised portion has a change in its plan boundary. This edge stops at the top of the bottom slab. It must not be transferred into the bottom slab: that would describe a different visible boundary.

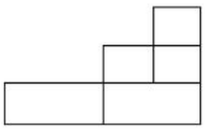
Step 3: Compare all four answer figures Option (A) has both required features: the slope begins at the middle level, and the additional short vertical edge lies in the middle band. In (B), the slope incorrectly begins at the highest level. In (C), the slope begins correctly but the short vertical edge is incorrectly shown in the bottom band. Option (D) combines both errors: its slope begins too high and its short vertical edge is in the bottom band.

Step 4: Conclusion The elevation in the arrow direction is the figure with a middle-level slope and a short internal vertical edge in the middle band. Hence, the correct option is (A).

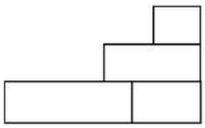
Quick Tip to Solve: For elevation options that look similar, compare where a slope starts and in which height band each short vertical edge appears.

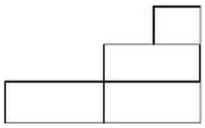
75. From the given 3D view of an object, identify the most appropriate elevation looking in the direction of the given arrow. [4 marks]

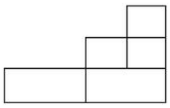


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An arrow fixes the observer's viewing direction. An orthographic elevation retains height and horizontal position across that view while suppressing depth.
- Correct identification needs the visible internal edges as well as the stepped outer boundary; edges must end where the corresponding physical face ends.

Step 1: Read the solid from the arrow side The arrow at the lower right directs the observer towards the object. From this side, the front of the view begins with the low base at the left, followed by the middle raised portion and then the highest portion at the right. Thus the required outline rises in three levels from left to right. The inclined surface is viewed along its length in this direction, so its presence does not turn this stepped silhouette into a diagonal outer roof.

Step 2: Locate the divisions between the visible faces The visible base has a vertical division at the position below the left boundary of the middle raised region. A second vertical line separates

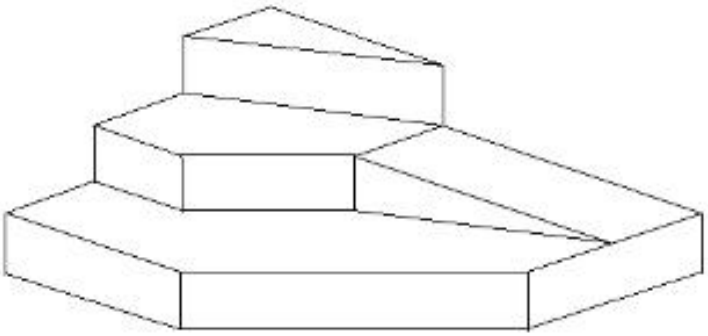
the middle region from the face beneath the highest region, but this second line ends at the top of the base. Therefore the middle-height band is divided, while the bottom band does not acquire an additional continuation of that right-hand division.

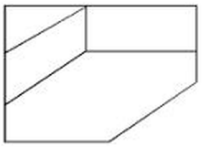
Step 3: Reject the altered edge patterns Option (A) preserves the stepped outline and both visible divisions in their proper bands. Option (B) extends the right-hand division down through the bottom slab, adding an edge absent from this view. Option (C) removes the required division within the middle band and places the bottom division farther to the right. Option (D) also omits the required internal division in the middle band. The silhouette alone cannot distinguish these choices; the edge terminations do.

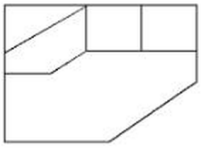
Step 4: Conclusion The observer sees the three-level stepped outline and the internal edges arranged as in option (A). Hence, the correct option is (A).

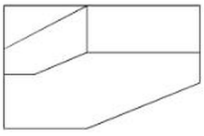
Quick Tip to Solve: After matching a stepped silhouette, trace every internal vertical line to its endpoint; an extra continuation through a lower slab changes the elevation.

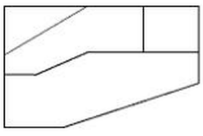
76. Choose the correct top view of the given 3D image from the options. [4 marks]

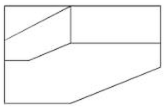


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A top view is obtained by projecting the solid vertically onto a horizontal plane. It shows the plan footprint and boundaries between visible upper surfaces, not the heights of vertical faces.

- An edge is drawn in the top view only when it corresponds to a visible boundary or change of surface in the solid. Do not add subdivisions merely because another option contains them.

Step 1: Project the overall footprint Look straight down on the base, keeping its plan corners in their original order. The base has a clipped corner, so its top-view outline contains a slanting side rather than being a complete rectangle. The footprint of the raised middle portion similarly has a short straight segment on the left followed by a slanting boundary leading towards the central junction. These changes of direction must survive vertical projection.

Step 2: Track the upper surface boundaries The rear upper portion contributes an inclined boundary from the left edge towards the upper central junction. A vertical-in-the-plan segment connects this junction to the middle junction below it, and the boundary then runs towards the right. The upper-right region is not divided by an additional edge in the given solid, so its top view must remain a single region. These are plan directions; they do not mean that a vertical face itself is seen from above.

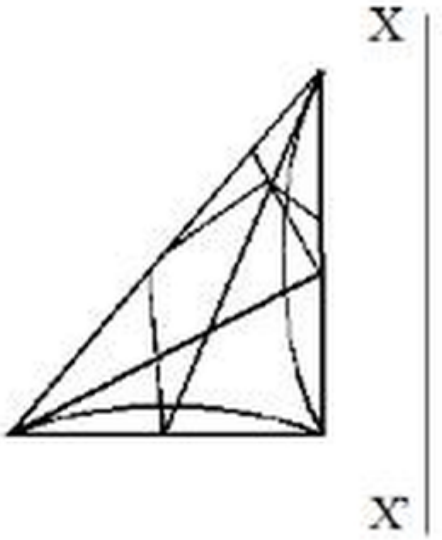
Step 3: Compare the projected pattern with the options Option (C) retains the clipped outer boundary, the short left segment before the inner sloping boundary, and the connection between the two central junctions without adding a right-hand partition. Option (A) carries the inner diagonal directly to the left edge and loses the required short left segment. Option (B) introduces an extra division in the upper-right region. Option (D) changes the central connection and also adds a right-hand partition. Each of those patterns represents different surface boundaries.

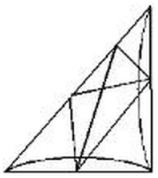
Step 4: Conclusion The footprint and all visible upper-surface boundaries match option (C). Hence, the correct option is (C).

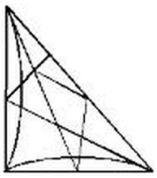
Quick Tip to Solve: For a top view, compare plan corners and surface junctions; ignore face heights and reject any extra partition not present on the solid.

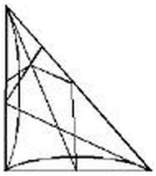
77. Identify the True mirror image of the figure amongst the answer figures with respect to X-X.

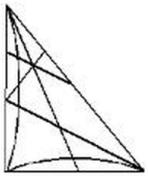
[4 marks]

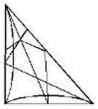


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- Reflection in a vertical mirror reverses left and right but preserves the height of every point. A point and its image lie at equal perpendicular distances on opposite sides of the mirror.
- A correct reflected figure must preserve every line junction and curved connection, not merely reverse the outer triangular outline.

Step 1: Reflect the outer triangle across X-X The mirror X-X is vertical and lies to the right of the original triangle. The original has its near-vertical side on the right, with its highest vertex at the upper-right end. Its reflected image therefore has the near-vertical side on the left and the highest vertex at the upper-left end. The low left vertex of the original becomes the low right vertex. Option (A) keeps the original handedness and is immediately ruled out.

Step 2: Follow the internal lines and junctions Now reverse each internal connection without changing its height. The internal line descending from the top vertex towards the base must lean in the reflected direction. The short near-vertical segment adjoining the long sloping boundary shifts to the right-hand side of the reflected figure. The curved line near the bottom remains a bottom curve, and the crossings near the upper part of the triangle must join the same corresponding strokes after reversal. Reflection does not permit sliding a junction along an edge.

Step 3: Check the remaining candidates Option (C) reproduces the reflected upper crossings, the short internal segment near the sloping right boundary, the lower curve and the diagonal connections together. Option (B) has the correct outer orientation but places the upper internal junctions differently, so its strokes do not match a left-right reflection of the source. Option (D) changes the diagonal and internal-segment arrangement and likewise fails the junction check. Checking these internal landmarks distinguishes (C) from outlines that only look approximately correct.

Step 4: Conclusion Only option (C) reverses left and right while preserving the heights and connections of the complete pattern. Hence, the correct option is (C).

Quick Tip to Solve: After reversing the outline, check one unusual upper crossing and one short internal segment; both must move left-to-right without moving up or down.

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 includes the initial building investment and the expenses of operation, maintenance and replacement over the building's service life.
- Efficient green-building systems reduce recurring resource use. A comparison of life-cycle costs therefore differs from a comparison of initial construction prices alone.

Step 1: Evaluate the assertion about total cost Assertion A is correct in the intended comparison of green buildings with conventional buildings. A green building can require an initial investment in efficient equipment, insulation or water-saving systems, yet save money throughout its use. Lower repeated expenditure can outweigh that investment over the service life. Thus, a possible higher purchase or construction price does not contradict a lower life-cycle cost; the assertion concerns the complete period rather than only the first payment.

Step 2: Evaluate the stated operating savings Reason R is correct: resource-efficient design lowers energy and water demand, and appropriate durable materials and systems reduce maintenance needs. Lower consumption reduces the corresponding bills, while reduced maintenance lowers expenditure on upkeep. These are recurring components of the life-cycle account, so they directly influence the total rather than being unrelated environmental benefits.

Step 3: Test whether the reason explains the assertion The connection is causal. Savings in energy, water and maintenance reduce the operating and upkeep components of total ownership cost, explaining why green buildings have the lower life-cycle cost described in A. Option (B) wrongly denies this explanatory link. Options (C) and (D) incorrectly reject one of the two valid statements.

Step 4: Conclusion Both A and R are correct, and R correctly explains A through lower recurring operating and maintenance expenditure. Hence, the correct option is (A).

Quick Tip to Solve: For life-cycle cost questions, include future utility and maintenance bills rather than judging only the initial construction price.

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:

- Match each landmark with its distinctive silhouette rather than with the number of vertical elements alone. A bridge, a gateway, a prehistoric stone arrangement and paired skyscrapers have different structural forms.
- The Roman numerals label the pictures in List II; the letters label the names in List I. A correct option must preserve all four associations simultaneously.

Step 1: Identify the bridge and the gateway Picture IV shows two elaborate bridge towers, an upper connecting link and raised bascule leaves over water. These features identify Tower Bridge, so A matches IV. Picture I shows two posts carrying horizontal crosspieces, with the characteristic projecting curved upper lintel of a Japanese torii gateway. Thus Torii, B, matches I. The two horizontal levels and simple gateway outline distinguish this image from either a bridge or a skyscraper pair.

Step 2: Identify the stones and the twin towers Picture II consists of massive upright stones supporting horizontal stone lintels, with separate standing stones beside them. This is Stonehenge, giving C-II. Picture III shows two tall tapering towers with pointed tops and a connecting skybridge. That silhouette represents the Petronas Towers, giving D-III. The relative height, repeated storey-like bands and skybridge distinguish the twin towers from the low prehistoric stone setting.

Step 3: Check the complete mapping against every option Combining the observations gives A-IV, B-I, C-II and D-III. Option (D) contains all four matches. Options (A) and (C) begin with A-III, which

incorrectly identifies the twin skyscrapers as Tower Bridge. Option (B) starts correctly with A-IV but pairs Torii with III rather than the gateway in I; it also places Stonehenge and the Petronas Towers against the wrong pictures. A single correct pair is insufficient for a matching question.

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

Quick Tip to Solve: First fix the unmistakable forms—water under the bridge and lintels on prehistoric stones—then use the gateway and twin-tower silhouettes to verify the 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 attached to a building's structural backing. Identifying cladding requires distinguishing the visible finish from the material carrying the building loads.
- The Lotus Temple in New Delhi is recognised by its white, petal-shaped external surfaces. These surfaces are faced with white marble.

Step 1: Identify the material of the visible facing Read the demand carefully: it asks for the building material primarily used for cladding, rather than the structural frame or a constituent of a mortar. The Lotus Temple's distinctive white exterior is marble cladding fixed over its reinforced-concrete shell. Thus the material named in the answer should describe that external facing. The use of a concrete structural shell does not make concrete the answer to a question specifically about cladding.

Step 2: Compare the four material names Marble, option (C), directly identifies the white stone facing associated with the temple. Dolomite is a mineral and a rock name and does not identify the specified architectural facing here. Lime is a binder used in construction materials, rather than the finished stone cladding requested. Granite is another durable dimension stone, but it is not the characteristic cladding material of the Lotus Temple. The distinction concerns the named building's actual finish, not whether a material could be used to clad some other building. Select the specific material rather than a related mineral or a general-purpose building stone.

Step 3: Conclusion The primary cladding material of the Lotus Temple is white marble. Hence, the correct option is (C).

Quick Tip to Solve: For questions about a famous building's materials, separate its visible cladding from its supporting structure: the Lotus Temple pairs a concrete shell with a white-marble exterior.

Drawing Test (100 marks)

81. Draw a proportionate Sketch of the image given below in detail. Sketch this using Black and White Medium only. [50 marks]



Solution:

Concept:

- An observational sketch preserves the reference image's proportions, pose, overlaps and viewpoint. The subject is a man standing in front of a two-wheeled hand rickshaw and holding its shafts, with the passenger seat behind him.
- Construction begins with the largest shapes and relative measurements. Details such as spokes, facial features and fabric folds are added only after the overall silhouette and alignment are accurate.
- Black-and-white rendering creates form through line weight, hatching and a controlled range from paper white to dark graphite. Tonal contrast should describe the visible surfaces without

introducing colour or changing the reference lighting.

Step 1: Establish the complete composition Use a vertical working area and lightly mark the top of the man's hair, the bottoms of the feet and wheels, and the farthest left and right edges of the vehicle. Leave a modest clear margin around the subject. The man's head lies near the upper centre-left of the composition; his body and feet stand between the two large wheels. The rickshaw backrest extends behind his upper body toward the right. Mark these positions as simple envelopes before drawing any small feature. Compare the total height with the wheel-to-wheel width directly from the reference so that neither the person nor the vehicle becomes disproportionately large.

Step 2: Construct the man and preserve his pose Draw a light head shape and a centreline through the neck, torso and lower body. Establish the shoulder slope, elbow bends and hand locations from the reference. Both arms extend to grasp the shafts; preserve the actual hand-to-shaft contacts and the overlap of the arms over the vehicle. Block the shirt, the cloth around the neck and the draped lower garment with broad shapes. Locate the knees, ankles and feet before refining the folds. Preserve the head's turn, the dark hair and moustache, and the relative spacing of the eyes, nose and mouth without enlarging these features. Continually compare the lengths of the head, torso and lower limbs against the reference.

Step 3: Build the rickshaw around the figure Place the two large spoked wheels exactly where they appear on either side of the man. Because the wheels are seen obliquely, use narrow elliptical outlines with consistent centres and rims rather than full circles. Establish the hubs and the visible framework between the wheels. Construct the passenger seat, backrest and their supporting members behind the figure, keeping their tilt and visible depth consistent. Trace each shaft from the vehicle toward the man's hands; do not let a shaft pass incorrectly through an arm or torso. Keep visible edges continuous where the reference shows them and interrupt them where the person or a nearer vehicle member occludes them. Add spokes radiating from each hub only after the wheel shapes are settled.

Step 4: Develop monochrome form and texture Reserve the lightest paper areas for the highlights visible on the clothing and vehicle. Lay in broad midtones on the man's clothes and the rickshaw seat, then deepen the dark hair, moustache, wheel rims, recesses and overlapping frame members. Use curved or angled hatching to follow fabric folds, and straighter directional marks for the harder vehicle surfaces. Vary the spacing of strokes to express tonal depth. Keep the facial planes readable with restrained shading instead of outlining every feature equally dark. Follow the tonal relationships in the supplied picture and retain the sparse ground contact marks beneath the subject rather than adding a new setting or a strong invented cast shadow.

Step 5: Refine details and check the whole sketch Finish the hands around the shafts, garment edges, seat divisions, frame joints and visible wheel spokes. Use stronger lines at the nearest overlaps and deep recesses, with lighter construction and secondary edges. Step back to compare the outside silhouette, wheel heights, head position, hand positions and feet with the reference. Correct any misalignment before erasing unnecessary construction lines. Ensure that the face, clothing, seat and wheels remain distinguishable and that the darkest areas are balanced across the image. Present the result entirely in black and white, with no coloured accents or added objects.

Step 6: Conclusion Produce a detailed, proportionate black-and-white sketch of the man holding the shafts of the hand rickshaw. Preserve the reference pose, two spoked wheels, passenger seat, overlaps and viewpoint, and use controlled monochrome shading to distinguish the human figure, fabric and

vehicle structure.

Quick Tip to Solve: Compare five anchors before adding detail: the top of the head, both wheel hubs and both hand-to-shaft contacts. Correcting these early keeps the figure and rickshaw aligned.

82(a). Combine Musical Instruments like Guitar, Microphone (mic), Drums, Tabla, Keyboard, etc. into a 3D Abstract Sculpture, using different colors to represent various Texture and Instruments. You can scale each object to any size of your choice. Apply the effect of light and shadow on your Sculpture. [50 marks]

Solution:

Concept:

- An abstract sculpture reorganises recognisable forms into a unified spatial composition. Musical instruments can supply contrasting masses, cylinders, curves, planes and repeated linear details while retaining enough identifying features to communicate the theme.
- Three-dimensional form is conveyed through overlapping, consistent perspective and tonal modelling. A single light direction makes the highlights, shaded surfaces and cast shadows agree throughout the sculpture.
- Colour contrast and surface treatment distinguish materials, while a limited repeated palette connects the different instruments into one design. Texture should follow each curved or flat surface rather than flattening it.

Step 1: Establish the overall silhouette and balance Use a portrait composition with a low elliptical plinth and a rising diagonal arrangement. Place an enlarged guitar body near the lower centre as the principal mass, tilted slightly to one side. Let its neck rise diagonally, carrying the eye upward. Balance this diagonal with a smaller microphone on the opposite side and a horizontal keyboard crossing behind the guitar. Position a drum and a pair of tabla near the base, at different depths, to anchor the tall forms. Leave visible spaces between selected elements so the silhouette remains legible. This is one possible design: scaling the instruments differently is permitted, but the arrangement must still feel stable and connected.

Step 2: Construct convincing volumes in one perspective Begin with light geometric guides: a rounded block for the guitar, cylinders for the drums and microphone, tapered volumes for the tabla and a shallow rectangular prism for the keyboard. Choose a slightly elevated eye level so some top surfaces are visible. Draw the circular drumheads and tabla skins as ellipses whose axes agree with the orientations of their bodies. Keep the keyboard edges converging consistently and place its keys on the receding upper plane. Overlap the lower instruments in front of the keyboard, and let the guitar neck pass behind the microphone head where this strengthens the composition. Make every contact convincing by showing the relevant junctions or supports; avoid unrelated objects apparently floating above the plinth.

Step 3: Retain musical identity through selected details Add the guitar's sound hole, bridge, strings and tuning head, simplifying small details where the form recedes. Indicate alternating keyboard keys with their spacing compressed by perspective. Give the microphone a rounded mesh head and a narrow handle. On the drum, show the rim and a few fastening lugs; on each tabla, distinguish

the membrane, dark central patch and vertical lacing. Repeat curves and string-like lines across the design to create rhythm, but keep the main masses stronger than the decorative details. The result should read as one abstract sculpture assembled from musical forms rather than a row of separate instrument drawings.

Step 4: Apply colour, texture and consistent illumination Choose light from the upper left. Use warm ochre and brown for wood, a restrained blue or grey for metal, cream for drum skins and dark accents for the guitar opening and key separations. Repeat one accent colour in several locations to unify the sculpture. Build the darkest form shadows on the lower-right sides and put the deepest contact shadows where objects meet. Cast shadows fall across the plinth toward the lower right, following its surface. Use broad, smooth tonal transitions on curved wooden bodies, narrow highlights on metal and fine restrained crosshatching for the microphone mesh. Keep lit surfaces lighter even when their local colour is dark. Finish with a clean outer contour and reduce distracting construction lines, preserving the contrast around the main guitar form.

Step 5: Conclusion A balanced model composition combines a dominant tilted guitar, a counterbalancing microphone and keyboard, and drum and tabla forms around a common base. Consistent perspective, selective instrument details, related colours and upper-left lighting give the abstract sculpture a unified three-dimensional appearance.

Quick Tip to Solve: Decide the silhouette, eye level and light direction before adding strings, keys or texture. Check the composition as simple masses first, then use details to identify the instruments.

OR

82(b). Considering yourself as one of the spectators, draw a beautiful sketch of a Football stadium where a match is going on. [50 marks]

Solution:

Concept:

- A spectator-view scene places the observer inside the seating area, looking toward the pitch. Foreground spectators, the playing field and the opposite stands establish near, middle and far spatial layers.
- Perspective makes parallel field edges converge toward vanishing points on a common eye-level line. Overlap, diminishing size and reduced detail reinforce the depth already established by the construction.
- A match scene needs both architectural structure and human action. Players, a ball, goals, spectators and stadium features should support one clear focal area rather than compete equally for attention.

Step 1: Set the observer's position and frame the scene Choose a seat partway up a stand near a corner of the pitch, looking diagonally across the field. Use a landscape format to include the playing area and the curve of the opposite seating bowl. Place the eye-level line above the pitch because the observer is seated at an elevated position. Include the cropped shoulders or backs of a few nearby spectators at the bottom edge and a short piece of railing to establish that the view belongs to someone in the audience. Keep the central view open so these foreground elements frame the match rather

than obscure it. Position the main action near one goal, slightly away from the centre of the page, to give the scene a clear visual focus.

Step 2: Build the pitch and stadium in perspective Construct the rectangular field with its two principal sets of parallel edges converging toward their respective vanishing points on the same eye-level line. Extend guides lightly beyond the picture when a vanishing point lies off the sheet. Add the touchlines, goal lines, halfway line and penalty-area rectangles in that same perspective. Represent the centre circle as a foreshortened ellipse within its perspective boundary. Place a goal at each end with upright posts and crossbars consistent with the field construction. Draw the opposite stand as rising tiers that wrap around the pitch, with entrances and a roof canopy simplified into repeated structural bays. Recede seat rows and roof members progressively; do not space distant rows as widely as the near ones.

Step 3: Show the ongoing match and the spectators Arrange a small group of players around the ball near the chosen focal area, with one player kicking, another responding and the goalkeeper alert near the goal. Distribute additional players across the field so the game appears active without filling every space. Use two contrasting tonal groups for the opposing teams, and distinguish the referee with a separate value or simple silhouette. Keep figures proportional to their distance: players across the field are smaller than those near the observer. Suggest the crowd in the opposite stand with grouped marks and alternating light and dark patches, reserving recognisable heads, shoulders and gestures for the foreground spectators. A few raised arms can convey excitement while leaving the key play visible.

Step 4: Organise light, tone and finishing details Choose a consistent daylight direction and show short cast shadows on the pitch that agree for all players and goalposts. Keep the open field relatively light, the covered seating somewhat darker and the foreground spectators stronger in contrast. Darken the underside of the canopy and selected entrances to clarify the stadium structure. Add only a few supporting features, such as a scoreboard, floodlight towers and simple advertising panels along the far boundary, keeping their scale and perspective consistent. Avoid prominent text that distracts from the match. Strengthen contours near the observer and soften distant architectural details. Review the entire image for a clear foreground-to-background progression, readable football action and a coherent enclosed stadium before cleaning the construction lines.

Step 5: Conclusion The model sketch shows a match from an elevated seat near a pitch corner, with nearby spectators framing the foreground, players and goals on a correctly foreshortened field, and a receding seating bowl beyond. Consistent perspective, scaled figures and controlled tonal contrast establish the spectator's viewpoint and the atmosphere of a live football match.

Quick Tip to Solve: Construct the pitch and its shared eye level before drawing the players. Use a few strong foreground silhouettes and much smaller distant figures to make the spectator's position immediately clear.